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ONE YEAR LATER: THE AMERICAN INNOVATION AND COMPETITIVENESS ACT

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

JANUARY 30, 2018

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

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ONE YEAR LATER: THE AMERICAN INNOVATION AND COMPETITIVENESS ACT

TUESDAY, JANUARY 30, 2018

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 2:38 p.m., in room SR–253, Russell Senate Office Building, Hon. Cory Gardner, presiding.

Present: Senators Thune, Fischer, Gardner [presiding], Nelson, Cantwell, Klobuchar, Blumenthal, Markey, Peters, Hassan, and Cortez Masto.

OPENING STATEMENT OF HON. CORY GARDNER, U.S. SENATOR FROM COLORADO

Senator GARDNER. Well, good afternoon, and thank you, everyone, for participating in this hearing today. Thank you to our witnesses. And, Dr. Córdova and Dr. Copan, thank you so much, both of you, for being here.

I would also like to extend a special thank-you to Chairman Thune for allowing me to chair this hearing, as well as Ranking Member Nelson and Senator Peters for your partnership, your incredible work that we did on the American Innovation and Competitiveness Act, or I have an acronym here, AICA. I guess nobody uses that one, right?

[Laughter.]

Senator GARDNER. How about America COMPETES last Congress?

It's an honor to represent a state like Colorado, where we have so many incredible Federal labs, including facilities operated by NSF and NIST. Whether in car, in rail, or any of the other nearly 30 Federal labs, Colorado is lucky to house our Nation's foremost thinkers in the research and development space.

This hearing marks just over one year since President Obama signed the American Innovation and Competitiveness Act into law. Senator Peters and I worked closely with Chairman Thune, Ranking Member Nelson, and other members of this Committee over the course of about 18 months to assemble a bill that built on the successes of the America COMPETES legislation passed in 2007 and in 2010. Our goals revolved around three principal components: maximizing basic research, improving STEM education, and encouraging greater commercialization and technology transfer opportunities. We developed our legislation through a series of roundtable discussions, dozens of stakeholder meetings, a Commerce

Committee hearing and markup, and a thorough review of countless comments, interested parties, and agencies alike submitted for consideration.

In the end, we were able to pass the first major Commerce Committee-led reauthorization of the National Science Foundation and National Institute of Standards and Technology in 6 years. Former Vice-Chair of the National Science Board, Dr. Kelvin Droegemeier, supported this process and thanked us for helping to, quote, make science bipartisan again.

Despite all the successes we were able to achieve, there is still much work to be done. While the United States remains the global leader in research and development investments at approximately 26 percent of the global total according to recent National Science Board publications, China is quickly closing the gap and is now spending about 21 percent of the global R&D total. And the recently published ITIF study shows that the U.S. is falling out of the top 10 global innovators for the first time in history.

While this isn't a hearing on funding, I would like to reiterate my strong support for robust funding increases in both the National Science Foundation and the National Institute of Standards and Technology. Unless we dedicate more support to our Nation's research and development enterprise, we will lose out to competitors like China, who are quickly working to displace the United States as the world's greatest innovator.

But we also have to ensure our research agencies are functioning at all levels and are able to continue to produce the best possible outcomes for our country. And so now that more than a year has passed since the Act's passage, it presents a great opportunity to hear about the progress of AICA—I'm just going to keep saying that, just get it out——

[Laughter.]

Senator GARDNER.—implementation from the well-qualified leaders, both at NSF and NIST in their first appearances before the Senate Commerce Committee since taking the helms at their agencies.

With that, it's my pleasure to first introduce Dr. Córdova and Dr. Copan, but before we do the formal introductions, I want to turn it over to Ranking Member Bill Nelson for his comments, and then some comments from Senator Peters.

STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Mr. Chairman, as you know, I approach my service in the Senate in a bipartisan way. You and I specifically have worked together with regard to the DACA kids and I want you to know that my comments are not partisan, they are an observation of some of the things that this Senator thinks are alarming with regard to science from the new administration over the past year. What I am saying is built on a lifetime of having an appreciation for science, having participated in one of the major science programs of the U.S. Government, and wanting to continually support the advancement of science as a major contributor to the quality of life of us, as individuals, as well as a nation.

The public interest, public health and national security are going to depend on advancements in science. It is the fuel for innovation and the U.S. has led the world for a century in the development of new technologies and scientific achievement. The examples are legion. The Russians thought they were going to get to the Moon first. They shot the pants off us by putting up the first satellite. They shot the pants off us by putting up Gagarin. Then one orbit and then they ticked off three orbits before we could ever even get out of suborbit. I could go on and on and on from satellite communications to cutting-edge fields like gene editing. Look what Dr. Francis Collins did at NIH in harnessing understanding the whole genome code.

The advancement of science has depended on a healthy investment in research by the Federal Government. But I think what we're doing is losing ground to overseas competition. The National Science Board just released their report on the state of the U.S. science enterprise and their findings are chilling. China is now the second largest investor in R&D, a key driver of global competitiveness. And China's R&D investment continues to grow at a much higher pace than other nations. At this rate, China may soon eclipse the U.S., and we will lose the competitive advantage that has made us the most powerful economy in the world. These findings echo what we've heard time and again from the National Academies of Science as well as industry leaders like a former Coloradan, Norm Augustine, who first sounded the alarm 10 years ago.

And so what we see in the proposed 2018 budget is slashing National Science Foundation spending by 11 percent, slashing the very agency that you just gave appropriate accolades to, NIST, by 23 percent. By contrast, the version of American Innovation and Competitiveness Act, that this Committee reported unanimously recommended a 4 percent increase for those agencies.

Now, part of the problem is that there are still vacancies in the administration—science advisor is one. That means when decisions like budget or leaving the Paris climate accords are under consideration, there is no science voice in the room.

Just as troubling are the many reports of interference in science. Nearly a year ago, we introduced legislation to ensure that science was protected from political interference. And yet, what do we see? Listen to what Columbia Law School has documented, over 100 cases of censorship and other meddling in science over the last year. At EPA, a political appointee is now reviewing grant applications instead of a career Federal employee.

Some scientists have been told that they cannot talk about their research and others have been moved out of science jobs. Given the stakes, we better be paying attention to this. Now, luckily, at NSF and NIST, we have qualified leadership.

Dr. Córdova and Dr. Copan, you are on the front lines of protecting scientists and their research from politics. I hope you remain strong. The bottom line is science should be a nonpartisan issue. That's what I say about NASA all the time. It should be not partisan or even bipartisan, it ought to be nonpartisan. So hopefully you all can shed some light on this.

And, Senator Gardner, I want to recognize your leadership as well as Chairman Thune's and Senator Peters' in passing into law the American Innovation and Competitiveness Act just one year ago. I was proud of you, I was proud to cosponsor that legislation, and that was a truly bipartisan consensus-building effort.

Thank you.

Senator GARDNER. Thank you, Senator Nelson.

And to Senator Peters we turn next. But again my appreciation for your work on this legislation.

STATEMENT OF HON. GARY PETERS, U.S. SENATOR FROM MICHIGAN

Senator PETERS. Well, thank you, Chairman Gardner. And it was wonderful working with you on this legislation. And I echo Senator Nelson's comments. It truly was a bipartisan process. You mentioned in your comments the roundtables that we held. Those were some of the most productive roundtables that I've ever attended. As a Member of the Senate, we got very frank advice from all of the stakeholders involved in the scientific enterprise, from the business community to academics to innovators, and all of that went into this legislation, and certainly Senator Nelson and Senator Thune were a big part of making this legislation a success.

But it is only a success if it actually gets implemented properly, and that's why both Dr. Córdova and Dr. Copan, you're here. Thank you for your leadership. Thank you for taking up these issues and working on making sure that our bill, which was designed to promote Federal science and research, to strengthen innovation, advance manufacturing, also concerned about skilled workforce to make sure STEM education, or STEAM education, is a priority going forward.

But I want to echo what my colleagues have said, that now is really the time, in my mind, to double down on these policy goals and to make sure that they're actually met. I believe that we're living in perhaps one of the most fascinating times in human history when it comes to the breakthroughs that we're likely to see in scientific and engineering breakthroughs, but we're also facing significant competition from folks all around the world, and we need to step up our game and continue to do what we do so well. And a lot of that is going to rely on you, and it's on your shoulders and all of the colleagues you work with in the scientific community generally.

So I look forward to having a very close relationship with both of you. Thank you for your commitment to this, and we hope that this Committee will be, continue to be, a beacon of bipartisanship in the area of scientific endeavor.

Thank you.

Senator GARDNER. Thank you, Senator Peters. And with that, it's my great pleasure to introduce Dr. Córdova and Dr. Copan.

Dr. Córdova is the Director of NSF, where she has served since March 2014. Prior to that role, she served as President of Purdue University and Chancellor of the University of California at Riverside as a Distinguished Professor of Physics and Astronomy.

Dr. Córdova has also served as NASA's chief scientist in addition to numerous other prominent roles in science and academia.

Dr. Copan has served—has been serving as NIST's Director since October 2017. Prior to his confirmation, Dr. Copan worked as the head of an engineering firm in the great State of Colorado, where it got a lot of snow last week, and the ski resorts are great, and served as a board member at Rocky Mountain Innovation Partners, where he advocated for Federal labs and the U.S. research and development enterprise.

Dr. Copan has a long history in the technology commercialization space and has worked in several positions in the private sector.

Dr. Córdova, if you would like to begin, and then we'll follow that up with Dr. Copan.

STATEMENT OF DR. FRANCE CÓRDOVA, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. CÓRDOVA. Thank you, Chairman Gardner, members of the Committee, Mr. Peters, Ms. Cantwell, Mr. Blumenthal, Ms. Cortez Masto.

I'm pleased to be here today to celebrate the one-year anniversary of the American Innovation and Competitiveness Act. The Act represents a bipartisan endorsement of the mandate and mission of the National Science Foundation and the innovation, scientific discovery, economic impact, and transformative effects of the fundamental research we fund.

Last month, I attended the 2017 Nobel Prize Award ceremony in Stockholm, Sweden. I was there to celebrate scientists in the fields of physics, economics, biology, and chemistry. All eight U.S. Nobelists were at some point supported by the National Science Foundation. In fact, NSF-funded researchers account for 231 Nobel Prizes dating back to 1955. Congress' support for basic research has been vital to their breakthroughs. In fact, in the LIGO observation that was given the Breakthrough of the Year award by *Science Magazine* and the Nobel Prize in Sweden, that research has been supported by Congress for 40 years. So congratulations to all of you.

The AICA further serves to codify how NSF invests in science, innovation, and education. When the bill was signed into law, I directed an agency-wide approach to its implementation, which included establishing a coordinating committee to ensure an effective and efficient response. And I have with me in the audience Dr. Wanda Ward, who leads the Coordinating Commission.

Wanda, if you would just lift your hand, please.

I'm very proud of the work done to date, and I'll highlight just a few of the provisions of the law, how NSF is responding, and how they're positively impacting the Nation.

First, on transparency and accountability. Importantly, the AICA affirms NSF's longstanding and world-renowned merit review process and addresses NSF's implementation of increased transparency and accountability.

Recognizing the importance of the public's confidence in our work, the Act requires that the research goals of funded projects are clearly identified in a manner that can be easily understood by all audiences. Over the past year, I've met with leaders across NSF to reemphasize the need for clarity and strong justifications so that the public can understand what we are funding and, most impor-

tantly, why we're funding it. Each award now explains the project's significance and importance in clear language.

On facilities, NSF's work would not be possible without the world-class facilities that are the tools of scientists around the country and the world.

And, Senator Gardner, you mentioned a few of those in the Boulder area.

To be at the forefront of science often requires unique instruments that take decades to design, build, and perfect. And an apt example is the one I mentioned, the LIGO Observatory, which in 2015 detected gravitational waves first predicted by Albert Einstein a century ago, and it opened a new and most exciting chapter in astrophysics.

LIGO was first conceived in the 1970s. Construction began in the 1990s. After 40 years of significant investments in resources, it has become a revolutionary tool that will allow us to unlock mysteries of the universe.

The AICA focuses on strengthening oversight and accountability for large facilities and support for what they call mid-scale projects. In response, NSF has maintained a Large Facilities Office, and I have appointed Dr. James Ulvestad, also sitting with me in the audience—Jim, raise your hand, please—as the agency's first Chief Officer for Research Facilities. This position sits in the Office of the Director and reports directly to me. I'm confident these steps and others we've taken, such as requiring independent cost estimates, will lead to improved outcomes.

NSF is also evaluating the existing and future needs for mid-scale projects as defined by the AICA. We've issued a Request for Information to assess the demand for projects that could cost between $20 and $100 million. We received nearly 200 responses, totaling a demand of about $10 billion for such projects. This is an area that we don't even fund right now, a $10 billion demand out there for first-class facilities in this cost range. NSF will now use this information to develop strategies for supporting these efforts.

On STEM education and I-Corps, Title III of the Act highlights some areas of STEM education that have been key investments for NSF for many years and where we're seeing positive impacts. The law also demonstrates a commitment to drawing in more people who are talented into STEM fields by inspiring them early on, just as I was inspired, just as you were inspired, with excellent learning opportunities, including engagement in computer science.

NSF, in collaboration with other agencies, is standing up a STEM Education Advisory Council, as required by Section 303. We solicited nominations, and the response has been most impressive. We have received over 400 discrete individual nominations, including many with support from Members of Congress. We're working toward having the appointments made in the next month or two.

And, finally, I would like to highlight the Innovation Corps, or I-Corps, program. Since it was established in 2011, NSF has enabled the formation of over 450 companies through this program. They've collectively raised over $250 million in seed capital. The I-Corps program is helping to focus efforts and ideas that are commercially viable, thus, avoiding expenditures on those that are not. This efficiency, in addition to the entrepreneurial skills that I-

Corps teaches, has made it a highly sought program. NSF has MOUs with nine other Federal agencies now, we've inspired their own I-Corps programs, and the State of Ohio.

Mr. Chairman, these are but a few of the successes we're seeing in the implementation of I-Corps, so thank you for this marvelous Act.

And now I turn to my colleague here. And thank you for the time. And I'm pleased to answer your questions.

[The prepared statement of Dr. Córdova follows:]

PREPARED STATEMENT OF DR. FRANCE CÓRDOVA, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Chairman Thune, Ranking Member Nelson, and Members of the Committee, it is a privilege to be here with you today to discuss the American Innovation and Competitiveness Act (AICA) following its one-year anniversary. There is much to celebrate.

Established by the National Science Foundation Act of 1950 (Public Law 81–507), the National Science Foundation (NSF) is an independent Federal agency whose mission is "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF is unique in carrying out its mission by supporting fundamental research across all fields of science, technology, engineering and mathematics (STEM) and all levels of STEM education. Investing in STEM research and education is essential to America's prosperity, economic competitiveness, and quality of life. A vibrant scientific workforce and breakthrough discoveries enabled by NSF investments sustain, accelerate, and transform America's globally preeminent innovation ecosystem. NSF is a respected steward of taxpayer dollars, operating with integrity, openness, and transparency.

In January 2017, the President signed into law the American Innovation and Competitiveness Act (Public Law 114–389), a bipartisan effort, led by this Committee, that reflect continued strong support for NSF's investments in basic and collaborative research that benefit our country and the world. This support allows NSF to continue to fund incredible discoveries and advances. In fact, NSF-funded researchers account for 231 Nobel prizes, including most recently in October of last year for physics (observation of gravitational waves), economics, biology and chemistry. In all, NSF's awards have led to transformational discoveries for the Nation—impacting Americans' everyday lives.

The AICA also affirms NSF's long-standing and world-renowned merit review process and addresses NSF's implementation of issues of importance such as increased transparency and accountability, and management of multi-user facilities and mid-scale projects while maximizing research and education opportunities that help create the innovations that fuel our economy. The AICA promotes the Foundation's commitment to diversity in STEM fields, incentivizes NSF's programs that encourage private-sector involvement, and re-affirms NSF's continued commitment to entrepreneurship and commercialization.

The AICA does not change the Foundation's portfolio of investments or the way we do business—in research, education, infrastructure, and administration—rather, it enhances and strengthens it, and serves to codify how NSF invests in science, innovation, and education.

The AICA requirements are well aligned with NSF's mission. They vary considerably, however, in scope, complexity, and stage of development/completion. Thus, we take an intentional and strategic approach in responding to and complying with each requirement.

Oversight and Implementation of NSF's Response to the AICA

NSF has taken an agency-wide approach in the implementation of AICA requirements. In May 2017, I established the AICA Coordinating Committee to ensure an effective and efficient agency response to the AICA. The Coordinating Committee was charged to: coordinate and oversee the implementation of NSF's response to the AICA; produce an agency wide action plan to identify AICA sections requiring policy development or executive management decisions; and develop a central repository of AICA-related tasks, deliverables, and documentation.

I would now like to highlight some of the major provisions of the bill of special interest to the Committee, and how NSF is responding.

Title I—Maximizing Basic Research

Sec. 102 Transparency and Accountability

This section requires NSF to issue and periodically update policy guidance on the importance of transparency and accountability to the outcomes made through the merit review process. The AICA requires that each public notice of a Foundation-funded research project justify the expenditure of Federal funds by describing how the project reflects the statutory mission of the Foundation and how it addresses the Foundation's intellectual merit and broader impacts criteria. Sec. 102 also requires that the research goals of the project are clearly identified in a manner that can be easily understood by both technical and non-technical audiences.

NSF consistently makes awards that meet the Intellectual Merit and Broader Impacts criteria and contribute to the NSF mission. Over the past year, I have met with leaders at the directorate level and at the division level to re-emphasize the need for clarity and justification in our award abstracts so that the public can understand what we are funding and why we are funding it.

To become more transparent and explicit about this process, each award abstract now includes a nontechnical description of the project, which explains the project's significance and importance in lay language, as well as a technical description. In addition, NSF continues to enhance its staff training on the writing of titles and abstracts to improve the clarity of the award abstracts.

Finally, NSF is updating the Proposal and Award Manual, so that the final paragraph of all award abstracts will include the following common statement: "This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria." This policy adds a direct restatement of the AICA language to each abstract. By adding this statement, NSF affirms to all readers that every award made is aligned with our mission and is made according to our merit review process.

Sec. 109 Midscale Project Investments

This section established a definition for mid-scale projects, and directs NSF to evaluate existing and future needs for mid-scale funding. The definition of mid-scale contained in this provision aligns with NSF's current internal definition for mid-scale programs.

Instrumentation and equipment up to $4 million has been routinely funded through the Major Research Instrumentation (MRI) program, while large-scale research infrastructure projects have been successfully funded through NSF's Major Research Equipment and Facilities Construction (MREFC) Account. The adjustment in November 2016 to lower the MREFC threshold to $70 million was an initial step to support potential priorities in mid-scale science and infrastructure.

On October 6, 2017, NSF issued a Dear Colleague Letter: Request for Information on Mid-Scale Research Infrastructure (NSF 18–013) to assess the needs for mid-scale research infrastructure with an anticipated NSF contribution of between $20 million and $100 million towards construction and/or acquisition. This range is of primary interest to NSF as it will help us to identify types of projects that remain difficult to address within program budgets due to the comparatively large investment needed in a relatively short period of time.

NSF received 191 responses to the Request for Information, is currently analyzing the input, and plans to summarize the high-level insights drawn from this analysis for the science community and internal NSF use to develop possible strategies for supporting mid-scale research infrastructure.

Sec. 110 Oversight of NSF Major Multi-User Research Facility Projects

Sec. 110 strengthens oversight and accountability over NSF's large-scale research facility projects funded by the major research equipment and facilities construction account in order to maximize research investment. In response, NSF has made revisions to the *Large Facilities Manual,* the *Standard Operating Guidance,* and the *Process Narrative for A–123 Internal Controls Compliance* in order to clarify the roles and responsibilities of all organizations, including policies and procedures for planning, management, and oversight of major multi-user research facility projects, at each phase of the lifecycle. NSF has maintained a Large Facilities Office to support the research directorates and, on December 12, 2017, NSF announced that Dr. James Ulvestad will serve as the agency's first Chief Officer for Research Facilities. This position sits in the Office of the Director and reports directly to me. Dr. Ulvestad will have full lifecycle oversight responsibility for NSF major research facilities. He has initiated an NSF Facilities Governance Board for strategic issues, as well as a group of Accountable Program Officials from the relevant research directorates to provide uniform information for the full lifecycle oversight.

In response to the direction of the AICA, NSF has revised the *Large Facilities Manual* and *Standard Operating Guidance* to require external analysis of the proposed construction budget for each major multi-user facility project in accordance with the *Government Accountability Office Cost Estimating and Assessment Guide.* An independent cost estimate is now required for every proposed construction project, and an independent cost analysis of operational proposals is required for each major multi-user research facility project. NSF has also updated its policy guidance to require a risk assessment to inform its use of business system reviews, incurred cost audits, and other oversight tools.

In addition, NSF has strengthened internal controls to improve oversight of contingency, retained control over funds budgeted for contingency, tracked contingency use, and ensured the amounts allocated to the project performance baseline are reasonable and allowable. The updated *Large Facilities Manual* and recently issued *Standard Operating Guidance* also establish guidelines for awardees regarding inappropriate expenditures associated with all fee types used in cooperative agreements.

Finally, a notification letter was provided to the Committee earlier this month on the status of NSF's implementation of the recommendations made by an expert panel of the National Academy of Public Administration in the December 2015 report, *National Science Foundation: Use of Cooperative Agreements to Support Large Scale Investment in Research* [1]. In summary, NSF has addressed all the NAPA recommendations and, under the leadership of the new Chief Officer for Research Facilities, will finalize the details of implementation over the coming year. Also, I am very proud to say that in 2017, for the first time in five years, the OIG's auditor closed the Agency's Significant Deficiency in the Financial Statement Audit Report for NSF's oversight of large facility cooperative agreements.

Sec. 112. Management of the U.S. Antarctic Program

Sec. 112 requires the Director to continue to review NSF's efforts to sustain and strengthen scientific efforts in the face of logistical challenges for the U.S. Antarctic Program (USAP).

The Blue Ribbon Panel Report (BRP), *More and Better Science in Antarctica through Increased Logistical Effectiveness,* released on July 23, 2012, outlined eleven broad areas of concern and eighty-four implementing recommendations to address those concerns. Upon receipt of the report, a "Tiger Team" of senior NSF leaders was established that developed a point-by-point response to the BRP recommendations. The National Science Board (NSB) reviewed and strongly endorsed these responses at their December 2012 and February 2013 meetings. Substantial progress was made in implementing many of the recommendations when NSF's summary response was formally released on March 19, 2013.

NSF has made steady progress on the BRP Report recommendations. The responses have addressed safety concerns, change of contractor from Lockheed Martin Polar Services to Leidos, and new management of IT systems, among other things.

The Antarctic Infrastructure Modernization for Science (AIMS) project is being undertaken to address most of the remaining concerns. AIMS is now in the final design phase to prepare for the construction phase. The AIMS program will consolidate the footprint and core facilities at McMurdo station toward significantly enhanced efficiency and cost-effectiveness of science support. AIMS will provide flexibility and resilience to sustain world-class science, and will result in a number of efficiencies including a reduction in fuel consumption and vehicle requirements, as well as modernized efficient buildings, and enhanced safety and improved operational and energy efficiency. NSF is committed to keeping the United States at the forefront of science and discovery in Antarctica and the recapitalization of the Antarctic infrastructure in response to the BRP is critical to doing so.

Approximately 13 USAP-related findings yielded recommendations that appeared in the Office of Inspector General's (OIG's) annual Federal Information Security Management Act (FISMA) reports in the last four years (FY 2013 thru FY 2016).[2] In view of NSF's responsive actions for approximately nine of the findings, the NSF OIG has closed the related recommendations. As part of the FY17 FISMA audit currently underway, the NSF OIG is evaluating NSF's responsive actions to the remaining four findings.

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[1] Available at *http://www.napawash.org/2015/1785-national-science-foundation-use-of-cooperative-agreements-to-support-large-investments-in-research.html.*

[2] Please note that a finding that was repeated, in whole or in part, during FY13–16, is counted as one finding.

Title III—Science, Technology, Engineering and Math (STEM) Education

The AICA highlights some areas of STEM Education that have been key investments for NSF for many years and where we are seeing positive impacts. Several of the provisions signal Congress's support for improving K–12 STEM education, and the understanding of NSF's key role by drawing on the integration of research and education that is at the core of NSF's uniqueness.

The AICA demonstrates a commitment to drawing more people who are talented into STEM fields by inspiring them early on with excellent learning opportunities, including engagement in computer science. The AICA also focuses on government-wide coordination of STEM education (and the resulting efficiencies). NSF has played a key role in working toward this through the National Science and Technology Council (NSTC) efforts in collaboration with other agencies.

At NSF, because our education activities are integrated with science and engineering, research and innovation, we recognize that combining the best that we know from research about learning and cognition with exciting opportunities to learn STEM is a winning combination for helping to effectively inspire the next generation.

I would now like to highlight some of the major provisions of Title III, and how NSF is responding.

Sec. 303 STEM Education Advisory Panel

This section requires NSF, the Department of Education (ED), the National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration (NOAA) to jointly establish an advisory group made up of non-federal STEM education stakeholders. The Panel is tasked with advising the NSTC Committee on Science, Technology, Engineering, and Math Education (CoSTEM) and recommending improvements to Federal STEM Education programs.

The STEM Education Advisory Panel (the Panel) was established on October 18, 2017, under the authority of the AICA and the Federal Advisory Committee Act of 1972. The Panel will provide advice and recommendations to CoSTEM, assess CoSTEM's progress in carrying out responsibilities related to the America COMPETES Reauthorization Act, and help identify need or opportunity to update the Federal STEM Education 5-Year Strategic Plan. NSF, ED, NASA, and NOAA have requested recommendations for membership, and have received over 500 individual recommendations from Members of Congress, as well as the STEM education community. Going forward, the Panel will continue to accept recommendations year-round.

The heads of the Federal science agencies will work to appoint an energized and engaged group of individuals to an initial term on the STEM Education Advisory Panel in early 2018. The STEM Education Advisory Panel membership will consist of no less than 11 individuals. Members may serve on the panel for up to a three-year term. Advisory panel meetings will be held twice a year.

Sec. 305 Programs to Expand STEM Opportunities

Section 305 of the AICA reaffirms that NSF should continue to support programs designed to improve the participation of underrepresented groups in STEM. Such programs could include grants for the establishment of a Center of Excellence to increase participation of underrepresented populations in STEM fields, the purpose of which would be to build on the success of the Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) program.

NSF INCLUDES is a comprehensive effort to enhance U.S. leadership in science and engineering discovery and innovation by proactively seeking and effectively developing STEM talent from all sectors and groups in our society. A key objective of the NSF INCLUDES initiative is to engage current NSF awardees working on broadening participation as well as the broader STEM community in the creation and development of the NSF INCLUDES National Network.

The initiative is currently developing a National Network composed of NSF INCLUDES Design and Development Launch Pilots, NSF INCLUDES Alliances (NSF 18–529), an NSF INCLUDES Coordination Hub (NSF 17–591), NSF-funded broadening participation projects, other relevant NSF-funded projects, scholars engaged in broadening participation research, and other organizations that support the development of talent from all sectors of society to build an inclusive STEM workforce.

By building the infrastructure for partnerships, communication and collaboration, NSF aims to advance and scale up what works in broadening participation programs to reach underserved populations nationwide.

Sec. 310 Computer Science Education Research

This section requires NSF to make grants to support computer science (CS) education and computational thinking and report to Congress in the annual budget submission on the success of the program.

Since 2008, NSF has funded projects to build an evidence-based foundation for K–12 CS education and an ecosystem of curricula, course materials, assessments, scalable models of professional development and online support networks and resources for teachers. CS courses enable students to develop skills and competencies in problem-solving, critical thinking, creativity and collaboration that will help them excel in today's increasingly digital and computational world.

NSF is strongly committed to building the knowledge base—creating research and development—for computer science education, and broadening participation among underrepresented students for years to come. NSF recently released a solicitation entitled Computer Science for All: Researcher Practitioner Partnerships. This program aims to provide all U.S. students the opportunity to participate in computer science and computational thinking education in their schools at the K–12 levels. With this solicitation, NSF focuses on researcher-practitioner partnerships that foster the research and development needed to bring computer science and computational thinking to all schools.

Specifically, this solicitation aims to provide high school teachers with the preparation, professional development, and ongoing support that they need to teach rigorous computer science courses, and K–8 teachers with the instructional materials and preparation they need to integrate computer science and computational thinking into their teaching.

Sec. 311 Informal STEM Education

Section 311 of the AICA amends the STEM Education Act of 2015 to develop "a national partnership of institutions involved in informal STEM learning." The section also encourages, "fostering and implementing on-going partnerships among institutions involved in informal STEM learning, institutions of higher education, and education research centers; and developing, adapting, and making available informal STEM education activities and educational materials for broad implementation."

Informal STEM education programs are important for engaging the public and promoting understanding of STEM. Partnerships of many kinds are invaluable in this effort. NSF's primary program to support informal STEM learning is the Advancing Informal STEM Learning (AISL) program in the Directorate for Education and Human Resources.

One mechanism for partnership with other directorates is the opportunity for co-funding individual projects. At present, more than 50 NSF-projects are co-funded between AISL and a program in another directorate. In addition, the AISL program itself encourages collaboration across informal STEM institutions. Two tracks of the program are specifically dedicated to partnerships, and a national center was recently awarded to a collaboration among several academic and non-governmental organizations. The purpose of this center is "to measurably advance R&D activities and findings that have the potential to improve innovation, knowledge building and networking, and the fostering of a more cohesive field of informal STEM learning."

Looking forward, NSF will continue to encourage partnerships among diverse entities to further informal STEM education across the Nation.

Title VI—Innovation and Technology Transfer

Sec. 601 Innovation Corps

The AICA encourages the development and expansion of NSF's Innovation Corps (I-Corps) and other training programs that focus on professional development, including education in entrepreneurship and commercialization. It also encourages competitive grants, in consultation with the Small Business Innovation Research Program, to help support prototype or proof-of-concept development and activities necessary to build local, regional, and national infrastructure for science and engineering entrepreneurship.

The NSF I-Corps program started in 2011 through the convergence of several trends in the economy, in the understanding of startup formation, and through NSF's experience with seeding startups through the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs. These trends strongly resonated with NSF's experience. Our data showed that of the new startups in the SBIR/STTR programs, many of which were academic spinouts developing cutting edge and state of the art deep technologies, the greatest challenge to success was more typically market failure, not technical failure that they had to

overcome. We wanted to work with these trends to try something new that might better support translating cutting-edge innovations from the lab to the market.

NSF has enabled over 450 companies to develop through I-Corps teams. These companies have collectively raised over $250 million in seed capital. Traditionally, these types of companies take 5–10 years to fully develop into commercial successes. Early fundraising and improved success rates in SBIR/STTR programs are a testament to I-Corps' value in improving the preparation of early stage startups. I-Corps programs have been adopted and adapted in partnerships with a growing number of Federal agencies, including the National Institutes of Health (NIH), Department of Energy (DOE), Department of Defense (DOD), National Security Agency (NSA), United States Department of Agriculture (USDA), Department of Homeland Security (DHS), National Aeronautics and Space Administration (NASA), and the Small Business Administration (SBA). The I-Corps model has also been adopted by the state of Ohio.

NSF is currently working to scale the I-Corps program in line with the guidance of the AICA. NSF has established an I-Corps Working Group that is focused on determining how to best meet these requirements. The Working Group has also developed a draft of metrics to evaluate program effectiveness.

In addition, to address Section 601 of the AICA, NSF currently has two pilot programs underway. The first pilot is focused on the Expansion of I-Corps, and the second pilot is focused on developing Follow-On Grants. NSF is funding eight I-Corps sites to increase participation and promote inclusion of underrepresented populations in entrepreneurship. These sites will pilot novel approaches and partnerships to engage differently-abled individuals, first-generation college students, racial and ethnic minorities and women, as well as Minority-Serving Institutions.

In collaboration with the NSF SBIR/STTR program, NSF launched the I-Corps Phase 0 pilot. This pilot supports non-academic teams of very early startups or prestartups that are developing game-changing technologies. The Phase 0 Teams will receive national I-Corps training and participate in a follow-on curriculum called "I-Corps Go" that addresses some of the more common issues in startup formation, including incorporation, negotiation of intellectual property, and fundraising.

The I-Corps program is an integral part of the NSF strategy to stimulate innovation and address societal needs through the commercialization of the results of fundamental research. NSF will continue to work with the Committee to expand the program.

While this is not an exhaustive list of all the provisions of the AICA that impact NSF, please rest assured NSF has assigned action to each and every section through the AICA Coordinating Committee. We would be happy to provide the Committee any additional updates.

Conclusion

Mr. Chairman, I can say with certainty that the results of frontier research funded by NSF have a long record of improving lives and meeting national needs. With the support of this Committee, Congress, and the guidance provided by the AICA, NSF will continue to invest in the fundamental research and the talented people who make the discoveries that transform our future. These discoveries are a major driver of the U.S. economy, enhance our Nation's security, and give the country the competitive edge needed to remain a global leader.

Thank you for the opportunity to testify today and for your continued support of NSF. I will be pleased to answer any questions.

Senator GARDNER. Thank you, Dr. Córdova.

And, Dr. Copan.

STATEMENT OF DR. WALTER COPAN, UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY AND DIRECTOR, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, UNITED STATES DEPARTMENT OF COMMERCE

Dr. COPAN. Thank you, Senator Gardner, Ranking Member Nelson, and members of the Committee. I'm Dr. Walter Copan, Under Secretary of Commerce for Standards and Technology, and Director of the National Institute of Standards and Technology, NIST.

Thank you for the opportunity to appear before you today to discuss the implementation of the American Innovation and Competitiveness Act, or AICA. I would like to thank the Committee for

your work in the passage of this bill, which has provided new tools and authorities that are helping NIST to deliver on its mission.

As a nonregulatory agency, NIST has an outsized, positive impact on the U.S. economy, our quality of life, and national security. Supporting NIST's work in measurement science standards and technology, the AICA authorized new programs, recommended changes to improve our processes, and supported our world-class personnel at NIST.

NIST has responded to this bill, and we have seen the benefits to our laboratory programs and operations, which include codifying NIST's continuing efforts in cybersecurity, addressing the development of a comprehensive strategic plan for our laboratory programs, carrying out research leading to the development of standards for voting security, expanding interactions with academia, industry, and international researchers, and, further, increasing NIST's focus to enable commercial and industrial applications.

Additionally, the AICA reduced the minimum required non-Federal cost share for cooperative agreement awards under the Hollings Manufacturing Extension Partnership, the MEP, and implemented new accountability and oversight provisions for that program. These changes have increased the effectiveness of MEP. NIST has also significantly strengthened its site security as well as the culture of security awareness.

The law acknowledges the importance of sharing research findings and fostering collaboration by facilitating the process for NIST employees to attend scientific conferences, workshops, and communicating. It also builds upon previous authority to conduct prize competitions, and broadens it to include crowdsourcing and collaborative citizen science, which serve to advance the NIST mission.

My written testimony provides further details on how NIST has worked to implement the provisions of the law. NIST opportunities for impact are directly tied to the Institute's mission and historic role, and NIST's future must build on the solid foundation of technical expertise and stakeholder engagement.

NIST's current priorities, including advanced manufacturing, technology transfer, cybersecurity, quantum technologies, and disaster resilience will remain national imperatives for the decades to come.

To continue to be the bedrock of innovation in the U.S., NIST must grow new capabilities, and, as such, we are expanding our capabilities in the areas of the Internet of Things, Artificial Intelligence, and the Bioeconomy over the next decade. With emphasis on these emerging key areas coupled with continued dedication to areas of traditional expertise and contribution, NIST will ensure impact over the coming decades.

While the NIST strategic priorities will endure, they will be influenced by new and rapidly evolving technologies. NIST is proud of the positive impact we have had and of the improvements we have been able to make with the AICA authorization.

NIST maintains its longstanding commitment to advancing measurement science in order to further innovation and to increase the competitiveness of the U.S. industry. Our very broad technical portfolio positions the agency to contribute productively and rapidly to emerging national needs and international trade. With NIST's

dedicated technical staff, our unique facilities, and our objective nonregulatory role, we are well positioned to continue to thrive on delivering on our important mission, to promote U.S. science, innovation, and industrial competitiveness.

Thank you for this opportunity to testify on NIST's implementation of the AICA. And I'd be happy to answer any questions you may have.

[The prepared statement of Dr. Copan follows:]

PREPARED STATEMENT OF DR. WALTER COPAN, UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY AND DIRECTOR, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, UNITED STATES DEPARTMENT OF COMMERCE

Introduction

Chairman Thune, Ranking Member Nelson, and Members of the Committee, I am Dr. Walter Copan, Under Secretary of Commerce for Standards and Technology and Director of the Department of Commerce's (DOC) National Institute of Standards and Technology (NIST). Thank you for the opportunity to appear before you today to discuss the implementation of the *American Innovation and Competitiveness Act* (AICA) (P.L. 114–329).

Before I begin, let me thank the Committee for your work in the passage of the AICA, which provided new tools and authorities that are helping NIST deliver on its mission.

NIST Mission

NIST is the Nation's measurement science institute. As a non-regulatory agency within DOC, 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.

Founded in 1901 as the National Bureau of Standards, today NIST develops and disseminates measurements and standards that enable comparison, ensure interoperability, and support commerce. NIST's role is unique: our Federal workforce of over 3,000 employees, over half of whom are Ph.D. scientists and engineers, work to create the measurement tools that enable innovation.

NIST's cutting-edge work takes place at two main campuses, the headquarters in Gaithersburg, MD and a campus in Boulder, CO, as well as through NIST personnel in Charleston, SC, Kauai, HI, and Palo Alto, CA. NIST researchers also work in partnership with nine collaborative research institutes across the country to align the most advanced metrology with leading scientific research at U.S. universities and help accelerate the pace of innovation.

The NIST mission has three key themes:

- *Measurement Science:* Creating the experimental and theoretical tools—methods, metrics, instruments, and data—that enable innovation.c
- *Standards:* Disseminating measurement standards and providing technical expertise to further the development of documentary standards that enable comparison, ensure interoperability, and support commerce.
- *Technology:* Driving innovation through knowledge dissemination and public-private partnerships that bridge the gap between discovery and the marketplace.

Through work in these areas, NIST has an outsized impact on the U.S. economy, quality of life, and national security.

AICA Passage

To support NIST's work in measurement science, standards and technology, the "American Innovation and Competitiveness Act" (AICA) (P.L. 114–329)—the successor to the America COMPETES Act—became law on January 6, 2017 and updated the authorizing legislation for NIST.

The new law authorizes new programs, recommends changes to improve processes, and supports personnel at NIST. Highlights of the bill related to our laboratory programs include:

- Codifying NIST's continued efforts in cybersecurity;
- Requiring the development of a comprehensive strategic plan for laboratory programs;

- Authorizing research leading to the development of standards for voting security;
- Supporting broader interactions with academia, international researchers, and industry; and,
- Directing NIST to expand its focus on enabling commercial and industrial applications.

The AICA implemented new accountability and oversight provisions for the Hollings Manufacturing Extension Partnership Program (MEP). Further, it authorizes the transfer of direct management of NIST law enforcement and site security through an assigned Director of Security for NIST who reports to the Department of Commerce Office of Security (DOC OSY). The bill acknowledges the importance of allowing employees to attend scientific conferences and workshops to share findings and foster collaboration. It also builds upon previous authority to conduct prize competitions and broadens it to include crowdsourcing and collaborative citizen science to advance our mission.

My testimony will provide additional details on the provisions of the legislation and how NIST has worked to implement them.

Cybersecurity Research (Section 104)

Continuing efforts in cyber standards for critical infrastructure.

Section 104 of the bill made a number of changes to the NIST Cybersecurity program. Under Section 104, NIST has continued its work on the Cybersecurity Framework, Next-Generation Internet of Things (IoT), Addressing Botnet Threats, and Securing Unclassified Government Information.

- *Cybersecurity Framework:* The NIST Cybersecurity Framework (Framework) serves as voluntary guidance for industry, based on existing standards, guidelines and practices, for critical infrastructure organizations to better manage and reduce cybersecurity risk. In 2017 NIST published two public drafts, requesting and addressing public comments, for version 1.1 of the Framework. These updates provided new details on managing cyber supply chain risks, clarified key terms, and introduced measurement methods for cybersecurity. Executive Order 13800, *Strengthening the Cybersecurity of Federal Networks and Critical Infrastructure,* requires that all Federal Executive Branch agencies use the NIST Framework to manage cybersecurity risk. In 2018, NIST will continue to improve the clarity and applicability of the Framework focusing on its usability and to communicate the Framework in support of its effective implementation.
- *Next-Generation Safeguards for Information Systems and the Internet of Things:* For the emerging area of Internet of Things, NIST's Cybersecurity for IoT program supports the development and application of standards, guidelines and related tools to improve the cybersecurity of connected devices—which is a network of connected objects that are able to collect and exchange data using embedded sensors such as thermostats, cars, lights, appliances—and the environments in which they are deployed. NIST has issued a draft revision of its widely used Special Publication *Security and Privacy Controls for Information Systems and Organizations* representing an ongoing effort to produce a unified information security framework for the Federal Government. This latest draft addresses ways various organizations can maintain security and privacy in their interconnected systems. Next-generation safeguards include advanced encryption, secure and reliable connectivity, and cybersecurity for smart grid systems and cyber physical systems. In 2018, NIST is working to broaden strategic collaborations and partnerships with IoT industry experts and its Federal Government partners to facilitate the development and advancement of IoT interoperability standards, security and best practices.
- *NIST initiative seeks industry solutions in support of the Administration's Botnet initiative:* In Executive Order 13800, the Administration required the Departments of Commerce and Homeland Security to promote stakeholder action against botnets and other automated, distributed threats. NIST worked with NTIA and DHS, in consultation with several other agencies and the private sector, to publish a draft report earlier this month on enhancing the resilience of the Internet against botnets. The report contains draft goals and actions that would improve the resilience of the ecosystem. The Department is collecting stakeholder input on the draft report and will incorporate that input into a final report to the President in May. NIST's National Cybersecurity Center of Excellence (NCCoE) will also develop a "practice guide" to help protect Internet of Things devices from botnet threats that leverages industry solutions.

The NCCoE is soliciting "products and technical expertise to support and demonstrate security platforms" for securing IoT from botnet threats, as part of the "Mitigating IoT-Based DDoS Building Block" practice guide.

- *Securing Unclassified Government Information:* Another area to highlight in our cybersecurity research work is the publication of *Protecting Controlled Unclassified Information (CUI) in Nonfederal Systems and Organizations,* which provides Federal agencies with recommended requirements for protecting the confidentiality of CUI that resides on nonfederal systems. NIST has released for public comment the special publication *Assessing Security Requirements for Controlled Unclassified Information,* which is a guideline for any organization seeking to comply with the CUI regulation governing the safe handling of information that is important to the U.S. Government. CUI is a diverse classification that includes information involving privacy, proprietary business interests and law enforcement investigations. The public comment period closed on January 15, 2018; NIST will now address public comments before publishing an updated version later this year.

Development of quantum computing and cryptography standards.

NIST has made additional advances in the development of quantum computing and cryptography standards.

Quantum information science research at NIST explores ways to employ phenomena exclusive to the quantum world to measure, encode and process information for useful purposes, from powerful data encryption to computers that could solve problems intractable with classical computers. Some specific areas that are being addressed are:

- *Post-Quantum Cryptography Standardization:* NIST has initiated a process to solicit, evaluate, and standardize quantum-resistant public-key cryptographic algorithms. NIST solicited public comment on draft minimum acceptability requirements, submission requirements, and evaluation criteria for candidate algorithms.
- *Qubits:* A team of scientists from the NIST and University of Maryland with the Joint Quantum Institute (JQI) have created a quantum simulator using 53 interacting atomic qubits to mimic magnetic quantum matter. Prior to this breakthrough, researchers had only created quantum simulators of 20 qubits or less. The building of qubit simulators is a key step toward building a full-fledged quantum computer.
- *Single Photon Detector:* Individual photons of light now can be detected far more efficiently using a device patented by a team including NIST whose scientists have overcome longstanding limitations with one of the most commonly used type of single-photon detectors. Their invention could allow higher rates of transmission of encrypted electronic information and improved detection of greenhouse gases in the atmosphere.
- *Chained Bell Test:* NIST recently demonstrated a Chained Bell Test experiment to probe a fundamental assumption of quantum mechanics. Albert Einstein had described the quantum phenomenon as "spooky actions at a distance." The NIST method produced statistically significant results, demonstrating the predicted quantum behavior by using an ion trap setup to probe quantum entanglement by manipulation of ion pairs.
- *Photon Measurement:* Future communications networks that are less vulnerable to hacking are closer to reality because of a NIST invention that measures the properties of single-photon sources with high accuracy. The NIST invention measures detailed information in the spectral properties of photons 10,000 times better than current state-of-the-art devices.

Determine information security vulnerability, challenges and deficiencies, and evaluate effectiveness of implementation standards.

Under this authority, critical continuing work for security includes:

- *Behavioral Cybersecurity:* NIST will assemble a team with experts in cybersecurity, computers science, networking, human actors and cognitive psychology, and sociology to answer questions such as: What technical information does the public need and how can we make this information more understandable? Why don't individuals practice safe computing? What societal factors influence the adoption of safe computing practices?
- *National Vulnerability Database:* The National Vulnerability Database (NVD) is the U.S. Government repository of standards-based vulnerability management data represented using the Security Content Automation Protocol. Over 56,000

entries in the vulnerability database were either new or modified during 2017. In 2018, NIST will continue to research and develop new methodologies to increase efficiencies in analyzing and publishing vulnerability data, while simultaneously improving data reliability.

Codifies research for standards on voting security.

The final new authority under this section codifies the work NIST has been doing on cybersecurity of voting systems.

Voting System Cyber Security Public Working Group: The NIST Voting System Cybersecurity Working Group is the Nation's forum for review and further development of guidance for voting system cybersecurity-related issues, including various aspects of security controls and auditing capabilities. The guidance will inform the development of requirements for the Election Assistance Commission (EAC) Voluntary Voting System Guidelines (VVSG).

NIST conducted the research necessary to develop the Draft Voluntary Voting System Guidelines, version 2.0, progressed interoperability by advancing the Common Data Format (CDF) for election systems, and collaborated with interagency partners in providing additional election security guidance.

NIST research considered significant advances in the technology used in U.S. voting systems, as well as the public's input for addressing the needs of all voters to participate in elections. For example, universal design, mobile devices, and assistive technology now provide much greater accessibility to voters with disabilities. Better quality assurance and configuration management methods, new programming languages, greater fault-tolerance and increased capacity in hardware components, as well as new approaches to data exchange, software assurance, and security have emerged in the last decade.

This research in hardware and software, security, human factors and data exchange led to a draft set of VVSG Principles and Guidelines [1] and five data formats that were discussed and revised through bi-weekly teleconferences with the technical Voting Public Working Groups on *Cybersecurity (121 members), Usability and Accessibility (106 members), and Interoperability (158 members).* In addition to the expert review by the 385 members of these working groups, the draft was adopted at the September 2017 Technical Guidelines Development Committee (TGDC) meeting, and is currently under review by the Election Assistance Commission (EAC) Standards Board and Board of Advisors.

Lab Program Improvements (Section 107)

NIST leadership has been working towards developing a long-range strategic plan for NIST's laboratory programs with the goal to identify high-level research priorities to best position NIST looking towards a 10-year horizon. This process, which built on years of work developing short-term prioritized operational plans for each Lab and a year of engagement articulating NIST's values, sought to produce a long-range plan that allows NIST leadership to be proactive instead of reactive in shaping NIST's research environment to address the needs of U.S. commerce in an ever-changing landscape of both Federal funding and technical opportunities.

In examining what new technical and organizational capabilities NIST will require in a decade, NIST's leadership considered what are likely to be the requirements of NIST's existing priority areas, such as manufacturing and cybersecurity. What systems will emerge that will require expanded cybersecurity and privacy capabilities? What technologies are likely to change the way cryptography works? What novel products will U.S. manufacturers make, and what new technologies must they use to be competitive? What technical breakthroughs will impact NIST's own business models, and how can NIST lead that change? These questions shaped NIST's identification of opportunities for this strategic vision.

To lay the groundwork for the strategic plan, a scan of the technical landscape was completed, and numerous interviews with NIST senior leadership, former NIST directors, as well as former Visiting Committee on Advanced Technology members were conducted. The interviews explored major opportunities, risks, areas for investment/divestment, NIST culture, leadership, indicators of success, and advice for Commerce Secretary Ross. During a 2-day workshop held at the end of May 2017, a five-person thought leader panel provided their perspectives on the future of technology. One theme that was clear is that science increasingly depends on systems thinking and learning, multimodal data, and multimodal measurements. The second key theme was that NIST has a place and a part in teaching people about measurement science and ensuring measurements are being conducted to get the best data out. During these early stages of discussion, three possible areas for growth were

[1] *http://collaborate.nist.gov/voting/bin/view/Voting/VVSGPrinciplesAndGuidelines*

identified in vertical capabilities, meaning associated with specific disciplines: bioscience; quantum science; and IoT. In horizontal capabilities, meaning cross-cutting areas, potential areas for growth include data science and artificial intelligence and systems-level thinking and modeling.

NIST's opportunities for impact are inescapably tied to the Institute's mission and historic role. NIST's future must build on a solid foundation of technical expertise and stakeholder engagement. Since its founding in 1901, NIST has been known as "Industry's National Laboratory," dedicated to supporting U.S. competitiveness. To continue to be the bedrock of innovation in the U.S., NIST must grow new capabilities over the next decade. With investments in emerging key areas coupled with continued dedication to areas of traditional expertise and contribution, NIST will ensure impact in the coming decades.

NIST's current priorities—including manufacturing, technology transfer, cybersecurity, quantum technologies, and disaster resilience—will continue to align with national imperatives for the decades to come. The manufacturing sector will continue to be a driving force of innovation and productivity for the U.S. economy. Transitioning technologies effectively from laboratory to market is the seed corn for our innovation economy as well as entrepreneurship. The need for strong and practical cybersecurity approaches are growing rapidly as digital systems integrate into more of our lives and commerce. The very real hazards of natural disasters must be addressed through effective standards and technologies, and America's built infrastructure and communities must be able to withstand and recover from those events. Quantum-based devices, communications and cryptography hold great promise for the U.S. and for the future of measurements and standards, and our Nation must be positioned to address market, technology and cyber threats from others in this domain. While the NIST strategic priorities will not change, they will be influenced by new and rapidly evolving technologies.

To extend its reach and amplify its influence, NIST will work with stakeholders within the Institute, across government, in industry and academia on the opportunities with greatest impact potential for the Nation. These interdisciplinary areas—or themes—are at the forefront of science and technology, and will therefore require the collective talent and ingenuity of researchers and leaders across the NIST laboratories.

Theme 1: Provide a foundation of trust in new industries

- Enabling the future *bioeconomy.* As proof-of-concept laboratory work in engineering biology meets the market realities of bringing lab science into commercial introduction, there are questions about how to compare biological products, measure whether desired outcomes are realized, and optimize biological systems for desired behaviors. NIST will deliver tools and standards to measure biological technologies, outputs, and processes that will enhance economic sectors from healthcare to manufacturing and beyond.
- Unleashing the economic potential of *IoT.* Robust, secure, and competitive technology advances in the Internet of Things must be built on a solid foundation of measurement and standards. NIST will develop new tools and approaches for IoT systems security, establish technologies to relieve network congestion and device interference, and facilitate greater confidence in device interoperability.

Theme 2: Apply new technologies to revolutionize mission delivery

- Enhancing mission-critical research through *Artificial Intelligence (AI)* and data. NIST will develop resources and expertise to apply AI, machine learning, and big data techniques to measurement science, including curated datasets to train and test AI systems, model AI behavior and compare AI systems, as well as to apply AI to research efforts where big data requires the application of advanced learning algorithms.
- Revolutionizing commerce through quantum measurements. In May, 2019, the International System of Units (SI) is slated to be redefined with units based on fundamental constants of nature, and NIST must lead in this transition to quantum definitions. NIST will use its world-leading quantum science expertise to develop physical reference standards and "self-calibrating" sensors that will enable a world where measurement devices are ubiquitous, reliable, and affordable.

NIST Campus Security (Section 113)

The legislation supports the Department's efforts to continue to improve overall security. Security and safety begins with the leadership of NIST, and I am ultimately responsible for the organization's security and safety culture and perform-

ance. The Department also continues to take steps to improve the physical security at NIST. NIST, working with the Department, is committed to improving the security culture at both NIST campuses. Let me highlight the steps we have taken to ensure successful implementation of the legislation's provisions.

The AICA authorized in the Department of Commerce Office of Security (OSY) supervisory authority for law enforcement and site security at NIST. OSY manages and implements all security, emergency management, and threat investigations across the Department and its thirteen bureaus and operating units.

Responsibility for security clearly does not rest solely with OSY. Security is also directly related to safety at NIST. At NIST, I am responsible for ensuring the security of the personnel, facilities, property, information and assets in accordance with applicable laws, regulations, Executive Orders, and directives. The Director of Security is responsible for advising and assisting heads of operating units. Thus, OSY and NIST mutually support one another to protect the personnel, mission, information, and infrastructure at NIST's facilities.

I am committed to a comprehensive assessment of the roles and responsibilities of OSY and NIST at NIST's two campuses, in Gaithersburg, MD, and Boulder, CO, as recommended in the GAO report. Currently, OSY is charged with delivering integrated law enforcement and security services and protection, while NIST is responsible for ensuring the physical security of the buildings. In practice, this means that NIST has primary responsibility for providing and maintaining electronic locks, surveillance devices, and alarms at NIST's campuses. NIST also is responsible for establishing local campus security procedures, and the maintenance and management of the physical security systems such as access control systems, intrusion detection systems, identification badging, and other security and safety systems designed to protect NIST assets.

In turn, OSY provides the security personnel to monitor security cameras, undertake routine patrols of NIST's campuses and buildings, and provide emergency assistance. It also oversees a contract guard force that secures entry points to the campuses.

Scientific and Technical Collaborations (Section 202)

NIST hosts over 110 conferences a year with over 13,000 attendees on our campus. The AICA enables streamlining of conferences at NIST and is critical for not only conferences but for the promotion of measurement science and technology transfer that is key to the NIST mission.

In August of 2017, NIST participated in a Department of Commerce pilot effort to review, change and streamline the conference pre-approval process. One significant policy change that resulted from this pilot effort was to now permit NIST to approve personnel to attend conferences at which the costs to attend did not exceed $200,000, which greatly facilitated the approval process.

NIST continues to evaluate conference attendance policies to ensure that our scientists and engineers are able to provide their expertise for the benefit of the U.S.; conference participation is critical for scientific openness and effective technology transfer.

NIST Education and Outreach (Section 306)

To further support NIST's efforts in promoting science and technology, NIST has already begun using the authority conferred under the AICA to support the mission of NIST and broaden the public's awareness and understanding of measurement science.

Promoting Public Awareness of Measurement Science: NIST is producing a series of special reports on the worldwide consensus plan to redefine four of the seven basic units of measurement in the SI and we are funding a documentary film to help explain the case for redefinition.

Hiring Authority: The new hiring authority in AICA gives NIST the opportunity to broaden its hiring processes. NIST is working with OPM to obtain critical pay authority for NIST Fellows and has submitted a formal request to institute this process. This request was submitted in November of 2016 and is pending approval.

STEM Undergraduate Experiences (Section 309)

NIST has a long history of supporting the STEM (Science, Technology, Engineering, and Mathematics) career paths and growing the next generation of young scientists. The NIST Summer Undergraduate Research Fellowship (SURF) Program is designed to inspire undergraduate students from across the country to pursue careers in STEM through a unique research experience that supports the NIST mission. SURF students from across the country have the opportunity to gain valuable, hands-on experience, working with cutting edge technology in one of the world's leading research organizations and home to three Nobel Prize winners.

Over the course of 11 weeks, SURF students at NIST contribute to the ongoing research of one of the seven NIST labs in Gaithersburg and Boulder. SURF provides opportunities for undergraduates to engage in hands-on research pertaining to the NIST mission under the guidance of a NIST scientist or engineer. To date 2,600 undergraduates have participated in the program from U.S. institutions of higher education including Puerto Rico and last summer NIST hosted 213 students.

Prize Competition, Crowdsourcing Authority (Sections 401 and 402)

To tackle ambitious problems in support of the NIST mission, NIST has long used challenges to bring a community together. In the early 1970s, for example, NIST issued a public challenge to develop a data encryption standard to support computer security.

NIST continues to use challenges to incentivize action around important technical issues. For example, NIST's Global City Teams Challenge (GCTC) provides a collaborative platform for local governments, non-profits, academic institutions, and corporations to form project teams in areas such as smart and secure cities and communities.

The Federal Government, and NIST's, use of prizes has ramped up significantly in recent years, in part due to explicit legal authorities, expanded under the AICA, to conduct cash and non-cash prize competitions. In addition to providing the explicit authority to offer cash prizes to winners, this authority allows Federal agencies to partner with private sector, for-profit and nonprofit entities.

Since 2015, NIST has launched eleven prize competitions, all of which are posted on challenge.gov. The topics of these competitions range from the development of advanced materials that better absorb impacts such as those experienced by athletes and the warfighter, to the development of software applications using NIST scientific data, to new virtual reality environments for heads-up displays that can be worn by first responders. The last of these is part of a larger open innovation program housed in NIST's Public Safety Communications Research division (PSCR) of the Communications Technology Laboratory in Boulder, CO. PSCR is focusing on key areas for technology acceleration through prize competitions including location based services and enhanced user interfaces for the increased effectiveness of deployed technologies.

As we continue to build our experience in prize competitions, we are finding new opportunities to use this mechanism to further our mission. The NIST Program Coordination Office is a focal point for Institute-wide activity in prize competitions: they serve as the White House point of contact for NIST's prize activities, convene a Community of Interest in Prizes and Challenges that allows staff to share lessons learned and best practices and host an internal website with resources for any staff interested in learning more about using prize competitions.

NIST benefits greatly from the resources provided by the General Services Administration under the AICA. NIST posts all its prize opportunities on the GSA website challenge.gov, and has used the GSA's free platform to host several of our prize competitions. Challenge.gov provides additional valuable content and background about this topic at *https://www.challenge.gov/toolkit/,* which includes some content provided by NIST to be shared among the community.

Crowdsourcing and Citizen Science: The authority in this Act for agencies to conduct crowdsourcing and citizen science activities is also of interest to NIST. NIST has a history of citizen science activities that includes decades-long high-frequency radio wave propagation reports for NIST radio station WWV, which broadcasts time and frequency information 24 hours per day, 7 days per week to millions of listeners worldwide from Boulder, Colorado. We are exploring the potential to further amplify the Institute's programmatic goals using the AICA authority.

MEP Program Updates (Section 501)

Hollings Manufacturing Extension Partnership (MEP)

With Centers in all 50 states and Puerto Rico dedicated to serving small and medium-sized manufacturers, MEP has instituted the programmatic modifications authorized in the bill.

Cost-Share: The Act changed the non-federal/federal cost sharing ratio for MEP Centers from a 2:1 minimum matching ratio to a 1:1 ratio. As a result, MEP Centers have increased partnering opportunities with manufacturers.

Re-competition: Another important change contained in the AICA required Centers to undergo a re-competition after ten years of consecutive funding. Prior to the AICA, some Centers had not been competed since their initial funding. The re-competitions for all Centers that were not competed in the past 10 years were by April of 2017. Surveys for Center project impacts go out one year after project completion,

so the full network of Centers will have initial survey results of the impact of the re-competition in Spring 2019.

Evaluations: The AICA provided clear guidance on Center evaluations. Under the legislation, a Center is to undergo a peer evaluation during its third and eighth-year of operation with a Secretarial review at year five, which used by NIST in determining whether a Center's performance merits continued NIST funding. MEP has instituted new processes by which these evaluations, known as Panel Reviews and Secretarial Reviews, are conducted. MEP is now piloting the new process for Centers which have entered their third year of operations.

Advisory Board: The MEP Advisory Board provides guidance and assesses the overall performance of the Program. Under AICA, the membership of the Board was updated to require no fewer than 10 members with at least one community college representative, allowing MEP to increase the size of the Board and broaden its geographical reach and membership expertise. Following the passage of the AICA, MEP added ten new members to expand the Board and to replace members whose terms had expired. The AICA also instituted several changes to the Center Oversight Boards regarding membership, composition, term limits and conflicts of interest policies. These have been incorporated in the General Terms and Conditions of each Center's cooperative agreement.

Competitive Awards: The legislation also clarified the criteria to make special competitive awards. These awards allow Centers in good standing to receive additional funds based on the availability of funding for projects outside the scope of their base award.

Conclusion

NIST is proud of the positive impact it has had and of the improvements we have been able to make with the AICA authorization. NIST maintains its longstanding commitment to advancing measurement science in order further innovation and increase the competitiveness of U.S. industry. NIST's broad technical portfolio positions the agency to contribute productively and rapidly to emerging national needs. With NIST's dedicated technical staff, one-of-a-kind facilities, and objective, non-regulatory role we are well positioned to have an outsized impact on the U.S. economy, quality of life, and national security. With the continued support of this Committee, NIST will continue to thrive in its important mission to promote U.S. innovation and industrial competitiveness.

Thank you for the opportunity to testify on NIST's implementation of AICA. I would be happy to answer any questions that you may have.

WALTER G. COPAN, PHD., UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY, AND NIST DIRECTOR

Dr. Walter G. Copan was confirmed by Congress as Under Secretary of Commerce for Standards and Technology and NIST Director on October 5, 2017.

As NIST Director, Dr. Copan provides high-level oversight and direction for NIST.

He has had a distinguished and diverse career as a science and technology executive in large and small corporations, U.S. Government, nonprofit and other public-sector settings.

Dr. Copan formerly served as president and CEO of the IP Engineering Group Corporation, providing services in intellectual property strategy, technology commercialization and innovation. Until June 2017, he was founding CEO and Chairman of Impact Engineered Wood Corporation, an advanced materials technology company. He also is a founding board member of Rocky Mountain Innovation Partners, where he led technology transfer programs and innovation services on behalf of the U.S. Air Force Academy, U.S. Federal labs and academic institutions and helped foster entrepreneurial businesses in the Rocky Mountain West. He also served with the National Advisory Council to the Federal Laboratory Consortium for more than 5 years, providing industry inputs to advance the U.S. economic impacts of the Federal laboratory system.

From 2010–2013, Dr. Copan served as managing director of Technology Commercialization and Partnerships at DOE's Brookhaven National Laboratory (BNL). Among his accomplishments were leading the creation and implementation of the new DOE technology transfer mechanism, "Agreement for Commercializing Technology" (ACT), to facilitate collaborations between the Federal labs and U.S. corporations. He led the "Startup America" initiative on behalf of DOE for entrepreneurial business creation, and he initiated the DOE's new Small Business Innovation Research—Technology Transfer (SBIR–TT) program, which built upon the experiences of NIST. He served as founding partner and board member of the "Accel-

erate Long Island" alliance for innovation, economic development and early stage investment.

From 2005–2010, Dr. Copan was executive vice president and chief technology officer at Clean Diesel Technologies, Inc., an international technology development and licensing firm. He spearheaded the company's transformation, growth and listing on NASDAQ (CDTI), as well as the company's subsequent merger. Prior to joining CDTI, Dr. Copan served at the DOE's National Renewable Energy Laboratory (NREL) as Principal Licensing Executive, Technology Transfer. There, he led organizational changes that strengthened relationships with industry and the investment community, and led to the more productive commercialization of energy-related technologies.

After earning dual B.S./B.A. degrees in chemistry and music from Case Western Reserve University in 1975, Dr. Copan began his career in chemicals and materials research at the Lubrizol Corporation (now part of the Berkshire Hathaway Group). He earned a Ph.D. in physical chemistry from Case Western in 1982, and subsequently held leadership positions at Lubrizol in research and development, strategy, business unit management, venture capital, and mergers, acquisitions and strategic alliances in the U.S. and abroad. As managing director, Technology Transfer and Licensing, from 1999–2003, he was responsible for Lubrizol's corporate venturing and open innovation, technology strategy, business development, intellectual assets and the technology licensing business.

Dr. Copan is a patent holder, has authored numerous professional publications and presentations, and has served on the boards of many organizations, including the Licensing Executives Society (LES) USA and Canada, where he recently served as regional vice president for LES USA. He has contributed to the U.S. National Academy of Sciences, the Council on Competitiveness, the World Intellectual Property Organization and the United Nations on innovation, technology transfer, energy and economic development matters.

Senator GARDNER. Thank you, Dr. Copan.

And I would ask unanimous consent to insert into the record a letter to Senators Thune and Nelson from the Office of Science and Technology Policy.

Without objection.

[The information referred to follows:]

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20502

January 30, 2018

The Honorable John Thune
Chairman
Committee on Commerce, Science, and Transportation
United States Senate
Washington, D.C. 20510

The Honorable Bill Nelson
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate
Washington, D.C. 20510

Dear Chairman Thune and Ranking Member Nelson,

In anticipation of this afternoon's hearing, we appreciate the opportunity to highlight important accomplishments in the first year of the bipartisan American Innovation and Competitiveness Act.

When S.3084 was signed into law just over a year ago, Chairman Thune commented, "This bill is a victory for science and economic competitiveness." Indeed it was, and we are fast seeing the fruits of that legislative effort.

Fast forward to today, the White House Office of Science and Technology Policy, along with the National Science Foundation and National Institute of Standards and Technology, have been working to fulfill this important law's requirements.

OSTP has updated the charters of the National Science and Technology Council's Physical Sciences Subcommittee and Subcommittee on International Issues to align to the priorities laid out in AICA. Conversations have been ongoing and both Subcommittees are slated to formally gather in the coming weeks. We believe that high-energy physics research, fusion research, radiation biology, and other physical sciences are poised for breakthroughs that have potential to transform our daily lives. Underscoring our interest in the physical sciences, we have appointed our first-ever Assistant Director for Quantum Information Science.

OSTP also values the important opportunities presented by international science and technology cooperation. The office looks to build upon recent successes in this regard, including the United States/United Kingdom S&T Partnership, the G7 Tech Ministerial, and the Long-Baseline Neutrino Facility/Deep Underground Neutrino Experiment project that boasts the participation of 30 countries a mile beneath South Dakota (which OSTP was delighted to participate in the groundbreaking in July).

OSTP has also been working to identify and reduce regulatory burdens while protecting the public interest. In close collaboration with the Office of Management and Budget, the NSTC Research Business Models Working Group is currently finalizing a report required by AICA that examines centralized assurances database, research profile database, uniform grant application, uniform progress reporting, and strategies for additional activities. We look forward to sharing the findings with the Committee and Congress as we work to reduce burdens on researchers so they can focus on research instead of onerous paperwork.

Additionally, OSTP appreciates the Committee's revisions to the National Nanotechnology Initiative's (NNI) reporting and external review process that coordinated the National Nanotechnology Advisory Panel (NNAP) and National Academies' reviews to complementary rather than redundant and overlapping cycles. As a result of the streamlining of the reporting process, NNI now has sufficient time to respond to recommendations and to incorporate recommendations into the strategic planning process.

AICA also takes important steps to improve STEM education in the United States. STEM is an urgent priority for OSTP and the Trump Administration. In September, President Trump signed a Presidential Memorandum to boost investment in STEM Education and Computer Science, which was immediately matched by private industry. We look to continue the momentum as OSTP, in close collaboration with the NSF, is currently laying the groundwork for the Federal STEM 5-Year Strategic Plan, expected to be released this Fall. We have an exciting opportunity to make great strides in strengthening and improving Federal STEM activities to ensure younger generations of students have the tools they need to succeed in an ever-evolving workforce, and that the United States has the talent necessary to maintain our global leadership in science and technology. It is imperative that our citizens young and old have the opportunity to develop the skills necessary to fill 21st century jobs.

We also take seriously our responsibilities to ensure diversity and inclusion in STEM fields. AICA's inclusion mandates have been incorporated into the NSTC's Broadening Participation Interagency Working Group, ensuring a single, clear NSTC focal point for efforts to improve diversity and inclusion. Students from all backgrounds, boys and girls in every community, should have access to strong STEM and computer science programs in order to succeed and achieve the American Dream.

OSTP looks forward to continuing to advance basic research and partnering with the private sector. As we highlighted in our FY 2019 Administration R&D Budget Priorities Memo, "Basic and early-stage applied research are critical components of the American research enterprise and the basis of new technological development and commercialization. … (A)gencies should give priority to funding basic and early-stage applied research that, supplemented by private sector financing of later-stage R&D, can result in the development of transformative commercial products and services. Strong partnerships with the private sector will be critical to maximizing the efficacy of Federal funding. Furthermore, agencies should take advantage of innovation from the private sector, where possible, to adapt to Federal needs, rather than re-inventing solutions in parallel."

Ensuring and encouraging American innovation and competitiveness is critical to continued job growth and economic prosperity. The United States is the global leader in science and

technology, and with the American Innovation and Competiveness Act, we have the framework to continue to lead. OSTP appreciates the Committee's leadership, and welcomes our responsibility and role in advancing our nation's science and technology for the betterment of America.

Sincerely,

Ted M. Wackler
Deputy Chief of Staff and Assistant Director
Office of Science and Technology Policy

Senator GARDNER. Dr. Córdova, you mentioned LIGO. I had the opportunity two months ago to visit a company, a business in Boulder, Colorado, called High Precision Devices, very, very much involved in the development and the research done to reach the incredible work they did with the LIGO project. And we talked about a number of other work that they were doing there, a number of other projects that they were undertaking there, including the calibration for MRIs and how you can get the most data out of an MRI and what to do, a lot of it funded through NSF. NSF is responsible for about, if I'm correct, about 20 percent of our Nation's federally funded research. Is that a good ballpark figure?

Dr. CÓRDOVA. I think we like to claim a little higher, about 27 percent.

Senator GARDNER. About 27 percent. Very good, very good. And so could you—27 percent. Does NIST have the other 73 percent? There is no other function, though, really, like NSF that gets dollars out into the community, is that correct?

Dr. CÓRDOVA. Well, the thing about NSF, it's so broad, its spectrum of what it funds all the way from computer science, social and behavioral sciences, the physics, chemistry, math, it has got a very, very broad portfolio, whereas other, most other agencies are just specifically on health, for example, or space or energy. So it's really—it's really the breadth of it.

In computer science, for example, we fund 83 percent of the academic research that's funded in the entire Nation, 83 percent.

Senator GARDNER. And that's pretty incredible. So, you know, when it comes to funding issues, 83 percent of the work being done in computer science, and when you talk to anybody in industry, when you talk to somebodhuy in, you know, Silicon Valley, when you talk to somebody in Boulder, Colorado, they talk about the need for additional computer scientists and majors, and so that's why it's so important to get this right from a funding perspective.

Dr. Córdova, a follow up. NSF was not charged with the basic responsibility of coming up with how to reduce the burden, the regulatory or administrative burden, on some of the grants that are out there. I believe OSTP was, and that work continues there.

When we had our roundtables, we heard from researchers, who talked about as much as 42 percent of their time filling out administrative paperwork and complying with government regulations, 42 percent of their dollars would go to that kind of overhead. In the bill, we directed OMB and OSTP to come up with ways to reduce these burdens.

You've not been tasked with this yourself, but could you talk about some of the ways that you think would help benefit OMB and OSTP will head when it comes to reducing the burdens that researchers face and how NSF can work to make sure those dollars are spent more efficiently on the science itself?

Dr. CÓRDOVA. Yes. You mentioned the National Science Board in your remarks. And the National Science Board had a task force on administrative burden a couple of years ago, and they identified a number of ways in their report that NSF could help out the research community. And we've been implementing a number of those recommendations, and, of course, we have our own internal groups on administrative burden.

Part of our effort we call "Renewing NSF" is focused on streamlining all our processes and our practices. And we're starting with the merit review practice, which, as you know, that's the heart of NSF, that's what we do, is we get money out through the merit review process to the community. And we figure if we can streamline that process and make it more effective, then we will reduce the burden on proposers by having the proposals process look the same no matter where you're applying through NSF, have more standardized solicitations, more regular kinds of deadline requirements, and so forth.

So, yes, we can do our part. And then this is something that everybody can take a part in Congress and the universities themselves in streamlining processes. I was at one time a researcher at the university, and I know all about the 40 percent administrative burden in filling out paperwork, so I'm a very sympathetic player here.

Senator GARDNER. Thank you, Dr. Córdova.

Dr. Copan, when you had your confirmation hearing, we talked a lot about commercialization, which is also an integral part of the American Innovation and Competitiveness Act. Could you talk a little bit about the commercialization efforts that you've undertaken at NIST since you've been there?

Dr. COPAN. Absolutely. And as someone who has worked in this field for many years, this is a passion that I bring to NIST as well as to the Federal sector as a whole.

As we've been comparing notes with the National Science Foundation, we've been utilizing common practices and sharing practices across the Federal sector. And as we also now look to the future to the implementation of the review that I described at my confirmation hearing, the opportunity to enhance return on investment from the United States investment in science and technology is a great opportunity for this Nation.

The Bayh-Dole Act has served the Nation well, Stevenson-Wydler has in addition, but we continue to hear from both practitioners as well as from industry. There are opportunities to do it better. And so during the time that I am with NIST, we will be expanding our review of Federal technology transfer and seeking ways to reduce the administrative burden and some of the unintended barriers to bringing commercialization from the laboratory into the commercial marketplace for this Nation's benefit.

Senator GARDNER. Thanks.

Senator Peters.

Senator PETERS. Thank you, Mr. Chairman. Actually, I want to pick up on those thoughts on commercialization because I've been hearing this a great deal as I've been out talking to folks. It certainly was a critical part of our legislation as well. And there certainly is significant challenge for these ideas to cross the valley of death to actually become companies going forward.

Dr. Córdova, you mentioned the I-Corps program as being extremely successful, and, of course, we expanded that in this legislation. And I can speak from experience from one of my universities. We have many great ones in Michigan, but the University of Michigan in particular is home to one of the seven I-Corps nodes and for

years I think has been quite an example of how you bridge that valley.

Dr. Córdova, could you provide a little bit more detail as to the mechanics of how NSF is going to be collaborating with other agencies, like the Department of Energy, NASA, and even the Department of Defense going forward?

Dr. CÓRDOVA. I-Corps is a very structured program that includes mentorship and entrepreneurship, the academic component, and, of course, the student practitioners, graduate and undergraduate students. And it has a very well-defined curriculum that it takes the students through, and then there's the partnership aspect, and then there is the business aspect going out and making the calls to the marketplace widely to see if the research or discovery of interest has any market potential. So they learn all of that in this structured way. And it takes this whole environment to kind of get them the wherewithal and to rev up this whole process of learning and understanding what market potential really means.

So that's a process that others have copied—they utilize our processes and our people, and they've learned how we do this, how we do this course of instruction and engagement; and we are the ones that help them out. So, our folks that do this with the nodes, the eight nodes, around the country and all the sites, are then loaned, as it were, to these other agencies to make sure that they have the same kinds of approaches. And then they take off, they learn it, as it were, of course, themselves, and then they can replicate it and do it. And that's how we build scale into the program because, as you know, scale in these kinds of things that are human endeavors are the most difficult things to achieve.

And so the only way we can achieve really a great scale on the Innovation Corps is to be teaching this to others so that they in turn can teach it. And so that's what's happening. We've done that course in Mexico and in Ireland and in the State of Ohio, which is now I think in its third year of doing it.

Senator PETERS. Right. Thank you.

I want to comment on the other program that you mentioned as well in your testimony, is the MEP program, Manufacturing Extension Partnership. I've just seen great success with that in Michigan, particularly helping small to medium-size manufacturers leverage what they do so well, but do it in a way even better as a result of that program.

If you could talk a little bit about the cost share and also the success of that program and why we really need to continue to fund it and the fact that it really—it has really measurable results that we should all be proud of.

Dr. COPAN. Thank you, Senator Peters. As Secretary Ross had also testified, the MEP is a program that has delivered success for the country, and I believe that the statistics for return on investment to the U.S. taxpayer have been well publicized and have been experienced state by state, including in the State of Michigan.

We have benefited, I believe, from the change to the cost share model. All of the centers across the Nation have shifted to the new guidance, and we have seen greater leverage from the outreach from each of the MEP centers nationwide.

In addition to programs like that, we've also focused on the resilience of the U.S. manufacturing infrastructure in the wake of the hurricanes that affected Puerto Rico and the Gulf border states. We have seen the MEP program step up to help the small manufacturers restart their business operations through the direct engagement of the MEP centers. So not only is it enabling U.S. industry, but certainly we've seen it as a program that's important to keep America strong in the wake of natural disasters.

Senator PETERS. Great. Thank you.

Senator GARDNER. Senator Cortez Masto.

STATEMENT OF HON. CATHERINE CORTEZ MASTO, U.S. SENATOR FROM NEVADA

Senator CORTEZ MASTO. Thank you.

First of all, let me just say I wasn't here the time you passed the American Innovation and Competitiveness Act, but——

Senator GARDNER. It was a wonderful time.

Senator CORTEZ MASTO. I want to thank both of you. I mean, it really is good legislation and it has a positive impact in our communities in the country, so thank you for that.

Senator GARDNER. Thank you.

Senator CORTEZ MASTO. And thank you, both of you, for being here.

Dr. Córdova, I'd like to start with you. I am a proud supporter of broadening opportunities in STEM fields for minorities and women. That's why I introduced the Code Like A Girl Act, which is supported by groups like our Girl Scouts, to further promote efforts to engage young girls in computer science and hopefully provide the role models and exposure to make the estimated millions of unfilled STEM jobs an option for everyone.

I know, Dr. Córdova, you obviously are one of those incredible role models, as I've looked at your background, and while we are talking about this, however, and the need for it, and we are making advancements, just last November, GAO documented that from 2005 to 2015, they found that no growth occurred for female workers in technology.

So would you agree, is there more work that can be done really to get young women exposed and motivated and energized in these fields? And if you would, talk a little bit about how we can do just that.

Dr. CÓRDOVA. Yes, absolutely, that's kind of a shocking statistic. There's just enormous potential out there, and we really need it. I mean, just hearkening back to Senator Gardner's remarks about the recent science and engineering indicators report: We have a lot of other countries that are making faster progress than we are, and we really need to, for many reasons, including that one, turn to the talent pool that is right here all around us and develop that for our country's future.

So NSF has been involved in all disciplines, including, of course, computer science, in promoting the advancement of—well, in broadening participation in general and promoting the advancement of women and underrepresented minorities in particular.

And I just want to mention two programs really quickly and then go to computer science.

We've had for a long time the ADVANCE program, which is to promote women in universities to engage them in joining universities' professorships and then assure that they stay, they're sustained, and then achieve higher levels. And I myself was a PI for the ADVANCE grant at Purdue, and so like—love—the program.

And more recently, we've initiated a program called INCLUDES, which is really addressed to bringing in everyone in the Nation to giving them more access to STEM careers and with a particular focus on women and, again, underrepresented minorities.

We are funding currently 70, 69, INCLUDES pilot programs all across the Nation, which are really community groups comprising universities and civic organizations, community colleges, in some cases, the state itself, in furthering opportunities, and many of those INCLUDES grants have to do with computer science in a number of states, and I can give you a list of those.

And more specific to computing, we have a program called Computer Science For All, which is to make sure that teachers have the preparation they need because, after all, going back to my remarks about scaling, in order to really scale something, you have to train the trainers and so forth. This has to go forward through other people.

So this effort combines professional development opportunities for teachers at all grade levels together with research studies at the pre-K to 8 level that will focus on how to integrate computer science and computational thinking into their classrooms.

And I have any number of examples which I could send you subsequently, Senator, about specific examples of computer science programs that we're funding that are making a real difference, I think, that are directed towards increasing women and underrepresented minorities, and we have the data to show that they are making the difference.

Senator CORTEZ MASTO. Thank you. And so I'm glad you highlighted that because I know particularly in Nevada as well, UNR is a recipient and works with you and include a program; our community colleges are HSIs, Hispanic-serving institutions, work closely. So thank you. I think there is a benefit to the funding and the support of really targeted in this area and working with our colleges and our universities.

At the same time, you also focused on the last question I had with the metrics. I think it's so important that not only as we put the money in here and we're working very hard to open this door, that we are collecting data and the metrics to show that it is having the positive impact or the intended impact that we are focused on through this Act. So thank you very much.

I ran out of time, Mr. Copan, so I didn't get a chance to ask you questions, but I'll submit those for the record.

Thank you very much for being here.

Dr. COPAN. Thank you so much.

Senator GARDNER. If you don't mind, we'll also go another round, so you're welcome to stay, Senator. I know we all have busy schedules and other committees, so if you have to leave, we'll take it for the record.

But I would just say that this was a great effort by the Committee, as a team, to pass this bill. In fact, I think there were three

times a year ago that it was written that the bill had died and would never be passed by the House.

[Laughter.]

Senator GARDNER. It was the bill that kept coming back to life. And I think it was finally signed—Senator Peters and I thought that this bill would go down in history as the last bill signed by President Obama before the inauguration. Unfortunately, I've been told that there may have been a bill he signed on the last day he was in office, so we will forever be lost in history as the third or fourth last bill to ever be signed by the President, but a great accomplishment I think in terms of making sure that we're growing the bipartisan support for science.

Dr. Córdova, this morning I had a chance to meet with some people about investment in science by China, and we were talking about the overall—I think the U.S. basically contributes about .7 percent of our GDP toward research and development. And this group thought it would be in our best interest if we could grow that number to 2 percent of GDP that the Federal Government would contribute towards research and development. What would happen in terms of our research and development opportunities if we were to hit that level and to greatly expand our research to something like 2 percent of GDP?

Dr. CÓRDOVA. I think you have to break down research and development into its components of basic research and applied research and development. I think development has a lot of investment in it, especially by the business community, they're the dominant players. And so where I think the emphasis is or should be from our point of view is on really growing investment in basic research because that's at the root of technology and tech transfer, and that's why we work so closely with NIST in going to the next level to the more applied research and then eventually then business takes it over into development.

It would be transformational to grow the basic research budget. I mean, look at all the things we have, some of which you all have mentioned. I know Senator Peters was recently at the auto car show in Washington, D.C., and there is the artificial intelligence that's being used in autonomous vehicles, self-driving cars, much of it is NSF-funded, and that's just one segment of society. There's the medical, and you mentioned MRI machines. That was also from NSF-funded discoveries. Gene editing was mentioned. The very first grants in gene editing were from the National Science Foundation because before something can be applied, it has to be discovered, it has to be new knowledge, and that's where we come in.

So in all things, if you come to our new building in Alexandria, you see—the first thing you see is a giant wall that looks to me like it's 100 feet long, I'm sure I'm exaggerating, it's probably more like 30 or 40 feet long, but it's a painting, original painting, of all the different discoveries and impacts, the really big ones, that NSF has made. And somewhere in the middle there is Google because we funded the original founders of Google, as you know.

And I mentioned all the companies that have been created just in the last few years with investments in the Innovation Corps program. So thinking about doubling or quadrupling that, as you've

suggested, would be, I mean, just tremendous horsepower for the Nation.

And if you want, as a country, to stay ahead, if we want to continue to be first, and we're looking over our shoulders, and as you said, seeing China and other countries coming up faster and faster behind us where before they used to be way behind, then we're just—we're going to have to be smarter, we're going to have to invest in and broaden the participation of more of our own youth, women, to be a part of STEM, and we're going to have to step up our investments in basic research so that these kinds of discoveries, ones that I said are the breakthroughs of the year for the last 2 years, have been NSF-funded basic research discoveries.

We talked about LIGO, and those are—for those of you who have seen pictures of it—they're really long tubes, 4 kilometers long, in different directions. Those tubes are not empty, they're full of the most sophisticated kind of engineering devices that are on this planet, you know, inventions that are unbelievable. And the transfer, the tech transfer, of that kind of invention that suspends the mirrors and they can detect something that moves the distance of a thousandth of the diameter of a proton; that is absolutely amazing: what that is going to do for the country when that's translated out. So the future is ours, but we have to seize it and invest in it.

Senator GARDNER. Thank you, Dr. Córdova.

And I know the Chairman of the Full Committee is here, Senator Thune.

I'll turn it over to you.

STATEMENT OF HON. JOHN THUNE,
U.S. SENATOR FROM SOUTH DAKOTA

The CHAIRMAN. Thank you, Senator Gardner, for presiding over today's hearing on the American Innovation and Competitiveness Act, or AICA, which we introduced and enacted last year along with Senators Peters and Nelson. So I'm pleased that NSF, NIST, and OSTP have made real progress in implementing the bill.

Dr. Córdova and Copan, I also want to—I should say "Doctors" plural—I also want to thank you for being here today. I think it's probably the first time that you each have testified in front of this Committee in your new position.

Dr. CÓRDOVA. Yes.

The CHAIRMAN. Is that correct?

AICA represents, as you know, the most comprehensive science and technology policy legislation enacted since the America COMPETES Act in 2007 and 2010, and like those Acts, it reauthorized and updated policies at NSF, NIST, OSTP, and other Federal science agencies. Specifically AICA sought to maximize basic research, advance public-private partnerships, enhance agency oversight, promote STEM education, and increase research commercialization.

In my home state of South Dakota, AICA provided further support for the Deep Underground Neutrino Experiment and the Long-Baseline Neutrino Facility at the Sanford Underground Research Facility by tasking OSTP with new responsibilities related to the prioritization and coordination of high energy physics research and international science and technology partnerships. It also updated

the Established Program to Stimulate Competitive Research, or EPSCoR, which assists South Dakota in maintaining a self-sustaining and competitive academic research enterprise.

The Act required updates based on recommendations of previous EPSCoR reviews to maximize the impact of Federal support for building a competitive research infrastructure across all states. So I want to again thank you for the progress that you have made in implementing the legislation.

And I do have a couple of very quick implementation questions I'd like to ask. One deals with how AICA prioritized cybersecurity standards and research at NIST and NSF, including NIST research for future cybersecurity needs, like quantum computing, and NSF-sponsored research into the role of human factors in cybersecurity.

This Committee has also advanced other bills and laws this year that address the issue of cybersecurity, including the MAIN STREET Cybersecurity Act to facilitate the use of NIST's cybersecurity framework by small businesses, and the Cybersecurity Scholarship Opportunities Act to update NSF's CyberCorps Scholarship for Federal Service program, a program, which I might add, Dakota State University of Madison, South Dakota, is the largest participant in, in terms of supported students.

So the question is, if you could highlight how your agencies have and will continue to advance work in the critical area of cybersecurity, aligned with AICA, and how you see your role in partnering with educational institutions like DSU?

Dr. COPAN. Thank you, Mr. Chairman. The opportunity to discuss cybersecurity is very near and dear to my heart with the role that NIST plays in the leadership of cybersecurity and the development of the cybersecurity framework, which has been transformative for this Nation. Also in the Cybersecurity Framework's implementation in government as well as broad penetration through U.S. industry all the way through to the Department of Defense supply chain through small business and through the support that's provided throughout the NIST programs.

We see that the scientific integrity that underpins the development of cryptography and also post-quantum cryptography is an important area of ongoing research at NIST. As we look at the future integrity of our systems, we also look to the implementation of blockchain technologies more broadly than in crypto currencies. And NIST has recently issued a report highlighting some of the implications of blockchain technologies, which I believe this Committee will be hearing more about in the days and weeks to come.

The Framework is an essential element of our programs and so is Cybersecurity education which will enable the next generation of scientists and engineers to be prepared for careers in cybersecurity and cryptography research.

Thank you.

Dr. CÓRDOVA. Chairman Thune, I'll add just a bit. We appreciate the leadership that you and this Committee have shown on this very important issue. NSF also is committed to strengthening cybersecurity education. And the CyberCorps program has been successful to date.

You mentioned Dakota State University near Sioux Falls. It's one of the 13 Centers of Academic Excellence in Cyber Operations, as designated by the NSA, and NSF has a partnership with it.

The focus on cybersecurity education has also resulted in the school receiving a very generous gift from private industry, which is further leveraging these efforts.

NSF was pleased to respond to the requirements of the Cyber Scholarship Opportunities Act, which expands CyberCorps' scholarship availability to community college students, and this is very important. As you know, we've had the CyberCorps Program Scholarships for Service for a long time, and that—the aim of that program is to develop a well-educated cybersecurity workforce for the government. It gives students up to 3 years scholarship in return for their service to the Federal Government, state, or local, or tribal government.

At this point, there are 14 collaborations between community colleges and four-year institutions that we funded. And in addition, the Cyber Scholarship Opportunities Act codifies the CyberCorps K–12 education program called "Inspiring the Next Generation of Cyber Stars." The GenCyber summer camps—I wish I had been able to go to such a camp, it sounds great—helps to seed the interests of young people in this exciting and exploding field.

The CHAIRMAN. Right. Now, Senator Gardner would have liked to have gone to some of those camps, too, but he was——

[Laughter.]

The CHAIRMAN.—probably busy doing—no, I'm kidding.

Senator GARDNER. Exactly.

The CHAIRMAN. You were very busy. Yes.

I have one other question that I can submit for the record, Mr. Chairman, but I appreciate again your efforts to implement—and I guess I'm supposed to call it AICA. There's an acronym for everything around, you try to summarize it, yes, but, OK. All right. Thank you.

Senator GARDNER. Thanks, Senator Thune.

Senator Hassan.

STATEMENT OF HON. MAGGIE HASSAN, U.S. SENATOR FROM NEW HAMPSHIRE

Senator HASSAN. Thank you, Senator Gardner.

And to Chairman Thune and Ranking Member Nelson, I'm very grateful to both of them for this important hearing.

And thank you to both of our witnesses for being here today.

Before I get into my questions, I just did want to point out that it's my understanding that the Committee had hoped to have someone from the Office of Science and Technology Policy, OSTP, join us as a witness today. However, because there still has been no one appointed to head the office, OSTP is not able to join us. I've called on the President to make OSTP a priority, as science and innovation are the keys to unlocking our Nation's economy and spurring U.S. global competitiveness.

So I've written to the President about this topic several times. I just would like to register my disappointment that no action has been taken to fill this very critical role.

As to questions for the panel, to both of you, some politicians, most of whom have no scientific training or background, have targeted federally funded research in science for funding cuts. But federally funded research has resulted in breakthroughs that have saved lives, prevented disease, and saved citizens, businesses, and taxpayers significant amounts of money.

For example, the U.S. Department of Agriculture research made it possible to effectively eradicate the screwworm that was killing off our Nation's cattle supply. This saved the U.S. cattle industry billions of dollars over the last 50 years. Today, that same research is being used to investigate methods to control Zika-carrying mosquitoes. This underscores the importance of funding studies into various issues, as we just don't know when this research will come in handy to save lives and money.

So how are your agencies looking to balance the need for fiscal responsibility with the need to fund various types of research?

And, Dr. Córdova, I'd love to start with you.

Dr. CÓRDOVA. How are we doing more with less? Is that——

Senator HASSAN. Or how are you balancing and where would you like more?

Dr. CÓRDOVA. So we're always looking for efficiencies. In fact, today we had a town hall on this subject called "Renewing NSF," and we identified four ways going forward to look for efficiencies, upping our IT game, fitting the workforce better to the work through training programs, streamlining our processes and practices, especially starting with the merit review practice, and looking even further to more partnerships to leverage what we do so we can do more, and also leveraging—our partnerships has the added effect of just bringing more people in and engaging them in our furthering the progress of science.

So, but ultimately it really devolves to making priorities about what—you know, what you're going to do with the funds that you have. And so we do that in a couple of different ways. We have a bottoms-up approach, which is the community, through decadal reports of the National Academy of Science and Engineering and Medicine, we get input from the communities. We also get it from our advisory committees, and we get it from individuals and crowdsourcing and all.

And then we have a more top-down approach where we have congressional, administrative, and senior leadership priorities, and we bring those all together and devise constantly a continuing strategic plan on where the country is going—what's important to invest in.

So let me just give you one example——

Senator HASSAN. You know, I'm sorry, but I only have about 2 minutes left.

Dr. CÓRDOVA. OK, sure. Of course.

Senator HASSAN. And I want to give Dr. Copan a chance.

Dr. COPAN. Sure. Thank you very much. The budget balance is always a challenge, and it's also an opportunity. And I think, as Dr. Córdova has said, it's an opportunity to gain greater efficiencies and greater leverage within the Federal sector, working more effectively with the private sector, and across the Federal enterprise to

identify opportunities that will really make a difference for this Nation.

We have gone through, and the AICA has been an important spur to NIST in revitalizing our strategic planning process and looking at the impact of critical programs and looking at cross-disciplinary leverage across our organization because, indeed, NIST touches every facet of the U.S. economy.

Senator HASSAN. Right.

Dr. COPAN. And so it's really our goal, as we look at those strategic thrust areas that we identify that are cross-cutting, that they will leverage, they will build upon the shoulders of the great research that we're doing now, and will be able to have cascading effects into the economy.

Senator HASSAN. Well, OK. Thank you very much. That's helpful.

I have just 50 seconds, and I want to ask I think a quick question. I know Senator Gardner noted that the Federal Government has been spending less as a portion of its GDP on research and development. And while our investment levels are relatively low, other countries, like China, are spending more on R&D and making great strides in innovation.

So how important is Federal investment to maintaining global leadership when it comes to new technologies and innovations? And should Federal R&D be considered a matter of national security? Just briefly from both of you.

Dr. Copan, I'll start with you.

Dr. COPAN. Investment in science and technology is critical for the Nation's future, for our competitiveness. I believe that we can be prudent about how we invest to gain maximum benefit for the U.S. economy and to assure our leadership. We see that we have to not only invest in fundamental research, but, indeed, to translate that research into applications. The critical role that NIST plays in standards takes what we learn in our measurement research and how we apply that research to the products and services of U.S. industries and that helps maintain a level playing field for the U.S. in international trade, which is a critical part of national and economic security.

Senator HASSAN. Well, thank you. I'm over time. I see—I'll ask the question on the record, too, and look forward to your response, Doctor.

Dr. CÓRDOVA. Thank you.

Senator GARDNER. Thank you.

Senator Peters.

Senator PETERS. Thank you, Mr. Chairman.

I think on the funding issue in the fact that when Senator Gardner and I held all of those roundtables, the issue of money came up quite a bit with each and every one of those roundtables. But I think the real takeaway from it wasn't just the increase in funding, although that's obviously very important to the scientific enterprise, but the big part of it was just to have some stability, to have an idea of what's going to be coming in the years ahead so that you can make plans.

So my question is to get a sense from how the fact that we have been basically passing continuing resolutions, CRs, for about 2, 3, 4 weeks at a time, whatever it may be, multiple ones of those, that

to me I know it's very difficult to manage an organization 3 or 4 weeks at a time. I'm sure it's very difficult for you to do that. And I would just like to get a sense, given the fact that I'm actually—we're going to be holding a hearing and working with Senator Rand Paul, the Ranking Member on the Federal Spending Oversight Subcommittee, and we're going to look at the impact of the short-term CRs on the management of the business of government.

But I'll start with you, Dr. Córdova, and then, Dr. Copan, if you could follow, what has it meant for you in managing your organization as a result of the short-term CRs?

Dr. CÓRDOVA. Well, Senator, I think, as you're implying, it's disruptive. So, for example, on the last pre-shutdown, of course, we didn't know which way it was going to go, and so all the senior leadership stopped work to plan just in case there was a shutdown, of course. So we cancel meetings. We look at all the travel that our own people have. There were 85 people scheduled to travel that weekend, and they were all wondering, "Should I travel or not?" and we said, "After midnight you will know." And we had hundreds of people that were coming from the outside to participate in the merit review process for the next week. And so all of—when the shutdown actually happened, we had to cancel all of that. We canceled 10 merit review panels. Just for those who don't know, on any given day, we have between 200 and 600 visitors who are part of the merit review process, they're coming from other universities and other establishments, foundations, and all to help evaluate the proposals. And so all of that was canceled; it was disruptive in their lives.

And so in preparing for next week, we learned some lessons, so we'll smooth out—we'll have more meetings, of course, so we're dropping other things. And tomorrow will be the start of the first meeting to prepare for perhaps a post-February 8 shutdown. And just one example that I shared earlier with Senator Peters, and this is only one out of hundreds, we had the three Nobel Prize winners in physics this year who won the prize for the discovery of gravitational waves all coming, flying in, on February 8 to give a talk to reprise their Nobel lectures for the NSF staff because they're so grateful to having been funded for those decades, on February 9, and they're asking us, "Should we come?" So that's just—because they may come, and if we're shut down, then, of course, they can't give their lectures, and we have to send them home, and that's to California for two of them, and Boston for the third.

And so that's just one example out of hundreds of the kinds of disruption, but everybody just basically stops work in order to gear for shutdown and their further instructions.

Dr. COPAN. I must echo some of those remarks in terms of disruption to operations and travel. We have a lot of user facility engagement at NIST that includes a small nuclear reactor facility as our source for neutron research and biological systems, biomolecules, and polymer systems, et cetera. And so we had to go through an orderly process to deal with visitors from across the Nation and from around the world so that they would not lose the experiments in some cases that they have been planning for months and, indeed, years.

So it is a challenging environment in which to manage. I must say that there are lessons that have been learned as a result of the process, and I believe that we will be able to manage effectively as we deal with further uncertainties. But I think that ultimately putting the U.S. science and technology enterprise to work as quickly as possible and maintaining, as you've indicated, the stability of the environment for research so that we can look to the long-term impact onto the economy.

Senator GARDNER. Thank you.

Senator Cortez Masto.

Senator CORTEZ MASTO. Thank you.

Just one follow-up because, Dr. Copan, one of the concerns I had, and we has this discussion last time, over cybersecurity. And last time we had a conversation, and I know through written questions I had asked you about working on the critical need for engagement of cybersecurity support for our small businesses. And I am just curious, can you talk about what efforts you are putting in place since your confirmation and maybe elaborate a little bit more on apparently the report that was issued. Is that also something that should be given to our small businesses as well so they can have that assistance?

Dr. COPAN. Thank you, Senator. Cybersecurity is important for corporations large and small, and small companies, as we've seen reports, are the most vulnerable, and the probability is high that those companies will no longer be in business as they are victims of a cyber attack or breach. So it has been a high priority for NIST.

The AICA authorization has been an important part of supporting NIST's focus in this area. We've worked through our advanced manufacturing institutes. We have worked using our broad network of U.S. manufacturing focused on small to medium-size enterprises providing cybersecurity training basically to translate the cybersecurity framework into the language and the format the small enterprises can utilize, and that has been a process that has been hugely appreciated. It has also been part of the Department of Defense supply chain readiness around cybersecurity that has been a strong partnership between NIST, the Department of Defense, and our U.S. manufacturing infrastructure. We take that very seriously, and we know that this is a challenging environment with threats that are emerging and evolving. We've certainly seen evidence of that in the press on a regular basis with threats to central processors, for example.

And so we look forward to continuing to work in providing information, even in the phase of a shutdown. The National Vulnerability Database on cyber threats and the patches to be implemented, and the testing processes behind those patches have been maintained again in support of U.S. industry large and small.

Senator CORTEZ MASTO. Thank you. So I know in Nevada—and I talk on a regular basis with our small businesses—this is one of the issues—right?—because they don't have the resources they need to really tackle cybersecurity, and they're looking for additional resources. Is there something that you can provide to me, some information, that I can give to them? So I have a small business manual that I put out in the State of Nevada for a lot of our chambers and our small businesses. Is there—if my staff reaches

out, can we get some information that we can share with them that helps them address the cybersecurity needs that they have?

Dr. COPAN. Absolutely. We have materials, we have training. And through our Baldrige Performance Excellence Program, we have a Cybersecurity Excellence implementation framework for companies, again, large and small, to utilize best practices that are available, and these are all materials that are available and we'd be delighted to provide.

Senator CORTEZ MASTO. Great. Thank you. Thank you very much.

Senator GARDNER. Thank you.

And I know Senator Markey is on his way and wanted to ask some questions, so we'll ask a few more, too, if you don't mind.

I guess the final question that I would have for you is twofold. One, given the authorizations, the language of the American Innovation and Competitiveness Act, what more should we do? Did we get it all right? Did we get something wrong? Are there additional tools, resources, or legislation that you need or are looking for, or guidance that you're looking for? And then where do we go from here if that's on the right path?

Dr. CÓRDOVA. That's a real——

VOICE. Your mic, please. Your mic.

Dr. CÓRDOVA. To suggest legislation?

[Laughter.]

Senator GARDNER. Please.

Dr. CÓRDOVA. No——

Senator GARDNER. Staff—just so you can know, staff are shaking their heads violently no.

[Laughter.]

Senator GARDNER. You can't see them, but they're shaking their heads.

[Laughter.]

Dr. CÓRDOVA. No. I think you've given us quite a bit here to do, just a lot of different emphases. And I think there just are a lot of challenges. If we can realize what is here in the Act and just do a really good job on it, we'll be a much improved part of Federal Government in delivering, especially in STEM education and facilities. I mean, you've just taken on a lot of very, very big issues. So I think there's plenty for now.

Senator GARDNER. Good. Thank you. And as you've gone through the Act, there are no areas where you wish it would provide greater clarity or additional information, so everything seems to be to your satisfaction in the legislation as it is right now.

Dr. CÓRDOVA. Yes. And your staff are just wonderful to work with, and with our staff, and so I think where there is desire for more clarity, we just—you know, we just feel very good about interacting with them and seeing that we have it.

But, no, I don't—I certainly don't have anything to add.

Senator GARDNER. Dr. Copan?

Dr. COPAN. Thank you. This legislation has been very important for NIST and for American science. And I'd like to thank this Committee once again, as I did in my opening remarks. It has provided clarity, it has provided enablement. I mentioned before the NIST focused on security, and the fact that that was reflected in the

AICA is something that resonates with me as the new Director for NIST and the implementation of greater security awareness and a security culture within the NIST organization. I must say that organization has embraced that mandate, which needs to be led from the top.

I believe that, looking to the future, this Committee needs to keep a finger on the pulse, and we, from our side and I'm sure between Dr. Córdova and myself, we will do our very best to indicate to you the challenges that we face.

Several of the questions today have indicated the competitiveness issue of U.S. science and technology investment. We see very significant moves around the world to try to take the high ground around standards leadership. NIST has a very important role to play as we push the boundaries of measurement science and technology, which enables Nobel science-winning research that's funded by NSF, that's funded directly through the Department of Commerce, and through our other agencies.

We have a very new environment around international competitiveness now that goes beyond investment strictly in fundamental science and technology, but we're looking to move our technology transfer capabilities beyond where we are today as a nation, as I've indicated in my response to the earlier question. And we have a chance, I believe, to look at policies and implementation more broadly to unleash the innovation engine in this American economy even further to remove unintended barriers to commercialization to access to our Federal research environment.

We know that some state institutions sometimes have challenges in accessing Federal research because of their legal constructs versus what's required in Federal technology transfer legislation.

So I believe all those areas will move the needle for the U.S. economy. And so this new frontier now in areas that are critical to the economy, to U.S. competitiveness, we've mentioned the frontiers of quantum, of future communications, artificial intelligence and mobility, machine learning, structural biology and what that means to the future of medicine in this Nation. So all of those will ultimately be reflected in the standards that drive U.S. commerce and international trade.

Senator GARDNER. Great. Thank you.

Senator Markey.

STATEMENT OF HON. EDWARD MARKEY, U.S. SENATOR FROM MASSACHUSETTS

Senator MARKEY. Thank you. Thank you, Mr. Chairman, very much.

Thank you for being here. Thank you for representing science and technology at this important time in our Nation's history.

Director Copan, you know, when I think about cybersecurity and having a framework that ensures that with all of the advances that are made in technology, that there are also defenses that are put in place. So IoT is the Internet of Things, but in the wrong hands, it means "Internet of Threats."

Dr. COPAN. Indeed.

Senator MARKEY. And so what we need to do, obviously, is to ensure that those safeguards are put in place. Do you have a way at

NIST of measuring the adoption and compliance of NIST's cybersecurity framework? How will we know if your great thinking actually gets implemented?

Dr. COPAN. Thank you, Senator. That's a very, very important question. I know it's very dear to both of us as we look at the security of this Nation and taking advantage of the thought leadership that comes from NIST and our technological capacity there in understanding processes around cyber threats.

NIST, as you know, is a nonregulatory agency of the Federal Government, and, as such, we don't have that kind of oversight in terms of audit. We do have very close relationships, however, with industry and across the entire Federal sector where we do get very regular information about the adoption of the cybersecurity framework across the Federal sector. We know that others, including the Department of Homeland Security, and, of course, our inspector generals, have a very keen interest in the deployment of the cybersecurity framework for the Nation.

NIST has focused on the Internet of Things, interoperability, and identification of threats as well as strategies to mitigate threats and ultimately to ensure the resilience of our infrastructure for manufacturing——

Senator MARKEY. So would you—I've introduced a bill called the Cyber Shield Act that would create an advisory committee of cybersecurity experts from academia, industry, consumer advocacy communities, and the public to create cybersecurity benchmarks for IoT devices, for baby monitors, for cameras, for cell phones, for laptops, for tablets. It could be voluntary, but each one could just have a grade that it gets in terms of its ability to be able to thwart, you know, cyber attacks.

So what would you think of something like that so that manufacturers could voluntarily certify that their product meets the industry guidelines?

Dr. COPAN. As a standards-focused organization, I think NIST very much resonates with the idea of having voluntary standards approaches and the ability to measure how organizations are working with respect to compliance. So I look forward to our ongoing dialogue about the implementation in a way that's appropriate for NIST and ultimately appropriate for the Nation.

Senator MARKEY. Yes. I think we—it's always better to start out where you're going to be forced to wind up anyway because we're going to be forced to wind up there after the horrific acts that occur after the accidents, the mistakes, the compromise of the privacy of people, or the security of people. So we are going to wind up there, it's just how many accidents, how many compromises of security. And it's every device, so the opportunities are going to be vast as this technology continues to move ever more quickly.

And, Dr. Córdova, so good to see you again. It was great to see you at the dedication of the new science building up at Northeastern University.

And so what I would like, if I could, with my remaining time, to give us some insight, if you would, into the recommendations that might be made by the National Research Council to improve reproducibility of scientific data. How would you envision that these recommendations be implemented?

Dr. CÓRDOVA. So on March 8, you might know that we established an agreement with the National Academies to go forward to conduct a study for the assessment on reproducibility and replicability in science. And they have formed a committee of 15 experts. They held their first meeting in December. And they have four additional meetings scheduled in 2018.

After a widely advertised public gathering and interactive webcast that included the scientific community, they have a lot of input and they plan to have a lot more before they actually give their report.

We don't know at this point what, of course, will be in the report. That's—we're hands-off, and so they provide us with that expert external advice that we're really counting on, but we have high hopes that they'll give us more insight into the field. I can say that from NSF's own studies and its advisory committee studies, the subject is very heterogeneous depending on what field you're in.

And some fields, like my own in astrophysics, have had standards for a very long time. And when something is reported that is important, everybody dives into it, and you can—you do the reproducibility and replicability immediately to test it—but it becomes harder in some fields, like biomedical sciences and social and behavioral sciences. And so we're hoping that the Academies take a very nuanced approach to the different fields and what kind of challenges that they have and provide some best practices that they see going on around the country that we can publicize and share with everybody and learn from.

Senator MARKEY. They very much appreciate it. And my time is expired. But, you know, over the portal of the Boston Public Library, it says, "The best defense of a nation is the education of its people." And that's what the National Science Foundation and that's what NIST does on an ongoing basis, and we very much thank you for all of the work you do to advance that American ideal. Thank you.

Thank you, Mr. Chairman.

Senator GARDNER. Thank you, Senator Markey.

Dr. Córdova informed us that 300 Nobel laureates are attending I think February 9, to make sure that the government doesn't shut down. Is that correct? Is that what you said?

[Laughter.]

Senator GARDNER. To help us figure that out. They deserve a Nobel at that point.

Thank you very much to both of you for your time and testimony today, and your commitment to what we all need to do in this country, to focus on the incredible work we're doing in our science and science fields. So thank you very much.

I will give you your homework assignment now. We'll leave the record open for the next two weeks for members to submit their questions.

Dr. CÓRDOVA. Of course.

Senator GARDNER. If you don't mind replying to those as soon as you can, we would be grateful for that.

With thanks to this Committee, thank you for your testimony today.

Dr. CÓRDOVA. Thank you.

Senator GARDNER. We're adjourned.
Dr. COPAN. Thank you.
[Whereupon, at 4 p.m., the hearing was adjourned.]

A P P E N D I X

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN THUNE TO DR. FRANCE CÓRDOVA

Question. AICA directed NSF to implement recommendations from the NSF Inspector General and the National Academy of Public Administration to improve oversight of its large scale research facilities' construction and life-cycle costs. This provision was based on our Committee's oversight of projected cost overruns in major facilities construction, and of research facility life-cycle management. Could you share an estimated time frame for completion of the remaining recommendations NSF is still in the process of fully implementing, and highlight what you see as the most significant savings, efficiencies, or other outcomes that have already resulted or that you expect to result from NSF's improved oversight of this area?

Answer. Throughout my tenure it has been a top priority to improve NSF's oversight of major facility projects, and I thank the Committee for your unwavering support in this area. We are pleased to report that we have completed all of the new AICA requirements regarding facilities.

The new management fee policy that NSF put into place will help us to align our policies more closely with those used by the rest of the Government. This will include using the same methods to develop reasonable fee amounts, including considering such factors as the technical complexity of the work and the amount of cost risk undertaken by the awardees in performance.

NSF will keep in place the controls that we have developed to ensure that fees are not misused. These controls include providing guidance to awardees on inappropriate uses of fee, separate tracking of fee expenses, our authority to examine those records, and our ability to reduce fees if they are not being used appropriately.

As required by Section 110 of AICA, the newly-appointed Chief Officer for Research Facilities is serving as the senior agency official with responsibility for oversight of the development, construction, operations, and divestment of major multi-user research facilities across the National Science Foundation. The Chief Officer for Research Facilities is in the Office of the Director and reports directly to me as the NSF Director. He is responsible for complete lifecycle oversight of NSF's major facilities, including divestment.

The Chief Officer for Research Facilities has taken a new look at our oversight structures, streamlined them to eliminate duplication, and set up a clear reporting line that enables any potential issues to come to the attention of my office before they become serious.

NSF has taken a number of important steps to strengthen its oversight of cost proposals as required by AICA and recommended by NAPA. These steps began several years ago with aligning our internal processes more closely with GAO good practices and clearly articulating our expectations for proposals from recipients.

The changes in internal processes include more effective use of independent cost assessments and clear requirements for well-documented bases of estimate for both construction and operations. The required independent cost estimate for new construction awards, and our expert panel reviews, are just two types of independent cost assessments we use.

We also have put in place procedures whereby NSF can hold up to 100 percent of the budget contingency for a construction project to manage known risks until the realization of risks necessitates the obligation of a portion of that contingency.

To ensure that actual costs are allowable, incurred cost audits are used based on an NSF risk assessment with the interval between audits on construction awards not exceeding the three years mandated by AICA.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER WICKER TO DR. FRANCE CÓRDOVA

Question 1. Do you agree that a current threat facing the cybersecurity labor force is a lack of professors available to teach our next generation of cybersecurity professionals?

Answer. Yes, and we appreciate your leadership on this issue, including through the passage of the Cyber Scholarship Opportunities Act of 2017.

The National Science Foundation (NSF) has long been focused on the workforce needs surrounding the preparation of the computer science and STEM workforce of tomorrow. We describe some of the initiatives in the answer to Question 2 below.

Question 2. How can we increase our number of professors and educators available to train our CyberCorps students?

Answer. NSF recently funded the National Academies of Sciences, Engineering, and Medicine (NASEM) to explore the increases in enrollment in undergraduate computer science courses, and make recommendations to address how institutions can best manage high enrollments, respond to pressures and demands computer science departments are feeling in the short and long terms, and provide new opportunities to increase diversity in the discipline. The NASEM responded with the release of a Consensus Study Report titled, Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments. While the report has not been formally released, the prepublication report, which includes NASEM's findings and recommendations is already helping NSF to formulate and implement effective actions for what is indeed a pressing and important problem.

As computing has become increasingly central to addressing scientific and societal challenges, NSF has made significant investments in the computer science "pipeline" of K–12 and undergraduate students through programs such as Computer Science for All (CSforAll) and Revolutionizing engineering and computer science Departments (RED), respectively. At the undergraduate level, computer science departments are experiencing a tremendous surge of non-major students in their mid-level and advanced courses, as noted in the NASEM report. In FY2018, NSF is considering how best to support computer science departments and universities in responding to this changing landscape, perhaps by funding opportunities for restructuring departments and universities to better prepare students to employ the power of computing across the interdisciplinary and multidisciplinary collaborations of the future.

NSF also makes critical investments in support of doctoral students and early-career faculty in computer science:

- *Early-career faculty in computer science.* NSF supports early-career faculty in computer science through multiple targeted programs. For example, early-career faculty are supported through the NSF-wide Faculty Early-Career Development (CAREER) program which provides support for up to five years to pursue innovative research at the frontiers of the field as well as community service as demonstrated through scientific leadership, education, or community outreach. Additionally, since FY2015, the Computer & Information Science & Engineering (CISE) directorate has funded the CISE Research Initiation Initiative program, providing very early career faculty with the ability to undertake exploratory research, acquire preliminary data, develop new collaborations, and/or develop new approaches that may lead to improved capacity to write successful grant proposals in the future.
- *Incorporating teaching into computer science doctoral programs.* Many universities operate centers for teaching and learning that provide opportunities for graduate students to acquire expertise and experience in teaching and learning. In computer science, NSF's CISE directorate has also provided funding to mentoring programs—examples include funding a biennial "Career Mentoring Workshop" organized by the Computing Research Association (CRA), and a "Grad Cohort Workshop" organized by CRA's Committee on the Status of Women in Computing Research—both programs provide career mentoring and teaching advice to attendees.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO DR. FRANCE CÓRDOVA

Question 1. What is the status of plans to find partners to help keep aging, but still world-class facilities like Arecibo and the Green Bank Observatory in West Virginia operational? Do you have the support you need in Congress to move forward?

Answer. NSF greatly appreciates the strong support Congress continues to show for our world-class facilities. The 2012 report of the NSF Portfolio Review Committee, a commissioned subcommittee of the NSF Directorate for Mathematical and Physical Sciences Advisory Committee, was charged with recommending a balanced portfolio for NSF's Division of Astronomical Sciences. This report was meant to maximize the science recommended by "New Worlds, New Horizons in Astronomy and Astrophysics", the 2010 National Academies sixth decadal survey in astronomy and astrophysics. The recommendations were further endorsed by the 2016–2017 annual report of the NSF Astronomy and Astrophysics Advisory Committee, and the 2016 National Academies' mid-decadal report "New Worlds, New Horizons, A Midterm Assessment." As part of these recommendations NSF began the process of evaluating its facilities in line with these priorities. Regarding the Arecibo and Green Bank Observatories specifically:

- *Arecibo:* Beginning February 22, 2018, the University of Central Florida (UCF) began formal transition activities to take on the operations and management of NSF's Arecibo Observatory in Puerto Rico. With this award, UCF will fulfill NSF's preferred alternative for management and operations of the observatory. The university will take over formal management and execute a program of research and education consistent with the objectives and priorities of the scientific community. The university will provide support and technical personnel to manage the observatory, including its research and educational activities. The award duration is expected to run five years, with NSF contributions decreasing over time from the current level of approximately $8 million per year to approximately $2 million per year by the second half of FY 2022. This award ensures continued science-focused operations that maintain atmospheric, planetary and astronomical research, including radio observations of astronomical sources, planetary radar observations of solar system and near-Earth objects, and studies of Earth's atmosphere.
- *Green Bank Observatory (GBO):* On November 8, 2017, NSF published the Draft Environmental Impact Statement (DEIS) for the Green Bank Observatory (GBO) in the Federal Register. The DEIS was prepared in compliance with the National Environmental Policy Act of 1969, as amended, to evaluate the potential environmental impacts resulting from proposed operational changes due to funding constraints for the GBO. The agency-preferred alternative is Action Alternative A: Collaboration with Interested Parties for Continued Science and Education-Focused Operations with Reduced NSF funding. NSF accepted comments for 60 days following the publication of the DEIS (an additional 15 days beyond the normal 45 days were provided because of the holidays). During the comment period, NSF held a public meeting at GBO on November 30, 2017, to receive comments from interested parties and stakeholders. Following the end of the comment period on the DEIS, the agency reviews and considers the public comments and begins preparation of the Final Environmental Impact Statement (FEIS), which NSF hopes to have available in the fall of 2018. The FEIS will identify a preferred alternative. Once the document is prepared, there is a 30-day "cooling off period" before the Record of Decision (ROD) is released to the public. The purpose of the cooling off period is to allow the agency to consider its decision. NSF is actively seeking collaborators for GBO. On March 5, 2018, NSF issued a Dear Colleague Letter inviting consultations regarding future continued operations and management of Green Bank Observatory, to alert the community of the opportunity to provide expressions of interest in providing funding support and in management and operation of GBO. A Solicitation would be anticipated during FY 2018.

Question 2. The National Science Board is among the many who have noted our slumping investment in research and development while countries in southern and eastern Asia, most notably China, accelerate their efforts. The FY18 budget request proposed cutting the NSF by eleven percent. What would a cut of that magnitude mean in terms of research and grants funded by NSF?

Answer. NSF was funded at $7.5B in FY 2016 and under the FY 2017 CR. The FY 2018 request was a reduction of 11.2 percent for a budget of $6.65B. However, after the Bipartisan Budget Act of 2018 was signed into law, the Administration recommended adding back $819 million to the FY 2018 request to provide level funding with FY 2017 enacted level. The FY 2019 Budget Request for NSF is also $7.472 billion, the same as the FY 2017 Current Plan level. The FY 2019 requested level will allow NSF to invest in priority areas like Advancing NSF's Big Ideas –bold questions that will drive NSF's long-term research agenda; implementing agency reforms centered on accelerating focused, cross-disciplinary efforts around two of the NSF Big Ideas –The Future of Work at the Human-Technology Frontier and Har-

nessing the Data Revolution; and beginning construction on the Antarctic Infrastructure Modernization for Science project.

Question 3. The committee is pleased by NSF's progress in opening up new mid-scale project opportunities. As noted in your testimony, NSF received 191 responses to its RFI on mid-scale infrastructure. The committee is mindful of the tension, especially in a constrained budget environment, between funding infrastructure and research. How is NSF approaching this challenge of balancing resources? Is NSF exploring funding mechanisms other than the research directorates?

Answer. As noted, NSF received nearly 200 replies to its Request for Information on potential mid-scale research infrastructure projects in the $20 million to $100 million range. Replies were received from areas of science covered by all of NSF's seven directorates. These responses amount to a total demand of at least $10 billion for mid-scale research infrastructure in that cost range. We are currently completing analysis of the responses in order to finalize mechanisms to support mid-scale research infrastructure in the future, Based on the demand evident from the responses, NSF has added $55 million for mid-scale research infrastructure in its FY 2019 budget request. Separate tracks within the Mid-scale program will fund acquisition, design/development, and implementation. NSF will also conduct strategic discussions of the long-term development of mid-scale research infrastructure with our Advisory Committees and the National Science Board.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. CATHERINE CORTEZ MASTO TO DR. FRANCE CÓRDOVA

Science Vacancies in the Administration. The Administration's commitment to science has understandably raised concerns because of actions it has *and* has not taken. While I could give you a long list of just the policy decisions alone, I wanted to ask about vacancies and their hiring freeze policy.

Question 1. Dr. Cordova, the NSF site's own figures are that your agency "supports an average of about 200,000 various scientific personnel around the world." What are the detrimental impacts of the White House still not having nominated or filled various leadership positions within the White House Office of Science and Technology Policy (OSTP)?

Answer. NSF works closely with the White House Office of Science and Technology Policy and maintains a very strong working relationship with the staff in that office.

Question 2. What impact, if any, did the questionable hiring freeze policy the Administration has employed have on your department, and the scientific progress you're making?

Answer. NSF supports research, innovation, and discovery that provides the foundation for economic growth in this country. By advancing the frontiers of science and engineering, our Nation can develop the knowledge and cutting-edge technologies needed to address the challenges we face today and will face in the future. NSF complied with the terms of the Administration's hiring freeze, and as an already lean organization operationally, we continue to strive to fulfill our mission both through the hard work and commitment of the Foundation's excellent workforce and the effective use of innovative information technologies.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO DR. FRANCE CÓRDOVA

Question 1. I authored Section 310 of the AICA bill which focuses on how to promote more inclusive STEM education especially in rural and tribal communities. As you know that section askes NSF to award grants that focus on developing tools to create inclusive STEM education environments for underrepresented populations, particularly rural and tribal communities. I asked NSF to develop metrics to measure success and report on the progress of the program. I see that to date, that report has not been completed. Has there been interest in the grant program? Have there been grants awarded?

Answer. As required by the AICA, NSF has been providing this report as part of its annual budget submission to Congress. The first report was included in the FY 2018 budget submission, and the next was included in the FY 2019 budget request.

- FY 2018 Report: *https://www.nsf.gov/about/budget/fy2018/pdf/16*_fy2018.pdf
- FY 2019 Report: *https://www.nsf.gov/about/budget/fy2019/pdf/20*_fy2019.pdf

The Computer Science for All: Researcher Practitioner Partnerships (CSforAll RPP) program (NSF 17–525) combines professional development opportunities for teachers at all grade levels together with research studies that at the PreK–8 level will focus on how to integrate computer science and computational thinking into their classrooms; and at the high school level on how to help teachers teach rigorous computer science courses. Importantly, *all proposals must address groups underrepresented in computing,* including women, persons with disabilities, African Americans/Blacks, Hispanic Americans, American Indians, Alaska natives, Native Hawaiians, Native Pacific Islanders, and persons from economically disadvantaged backgrounds.

The CSforAll: RPP program's first deadline for proposals was February 28, 2017. NSF convened merit review panels in April 2017, and the program made its first cohort of 34 two-to four-year awards by the end of FY 2017. All awards identified at least one underrepresented or underserved group, as outlined in the table below.

Underrepresented or Underserved Group
Served by Backbone Organizations

Category	Groups Served
Rural	12
Low Socio-Economic Status	8
Disabilities	4
Pacific Islanders	1
Women/Girls	10
English Language Learners	2
African-Americans	10
Native Americans	4
Latino/a	17

NSF works to create inclusive STEM education environments for underrepresented populations through a variety of additional programs. For example, STEM + Computing Partnerships (STEM+ C) addresses the integration of computational thinking and computing activities in early childhood through high school (preK–12). The program emphasizes computing both as a STEM discipline and a discipline integral to the practice of all other STEM disciplines. In addition, STEM+C projects include strategies to address issues of underrepresentation in STEM and computing.

Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) is a comprehensive national initiative designed to enhance U.S. leadership in science, technology, engineering and mathematics (STEM) discoveries and innovations focused on NSF's commitment to diversity, inclusion, and broadening participation in these fields. NSF INCLUDES supports efforts to create networked relationships among organizations whose goals include developing talent from all sectors of society to build the STEM workforce. This initiative seeks to improve collaborative efforts aimed at enhancing the preparation, increasing the participation, and ensuring the contributions of individuals from groups that have traditionally been underrepresented and underserved in the STEM enterprise: women, persons with disabilities, African Americans/Blacks, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, Native Pacific Islanders, and persons from economically disadvantaged backgrounds. Significant advancement in the inclusion of these groups will result in a new generation of STEM talent and leadership to secure our Nation's future and long-term economic competitiveness.

Question 2. Are there other things that NSF is doing to address the under inclusion problem, particularly for rural and tribal communities?

Answer. NSF's Tribal Colleges and Universities Program (TCUP) promotes improvement and continued quality in undergraduate science, technology, engineering and mathematics (STEM) instructional and outreach programs at Tribal Colleges and Universities, Alaska Native-serving institutions and Native Hawaiian-serving institutions.

TCUP allows proposers flexibility and creativity in the design of efforts to improve undergraduate STEM education. Proposed activities should be the result of a careful analysis of institutional needs, address institutional and NSF goals, and have the potential to result in significant and sustainable improvement of STEM programs. TCUP emphasizes the expansion of course and degree offerings; development of undergraduate research opportunities, faculty skills, and STEM-education tech-

nologies; and the integration of community goals and traditional knowledge with mainstream STEM education and research. Partnerships among institutions of higher education and collaborations with K–12 schools, tribal government units or other relevant groups are encouraged.

TCUP support is available through three main foci: (1) the *Transformative Capacity Building* focus includes *Instructional Capacity Excellence in TCUP Institutions* awards, *Targeted STEM Infusion Projects,* and *Preparing for TCUP Implementation* awards; (2) the *Multiple Institution Collaborations* focus includes *Partnerships for Geoscience Education, Partnerships for Documentary Linguistics Education,* and *Pre-Engineering Education Collaboratives;* and (3) the *Individual Investigator Studies* focus offers *Small Grants for Research.* Typical project goals and approaches include course, degree, and curriculum development, reform and enhancement; faculty professional development; the integration of active learning strategies into the STEM curriculum; disciplinary and education research; community outreach and engagement; student support; internships and other educational enrichment activities; student recruitment, retention and placement; infusion of technology to enhance STEM instruction; collaborations with other educational institutions, business, or other community partners; and activities that enhance the knowledge and skills of technical support personnel.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. AMY KLOBUCHAR TO DR. FRANCE CÓRDOVA

Expanding Digital Literacy. Expanding opportunities for all students interested in STEM is a crucial part of ensuring a healthy pipeline of workers who are equipped with the skills needed for the jobs of tomorrow. One Minnesota company, Best Buy, is helping to bridge the opportunity gap by providing underserved youth access to new technology. Best Buy's Teen Tech Centers are free, year-round, after-school programs where teens can get hands-on experience exploring programing and computer science.

Question. Dr. Córdova, what is NSF doing to partner with outside groups working to expand digital literacy and computer skills?

Answer. As part of the Computer Science (CS) for All initiative, NSF is investing in activities to advance the effective teaching and learning of computer science and computational thinking in K–12 education.

NSF's efforts have been leveraged by many partnering Federal agencies and private organizations that are working to bring CS education to schools across the country. Within the Federal Government, NSF has partnered with the Office of Science and Technology Policy, the Department of Education, and the Department of Defense. NSF has also worked closely with the Corporation for National and Community Service, Code.org, the College Board, Teach for America, Project Lead The Way, the National Math and Science Initiative, and 100Kin10.

NSF has also funded a CSforAll Consortium, to provide a central resource, and to serve as a platform for connecting diverse stakeholders, providing support to new and developing initiatives, tracking and sharing progress, and communicating about the work to local and national audiences. Information on the CSforAll Consortium can be found at: *https://www.csforall.org/*

In addition, NSF's Advanced Technological Education (ATE) program focuses on the education of technicians for the high-technology fields that drive the Nation's economy. The program involves partnerships between academic institutions and industry to promote improvement in the education of science and engineering technicians at the undergraduate and secondary school levels. The vast majority of projects are situated at community colleges, giving many students underrepresented in STEM access to career opportunities.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. RICHARD BLUMENTHAL TO DR. FRANCE CÓRDOVA

Funding Cuts. Last May, President Trump released a proposed budget that would cut science programs across the Federal Government in FY 2018. Specifically, the proposal would cut funding for the National Science Foundation by $776 million, or about 11 percent. As you know, NSF provides $7.5 billion per year in funds for vital research efforts. This is about 25 percent of Federal support to academic institutions for basic research. This funding supports projects that are integral to our country's health, safety, security, and economic competitiveness. Colleges and institutions throughout Connecticut have a long history of successfully securing funds from the

National Science Foundation and putting them to work on important, innovative projects. These cuts specifically target your foundation.

Question 1. Will these cuts set your organization back and harm the scientific community?

Answer. NSF was funded at $7.5B in FY 2016 and under the FY 2017 CR. The FY 2018 request was a reduction of 11.2 percent for a budget of $6.65B. However, after the Bipartisan Budget Act of 2018 was signed into law, the Administration recommended adding back $819 million to the FY 2018 request to provide level funding with FY 2017 enacted level. The FY 2019 Budget Request for NSF is also $7.472 billion, the same as the FY 2017 Current Plan level. The FY 2019 requested level will allow NSF to invest in priority areas like Advancing NSF's Big Ideas –bold questions that will drive NSF's long-term research agenda; implementing agency reforms centered on accelerating focused, cross-disciplinary efforts around two of the NSF Big Ideas –The Future of Work at the Human-Technology Frontier and Harnessing the Data Revolution; and beginning construction on the Antarctic Infrastructure Modernization for Science project.

Question 2. Do you join me in my concern about Trump's budget cuts?

Answer. The FY 2019 Budget Request for NSF is $7.472 billion, the same as the FY 2017 Current Plan level. NSF is committed to supporting ground-breaking research, world-leading facilities, and a skilled and innovative workforce across all fields of science and engineering. NSF is vital to our Nation because we invest in the fundamental research and the talented people who make the discoveries that transform our future. Those discoveries are a primary driver of the U.S. economy, enhance our Nation's security, and give the country the competitive edge to remain a global leader. Under the President's FY 2019 budget request, NSF will continue its support for groundbreaking research in areas including computer science, biology, engineering, geoscience, mathematics, the physical sciences, and the social sciences.

Question 3. How do you believe these cuts would affect the United States' global competitiveness?

Answer. As the only Federal agency that invests in fundamental, basic research across all fields of science and engineering, NSF has spent nearly seven decades laying the foundation upon which the future is built. Basic research supported by NSF allowed for the emergence of fields of research such as data science, encryption, gene editing, nanotechnology, artificial intelligence and autonomous systems. Our support will foster new growth in these fields vital to the economy and security. NSF-supported research has added hundreds of billions of dollars to the economy and led to advances that benefit all Americans, from Doppler radar to MRI scans and the computer architecture that led to the internet. The President's FY 2019 budget request will enable us to continue that work.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. TOM UDALL TO ALL WITNESSES

Question. I am concerned about the increased political interference in scientific research by this Administration. Can each of you identify the specific actions you are taking to protect scientists, both agency scientists and grant recipient scientists?

Answer. The very first section of the American Innovation and Competitiveness Act (AICA), affirms the importance of our merit review process. Through this process, the National Science Foundation ensures that proposals submitted are reviewed in a fair, competitive, transparent, and in-depth manner. This is a non-partisan process that has stood the test of time and been emulated all over the world.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. TOM UDALL TO DR. FRANCE CÓRDOVA

Diversity in STEM. This Committee recently had a hearing on Artificial Intelligence. During the hearing, we discussed the need for diversity among the individuals creating AI software and programs.

Question 1. Dr. Córdova, your testimony highlights the effort of the NSF INCLUDES program, and underscores the importance of promoting diversity within STEM education and careers. What are other actions or initiatives you are undertaking to increase diversity within the ranks of NSF?

Answer. The NSF INCLUDES program is a comprehensive national initiative designed to enhance U.S. leadership in STEM discoveries and innovations by focusing on diversity, inclusion, and broadening participation in these fields at scale. The vi-

sion of NSF INCLUDES is to catalyze the STEM enterprise to collaborative work for inclusive change, which will result in a STEM workforce that reflects the diversity of the Nation.

To achieve national impact, NSF INCLUDES shifts away from single-project efforts, and recognizes that complex problems are best addressed through collaborative approaches. NSF INCLUDES has already funded nearly 70 Design and Development Launch Pilotss across the country that range across the PreK-graduate spectrum, involve community partners, and will provide new bold models for broadening participation.

NSF has taken a variety of additional approaches to broaden participation across its many programs. NSF's broadening participation investments range from capacity building, research centers, partnerships, and alliances to the use of co-funding or supplements to existing awards in the core research programs.

NSF's merit review criteria of intellectual merit and broader impacts incorporates consideration of broadening participation and the science of broadening participation. Furthermore, some program announcements and solicitations specifically target or emphasize opportunities to broaden participation within the STEM enterprise.

NSF's broadening participation portfolio, presented below, is divided into three categories: (1) programs that are primarily focused on broadening participation, (2) programs that have broadening participation as one of several emphases, and (3) Dear Colleague Letters expressing interest in specific aspects of broadening participation.

Focused Programs		
Programs with an explicit broadening participation program goal. The majority of each award's budget goes to broadening participation activities, and could involve research on the topic.		
PROGRAM NAME	**Publication No.**	**Directorate**
Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES)	*17–522*	All
ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers	*16–594*	All
Broadening Participation in Engineering	*16–7680*	ENG
Centers of Research Excellence in Science and Technology (CREST) and HBCU Research Infrastructure for Science and Engineering (RISE)	*16–525*	EHR, ENG
Disability and Rehabilitation Engineering	*17–5342*	ENG
EPSCoR Research Infrastructure Improvement Program Track-3: Building Diverse Communities	*13–553*	OIA
Experimental Program to Stimulate Competitive Research: Workshop Opportunities (EPS–WO)	*12–588*	All
Historically Black Colleges and Universities Undergraduate Program	*16–538*	EHR
Louis Stokes Alliances for Minority Participation	*15–594*	EHR
NSF Scholarships in Science, Technology, Engineering, and Mathematics	*17–527*	EHR
Partnerships for Research and Education in Materials	*14–606*	MPS
Partnerships in Astronomy & Astrophysics Research and Education	*13–566*	MPS
Postdoctoral Research Fellowships in Biology	*15–501*	BIO
Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM)	*16–534*	EHR
SBE Postdoctoral Research Fellowships	*16–590*	SBE
Tribal Colleges and Universities Program	*16–531*	EHR, ENG, GEO, SBE

Emphasis Programs		
Programs with an additional review criterion on broadening participation. All awards have broadening participation components (e.g., a project diversity plan) along with components not necessarily related to broadening participation.		
PROGRAM NAME	**Publication No.**	**Directorate**
Advancing Informal STEM Learning	*15–593*	EHR
Computer Science for All	*17–525*	CISE, EHR
EMERGING FRONTIERS IN RESEARCH AND INNOVATION 2017	*16–612*	CISE, ENG, MPS
Gen-3 Engineering Research Centers	*15–589*	ENG
Graduate Research Fellowship Program	*16–588*	All
Innovative Technology Experiences for Students and Teachers	*15–599*	EHR
International Research Experiences for Students	*12–551*	All
Major Research Instrumentation Program:	*15–504*	All
Materials Research Science and Engineering Centers	*16–545*	MPS
Research Experiences for Undergraduates	*13–542*	All
Science and Technology Centers: Integrative Partnerships	*14–600*	All
Science of Learning	*16–004Y*	SBE
Dear Colleague Letters		
PROGRAM NAME	**Publication No.**	**Directorate**
Historically Black Colleges and Universities Excellence in Research Program	*DCL 17–138*	BIO, CISE, EHR, ENG, GEO, MPS, SBE, OIA
Life STEM	*DCL 16–143*	EHR
Strengthening Transfer of Students from Two-year Hispanic-serving Institutions to Four-year STEM Programs	*DCL 16–094*	EHR
Strengthening Research Capacity at Historically Black Colleges and Universities	*DCL 16–080*	All
Fundamental Research to Improve STEM Teaching and Learning, and Workforce Development for Persons with Disabilities within the EHR Core Research Program	*DCL 16–064*	EHR
Stimulating Research on Effective Strategies in Undergraduate STEM Education at Two-Year Hispanic Serving Institutions	*DCL 15–078*	All
Stimulating Research Related to the Science of Broadening Participation	*DCL 15–066*	SBE, EHR
Effort to Broaden the Participation of Students in Two-Year Hispanic Serving Institutions in Science, Technology, Education, and Mathematics (STEM)	*DCL 15–063*	All
Veterans Research Supplement Program (VRS)	*DCL 14–124*	ENG
Research Assistantships for High School Students (RAHSS): Supplemental Funding to Current SBIR/STTR Phase II Awards to Broaden Participation in Science and Engineering	*DCL 14–073*	ENG
Career-Life Balance (CLB) Supplemental Funding Opportunities in Support of Postdoctoral Investigators Funded by NSF Awards	*DCL 13–109*	All
Career-Life Balance (CLB)—Graduate Research Fellowship Program (GRFP) Supplemental Funding Requests	*DCL 13–099*	All
Balancing the Scale: NSF's Career-Life Balance (CLB) Initiative	*N/A*	All

Career-Life Balance (CLB) Initiative	*DCL 13–075*	All
MPS Alliances for Graduate Education and the Professoriate—Graduate Research Supplements	*DCL 13–071*	MPS
Announcement of Efforts to Increase Hispanic Participation in STEM Fields	*DCL 12–081*	BIO, CISE, EHR, ENG
Research Assistantships for High School Students RAHSS)—BIO supplements	*DCL 12–078*	BIO
Research Experience for Teachers (RET): Funding Opportunity in the Biological Sciences	*DCL 12–075*	BIO
Engineering Research Experiences for Veterans	*DCL 12–074*	ENG
Research Experiences for Veterans/Teachers	*DCL 12–073*	ENG
Supplemental Opportunity for Small Business Innovation Research and Small Business Innovation Research/Small Business Technology Transfer for CREST/HBCU–RISE Collaborations	*DCL 12–069*	ENG, EHR
SBIR/STTR Supplemental Funding for Community College Research Teams	*DCL 08–029*	ENG, EHR
Research Assistantships for High School Students (RAHSS)—SBIR/STTR Phase II Supplements	*DCL 06–003*	ENG

NSF has also released a solicitation entitled "Computer Science for All: Researcher Practitioner Partnerships" (CS for All: RPP) to provide high school teachers with what they need to teach rigorous computer science courses, and K–8 teachers with needed instructional materials and preparation to integrate computer science and computational thinking into their courses. All proposals must address groups underrepresented in computing, including women, persons with disabilities, African Americans/Blacks, Hispanic Americans, American Indians, Alaska natives, Native Hawaiians, Native Pacific Islanders, and persons from economically disadvantaged backgrounds.

Question 2. NSF's Innovation Corps program was expanded to address some of the technology transfer challenges. Arrowhead Center at New Mexico State University and Innovation Academy at the University of New Mexico were both awarded grants from this program and have helped entrepreneurs commercialize their innovations. How can we build on the success of the I-Corps program and continue to help the research community with business development and entrepreneurship?

Answer. Since the start of the I-Corps™ Program in 2011, NSF has funded 8 I-Corps™ Nodes, 87 I-Corps™ Sites, and more than 1,100 I-Corps™ Teams. The I-Corps™ Teams have come from 230 universities and have created 440 startups to date with the startups located in 46 states plus Puerto Rico.

The Nodes and Sites form a National Innovation Network containing more than 100 universities that are working collaboratively to build, utilize, sustain, and expand the national innovation ecosystem.

To address Section 601 of the AICA, NSF currently has two pilot programs underway. The first pilot is focused on the expansion of I-Corps, and the second pilot is focused on developing follow-on grants.

- Expansion of I-Corps: NSF is funding eight I-Corps™ sites to increase participation and promote inclusion of underrepresented populations in entrepreneurship. These sites will pilot novel approaches and partnerships to engage differently-abled individuals, first-generation college students, racial and ethnic minorities and women, as well as Minority-Serving Institutions.
- Follow-on grants: Since 2017 the National Science Foundation awarded seven Innovation Corps (I-Corps™) Nodes with $350,000 to $400,000 each in supplemental funding to launch pilot Phase Zero I-Corps™ programs. Each Node will use the funding to support up to ten teams through the canonical I-Corps™ training program, recruit new teams, create additional entrepreneurship trainings, and help startups prepare Small Business Innovation Research (SBIR) proposals. Unlike the typical I-Corps™ program, which requires a recent NSF lineage and an academic team member, the technology from Phase Zero I-Corps™ teams may come from any source, and Phase Zero team members do not need a university affiliation. These Phase Zero grants help expand participation in the I-Corps™ Program and broaden the National Innovation Network.

NSF is funding eight I-Corps™ sites to increase participation and promote inclusion of underrepresented populations in entrepreneurship. These sites will pilot novel approaches and partnerships to engage differently-abled individuals, first-generation college students, racial and ethnic minorities and women, as well as Minority-Serving Institutions.

Question 3. The NSF has a significant role in aiding technology transfer from government sources to the private sector. This is an important program for the National Laboratories in New Mexico. Sometimes, Federal agencies may not be as successful with technology transfer. Can you speak of ways that NSF can partner with other agencies or programs to increase their success?

Answer. Existing NSF innovation research alliances include consortia such as Engineering Research Centers (ERC), Industry University Cooperative Research Centers (IUCRC), PFI, Science and Technology Centers (STC), and Materials Research Science and Engineering Centers (MRSEC). They are also exemplified by the Grant Opportunities for Academic Liaison with Industry (GOALI) program, and the SBIR/STTR program. Many of these programs have been part of the NSF investment portfolio for decades. For example, SBIR is a government-wide program initiated at the NSF in 1976. These programs complement our other significant investments in fundamental scientific and engineering research by offering multiple pathways for moving discovery to innovative technologies.

NSF I-Corps™ has 9 MOUs with other Federal Agencies. I-Corps™ programs have been adopted and adapted in partnerships with a growing number of Federal agencies, including the National Institutes of Health (NIH), Department of Energy (DOE), Department of Defense (DOD), National Security Agency (NSA), United States Department of Agriculture (USDA), Department of Homeland Security (DHS), Advanced Research Projects Agency—Energy (ARPA–E), National Aeronautics and Space Administration (NASA), and the Small Business Administration (SBA). A MOU between NSF and the Department of Energy established *Energy I-Corps,* a program specifically created to accelerate the commercialization of technologies from DOE national laboratories.

Question 4. The American Innovation and Competitiveness Act (AICA) included provisions to provide grants to Hispanic-Serving institutions, such as the University of New Mexico. Can you update the Committee on the implementation of expanding grants to these institutions? And, what else is NSF doing in its' commitment to diversity in STEM fields?

Answer. To enhance the quality of undergraduate STEM education at Hispanic-serving institutions (HSIs), NSF has established the Improving Undergraduate STEM Education: Hispanic-Serving Institutions (HSI Program) (NSF 18–524).

In designing the HSI Program, NSF sought community input in a variety of ways that included releasing a Dear Colleague Letter, awarding conference grants to seek stakeholder input, establishing and holding a meeting of the Building Capacity at Hispanic-Serving Institutions Subcommittee (HSI Subcommittee) of the Education and Human Resources Advisory Committee, and conducting three virtual listening sessions that invited commentary from members of the HSI community.

NSF released a program solicitation (NSF 18–524) to guide the initial focus of the HSI Program. NSF will continue to gather community input from funded HSI conferences to inform future components of, or modifications to, the HSI Program.

NSF issued the first HSI Program awards for seven conferences in FY 2018. The awarded conference projects, their principal investigators and their institutions are listed below:

- *PROMISE: Providing Resources and Opportunities for Minorities in STEM Education,* Nora Garza, Laredo Community College.
- *Catalyzing Progress in Undergraduate STEM Education with Insights from Midwestern HSIs,* Laura Sanders, Northeastern Illinois University.
- *Stakeholder Perspectives on Challenges and Opportunities for Improving Undergraduate STEM Education at HSIs,* William Kitch, Texas A&M Engineering Experiment Station.
- *Dissecting the STEM Education Ecosystem in Hispanic Serving Institutions (HSIs): Regional Insights from Southern California,* Yusheng Liu, California State University, Fullerton.
- *Co-Designing an Engineering Education Research Agenda,* Meagan Kendall, University of Texas at El Paso; Alexandra Strong, *Franklin W. Olin College;* Ines Basalo, *University of Miami.*
- *Urbano-Increasing Access and Success in Urban Stem Programs,* Jorge Gonzalez, The City College of New York.

- *Accelerating the Impact of HSI STEM Education and Research on Innovation Ecosystems,* Rodolfo J. Romañach, University of Puerto Rico Mayaguez.

In FY 2017, NSF made four awards for conferences aimed at informing the HSI program's design. Those four awards, their principal investigators and their institutions are listed below:

- *Hispanic-focused STEM Ideas for Inspiration and Innovation,* Meline Kevorkian, Nova Southeastern University.
- *Transforming STEM Education in Hispanic Serving Institutions—Regional Insights from the Southwest,* Guadalupe Lozano, University of Arizona.
- *Understanding and Improving Readiness and Student Transitions,* Andrew Hamilton, University of Houston.
- *Pathways for Hispanic Students in STEM,* Michael Dennin, University of California-Irvine.

The HSI program will accept proposals in two tracks: (1) Building Capacity and (2) HSIs New to NSF. The Building Capacity track funds projects from $500K to $1.5M for up to 5 years and is open to all eligible institutions. The HSIs New to NSF track funds projects up to $250K for up to 3 years and is open only to eligible institutions that have never received NSF funding, or that have not received NSF funding in the five years preceding the proposal deadline.

The HSI Program will also fund one Resource Hub project up to $3M for up to five years. The Resource Hub will support the needs of HSIs with little or no prior NSF funding, such as assistance with proposal writing and financial compliance. In addition, the Resource Hub will facilitate networking and professional development that build and strengthen collaborations among HSIs.

Question 5. There was a provision that I backed that supported the need to coordinate research and efforts on sustainable chemistry. Has NSF undertaken any activity to further the mission of the Sustainable Chemistry Research Program that had been originally authorized in the National Science Foundation Authorization Act of 2010?

Answer. NSF continues to broadly define sustainable chemistry as efforts that seek to improve the efficiency with which natural resources are used to meet human needs for chemical products and services. Sustainable chemistry encompasses the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes; stimulates innovation across all sectors to design and discover new chemicals, production processes, and product stewardship practices; and, increases performance and value while meeting the goals of protecting and enhancing human health and the environment.

In response to the enactment of the America COMPETES Authorization Act of 2010, NSF established the Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES) to advance science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human well-being. As part of the SEES portfolio of activities, the Sustainable Chemistry, Engineering, and Materials (SusChEM) Initiative began in 2013. The SusChEM initiative addressed the interrelated challenges of sustainable supply, engineering, production, and use of chemicals and materials. Since FY 2013, the SusChEM program has funded over 349 grants totaling over $134 million in the Divisions of Chemistry (MPS), Materials Research (MPS), Earth Sciences (GEO), Civil, Mechanical and Manufacturing Innovation (ENG), and Chemical, Bioengineering, Environmental and Transport Systems (ENG). Each SusChEM-participating division continues to mainstream sustainable chemistry, materials and engineering into their core research programs.

The NSF Division of Chemistry has funded a total of ten Centers for Chemical Innovation (CCIs) since the inception of the CCI program. These Phase II centers are major investments of up to $4 million per year for up to 10 years, supporting large teams of researchers working on frontier questions. While sustainability in not a required topic for the CCIs, five of these ten total centers have focused on challenges related to sustainable chemistry including, for example, the Center for Selective C–H Functionalization and the Center for Sustainable Polymers. The collaborative and interdisciplinary environment within the CCIs provides valuable training for developing scientists in SusChEM fields.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. MAGGIE HASSAN TO DR. FRANCE CÓRDOVA

The Opioid Crisis. My home state of New Hampshire is being heavily impacted by the fentanyl, heroin, and opioid crisis. We truly need an all-hands-on-deck approach to tackle this epidemic.

Question. What kind of work is the National Science Foundation doing that might help address the opioid epidemic?

Answer. In October, the Administration officially declared the opioid crisis a national public health emergency and signed a Presidential Memorandum outlining the efforts the Federal Government would undertake to address the crisis.

As part of that important work, OSTP initiated an effort to coordinate health-focused Federal Government research and development activities related to the opioid crisis. NSF has been included in this effort, which will connect R&D efforts across the Executive Branch and link them with private sector and intergovernmental capabilities and needs.

NSF has a long history of supporting interdisciplinary basic research that spans Biological Sciences, Social, Behavioral and Economic Sciences, Mathematical and Physical Sciences, Engineering, Computer Science, and Education. So, the Foundation is in the excellent position of being able to leverage this culture of convergence and join our colleagues at mission-driven agencies to contribute to Combating the Opioid Crisis.

We are living in a time of remarkable advances in a range of powerful technologies applied to measure, interrogate, and repair brain function and NSF has supported many critical studies. Advances have resulted in quantitative measurements of protein functions and neural signaling, experience-dependent and epigenetic regulation of cellular functions, and neural circuits—to name just a few examples. New empirical methods and new datasets used by labor and health economists could be used to assess long-term developmental outcomes. And studies of both legal and illegal markets for opioids will help us understand how various policy alternatives can restrict access to illicit drugs. Quantitative-based analysis of these data is becoming increasingly important to understand the causes, pathways, diagnosis, prognosis, and treatment of addiction.

Biologists, psychologists, and clinicians commonly lack the extensive skills in math, physics, computer science, and chemistry that are required for the sophisticated levels of analysis that are needed to extract useful information from these large datasets. So, NSF programs such as Integrative Approaches to Neural and Cognitive Systems and Next Generation Networks for Neuroscience bring together mathematicians, physicists, computer scientists, and engineers with strong backgrounds in biological research with psychologists and neuroscientists—groups of scientists whose research fields do not traditionally intersect. The goal of these programs is to catalyze understanding of the brain at the convergence of quantitative, biological, and behavioral research.

These types of activities are also strengthened by inter-agency partnerships. For example, in partnership with the NIH and several international funding agencies, multiple NSF Directorates support collaborative research. NSF's long-standing support of chemistry, bioengineering, nanotechnology, microfabrication, and materials research pave the way for the development of designer drugs that can target pain receptors without engaging the signaling pathways that result in the development of addiction.

These existing NSF activities serve well to help combat the opioid crisis through: [1] catalyzing new scientific breakthroughs, [2] unleashing the power of data, and [3] accelerating the delivery of new therapeutics to patients.

NSF's mission is to be pioneering and exploratory. Unpacking the complexity of the opioid crisis will require convergence of research across behavioral sciences, social sciences, biology, computer science, mathematics, the physical sciences, and engineering. NSF is uniquely positioned to support cutting edge research in this culture of convergence.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO DR. WALTER COPAN

Question 1. In 2002, Congress passed the Help America Vote Act, partially in response to issues in my state during the 2000 presidential election. Under that act, NIST is charged with conducting research to ensure security in voting systems. What are the biggest threats to the security of our voting system? What protocols should be improved or implemented in voting systems?

Answer. To prevent large scale electronic attacks on the Nation's voting systems and to prevent errors which may be due to aging voting equipment and infrastructure, NIST looks deeply at technical issues and vulnerabilities, risk profiles, and the potential impacts on the integrity and performance of voting systems and their associated processes. In voting systems there are many potential threat vectors, vulnerabilities, and associated impacts that vary from state to state based on technologies used, architectures, policies, and other requirements. Ensuring that the entities that run elections can understand these risks and make informed risk-based decisions with the resources they have can help with this wide assortment of issues. NIST helped develop the Voluntary Voting System Guidelines (VVSG), which are a set of requirements that voting system hardware and software must meet to receive an Election Assistance Commission (EAC) certification, as one tool that states can use to help manage their risks. The most recent draft of these standards, VVSG 2.0, was proposed to the EAC by the Technical Guidelines Development Committee (TGDC) on September 12, 2017. States may also tailor the voluntary NIST Framework for Improving Critical Infrastructure Cybersecurity (Cybersecurity Framework) to better understand, manage, and reduce cybersecurity risk in the context of voting system processes.

Question 2. NIST's talented workforce is a key asset for the agency. What tools does NIST have to support and retain their research staff?

Answer. NIST is committed to furthering the Administration's science and technology efforts to advance technological development and conduct research and development to ensure national security, grow the economy, and create well-paying jobs to improve the lives of all Americans. NIST's scientific and technical workforce is a critical tool in accomplishing these goals. NIST uses various tools to support, maintain, and recruit workforce talent, including providing an environment conducive to scientific innovation among staff, recognizing staff achievements, offering promotion and leadership opportunities and developmental assignment opportunities, and using authorized competitive compensation systems and retention allowances.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO DR. WALTER COPAN

Voting Security. As the Ranking Member on the Rules Committee, I introduced the Secure Elections Act with Senators Lankford, Harris and Graham, to upgrade our election equipment and protect against cyber-attacks. The Department of Homeland Security recently confirmed that hackers targeted 21 states' election systems in the run-up to the 2016 election. As we prepare for 2018 and beyond, we must ensure that our election systems are secure. The National Institute of Standards and Technology (NIST), worked with the Election Assistance Commission (EAC) to develop voting system guidelines and the American Innovation and Competitiveness Act authorized research to develop standards for voting security.

Question 1. You have worked closely with the EAC on cybersecurity, do you agree that states need more information and resources when it comes to updating our election equipment and protecting against future cyberattacks?

Answer. Each state has its own set of voting concerns based on choices of technologies and architectures, implemented policies, and the resources available. While additional cybersecurity guidance to the states may be useful, it is important that each election jurisdiction be allowed and encouraged to fit the guidance to its own local needs. The Voluntary Voting System Guidelines (VVSG) standard represents an important toolkit that NIST has made available to states via the Election Assistance Commission (EAC) to assist each state manage its cybersecurity risk. In addition, the EAC, the Department of Homeland Security (DHS), non-government organizations, and others are working to provide further election assistance.

Question 2. What steps is NIST taking to help state and local governments improve their cybersecurity in advance of the elections?

Answer. Strengthening cybersecurity is a top priority for the Administration and the Department of Commerce. As the lead agency for cybersecurity in the Department, NIST is actively working to provide industry, government, and the public with the tools and best practices to strengthen cybersecurity capabilities. With respect to cybersecurity around voting, NIST chairs and manages the Technical Guidelines Development Committee (TGDC) as part of its voting systems responsibilities. In September 2017, the TGDC proposed to the EAC the most recent iteration of the Voluntary Voting System Guidelines (VVSG) standard, which is a set of requirements that voting system hardware and software must meet to receive an EAC certification. VVSG 2.0 consists of a high-level set of principles accompanied

by technical requirements for how systems can meet the new guidelines. To obtain feedback for the development of the VVSG on a continuous basis, NIST leads a set of public working groups. One of the technical groups focuses on voting system security. NIST security research is encapsulated in the principles, guidelines, and requirements that are discussed and revised through bi-weekly teleconferences with the cybersecurity working group, which consists of 121 experts across the Nation. NIST also works to accredit independent laboratories that will validate voting systems to ensure that the voting systems comply with evolving guidelines and requirements.

NIST participates in several efforts led by the EAC, DHS, and non-government entities, providing technical advice on voting system security, including the Election Infrastructure Subsector (EIS) Government Coordinating Council (GCC). The EIS GCC enables the Federal Government to share information and collaborate with state, local and tribal governments on best practices to mitigate and counter threats to election infrastructure.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. RICHARD BLUMENTHAL TO DR. WALTER COPAN

Staffing Vacancies. Over a year after President Trump took office, the ranks of his government are still lacking in science and technology experts. As I understand, the President still has no top science advisor. Nor has he tapped a chief technology officer. In some cases, Trump is relying on holdovers from the administrations of his predecessors. In others, the president left key jobs unfilled. When President Trump has submitted nominees to fill some of these positions, they have often been highly unqualified or riddled with deep conflicts of interest—making it impossible for the candidates to receive the support needed to be confirmed.

Question 1. Are you concerned by the fact that many of the top science and technology posts in the Federal Government are still lacking leaders and in many cases nominees?

Answer. No. Since the President's inauguration, the Office of Science and Technology Policy has built a team of over 50 staff members to advise the President and advance his science and technology agenda. Additionally, on August 1, 2018, the President nominated the University of Oklahoma Vice President Kelvin Droegemeier to be the Director of the Office of Science and Technology Policy. The Senate Committee on Commerce, Science, and Transportation held the confirmation for Dr. Droegemeier on August 23, 2018. Collectively, the OSTP staff is working on a robust agenda that touches a wide range of issues including advanced manufacturing, artificial intelligence, autonomous vehicles, biotechnology, quantum information science, cybersecurity, and other important areas. As NIST Director and Under Secretary of Commerce for Standards and Technology, I also provide leadership in matters of science and technology, as do many other qualified senior officials in numerous government agencies.

Question 2. How do these vacancies harm the scientific community?

Answer. These vacancies do not harm the scientific community. The Trump Administration is committed to advancing technological development and conducting research and development to ensure national security, grow the economy, create well-paying jobs, and improve the lives of Americans across this great nation. The Administration has not experienced any trouble obtaining advice and input from the scientific community as it develops its agenda. While the Administration is working to identify qualified individuals fill vacant positions, experienced Federal staff are discharging many of the functions of these posts, consistent with the Administration's priorities and plans.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. TOM UDALL TO ALL WITNESSES

Question. I am concerned about the increased political interference in scientific research by this Administration. Can each of you identify the specific actions you are taking to protect scientists, both agency scientists and grant recipient scientists?

Answer. NIST scientists are empowered to present and speak about their research. The December 16, 2011, Department of Commerce Memorandum on Scientific Integrity explicitly commits to the protection of scientific and technical findings from suppression or alteration by any official. This policy is applied to all research conducted at NIST, as well as to research supported by NIST, including all NIST contracts, grants, and cooperative agreements.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. TOM UDALL TO DR. WALTER COPAN

Question 1. Dr. Copan, you have stated that technology transfer is a top priority for NIST. What do you think are the challenges of technology transfer? What have you done at NIST to address those challenges and improve technology transfer from federally funded research to the private sector?

Answer. Under my direction, NIST will advance the President's Management Agenda to modernize government for the 21st century through the associated Lab-to-Market Cross Agency Priority Goal in coordination with the White House's OSTP through our Return on Investment (ROI) Initiative. NIST has issued a Request for Information (RFI) in the Federal Register, to engage broadly with private-and public-sector stakeholders in a comprehensive assessment of our technology transfer landscape. As part of this ROI Initiative, NIST will hold four public meetings across the country in San Jose, California; Denver, Colorado; Chicago, Illinois; and at NIST's headquarters in Gaithersburg, Maryland. The intent of this initiative is to conduct a comprehensive assessment of the Federal technology transfer system that will identify opportunities to improve Federal technology transfer efforts, policies, and practices. The goal of this effort is to, where appropriate, streamline and accelerate transfer of technology from Federal R&D investments to attract greater private-sector investment for innovative products, processes, and services, as well as new businesses and industries that will create jobs, grow the economy, and enhance national security.

Question 2. Dr. Copan, AICA authorizes NIST to provide financial and logistical support for research fellowships for undergraduate, graduate and post-graduate students. Can you tell me how investing in STEM research and education is essential to America's economic and global competitiveness, prosperity and quality of life? Are there specific examples of research projects that highlight the importance of this investment?

Answer. A robust pipeline of future scientists, engineers, and technologists must be supported to assure U.S. competitiveness for the coming years and generations. The desired long-term impact is a healthy future economy that is driven by a strong science and technology sector being supplied by talented scientists, engineers, and technologists, including those with highly developed measurement science skills.

To help expand the Nation's cumulative talent in measurement science, NIST has established a number of programs to support undergraduate, graduate, and post-graduate students including the NIST Postdoctoral Research Associateships Program, Graduate Student Measurement Science and Engineering Fellowship, Professional Research Experience Program, Summer Undergraduate Research Fellowship Program, and Summer Institute for Middle School Science Teachers.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. CATHERINE CORTEZ MASTO TO DR. WALTER COPAN

Transportation Innovation and Cybersecurity. Dr. Copan, during your confirmation process I noted my leadership on establishing more SMART communities, and NIST's role in cybersecurity in this area, in your nomination hearing questions for the record. As well, the Senate Commerce, Science and Transportation Committee has been very active on working to safely advance autonomous vehicles. In your response, you said that you looked "forward to being more fully briefed on this (my) legislation" and on the status of the NIST work in relation to future transportation technologies.

Question 1. Can you tell me what you've learned in relation to cybersecurity and the future of transportation?

Answer. Over the past five years, NIST has increased its involvement with the transportation sector in the area of cybersecurity. NIST leadership in cybersecurity, the security and interoperability of the Internet of Things, and programs on artificial intelligence and machine learning supports a broad portfolio of NIST work related to measurements, standards and enabling technologies for autonomous ground-based, airborne and seaborne vehicle systems.

The transportation sector has seen a rising awareness of cybersecurity risks to both installed infrastructure and future products. NIST has seen increased concern in the vehicle, aeronautics and railroad sectors, as well as increased reporting of discovered cybersecurity vulnerabilities by independent researchers.

Specific NIST engagements include:

1. A joint project at National Cybersecurity Center of Excellence (NCCoE) with the federally funded research and development Volpe Center and U.S. Depart-

ment of Transportation (DOT), examining cybersecurity and privacy issues in connected transportation;

2. A project with DOT at NIST's NCCoE that is applying both the NIST Framework for Improving Critical Infrastructure Cybersecurity and the NIST Privacy Framework to the data-sharing aspect of the Columbus Smart City project;
3. Participation on various committees at the Society of Automobile Engineers (SAE), including work on the cybersecurity issues related to the on-board diagnostic 2 Port;
4. Participation in the joint SAE–ISO working group that is developing the first international standard on cybersecurity management in the development of vehicles;
5. Expert review and comments to DOT and vehicle industry stakeholders on the proposed V2V communications structure; and
6. Consultation by NIST experts with the Automotive Information Sharing and Analysis Center on that organization's cybersecurity best practices guide.

Question 2. Also, is your updated cyber framework useful in seeing into the future and helping to protect these emerging technologies?

Answer. Yes. Version 1.1 of the Framework for Improving Critical Infrastructure Cybersecurity (the NIST Cybersecurity Framework), released in April 2018, provides a way to understand emerging technologies and manage their associated cybersecurity risk. The NIST Cybersecurity Framework prompts us to ask critical questions about a given technology, such as:

- How will this emerging technology achieve all of the cybersecurity outcomes defined in the Framework?
- Are there any outcomes in the Framework that are difficult or impossible to achieve with the emerging technology?
- Can we make provision for those cybersecurity outcomes that are difficult to achieve by helping to identify compensating capabilities in the Framework to the achieve those outcomes?
- Are there any additional security capabilities enabled by the emerging technology that should be added to the Framework to enhance the Framework's comprehensiveness?

The Framework also supports organizations in answering important implementation questions about a given emerging technology such as:

- Will implementing the technology introduce untenable risk to my organization?
- If not, what do I need to do to ensure secure implementation and on-going risk management of this new technology?

MEP Program Support. Dr. Copan, as part of your confirmation I asked you about whether manufacturers and Nevadans could count on the Commerce Department and NIST's continued commitment to the Manufacturing Extension Partnership. You provided me a response essentially about how the FY18 budget prioritized the military, national security and cuts in other areas were needed to "keep the Nation on a responsible fiscal path." In addition, you underscored you would "develop a more complete understanding of the status of the MEP program and to implement the planned transition to non-federal funding."

Question 3. Is that your actual opinion of what needs to happen with regards to cuts to MEP?

Answer. The Administration and I continue to believe that to keep the Nation on a responsible fiscal path, it is necessary to make tough choices. As you know, Congress appropriated $140 million for the Manufacturing Extension Partnership Program (MEP) for FY 2018 and I will work to ensure that each dollar spent maximizes the return on investment to American taxpayers. The Administration's proposed elimination of Federal funding support for the MEP Program will not necessarily destroy the ability of the MEP Program to accomplish its mission. The MEP Program requires each local independent center to provide one dollar in non-federal funds to match each Federal dollar it receives. The Administration believes that local MEP Centers could continue to serve manufacturers without Federal support and that these centers would transition to entirely non-federal revenue sources.

Question 4. Does that mean you don't see any value in continuing to ensure there is a Federal funding role, including in the benefit of our Nation's security, for the important and valuable role of the MEP program from my Nevada small and medium sized businesses?

Answer. See response to prior question.

Science Vacancies in the Administration. The Administration's commitment to science has understandably raised concerns because of actions it has and has not taken. While I could give you a long list of just the policy decisions alone, I wanted to ask about vacancies and their hiring freeze policy.

Question 5. What are the detrimental impacts of the White House still not having nominated or filled various leadership positions within the White House Office of Science and Technology Policy (OSTP)?

Answer. Since the President's inauguration the Office of Science and Technology Policy has built a team of over 50 staff members to advise the President and advance his science and technology agenda. That agenda touches a wide range of issues including advanced manufacturing, artificial intelligence, autonomous vehicles, biotechnology, quantum information science, cybersecurity, and other important areas. The Administration has not experienced any trouble obtaining advice and input from the scientific community as it develops its agenda. As NIST Director and Under Secretary of Commerce for Standards and Technology, I also provide leadership in matters of science and technology, as do many other qualified senior officials in numerous government agencies. While the Administration is working to identify qualified individuals fill vacant positions, experienced Federal staff are discharging many of the functions of these posts, consistent with the Administration's priorities and plans.

Question 6. What impact, if any, did the questionable hiring freeze policy the Administration has employed have on your department, and the scientific progress you're making?

Answer. NIST did not experience any impacts and is presently hiring personnel as needed. NIST continues to make outstanding scientific progress in all areas of measurement science.

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