AN OVERVIEW OF THE BUDGET PROPOSALS FOR THE NATIONAL SCIENCE FOUNDATION AND NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY FOR FISCAL YEAR 2016

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH & TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

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February 26, 2015

AN OVERVIEW OF THE BUDGET PROPOSALS FOR THE NATIONAL SCIENCE FOUNDATION AND NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY FOR FISCAL YEAR 2016

THURSDAY, FEBRUARY 26, 2015

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

The Subcommittee met, pursuant to call, at 11:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Barbara Comstock [Chairwoman of the Subcommittee] presiding.

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RANKING MEMBER

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Subcommittee on Research and Technology

An Overview of the Budget Proposals for the National Science Foundation and National Institute of Standards and Technology for Fiscal Year 2016

Thursday, February 26, 2015
10:00 a.m. to 12:00 a.m.
2318 Rayburn House Office Building

Witnesses

The Honorable France Córdova, *Director, National Science Foundation*

The Honorable Daniel Arvizu, *Chairman, National Science Board*

Dr. Willie E. May, *Acting Director, National Institute of Standards and Technology*

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

HEARING CHARTER

An Overview of the Fiscal Year 2016 Budget Proposals for the National Science Foundation and National Institute of Standards and Technology for Fiscal Year 2016

Thursday, February 26, 2015
10:00 a.m. - 12:00 p.m.
2318 Rayburn House Office Building

1. Purpose

On Thursday, February 26, 2015, the Subcommittee on Research and Technology will review the Administration's fiscal year 2016 (FY16) budget request for the National Science Foundation and National Institute of Standards and Technology.

2. Witnesses

The Honorable France Córdova, Director, National Science Foundation

The Honorable Dan Arvizu, Chairman, National Science Board

Dr. Willie E. May, Acting Director, National Institute of Standards and Technology

3. Hearing Overview

The National Science Foundation (NSF) is an independent federal agency established in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes".[1] This hearing will examine the Foundation's funding priorities for FY16. The NSF budget request for FY16 is $7.72 billion, a 5.2 percent increase over the 2015 enacted level of $7.34 billion. NSF is the funding source for over 24 percent of all federally-supported basic research conducted at approximately 2,000 American colleges, universities, and other research institutions.[2]

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

[1] https://www.nsf.gov/about/history/legislation.pdf

[2] http://www.nsf.gov/news/news_summ.jsp?cntn_id=100595

by the private sector. This hearing will also examine NIST's funding priorities for FY16. The President's budget request for the National Institute of Standards and Technology (NIST) is $1.12 billion, an increase of $255.8 million (29.6%) over FY15.

National Science Foundation (NSF) Overview

The National Science Foundation (NSF) is the primary source of federal funding for non-medical basic research. The NSF is the major source of federal funding for many scientific fields like mathematics, computer science, and the social sciences. It supports the fundamental research that ultimately serve as the foundation for progress in nationally significant areas such as national security, technology-driven economic growth, energy independence, health care, nanotechnology, and networking and information technology.

Through over 11,000 competitive awards per year, NSF supports an average of 320,900 scientists, engineers, educators and students at universities, laboratories and field sites all over the U.S. and throughout the world. These grants fund specific research proposals that have been judged the most promising by NSF's merit-review system. Approximately, only one out of five proposals submitted to NSF are awarded funding.[3]

National Science Foundation (NSF) Spending

(dollars in millions)

Account	FY14 Actual	FY15 Estimate	FY16 Request	Change Over FY2015 Estimate	
				$	%
Research and Related Activities (RRA)	**5775.32**	**5933.65**	**6186.30**	**252.66**	**4.3**
Biological Sciences (BIO)	*720.84*	*731.03*	*747.92*	*16.89*	*2.3*
Computer and Info. Science and Engineering (CISE)	*892.60*	*921.73*	*954.41*	*32.68*	*3.5*
Engineering (ENG)	*833.12*	*892.31*	*949.22*	*56.91*	*6.4*
Geosciences (GEO)	*1321.32*	*1304.39*	*1365.41*	*61.02*	*4.7*
Mathematical and Physical Sciences (MSP)	*1267.86*	*1326.72*	*1366.23*	*29.51*	*2.2*
Social, Behavioral, and Economic Sciences (SBE)	*256.84*	*272.20*	*291.46*	*19.26*	*7.1*
International Science and Engineering (OISE)	*48.31*	*48.52*	*51.02*	*2.5*	*5.2*
Integrative Activities	*433.12*	*425.34*	*459.15*	*33.81*	*7.9*
U.S. Arctic Research Commission	*1.30*	*1.41*	*1.48*	*0.07*	*5.0*
Education and Human Resources (EHR)	**832.02**	**866.00**	**962.57**	**96.57**	**11.2**
Major Research Equipment & Facilities Construction (MREFC)	**200.00**	**200.76**	**200.31**	**-0.45**	**-0.2**
Agency Operations & Award Management	**305.95**	**325.00**	**354.84**	**29.84**	**9.2**
National Science Board (NSB)	**4.25**	**4.37**	**4.37**	**-**	**-**
Office of Inspector General (OIG)	**13.84**	**14.43**	**15.16**	**0.73**	**5.1**
Totals:	**7131.38**	**7344.21**	**7723.55**	**379.34**	**5.2**

[3] http://www.nsf.gov/nsb/publications/2014/nsb1432.pdf

National Science Foundation (NSF) Budget Summary[4]

The FY16 budget request for NSF is $7.724 billion, an increase of 5.2 percent, or $379.34 million, over the FY15 enacted level. The budget for NSF is divided into three major accounts: Research and Related Activities, Education and Human Resources, and Major Research Equipment and Facilities Construction. It also includes funding requests for Agency Operations and Award Management, the National Science Board, and the Office of Inspector General.

In the NSF's FY16 budget presentation provided to the Committee, the NSF identified four new priority investments and eight ongoing priorities:

New NSF-wide priorities are:
1) Understanding the Brain, encompassing new and ongoing investments as part of the Administration's Brain Research through Advancing Innovation and Neurotechnologies (BRAIN) Initiative;
2) Risk and Resilience, aims to improve predictability, risk assessment, and improve resilience to extreme natural and manmade events;
3) Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS); and
4) Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (INCLUDES)

Ongoing NSF-wide priorities are:
1) Clean Energy Technology;
2) Cyber-enabled Materials, Manufacturing, and Smart Systems;
3) Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education;
4) Innovation Corps;
5) NSF Research Traineeship;
6) Research at the Interface of Biological, Mathematical, and Physical Sciences;
7) Science, engineering, and Education for Sustainability; and
8) Secure and Trustworthy Cyberspace

The NSF has also highlighted its plan to invest $200.3 million in major research equipment and facilities construction (MREFC), which includes ongoing funding for construction of the Inouye Solar Telescope in Hawaii, the Large Synoptic Survey Telescope in Chile, and the National Ecological Observatory Network (NEON) of field sites across the United States.

NSF's request for funding of STEM education activities remains centered in the Directorate for Education and Human Resources (EHR). The Administration is seeking an 11 percent, or $96.57 million, increase for the Directorate. STEM learning and learning environments, broadening participation and capacity in STEM, and the STEM professional workforce are three areas of focus for EHR.

[4] http://www.nsf.gov/about/budget/fy2016/index.jsp

The request also includes $30.77 million for expenses related to the NSF Headquarters relocation to Alexandria, Virginia, an 83 percent increase of $13.96 million (83%) over FY15. Leases for the current facility expired in 2013, and has been extended until 2017.

National Institute of Standards and Technology (NIST) Overview

The National Institute of Standards and Technology (NIST) was originally founded in 1901 as the National Bureau of Standards. A non-regulatory agency within the Department of Commerce, NIST works to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. By working closely alongside industry, NIST has become recognized as a provider of high-quality information utilized by the private sector.

NIST operates two main research laboratories in Gaithersburg, Maryland, and Boulder, Colorado. NIST employs nearly 3,000 scientists, engineers, technicians, and support administrative personnel. NIST hosts about 2,700 associates and facility users from academia, industry, and other government agencies each year. [5] NIST Laboratories conduct research that advances the nation's technology infrastructure and helps U.S. companies continually improve products and services.

NIST utilizes several programs to carry out its mission. The Hollings Manufacturing Extension Partnership is a nationwide network of local centers offering technical and business assistance to smaller manufacturers to help them create and retain jobs, increase profits, and save time and money. NIST partners with 1,300 manufacturing specialists and staff at more than 400 MEP locations around the country. The Advanced Manufacturing Technology Consortia program is intended to establish new or strengthen existing industry-driven consortia that address high-priority research challenges impeding the growth of advanced manufacturing in the United States. Finally, in December 2014 Congress authorized the Network for Manufacturing Innovation through the *Revitalize American Manufacturing and Innovation Act* (RAMI) to improve the competitiveness of U.S. manufacturing and increase the production of goods manufactured within the U.S.

[5] http://www.nist.gov/public_affairs/general_information.cfm

National Institute for Standards and Technology (NIST) Spending
(dollars in millions)

Account	FY14 Actual	FY15 Enacted	FY16 Request	Change Over FY15 Enacted	
				$	%
Scientific & Technical Research and Services (STRS)	**651.0**	**675.5**	**754.7**	**79.2**	**12**
Construction of Research Facilities (CRF)	**56.0**	**50.3**	**59.0**	**8.7**	**17**
Industrial Technology Services (ITS)	**143.0**	**138.1**	**306.0**	**167.9**	**122**
Manufacturing Extension Partnership (MEP)	*128.0*	*130.0*	*141.0*	*11*	*8*
Advanced Manufacturing Technology Consortia (AMTech)	*15.0*	*8.1*	*15.0*	*6.9*	*85*
National Network for Manufacturing Innovation	-	-	*150.0*	*150.0*	*100.0*
Totals:	**850.0**	**863.9**	**1,119.7**	**255.8**	**30**

National Institute of Standards and Technology (NIST) Budget Summary[6]

The President's FY16 budget request for NIST is $1.12 billion, an increase of $255.8 million (29.6%) over FY15.

Scientific and Technical Research Services

The FY16 Budget Request for NIST's Scientific and Technical Research Services (STRS) is $754.7 million, an increase of nearly $80 million from FY15 enacted levels. STRS includes NIST's laboratory programs, the National Measurement and Standards Labs and user facilities would both receive increased funding through the President's request. The Strategic and Emerging Research Initiative fund and postdoctoral research associates program would both be cut in the request. The request includes increases for work conducted on the materials genome initiative, in addressing radio spectrum interference issues, strengthening cryptography, advanced sensing for manufacturing, cyber physical systems and quantum-based sensors and measurements.

[6] http://www.osec.doc.gov/bmi/budget/FY16BIB/EntireDocument-WebVersionWithCharts.pdf

Construction of Research Facilities

The FY16 Budget Request for NIST's Construction of Research Facilities (CRF) is $59 million, an increase of nearly $9 million from FY15 enacted levels. The FY16 request would fund the next phase of planned multiyear renovations.

Industrial Technology Services

The FY16 Budget Request for NIST's Industrial Technology Services (ITS) is $306 million, an increase over $167 million or nearly 122 percent from FY15 enacted levels. The request includes $141 million for NIST's Manufacturing Extension Partnership (MEP), an increase of $8 million, and $150 million for the newly authorized Network for Manufacturing Innovation. The *Revitalize American Manufacturing and Innovation Act* (RAMI) was signed into law last December and authorized NIST to use not more than $5 million annually for 10 years for the Network for Manufacturing Innovation. RAMI also authorized $250 million over 10 years from the Energy Efficiency and Renewable Energy appropriation account to pay for the bulk of program costs. The NIST request also includes $15 million for the Advanced Manufacturing Technology program (AMTech), an increase of over $6 million.

Chairwoman COMSTOCK. Good morning. The Subcommittee on Research and Technology will come to order. Excuse me.

Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time.

Welcome to today's hearing entitled "An Overview of the Fiscal Year 2016 Budget Proposals for the National Science Foundation and National Institute of Standards and Technology for Fiscal Year 2016."

In front of you are packets containing the written testimony, biographies, and truth-in-testimony disclosures for today's witnesses.

I now recognize myself for five minutes for an opening statement.

I would first like to thank our witnesses for appearing today to discuss these budget requests: Dr. France Córdova, Director of the NSF, Dr. David—okay, I am going to get these names right here—Arvizu, Chairman of the National Science Board; and Dr. Willie May, Acting Director of NIST, who I want to acknowledge has been nominated by the President for the position of Under Secretary of Commerce for Standards and Technology.

The Fiscal Year 2016 budget request for NSF totals $7.72 billion, an increase of $379.34 million, 5.2 percent over the Fiscal Year 2015 enacted level. NSF is the primary source of federal funding for non-medical basic research. Basic research is about good jobs and a secure future. We want to be strong advocates for federal support of basic research that advances science in the national interest.

But in this budget environment, just maintaining the current level of basic research support is a challenge. We have a constitutional obligation and a responsibility to ensure every dollar allocated for scientific research is spent as effectively and efficiently as possible.

I look forward to hearing from our witnesses on how NSF plans to prioritize and manage the funding in Fiscal Year 2016.

The Fiscal Year 2016 budget request for NIST totals $1.12 billion, an increase of $255.8 million or almost 30 percent from the Fiscal Year 2015 enacted level.

The Committee has a long bipartisan record of support for NIST and its contributions to research and development. Just last year the House passed a bipartisan reauthorization of the Institute. A 30 percent increase will be difficult to achieve and would require significant changes in other areas, so we can keep that in mind as we have today's discussion.

The requested increases would be devoted in large part to bolster advanced manufacturing initiatives at NIST. $150 million dollars is requested for the Network for Manufacturing Innovation, which I believe is set in law at $5 million annually. We are here today to learn more about the justification for this request, and I am appreciative of the opportunity to learn more about how Fiscal Year 2016 funds would be prioritized by NIST.

I look forward to hearing from our witnesses today and learning how priorities and budgets are set by both organizations.

[The prepared statement of Mrs. Comstock follows:]

PREPARED STATEMENT OF SUBCOMMITTEE
CHAIRWOMAN BARBARA COMSTOCK

I would first like to thank our witnesses for appearing today to discuss these budget requests: Dr. France Córdova, Director of the NSF, Dr. David Arvizu, Chairman of the National Science Board, and Dr. Willie May, Acting Director of NIST, who I want to acknowledge has been nominated by the President for the position of Under Secretary of Commerce for Standards and Technology.

The fiscal year 2016 budget request for NSF totals $7.72 billion, an increase of $379.34 million, 5.2 percent over the fiscal year 2015 enacted level.

NSF is the primary source of federal funding for non-medical basic research. Basic research is about good jobs and a secure future. We want to be strong advocates for federal support of basic research that advances science in the national interest.

But in this budget environment, just maintaining the current level of basic research support is a big challenge. We have a constitutional obligation and a responsibility to ensure every dollar allocated for scientific research is spent as effectively and efficiently as possible.I look forward to hearing from our witnesses, Dr. Cordova and Dr. Arvizu, on how NSF plans to prioritize and manage funding in fiscalyear 2016.

The fiscal year 2016 budget request for NIST totals $1.12 billion, an increase of $255.8 million or almost 30 percent from the fiscal year 2015 enacted level.

This Committee has a long, bipartisan record of support for NIST and its contributions to research and development. Just last year the House passed a bipartisan reauthorization of the Institute. But a 30 percent increase will be difficult to achieve and would require significant changes in other areas. The requested increases would be devoted in large part to bolster advanced manufacturing initiatives at NIST, $150 million dollars is requested for the Network for Manufacturing Innovation, which I believe is set in law at $5 million annually.

We are here today to learn more about the justification for this request, and I am appreciative of the opportunity to learn more about how fiscal year 2016 funds would be prioritized by NIST. I look forward to hearing from our witnesses and learning how priorities and budgets are set by both organizations.

Chairwoman COMSTOCK. I now recognize our Ranking Member, the gentleman from Illinois, Mr. Lipinski, for his opening statement.

Mr. LIPINSKI. Thank you, Madam Chairwoman, and welcome to our distinguished panel here today.

I am pleased we are having this hearing to review the Fiscal Year 2016 budget proposals for the National Science Foundation and the National Institute for—of Standards and Technology.

There is a lot to cover when we discuss these two critical agencies, and I believe that we would have been better able to examine these budgets with two separate hearings but I am hopeful that we can give a thoughtful and thorough consideration here today.

As many of you know, I have said many times from when I first came here ten years ago how NSF and the role that this Committee plays in overseeing NSF is one of the big reasons I wanted to serve on this Committee when I got to Congress, and I want to thank both NSF and NIST for the great work that you are doing.

The National Science Foundation is the only agency in our government that supports fundamental research across all fields of science and engineering. NSF has always been the primary source of federal support in a variety of fields, including the social and economic sciences. As other agencies such as DARPA and NIH have increasingly shifted to a more mission-focused and translational research, NSF has become the primary source of support for many more fields.

$7 billion sounds like a lot of money and of course it is. However, given the breadth and depth of our nation's scientific talent and their capacity to transform the world through scientific and techno-

logical breakthroughs, $7 billion still leaves a lot of excellent ideas on the cutting room floor. NSF is requesting a 5.2 percent increase in its budget for Fiscal Year 2016, which I believe is fully justified and I am going to strongly support.

I would like to highlight a couple of items in the NSF request. I am pleased to see the increase for the very successful Innovation Corps, also known as the I–Corps program. If my newer colleagues are unfamiliar with I–Corps, I urge them to get a briefing from NSF.

Being from Chicago, I am also interested in the INFEWS Initiative and the positive impacts research in that area could have on water quality in the Great Lakes.

Today, we are also looking at the budget request for NIST, the most important, least-known agency in our government, which has a budget of less than $900 million. NIST has always been the world's premier measurement science and standards organization. In recent years, policymakers in Congress and the White House have called on NIST to take on leadership roles in an increasing number of critical areas, including cybersecurity, disaster resilience, forensic science, and advanced manufacturing. On the one hand it is a great compliment to NIST that we entrust them with these responsibilities and they continue to live up to our expectations. On the other hand, many of these responsibilities have been making it difficult for the agency to carry out its mission.

NIST is requesting a 30 percent increase but over a relatively small base. I fully support NIST's request in light of all the increased responsibilities.

I hope that all my colleagues will join me in urging full funding for NIST laboratories and construction budget. NIST infrastructure is 40 to 50 years old and much of it is crumbling. As they face the same wave of retirements that many of our agencies face, NIST is struggling to attract top new talent. If we do not fully fund this agency, we may be compromising its ability to remain the world's leader in measurement science and standards development. This would be a heavy blow to our economic growth and security given the importance of NIST's work.

Before I close, I want to say a few words about legislation I expect will come before this Committee soon in regards to reauthorizing both of these agencies. Last year, the agencies were not given the opportunity to testify on the reauthorizing legislation before we marked it up. I am sure there will be some questions from both sides today that will be relevant to any new reauthorization bill, but it is important to allow these agencies to testify again once legislation has been introduced. This will allow our Subcommittee and full Committee to better understand the impact of any proposals for consequential policy changes.

I look forward to this morning's testimony and discussion and I yield back.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF SUBCOMMITTEE
MINORITY RANKING MEMBER DANIEL LIPINSKI

Thank you Madam Chairwoman and welcome to our distinguished panel. I am pleased we are having this hearing to review the Fiscal Year 2016 budget proposals

for the National Science Foundation and the National Institute of Standards and Technology. There is a lot to cover when we discuss these two critical agencies and I believe that we would have been able to examine these budgets better with two separate hearings. But I am hopeful that we can give a thoughtful and thorough consideration here today.

The National Science Foundation is the only agency in our government that supports fundamental research across all fields of science and engineering. NSF has always been the primary source of federal support in a variety of fields, including the social and economic sciences. As other agencies such as DARPA and NIH have increasingly shifted toward more mission-focused and translational research, NSF has become the primary source of support for many more fields. $7 billion sounds like a lot of money, and of course it is. However, given the breadth and depth of our nation's scientific talent, and their capacity to transform the world through scientific and technological breakthroughs, $7 billion still leaves a lot of excellent ideas on the cutting-room floor. NSF is requesting a 5.2 percent increase in its budget for FY 2016 which I believe is fully justified and I will strongly support.

I would like to highlight a couple of the items in the NSF request. I am pleased to see the increase for the very successful Innovation Corps, aka the I-Corps program. If my newer colleagues are unfamiliar with I-Corps, I urge them to get a briefing from NSF. Being from Chicago, I'm also interested in the INFEWS initiative and the positive impacts research in that area could have on water quality in the Great Lakes.

Today we are also looking at the budget request for NIST, the most important least-known agency in our government, which has a budget of less than $900 million. NIST has always been the world's premier measurement science and standards organization. In recent years, policymakers in Congress and the White House have called on NIST to take on leadership roles in an increasing number of critical areas, including cybersecurity, disaster resilience, forensic science, and advanced manufacturing. On the one hand, it is a great compliment to NIST that we entrust them with these responsibilities and they continue to live up to our expectations. On the other hand, many of these responsibilities have been assigned without needed increases in funding, making it difficult for the agency to carry out its mission. NIST is requesting a nearly 30 percent increase, but over a relatively small base. I fully support NIST's request in light of all the increased responsibilities.

I hope that all of my colleagues will join me in urging full funding for NIST's laboratories and construction budget. NIST's infrastructure is 40–50 years old and much of it is crumbling. As they face the same wave of retirements that many of our agencies face, NIST is struggling to attract top new technical talent. If we do not fully fund this agency, we may be compromising its ability to remain the world's leader in measurement science and standards development. This would be a heavy blow to our economic growth and security given the importance of NIST's work.

Before I close, I want to say a few words about legislation that I expect will come before this Committee soon in regard to reauthorizing both of these agencies. Last year, the agencies were not given the opportunity to testify on the reauthorizing legislation before we marked up it. I'm sure there will be some questions from both sides today that will be relevant to any new reauthorization bill, but it's important to allow these agencies to testify again once legislation has been introduced. This will allow our Subcommittee and the full Committee to better understand the impact of any proposals for consequential policy changes.

I look forward to this morning's testimony and discussion, and I yield back.

Chairwoman COMSTOCK. Thank you, Mr. Lipinski.

Now, Chairman Smith—I recognize Chairman Smith, our Chairman of the full Committee.

Chairman SMITH. Thank you, Madam Chair, and let me observe and state the obvious at the beginning that we have an excellent panel with us today and we look forward to hearing from them shortly.

The National Science Foundation and the National Institute of Standards and Technology support fundamental scientific research that is critical to American innovation and competitiveness. Our challenge is to set funding priorities that ensure America remains first in the global marketplace of ideas and products, without misusing the American people's hard-earned tax dollars.

For example, why does the Administration increase funding for the Social, Behavioral and Economic Science Directorate by over seven percent while proposing an average of less than four percent for the Biology, Computer Science, Engineering and Mathematical and Physical Science Directorates?

But I do want to emphasize and mention and applaud the steps taken by NSF to improve transparency and accountability. NSF's new policy acknowledges the need for NSF to communicate clearly and in nontechnical terms when the agency describes the research projects it funds. The new policy also emphasizes that the title and abstract for each funded grant should act as the public justification for NSF funding. It should explain how the project serves the national interest and is consistent with the NSF mission, as set forth in the 1950 legislation that created the Foundation. And I understand Dr. Córdova presented this at the November National Science Board meeting and received positive comments.

It appears the new NSF policy parallels a significant provision of the FIRST Act approved by this Committee last fall, a requirement that NSF publish a justification for each funded grant that sets forth the project's scientific merit and national interest. The reference to the 1950 original enabling legislation and its NSF mission statement is consistent with the FIRST Act, too.

NIST does valuable, important work as well, which includes maintaining industrial and technical standards and managing cybersecurity guidelines for federal agencies. But the proposed 30 percent increase in the NIST budget for next year is unrealistic.

Although there are a number of areas proposed for very large increases, the $150 million for the National Network of Manufacturing Innovation program is of particular concern. Last year, with strong bipartisan support, this Committee, the full House, and the Senate approved H.R. 2996, the Revitalize American Manufacturing Innovation Act, or RAMI. This bill authorized about $5 million per year for NNMI from NIST with the bulk of the program funding to be transferred from the Office of Energy Efficiency and Renewable Energy budget at the Energy Department's Office of Science. I don't know why the Administration is ignoring the duly enacted RAMI Act.

Other than that, I look forward to hearing from our witnesses today on the subject that I mentioned above and yield back.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
CHAIRMAN LAMAR SMITH

Thank you Madam Chair, and thank you to Dr. Cθrdova, Dr. Arvizu and Dr. May for being with us here today.

The National Science Foundation (NSF) and the National Institute of Standards and Technology (NIST) support fundamental scientific research that is critical to American innovation and competitiveness. Our challenge is to set funding priorities that ensure America remains first in the global marketplace of ideas and products, without misusing the American people's hard-earned tax dollars.

For example, why does the administration increase funding for the Social, Behavioral and Economic Science Directorate by over seven percent while proposing an average of less than four percent for the Biology, Computer science, Engineering and Mathematical and Physical science directorates?

I do want to mention and applaud the steps taken by NSF to improve transparency and accountability. NSF's new policy acknowledges the need for NSF to

communicate clearly and in non-technical terms when the agency describes the research projects it funds.

The new policy also emphasizes that the title and abstract for each funded grant should act as the public justification for NSF funding. It should explain how the project serves the national interest and is consistent with the NSF mission, as set forth in the 1950 legislation that created the Foundation.

I understand Dr. Cθrdova presented this at the November National Science Board meeting and received positive comments.

It appears the new NSF policy parallels a significant provision of the FIRST Act approved by this Committee last fall—a requirement that NSF publish a justification for each funded grant that sets forth the project's scientific merit and national interest. The reference to the 1950 original enabling legislation and its NSF mission statement is consistent with the FIRST Act, too.

NIST does valuable, important work as well, which includes maintaining industrial and technical standards and managing cybersecurity guidelines for federal agencies. But the proposed 30 percent increase in the NIST budget for next year is unrealistic.

Although there are a number of areas proposed for very large increases, the $150 million for the National Network of Manufacturing Innovation (NNMI) program is of particular concern. Last year, with strong bipartisan support, this Committee, the full House, and the Senate approved HR 2996, the Revitalize American Manufacturing Innovation Act (RAMI).

This bill authorized about $5 million per year for NNMI from NIST with the bulk of the program funding to be transferred from the Office of Energy Efficiency and Renewable Energy budget at the Energy Department's Office of Science.

I don't know why the administration is ignoring the duly enacted RAMI Act.

I look forward to hearing from our witnesses today on the subjects I mentioned above.

Chairwoman COMSTOCK. Okay. Thank you, Mr. Smith.

And now I recognize the Ranking Member of the full Committee for a statement.

Ms. JOHNSON. Thank you very much, Madam Chairwoman, for holding this important hearing, and I welcome the National Science Foundation and the National Institute of Standards and Technology witnesses here. Both are agencies that are central to the federal role in advancing science, promoting innovation, and creating a more prosperous nation.

I look forward to hearing from the distinguished witnesses before us this morning. I only wish they could each have had in their own hearing because there are so many important topics to discuss for each of the agencies.

I am pleased with the budget request for both NSF and NIST. I hope Congress will have the wisdom to fully fund both requests. There are many worthy programs across the government and we cannot fund everything. However, I believe that funding science and innovation should be an easy choice, for this is about our future, and even more important, it is about our children's future.

That said, there are a few programs in the budget request that I would like to highlight. First, I am pleased to see NIST and NSF's increased investments in engineered biology. Many of the experts believe that biology will be the driver of economic prosperity in the 21st century, as physics was in the 20th century. Mr. Sensenbrenner joined me in introducing the *Engineering Biology Act of 2015*, which would create a framework for coordinated federal initiative in engineering biology. I hope we have the opportunity to move the bill this Congress.

Next, I am happy to see NIST leadership in the area of forensic science and standards. The partnership between NIST and the Department of Justice must continue to recognize NIST's critical role

in developing technical standards for forensic evidence. The justice system must be just for all, including the wrongfully accused. I would be reintroducing my *Forensic Science and Standards Act* soon and I welcome my colleagues to cosponsor the legislation with me.

Also, while public access is not addressed in the budget request directly, it is a timely issue. I am pleased to see that several agencies, including NIST, have released their public access plans for federally funded research, a process that this Committee started back in the year 2009. Dr. Córdova, I understand you will still be negotiating with OSTP on your plan and I encourage you to resolve that as soon as possible.

Let me conclude with a few words about the debates in this Committee regarding our support for different fields of science and for merit review. We all have beliefs we would hold very strongly whether or not there is evidence to support them. Some of my colleagues believe very strongly that some fields of science are less valuable than other fields and that some grants are less worthy than other brands. Personally, I do not presume to have the expertise to make that determination. I trust the merit review process, and I trust NSF to make those decisions. The experts before us today will have an opportunity to educate us as to why we must invest in all STEM fields, and why it is so important to keep the merit review process free from political review. I just hope that all of my colleagues truly listen and consider what our witnesses have to say.

I very much look forward to the testimony, and with that, yield back. Thank you.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
RANKING MEMBER EDDIE BERNICE JOHNSON

Thank you, Madam Chairwoman for holding this important hearing. The National Science Foundation and the National Institute of Standards and Technology are both agencies that are central to the federal role in advancing science, promoting innovation, and creating a more prosperous nation. I look forward to hearing from the distinguished witnesses before us this morning. I only wish they could each have their own hearing because there are so many important topics to discuss for each agency.

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I very much look forward to the testimony and with that I yield back.

Chairwoman COMSTOCK. Thank you, Ms. Johnson.

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

At this time I would like to introduce our witnesses. Hon. France Córdova is the Director of the National Science Foundation; Hon. Dan Arvizu is the Chairman of the National Science Board; and Dr. Willie May is the Acting Director of the National Institute of Standards and Technology.

In order to allow time for discussion, please limit your testimony to five minutes and your entire written statement will be made part of the record.

I now recognize Dr. Córdova for five minutes to present her testimony.

TESTIMONY OF THE HONORABLE FRANCE CÓRDOVA, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. CÓRDOVA. Chairman Smith, Ranking Member Johnson, Madam Chairwoman, Ranking Member Lipinski, and Members, I am very pleased to be with you today to present the National Science Foundation's Fiscal Year 2016 budget request.

I would like to begin my remarks with three short stories about breakthroughs in NSF-funded science in 2014. Dr. Danielle Bassett of the University of Pennsylvania was awarded a MacArthur Fellowship, often called the "genius grant," for her NSF-sponsored work on how different regions of the brain interact. She uses MRI technology and computer algorithms in her research, which may ultimately lead to what she calls "personalized therapeutics for rehabilitation and treatment of brain injury and psychiatric disorders." Her work may have application to Alzheimer's, schizophrenia, autism, epilepsy, and Parkinson's disease.

Dr. Perena Gouma, material science research at SUNY Stony Brook, has created a novel nanogrid that when activated by sunlight can break down oil from a spill. She was the first scientist to receive an I–Corps grant and has started a company based on patents from this original research.

Dr. Jennifer Doudna of UC Berkeley was awarded a Breakthrough Prize by leading technology companies. Her inspiration, she says, was her father, a literature professor who introduced her to cryptograms. Today, she has decrypted bacterial immunity, and with that discovery enabled the development of a precision genome

editing tool, which could be used to treat diseases like cancer and AIDS, as well as hereditary disorders. At a recent session where I joined her to talk about future breakthroughs, she spoke of her experiences with K through 12 students. There is a scientist in every child, she said.

These young women scientists and their game-changing discoveries were all funded by NSF. They were all drawn into science by family, friends, or teachers at a young age. Their research is truly innovative and interdisciplinary and shows a commitment to the STEM workforce.

NSF has a long history of funding research that leads to breakthroughs in science and engineering. These breakthroughs excite the next generation and generate promise for the future. NSF has funded 214 Nobel Prize winners, including the most recent winners, W.E. Moerner in chemistry and Jean Tirole in economics.

This past year, the NSF-funded supercomputer called Stampede at UT Austin has been used to explore a new method of DNA sequencing, which could make getting one's genome affordable. The new telescope in Chile called ALMA produced an iconic image of a proto-solar system forming around a relatively nearby star in our galaxy. This telescope is managed by the National Radio Astronomy Observatory located in Virginia.

In addition, the NSF-funded Blue Waters supercomputer at the University of Illinois Urbana-Champaign is being used by researchers from the Mayo Clinic to understand gene expression in the brain with an eye to better understanding Alzheimer's disease.

How do these stories and examples inform NSF's future investments? In Fiscal Year 2016 NSF proposes to uphold the essential approach that it has pursued for more than 60 years, to invest in discovery research and education in science and engineering, and by doing so, to address complex challenges facing the Nation for our Nation.

In Fiscal Year 2016 there are four NSF-wide investments that address issues of major scientific national and societal importance. The first focus is on understanding the brain and it will offer novel insights into how cognitive abilities develop and can be maintained and improved throughout people's lives. The second is focused on the discovery science needed to understand the complicated and interconnected food-energy-water nexus. The third area of emphasis in 2016 is risk and resilience. It focuses on the advances needed to address pressing challenges associated with extreme events and how we can be prepared for them. The fourth is to develop an integrated national effort to increase the participation of young people who have been traditionally underserved and/or underrepresented in the STEM enterprise.

What we are presenting today is therefore a robust investment in discovery. The total budget request is for $7.7 billion, a 5.2 percent increase above the current level. This request builds on the foundation strength in funding breakthroughs and discoveries across a broad range of fields and in educating the STEM workforce.

My written remarks provide additional detail on these investments.

Most of all, it continues NSF's tradition of funding great ideas and growing great talent and ensures that NSF remains the place where discoveries began.

Thank you very much, Madam Chairwoman and Members of the Subcommittee. Thank you for your support of the National Science Foundation. I look forward to working with you as together we advance science in the national interest.

[The prepared statement of Dr. Córdova follows:]

Dr. France Córdova
Director
National Science Foundation

Before the
Committee on Science, Space, and Technology
Subcommittee on Research and Technology
United States House of Representatives

on
The President's Fiscal Year 2016 Budget Request
for the National Science Foundation

February 26, 2015

Chairwoman Comstock, Ranking Member Lipinski, and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's fiscal year (FY) 2016 Budget Request.

NSF is the only federal agency with a mandate to support research and education in every science and engineering discipline. The results of discovery research have a long record of improving lives, investing in the national interest, and meeting national needs. They are the very bedrock of economic growth; the path to sustainability in energy, agricultural, and environmental domains; the seeds of the next technology revolution; and the foundation for advances in medicine. Sustained momentum in NSF's core programs is essential for progress in science and engineering. NSF's broad scope uniquely positions us to integrate the natural sciences and engineering with social, behavioral, and economic sciences to address the complex societal challenges of today. For all these reasons, the FY 2016 Budget Request provides increased support for the core fundamental research programs across NSF.

NSF's organization represents the major science and engineering fields, including: biological sciences; computer and information science and engineering; engineering; geosciences; mathematical and physical sciences; and social, behavioral, and economic sciences. NSF also carries out specific responsibilities for education and human resources, cyberinfrastructure, integrative activities, international science and engineering, and polar programs. The 25-member National Science Board sets the overall policies of the Foundation.

The Foundation's annual budget represents 25 percent of the total federal budget for basic research conducted at U.S. colleges and universities, and this share increases to 60 percent when

medical research supported by the National Institutes of Health is excluded. In many fields NSF is the primary source of federal academic support.

With this request, NSF expects to evaluate over 51,700 proposals through a competitive merit review process and make over 12,000 new awards. This will require over 225,000 proposal reviews, engaging on the order of 35,000 members of the science and engineering community participating as panelists and proposal reviewers. NSF awards reach over 1,800 colleges, universities, and other public and private institutions in 50 states, the District of Columbia, and U.S. territories. In FY 2016, NSF support is expected to reach approximately 356,000 researchers, postdoctoral fellows, trainees, teachers, and students.

NSF's comprehensive and flexible support of meritorious projects enables the Foundation to identify and foster both fundamental and transformative discoveries and broader impacts within and among fields of inquiry. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations, and research that pushes – and even creates – the very frontiers of knowledge. In these ways, NSF's discoveries inspire the American public – and the world.

NSF: Where Discoveries Begin

Sustained federal support for research and education has fueled innovation and provided benefits to the American public for decades, and NSF has played a significant role in this success. For over 60 years, NSF has been a catalyst for the development of new ideas in science and engineering and supported the people who generate them.

In 1952, Caltech professor Max Delbruck used one of NSF's first grants to invent molecular biology techniques that enabled one of his students, James Watson, to determine the molecular structure of DNA. Since then, an entire biotechnology industry has bloomed and prospered, with profits reaching $3.7 billion last year.

In the 1960s and '70s, NSF provided seminal funding for fundamental mathematical and process innovations for manufacturing that industry considered too risky to fund. These led directly to rapid prototyping—and revolutionized how products are designed and manufactured.

In the 1980s, NSF supported the very first computer science departments in U.S. universities, bringing computer science into the mainstream of research, and providing a training ground for the first and subsequent generations of computer scientists and entrepreneurs. Today, NSF provides 89 percent of total federal support for research in computer science conducted in the nation's universities and colleges. Jobs related to computer and information technologies are among the most rapidly growing in the nation according to Bureau of Labor Statistics projections.

In the 1990s, NSF supported pioneering research in the emerging field of nanotechnology. Between 2001 and 2010, NSF-supported centers and networks created 175 start-ups and developed collaborations with over 1,200 companies.

Investments in discovery research often yield unexpected benefits as well. NSF's support of game theory, abstract auction theory, and experimental economics provided the Federal Communications Commission (FCC) with its current system for apportioning the airwaves. Since 1994, FCC "spectrum auctions" have netted over $45 billion in revenue for the federal government and more than $200 billion in worldwide revenue.

The NSF FY 2016 Budget Request builds on these past accomplishments and provides a direction for future success. To fuel the innovations of the future, NSF continues to support fundamental research and education in all fields of science and engineering to maintain a global edge in the competition for new ideas and the most talented people. The core science and engineering disciplines form the "building blocks" for future innovations, and provide the new ideas and approaches needed to advance the interdisciplinary research that is a hallmark of contemporary science and engineering. In all these activities, we keep a steady focus on the frontier, where discoveries begin.

In short, the NSF mission is to look toward the frontier – to identify the most innovative and promising new research and education projects. NSF specifically targets its investments in discovery research at the frontiers of science and engineering. Here, advances push the boundaries of innovation, progress, and productivity.

We identify such frontiers by sticking to our proven, "bottom-up" philosophy. The best ideas come directly from the scientific and engineering community. We support workshops, conferences, and symposiums to tap the extraordinary talent of the community in plotting innovative strategies for research and education directions for the future.

Before I get into the details of our FY 2016 request, let me first expand upon the question of priority setting at the Foundation. Although my testimony below mentions some of the mechanisms for priority setting for NSF – how they are set both across and within accounts and among agency objectives, let me briefly expand upon those points, as this is an excellent starting point for gaining a proper perspective on NSF, because setting priorities is at the core of what we do every day.

The most important source of information for setting priorities comes from the research communities themselves. The research proposals that we receive help identify the leading edge of research and areas ripe for greater investment. The broader research communities also provide continuous input in the form of advice and analyses from myriad National Academy reports, analyses by professional societies, and national and international workshops and conferences. Our Committees of Visitors provide top-to-bottom reviews of existing programs and help formalize research priorities within and across disciplines. Ultimately the priorities reflected in our budget request are refined through consultations with the NSF's Assistant Directors. We then work closely with the National Science Board to ensure our priorities match the broader needs of the scientific community, and the multi-agency science and technology priorities enumerated yearly by the Office of Science and Technology Policy and the Office of Management and Budget (OMB). Finally, the decisions are reflected in the President's budget request to Congress.

At a more local level, NSF internal programs work closely together to align investment decisions and to balance the portfolio of work we fund. For example, if a strong proposal is received by one directorate, program officers may reach out to another directorate – or multiple directorates – where they see opportunities to co-fund projects that are multidisciplinary. My testimony also highlights a number of cross-directorate efforts that are coordinated from their genesis amongst the various directorates. These efforts are coordinated through working groups that regularly meet to examine priorities, directions, and future opportunities.

These mechanisms both inside and outside of NSF ensure that on a daily basis we make sure to complement other agency efforts and that our funding supports the most important research for the nation.

THE NSF FY 2016 BUDGET REQUEST

This FY 2016 Budget Request for the National Science Foundation continues NSF's longstanding commitment to making investments in learning and discovery that will grow our economy, sustain our competitive advantage, and enable America to remain the world leader in innovation. It embraces the challenge of ensuring that scientific discovery and technological breakthroughs remain engines for expanding the frontiers of human knowledge and responding to the challenges of the 21st century.

NSF's FY 2016 Budget Request is $7.724 billion, an increase of $379.34 million (5.2 percent) over the FY 2015 Estimate. This reflects a strong commitment from the Administration to support science and engineering broadly, as well as the people that keep our Nation's scientific enterprise at the forefront of knowledge and discovery.

In turn, NSF is committed to a careful and continuous evaluation of its portfolio to maximize efficiency, effectiveness, and return on investment. This ensures that the agency establishes clear priorities, and it also fosters the development of innovative mechanisms for achieving its investment goals. NSF also works to leverage resources, infrastructure, networks, and data across the federal government and invest in promising collaborative international opportunities.

The investments that form this Budget Request flow from the goals established in the agency's strategic plan: Transform the Frontiers of Science and Engineering, Stimulate Innovation and Address Societal Needs through Research and Education, and Excel as a Federal Science Agency. In FY 2016, key NSF investments in all fields of science and engineering strive to create new knowledge, enable discovery, address complex societal problems, and promote national prosperity.

CROSS-FOUNDATION INVESTMENTS

NSF continues to bring together researchers from all fields of science and engineering to address today's cross-disciplinary questions and challenges through Foundation-wide activities. In FY 2016, four priority investments address issues of major scientific, national, and societal importance.

Understanding the Brain ($143.93 million) encompasses ongoing cognitive science and neuroscience research and NSF's contributions to the Administration's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative. The goal of the Understanding the Brain investment is to enable scientific understanding of the full complexity of the brain in action and in context. Priorities include: development of innovative technologies, tools and instrumentation, computational infrastructure, theory, and models to understand the brain; increased understanding of relationships between neuronal activity, cognitive processes, and behavior; exploration of links between environment, behavior, and brain function; and training for the next generation of neuroscientists and neuroengineers. Improved understanding of the brain will promote brain health; enable engineered solutions that enhance, replace or compensate for lost function; improve the effectiveness of formal and informal educational approaches; and lead to brain-inspired smarter technologies for improved quality of life. Basic research in these areas can provide novel insights into how cognitive abilities develop and can be maintained and improved throughout the lifespan.

Risk and Resilience ($58.0 million) investments aim to improve predictability and risk assessment and increase resilience to extreme natural and man-made events in order to reduce their impact on quality of life, society, and the economy. NSF is uniquely positioned to support such improvements that require multidisciplinary expertise in science, engineering, and education, such as understanding the dynamic processes that produce extreme events, how people respond to extreme events, and how to engineer resilient infrastructure. One supporting program is Critical Resilient Interdependent Infrastructure Systems and Processes, which directly addresses the need for the resilient and reliable infrastructure that is critical to U.S. economic competitiveness and national security. Another is Prediction of and Resilience against Extreme Events, which aims to enhance the understanding and prediction of, as well as resilience and sustainable responses to, extreme events and geohazards, as well as their impact on natural and human systems.

Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) ($74.96 million) is an NSF-wide investment that aims to understand, design, and model the interconnected food, energy, and water system through an interdisciplinary research effort that incorporates all areas of science and engineering and addresses the natural, social, and human-built factors involved. Throughout NSF, activities address food, energy, or water, such as the SEES portfolio, particularly Water Sustainability and Climate and Hazards SEES; Coupled Natural and Human Systems; and Basic Research to Enable Agricultural Development. INFEWS, however, will be the first program to study the interconnected food-energy-water nexus. The need for this program is increasingly urgent, as growing U.S. and global populations, changes in land use, and increasing geographic and seasonal variability in precipitation patterns are placing an ever-increasing stress on these critical resources. NSF, through INFEWS, is uniquely poised to focus not only on the fundamental science and engineering questions at this nexus, but to train the next generation of researchers in this interdisciplinary area.

A new approach, **NSF INCLUDES (Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science)** ($15 million) is an integrated, national initiative to increase the preparation, participation, advancement, and

potential contributions of those who have been traditionally underserved and/or underrepresented in the science, technology, engineering, and mathematics (STEM) enterprise. Following wide community engagement in FY 2015, FY 2016 efforts will focus on the development of a set of new scalable concepts that will provide focus for collaborative action. Our investments are intended to produce rapid progress on changing the balance of diversity in S&E, have significant national impact for the participation of underrepresented groups, stimulate the community, forge new partnerships, and catalyze new approaches. NSF INCLUDES will build on and amplify NSF's nearly $800 million investment portfolio in broadening participation.

ONGOING NSF-WIDE PRIORITIES

NSF addresses many of the complex issues that face the Nation today through interdisciplinary science, engineering, and educational activities. Foundation-wide programs and priorities bring together researchers from all fields of science and engineering to focus on these challenges from a myriad of perspectives, methodologies, and knowledge bases. These interdisciplinary investments are carefully balanced with a longstanding commitment to the fundamental research that addresses grand challenges and furthers basic scientific knowledge.

- **Clean Energy Technology** ($377.22 million) investments are driven by the fundamental research questions that underlie future energy pathways. NSF's clean energy investments support research and education in alternative energy for electricity (solar, wind, wave, geothermal) and fuels (chemical and biofuels). NSF funding also addresses the collection, conversion, storage, and distribution of energy from diverse power sources, including smart grids; the science and engineering of energy materials; energy use; and energy efficiency. Clean energy research addresses our advancement toward reliable and sustainable energy resources and systems that preserve essential ecosystems and environmental services, promote positive social and economic outcomes, and prepare society to responsibly adopt them.

- **Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS)** ($256.95 million) aims to integrate a number of science and engineering activities across the Foundation – breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems. It will address pressing technological challenges facing the Nation and promote U.S. manufacturing competitiveness. In FY 2016, CEMMSS continues to leverage key interagency activities, including the Administration's Materials Genome Initiative, Advanced Manufacturing Partnership, and the National Robotics Initiative. Through CEMMSS, NSF also invests in Advanced Manufacturing ($176.57 million).

- **Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)** ($143.06 million) accelerates and transforms the process of scientific discovery and innovation by providing advanced cyberinfrastructure and new capabilities in computational and data-enabled science and engineering. In FY 2016, NSF will continue to lead the Big Data/National Data Infrastructure program, a joint solicitation with the National Institutes of Health that strives to enable breakthrough discoveries and innovation in science, engineering, medicine, commerce, education, and national security.

- **Innovation Corps (I-Corps™)** ($30.0 million) improves NSF-funded researchers' access to resources that can assist in bridging the gap between discoveries and downstream technological applications. In FY 2016, NSF will continue to support I-Corps™ Nodes and I-Corps™ Sites to further build, utilize, and sustain a national innovation ecosystem that augments the development of technologies, products, and processes that benefit the Nation.

- **NSF Research Traineeships (NRT)** ($62.01 million) in its third year, continues to identify priority research themes that both align with NSF priority research activities and have strong potential in areas of national need where innovative practices in graduate education can be developed. NRT investments aim to advance the research agenda of these themes, as well as develop and conduct research on new approaches and models for educating the next generation of scientists and engineers.

- **Research at the Interface of Biological, Mathematical, and Physical Sciences (BioMaPS)** ($32.81 million) involves the Directorates for Biological Sciences, Mathematical and Physical Sciences, and Engineering, and it seeks to advance discovery at the intersections of these established disciplines. Research includes activities such as development of models, informed by statistical physics that establish the mechanisms linking the biological function of chromosomes to their cellular structure.

- **Science, Engineering, and Education for Sustainability (SEES)** ($80.50 million) aims to increase understanding of the integrated system of supply chains, society, the natural world, and alterations humans bring to Earth, in order to create a sustainable world. In FY 2016, SEES continues to ramp down in anticipation of a planned FY 2017 sunsetting; however, SEES continues to support important scientific and societal contributions during the phase-down period and will make significant progress towards achieving programmatic goals through projects currently underway. The success of several SEES research programs motivates new FY 2016 investments in INFEWS and Risk and Resilience.

- The **Secure and Trustworthy Cyberspace (SaTC)** investment ($124.25 million) aims to build the knowledge base in cybersecurity that enables discovery, learning and innovation, and leads to a more secure and trustworthy cyberspace. Through a focus on long-term, foundational research, SaTC will develop the scientific foundations for cybersecurity research for years to come. SaTC aligns NSF's cybersecurity investments with the four thrusts outlined in the national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program.*

ADDITIONAL PRIORITIES AND HIGHLIGHTS

In FY 2016, NSF continues to emphasize investments in important or emerging areas that have been developed in recent years, including:

- **Synthetic Biology** (approximately $60 million) investments support the design and construction of new biological components as well as the redesign of existing natural biological systems for tailored purposes (e.g., improving the efficiency of photosynthesis for clean energy generation, or introducing the ability of economically important crop plants to

fix nitrogen thereby eliminating dependence on environmentally damaging fertilizers). Also included are investments in the basic biological, physical, and computational sciences and engineering that will enable the construction of a rule set and design tools for synthetic biology (i.e., the rules that govern the construction and function of new biological parts). This portfolio, which promises to develop rapidly emerging technology for new applications and disruptive technology for long-standing problems in food, energy, biomanufacturing, and other areas of national need, spans several NSF directorates as the synthetic biology approach integrates engineering and computer assisted design with biological research. There are also a number of potential partnerships with industry, other federal agencies, and other countries that will be further explored.

- **Urban Science** ($7.50 million) investments will focus on the research and development of critical infrastructure and applications, which address pressing urban challenges, such as sustainability, livability, and equity, through both fundamental research and translational research that is supported via partnerships. Multidisciplinary Urban Science research efforts at NSF and other agencies will address the question of how we can intelligently and effectively design, adapt, and manage cities to maximize their positive potential. It will enable the integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities.

- NSF aims to increase the operational efficiency of **U.S. activities in the Antarctic** ($18.50 million) by continuing progress on a multi-year commitment toward more efficient and cost-effective science support as recommended by the U.S. Antarctic Program Blue Ribbon Panel report, *More and Better Science in Antarctica through Increased Logistical Effectiveness*. Emphases include safety and health improvements, and facilities renewal at McMurdo and Palmer stations. Additionally, NSF aims to plan and execute more effective observational approaches to the Antarctic science community, as outlined in the 2011 National Research Council report, *Future Science Opportunities in Antarctica and the Southern Ocean.*

STEM Education

To ensure lasting capabilities to address these disciplinary and interdisciplinary challenges, NSF's educational programs and activities integrate research and education in all fields to engage tomorrow's workforce. These programs target all educational levels and emphasize broadening participation, so that STEM fields become more accessible to all whose imagination has been sparked by science and engineering.

NSF's STEM education investment, centered in the Directorate for Education and Human Resources (EHR), funds activities that support students, teachers, researchers, and the public. In keeping with the Administration's priorities and the strategic goals for STEM education as described in the 2013 National Science and Technology Council report, *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan*, NSF's key investments for FY 2016 focus on areas where NSF has a central role in STEM education, notably graduate education and undergraduate education, and they also emphasize the need to strengthen foundational STEM education research.

- **Improving Undergraduate STEM Education (IUSE)** ($134.58 million) aims to accelerate the quality and effectiveness of the education of undergraduates in all STEM fields by using decades of research on STEM learning and best practices in education to address challenges across fields as well as within specific disciplines. IUSE priorities are aligned with the four strategic objectives for undergraduate education identified in the federal STEM education strategic plan: increase use of evidence-based practices; increase authentic research experiences for students; improve the recruitment, retention, and STEM degree completion for students in two-year colleges; and address the high rates of failure in introductory college mathematics.

- **EHR Core Research (ECR)** ($103.84 million) remains a top priority. In FY 2016, ECR strengthens investments in and impact on the improvement of STEM learning, teaching, and workforce development, through three key areas: learning and learning environments, broadening participation and institutional capacity, and development of the STEM professional workforce.

- The **CyberCorps®: Scholarships for Service (SFS)** program ($45.0 million) supports cybersecurity education and research at higher education institutions. SFS also focuses on workforce development by increasing the number of qualified students entering the fields of information assurance and cybersecurity, which enhances the capacity of the United States higher education enterprise to continue to produce professionals in these fields to secure the Nation's cyberinfrastructure.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

In FY 2016, NSF requests funding to continue construction of three projects: the Daniel K. Inouye Solar Telescope, the Large Synoptic Survey Telescope, and the National Ecological Observatory Network. Funding concluded in FY 2014 for two projects, the Advanced Laser Interferometer Gravitational-wave Observatory and the Ocean Observatories Initiative.

- The **Daniel K. Inouye Solar Telescope** ($20.0 million) will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere, and corona at unprecedented spatial, temporal, and wavelength resolution to gain information on the creation, interaction, and ultimate annihilation of solar magnetic fields. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity, including flares and coronal mass ejections. These can affect civil life on Earth through the phenomena generally described as "space weather" and may have impact on the terrestrial climate. FY 2016 is year eight of an eleven year construction process. By the end of FY 2016, the adjacent Support and Operations building will be completed, site testing of the telescope Enclosure will be finished, and the Coudé Rotator Lab will be installed in the pier. In addition, the Telescope Mount Assembly base erection will begin inside the weathertight Enclosure, along with the start of the electrical installation.

- The **Large Synoptic Survey Telescope** ($99.67 million) will be an 8-meter-class wide-field optical telescope designed to carry out surveys of the entire sky visible from its site. LSST

will collect nearly 40 terabytes of multi-color imaging data every night for ten years and will produce the deepest, widest-field sky image ever. It will image the entire visible sky twice per week, as well as issue alerts for moving and transient objects within 60 seconds of their discovery. The LSST surveys will result in a comprehensive data set that will enable hundreds of other fundamental astrophysical studies by the entire research community. FY 2016 is year three of a nine year construction process. In FY 2016, work on the lower enclosure will be complete at the LSST site, making it ready for construction of the telescope dome atop that enclosure. Following conclusion of a full bid-and-propose process, the contract for construction of the base facility will be awarded. The first components of the sensor, developed by the Department of Energy, will be delivered to the camera team, with production of the first "raft" of sensors (12K by 12K pixels) nearing completion.

- The **National Ecological Observatory Network** ($80.64 million) will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. NEON is the first research platform and the only national experimental facility specifically designed to collect consistent and standardized sensor and biological measurements across 106 sites nationwide in close to real-time, enabling basic research on complex phenomena driving ecological change and at the scales appropriate for studying many grand challenge questions in ecology. NEON allows researchers to expand the scale of their research to understand large-scale dynamics affecting ecosystems. FY 2016 is the final year of construction funding, and this will allow the project to complete civil construction, continue sensor deployment at terrestrial and aquatic locations, expand biological sampling, continue cyberinfrastructure hardware and software deployments in support of sites and domain Support Facilities acceptance, expand operational support systems, and ongoing development of data algorithms and related data release via NEON's web portal.

ORGANIZATIONAL EXCELLENCE

NSF seeks to integrate mission, vision, and core values to efficiently and effectively execute our activities and provide the flexibility and agility required for all aspects of its operations. This goal incorporates a culture of continuous improvement to ensure effective, inclusive, and accountable programs and merit review processes that provide the greatest value for taxpayer dollars.

In FY 2016, NSF will work towards full utilization of its established FTE allocations, which are increased from the FY 2015 request to a total of 1,367 to accommodate additional staffing for a Digital Service team and requirements of the DATA Act as noted below. The Foundation recognizes that maintaining staffing levels is vital for managing increasing numbers of proposals and the subsequent increase in workload.

In FY 2016, the primary drivers of the increase for the Agency Operations and Award Management (AOAM) account are the headquarters relocation and the 1.3 percent cost-of-living adjustment and related salary and benefit increases. AOAM also supports operational activities to ensure the Foundation has sufficient resources to fully fund ongoing operational requirements and maintain essential services as we approach the transition to the new NSF headquarters. These include strengthening capabilities in human resource management, consistent with the

opportunities for action or improvement identified in the FY 2014 Strategic Review. FY 2016 funding also includes equipment and technology costs related to NSF's Headquarters relocation.

In addition, $2.85 million will support NSF's efforts to implement the Digital Accountability and Transparency Act (DATA Act; P.L. 113–101) to include changes in business processes, workforce, or information technology to support high quality, transparent Federal spending information. Further, $1.0 million will fund staffing costs to build a Digital Service team that will focus on transforming the agency's digital services with the greatest impact to citizens and businesses so they are easier to use and more cost-effective to build and maintain.

Concluding Remarks

With intense global competition for knowledge and talent, we must focus our attention on finding the sophisticated solutions that will ensure a prosperous, secure, and healthy future for the nation and the world. Robust NSF investments in discovery research have returned exceptional dividends to the American people, expanding knowledge, improving lives, and ensuring our security. To keep those benefits flowing, we need to constantly replenish the wellspring of new ideas and train new talent while serving as good stewards of the public trust. That is the fundamental and continuing mission of NSF.

Madam Chair and members of the Subcommittee, I hope my testimony explains how the Foundation plays a vital role in ensuring that America remains at the epicenter of the ongoing revolution in research, innovation, and learning that is driving 21st century economies. More than ever, the future prosperity and wellbeing of Americans depend on sustained investments in our science and technology. NSF has been and continues to be central to this endeavor.

I hope that this overview has given you a taste of how important the National Science Foundation and its activities are to the future prosperity of the United States. I look forward to working with you in months ahead as we continue to advance science and engineering in the national interest, and I thank you for your leadership.

I will be pleased to answer any questions you may have.

Dr. France A. Córdova
Director
National Science Foundation

France A. Córdova, was sworn in as director of the National Science Foundation (NSF) on March 31, 2014. Nominated by President Barack Obama to head the $7.2-billion independent federal agency, she was confirmed by the U.S. Senate on March 12. Córdova leads the only government science agency charged with advancing all fields of scientific discovery, technological innovation, and science, technology, engineering and mathematics (STEM) education. NSF's programs and initiatives keep the United States at the forefront of science and engineering, empower future generations of scientists and engineers, and foster U.S. prosperity and global leadership.

Córdova is president emerita of Purdue University, where she served as president from 2007 to 2012. From 2002 to 2007, she led the University of California, Riverside, as chancellor and was a distinguished professor of physics and astronomy. Córdova was the vice chancellor for research and professor of physics at the University of California, Santa Barbara, from 1996 to 2002.

From 1993 to 1996, Córdova served as NASA's chief scientist. Prior to joining NASA, she was on the faculty of the Pennsylvania State University where she headed the department of astronomy and astrophysics from 1989 to 1993. Córdova was deputy group leader in the Earth and space sciences division at Los Alamos National Laboratory from 1988 to 1989 and staff scientist from 1979 to 1989. She received her Bachelor of Arts degree from Stanford University and her doctorate in physics from the California Institute of Technology in 1979.

More recently, Córdova served as chair of the Board of Regents of the Smithsonian Institution and on the board of trustees of Mayo Clinic. She also served as a member of the National Science Board (NSB), where she chaired the Committee on Strategy and Budget. As NSF director, she is an ex officio member of the NSB.

Córdova's scientific contributions have been in the areas of observational and experimental astrophysics, multi-spectral research on x-ray and gamma ray sources and space-borne instrumentation. She has published more than 150 scientific papers. In 1997, she was awarded an honorary doctorate by Loyola Marymount University, Los Angeles. She is a recipient of NASA's highest honor, the Distinguished Service Medal, and was recognized as a Kilby Laureate in 2000. The Kilby International Awards recoginze extraordinary individuals who have made "significant contributions to society through science, technology, innovation, invention and education." Córdova was elected to the American Academy of Arts and Sciences and is a National Associate of the National Academies. She is also a fellow of the American Association for the Advancement of Science (AAAS) and the Association for Women In Science (AWIS).

She is NSF's 14th director, succeeding Subra Suresh who stepped down in March 2013.

Córdova is married to Christian J. Foster, a science educator, and they have two adult children.

Chairwoman COMSTOCK. Thank you.

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

TESTIMONY OF THE HONORABLE DANIEL ARVIZU, CHARIMAN, NATIONAL SCIENCE BOARD

Dr. ARVIZU. Thank you.

Full Committee Chair, Chairman Smith, Ranking Member Johnson, Subcommittee Chairwoman Comstock, and Ranking Member Lipinski, and Members of the Subcommittee, I appreciate this opportunity to speak with you today in support of the National Science Foundation's fiscal 2016 budget request.

I am Dan Arvizu, the Chairman of the Science Board, and in my day job I am the Director and the Chief Executive at the Department of Energy's National Renewable Energy Laboratory. The National Science Board, as you know, is the governing board of the National Science Foundation and an independent advisor to both Congress and the President.

To begin, I would like to take a few moments to comment on my colleague here, the National Science Foundation Director France Córdova. Dr. Córdova has been at the agency's helm for almost a year now and the board is very appreciative and impressed by her leadership. From day one she has worked to ensure that the NSF supports and will be able to continue to support the strongest portfolio of discovery research in the world. She attends to both processes and to people embracing the Foundation's efforts to enhance transparency and accountability and strengthen its workforce. And Dr. Córdova is a terrific ambassador, as many of you know, for the agency connecting with other nations and scientists across all fields so that NSF can achieve its mission in advancing the frontiers of science.

Chairwoman Comstock, this morning on behalf of my 24 colleagues on the National Science Board, the science and engineering education communities which I represent as well, I would like to thank Members of the Subcommittee for their long-standing support of the NSF. The board takes very seriously our shared responsibility to provide strong governance and proper stewardship of this critical taxpayer investment.

As you know, NSF is the only agency that supports fundamental science and engineering research across all fields advancing the national interest by enabling scientific breakthroughs and the next generation of scientists and engineers. At the core, NSF is simple. We fund the best ideas, proposed and evaluated by scientists and engineers throughout the country, and we do this in fact relying on a lean, dedicated workforce that is supplemented by rotating experts and volunteers and volunteer reviewers. This approach has delivered enormous value to the U.S. taxpayer and become part of the well-known international gold standard, as we like to say, that the Foundation has always worked to both protect and improve.

NSF discovery science exists at the core of much larger national science and technology ecosystem. The early-stage research that NSF drives lays the foundation for the application-oriented science pursued by other agencies and the technological innovations devel-

oped by our nation's businesses. For example, ten years ago NSF invested in research on how to design and build a secure cyber infrastructure for the power grid. The DOE's Office of Electricity Delivery and Energy Reliability and the Department of Homeland Security have carried this research forward, and thanks to these successive investments, today, the trustworthy cyber infrastructure for the power grid project is collaborating with national labs and utility sectors to improve the design security, safety, and resiliency of the U.S. power grid.

We are always looking to improve our processes, and as a result, NSF, as you know, the agency has implemented new policies to begin and to better communicate how awards serve the national interest, how management of the NSF's large facilities is—are managed as well, and the Board and the Director planned a joint commission, an external independent review, to look at how NSF manages its cooperative agreements and to explore areas where they might make improvements to our procedures and processes.

The National Science Foundation's 2016 budget request reflects a strategic commitment to support the best basic research, economic growth, job creation through innovation, and a globally competitive science and engineering workforce. The Board believes that the proposal reflects the priorities set by the scientific community and a clear commitment to investments that will strengthen our nation over the long term.

I particularly ask for your support for funding of—full funding of the Agency Operations Award Management account. This request reflects the need to bring on additional staff to meet the requirements of the Digital Accountability and Transparency Act, cost effectively supporting high-quality, transparent federal spending information.

Like all Americans, the research community must make tough choices and set a priority, a challenge that my colleagues and I, along with the Director, have embraced. Even in times of severe budget constraints, the Board believes that the investment in our science and technology capabilities, including our S&E workforce are essential to our Nation's long-term prosperity and security.

Our researcherships, observatories have led to revolutionary technologies, Nobel prizes, and even new states of matter, accomplishments that are a result of 65 years of a partnership among scientists, universities, NSF, and Congress.

Thank you for your leadership and for this opportunity to testify and I look forward to your questions.

[The prepared statement of Dr. Arvizu follows:]

Testimony of
Dr. Dan E. Arvizu, Chairman
National Science Board

Before the Subcommittee on Research and Technology
House Committee on Science, Space, and Technology
February 26, 2015

Introduction

Chairwoman Comstock, Ranking Member Lipinski, and members of the Subcommittee, I appreciate the opportunity to speak with you today in support of the National Science Foundation's Fiscal Year 2016 Budget Request. I am Dan Arvizu, Chairman of the National Science Board (NSB, Board) and Director and Chief Executive of the Department of Energy's National Renewable Energy Laboratory. NSB is the governing Board of the National Science Foundation (NSF) and an independent advisor to Congress and the President. I have served on the Board since 2004 and was elected Chairman of the Board by my peers in 2012.

Before beginning, I would like to comment on NSF Director France Córdova. Dr. Córdova has been at the agency's helm for nearly a year, and the Board is very appreciative of and impressed by her leadership. She should be commended for her focus on strengthening NSF as an institution. From day one, her work has been dedicated to ensuring that NSF supports and will be able to continue to support the strongest portfolio of discovery research in the world. Dr. Córdova has been attentive to both processes and people, placing herself at the forefront of the Foundation's efforts to enhance transparency and accountability and continuing to focus on strengthening the Foundation's workforce. Dr. Córdova is a terrific ambassador for the agency, domestically and internationally, connecting with scientists across all fields so that NSF can achieve its mission of identifying and funding the best work at the frontiers of science.

Core of NSF: Basic Research

NSF's mission is to enable the pursuit of unfettered discovery science. For 65 years, NSF has demonstrated that federal support of such science – that is, science without a known application at the time of its initial pursuit – is squarely in the nation's interest. Fundamental science funded by NSF has yielded knowledge that has changed our understanding of the world around us, led to advances and applications that have improved our quality of life, enhanced our health, and helped secure our national defense. This commitment to discovery science – a commitment

unlikely to be undertaken by any entity other than the federal government – has propelled the U.S. economy to global leadership in science and innovation and has been a building block of our nation's prosperity in the post-World War II era. Chairwoman Comstock, on behalf of my 24 colleagues, and the science, engineering, and education communities which we represent, I'd like to thank members of this Subcommittee for their long-standing support of NSF's mission. My colleagues on the Board and I recognize that these are tough fiscal times, and we do not take your support for granted. To this end, the NSB takes very seriously its responsibility to provide strong governance and proper stewardship of this taxpayer investment.

NSF's mission of discovery science exists at the core of a much larger national science and technology ecosystem that serves the national interest. NSF drives early stage research in all scientific fields, laying the knowledge foundation that makes possible the application-oriented science pursued at other agencies and the technological innovations developed by the nation's businesses. NSF has done its job when other entities can build upon or find applications for this knowledge. In order to fuel this entire ecosystem, NSF's discovery research – of necessity – has cross-cutting themes and disciplinary overlap with the domains (but not necessarily the research stages) of other federal science agencies. Let me illustrate this through a few examples.

Nearly a decade ago, NSF – recognizing that the electricity sector was insufficiently focused on security – invested in early stage research on how to design and build a secure cyberinfrastructure for the power grid. This research, sponsored by NSF's Computer and Information Science and Engineering (CISE) Directorate, has since been carried forward with funding from the Department of Energy's Office of Electricity Delivery and Energy Reliability (DOE-OE) and the Department of Homeland Security Science and Technology Directorate. Today, the Trustworthy Cyber Infrastructure for the Power Grid Project (TCPIG) is collaborating with national laboratories and the utility sector to improve the design, security, safety, and resiliency of the U.S. power grid. Thanks to these successive federal investments, the group's technologies are being piloted in real utility environments and their work has become foundational technology for three start-up companies.

Another example demonstrates the power of cross-agency, multi-disciplinary research. A joint initiative between NSF's Division of Mathematical Sciences (DMS) and the National Institute of Health's National Institute of General Medical Sciences (NIGMS) supports research at the interface of the Biological and Mathematical Sciences. The spread of infectious diseases from wildlife to humans is on the rise, with last year's historic Ebola outbreak a recent example. Factors that affect such outbreaks include the density of human and wildlife populations, changes in land use, and human behavior. The joint DMS and NIGMS Initiative has supported work on Ebola, fostering collaborative research projects that leverage the contributions of disease ecologists, epidemiologists, mathematicians and economists to better understand this and other rapidly evolving infectious diseases.

Examples such as these underscore that cross-cutting research and federal support for different aspects and phases of scientific research help NSF investments reach full fruition.

NSF's research priorities are developed through a long-established bottom-up process that begins with the scientific community. Community priorities are identified in a variety of ways – through

the grant making process, through the work of NSF's advisory committees, through National Academies' reports, and through crowdsourcing ideas directly from NSF's principal investigators. These ideas are vetted and prioritized at every level of NSF leadership – programs, divisions, directorates, and the Office of the Director – always with an eye toward advancing science and the Foundation's mission. The NSB – primarily through its Committee on Strategy and Budget that is chaired by former AAAS CEO Dr. Alan Leshner – provides input to the Foundation's leadership as these research priorities are put into the agency's budget. When the Board approves NSF's budget submission, our goal is to ensure that the scientific priorities are sound and consistent with the Foundation's mission, while not squelching the creativity of the scientific community or undercutting the bottom-up priority setting processes that have served our nation so well.

FY 16 Budget Request

The NSF's FY 2016 Budget Request reflects a strategic commitment to supporting the best basic research, economic growth, job creation through innovation, and a globally competitive science and engineering workforce. The Board believes that the priorities in this proposal reflect a clear commitment to investments that will strengthen our nation over the long-term.

NSF's budget request for its Research and Related Activities account is the result of priorities set by the scientific community, NSF management, and the Board, about where the most fertile national and global research challenges lie. This request includes support for research across all fields of science and engineering, which the Board endorses as necessary to fulfill NSF's mission to advance the national health, prosperity, and welfare, and to secure the national defense. This flexibility allows NSF to fund the best research opportunities, regardless of field. For instance, over the past fifteen years, computing research has grown significantly in response to opportunities created by cyberinfrastructure and big data. Interdisciplinary science, which is often at the frontier of new knowledge, is also playing a more prominent role in fostering advances in discovery science.

I would like to also highlight NSF's Agency Operating and Award Management account, known as AOAM. This account covers NSF's scientific, professional, and administrative workforce; the physical and technological infrastructure necessary for a productive, safe and secure work environment; NSF's relocation to Alexandria, Virginia, and the essential business operations critical to managing NSF's administrative processes and providing high-quality customer service. AOAM is lean – in FY 2015, it accounted for only about 6 percent of NSF's budget.

The requested budget for AOAM would allow NSF to bring on additional staff to meet the requirements of the Digital Accountability and Transparency Act and build a digital service team. This will enable the agency to support high quality, transparent federal spending information and transform NSF's digital services, making them easier to use and more cost-effective.

For the National Science Board, we are requesting $4.37 million – unchanged from the current fiscal year – to meet our oversight responsibility of NSF's performance and fiscal integrity and

to work with the Director to capitalize on the opportunities continually arising from the expanding frontiers of scientific knowledge. The Board, through its Audit and Oversight Committee chaired by Dr. Ruth David, president and chief executive officer of Analytic Services, Inc., also works with the agency's Office of the Inspector General to ensure American taxpayers receive the best scientific research in the Nation in return for their investments. NSF's great successes are a tribute to the NSF staff whose excellent work and deep commitment to the mission of this agency is truly inspiring.

Focus Areas and Board Activities

Assessing the U.S. science and engineering enterprise

Access to high quality data, and associated thoughtful critical analyses of it, are essential first steps for decision-makers across government, business and education to craft policies that address our nation's challenges and opportunities in the STEM education and workforce arenas. Providing comprehensive, high quality, accessible data is one of the chief contributions of the National Science Board and its Committee on Science and Engineering Indicators led by Dr. Kelvin Droegemeier, vice president for research at the University of Oklahoma. The Board's congressionally mandated biennial *Science and Engineering Indicators* report – along with a suite of related resources – provides comprehensive data and findings on educational and workforce issues and insights on areas where we can and must do better as a nation. The Board will soon be releasing a policy report that revisits the U.S. STEM workforce and provides a new perspective on how we view both STEM education and training opportunities as well as the nation's job landscape.

Working to enhance time spent on discovery

Another area where we see both opportunities and challenges is that of addressing the administrative burdens placed on federally supported researchers. We share the Subcommittee's concern that administrative tasks related to the increasing number and complexity of federal regulations may unnecessarily be consuming taxpayer dollars and time that our nation's scientists, engineers, and educators could otherwise devote to federally sponsored research. As a result, the Board created a Task Force on Administrative Burdens led by Dr. Arthur Bienenstock of Stanford University. Last year, this task force released a report that assessed current requirements on Federally-supported researchers, and offered recommendations on relieving the administrative workload. The Board is very pleased that its report has been helpful to bipartisan, legislative efforts to address this important issue. NSB will continue to work to help advance progress in this area, and we look forward to working with you to increase efficiency, reduce red-tape, and obtain more research per taxpayer dollar.

Managing risk and balancing the dual needs for large facilities and research

I would like to turn to another Board priority area. NSF's large research facilities advance science and engineering, help maintain U.S. competitiveness, and deliver substantial economic benefits to the nation. Their size and long-term commitment demand priority setting, frequent

assessment, and careful management of risks. The National Science Board, through its Subcommittee on Facilities and its Committee on Programs and Plans, chaired respectively, by Dr. Carl Lineberger of the University of Colorado and Dr. Anneila Sargent of Caltech, plays a strong and active role in this area. Although each and every one of these large projects has grown out of a lengthy science-driven prioritization process, and includes the Foundation's internal review boards, Large Facilities Office, and Major Research Equipment and Facilities Construction (MREFC) Panel, which scrutinizes plans and budgets every step of the way, approval of these projects ultimately comes from the Board. We approve, oversee, and conduct careful review of large facilities at all life cycle stages.

The Board's Annual Portfolio Review looks at NSF's Facilities Portfolio in its entirety and upcoming changes to it. It is attentive to the balance within divisions and directorates and includes an assessment of the trade-offs between large facility maintenance and usage and NSF's support of core research. Recent Board meetings have featured in-depth updates from the agency about the significant progress it is making in clarifying the careful internal and external processes involved in management of its large facilities.

As you know, cooperative agreements play an important role in this arena and the Board and Director have heard concerns about these agreements from the Inspector General. NSB and the Director plan to jointly commission an external, independent review to assess how NSF manages cooperative agreements, and to explore areas where we might improve our procedures. We will give serious consideration to any recommendations that come out of this evaluation.

Accountability and transparency are needed at all federal agencies. NSF is always looking to improve our processes and results. Among recent efforts are reducing regulatory burden through innovative pilot programs and new guidelines to implement nontechnical abstracts that describe how a project serves the national interest. Embracing improvement and transparency are changes we believe will make NSF better and stronger in the long-run and Director Córdova deserves recognition for her attention and leadership in this arena.

Conclusion

In closing, Chairwoman Comstock, I would like to again thank Subcommittee members for their leadership on science and engineering issues.

My colleagues and I understand that, like all Americans, the research community must be willing to make tough choices and set priorities. This is a challenge that my colleagues and I, along with the Director, have embraced, as we understand that it is our responsibility to obtain the best return on the taxpayers' investment.

Even in a time of severe budget constraints, the Board believes that investments in fundamental discoveries, in STEM education, and in our nation's S&E workforce are essential to the nation's long-term prosperity and security.

The Proverbs quote in the House Science, Space and Technology's hearing room perfectly captures the sentiment behind discovery science: "Where there is no vision, the people perish."[1] As you consider NSF's future budgets and priorities, I hope you will remember that discovery requires foresight, daring, and long-term commitments. Congress has always recognized this, and as a result NSF has steadily advanced the frontiers of science. Our researchers, ships, observatories, and long-running surveys have led to revolutionary technologies, Nobel prizes, and even a new state of matter. These tremendous accomplishments are the results of 65 years of partnerships among scientists, universities, the NSF, and Congress.

Thank you for your willingness to engage and respond to the community on NSF reauthorization efforts, for your leadership, and for the opportunity to testify.

[1] Proverbs 29:18.

Dr. Dan E. Arvizu
Director
National Renewable Energy Laboratory

Dan E. Arvizu has served as the Director and Chief Executive of the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colorado, and President of Alliance for Sustainable Energy, LLC since January 2005. He is also an Executive Vice President with MRIGlobal, headquartered in Kansas City, Missouri. He was appointed by two successive U.S. presidents to serve six-year terms on the National Science Board, which governs the National Science Foundation and advises the President and Congress on science policy. He is presently serving as Chairman. He is a Fellow of the National Academy of Engineering and the National Academy of Public Administration.

Prior to joining NREL, Dr. Arvizu was a chief technology officer with CH2M HILL Companies, Ltd. Before joining CH2M he was an executive with Sandia National Laboratories in Albuquerque, New Mexico, leading organizations in energy technologies, material science, and technology commercialization. He started his career and spent four years at the AT&T Bell Telephone Laboratories.

Dr. Arvizu serves on a number of boards, panels and advisory committees including the American Council on Renewable Energy Advisory Board, the Singapore International Advisory Panel on Energy, the Colorado Renewable Energy Authority Board of Directors, and the Stanford Precourt Institute for Energy Advisory Council.

Dr. Arvizu has a Bachelor of Science in Mechanical Engineering from New Mexico State University, and a Master of Science and Ph.D. in Mechanical Engineering from Stanford University.

Chairwoman COMSTOCK. Thank you. And I now recognize Dr. May for five minutes to present his testimony.

TESTIMONY OF DR. WILLIE E. MAY,
ACTING DIRECTOR,
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Dr. MAY. Thank you for the opportunity to appear before you today to present the President's Fiscal Year 2016 budget request for the National Institute of Standards and Technology, NIST, whose mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science standards and technology in ways that enhance our economic security and improve our quality of life. The budget reflects NIST's important role in establishing and addressing the Nation's top scientific and technical challenges that will indeed foster the innovation that creates jobs and strengthens the U.S. economy.

Specifically, the President has proposed a budget for NIST of $1.1 billion that we—as we have heard earlier. This is a $256 million increase in the 2015-enacted level. The budget will support U.S. manufacturers, aid our communities in recovering from disasters, and improve the ways that we connect to the world around us from online banking transactions to using technology to effectively and efficiently manage the smart grid to support the implementation of smart cities.

The largest portion of the requested increase, $194.4 million, focuses on U.S.-based manufacturing. This includes research in the NIST labs, support for the Hollings Marine—Hollings Manufacturing Extension Partnership, MEP, and a new request for the National Network for Manufacturing Innovation, or NNMI.

The NIST laboratories represent the core of our mission. Our researchers conduct world-class research that advances the Nation's technological infrastructure and helps U.S. companies continually improve their products and services. The basic research in the NIST laboratories has garnered five Nobel prizes over the last 18 years, a Kyoto Prize in material science, two National Medals of Science, and over 100 other national and international scientific awards and prizes.

NIST conducts more applied research in the standards area in areas of national and global importance including but not limited to cybersecurity, advanced communications, advanced manufacturing, advanced materials, and strengthening the science that underpins the forensic data and information used to make decisions in our criminal justice system.

The Fiscal Year 2016 budget request for—on Standards and Technology Research Services account is for $754.7 million. This is an increase of $79.2 million over the 2015 budget, and this is to grow our capacity in advanced manufacturing, cybersecurity and privacy for our nation's growing digital economy and for the fundamental measurement science and technology that is critical to U.S. innovation and improved quality of life.

The increase will also provide for continued operation of our world-class Center for Neutron Research and will strengthen our efforts to support the Nation's community disaster resilience programs.

Madame Chairwoman, NIST Industrial Technology Services appropriations supports our External Partnership programs designed to enhance American innovation and global competitiveness through partnerships at the state and local level. For ITS account the Fiscal Year 2016 request is for $306 million. That is a $167 million increase and we recognize that. $150 million of that would support the establishment of the NNMI that we have heard about envisioned to be a globally diverse set of regional hubs coordinated by NIST to accelerate the development and adoption of new cutting-edge manufacturing technologies.

The major portion of this amount is to establish two manufacturing innovation institutes to address the advanced manufacturing needs identified by industry. The eight institutes that have been identified to date are focused on U.S. Government agency needs, namely those of the DOD and the DOE. The ITS report also supports an $11 million increase—$11 million to increase the ability of our MEP centers to service small, rural, and young companies.

Our construction budget request is for $59 million. It represents an $8.7 million over 2015. Simply put, the aging and deteriorating buildings and infrastructure on our two campuses are beginning to threaten our ability to accomplish our mission.

Ms. Chairwoman, the NIST labs play a unique role in the Nation's research and technology development enterprise. We sit at the nexus of the science and industry conducting cutting-edge world-class science and developing standards that will allow industry to innovate and compete successfully. Both our labs and our extramural programs are clearly focused on providing the tools to allow U.S. manufacturing to experience a renaissance of technological leadership.

Thank you for inviting me to testify today and I will be happy to answer questions.

[The prepared statement of Dr. May follows:]

Testimony of

Willie E. May, Ph.D.

Acting Under Secretary of Commerce for Standards and
Technology and Acting Director, National Institute of Standards
and Technology
United States Department of Commerce

Before the
United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Research & Technology

An Overview of the Fiscal Year 2016 Budget for the National Institute of Standards and Technology

February 26, 2015

Chairwoman Comstock, Ranking Member Lipinski, and members of the Subcommittee, thank you for the opportunity to appear before you today to present the President's Fiscal Year (FY) 2016 budget request for the Department of Commerce's National Institute of Standards and Technology (NIST). This budget reflects the important role that NIST plays in addressing our Nation's top scientific and technical challenges. In releasing the budget, the President said he wanted to ensure that we "*invest in America's future and commit to an economy that rewards hard work, generates rising incomes, and allows everyone to share in the prosperity of a growing America.*" The FY2016 request for NIST will contribute to a more competitive and prosperous America through investments that help secure cyberspace, revolutionize communications, strengthen U.S. manufacturing, and make our communities smarter and more resilient.

The President has proposed a fiscal year budget for NIST of $1.1 billion. This is $255.8 million above the FY 2015 enacted level

This budget request will support U.S. manufacturers both large and small, aid our communities in recovering from disasters, and improve the ways we connect to the world around us—from online banking transactions to using technology to efficiently manage the smart grid and health care systems. These funds will support NIST's work to foster innovation that creates jobs and strengthens the U.S. economy.

The largest portion of the requested increase, $194 million, focuses on U.S. based manufacturing, including support for the National Network for Manufacturing Innovation (NNMI). The NNMI is envisioned to be a geographically diverse set of regional research hubs coordinated by NIST to accelerate development and adoption of cutting edge manufacturing technologies. The request seeks $150 million to allow NIST to establish two new openly competed institutes that address manufacturing needs identified by industry. The funds requested for NIST are part of a larger $350 million request across multiple agencies that will bring the total number of manufacturing institutes to sixteen.

Scientific and Technical Research Account Initiatives (+$79.2M)

The NIST Laboratories are at the core of our mission. Our researchers conduct world-class research, often in close collaboration with industry that advances the nation's technology infrastructure and helps U.S. companies continually improve products and services. The FY 16 budget request of $754.7 million, which is a $79.2 million increase above FY 2015, makes the investments begun in FY 2008 to grow NIST's scientific capacity supporting manufacturing, advancing cybersecurity of critical infrastructure and the digital economy, and helping us to remain at the forefront of measurement science and technology research and development.

Ensuring a World Class Neutron Facility (+11.0M)

One of NIST's top priorities this year is ensuring the continued operation and availability to users in industry and academia of one of the world's foremost neutron research facilities.

The budget proposes an increase of $11.0 million to ensure that NIST continues to provide a world-class neutron research facility and provide access to sophisticated measurement tools that can be used by industry. NIST is requesting funds for reactor facility enhancements in three areas in order to maintain the high availability and reliability of the source for the NIST Center for Neutron Research (NCNR) users: fuel manufacturing and shipping, primary cooling system upgrades, and heavy water replacement.

Neutrons have been enormously successful as a unique probe of the structure and dynamics of materials for researchers from many different backgrounds, including academia and industry. NCNR will maintain and grow its high quality facility to address the neutron supply-demand mismatch by investing in a lifetime extension of the source facility to maintain reliable operations and high availability to the end users.

NCNR is the only U.S. facility with a focus on enhancing industrial competitiveness. It is therefore essential to U.S. industry, and the long-term economic growth of the U.S., that the NCNR is optimally equipped to provide state-of-the-art measurement tools to the U.S. scientific and engineering community. The NCNR operates 24 hours a day, seven days a week for approximately 250 days of the year to support experiments by over 2,000 research participants annually. It is critical that the research reactor operates safely and reliably in order to support the NCNR mission to develop and provide advanced neutron measurement techniques and instrumentation for research.

Enhancing Cryptographic Capabilities and Privacy Technologies (+7M)

Cybersecurity remains one of the most pressing challenges facing our nation today, and the FY2016 request will continue to strengthen NIST's capabilities in this important area. Specifically, NIST requests an increase of $7.0 million to strengthen the Nation's cybersecurity posture by providing strong cryptographic solutions and the development of privacy enhancing solutions and tools.

$5.0 million of the $7.0 million increase is aimed at ensuring the continued delivery of robust and independent cryptography capabilities. NIST must increase both its cadre of Federal cryptographers and its access to top academic talent and begin to build the quantum resistant public-key architectures and systems, which will take more than 15 years to fully develop and deploy.

The remaining $2.0 million would fund development of privacy-enhancing technologies and architectures based on commercially available products that provide privacy protecting capabilities that are easy to use, design, and deploy by system users and developers.

In addition to the obvious financial ramifications with nearly $262 billion of e-commerce transactions in the U.S. alone for 2013[1], interconnected networks of computers have become essential for critical functions that affect every aspect of our lives including air traffic control, factory operation, and electrical power distribution.

The annual cost to the global economy from cybercrime is estimated at more than $445 billion[2], including both the gains to criminals and the costs to companies for recovery and defense. Investments in cybersecurity and the development of privacy tools are critical to prevent further expansion in the gap between attackers' capabilities and defenders' ability to prevent attacks from succeeding and limit the impact of those attacks that do succeed.

Quantum-Based Sensors and Measurements (+$5M)

NIST requests an increase of $5 million to develop and deploy cutting edge quantum-based measurement capabilities and quantum standards necessary to maintain U.S. leadership in quantum information science. NIST research will be targeted to engineer quantum systems for improved sensing and better and/or cheaper quantum standards.

The program will create, develop, and characterize robust and efficient hybrid quantum systems that enable efficient transformation of quantum information from one modality to another; develop tools for understanding, manipulating, controlling and measuring complex quantum systems; and to develop and explore quantum materials for future advanced quantum devices.

Quantum information science is an emerging research field that will revolutionize everything from computation and communications, to the development of precision measurement technologies. This field seeks to harness the fundamental laws of physics to dramatically improve information acquisition, transmission, and processing. Improvements in both basic and applied quantum information science have far-reaching industrial applications, national security implications, and economic benefits.

Measurement Science for Advanced Manufacturing Initiatives (+$24M)

Strengthening measurement science R&D across the NIST labs that directly impacts manufacturing continues to be a top priority for NIST. As noted by the President's Council of Advisors on Science and Technology, "the United States' (U.S.) leadership in manufacturing comes from its leadership in advanced technologies and the innovation that fuels their discovery and adoption. Sustaining U.S. competitiveness in manufacturing is thus, ultimately, an exercise in staying at the forefront of new technologies and continually breaking boundaries in both what and how it can be manufactured." NIST has partnered with the U.S. manufacturing sector for more than a century, providing the measurement tools and other essential technical assistance that existing manufacturers and aspiring start-ups need. NIST continues to help manufacturers invent, innovate, and produce new products and services more rapidly and more efficiently than their competitors around the world.

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[1] Forrester Research, Inc.'s February 4, "Market Overview: eCommerce Fraud Management Solutions, 2014.
[2] http://www.mcafee.com/us/resources/reports/rp-economic-impact-cybercrime2.pdf

NIST is requesting increases in the following areas:

» **ADVANCED SENSING FOR MANUFACTURING (+$5M)**

NIST requests an increase of $5 million to support sensing and measurement gaps in the areas of advanced sensors used for process control in manufacturing.

A highly integrated effort across NIST laboratories in measurement science and standards will accelerate the design, development, and manufacturability of advanced electronic and photonic devices -those that require new concepts, architectures, materials, and manufacturing methods.

The NIST laboratories have a long tradition of developing and delivering measurement science tools that support advanced manufacturing technologies. NIST will leverage its existing capabilities in materials modeling and simulation, in support of the Administration's Materials Genome Initiative, as well as expertise in nanomanufacturing, digital design, chip-scale measurement technologies, robotics, additive manufacturing, and cyber physical systems.

» **MATERIALS GENOME INITIATIVE (MGI) (+$10M)**

The proposed $10 million increase for the Materials Genome Initiative (MGI) provides the resources to accelerate NIST's progress in its key role in the MGI, an interagency effort to dramatically influence the pace for bringing new materials to market. NIST is already working to develop an advanced materials innovation infrastructure, including data assessment and validation, data standards, and modeling and simulation tools. This increase is necessary to enable NIST to meet the ambitious timelines demanded by industry and other stakeholders to provide this interoperability and accessibility of materials information. By leveraging resources and partnerships, NIST will assist U.S. manufacturers in achieving materials-by-design for high-tech products in a range of industrial sectors.

The proposed increase in funding will enable NIST to accelerate the development of a materials data infrastructure. New measurement science and standards developed based on the availability of this infrastructure will enable industrial researchers to effectively discover the data and models they need, assess the quality of these data and models, and use these data and models to maximum effect.

» **ENGINEERING PRINCIPLES FOR EFFICIENT BIOMANUFACTURING (+$4.0M)**

NIST requests an increase of $4.0 million to ensure quality and predictability in the design of synthetic biological systems for efficient production of fuels, chemicals, pharmaceuticals, and medical therapies. Maintaining a strong investment in forward-looking basic research is a critical component to maintaining the technical infrastructure required in innovation-intensive economies. Biomanufacturing has the potential to usher in the next Industrial Revolution into many U.S. manufacturing sectors. However, for biomanufacturing to reach a sustainable maturity in all sectors, there are three main hurdles that need to be overcome: reducing the risk of contamination; maintaining high productivity and efficiency, and;

reducing product variability among different manufacturing runs. Creating a more reliable, even predictable biomanufacturing process would address all the technological hurdles and help to reduce the uncertainty that currently hampers the regulatory process, most immediately for biologics.

This initiative addresses the technical challenges faced by the biomanufacturing industry by developing a suite of quantitative methods for accurate measurement of biological systems, creating the necessary tools to methodically design and test engineered organisms, and, by engaging relevant stakeholders, develop and evaluate predictive models.

» **MANUFACTURING ENTREPRENEURSHIP (+$5M)**

To support innovation in the marketplace NIST has developed the NIST Manufacturing Entrepreneurship initiative, which will strengthen the U.S. manufacturing sector by reducing barriers that prevent new entrepreneurs from entering the manufacturing marketplace. NIST has the potential to foster and expand upon the early growth in manufacturing entrepreneurship by providing infrastructure needed to promote knowledge transfer among the "maker" community, and facilitate new models of collaboration between entrepreneurs, commercial manufacturers, and government agencies.

This initiative will provide access to manufacturing knowledge that increases the value and variety of what manufacturing entrepreneurs can design and manufacture and will provide a robust manufacturing eco-system that provides full support for new manufacturing entrepreneurs.

Advanced Communications (+$9M)

The availability of secure, reliable, high-speed wireless communications is essential for the United States' future economic health and security. Businesses and consumers are becoming increasingly dependent on wireless devices that require reliable, fast and secure access to broadband data as well as voice and video services. The proliferation of wireless connections, numbered at 7 billion in 2013, is estimated to grow to over 10 billion by 2018[3] placing a strain on the already congested frequency spectrum that is allocated to mobile wireless networks.

With the requested $9 million, NIST will focus its efforts on research that supports industry to develop and deploy advanced communication technologies for both the existing and future frequency spectrum bands allocated for wireless communication systems. In addition, this initiative would focus on improving spectrum efficiency and spectrum sharing by developing performance metrics, measurement methods and tools and their successful implementation in a test and evaluation environment, as well as facilitating R&D of innovative spectrum sharing technologies and expedite product development.

[3] 2013 Cisco VNI Mobile Forecast.

Finally, the initiative would fund the development of communications systems that operate at the recently-released millimeter-wave portions of the frequency spectrum that are well above the current cell-phone bands.

Disaster Resilience (+10M)

Preventing hazard events from becoming debilitating disasters requires resilient buildings and infrastructure. The development of improved building codes will first require a robust capability to predict the effects of hazards on the performance of complex structural systems, including: data to characterize the hazard, validated physics-based models to predict performance, metrics for measuring performance, acceptance criteria for differing levels of performance objectives, and mitigation strategies based on performance evaluation.

NIST requests $10 million to develop the scientific basis to enable technology innovations, improve prediction capabilities, and improve codes and standards for cost-effectively reducing loss of life and property damage due to natural and man-made hazards.

Smart Cities and Cyber-Physical Systems (+$5.0M)

NIST requests an increase of $5 million to develop and accelerate the adoption and use of measurement science foundations that enhance innovation in smart city technologies and increase the market size for and accessibility to markets for U.S. industry. Facing rapid population growth, inefficient and aging infrastructures, and the needs of an increasingly digital society, communities across the Nation and around the world look to harness the power of emerging cyber physical systems and technologies to improve livability, workability, resilience, and sustainability by addressing their core challenges, including traffic congestion, public safety, and inadequate infrastructure.

The requested funds will fund development of the measurement science foundations for cities and commercial technology innovators to design and develop interoperable platforms that reliably and demonstrably leverage sensor-driven data for improved results; enable solutions that meet today's needs while evolving to accommodate new technologies and expanded requirements in the future. Further, it would fund development of standards and guidelines for interoperability, Smart City test beds for science-based design, and the development of IT building blocks for Smart City solutions to enable Smart City systems that can be protected against cyber threats; protect the privacy of residents while ensuring they can benefit from Smart City services and resources; and provide for reliable systems that function under stress or crisis situations.

Lab-to-Market/Technology Transfer (+$4M)

Improving technology transfer from Federal R&D continues to be a top priority for the Administration. NIST requests an increase of $4 million to expand lab-to-market and technology transfer activities through the development and deployment of data sharing and collaboration tools and services. The U.S. invests more than $135 billion annually in research and development and a wide range of life-changing commercial technologies such as the Internet, to the Global Positioning System (GPS) to leading edge vaccines were nurtured by such

federally funded R&D in the past. Now we need to accelerate the transfer of federally funded R&D to U.S. businesses.

Industrial Technology Services (ITS) (+$168M)

NIST's Industrial Technology Services (ITS) appropriation supports its external partnership programs that are designed to enhance American innovation and global competitiveness through partnerships with State and local organizations. The FY 16 request of $306 million, an increase of $168 million above the FY15 enacted, for the ITS appropriation consists of three programs: the National Network for Manufacturing Innovation (NNMI), the Hollings Manufacturing Extension Partnership (MEP), and the Advanced Manufacturing Technology Consortia program (AMTech).

National Network for Manufacturing Innovation (NNMI) (+150M)

The top priority for the Department and Administration in the FY 2016 request is the $150 million to establish two new manufacturing institutes and conduct coordination activities related to the NNMI.

This initiative is part of a multi-agency effort to bring the National Network for Manufacturing Innovation (NNMI) to a total of 45 institutes, with discretionary funds requested in FY16 to launch or continue support a total of 16 institutes across the Departments of Energy, Defense, Agriculture, and Commerce. The $150M requested for NIST is critical as it will support the creation of 2 openly competed institutes that specifically address advanced manufacturing needs generated by industry that fit outside the missions of our Federal partners. Ensuring that the U.S. has the technical infrastructure to support and attract a robust and vibrant domestic civilian focused manufacturing base, in addition to a strong defense manufacturing base, is a primary goal of the NNMI program. NNMI institutes will facilitate the adoption of new manufacturing technologies, tools, and methodologies that will make U.S. manufacturers more competitive.

Hollings Manufacturing Extension Partnership (MEP) (+$11M)

The requested increase will focus on a recompetition of Centers in the MEP system. Through this process, MEP will take into account variations in the number of small and medium manufacturing firms in a region to ensure that Centers are adequately equipped and funded to address the needs of their manufacturing communities. In addition, MEP will disseminate the results and lessons learned from its pilot programs to build on efforts supporting industry collaboration through Business-2-Business networks; continue to support its partnership with the Department of Energy (DOE) and the Environmental Protection Agency (EPA) to focus on implementing sustainable manufacturing business practices; work with manufacturing firms to innovate and increase business opportunities to address new markets and to expand into overseas markets and identify manufacturers with current or future capabilities to address the procurement opportunities of the Federal government and original equipment manufacturers.

Advanced Manufacturing Technology Consortia (AMTech) (+$6.9M)

For FY 2016, NIST requests an increase of $6.9 million for the Advanced Manufacturing Technology Consortia. AMTech establishes industry-led consortia, which will identify and prioritize research projects supporting long-term industrial research needs. AMTech creates the incentive for multiple industry stakeholders to share financial and scientific resources, together with state and local government interests, as well as technical innovators at universities and government laboratories.

This year NIST will make planning awards to existing or established consortia for consortium enhancement and technology roadmap development. NIST will support and continually monitor newly established research consortia to track outputs and progress.

Construction of Research Facilities (CRF) (+8.7M)

Aging and deteriorating buildings and infrastructure threaten NIST's ability to meets its mission. State-of-the-art facilities are essential to supporting the world-class research conducted at NIST. The Construction of Research Facilities (CRF) appropriation supports both new construction and renovation efforts of NIST's physical plant and infrastructure at its two research campuses. The request for CRF of $59 million would enable NIST to fund the next phase of planned multiyear critical renovations in our laboratories in Boulder, Colorado. The major construction projects funded through this request are:

- $3 million for the renovation of Boulder Campus Building 3 to support existing and expanding Boulder research functions; and
- $12 million for concept development, design documentation and initial relocation efforts associated with the renovation of Wing 5 of Boulder Building 1, an Eisenhower Administration-era building that is woefully out of date for the type and level of research conducted in Boulder.

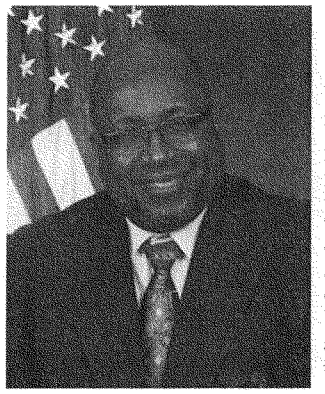
Summary

In conclusion, the FY 2016 NIST budget request reflects the Administration's recognition of the important role that NIST plays in innovation, as well as the impact that the research and services NIST provides can have on laying the foundation for long-term job creation and prosperity.

NIST will continue its mission to work with the private sector to ensure U.S. manufacturers have the research support they need. The NIST laboratory programs, along with its outreach efforts and standards development work, are dedicated to providing U.S. industry with the tools needed to innovate, compete and flourish in today's fierce global economy.

I look forward to working with you, Madam Chairwoman and members of the Subcommittee, and would be happy to answer any questions.

Dr. Willie E. May



Dr. Willie E. May is currently serving as the Acting Director of the National Institute of Standards and Technology (NIST). He also serves as Acting Under Secretary of Commerce for Standards and Technology, a new position created in the America COMPETES Reauthorization Act of 2010. Prior to this assignment, Dr. May served as Associate Director for Laboratory Programs, where he was responsible for oversight and direction of NIST's seven laboratory programs and served as the principal deputy to the NIST Director.
As Acting NIST Director, Dr. May provides high-level oversight and direction for NIST. The agency promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. NIST's FY 2014 resources total $850.0 million indirect appropriations, an estimated $47.3 million in service fees, and $107.0 million from other agencies. The agency employs about 3,000 scientists, engineers, technicians, support staff, and administrative personnel at two main locations in Gaithersburg, Md., and Boulder, Colo. NIST also hosts about 2,700 associates from academia, industry, and other government agencies, who collaborate with NIST staff and access user facilities. In addition, NIST partners with more than 1,300 manufacturing specialists and staff at more than 400 MEP service locations around the country.

Other National and International Responsibilities: Dr. May has several leadership responsibilities in addition to those at NIST. He is Vice President of the 18-person International Committee on Weights and Measures (CIPM), President of the CIPM's Consultative Committee on Metrology in Chemistry and Biology; Executive Board Member for the Joint Committee on Traceability in Laboratory Medicine; Board of Visitors for the University of Maryland College Park's College of Computer, Mathematical, and Natural Sciences.

Honors and Awards: Department of Commerce Bronze Medal Award, 1981; National Bureau of Standards (NBS) Equal Employment Opportunity (EEO) Award, 1982; Department of Commerce Silver Medal Award, 1985; Arthur Flemming Award for Outstanding Federal Service, 1986; NOBCChE Percy Julian Award for Outstanding Research in Organic Analytical Chemistry and Presidential Rank Award of Meritorious Federal Executive, 1992; Department of Commerce Gold Medal, 1992; American Chemical Society Distinguished Service in the Advancement of Analytical Chemistry Award, 2001; Keynote Speaker for the 2002 Winter Commencement Ceremonies, University of Maryland, College of Life Sciences; Council for Chemical Research Diversity Award, the NOBCChE Henry Hill Award for exemplary work and leadership in the field of chemistry, Science Spectrum Magazine Emerald Award in 2005, the 2007 Alumnus of the Year Award from the College of Chemical and Life Sciences at the University of Maryland, member of first class of inductees into the Knoxville College Alumni Hall of Fame in 2010 and Fellow of the American Chemical Society in 2011; Honorary Doctor of Science and Speaker at Graduate School of Arts and Sciences Commencement Exercises, Wake Forest University in 2012.

Employment History:

Worked as a senior analyst at the Oak Ridge Gaseous Diffusion Plant for three years prior to coming to the National Bureau of Standards in 1971. Led research activities in analytical chemistry for more than 20 years with his personal research being focused in the area of trace organic analytical chemistry, with special emphasis on retention mechanisms in liquid chromatography, the development of liquid chromatographic methods for the determination of individual organic species in complex mixtures (i.e., extracts of environmental, food, and clinical samples) and the determination of physico-chemical properties such as aqueous solubilities, octanol/water partition coefficients, and vapor pressures of organic compounds. This work is described in more than 100 peer-reviewed publications. More than 250 invited lectures have been presented at U.S. industrial sites, Colleges/Universities and Technical Meetings throughout the world.

Education:

1968	Knoxville College	B.S.
1977	University of Maryland	Ph.D.

Chairwoman COMSTOCK. Thank you. And thank you to all of our witnesses. I appreciate having you here today and now we are going to have five minute question rounds. And I will recognize myself initially for a five minute round.

Following up on really what all of you talked about in some regard, could you give us a little bit more detail on the role that private industry plays in terms of creating and retaining science and engineering jobs and how—versus the public and how the money that we are spending can then leverage that private money? I think you all spoke to that a little bit but if maybe we could detail that a little bit more and how can we ensure that we are targeting our resources into areas that will leverage and create these new 21st century jobs that we all are very committed to expanding?

Dr. CÓRDOVA. I will be happy to start, Madam Chairwoman. So just two comments. One is that, as you know, NSF has a very strong STEM workforce investment, and we—especially at the undergraduate and graduate level but also in K through 12 and really the whole spectrum of training for science and engineering careers. In my experience as a university professor being very close to the students and close to their passion for getting a job and contributing to the economy and being happy was that business—private business was very, very interested in our students because of the skill sets that they got when they were at the university, and most of our students have the opportunity to participate because of the funding of places like NSF and NIST in science and engineering with—along with their faculty members. And this was just excellent training.

Chairwoman COMSTOCK. In terms of internships and things that were——

Dr. CÓRDOVA. Absolutely. Internships for the summer and engineering programs. There are internship programs for a whole year. So that is one aspect of this investment.

And the other is that NSF—I did a broad survey of the partnerships that our agency has with private industry, and we have over a couple of hundred partnerships, maybe even more than that across the whole spectrum of dollar funding that really leverage our federal investment with private funding. And sometimes that is on workforce and investment in students and university, say, centers, engineering centers, industry university research centers that we fund, and sometimes it is in the actual science and engineering programs themselves. So we are—I think we are very good partners. We have an emphasis this year in particular on accelerating the numbers and kinds of partnerships that we have with the private sector.

Chairwoman COMSTOCK. Thank you.

Dr. ARVIZU. If I may just add slightly to that, I will be brief. I mentioned the ecosystem of the Nation and how NSF supports fundamental research that ultimately finds its way into the marketplace. There is probably nothing better than a few examples——

Chairwoman COMSTOCK. Yes.

Dr. ARVIZU. —to describe kind of how that might occur and so I have got a couple that I think might be useful. I will just focus on one.

NSF has sponsored fundamental research on synthetic chemistry and transforming positron emission tomography, PET imaging, which is an important new technique, and an NSF-funded chemist, Stephen DiMagno, discovered how to create some organic compounds rapidly and efficiently. After that, PI was recognized and went through the I–Corps program that NSF sponsors along with SBIR, which is special grants. That has resulted in ground-floor pharmaceuticals from Lincoln, Nebraska, a company that produces radio tags for this kind of imaging and they have recently signed an exclusive license with Massachusetts General Hospital, which will give rise to a whole suite of new diagnostic techniques in a competitive manner and allow there to be the fundamental work that was done to provide a great opportunity for an expansion of things that really I think offer great and wonderful applications in the marketplace.

Chairwoman COMSTOCK. Great. Very good.

Dr. MAY. I think each of us is going to answer this a little different, so here is my spin on this.

When I came to NIST 43 years ago we had 3,000 employees. We—actually we had 3,300. Today, with all of the new assignments and the growth in the organization, we have 3,000 employees, less than we had then, but we have 3,500 associates. These are people who work on our campus almost on a daily basis that are not employees that we interact with. So we have changed our interaction platform considerably.

We have associates from industry, from academia, from other government laboratories, some foreign laboratories. A large portion of those are with our students, postdocs and students who spend time on our campus. We are also gaining new capabilities that we need to carry out our mission and do some of the new activities that I heard many of you speak about through something called joint institutes or centers of excellence that we are establishing with the university sector.

So as we are growing our program, addressing the new challenges that we are being asked by the Administration, the Congress, and industry to take on, we are not doing that by hiring more federal employees; we are doing more collaborations and using the talents in the university system and the private sector to work with us to deliver our mission.

Chairwoman COMSTOCK. Okay. Thank you.

And I would ask any of you, if you have additional examples because those examples are always very helpful for us to really have the object lessons on how this is impacting, so thank you.

And I did—my time is up but I did want to maybe for the record ask about regulatory and reporting burdens that might—you know, we have heard that from the universities and researchers and any of those things that might limit your ability to target the resources to the best use, and if you would like to identify any of those for us for the record.

So now I will recognize our Ranking Member Lipinski for his questions.

Mr. LIPINSKI. Thank you. I want to start with Dr. Córdova, and I have a number of questions. Hopefully we can have a second round and maybe get through a couple here. But, Dr. Córdova, I

know you have been actively engaged on improving transparency and accountability at NSF and I want to thank you for that. I want to join the Chairman in thanking you for that because all of us want to make sure that the research dollars are being spent in the best way possible.

But I want to give you an opportunity to explain to the Members, especially new Members on the Committee, just what you are doing that is new for transparency and accountability.

Dr. CÓRDOVA. Thank you, Member Lipinski.

So we have been very engaged in enhancing our transparency and accountability processes since I came 11 months ago to the agency, and the first thing I want to do is just thank Chairman Smith and the Members of the overall Committee for moving us more in that very important direction. It was definitely the right time and we want to be very responsive. We completely agree that this is very, very important that the public understands the investment that this country is making in science and engineering and STEM education.

We—so we—as of last May, we instituted some new practices, which—on transparency and accountability which focused on clarifying, communicating better the titles and the abstracts for proposals. Those two things were online for all proposals, and having a nontechnical description which would clearly say what the proposal's goals were about in clear English and also what is the potential impact of the research and how it serves the national interest.

And so that was the order of the day as of last May. As you can imagine, this is a big change. We get over 50,000 proposes a year from which we select about 11,000, so it is a big, complicated engine that works on the whole merit review process. So we then instituted our practices into guidance, which came out at the same time as the OMB Uniform Guidance that—they come out together. We changed our manuals, which are both internal for program officers doing the overseeing of the review process and for—and another one for the external community so that they could see what the expectation was.

And so the effective date of all these changes I would like to call January 1 of 2015 that we will really see a difference in what is being done and how it looks to the public and how they proposals are being reviewed.

On top of that we have training, new kinds of training for the program officers and division directors that really do the bulk of the merit review process, and it is—basically it is a cultural change for the agency. And as you know, Representative Lipinski, culture change takes a while to take hold. And so—but all the system directors who are sitting behind me are just firmly committed to this, each in their own disciplinary area, and I expect that we will see some real changes here.

I also should add I sent a so-called important notice, which is sent very rarely—I have only sent out one as NSF Director so far—to all the university presidents letting them know of these changes and we have a website of course for further clarification. We have working groups internally. Every speech that I have made—I

would say every speech that I have made for the last few months has included a description of our efforts in this regard.

Mr. LIPINSKI. Thank you very much. I know as a former academic how tough cultural change is.

I don't have much time but I want to throw this question out. SBE, the Social and Behavioral Science and Economics directorate, can you—Dr. Córdova, can you talk about how important that is to solving grand challenges that we have in health, energy, education, national security, cybersecurity, and so many other things?

Dr. CÓRDOVA. So the social and behavioral economic sciences are incorporated—when I go around my university visits—and I just came back from visiting a few universities and research centers in the country—are incorporated into really everything we do and think about as scientists and engineers. So there are lots of centers, some of which have been funded by NSF, some by other agencies and some by the universities themselves, or all of them, and they invariably include social and behavioral and economic scientists now because they are trying to address some grand challenges that face our country and our world and they realize the importance of having the social and behavioral sciences there to inform.

Let me just give you one example for Chairwoman Comstock that there is—and the Arizona State University there is a big bio-design center that embraces lots of particular kinds of research around that incorporates physics and biology and so on. They also have as an integral part of that a center called Nanoscience in Society which everyone goes through, all the other centers connect to, to evaluate if you are thinking of a new concept in nanotechnology or really any of the bio and physical sciences what could be the potential impact and what are the ethical and legal and kind of public considerations for how that technology could be used? And I was told that sometimes scientists just actually make a pause and head off maybe in a different direction based on being informed by social and behavioral economic scientists sitting at the table with them and looking at the potential impact of what they are developing in their new technological approaches.

Chairwoman COMSTOCK. Okay. I——

Mr. LIPINSKI. Thank you. I thank the Chairwoman for indulging me there.

Chairwoman COMSTOCK. Great.

And I now recognize Chairman Smith for questions.

Chairman SMITH. Thank you, Madam Chair.

Dr. Córdova, let me say at the outset that that was wonderful to hear your three examples of breakthrough winners dealing with treating diseases and oil spills and the brain. And you quoted the individual I think who won the award for treating diseases as saying that there is a scientist in every child. That is a wonderful quote. I intend to plagiarize that in the future. But I think it does point to frankly the responsibility we all have and that is to make the study of science more interesting to young people. And that is the subject of another hearing, but that certainly should be a goal of ours in lots and lots of ways.

Thank you, too, for mentioning the computer—the supercomputer at University of Texas. I only wish I became Chairman of the Com-

mittee a few years earlier so I could have taken more credit for that supercomputer. But they are pleased with it and it is doing a lot of good work.

I would like to address my first couple of questions to you and ask about your policy, which I appreciate and which you mentioned a few minutes ago as well. And I just want to make sure that I understand the policy and see if you feel if the National Science Foundation policy is compatible and agreeable to the similar provision in the FIRST Act. I am not asking you to endorse the FIRST Act but just to focus on that provision as parallel.

Dr. CÓRDOVA. Mr. Chairman, thank you for—and Mr. Lipinski for raising the important issue of greater transparency and accountability. Your legislative provision—I think it was Section 106 of the FIRST Act from the last Congress, which focuses on the national interest is very compatible with the new NSF internal guidelines and with the mission statement of NSF, which I quote "to promote the progress of science to advance the national health, prosperity, and welfare and to secure the national defense." We share the same goals and believe that these policies—transparency, accountability, the national interest—are to be found in the 1950 law that created NSF and established our mission.

And so we likewise thought it was important and appropriate to add the explicit reference the national interest in our revised guidelines.

Chairman SMITH. Okay. And you I assume then support the language we have in the FIRST Act that deals with that particular subject?

Dr. CÓRDOVA. Yes, we do.

Chairman SMITH. Okay. Thank you.

And, Dr. Arvizu, as Chairman of the Science Board, do you concur with that? I shouldn't ask you if you agree with Dr. Córdova because that is not fair but do you agree with the idea that the provisions in the FIRST Act that we are talking about and the NSF policy that Dr. Córdova has been promoting and when—we appreciate that—are compatible and similar and you support the language in the FIRST Act as well?

Dr. ARVIZU. Yeah. Thank you, Chairman Smith, for the questions and for asking our input on that.

I think I can speak without reservation that my colleagues and I on the board—I support the goal that is clearly articulated in this section and we agree that awards that NSF makes need to be able to support the best ideas and fulfillment of the mission that was essentially just quoted by Dr. Córdova. And we like the whole quote, which includes "and other purposes" but I think the main thing to say here is that we concur with her assessment of the changes that are being made——

Chairman SMITH. Okay.

Dr. ARVIZU. —so I want to thank you for your leadership on that.

Chairman SMITH. And again, it goes below—it goes beyond agreement, you agree with our language as well and you support the language we have?

Dr. ARVIZU. I think, again, we will offer the opportunity to offer additional input to make and strengthen that but——

Chairman SMITH. Dr. Córdova said she agreed with the language. Don't you as well or——

Dr. ARVIZU. Well, we agree in principle that this is actually meeting the goals that we are trying to accomplish and I think it is probably best to wait until the language actually comes out, but I—with what I have seen so far, I think we can agree with that language.

Chairman SMITH. Okay. Thank you very much.

I have two other questions. Let me come back to transparency and accountability because I want to ask you, Dr. Córdova, what you think needs to be done yet. But before I get there, you had a question a while ago about the SBE directorate. Do you consider the SBE directorate any more important than any other directorates? I mentioned in my opening statement that SBE got a seven percent increase. The others—Biology, Computer Science, Engineering, Mathematical, and Physical Science Directorates got less. Do you think SBE is there—more important than the other directorates? Why should it get a greater increase than the others if it should?

Dr. CÓRDOVA. Well, Chairman Smith, those are two different questions.

The reason why they have a bigger increase is in large part because of the funding—the increase in funding for the National Center for Science and Engineering Statistics, which is within SBE.

Chairman SMITH. If you take that out—what is the increase if you take that out?

Dr. CÓRDOVA. Well, let me just ask Mr. Sievert behind me——

Chairman SMITH. Okay.

Dr. CÓRDOVA. —what is the increase if we take out the Center because that center of course is the basis for the science and engineering indicators and the Congressional Research Service depends on——

Chairman SMITH. Okay. Well——

Dr. CÓRDOVA. —the statistics——

Chairman SMITH. Well, that is being——

Dr. CÓRDOVA. Sure. Thank you. Fine.

Chairman SMITH. —determined—if I can, let me just ask you to elaborate because I know you are doing some——

Dr. CÓRDOVA. Right.

Chairman SMITH. —positive things in this regard and that is what remains to be done in the areas of transparency and accountability? I know you are making some changes and I didn't know if you wanted to elaborate on those or not.

Dr. CÓRDOVA. I think improving communication is always important when you are making cultural change and so that people understand clearly what the expectations are. I think we will have a lot of work to do internally which we would like to share with the external proposing community on writing nontechnical descriptions of the research. This will be—this is kind of a new adventure for some, not for all, and so we—rather than—as you know, the number of proposals has—over the last decade has increased tremendously and the number of FTE have not, so workload is a consideration so we will have to figure out and we are trying out new pilot programs and merit review, including virtual panels and all the

rest of it to try to have the merit review process itself be efficient and effective. And this is all part of it is communicating how we do this work in that overall context.

Chairman SMITH. Thank you, Dr. Córdova. My time is way over.

And do you have a quick percentage—and here comes the answer. You feel like you are—oh, not yet? Okay.

Dr. CÓRDOVA. For the record. We will submit it for the record.

Chairman SMITH. Okay. We will look forward to getting that.

Dr. CÓRDOVA. Okay.

Chairman SMITH. Thank you.

Dr. CÓRDOVA. That is the answer.

Chairman SMITH. Thank you.

And thank you, Madam Chair.

Chairwoman COMSTOCK. Thank you, Mr. Chairman.

And I now recognize Mr. Tonko for his questions.

Mr. TONKO. Thank you, Madam Chair, and welcome to all of our panelists. The information feed is awesome.

I represent the capital region of New York, which has been dubbed by many to be one of the strongest hubs of growth—job growth in the clean energy innovation high tech economy. And with that we have great organizations like Rensselaer Polytechnic Institute and the corporate headquarters of GE with a lot of their innovation that they are incorporating, and the Polytechnic Institute. So my desire is to continue to build the foundations to further underpin that regional economy and certainly the Nation's economy with this growth that is so important.

By the two agencies that you speak for today, I am really impressed by the work that you do. So my question is—my focus is on the National Network for Manufacturing Innovation, the NNMI effort. Dr. May, can you discuss the level of demand for additional institutes under NNMI and what area of focus do you envision for those future institutes?

Dr. MAY. Well, there is a lot of pent-up demand. There is more than 135 needs that have been identified by NIST, and as I said earlier, there are eight institutes that have been stood up and they are mainly stood up to address the needs that were coherent with the needs of the Department of Defense and the Department of Energy.

What are the specific needs that we address? Once we—when and if we have funding in '16, we will begin a process to winnow down those unmet needs and have plans to move forward and establish two institutes going forward and then begin processing those needs that we have, allowing additional input obviously to—and then set up a plan for setting up additional institutes in the out years.

Mr. TONKO. Thank you. I am a solid advocate for additional funding for those innovative concepts. What—when making a selection for a new institute, what other factors are given consideration? Is it geography, for instance, taken into account or any prioritization for legacy cities that are transitioning from an older industrial reliance to perhaps a new day for—that comes via advanced manufacturing?

Dr. MAY. Excuse the analogy but we are looking to pick the best horse and the best jockey.

Mr. TONKO. Okay.

Dr. MAY. We don't care where that horse and jockey comes from.

Mr. TONKO. I represent Saratoga so I understand the language. I understand that language very well.

Dr. MAY. So we expect to make merit-based decisions.

Mr. TONKO. Okay. I appreciate that.

And to Dr. Córdova, again, welcome. My district includes the Stratton Air National Guard Base, which hosts, as you know, the 109th Airlift Wing in Schenectady, and I am proud of the fact that this year we share the 27th year that the 109th Airlift Wing has been supported by the National Science Foundation's Antarctic program as part of Operation Deep Freeze.

Over the past few months the Guard flew 241 missions delivering more than 3,000 passengers and 4.5 million pounds of cargo. Can you provide a brief update on NSF's polar research?

Dr. CÓRDOVA. With respect to the 109th I can provide what the investment is for both Arctic and Antarctic, yes.

Mr. TONKO. Okay. That is fine.

Dr. CÓRDOVA. Yes. And then more globally, polar research, whatever your particular questions are, I would be happy to do that.

So we have—the Arctic research, the expenditures for 2014 were approximately $2.5 million and we expect to spend the same in 2015. Spending for the 109th for the Antarctic program were about $29 million in the last fiscal year. In this Fiscal Year they will increase to $31.5 million due to higher personnel and aircraft maintenance costs.

And, by the way, Representative, we are pleased to be part of that cargo as well.

Mr. TONKO. Thank you.

Dr. CÓRDOVA. That is really a wonderful contribution to our overall program. We depend on the logistics of the Department of Defense.

Mr. TONKO. And, further, do you see any future plans to modernize the polar program's aging equipment and aircraft?

Dr. CÓRDOVA. We—I—since we get the aircraft support from a different agency, that is really a question I think that is appropriate for them. We are looking at substantial modernization program for the ground support, which of course services the aircraft, the landing bases and so on. And we are heavily engaged in preparing a modernization proposal for the coming fiscal years that is in response to the Blue Ribbon Committee known as the Augustine Committee. It is desperately needed after so many decades.

Mr. TONKO. Thank you. I see my time is out. Just let me throw a thank you out there for a focus on STEM education. We are working via some legislation that I have authored that I hope will continue to bolster our efforts in STEM.

And with that I thank you and yield back, Mr. Chair.

Mr. PALMER. [Presiding.] Thank you, Mr. Tonko.

I now recognize myself for five minutes for questions.

Dr. Córdova, at one point the National Science Foundation had over $1 billion in expired grant money. Is that still the case?

Dr. CÓRDOVA. I have no idea, Representative. Does—we will certainly supply that response for the record but—

Mr. PALMER. Okay. Well, one of the reasons I ask is when you have—you are under a time limit, that that can create some incentives to fund projects that I would say the public would find questionable in terms of scientific research. For instance, I believe we funded a grant to study the gambling habits of monkeys at $171,000. You spent $856,000 on studying—teaching lions to run on a treadmill and I am just wondering if—what the rationale would be for funding some of those projects because as a Member, we get some pretty intense criticism, particularly in such a tight budget environment that we are living in right now.

Dr. CÓRDOVA. I understand the question. I don't know about those proposals. We can certainly get back to you on that detail. But this really goes to our discussion earlier, Representative, on the transparency and accountability, and we just have to be better at communicating what are the goals of research and what are the potential impacts because sometimes things that sound obscure can actually be just absolutely revolutionary and groundbreaking, as you know. The—I—we like to point out that the original proposal that turned into Google was called Backrub. Now, that would be something that would catch your eye, would it not? And—

Mr. PALMER. And I would be interested.

Dr. CÓRDOVA. Yes. So—but you see the point and that is why we really need good titles and nontechnical descriptions and that makes everybody stop and pause and say, yes, what are the goals and what could be the impact for society.

Mr. PALMER. Thank you. Also, could you update us on your decision to relocate headquarters to Alexandria and explain some of the factors that are causing a delay in that move?

Dr. CÓRDOVA. Yes, of course. So we will—we are in the process of moving to Alexandria. We should have the shell of the building all completed I am told by this fall and so our budget for the relocation effort includes some systems, IT systems, and some furniture consistent with having that all ready by Fiscal Year 2016.

You—about the delay, we were told by GSA that they had accepted the proposal of Alexandria to move there and I believe that was in the summer of—before this summer in 2013 and then we reached an impasse with the union on what the—in particular the office space size would look like and that went to the Federal Impasse Panel in the late spring and we got the response in the fall on how that would settle out. And so we have been working with—we are following the guidance of the Federal Impasse Panel and actually I—they are—we are able to—because of the hard work of the team, a very talented team which I assure you is on this constantly, we are able to actually be cutting substantially the—in time delay the initial projections of how long this impasse would lead us to be delayed, Representative. And so——

Mr. PALMER. Let me——

Dr. CÓRDOVA. —this is—this situation is actually got worse and now is improving substantially and we are hoping to bring this is close to—as we possibly can——

Mr. PALMER. So you asked for——

Dr. CÓRDOVA. —by making compromises.

Mr. PALMER. Let me throw this in——

Dr. CÓRDOVA. Yeah.

Mr. PALMER. —real quick. You asked for almost $31 million to——

Dr. CÓRDOVA. Right.

Mr. PALMER. —to fund the move. Does that include a potential cost as a result of the delays?

Dr. CÓRDOVA. No, it doesn't because those would be in 2017——

Mr. PALMER. Okay.

Dr. CÓRDOVA. —the delays.

Mr. PALMER. Well, thank you all for being here. I am fascinated with the work you are doing, particularly the quantum-based information, Dr. May.

My time is expired. I now yield to Ms. Esty.

Ms. ESTY. Thank you very much. I want to thank the Chairman and Ranking Member for today's hearing and to the three of you for the tremendous work you are doing every day and for being so informative for us and ensuring that our country maintains its position as the leader in research and development really for the world.

Dr. Córdova, you had spoken about NSF's risk and resilience initiative so I want to hit two—your topics 3 and 4, risk and resilience and STEM education. So starting with the first one, living in Connecticut as I do and we are seeing the effects—still seeing some of the effects from Superstorm Sandy and Hurricane Irene. We are acutely aware of the impact that it is having on our economy as we see more and more extreme weather events and we are seeing it again with subzero temperatures almost into March now. Could you speak a little bit further about what NSF's goals are in focusing on risk and resilience; and as a follow-up, as someone who serves on the Transportation Infrastructure Committee where we are also looking at these issues, can you let us know whether you will be working with other agencies, including particularly FEMA and Department of Transportation as part of these initiatives?

Dr. CÓRDOVA. So risk and resilience is one of the four cross directorate initiatives that we are putting a focus on for the Fiscal Year 2016 budget just because of what you said, Representative Esty. It is a—we have been experiencing significant events that are natural, as well as human-made, but mostly natural events and we just feel that we have to put in an investment in basic research so that we can be prepared for those events.

The Fiscal Year 2016 request includes $8.5 million for cross directorate program that is called Critical Resilience Interdependent Infrastructure Systems and Processes, so we call it CRISP for short. It further—it goes a step further than our other programs that enable research on earthquakes and winds to include being resilient to all kinds of hazards like tornadoes and storms and so forth. It focuses on multiple interconnected systems like electrical power, water, gas, roads, and communications. And as you know, we have to consider all of these as a system to be truly prepared and resilient.

We do of course work with other agencies on this and I don't know the details about what their investments are but we could describe our particular programs and where they come into this, but this is something that concerns all the other agencies. I think our unique contributions are in a systems approach that brings in engi-

neering as well as basic science and the social sciences, too, because as you know, you can be told that a tornado is coming but if you don't have the right social preparedness among agencies on the ground and the mayor and the police force and respond to crises appropriately, lives can still definitely be lost. And so to make us more resilient so we—because we embraced all of the sciences and engineering, we figured we can do a lot of basic work.

And also in computer modeling, we have mentioned throughout this testimony that we have these big supercomputers, and those are really working very hard and I have gone to see the effort that they are doing on risk and resilience to really model the interactions of all the different components, you know, social and natural.

Ms. ESTY. Terrific. That is very helpful, and I am pleased to hear about that systems-wide approach, sort of an ecosystem of utilities, as well as transportation, critical infrastructure, which is also our schools and, you know, our core institutions.

I was struck by your testimony and highly supportive to hear you quotes the "there is a scientist in every child." So I wanted to give you an opportunity to expand a little bit on the INCLUDES initiative. I have been doing an enormous amount of work in my district on ensuring that every child, particularly that young women and children of color have an opportunity to get excellent STEM skills in each and every one of our schools and can see themselves as future engineers, scientists, researchers. So can you tell me a little bit about what you are doing, how you are collaborating with stakeholder communities? Thank you.

Dr. CÓRDOVA. Thank you, Representative Esty. The—INCLUDES is something that is a very personal effort to me. In fact, I have nominated myself team captain for this effort. It is—we spend—just if you look at the Congressional Research Service report, we do make a great investment in what we call broadening participation, which is another way of looking at inclusion. We have focused programs, we have emphasis programs in different areas. But—and as we go around the country and I do make lots of on-the-ground looks at our efforts—we notice that they can be very brilliant in their local ecosystem but they—what we have learned from them and the best practices are often not communicated to other potential groups and communities that want to do similar work.

So this emphasis and I think the small amount of money that we have requested here leverages that huge investment that we are already making, and this emphasis is on communication of those best practices, it is on networking. It is really almost a systems engineering approach and that is why the assistant directors that are all sitting in this room are—it is the goal that they are most excited about because they realize that who is sitting in the seats in our universities are the engineers of the future is—it should be a critical concern to us to tap into our national talent.

So we are enthusiastic. We will embrace lots of communities. We believe that this is a whole community effort. It starts when you are born and ends when you leave us, and we want to take advantage of all the talent and excitement and interest around there and have different approaches to this challenge.

Ms. ESTY. Terrific. Thank you very much. And I see my time is way expired but we appreciate your commitment on all these issues. Thank you so much.

Mr. PALMER. I now recognize Ms. Bonamici.

Ms. BONAMICI. Thank you very much, Mr. Chairman.

Dr. Córdova, welcome back to the Committee.

Dr. CÓRDOVA. Oh, welcome back from Antarctica.

Ms. BONAMICI. Thank you. Great trip. Thank you. As you have heard today in this Committee and as you frequently hear, so much of what the NSF does is important to our country's future and there are so many important priorities in your budget. I am glad to see on behalf of my constituents in Oregon—I will name just a few that are important—clean energy technology, secure and trustworthy cyberspace. In fact at the state level we are working with our institutions of higher education and industry on a Center for Cyber Excellence. STEM education, thank you for your passion on that issue. As a member of the Education Committee, there is so much we could be doing. And then as you discussed with my colleague from Connecticut, Ms. Esty, risk and resilience. On the West Coast we have different issues from the issues they face in Connecticut. However, my constituents are very concerned of course about natural disasters being on the Cascadia subduction zone.

But I wanted to ask you, Dr. Córdova, about a particular issue that currently the Oregon State University is leading an effort to design a regional class research vessel for NSF and will be operating the first of these new vessels that is built. We are very fortunate to have this opportunity in Oregon, not just for the university to have that experience of designing a vessel, but also for the potential of what we can learn through the observations made possible by this equipment.

So I was a little concerned because there was a recent survey conducted by the National Academies that recommended some reduced funding for operations within the Ocean Sciences facilities budget, so can you give us an idea on how a rebalancing of funding within OCE might influence plans to continue development of this new vessel?

Dr. CÓRDOVA. Thank you, Representative Bonamici. And let me just first say that I am just so impressed by your method as a Congresswoman. When we were on the Antarctica trip you were so committed to the students in your region that you were constantly doing very special videos and a whole series to bring back to the classroom, and you are a role model so——

Ms. BONAMICI. Thank you. And I just went out to the school and did a presentation before I came back to D.C. and they were thrilled.

Dr. CÓRDOVA. So on the regional class research vessels, so you are right. This is an opportunity, and ocean observing and understanding 70 percent of the planet and what is in there and how it functions with, you know, the whole world system is incredibly important research.

So there is intense study at NSF on how many regional class research vessels are needed and appropriate for the future. We completed the preliminary design review for this program in August of

2014 and we presented it as an information item at the February National Science Board meeting, and it is being considered right now for presentation as an action item at the May National Science Board meeting and then the next step would be if it were put in front of the NSB to request approval for the advancement to final design phase and inclusion in a future budget request.

Now, you mentioned the decadal panel. Okay. So that is—then the decadal panel, as you know, just came to us at the end of January and so that—an initial preliminary report was made to the board. It has not been fully digested by the agency. As you know, we are a very thinking agency——

Ms. BONAMICI. Right.

Dr. CÓRDOVA. —and we study things very closely and all the potential impacts and we always—we like to say we set our priorities based on community input. And so here, as you have pointed out, Representative Bonamici, there are lots of different kinds of input so that is being assessed and we will make a decision.

Ms. BONAMICI. Terrific. That sounds promising and I look forward to keeping in touch on that.

I wanted to get into questions for Dr. May. Thank you for your testimony. I look forward to having you visit the Collaborative Life Sciences Building at Oregon Health and Science University. We are doing some great work out there. Our Life Sciences Building is a great partnership between OHSU, Oregon State, and Portland State to expand the research activities and really offer a new approach to healthcare education, so I look forward to your visit.

The Manufacturing Extension Partnership program has really done a lot of good in Oregon leveraging federal funds in conjunction with state and local funding support. I wanted you to address of course the importance of growing American manufacturing. How can this budget proposal support a renewed focus on American manufacturing, especially through the MEP program?

Dr. MAY. Well, certainly the MEP program is a program that is currently authorized that reaches down and touches small and midsized manufacturers. Right now, we are undergoing a reshuffling of the deck if you will in the MEP program to try to do a better job of rightsizing the funding for the individual centers to the manufacturing ecosystem that they sit in. Initially for the—most of the MEP grants were made more than ten years ago. The world has changed a lot in the last ten years so we are right now trying to—we have just completed the re-competition for 10 centers. We will do an additional at least 10 States. We will do an additional 12 this year to try to make sure we can make sure that the federal contribution to the state is congruent with the needs of that particular manufacturing community.

Ms. BONAMICI. It is a very important program. I have seen it working on the ground at some of our businesses so thank you for your work on that.

My time is expired. Thank you, Mr. Chairman.

Mr. PALMER. I now recognize Ms. Clark.

Ms. CLARK. Thank you, Mr. Chairman. And thank you to all the panelists for being here today.

I am extremely lucky to represent the 5th District of Massachusetts, which is really a center of life sciences, biotech, and it is not

only an economic engine for Massachusetts and for the country but it is also, as I—a very personal effect on the research that you do and sponsor. As I heard one dad say, a rare disease is only rare until it affects your child. And the difference is that you are making not only in jobs and the economy in Massachusetts and across this country but also in the real effect on people's lives.

And people do not come to my district for the weather. In fact, when Dr. Córdova was welcoming back my colleague from Antarctica, I thought you had mixed us up.

But I am concerned. They come to Boston because we have incredible universities and we have incredible institutions doing research. That is why they come and that is why keeping that innovation pipeline is so critical. But there is cynicism and there is criticism of much of the work that you are doing. And so I am very interested if any of you can tell me a little bit more about the STAR METRICS program and how you are proceeding in being able to put real dollars and really track the impact of the investment and research that is going forward.

Dr. CÓRDOVA. Should I start?

Ms. CLARK. Sure.

Dr. CÓRDOVA. All right. Thank you very much. And actually my first experience as a graduate student, my first field trip from California was to one of your great institutions to the Harvard Smithsonian Astrophysical Observatory to do some research—satellite research.

So NSF really cares about the evaluation of its programs, especially in the STEM area that you are referring to. We lead the STAR METRICS, and STAR stands for Science and Technology for America's Reinvestment Measuring the Effects of Research on Innovation, Competitiveness, and Science. It is federal and research institution collaboration, as you know, Representative Clark, to create a repository of data and tools that would be useful to assess the impact of federal R&D investments. So we are very heavily engaged in that.

In addition, our Directorate of Education, Human Resources invests in foundational research and evaluation through a program we call PRIME, which stands for Promoting Research and Innovation in Methodologies for Evaluation program. It encourages the community to develop new evaluation methodologies, adapt methods that are successful in other disciplines, and expand the workforce with the capacity to conduct evaluation. In addition, we have an evaluation and monitoring group, which has a five-year evaluation monitoring plan for everything we do.

So we do take evaluation and educational research very seriously. In fact, when you see the 11 percent increase in the EHR, Education Human Resource Directorate, it is mainly for an increase in undergraduate education and in what you are talking about in educational research, which includes evaluation and monitoring.

Ms. CLARK. Thank you very much.

And, Dr. May, back to our historic snowfall, I wonder if you could discuss the progress around the disaster resilience framework that NIST is developing and other efforts that might be underway around disaster resilience.

Dr. MAY. I would say that—well, NIST is not operating by itself in this space——

Mr. PALMER. Dr. May, will you hit your button please?

Dr. MAY. I apologize. We don't operate alone in this space. I mean you have heard some of the things that NSF does. Even within the Department of Commerce there are equities when—in NOAA——

Ms. CLARK. Yeah.

Dr. MAY. —since they predict the weather and they look at the coastal environment, the Economic Development Agency, the Minority Business Development Agency, so we are all working together. But the unique thing that NIST does is sort of looks at what our science and engineering investigations can do to influence regulations and codes that might support the built environment. And speaking to recent activities in your area of the country, we have not dispatched a team there yet because one of the guidelines we have is that there is some new occurrence where we can glean things, so we don't go out like FEMA anytime there is an emergency. Our engagements are highly measured.

But certainly what will happen and would happen is we would look at what changes are there in the climate or whatever that would warrant scientific investigations that might need to have changes in the building codes and so forth to better protect the built environment.

Ms. CLARK. Great. Thank you.

I see my time is expired. Thank you, Mr. Chairman.

Mr. PALMER. Without objection, I recognize Ranking Member Lipinski for one minute.

Mr. LIPINSKI. Thank you very much.

I know we have a hard stop so we can't ask any more questions. I just wanted to thank you all for being here. One thing I was going to address but we talked about I–Corps. I am glad—very happy to see the strong support, strong number for I–Corps in the budget. I have been—everyone knows I have been the biggest supporter of that and it is great to see that it is very successful.

And, Dr. May, I am going to submit a question for the record about NIST activities concerning spectrum sharing also, but thank you all again very much and thank you, Mr. Chairman.

Mr. PALMER. Thank you, Mr. Lipinski.

I thank the witnesses for their valuable testimony and the Members for their questions. The record will remain open for two weeks for additional comments and written questions from the Members. The witnesses are excused and this hearing is adjourned.

[Whereupon, at 12:30 p.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by The Honorable France Córdova

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
Hearing on
An Overview of the Budget Proposals for the National Science Foundation and National Institute of Standards and Technology for Fiscal Year 2016

February 26, 2015

Questions for the Record Submitted by Barbara Comstock to

Dr. France Córdova,
Director,
National Science Foundation

CUTS, CONSOLIDATIONS, AND SAVINGS

Question 1. What steps does the Foundation take to evaluate if programs or projects are not working or are not meeting the intended goals? Can you provide the Committee with a list of all NSF programs or projects that you are proposing to eliminate, consolidate, or reduce in Fiscal Year 2016?

Answer: NSF is strengthening its culture of formal program evaluation emanating from its recently established Evaluation and Assessment Capability (EAC). EAC plans to select a different sub-set of cross-cutting programs every year and periodically evaluate them against their intended goals by contracting formal evaluations executed by independent third party experts.

NSF already has a tradition of performing different types of assessment of its programs and processes. Examples of different approaches of program evaluations and assessments include exploratory assessments of the state-of-the-art in the fields of study supported by NSF, portfolio analysis of its investments, formative evaluation of its merit review processes through the Committee of Visitors (COV) mechanism, workshops, decadal studies, and external evaluations.

In the case of workshops or decadal studies, NSF engages the scientific community to identify and prioritize leading-edge scientific questions and the work required to answer them. Often, the National Research Council of the National Academies of Science conduct these studies that provide the agency with information on the science community's consensus on key questions posed by NSF. When this occurs, NSF looks ten or more years into the future, and prioritizes research areas through a decadal study, which informs programmatic priority areas.

COV reviews also provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) feedback on how the results generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals. COV reports and the NSF responses to those reports may be found at: www.nsf.gov/od/iia/activities/cov/covs.jsp.

NSF did not submit permanent program terminations or reductions with the FY 2016 Budget Request to Congress. Table 1 shows NSF's permanent program terminations and reductions for FY 2010-FY 2016. Most programs displayed on the list are permanent terminations rather

than reductions. A few programs are shown as permanent reductions in one year and are subsequently terminated in a future year. These programs are Science of Learning Centers, Nanoscale Science and Engineering Centers, and University Radio Observatories.

Table 1: National Science Foundation Program Terminations and Reductions FY 2010 through FY 2016 Budget Requests

Budget Request Year	Program Title	Termination (T) or Reduction (R)	Savings Displayed in Request (Dollars in Millions)
FY 2010[1]	None submitted		
FY 2011[2]	Water and Environmental Research Systems (WATERS) Network Project	T	-$4.0
FY 2012[3]	Deep Underground Science and Engineering Laboratory (DUSEL)	T	-$36.0
	Graduate STEM Fellows in K-12 Education	T	-$27.0
	National STEM Distributed Learning (Digital Library)	T	-$16.0
	Research Initiation Grants to Broaden Participation in Biology	T	-$2.0
	Synchrotron Radiation Center	T	-$3.0
	Science of Learning Centers	R	-$6.0
FY 2013[4]	Cyber-Enabled Discovery and Innovation Program[5]	T	-$29.0
	Interface Between Computer Science and Economics and Social Sciences[5]	T	-$7.0
	Network Science and Engineering[5]	T	-$3.0
	Social-Computational Systems[5]	T	-$7.0
	Cultural Heritage Science[5]	T	-$4.0
	Grid Computing[5]	T	-$2.0
	Mathematical Physics[5]	T	-$2.0
	Solar Energy Initiative (SOLAR)[5]	T	-$2.0
	Nanoscale Science and Engineering Centers[5]	R	-$5.0
	Communicating Science Broadly[5]	T	-$2.0
	Connecting Researchers and Public Audiences[5]	T	-$4.0
FY 2014[6]	Nanoscale Science and Engineering Centers	T	-$19.0
	Geoscience Teacher Training (GEO-Teach)[7]	T	-$2.0
	Center for Ocean Science Education Excellence (COSEE)[7]	T	-$3.0
	Virtual Organizations	T	-$5.0
	Cerro Chajnator Atacama Telescope Design and Development	T	-$2.0
	International Materials Institutes	T	-$2.0
	University Radio Observatories	R	-$2.0
	Sensors and Sensing Systems	R	-$3.0
FY 2015[8]	Enhancing the Mathematical Sciences Workforce in the 21st Century	T	-$4.0
	Network for Earthquake Engineering Simulation	R	-$8.0
	Science of Learning Centers	T	-$12.0
	University Radio Observatories	T	-$1.0
	Virtual Astronomy Observatory	T	-$1.0
FY 2016[9]	None submitted		

[1] www.gpo.gov/fdsys/pkg/BUDGET-2010-TRS/pdf/BUDGET-2010-TRS.pdf
[2] www.gpo.gov/fdsys/pkg/BUDGET-2011-TRS/pdf/BUDGET-2011-TRS.pdf
[3] www.gpo.gov/fdsys/pkg/BUDGET-2012-TRS/pdf/BUDGET-2012-TRS.pdf
[4] www.gpo.gov/fdsys/pkg/BUDGET-2013-CCS/pdf/BUDGET-2013-CCS.pdf
[5] Termination/Reduction first listed in FY 2013 Budget, and also included in the FY 2014 Budget. Data displayed are consistent with FY 2013 Budget.
[6] www.gpo.gov/fdsys/pkg/BUDGET-2014-BUD/pdf/BUDGET-2014-BUD-28.pdf
[7] FY 2014 termination of GEO-Teach and COSEE were incorporated into the 11 program consolidation of NSF's STEM Education investments. These two programs were terminated and appear in NSF's FY 2014 Budget Request, page Overview-9, http://nsf.gov/about/budget/fy2014/pdf/01_fy2014.pdf.
[8] www.gpo.gov/fdsys/pkg/BUDGET-2015-BUD/pdf/BUDGET-2015-BUD-27.pdf
[9] www.gpo.gov/fdsys/pkg/BUDGET-2016-BUD/pdf/BUDGET-2016-BUD-5.pdf

RESEARCH MISCONDUCT REFERRALS FROM OIG

Question 2. By regulation, NSF has 120 days to decide whether or not to act on NSF Office of Inspector General (OIG) recommendations on referrals of research misconduct made to the Office of the NSF Director. According to the NSF OIG, there are currently 6 reports with 8 recommendations that exceed 120 days. In fact, one report, which lists three recommendations, has been stalled in in the NSF Director's office for over 500 days. What is the reason for these delays, and when will you respond to all the recommendations from the NSF OIG's 6 reports of investigation?

Answer: As documented in NSF's Research Misconduct regulation (2 C.F.R. §689), the NSF Office of Inspector General oversees investigations of research misconduct, and the NSF Deputy Director adjudicates research misconduct proceedings. When making determinations that often significantly affect the careers, livelihood, and reputations of individuals, it is important that NSF be correct and not just expedient.

NSF expects to issue determinations on all of the recommendations contained in the six cases referenced in your question within the next month.

NSF's research misconduct regulations (25 CFR 689) provide approximate time frames for completing investigations and adjudication:

- "*OIG will make every reasonable effort* to complete an NSF investigation and to report its recommendations, if any, to the Deputy Director within 180 days after initiating it." Section 689.6(f) (emphasis added).

- "*Normally within 45 days* after completing an NSF investigation or receiving the report from a satisfactory external investigation, OIG will submit to the Deputy Director the investigation report, any comments or rebuttal from the subject of the investigation, and a recommended disposition." Section 689.9(c)(2)(ii) (emphasis added).

- "*Normally within 120 days* after receiving OIG's recommendations or after completion of any further proceedings, the Deputy Director will send the affected individual or institution a written disposition, specifying actions to be taken. Section 689.9(c)(2)(iii) (emphasis added).

The flexible time-to-completion dates are needed for both OIG and the Office of the Director for the following reasons: (1) subjects of investigations make requests for extensions of time due to any number of legitimate reasons; (2) in the case of a debarment, the subject may request an oral presentation pursuant to 2 C.F.R. §180.815, and the agency is required under §180.830(c) to conduct additional proceedings in order to resolve disputed facts; (3) the subject is often allowed to provide comments, and NSF will consider the new information; and (4) complex cases take more time, especially when non-routine scientific issues are raised.

For example, in the case that has been under consideration for over 500 days in the NSF Office of the Director, the investigations took several years by two different universities and over five additional years of investigation by NSF's OIG. OIG's investigation alone took more than 1,825 days. Such exceedingly difficult, complex, and rare cases require more than the normal time for investigation and adjudication. The complexity presented by this particular case required an extensive review of a voluminous record in order to properly evaluate the recommendations by OIG and the rebuttals by the subjects.

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)

Question 3. Prior to his current position as the Chairman of the Board for NEON, Dr. James Collins was NSF Assistant Director for Biological Sciences from 2005 to 2009. What was the extent of Dr. Collins' involvement or input into (i) the design of the NEON project; (ii) the decision by NSF to award $433 million in taxpayer funds to NEON; and (iii) the initial award of "management fees" in 2008?

Answer: Dr. Collins served as NSF's Assistant Director of the Directorate for Biological Sciences (AD/BIO) from October 15, 2005 through October 14, 2009. The solicitation establishing the initial NEON matter (NSF 04-549) was issued on March of 2004, before Dr. Collins' appointment. While Dr. Collins was AD/BIO, he did have input into several preliminary NEON matters, including attending the conceptual design review in November 2006 at the University of California San Diego, where he provided some broad guidance to the review committee on realistic funding limits on construction. Dr. Collins, as is required of all Assistant Directors, approved a recommendation to the National Science Board for the "Organizational and Project Management Support to Complete the NEON Construction-Ready Design and Project Execution Plan" presented for review and approval at the December 2007 NSB meeting. NEON design at this stage was in the conceptual phase and did not reach final design until November 2009, after Dr. Collins had left as AD. Actual approval of required funding actions for design or concept and development awards was done by the Executive Officer, NSF Directorate for Biological Sciences.

Question: According to Dr. Collins, the final decision to fund NEON within NSF's MREFC account was made by the Director of NSF. How often did the then-NSF Director disagree with funding recommendations provided by Dr. Collins for projects under his Directorate's review?

Answer: The NEON construction award itself was funded in August of 2011. The initial operations for NEON, Inc. were funded in September of 2012. As these matters arose after Dr. Collins had left NSF (October 2009), he did not have any input into the final budget awarded to NEON, Inc.

Question 4. Have any NSF employees left the Foundation to work for NEON? Who are they and what input, if any, did they have on any aspect of the NEON project while employed by the NSF?

Answer: OGC and BIO does not track every person who leaves NSF nor do we track where they go after NSF. We are not aware of any former employee working for NEON. There are several former employees on the NEON Board. In addition to Dr. Collins, Dr. Susan Stafford (former Division Director, Division of Biological Infrastructure) and Dr. James Gosz (former program director in the Division of Environmental Biology) are both on the NEON Board of Directors. Neither individual had any involvement with NEON while employed at NSF. Dr. Gosz' appointment at NSF was well in advance of the NEON project inception.

CONFLICTS OF INTEREST

Question 5. What are NSF's policies regarding potential conflict-of-interest for employees who work on a project's application, and then leave NSF to work for that project shortly after it is awarded funds? How does NSF ensure enforcement of such policies?

Answer: NSF follows the Government-wide Post-Employment Restrictions, at 18 USC 207, and the U.S. Office of Government Ethics implementing regulations, at 5 CFR Part 2641. The NSF Ethics Team of the Office of the General Counsel conducts monthly exit interviews to advise those individuals who are leaving NSF of these restrictions. The NSF Office of the Inspector General is responsible for investigating violations of the restrictions and the U.S. Department of Justice is responsible for the enforcing these restrictions. These restrictions, however, do not prohibit an individual who previously worked for the U.S. Government from going to work for any outside entity, even when that individual dealt with the same entity while working for the Government.

MANAGEMENT AND OVERSIGHT OF LARGE FACILITIES STUDY

Question 6. The Committee understands that the Foundation and the National Science Board have commissioned a study by and external organization on the management and oversight of large cooperative agreements. What external organization is conducting the study, and what is the timeline for that study to be completed?

Answer: NSF management and the National Science Board have asked the National Academy of Public Administration (NAPA) to conduct a study to assess how NSF uses cooperative agreements to support large-scale investments in science and technology. The study will include a comparison to other funding mechanisms and will make recommendations on how NSF can make improvements. The study is expected to be complete by the end of calendar year 2015.

NSF RELOCATION

Question 7. In 2013, NSF and GSA announced that the NSF Headquarters would be relocating from its current location in Arlington, Virginia to a new development in Alexandria, Virginia in 2016. The Committee understands that for a variety of reasons the timeline has slipped and that NSF is now hoping for occupancy in late 2017. Can you explain the reasons for the delays, and describe what the impact will be to the overall budget and the original projection of $65 million in savings?

Answer: In June 2013, GSA announced a new lease agreement for the NSF's national headquarters to be located in Alexandria, Virginia. Construction of the building began in January 2014. Throughout the interior design process, NSF management has been negotiating with NSF's union on the interior design of the building space. Negotiations on the office space issue were unsuccessful and an impasse was declared by both sides in June 2014. NSF then referred the matter to the Federal Service Impasse Panel (FSIP), a part of the Federal Labor Relations Authority, for resolution. Subsequently, NSF directed the General Services Administration (GSA) to conduct a redesign of the new NSF headquarters to implement the FSIP decision.

The schedule for the interior design of the building was impacted by the lengthy union negotiations. NSF and GSA are currently engaged in productive discussions with the owner and construction team to develop a recovery plan to reduce schedule delays and related costs as much as possible. We anticipate having an acceleration plan formulated by the end of summer 2015, and we are currently projecting the move to occur sometime in late 2017. Once this plan is in place, we will be able to estimate a revised overall budget for the relocation project.

At the time that the new lease agreement was announced, GSA projected $65 million in savings due to the waiving of real estate taxes by Alexandria for approximately $30 million and a $35 million dollar cash allowance provided to the Government. The degree to which these savings will be impacted by schedule delays is still unknown; we will be able to determine the impact later this summer after discussions with the owner and construction team are completed and an updated schedule is finalized. NSF will inform our Congressional partners as soon as we are able.

FUNDING INCREASES FOR R&RA IN FY 2016, BY DIRECTORATE

Question 8. NSF is proposing a 7.1 percent increase of funding for the Social, Behavioral, and Economic Sciences (SBE) Directorate, compared to an average 3.6 percent increase for the four directorates- biology, computer science and engineering, engineering, and mathematical and physical sciences. Can you explain the Foundation's justification for a higher proposed percentage increase for the SBE Directorate?

Answer: SBE is the smallest directorate in the Foundation, representing 4.7 percent of the total for NSF's Research and Related Activities (R&RA) account. The next smallest directorate is the Directorate for Biological Sciences, which accounts for 12.1 percent of R&RA.

Total funding for SBE in NSF's FY 2016 Request is $291.46 million. This represents an increase of $34.62 million (13.5 percent) when compared to the FY 2014 level. The National Center for Science and Engineering Statistics (NCSES) increases by 36.7 percent, while the combined funding for SBE's three research divisions increases by 9.2 percent. Over this two year period, the largest share (42.1 percent) of the directorate's increase is for NCSES, as shown in Figure 1.

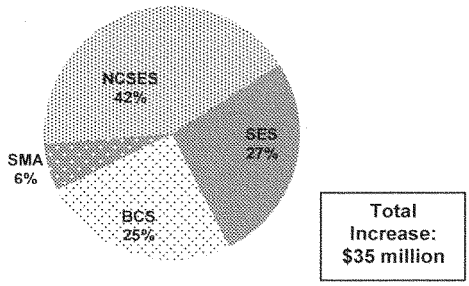


Figure 1: Distribution of SBE Funding Increase, FY 2014 - FY 2016

When comparing the FY 2016 Request to the level for FY 2015, the SBE funding increases $19.26 million or 7.1 percent. The three research divisions' funding increases by 7.1 percent and NCSES funding increases by 7.0 percent. The following table provides more detail on funding across SBE at the FY 2014 Actual, FY 2015 Estimate, and FY 2016 Request levels.

Social, Behavioral, and Economic Sciences (SBE) Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request Change Over FY 2014 Actual		FY 2016 Request Change Over FY 2015 Estimate	
				Amount	Percent	Amount	Percent
SES	$95.87	$97.72	$105.13	$9.26	9.7%	$7.41	7.6%
BCS	93.10	94.47	101.79	8.69	9.3%	7.32	7.7%
SMA	28.14	29.25	30.23	2.09	7.4%	0.98	3.4%
Subtotal, Research Divisions	*$217.11*	*$221.44*	*$237.15*	*$20.04*	*9.2%*	*$15.71*	*7.1%*
NCSES	39.73	50.76	54.31	14.58	36.7%	3.55	7.0%
Total, SBE	**$256.84**	**$272.20**	**$291.46**	**$34.62**	**13.5%**	**$19.26**	**7.1%**

Totals may not add due to rounding.

SBE's research budget plan for FY 2016 reflects its strong contribution to several NSF cross-foundation investments that address issues of major scientific, national, and societal importance. These include increased investments in Understanding the Brain (UtB) (which includes ongoing cognitive science and neuroscience research and NSF's contributions to the Administration's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative), the Science of Learning program, which was initiated in FY 2015, and Cyberinfrastructure for 21st Century Science, Engineering, and Education. SBE will also make an initial investment in the new NSF-wide Innovation at the Nexus of Food, Energy, and Water Systems (INFEWS) portfolio, which aims to understand, design, and model the interconnected food, energy, and water system through an interdisciplinary research effort that incorporates all areas of science and engineering and addresses the natural, social, and human-built factors involved. SBE will continue to invest in the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program, which focuses on the key social and behavioral research questions that are relevant for understanding risk and resilience of both designed and natural systems and of individuals interacting within and affected by these systems. The directorate also will continue to invest in the Secure and Trustworthy Cyberspace (SaTC) program. Additionally, SBE will invest in the NSF-wide effort to increase participation of underrepresented groups in STEM fields, the Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES) program.

SBE's FY 2016 Request also includes increased investment to support new projects in National Center for Science and Engineering Statistics (NCSES). The increased investment will be used to support (1) development of enhanced data access tools, techniques, and visualizations; (2) new data collection techniques building on administrative data and other "big data" sources; and (3) questionnaire redesign and survey improvements supporting current research and policy community needs, such as improved data on pathways for scientists and engineers and measures of innovation. NCSES is the Nation's leading provider of statistical data on the U.S. science and engineering enterprise, including data related to U.S. competitiveness and science, technology, engineering, and mathematics (STEM) education.

Finally, SBE will increase funding for the directorate's core programs to enhance research investments that advance fundamental knowledge in the social, behavioral, and economic

sciences broadly and that sustain the directorate's ongoing strategic transformation through support for interdisciplinary research and training.

EXPIRED AWARDS-UNDISBURSED BALANCES

Question 9. Can you identify the number of current NSF grants past their end date and the amount of undisbursed balances in grant accounts that have reached their end date and are eligible for closeout?

Answer: Information on NSF's undisbursed balances in expired grant accounts is published each year in the appendix of NSF's Annual Financial Report (AFR). In FY 2014 there were 4,295 expired grants with undisbursed balances of $72,612,661.[1] NSF's unexpired grant balances have been steadily declining over the last few years due to implementation of the Award Cash Management $ervice (ACM$) and having more award level information along with monthly close outs.

[1] FY 2014 AFR Appendix 5, pp III-32, 33; www.nsf.gov/pubs/2015/nsf15002/pdf/08_Chapter3-Appendices.pdf

Questions for the Record Submitted by Randy Hultgren

PHYSICS RESEARCH SUPPORT

Question 1. In January the Mathematical and Physical Sciences Advisory Committee submitted a report with recommendations for how NSF would implement recommendations from the DOE High Energy Physics Advisory Panel's P5 report. How does your agency plan to move forward with the recommendations from this report and how do both NSF and any larger collaboration benefit from your being a part?

Answer: The MPSAC subcommittee's over-riding recommendation was that the Division of Physics maintain a balance of support across all levels and all subareas of particle physics. The major large-scale effort under specific consideration by the subcommittee was participation in the phase-2 LHC upgrades, this being the number one priority in the short term in the P5 recommendations. The subcommittee believed that only a project at the MREFC level would enable NSF to make a significant contribution to the upgrade effort. Using the criteria listed by the subcommittee in the report, NSF is exploring internally, with DOE, and with potential investigators whether undertaking an MREFC effort is feasible while also maintaining a robust science program in the NSF's Division of Physics science program.

Question 2. What work is NSF currently doing in the Accelerator Science Program at the Division of Physics? What are the proposed applications of this technology that NSF is funding and why should NSF be charged with stewarding this kind of work?

Answer: The Accelerator Science program at the NSF is purely a fundamental science program. Its goal is to understand the science behind building accelerators. There are currently no specific applications targeted. But, as with all fundamental research, the knowledge gained from this research could have potential application in any situation in which accelerators are used, from scientific exploration to medical imaging and materials processing. In addition, as NSF support goes to universities, the program will also contribute to the training of future experts in accelerators, a cadre of individuals in short supply and much-needed in the U.S.

Question 3. Can you explain how NSF plans to coordinate with DOE for the second generation dark- matter experiments that were announced last year? What unique capabilities do both agencies bring to these experiments?

Answer: NSF has already begun coordination of the second-generation dark matter experiments with the Department of Energy (DOE). The first step in this coordination was the joint review held a year ago. Together the two agencies have developed a joint U.S. program in second-generation dark matter experiments. In this program, NSF will support principal investigators at universities; DOE will concentrate support on DOE laboratory efforts.

Questions for the Record Submitted by Daniel Lipinski

SBE RESEARCH SUPPORT

1. Some of my colleagues may be critical of the fact that the SBE Directorate receives a higher rate of increase in the fiscal year 2016 proposal than some other directorates. I would point out that this is an increase on a much smaller base. However, I want to hear from you about the value of the SBE sciences to our nation and our ability to solve grand challenges in health, energy, education, national security, and more.

Question Please provide specific examples of social and behavioral research that, early on may have sounded "funny" or not in the "national interest" but later proved to be significant factors in addressing national or global challenges.

Answer:

Parlor games: Paying off over $100 billion while optimizing the use of a vital resource

Over 50 years ago, mathematicians were studying parlor games to understand how people plot strategy when they compete with one another. Out of the study of poker, chess, and other pastimes emerged game theory. Many years later, researchers supported by the NSF Directorate for Social, Behavioral, and Economic Sciences provided the Federal Communications Commission (FCC) with its current auction system for apportioning the airwaves via a fruitful, practical application of game theory and experimental economics. The most recent auction, just completed in March, 2015, netted over $40 billion, bringing the total to over $100 billion in revenues for the federal government since the auctions' inception in 1994.[2]

As wireless communication blossomed in the early 1990s, the FCC received a concomitant increase in requests to use the limited commercial frequencies of the electromagnetic spectrum. The upsurge rendered the FCC's lottery-based licensing method inadequate, but economists Paul Milgrom and Robert Wilson of Stanford University, and collaborator Preston McAfee had a solution: an auction system based on their research. The team's NSF-funded studies had already documented conditions under which the proposed spectrum auction was expected to perform well, and experiments in NSF-supported labs run during the FCC's decision-making process provided additional evidence that the new system surpassed the proposed alternatives. The U.S. system of partitioning airwaves has been an enormous success, both in terms of providing much-needed revenue for the federal government and optimizing the use of an important resource, the electromagnetic spectrum. It is now emulated in several other countries around the world, resulting in total worldwide revenues of hundreds of billions of dollars.

From finding the right husband to finding the right kidney

It started as a theoretical exercise in matchmaking by a couple of economists comparing college admissions to men and women seeking partners in a marriage "market". But with support from the NSF Directorate of Social, Behavioral, and Economic Sciences, Alvin Roth of Harvard University, Tayfun Sönmez of Boston College, and M. Utku Ünver of the University of Pittsburgh applied market design theory to devise an ingenious solution to an important medical problem -- matching donors and recipients for kidney transplants.

Nearly four million Americans are diagnosed with kidney disease and nearly 50,000 people die from certain forms of the disease each year.[3] One life-saving treatment for severe kidney

[2] Federal Communications Commission: http://wireless.fcc.gov/auctions/default.htm?job=auctions_all

[3] Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2012: www.cdc.gov/nchs/data/series/sr_10/sr10_260.pdf

disease is a transplant. Over 15,000 kidney transplants are performed each year in the U.S.[4], but finding a compatible donor is very challenging. Roth and his colleagues developed powerful match-making software that facilitates kidney matching for patients who have willing but biologically incompatible donors. This system creates kidney exchanges that match an incompatible donor-patient pair with a similarly incompatible pair so that each of the patients receives a kidney from a compatible donor. The medical programs that use this software have already saved thousands of lives nationwide. The most recent exchange organized by the National Kidney Registry involves 70 people from 15 states and the District of Columbia. It is due to be completed in May, 2015. Roth's work has also been applied in the national matching of graduating medical students with residency programs and to match students with high schools in a number of large U.S. cities. Alvin Roth was a co-recipient of the 2012 Nobel Prize in Economic Sciences for his work on market design.

Nonverbal communication across cultures protects our troops

The ability to express and perceive emotion is a crucial component to communication. Errors in emotion recognition can not only lead to disruptions in communication, it can be a sign of neurological or psychological impairment. In military situations, when communication often occurs across cultures, the impact of such errors can be disastrous. For example, uncertainty about whether or not a civilian wishes you harm can needlessly and dangerously escalate an otherwise benign situation. With support from the NSF Directorate for Social, Behavioral, and Economic Sciences, Hillary Anger Elfenbein of Washington University in St. Louis and her collaborators investigated emotion recognition using nonverbal cues such as facial expressions, vocal tones and body language. Dr. Elfenbein's award was recommended for cancellation by a Congressman who thought it sounded silly.

Based on Elfenbein's research, the Army Research Institute now incorporates education on nonverbal communication into soldier training, thereby assisting troops in understanding cross-cultural, nonverbal communication with non-English speaking citizens with whom they interact overseas. Thus, this research has the potential to provide human solutions in military situations. Enhancing troops' interpersonal skills can enable them to anticipate and diffuse conflict, as well as facilitate cooperation, negotiation and compromise. In the future, these basic research findings will likely prove crucial for advancing face- and voice-recognition software, a practical use that has far-reaching implications in an increasingly digital world, and in the health arena, for autistic children and adults who suffer deficits in reading other people's emotions.

Political science studies inform cancer research

The NSF Social, Behavioral, and Economic Sciences Directorate's Political Science Program has funded basic research about the development of cooperative behavior that has not only affected our understanding of social phenomena, but also our understanding of diseases like cancer. Research by Robert Axelrod (University of Michigan) has explored how cooperation develops among individuals using theoretical insights tested by computer simulations. His research shows how certain strategies help individuals to be more successful in the long-run, and how these strategies can induce others to be fair and collaborative. The research provides crucial insights in areas important to U.S. national security like conflict resolution and post-war state-building.

In addition to applying his findings to political science, Axelrod extended his studies to other questions where the issue of cooperation and competition are core concerns. One such

[4] National Kidney and Urologic Diseases Information Clearinghouse, National Institute of Diabetes and Digestive and Kidney Disease, National Institutes of Health: http://kidney.niddk.nih.gov/KUDiseases/pubs/kustats/#11

question concerns the development of cancer. In a seminal paper published in the *Proceedings of the National Academy of Sciences*[5], Axelrod and his colleagues marshalled evidence that different types of cancer cells cooperate with each other to overcome the body's defense mechanisms by exchanging different growth products. This raises the possibility that nearby cell types can protect each other from a set of host defenses that neither could survive alone, potentially speeding the process of tumor formation. Cancer scholars continue to refer to this work[6] in their efforts to understand cancer and develop treatments. Cancer is the second leading cause of death in the U.S., killing nearly 600,000 people annually.[7] Axelrod's initial work developed a theory of cooperation, but its applications to conflict, as well as cancer, were unknown at the time. It is unlikely that this early work would have complied with the restrictions placed on Political Science projects in the FY 2013 Appropriations Act. In 2014, Dr. Axelrod was awarded the National Medal of Science.

[5] www.pnas.org/content/103/36/13474
[6] Google Scholar notes 186 publications that have referred to the original work on cooperation and cancer cells. http://scholar.google.com/scholar?cites=8672844158648006740&as_sdt=5,47&sciodt=0,47&hl=en
[7] Centers for Disease Control and Prevention: www.cdc.gov/nchs/fastats/deaths.htm

Responses by The Honorable Daniel Arvizu

UNITED STATES HOUSE OF REPRESENTATIVES
Committee on Science, Space, and Technology
Subcommittee on Research and Technology

"An Overview of the Budget Proposals for the National Science Foundation Budget Proposals for the National Science Foundation and National Institute of Standards and Technology for Fiscal Year 2016"
February 26, 2015
Dr. Dan Arvizu, Chairman, National Science Board

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

Question 1. Congress has not authorized NSF by Directorate since 1998. Appropriators have not done so since 1983, and even then it was for selective accounts rather than as standard practice for the entire R&RA account. Some of my colleagues would like to see Congress regularly authorize and appropriate by Directorate going forward. I can give a few reasons of my own why I think this would be an unwise move. For one thing, I think it reinforces 20th Century boundaries between fields of science rather than looking ahead to 21st Century science, so much of which is interdisciplinary and transdisciplinary. Do you share my concerns about authorizing by Directorate? Please elaborate.

Answer: I share your concerns. To quote our April 24, 2014 statement, "budget allocations to each NSF Directorate would significantly impede NSF's flexibility to deploy its funds to support the best ideas in fulfillment of its mission to 'promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.' "

As you note, the frontiers of science are increasingly found among and between disciplines. Areas such as cybersecurity, climate change, STEM education, synthetic biology, neuroscience, and advanced manufacturing are built on research from many disciplines and collaborations across NSF's research directorates. To offer one example, the Secure and Trustworthy Cyberspace (SaTC) investment in the FY 2016 Budget Request is led by Computer and Information Science and Engineering (CISE), but includes participation from Education and Human Resources (EHR), Engineering (ENG), Mathematical and Physical Sciences (MPS), and Social, Behavioral, and Economic Sciences (SBE). The SaTC solicitation recognize that game-changing solutions to cybersecurity risks may be identified through social science insights into individual, group, organizational, market and phenomena, or by leveraging mathematics, statistics and engineering with computer science, not just through computer science breakthroughs. The Board, Director, and scores of NSF program directors have worked hard to break down "silos" between disciplines and directorates. This requires cultural change in many areas of science, which is not easy to achieve, and I am concerned that authorizing by Directorate could inadvertently reinforce old walls.

In thinking about this question, it is useful to consider how our current process works. NSF's requested allocations are driven by science and scientists. Various scientific communities conduct priority-setting activities, such as decadal surveys or agenda-setting workshops to build consensus about what sorts of

work or investments are most promising. In addition, each Directorate has an advisory committee of distinguished scientists who keep the Assistant Directors (ADs) apprised of promising developments. As panels and program directors review proposals, the Foundation gets bottom up information about cutting-edge ideas. This crowd-sourced approach enables NSF leadership to identify where investments are needed to seize immediate opportunities and to ensure that we have the breadth and capacity needed to lead in the future.

A year before a Budget Request is submitted to Congress, the Director and ADs begin a series of meetings and retreats to reflect on these community inputs, discuss appropriate investments at the program level (given current and potential impacts), and envision possible new directions. As this process continues, senior management prioritizes opportunities at the portfolio level, making trade-offs that consider cost and long-term impacts. The Board is kept informed at regular intervals and provides advice through its Committee on Strategy and Budget. The Board also formally reviews and approves the Budget Request before it is transmitted to the Office of Management and Budget.

It would be challenging for Congress to invest the enormous time and effort it takes to fully appreciate the continually changing state of science in America. If Congress set authorization levels for Directorates absent the deep understanding built by NSF's dedicated staff, or failed to adjust them to seize the most promising opportunities, America's leadership in science and engineering could suffer. NSF could become less relevant, less nimble, less able to react quickly and efficiently to new discoveries and emergent national challenges. Most troubling, this could lead to losing our best scientists to our international competitors. American companies are widely admired for their ability to create and to innovate. The National Science Foundation reflects some of these ideals - lean, nimble, and always pursing the next big idea.

I am also concerned that per-Directorate appropriations could eventually lead to a focus on short-term priorities. For more than 60 years NSF has prioritized the scientific opportunities - across all areas of fundamental science and engineering - that best serve our country and further our mission. The NSF process, sifting hundreds of thousands of ideas through rigorous merit review, has a proven record of creating new knowledge and sustaining prosperity because the driving principle is to find and fund the best scientific ideas wherever they lie. In a worst-case scenario, allocations to specific scientific disciplines could contribute toward politicizing science, focusing proposers on short-term political priorities rather than long-term, scientific ones. It could therefore limit risk-taking and drive researchers toward what is "fundable" rather than what is transformative.

Question 2: There has been much discussion in this Committee in the last two years about NSF's merit review process. I for one disagree with the approach of some of my colleagues to impose their own personal values and opinions on the expert scientific merit-review process. There is already plenty of evidence of the chill this approach has sent across the entire scientific community. Moreover, I don't think all of my colleagues understand that this approach, ironically, discourages high-risk research by encouraging scientists to play it safe. However, I'm not sure every one of us has a full appreciation for NSF's process. Please describe NSF's merit-review process and why the entire world considers it to be the gold-standard for selecting research grants for funding. Do you

share my concern that imposing a legislated "national interest" criterion on every individual grant (rather than portfolios of grants) may discourage some high-risk proposals and otherwise lead scientists to self-censor in ways that may inhibit the progress of science? Do you share my belief that the mission statement in the 1950 NSF Act as amended provides sufficient statutory guidance to ensure that NSF grants serve the national interest?

Answer: Thank you for the opportunity to describe NSF's merit review process.

NSF's typical merit review process begins with independent written reviews of both the intellectual merit and broader impacts of a proposal by a set of qualified experts who are not NSF employees and do not have conflicts of interest. Both the review criteria – by which every proposal must be reviewed – are focused on contributions to the nation and taken together they embody our mission. Once initial assessments have been committed to paper, a panel of experts (including some of those who wrote reviews) convenes to deliberate over the proposed projects submitted to a particular research program. The deliberative panel considers all the comments in the reviews. The NSF program director (or, in many cases, several directors), who will eventually make the recommendation to fund or decline the project, ensures that the panel addresses all important issues related to both intellectual merit and broader impacts of each proposal. Once the panel has considered all the reviews and has converged on a rating for a proposal, a "panel summary" report is prepared, which explains the key factors determining the panel's judgment.

The NSF program director then considers all the advice: the written reviews, the content of the panel's deliberations, and the panel's rating of the proposal. The director makes a funding recommendation based on the promise of the proposal, the program's needs in terms of balancing its portfolio of investments, and available funds. Thereafter, a division director must concur with the soundness of the review process and the promise of the project in order for an award to be made.

Several factors ensure that this process identifies the most important and best scientific ideas. First, the independent reviews ensure that reviewers provide all their best insights before hearing anyone else's opinion. This protects against the convergence and groupthink that can emerge once a group begins discussing a topic. The program directors, trained in program management and expert in the relevant fields, manage panel processes to ensure that no problems occur that could distort funding decisions.

It is worth noting that NSF policies and the program directors socialize reviewers and panel members by providing instructions and guidance throughout the reviewing and deliberation processes. Program directors remind reviewers and panelists that their job is to identify the most promising research proposals, worthy of taxpayer funding because they have significant potential to advance knowledge as well as achieve broader impacts. In this regard, NSF activities play an extremely important role in the culture of American science. NSF is constantly convening groups of scientists to discuss the scientific potential of cutting edge ideas. They do this in a context that emphasizes honesty, integrity, and service to science and the nation (our reviewers receive compensation for expenses but not for their time and effort) as well as honesty and integrity. They return to their home institutions reminded of their commitment to science as a public good.

Regarding your concern about "national interest," I wholeheartedly share your belief that NSF's mission statement provides sufficient statutory guidance to ensure that NSF grants serve the national interest.

NSF's organic act set forth our purpose, a legislated mandate "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense, and for other purposes." The National Science Board ensures that NSF policies, particularly its merit review policies, advance that mission and that NSF management implements those policies so as to achieve that mission. It is our great pride that NSF's processes and resulting portfolios have yielded knowledge bases and innovations that have advanced the nation's safety, health, competitiveness and well-being in many, many instances.

NSF program directors and reviewers are guided by their passion for this mission, together with a strong sense of service to science and our nation. Every proposal recommended for funding is meant to be in the national interest, something the Foundation has recently tried to emphasize through new policies that clarify that the abstract for an award must "serve as the public justification for NSF funding by articulating how the project serves the national interest.[1]"

In this sense, further reifying NSF's contributions to the national interest in legislation should be non-problematic. However, if "the national interest" is interpreted more narrowly, it could inhibit the "progress of science." Any time a criterion exists other than the advancement of science, proposers and reviewers will adapt to it. Something other than the best science will be proposed.

Further, research, particularly basic or fundamental research, is inherently unpredictable. Requiring researchers to predict what benefits their proposed work would provide to the nation could have an extremely chilling effect on scientists' willingness to propose and conduct high-risk, potentially transformative NSF-sponsored projects.

NSF is viewed as the gold standard internationally in part because its peer review system is so rigorous. But the peer review process is something other nations can (and do) try to imitate. What is more important, what others find truly hard to imitate, is the NSF's freedom and resolve to pursue the progress of science rather than politically or bureaucratically defined agendas. The fact that the progress of science is the underlying principle guiding all NSF's peer review is what makes it exceptional.

Over many years, NSF has been authorized to invest in cutting edge and high-risk science as proposed and recognized by qualified scientists, processed though a merit review system designed to identify the ideas with the greatest promise to advance knowledge and produce innovations. It would be a danger to US competitiveness, and to all of science, to weaken NSF's innovation capability.

Questions for the Record Submitted by
Rep. Dan Lipinski, Ranking Member, Subcommittee on Research and Technology

Question 1. Some of my colleagues may be critical of the fact that the SBE Directorate receives a higher rate of increase in the fiscal year 2016 proposal than some other directorates. I would point out that this is an increase on a much smaller base. However, I want to hear from you about the value of the SBE sciences to our nation and our ability to solve grand challenges in health, energy,

[1] Important Notice 137, January 13, 2015, "New Steps to Enhance Transparency and Accountability at the National Science Foundation," http://www.nsf.gov/pubs/2015/in137/in137.jsp

education, national security, and more. Please provide specific examples of social and behavioral research that, early on may have sounded "funny" or not in the "national interest" but later proved to be significant factors in addressing national or global challenges.

Answer: Thank you for the opportunity to highlight the role of the social sciences in scientific grand challenges across many fields.

A number of science and engineering disciplines have identified sets of Grand Challenges for their research communities. For example, Engineering aims to advance personalized learning and health informatics, to prevent nuclear terror and improve urban infrastructure. To achieve those goals, an evidence base about how humans and social systems would interact with their potential engineered technologies is needed. Social science research provides this tool.

Another example of how social science is crucial to grand challenge efforts relates to the federal cross-agency Networking and Information Technology Research and Development (NITRD) program. NITRD's Grand Challenges include creating more high-confidence infrastructure control systems and creating knowledge environments for science and engineering. These socio-technical problems cannot be solved without sound understanding of social and human as well as technical phenomena.

Another example relates to the Grand Challenges set forth by the Systems Biology community. They point out that the genetics-enabled, personalized treatments that appear to be the future of medicine will require major changes in the education and behaviors of doctors and patients as well as changes in the design of medical institutions. Progress in the social and behavioral sciences will enable those changes to occur more efficiently and effectively, based on evidence rather than instinct or trial and error.

It is important to note, though, that, in the long run, the social sciences cannot be of service to other disciplines if they are only supported as applied science or in service to other disciplines. The base of social science knowledge that is useful for grand-challenge type activities is built on fundamental researcl into social phenomena. Principles of learning or of compliance with healthcare protocols are built upon theory-based studies of human perception, attention, memory, and motivation, among other basic social-science topics, for example. To design a high-confidence control system, one needs basic insights into what makes humans trust a system or invest their energies to comply with its protocols.

As requested, we offer the following three stories of SBE science that may have initially seemed odd but that led to important advances in knowledge that matter significantly to national well-being.

Studying Social Linkages, Setting the Foundation for Google

The original patent for PageRank, the algorithm upon which Google is built, cited two social science grants from NSF as the sources of key foundational knowledge upon which the invention relied. Both were employing and improving a nascent social science methodology known as social network analysis:

- *Mathematical Analysis of Corporate Networks*, from the Sociology program, 1974-1977
- *Center Periphery Relationships in the International Diffusion of Scientific Information*, from what is now call the Science, Technology and Society program, 1989-1991

Would anyone have predicted in 1974 that a study of inter-relations among corporate board memberships would yield foundational knowledge for an invention that allows anyone in the world to sort through vast stores of information for exactly the right bit needed, nearly instantaneously and at no cost? Or that a study of international linkages among citations in academic papers would be a key to the creation of one of the world's largest corporations?

Understanding Terrorists

Anthropologist Scott Atran was funded by NSF in 1994 to study how tribes in Central America manage shared resources in a rainforest. His title certainly may have sounded peculiar to non-scientists (*Local Ecological Knowledge of Common-Pool Resources in Campeche, Mexico*). That project showed how certain values – which he calls "protected values," such as protection of objects considered sacred by one's religion - play key roles in some disputes. This led Dr. Atran to study factors that may trigger protected values in social interactions. His grant for that study also had a title that might sound odd to non-scientists (*Culture, Psychological Distance and Modes of Moral Decision Making*).

Dr. Atran subsequently applied his theories and methods to questions of extremism in the Middle East. His field research has yielded highly reliable, promising, and practical insights into the pathways that lead to and from violent extremism. Dr. Atran is now a key national expert on countering extremism in the Middle East, valued as a consultant by the Department of Defense, the Department of State, and the UN Security Council.

Improving Pensions

In 1992, SBE funded Richard Thaler to study an economic anomaly known as the "Equity Premium Puzzle," wherein stocks earned much higher returns than bonds in the last century. Dr. Thaler hypothesized that a behavioral phenomenon could explain the puzzle.

Dr. Thaler's study of loss aversion and investment behavior was successful, leading to the founding of an industry-supported center for behavioral finance. That center created a program called Save More Tomorrow, which has been a great success, especially as companies have moved from traditional pensions to 401(k)-type plans. In its first application at a manufacturing firm, employees increased their retirement fund contributions from 3.5% to 13.6% over a three-and-a-half year period. Save More Tomorrow is now offered by many large employers in the United States, and a variant of the program was incorporated into the Pension Protection Act of 2006.

Responses by Dr. Willie E. May

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

"The Expanding Cyber Threat"

Dr. James Kurose, Assistant Director, Computer and Information Science and Engineering Directorate, National Science Foundation

Questions submitted by Rep. Barbara Comstock, Chairwoman, Subcommittee on Research and Technology

1. ***Microchip design today is incredibly complex. Thanks to this complexity, it is nearly impossible to test a chip for malicious hardware… What research does NSF perform in the realm of hardware attacks? How can companies build privacy and security into hardware so instead of being a risk for the consumer, it becomes a safeguard?***

NSF has a long history of supporting fundamental research on the security of hardware, enabling protections against vulnerabilities in hardware and product supply chains with new approaches for the detection of Trojans; protections against counterfeiting of integrated circuits; and new tamper-resistant security primitives for hardware systems.

Computing processors meet a tremendously wide range of needs, from leading-edge processors that are the "brains" behind critically-important systems and infrastructure, including networking and communications, electric power grids, finance, military, and aerospace systems, to smaller embedded processors, sensors, and other electronic components that provide "smart" functionality in a variety of applications, such as automotive braking and airbag systems, personal healthcare, industrial controls, and the rapidly growing list of connected devices often called the "Internet of Things." The wide range of devices and applications together with the exponential growth of the number of connected "things" has made security and trustworthiness of processors a critical concern. Indeed, as information and systems are increasingly connected, and are increasingly composed of software and hardware produced by global supply chains, the opportunities for malicious insiders to cause damage increases, and the risks of information leaks multiply.

Design and manufacture of today's complex hardware systems requires many steps and involves the work of hundreds of engineers, typically distributed across multiple locations and organizations worldwide. Today, semiconductor circuits and systems are designed so as to make it feasible or easier to verify, manufacture and test during subsequent steps. However, what is needed is an understanding of how to design for assurance, with the objective of decreasing the likelihood of unintended behavior or access, increasing resistance and resilience to tampering and counterfeiting, and improving the ability to provide authentication in the field. Designing for assurance requires new strategies for architecture and specification, and tools for synthesis, physical design, test, and verification, especially in design stages where formal methods are currently weak or absent. It is imperative to develop a theoretical basis for hardware security in order to design systems that are free of vulnerability and that are assured and resilient against attacks, even vulnerabilities and attacks that are not (yet) known.

As I noted in my oral testimony, NSF has worked closely with the Semiconductor Research Corporation (SRC), the world's leading technology research consortium consisting of member companies and university research programs across the globe, in the area of hardware security, with a particular focus on designing for assurance, as described above. Through the *Secure, Trustworthy, Assured, and Resilient Semiconductors and Systems (STARSS)* perspective within NSF's Secure and Trustworthy Cyberspace program, NSF and SRC are funding innovations in hardware security and facilitating close collaborations between academic researchers and industry. NSF and SRC jointly funded nine projects in FY 2014 spanning these areas; additional awards are anticipated in FY 2015. The projects funded in FY 2014 include the following:

- *IPTrust: A Comprehensive Framework for IP Integrity Validation* (Case Western Reserve University) – Modern chips include Intellectual Property (IP) blocks, or previously designed components of logic or data, from a variety of sources. This research project evaluates IP blocks to develop a framework for IP block trust analysis and verification, and develops tests to detect deeply embedded malicious changes to chip designs.

- *Combatting Integrated Circuit Counterfeiting Using Secure Chip Odometers* (Carnegie Mellon University) – This research aims to detect counterfeit integrated circuits (ICs) through Physically Unclonable Functions (PUFs) that are analogous to unforgeable Vehicle Identification Numbers (VINs) on automobiles, and also to detect used ICs through a secure chip "odometer" that is akin to vehicle odometers.

- *Trojan Detection and Diagnosis in Mixed-Signal Systems Using On-The-Fly Learned, Precomputed and Side Channel Tests* (Georgia Institute of Technology) – Trojan horses in hardware can cause integrated circuits to fail in the field. This project uses both pre-computed and dynamically generated tests to detect Trojans by using learning algorithms to refine tests in the field.

2. ***Excellent security does not necessarily equate to privacy, it just means the data is safer. How do we ensure our discussions about security also incorporate privacy? Thinking especially about how often children and students are accessing networked information technology, how can parents really know what information is available online directly pertaining to their children? How can they work to secure and maintain the privacy of that information?***

NSF agrees completely about the importance of information privacy research. In a recent NSF Dear Colleague Letter (NSF 14-021), we noted:

> "Privacy is a major issue of the information age. Organizations are increasingly acquiring and storing vast quantities of information about individuals. In addition, advances in big data analytics enable organizations to combine previously distinct information sources and to examine these data to uncover hidden patterns, correlations, and other revealing information. Research on privacy is needed to address how technological change and societal trends are combining to reshape privacy and the implications of such reshaping.

> The directorates for Social, Behavioral, and Economic Sciences (SBE) and Computer and Information Science and Engineering (CISE) invite investigators to submit proposals that address the need to develop new and deeper understandings of privacy in today's networked world."

The goal of privacy research, then, is to pursue approaches that protect a person's information. For example, as I noted in my testimony, as computers are embedded everywhere, from the cash register in the coffee shop to sensors in highways, actuators in medical devices, and controls in manufacturing plants, the threat landscape for one's privacy is expanding. Tire pressure sensors installed to help drivers avoid dangerous tire under- or over-inflation can be remotely identified, thus allowing a stalker to inconspicuously track movements of potential victims or allowing criminals to track undercover law enforcement officers around a city. Beyond computer virus infections that have disabled operating room computers, hospitals have been victim to breaches of patient records. Recent studies show that a large fraction of hospital equipment is vulnerable to computer attacks[1]. Deliberate and seemingly reasonable security measures can also backfire. GoGo Inflight, which provides WiFi access on airplanes, replaced digital certificates used to prove the identity of websites with its own certificates[2], allowing it to decrypt network traffic and prevent video streaming that would interfere with throughput for other passengers. As a side effect, however, sensitive email traffic could be decrypted before it leaves the airplane, and then re-encrypted, introducing risks for those using the airplane's wireless services. Attackers could employ the same strategy by placing open "hotspots" at coffee shops. While such a cyber threat is easily detectable and circumvented, it requires technical understanding by users who are used to clicking "yes" to messages.

NSF's investments in privacy research have led to a number of important contributions in recent years, including:

- Formal methods and software analyses that further the science of privacy via principled techniques for the specification, design and analysis of privacy-aware software programs, and for formalizing and enforcing privacy and accountability in web- and cloud-based systems;
- Differential privacy techniques that aim to provide actionable global, statistical information about sensitive data, while preserving the privacy of the users whose information is contained in the data set; and
- Usable security and privacy measures that explore ways to improve warning messages, privacy settings, security interfaces and primitives based on the how end users intuitively respond to such stimuli.

In FY 2014, NSF invested approximately $25 million to support privacy research as an extension of security, including exploring basic privacy constructs and their application in many areas of information technology. NSF's privacy support is largely driven bottom-up by research proposals from the academic research community, including through the *Trustworthy Computing* perspective within the Secure and Trustworthy Cyberspace program. Projects range in size from

[1] http://www.wired.com/2014/04/hospital-equipment-vulnerable/
[2] http://arstechnica.com/security/2015/01/gogo-issues-fake-https-certificate-to-users-visiting-youtube/

center-scale investments that bring together multiple disciplinary perspectives to small, single-investigator awards. Some examples of projects with a focus on privacy that received funding in FY 2014 include the following:

- *Towards Effective Web Privacy Notice and Choice: A Multi-disciplinary Perspective* (Carnegie Mellon University, Fordham University, and Stanford University) – This project explores ways to improve the usability of privacy policies by developing scalable technologies to semi-automatically extract key privacy policy features from website privacy policies, and presenting these features to users in an easy-to-digest format akin to nutrition labels on food products. This research will enable Internet users to make informed privacy decisions as they contemplate interacting with different websites.

- *A Socio-Technical Approach to Privacy in a Camera-Rich World* (Indiana University) – When a photograph is shared online through social media, the person sharing the photo (usually the photographer) makes decisions about who can see it, rather than the people whose images are in the photo. Ongoing research aims to address technical methods for allowing people to control how privacy protections can be developed and applied to their images.

- *Privacy's Sociocultural Divide Across American Youth* (University of New Mexico) – Teenagers have different attitudes toward privacy than adults. However, it is unknown whether those attitudes differ across genders, among different ethic groups, based on socioeconomic status, and/or based on technical expertise. Through interviews and focus groups, this research team aims to understand how sociocultural differences impact how teenagers engage with privacy both in their online presence and through their usage of devices and apps.

- *Digital Interventions for Reducing Social Networking Risks in Adolescents* (Florida International University) – Adolescents are at higher risk of engaging in risky behaviors in online social networks. This project develops digital intervention solutions to motivate, educate, support, and engender safe social networking behaviors among adolescents. The researchers are developing notifications and warnings for effectively detecting any risky behaviors by adolescents.

- *Designing Individualized Privacy and Security Systems* (International Computer Science Institute) – Security and privacy systems are generally "one size fits all." This project aims to design privacy systems that are tailored to a given user's personality, providing appropriate defaults without the user having to specify his or her preferences, but still allowing tailoring to an individual's needs and use.

Beyond our current investments, NSF is actively co-chairing the National Privacy Research Strategy (NPRS) effort being led by the Cyber Security and Information Assurance Research and Development Senior Steering Group (CSIA R&D SSG) of the federal Networking and Information Technology Research and Development (NITRD) program. The NPRS is seeking to establish objectives and prioritization guidance for federally-funded privacy research; to provide a framework for coordinating R&D in privacy-enhancing technologies; and to encourage multi-

disciplinary research that recognizes the responsibilities of the government, the needs of society, and opportunities for innovation in the digital realm. As part of this effort, the CSIA R&D SSG published a Request for Information in September 2014[3]. On the basis of this input[4], the CSIA R&D SSG convened a cross-sector workshop in February 2015 to identify key privacy perspectives, needs, and challenges that should be considered in forming a privacy research strategy; to gain a better understanding of what objectives should guide federal privacy research; and to examine prospective research themes that might be used to organize and prioritize federal research in privacy. The workshop, which spanned government, academia, industry, individual, and societal perspectives, will lead to a report that decomposes privacy into areas where goals for privacy research could be established; creates a framework that links privacy research objectives into a coherent picture; and formulates research objectives in ways that invite a variety of contributions and approaches from many disciplines.

[3] https://federalregister.gov/a/2014-22239
[4] https://www.nitrd.gov/cybersecurity/nationalprivacyresearchstrategy.aspx

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

"The Expanding Cyber Threat"

Dr. James Kurose, Assistant Director, Computer and Information Science and Engineering Directorate

Questions submitted by Rep. Elizabeth Esty, Subcommittee on Research and Technology

1. ***Many experts testifying before our Committee have agreed that humans are one of the weakest links in maintaining cybersecurity for both individuals, and our nation. In fact, a password management company recently released a study that found the most common passwords in the United States are "123456" and "password." Given how critical the human factor is in maintaining cyber security, can you expand on the role that NSF's Social, Behavioral, and Economic Sciences directorate plays in NSF's cybersecurity research agenda? What are some of the basic questions that behavioral and social scientists are pursuing that may contribute to our cybersecurity?***

With the rapid pace of technological advancement, we are witnessing the tight integration of financial, business, manufacturing, and telecommunications systems into a networked, global society. These interdependencies can lead to vulnerabilities and threats that challenge the security, reliability, and overall trustworthiness of critical infrastructure and the systems that people depend on and use every day. The result is a dramatic shift in the size, complexity, and diversity of cyber attacks.

In response to these changing threats, NSF has long supported fundamental cybersecurity research, resulting in many powerful approaches deployed today. NSF continuously brings the problem-solving capabilities of the Nation's best minds to bear on these challenges; it also promotes connections between academia and industry.

And projects are increasingly interdisciplinary, spanning computer science, mathematics, economics, behavioral science, and education. They seek to understand, predict and explain prevention, attack and defense behaviors, and contribute to developing strategies for remediation, while preserving privacy and promoting usability.

Indeed, as you note, there is increasing recognition that we need improved methods for building socio-technical systems that perform as intended, even in the face of threats. NSF's portfolio includes projects studying security in human-centric systems and in a variety of web-application contexts as well as in smartphones, voting systems, medical devices, automotive systems, and other cyber-physical systems. New methods explore how to effectively communicate security and privacy information to users in ways that they can better understand, and offer approaches for blind users to receive useful but unobtrusive security information, since "pop up" warnings are ineffective. Collaborations between computer scientists and social scientists continue to expand the scope of how we understand security problems and their solutions.

Since FY 2012, NSF's Secure and Trustworthy Cyberspace program has sought to secure the Nation's cyberspace from multiple perspectives. A key perspective is that of social, behavioral, and economic sciences, and aims to understand, predict, and explain prevention, attack and/or defense behaviors and contribute to developing strategies for remediation. Research that contributes to the design of incentives, markets, or institutions to reduce either the likelihood of cyber-attack or the negative consequences of cyber-attack are especially encouraged, as are projects that examine the incentives and motivations of individuals.

Let me highlight the results of two projects exploring socio-technical aspects of the cyber security challenge:

- *Beyond Technical Security: Developing an Empirical Basis for Socio-Economic Perspectives* (University of California at San Diego, International Computer Science Institute, and George Mason University) – This interdisciplinary team has sought to take a broader socio-economic view of cyber security to enable a more effective basis for designing security interventions. To date, the researchers have developed a classifier that will soon be integrated by Twitter to identify possible fraudulent Twitter accounts at the time when they are being registered by cybercriminals; and characterized the scale and complexity of the spam ecosystem, and worked closely with merchant banks to shut these down.

- *An Empirical Study of Text-based Passwords and Their Users* (Carnegie Mellon University) – The goal of this project was to research how passwords are created, how they resist hacking, and how usable they are. The project found that password-composition policies that emphasize length requirements rather than complexity often result in passwords that are both more secure and more usable. The use of password meters during password creation reliably led to stronger passwords without impact on usability. The researchers also found that detailed, step-by-step guidance has the potential to help users but can also cause lower user engagement, hurting security; on the other hand, detailed, specific feedback generally helped users create strong and easy-to-use passwords.

Beginning in FY 2013, NSF's Directorates for Computer and Information Science and Engineering (CISE) and Social, Behavioral and Economic Sciences (SBE) jointly authored a Dear Colleague Letter to accelerate progress in this interdisciplinary area by encouraging new collaborations between computer scientists and social, behavioral and economic scientists. The 2014 Dear Colleague Letter (NSF 14-021) noted:

> "The directorates for Social, Behavioral, and Economic Sciences (SBE) and Computer and Information Science and Engineering (CISE) invite investigators to submit proposals that address the need to develop new and deeper understandings of privacy in today's networked world. Our interest spans both disciplinary and interdisciplinary research in an array of SBE sciences. Proposals for workshops to explore novel and interdisciplinary SBE and SBE/CISE approaches to privacy are also welcome."

We have continued this DCL in FY 2015. To date, over 25 interdisciplinary awards have been funded, including the following:

- *The Game Changer: A New Model for Password Security* (Cleveland State University) – Most existing passwords are based on either text or patterns (e.g., a swipe pattern on a touchscreen smartphone). This collaboration between an electrical engineer, a sociologist, and a psychologist explores password schemes based on remembering layouts of pieces on a board game (e.g., chess, Monopoly), which are both more memorable than random strings of characters, and also more secure because users will not write them down.

- *Investigating Elderly Computer Users' Susceptibility to Phishing* (University of Colorado at Colorado Springs) – Existing studies have evaluated younger users' susceptibility to phishing attacks, but have not paid sufficient attention to elderly users' susceptibility to phishing in realistic environments. Seniors have become very attractive targets for online fraud. This collaboration between a computer scientist and a psychologist compares younger and older computer users' susceptibility to both the traditional and the newly emergent single sign-on phishing campaigns.

- *Consumer Response to Security Incidents and Data Breach Notification* (Carnegie Mellon University) – When customers receive notification of a breach of personal data, they may take advantage of the free notification frequently provided. But what is unclear is whether their behavior changes: do they change their buying habits with the merchant? This collaboration between a management science professor and a robotics professor uses a Big Data approach to determine how real users respond to reports of identity theft. Through cooperation with a major bank that has suffered data breaches, the researchers are able to establish the ground truth of how users behave when their data has been stolen, by specifically comparing behaviors of customers who have been notified that their data were breached to those whose data have not been breached.

Across its cyber security research and development programs, NSF continues to cast a wide net and let surface the best ideas for this socio-technical system, such as those highlighted above, rather than pursuing a prescriptive research agenda. It engages the cyber security research community in developing new fundamental, long-term, often interdisciplinary or multi-disciplinary ideas, which are evaluated by the best researchers through the merit review process. This process, which supports the vast majority of unclassified cyber security research in the U.S., has led to innovative and transformative results.