AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. HRG. 112–292

INVESTING IN FEDERAL R&D

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

MARCH 17, 2011

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

73–230 PDF WASHINGTON : 2012

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

JOHN D. ROCKEFELLER IV, West Virginia, *Chairman*

DANIEL K. INOUYE, Hawaii
JOHN F. KERRY, Massachusetts
BARBARA BOXER, California
BILL NELSON, Florida
MARIA CANTWELL, Washington
FRANK R. LAUTENBERG, New Jersey
MARK PRYOR, Arkansas
CLAIRE McCASKILL, Missouri
AMY KLOBUCHAR, Minnesota
TOM UDALL, New Mexico
MARK WARNER, Virginia
MARK BEGICH, Alaska

KAY BAILEY HUTCHISON, Texas, *Ranking*
OLYMPIA J. SNOWE, Maine
JOHN ENSIGN, Nevada
JIM DeMINT, South Carolina
JOHN THUNE, South Dakota
ROGER F. WICKER, Mississippi
JOHNNY ISAKSON, Georgia
ROY BLUNT, Missouri
JOHN BOOZMAN, Arkansas
PATRICK J. TOOMEY, Pennsylvania
MARCO RUBIO, Florida
KELLY AYOTTE, New Hampshire

ELLEN L. DONESKI, *Staff Director*
JAMES REID, *Deputy Staff Director*
BRUCE H. ANDREWS, *General Counsel*
ANN BEGEMAN, *Republican Staff Director*
BRIAN M. HENDRICKS, *Republican General Counsel*

SUBCOMMITTEE ON SCIENCE AND SPACE

BILL NELSON, Florida, *Chairman*
DANIEL K. INOUYE, Hawaii
JOHN F. KERRY, Massachusetts
MARIA CANTWELL, Washington
MARK PRYOR, Arkansas
MARK WARNER, Virginia

JOHN BOOZMAN, Arkansas, *Ranking*
JOHN ENSIGN, Nevada
ROGER F. WICKER, Mississippi
MARCO RUBIO, Florida
KELLY AYOTTE, New Hampshire

CONTENTS

	Page
Hearing held on March 17, 2011	1
Statement of Senator Nelson	1
Statement of Senator Boozman	3

WITNESSES

Dr. John P. Holdren, Director, Office of Science and Technology Policy, Executive Office of the President	5
Prepared statement	7
Dr. Subra Suresh, Director, National Science Foundation	17
Prepared statement	19
Patrick D. Gallagher, Ph.D., Under Secretary of Commerce for Standards and Technology, U.S. Department of Commerce	25
Prepared statement	26
Dr. Waleed Abdalati, Chief Scientist, National Aeronautics and Space Administration	33
Prepared statement	35

APPENDIX

Hon. John D. Rockefeller IV, U.S. Senator from West Virginia, prepared statement	59
Response to written questions submitted to John P. Holdren by:	
Hon. John D. Rockefeller IV	60
Hon. Bill Nelson	60
Hon. Mark Warner	61
Hon. Roger F. Wicker	62
Response to written questions submitted to Patrick D. Gallagher by:	
Hon. John D. Rockefeller IV	62
Hon. Bill Nelson	64
Hon. Roger F. Wicker	67
Response to written questions submitted to Dr. Subra Suresh by:	
Hon. John D. Rockefeller IV	68
Hon. Bill Nelson	69
Hon. Mark Warner	70
Hon. Kay Bailey Hutchison	75
Hon. Roger F. Wicker	75
Response to written questions submitted to Dr. Waleed Abdalati by:	
Hon. Bill Nelson	77
Hon. Kay Bailey Hutchison	82
Hon. Roger F. Wicker	84

INVESTING IN FEDERAL R&D

THURSDAY, MARCH 17, 2011

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

The Subcommittee met, pursuant to notice, at 10:34 a.m. in room SR 253, Russell Senate Office Building, Senator Bill Nelson, Chairman of the Subcommittee, presiding.

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

Senator NELSON. Good morning. Good morning everybody.

We are really looking forward to this hearing, and before we start, I want to introduce two of our special guests, Ms. Tracy Caldwell Dyson and Colonel Doug Wheelock. They are part of our very fine astronaut corps and they have both flown on the Space Shuttle, and Soyuz, to and from the International Space Station.

Both of them have spent quite a bit of time on the space station. Colonel, I think you spent close to 6 months. How about you Ms. Dyson?

Ms. DYSON. The same, sir. A hundred and seventy-six days.

Senator NELSON. Colonel, share with us a bit about your experience on the station.

Colonel WHEELOCK. Oh wow, where do I begin? Well we had—we were very, very excited about our mission because we were sort of ushering in the full utilization of the science platform that we had originally planned, you know, for the space station. And very excited about it and we had over 130 science experiments going on onboard. And it was just tremendously exciting. It took up most of our work day.

Then as space has it, always has a surprise sort of lurking around every corner, because of the hostile environment that we are orbiting in, and on July 31 last year we had a critical failure onboard the space station, a pump module failure. And—but it—just like the rest of the times, the challenging moments we face as NASA, as an administration and we as problem solving people, it really turned out to be one of NASA's finest hours. And we were so proud to be a part of that.

And I have spent 28 years in the military now and never in my life had I experienced teamwork like I did onboard that station. And Tracy and I got the opportunity to go outside and do three space walks to try to repair this station and bring our science platform back to life. It took us 3 weeks and it was—I kind of kidded

with the children that we go to speak to now to try to pass this dream of space exploration and discovery to them, that you know, there was a point on board where, you know, where you face this challenge. And I am one that always believed that, you know, adversity, sometimes we hear that adversity builds character but I am more that adversity exposes character. And this event that happened onboard really exposed the character of NASA, of our country, of our partner countries that we are working with in cooperation onboard the space station. And it was really just a terrific, I think, testament to teamwork and the way that we pulled together just to solve and overcome these challenges.

And we were able to bring the science back up on line and then really bring the station into full utilization. And we are so excited about the future of the station and where we are going and excited to be here, sir.

Thank you so much for the invite to spend a few moments with you.

Senator NELSON. Both of you did the space walk at the same time?

Colonel WHEELOCK. Yes, sir. We went outside three times for a total of about 23 hours outside to replace this pump. And the pump actually pumps ammonia through the outside lines on the space station to try to radiate some of the heat from space. And so half the space station was shut down. And we kind of kid that, you know, we don't have a shower onboard the space station so we go about 6 months without a shower, but we got an ammonia shower on the outside of that space station.

And again, it was a challenging effort but our problem solvers on the ground, you know, came up with ways for us to get the job accomplished and get things cleaned up and get back inside safely and bring our space station back up. So we were just real thrilled to be a part of it.

Senator NELSON. Did both of you launch on the same Soyuz?

Ms. DYSON. No, sir. Separate Soyuz. Separate three person crews. I launched April 2, 2010 with Alexander Skvortsov and Mikhail Kornienko. And Doug launched with Shannon Walker and Fyodor Yurchikhin.

Colonel WHEELOCK. I launched in June, sir and then came back on—actually returned to Earth on Thanksgiving day, so it was a nice Thanksgiving.

Ms. DYSON. I returned on September 25, just 2 months prior.

Senator NELSON. There was a malfunction on reentry on one of the Soyuz. Is that problem corrected, in your opinion?

Ms. DYSON. Are you speaking before our descents or?

Senator NELSON. I don't know about the time on your descent but there was a problem on a deploying of—go ahead.

Ms. DYSON. Well, there was a—when our Soyuz was docked to the space station, the day that we were supposed to undock the latches failed to release from the station, from our Soyuz, coming from the station and necessitated our return back into the vehicle space station while our Russian cosmonaut crewmates remedied the problem. We tried it again the next day.

There have been problems. I think you're maybe referring to earlier flights that some pyro bolts didn't fire. And yes, that has been

investigated and remedied and we haven't seen a problem like that since.

Senator NELSON. Well, we are just delighted that you are here.

When both of you were up there you had Russian colleagues onboard the station. You know, I see frequently General Tom Stafford who paved the way, having been a part of Apollo-Soyuz. And it is just amazing how that Russian crew, with still Tom Stafford and Vance Brand, of course Deke Slayton has since passed away, but how they stay in touch with each other. Aleksey Leonov and Valeri Kubasov, they're in touch with each other all the time.

And Tom Stafford has now adopted two Russian boys that he is raising and educated here in the United States. So it is quite a story of the cooperation between the U.S., back then the Soviet Union, and now Russia.

So thank you for being a part of that. Thank you for being a part of our space program. Miss Garver, thank you for coming and accompanying them, we appreciate it very much.

We are going to turn to a very distinguished science panel. And I am going to turn to my colleague Senator Boozman for his opening statement.

STATEMENT OF HON. JOHN BOOZMAN, U.S. SENATOR FROM ARKANSAS

Senator BOOZMAN. Thank you, Mr. Chairman.

And again, we appreciate you all being here. Appreciate your service to our country.

The director was in the office the other day and we talked about the importance of getting young people involved in math and science and those things and certainly these two witnesses are great examples of what, you know, following that career path. I don't think we could show any finer examples of people that have gone that route and we do appreciate their service.

I am really looking forward to being ranking member on the Science and Space Subcommittee and working with you, Mr. Chairman. We appreciate your leadership.

Advances in science and engineering are essential for America's economic growth and global competitiveness. They are also crucial to many of our other national priorities, including energy independence, cybersecurity and healthcare.

As you know, we are slowly moving out of a recession. We have experienced a very serious economic disruption and our nation's future growth must be based on the substantial, sustainable growth driven by technology and innovation.

During the next decade the U.S. demand for scientists and engineers is expected to increase at four times the rate for all other occupations. In fact, the pace of economic growth may very well depend on how well our nation can meet the demands of the global marketplace for the highly skilled researchers and advanced products that we are going to need.

As policymakers we must do what we can to support this growth, but here is the reality. We are faced with the largest deficit in our nation's history and at the same time nations around the globe are pouring money into their research and development systems with

the hope of attracting our scientists and surpassing our nation in cutting edge technologies.

Here is our Nation's challenge. How do we support America's spirit of innovation while being realistic that the federal government cannot sustain our current level of spending? The answer is that we must prioritize our spending in a manner that gets the biggest bang for the taxpayer's buck. We have to prioritize fundamental, basic research and we have to make sure that our previous federal investments do not go to waste.

In my home state of Arkansas we have worked hard to grow our research and development capacities. Many stakeholder groups have aligned across the science and technology spectrum, from our university system to the private sector, to make sure that new innovations get out of the labs and into the marketplace. We are also working hard to educate our students and inspire them to pursue the science, technology, engineering and math fields.

We must continue our commitment to fundamental research that cannot be carried out by the private sector because of long development timelines and high costs. This fundamental research is critical to maintaining our global technological advantage, but we must do this in a fiscally responsible way.

It is in this context that I think we need to evaluate our federal investments in research and development in STEM education and make sure that all of our investments represent the most efficient and effective use of the taxpayers' dollars. I look forward to hearing from the witnesses about the President's plan for funding these priorities, as the nation's key scientific research agencies, the National Science Foundation and National Institute of Standards and Technology.

And with that, I yield back, Mr. Chairman.

Senator NELSON. Thank you, Senator.

The subject of this hearing today is research and development, which has obviously, through the federal government, yielded untold benefits to the American people. A lot of our technological dominance today is a result of investments in research and technology, and those decisions were made years ago. And so what we want to look at here is those continuing investments, much of which will not bear fruit until years down the road.

And we also ought to be mindful that if we are cutting out the R&D, you are starting to eat your seed corn so that you don't have a crop to plant for next year. We have seen new technologies that have developed whole new industries that have kept America competitive in the global marketplace. And with places like China and South Korea that are dramatically increasing their governmental R&D, it is a significant challenge for us to keep up that leadership.

And we ought to remember that when you wonder, is governmental R&D worthwhile, and I preach this in NASA all the time. Remember that it has fueled the creation of the laser, the Internet, and GPS. As a result, it has created all kinds of business and spawned off thousands and thousands of high paying jobs. And those industries are led by American companies.

You know, I think back years ago, 25 years ago, we saw the semiconductor business going abroad. And that didn't make a lot of sense for us to become entirely reliant on other countries for our

semiconductors. So we formed a consortium called SEMATECH—it happened to be located in Texas and because of that effort they ended up keeping a good portion of semiconductor production here in the U.S., which was necessary to a lot of our high security and classified programs.

So too, we're seeing a major competition right at the present on the question of how we can make electricity cheaper from photovoltaic cells. And so there is a competition that is going through the Department of Energy right now to see who can do the R&D to get photovoltaic cells to produce electricity cheaper so that it becomes a viable alternative to making electricity from our standard energy sources such as petroleum.

Well, we have a star-studded panel here today. Dr. John Holdren is director of OSTP, the Office of Science and Technology Policy in the White House. He has been in that role since early 2009 and we are going to hear from him on the priorities and importance of federal investment in R&D. Dr. Subra Suresh is Director of the National Science Foundation. NSF funds reach all 50 states through grants to nearly 2,100 universities. He directs NSF programs and initiatives in order to advance all fields of fundamental science and engineering research in education. Dr. Patrick Gallagher is the Under Secretary of Commerce for Standards and Technology and directs what we call NIST, the National Institute of Standards and Technology. In his capacity he provides the oversight and direction on the mission to promote U.S. innovation and industrial competitiveness by advancing measurement science standards and technology. And Dr. Waleed Abdalati is NASA's newly named Chief Scientist. In this role he serves as the principal advisor to the NASA Administrator on the agency's science programs and its strategic planning and evaluation of related investments.

So, we welcome you. What I would like you all to do, in as much as you can possibly not just to read your statement, talk it through to us. Let's be mindful to keep to five or six minutes and then we want to get into some real questions.

So, we will start with you Dr. Holdren.

STATEMENT OF DR. JOHN P. HOLDREN, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. HOLDREN. Well thank you very much, Chairman Nelson, for convening this hearing. It is customary to say what a pleasure it is; I can say it is a genuine pleasure in this case. I have immensely enjoyed working with you since before my confirmation.

And of course, as you have pointed out, the topic today is the federal research and development components of the President's Fiscal Year 2012 budget. The premise behind that budget is one that I am very sure you and I share, I think all of us in this room share, and that is creating the jobs and industries of the future and the quality of life that we all want for our children and our grandchildren. That is going to require investing in the creativity of the American people and it is going to require investing in America's capacity to innovate.

We think the 2012 budget proposed by the President does that with responsible and targeted investments in the foundations of

discovery and innovation, that is in research and development, in science, technology, engineering and math education and in 21st century infrastructure. It does it in a way that offsets the increases in the highest priority areas with reductions in lower priority areas. It is a budget that is aimed at helping us win the future by out-innovating, out-educating and out-building the competition.

Very obviously, we need the continuing support of the Congress to get this done. All told, the budget proposes almost $67 billion for civilian research and development. Welcome back, Ranking Member Boozman. I started by thanking you both for convening this hearing.

Senator BOOZMAN. It is always good to be thanked.

[Laughter.]

Dr. HOLDREN. And that $67 billion proposed for civilian R&D is an increase of over $4 billion or about six and a half percent over the 2010 appropriated level in that category. But the administration is committed to reducing the deficit, even as we prime the pump of discovery and innovation.

Our proposed investments fit within an overall non- security discretionary budget that is frozen at its 2010 levels for a second year in a row. And we think that budget reflects some strategic decisions, hard decisions, to focus resources on those areas where the payoff for the American people is likely to be the largest.

Now I know, Mr. Chairman and Mr. Ranking Member, that this committee is already familiar with the details of the proposed budget. I just want to highlight, very briefly, a few key points. First of all, consistent with the America Competes Reauthorization Act that was passed in December with leadership from this committee, signed by the President in January, the budget calls for continuing the doubling trajectory for the National Science Foundation, the Department of Energy's Office of Science and the NIST Laboratories.

My colleague, Subra Suresh, Director of NSF and Pat Gallagher, the Director of NIST, lead two of those three agencies that are so important to our Nation's continued scientific and economic leadership. In the case of NASA, represented today by its Chief Scientist, Waleed Abdalati, the President's budget holds to the 2010 appropriated level of $18.7 billion, while still funding every initiative in the 2010 NASA Authorization Act.

In addition, the President's budget would allow NOAA to improve critical weather and climate services, invest more heavily in restoring our ocean and coasts and ensure continuity in crucial Earth observation satellite coverage. And I know you agree that that is indeed crucial. The budget also reinforces the Department of Energy's work to make clean energy affordable and abundant, as you, Mr. Chairman, have talked about in your opening statement.

To help the Nation win the future the budget also emphasizes STEM education to prepare our kids to be the skilled workforce of the future in part by providing a $100 million as a downpayment on a 10-year effort to help prepare a 100,000 new, highly qualified and effective science, technology, engineering and math teachers. That is part of a broader administration commitment to look carefully at the effectiveness of all of our STEM education programs and find ways to improve them.

To further that goal I have established a committee on STEM education under the National Science and Technology Council. It is co-chaired by OSTP's associate director for science, Dr. Carl Wieman, a Nobel Laureate, as you know, in physics, and Dr. Suresh. And it has participation from many of the federal agencies that are involved in STEM education activities, indeed from all of them. That committee began its work 2 weeks ago.

Three priority initiatives in science and technology that are interagency in character were also highlighted in the 2012 budget. The first is the Networking and Information Technology R&D Program which coordinates and plans agency research efforts in cybersecurity, high end computing systems, advanced networking. That budget, the 2012 budget, requests $3.9 billion for NITRD, an increase of $74 million over 2010 and that is a targeted increase which we believe is appropriate to the increased importance of information technology in American life, health, economy and national security.

The second of these interagency initiatives is the $2.1 billion for the National Nanotechnology Initiative, or NNI, increasing that by over $200 million from 2010. The participating agencies in that initiative are going to be guided by a revised NNI strategic plan submitted to the Committee last month. It reflects the emerging opportunities for frontier research at the nanoscale which we think have enormous potential for revolutionizing American manufacturing and other economic sectors.

The third interagency initiative I want to highlight is the U.S. Global Change Research Program for which the budget requests $2.6 billion, an increase of $446 million over the 2010 level.

I want to reiterate, in closing, the guiding principle that underlies this budget. America's strength, our prosperity, our global leadership depend directly on the investments that we are willing to make in R&D and STEM education and in infrastructure. Only by sustaining those investments are we going to be able to assure future generations of Americans a society and a place in the world worthy of the history of this great nation, which has been building its prosperity and its global leadership on a foundation of science, technology and innovation since the days of Jefferson and Franklin.

Staying the course in the current fiscal environment is not going to be easy, but I believe the President's 2012 budget provides a blueprint for doing that, that is both visionary and responsible. The support of this committee, which has been the source itself of so much visionary and also responsible legislation in this domain is going to be essential if we are to stay the course and I am very much looking forward to working with both of you and the rest of the committee toward that end.

Thank you very much.

[The prepared statement of Mr. Holdren follows:]

PREPARED STATEMENT OF DR. JOHN P. HOLDREN, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Chairman Nelson, Ranking Member Boozman, and members of the Committee, it is my distinct privilege to be here with you today to discuss investments in Federal research and development (R&D) in the President's Fiscal Year (FY) 2012 Budget.

Administration Initiatives in Education, Innovation, and Infrastructure

President Obama, in his most recent State of the Union address, called on all of us to help create the American jobs and industries of the future by doing what this Nation does best—investing in the creativity and imagination of the American people. The President identified this time in history as our generation's Sputnik moment. And just as investments in science and engineering research and development (R&D) turned the original Sputnik moment into a Golden Age of American technological and economic dominance, so new investments in science, technology, and innovation (STI) will be the foundation for continued American leadership in the future. Targeted investments in the most promising frontiers of science, made in the context of responsible reductions in less productive endeavors, will fuel this trajectory and allow us, in the President's words, to "out-innovate, out-educate, and outbuild the rest of the world."

President Obama understands that our ability to meet the grand challenges before us is intimately dependent on robust research and development; superior science, technology, engineering, and mathematics (STEM) education; and 21st century transportation, telecommunications, and energy infrastructure. His 2012 Budget provides strategic investments in these domains while also streamlining aspects of the Federal Government and responding responsibly to the deficit. At a difficult time in America's history, the President's 2012 Budget proposes to invest intelligently in innovation, education, and infrastructure today to generate the industries, jobs, and environmental and national security benefits of tomorrow. Obviously, we need the continued support of the Congress to get it done. I say "continued support" because much of the President's Federal research and education investment portfolio enjoyed bipartisan support during the first 2 years of the Administration. And in this 112th Congress, we hope to extend this partnership with both the Senate and the House across the entire science and technology portfolio. Such a collaboration to stimulate scientific discovery and new technologies will take America into this new century well-equipped for the challenges and opportunities that lie ahead.

In the remainder of this testimony, I elaborate on the reasons the President and I are most hopeful you'll provide that support.

The Federal R&D Budget

In his State of the Union address, the President said: "The first step in winning the future is encouraging American innovation," and he promised to deliver a budget that would ensure the Nation's ability to achieve that goal. Last month, the President released that budget. It proposes a record $66.8 billion investment in civilian research and development, an increase of $4.1 billion or 6.5 percent over the 2010 funding level, reflecting the Administration's firm belief that investment in civilian research is a key ingredient for cultivating the innovation that is so important to growing the American economy of the future.

(Because of the uncertainty around the outcome of 2011 appropriations, all the comparisons in my testimony are between the 2012 Budget and the enacted 2010 appropriations. My testimony discusses changes in current dollars, not adjusted for inflation. The latest economic projections show inflation of 2.7 percent between 2010 and 2012 for the economy as a whole, using the GDP deflator.)

These important R&D investments will bolster the fundamental understandings of matter, energy, and life that are at the root of much innovation, and they will foster significantly new and potentially transformative technologies in areas such as biotechnology, information technology, and clean energy.

The Obama Administration's investments in innovation, education, and infrastructure fit within an overall non-security discretionary budget that would be frozen at 2010 levels for the second year in a row and would stay frozen to 2015. The Budget reflects strategic decisions to focus resources on those areas where the payoff for the American people is likely to be highest, while imposing hard-nosed fiscal discipline on areas lacking that kind of promise. For example, the 2012 Budget proposes $79.4 billion for development within the Federal R&D portfolio—a decline compared to the 2010 funding level primarily because of reductions in development funding in the Department of Defense. Across government, important programs will have to make do with less, as noted in several of the program descriptions below. The total (defense and nondefense) R&D budget would be $147.9 billion, $772 million or 0.5 percent above the 2010 enacted level. That modest increase is difficult to accept, of course, given the many needs that could potentially be addressed by an expanded Federal R&D portfolio. But the Administration is committed to making tough choices and it has made many such in this Budget.

Budgets of Science Agencies

Three agencies have been identified as especially important to this Nation's continued economic leadership by the President's Plan for Science and Innovation, the America COMPETES Act, the Administration's Innovation Strategy, and the America COMPETES Reauthorization Act, passed by the Congress in December through the leadership of this Committee and signed by the President in January. Those three jewel-in-the-crown agencies are the National Science Foundation, a primary source of funding for basic academic research; the Department of Energy's (DOE's) Office of Science, which leads fundamental research relevant to energy and also builds and operates the major research infrastructure—advanced light sources, accelerators, supercomputers, and facilities for making nano-materials—on which our scientists depend for energy research breakthroughs; and the National Institute of Standards and Technology laboratories, which support a wide range of pursuits from accelerating standards development for health information technology and "smart grid" technologies to conducting measurement science research to enable net-zero energy buildings and advanced manufacturing processes.

In recognition of the immense leverage these three agencies offer and their key role in maintaining America's preeminence in the global marketplace, Congress and this Administration have worked together to put these agencies on a doubling trajectory. The FY 2012 budget maintains that trajectory, as newly authorized in the America COMPETES Reauthorization Act (Public Law 111–358), with a 12.2 percent increase between 2010 and 2012 for their combined budgets, totaling $13.9 billion. I want to emphasize that the proposed increases for these three agencies are part of a fiscally responsible budget focused on deficit reduction that holds overall non-security discretionary spending flat at 2010 levels for the second year in a row, meaning these increases are fully offset by cuts in other programs.

I now turn to the budgets of individual agencies in a bit more detail. I will focus on the agencies under the jurisdiction of the Committee. Therefore, I will not provide details of the defense R&D portfolio (the Department of Defense and DOE's defense programs) or the budget of the National Institutes of Health (NIH).

National Science Foundation (NSF)

The National Science Foundation (NSF) is the primary source of support for academic research for most non-biomedical disciplines, and it is the only Federal agency dedicated to the support of basic research and education across all fields of science and engineering. NSF has always believed that optimal use of Federal funds relies on two conditions: ensuring that its research is aimed—and continuously reaimed—at the frontiers of understanding; and certifying that every dollar goes to competitive, merit-reviewed, and time-limited awards with clear criteria for success. When these two conditions are met, the Nation gets the most intellectual and economic leverage from its research investments. In recognition of the time-proven truth that today's NSF grants are tomorrow's billion dollar, job-creating companies, the 2012 Budget request for NSF is $7.8 billion, an increase of 13.0 percent above the 2010 funding level. This keeps NSF on track to double its budget as promised in the President's Plan for Science and Innovation.

NSF puts the greatest share of its resources in the Nation's colleges and universities. Universities are the largest performers of basic research in the United States, conducting over fifty percent of all basic research. Basic research funding such as that provided by NSF is important not only because it leads to new knowledge and applications but also because it trains the researchers and the technical workforce of the future, ensuring the Nation will benefit from a new generation of makers and doers. In order to maximize this dual benefit to society and NSF's special contribution, the 2012 Budget sustains the doubling of new NSF Graduate Research Fellowships to support 2,000 new awards. The 2012 Budget also includes $64 million for the Advanced Technological Education (ATE) program to promote partnerships between higher-education institutions and employers to educate technicians for the high-technology fields that drive our Nation's economy; ATE is the centerpiece of an overall $100 million NSF investment in community colleges, an important part of the higher education system.

NSF also proposes to increase research funding to promote discoveries that can spark innovations for tomorrow's clean energy sources with a cross-disciplinary approach to sustainability science. The Science, Engineering, and Education for Sustainability (SEES) portfolio will increase to $998 million in the 2012 Budget for integrated activities involving energy and environment. NSF is also committed to enhancing U.S. economic competitiveness with Science and Engineering Beyond Moore's Law (SEBML), a multidisciplinary research program that aims to extend the technological and conceptual limits on computer processing, with an investment of $96 million in the 2012 Budget. NSF is also investing $76 million in a multi-di-

rectorate initiative on research at the interface of the Biological, Mathematical, and Physical Sciences (BioMaPS) that aims for an accelerated understanding of biological systems and the opening of new frontiers in biotechnology. The Administration proposes $15 million in the 2012 Budget for NSF's contribution to a new interagency initiative called Enhancing Access to the Radio Spectrum, or EARS, to support research into new and innovative ways to use the radio spectrum more efficiently so that more applications and services used by individuals and businesses can occupy the limited amount of available spectrum.

National Aeronautics and Space Administration (NASA)

This past October, the President signed the 2010 NASA Authorization Act (the "Act", Public Law 111–267), which stands as a statement of bipartisan agreement by Congress and the Administration regarding NASA and its many programs. NASA's programs not only support the grand and inspiring adventures of space exploration, scientific discovery, and aeronautical advancement, but also provide an indispensable platform for observing the Earth to ensure that we have the information we need to cope with weather-related and other environmental threats to human well-being. NASA programs also fuel new technology development and innovation and help launch new products, services, businesses, and jobs with enormous growth potential. The Act will further our joint goal of placing NASA's programs on a more stable footing and enhancing the long-term sustainability of these exciting endeavors as we chart a new path forward in space.

The FY 2012 NASA budget reaffirms the Administration's commitment to a bold and ambitious future for NASA. Every initiative called for in the Act is funded, including: a robust program of space science and Earth science, including a commitment to invest in new satellites and programs of Earth observation; a strong aeronautics research program; the Space Launch System (SLS) heavy-lift launch vehicle and Multi-Purpose Crew Vehicle (MPCV) needed to support human spaceflight and exploration missions beyond Earth's orbit; a vigorous technology development program; extension of International Space Station (ISS) activities through at least 2020, coupled with a plan to use this orbiting outpost more effectively; and the development of private-sector capabilities to transport cargo and crew into low Earth orbit, thus shortening the duration of our reliance solely on Russian launch vehicles for access to the ISS.

Within the context of a difficult budget environment and the President's decision to freeze non-security discretionary spending at 2010 levels for 5 years, NASA's budget remains at $18.7 billion in the 2012 Budget. This budget level demands difficult choices, and those choices were made while keeping in mind the priorities of the Act as well as the collective desire of the Congress and the Administration to have a balanced program of science, research, technology development, safe spaceflight operations, and exploration. One such difficult choice was limiting the budget for the James Webb Space Telescope, keeping the project funded at $375 million in 2012, to assure NASA the opportunity to begin work on new scientific opportunities identified in the National Academies' most recent decadal survey in astronomy and astrophysics. Similarly, the 2012 Budget reduces the planned increases in Earth-science research outlined in the 2011 Budget. The Budget demonstrates the President's continued commitment to our shared priorities even when difficult decisions are required, providing $1.8 billion in FY 2012 funding for the Space Launch System and $1.02 billion for the Multi-Purpose Crew Vehicle, thereby laying the critical foundation for these exploration programs. As NASA reported in January of this year, it is still in the process of shaping these efforts and will discuss them in more detail in a report to Congress this spring. Similarly, the Budget provides a solid foundation for the commercial crew and cargo transportation programs that are necessary to provide safe and cost-effective access to low-Earth orbit, including sufficient support for the operations of the ISS.

Department of Commerce National Institute of Standards and Technology (NIST)

The hugely complex web of technology that keeps this Nation's equipment and economy running smoothly depends on largely invisible but critical support in the fields of measurement science and standards. The National Institute of Standards and Technology (NIST) laboratories stand at the core of this Nation's unparalleled capacity in these areas, helping ensure that America remains the world leader in measurement innovation and systems interoperability. Reflecting NIST's vital role in supporting the economy and infrastructure, the 2012 Budget of $764 million for the Institute's intramural laboratories amounts to a 15.1 percent increase over the 2010 enacted level. That increase will support high-performance laboratory research and facilities for a diverse portfolio of investigations in areas germane to advanced manufacturing, health information technology, cybersecurity, interoperable smart

grid, and clean energy. For NIST's extramural programs, the 2012 Budget requests $143 million for the Hollings Manufacturing Extension Partnership (MEP), an $18 million increase over the 2010 enacted level. The 2012 Budget also requests $75 million for the Technology Innovation Program (TIP), a $5 million increase over 2010, and $12 million for the Advanced Manufacturing Technology Consortia program, a new public-private partnership that will develop road maps for research that will broadly benefit the Nation's industrial base. All of these NIST programs are important components of *A Framework for American Manufacturing,* a comprehensive strategy for supporting American manufacturers announced in December 2009, and the Administration's revised Innovation Strategy released in February.

Department of Commerce National Oceanic and Atmospheric Administration (NOAA)

NOAA plays a vital role supporting research on the Earth's oceans, atmosphere, and marine habitats. The NOAA budget of $5.5 billion is an increase of $749 million over the 2010 enacted level. This will allow NOAA to strengthen the scientific basis for consequential environmental decision-making, improve critical weather and climate services that protect life and property, invest more heavily in restoring our oceans and coasts, take advantage of high-performance computing to manage weather and climate data, and ensure continuity in crucial Earth-observation satellite coverage. The 2012 Budget proposes a restructuring of NOAA, including the creation of a Climate Service line office in NOAA that will focus on the delivery of climate services while sustaining research on oceans, atmosphere, and climate.

NOAA satellite systems are critical for our Nation's ability to forecast severe weather, such as blizzards or hurricanes, and as such can save lives and property. Ensuring that we retain these capabilities remains a top priority in the 2012 Budget. The former National Polar-orbiting Operational Environmental Satellite System (NPOESS) program had a troubled history, as illustrated by numerous Congressional hearings and GAO reports. Because of this, in early 2010 the Administration announced a significant restructuring of the program, and this plan was endorsed by Congress as part of the 2010 NASA Authorization Act (Section 727). This restructuring was accompanied by significant increases in NOAA's 2011 Budget request in order to expedite the launch schedule of these essential weather satellites and reduce the risks of a gap in forecasting data. However, because the current continuing resolution allows for only a fraction of the funding necessary in FY2011 to continue work on the instruments and spacecraft for the first of NOAA's satellites (the first Joint Polar Satellite System mission, or JPSS–1), work on the first JPSS satellite has been slowed down considerably. Under current funding scenarios, the JPSS–1 mission could be delayed by up to 2 years, thus forcing the weather forecasting community to rely solely on satellites that will be operating well past their planned mission life. The 2012 Budget request provides $1.1 billion to continue the development of the Joint Polar Satellite System, a significant increase over the 2010 enacted level which reflects the need for NOAA to fully fund the acquisition of satellites for the afternoon orbit within its own budget. NOAA recognizes the magnitude of the requested investment for environmental operational satellites. However, given the impact of weather on society and the Nation's economy, the ability to warn and protect our citizens from harm is well worth the cost.

Department of Energy (DOE)

The Administration is directing Federal innovation incentives to one of the most important, job-creating, innovation-inspiring challenges of our time: making clean energy affordable and abundant. The DOE R&D portfolio is a key part of this effort, which is why DOE R&D increases to $13.0 billion in the 2012 Budget. This represents targeted growth of 19.9 percent and does not include DOE's non-R&D cleanup, weapons, and energy-deployment programs. The 2012 Budget also proposes significant resources for demonstration and deployment incentives as part of a comprehensive framework for moving the United States toward a clean-energy future. The Administration's clean-energy R&D priorities focus on developing cutting-edge technologies with real-world applications to advance a clean-energy economy, increase energy efficiency in industry and manufacturing, reduce energy use in buildings, and reach the goal of having 1 million electric vehicles on the road by 2015. To help pay for these priorities, we are proposing to cut inefficient subsidies that we currently provide, unnecessarily, for fossil fuels.

The 2012 Budget proposes $550 million in appropriations for the Advanced Research Projects Agency-Energy, or ARPA–E, and another $100 million in mandatory funding under the Wireless Innovation Fund. The Budget will advance ARPA–E's portfolio of transformational energy research with real-world applications across areas ranging from grid technology and power electronics to batteries and energy storage. First funded as part of the American Recovery and Reinvestment Act

(ARRA), ARPA–E is a signature component of the America COMPETES Act, which was recently reauthorized.

The 2012 Budget also doubles the number of Energy Innovation Hubs to solve key challenges that require cross-cutting inputs from diverse disciplines. The three new Hubs will focus on Batteries and Energy Storage, Smart Grid Technology and Systems, and Critical Materials. In early February, the President visited the existing Energy Efficient Building System Design Hub, which will accelerate the development of innovative designs for cost-effective lighting, sunlight-responsive windows, and smart, thermodynamic heating and cooling systems, which together will help make America home to the most energy-efficient buildings in the world. The other two existing Hubs focus on Fuels from Sunlight and Modeling and Simulation for Nuclear Reactors.

The Department of Energy's Office of Science pursues fundamental discoveries and supports major scientific research facilities that provide the foundation for long-term progress in economically significant domains such as nanotechnology, advanced materials, high-end computing, energy supply and end-use efficiency, and climate change. The 2012 Budget of $5.4 billion, more than 10 percent above the 2010 enacted level, increases funding for facilities and cutting-edge research geared toward addressing fundamental challenges in many areas including clean energy and climate change, as well as multi-scale carbon cycle research to underpin measurement, reporting, and verification of greenhouse gas emissions.

Investments in DOE's clean-energy applied R&D programs target gains over the next several decades for reducing dependence on oil and accelerating the transition to a low-carbon economy. The President's 2012 Budget increases investments in Energy Efficiency and Renewable Energy by more than 40 percent over the 2010 appropriation to a total of $3.2 billion. EERE supports important work in industrial productivity, R&D on advanced batteries for electric and hybrid vehicles, and building technology R&D to cut energy consumption. It also supports new deployment activities in these areas, including a $200 million competitive grant program to encourage electric vehicle (EV) readiness and a $100 million competitive "Race to Green" program to encourage state and local governments to streamline codes, regulations, and performance standards and make efficient building the norm. Strong support continues for carbon capture and storage options that can significantly reduce the cost of transitioning to a low-carbon economy. The Budget also increases investments by more than 40 percent over 2010 funding levels in R&D to modernize the electric grid, critical to enabling clean energy sources, by providing $238 million for Electricity Delivery and Energy Reliability.

To help pay for these programs and align policies toward new clean energy technologies, the Budget proposes to repeal over $4 billion per year in inefficient fossil fuel subsidies. The Administration will continue to work in a bipartisan fashion to put in place market-based incentives to promote U.S. leadership in the clean-energy marketplace. Consistent with Administration policy to phaseout inefficient fossil fuel subsidies, the Budget eliminates funding for R&D focused on increasing hydrocarbon production.

Environmental Protection Agency (EPA)

The R&D portfolio of the Environmental Protection Agency (EPA) is $584 million in the 2012 Budget, a decline of $13 million or 2.2 percent compared to the 2010 funding level. With this investment, EPA will focus on enhancing and strengthening the planning and delivery of science by restructuring its research and science programs to be more integrated and cross-disciplinary. This request supports high-priority research of national importance in such areas as endocrine disrupting chemicals, green chemistry, e-waste and e-design, green infrastructure, computational toxicology, air monitoring, drinking water, and STEM fellowships. In addition, by way of strategic redirections, EPA will significantly increase—by $25 million—its outreach to the broader scientific community through its Science to Achieve Results (STAR) program. This investment will bring innovative and sustainable solutions to 21st century environmental science challenges by engaging the academic research community.

United States Geological Survey (USGS)

The total 2012 budget of the United States Geological Survey (USGS), Interior's lead science agency, is $1.1 billion or a $6 million increase from the 2010 enacted level. The Budget includes a total of $126 million in program increases, offsetting a total of $120 million in program reductions and savings, reflecting shifting priorities toward climate variability research and ecosystem restoration. There are significant decreases in minerals and water resources research as well as targeted increases, including $11 million to complete the network of climate science centers

that will develop research-based decision support tools for use by Federal land managers. The 2012 Budget also proposes an addition of $60 million over the 2010 level for Landsat operations and the development of a new operational Landsat satellite program, which will continue to collect remote sensing data that are invaluable for many purposes, including climate and land-use change research.

Department of Homeland Security (DHS)

Department of Homeland Security (DHS) R&D totals $1.1 billion in the 2012 Budget, up $167 million or 18.8 percent from the 2010 enacted level. Within the DHS Science and Technology Directorate, the 2012 Budget proposes $150 million to begin construction of the National Bio and Agro-defense Facility (NBAF), which will serve as a new, state-of-the-art biosafety level 3&4 facility for the development of vaccines and anti-virals and enhanced diagnostic capabilities for protecting the United States against emerging agricultural diseases. The Budget also proposes $64 million for research to support the Comprehensive National Cybersecurity Initiative (CNCI), an increase of $22 million from the 2010 enacted level.

Department of Transportation (DOT)

The 2012 Budget provides $1.2 billion for Department of Transportation (DOT) R&D, an increase compared to the 2010 funding level. One significant part of DOT's R&D activities is the Federal Aviation Administration's (FAA) Research, Engineering, and Development program. The Budget includes funding for several R&D activities in FAA's Next Generation Air Transportation System, known as NextGen. The Joint Planning and Development Office coordinates this important effort with NASA and other participating agencies. The Federal Highway Administration (FHWA) also manages a comprehensive, nationally-coordinated highway research and technology program, engaging and cooperating with other highway research stakeholders. FHWA performs research activities associated with safety, infrastructure preservation and improvements, and environmental mitigation and streamlining.

White House Office of Science and Technology Policy (OSTP)

The 2012 Budget requests $6.65 million for White House Office of Science and Technology Policy (OSTP) operations, 5 percent below the 2010 enacted funding level, in recognition of the need for shared sacrifice to freeze non-security discretionary spending. OSTP works with OMB to ensure that the President's S&T priorities are appropriately reflected in the budgets of all the Executive Branch departments and agencies with S&T and STEM-education missions. OSTP also provides science and technology advice and analysis in support of the activities of the other offices in the Executive Office of the President and supports me in my role as the Assistant to the President for Science and Technology, with the responsibility to provide the President with such information about science and technology issues as he may request in connection with the policy matters before him. In addition, OSTP coordinates interagency research initiatives through administration of the National Science and Technology Council (NSTC), serves as the lead White House office in a range of bilateral and multilateral S&T activities internationally, and provides administrative and technical support for the very active 21-member President's Council of Advisers on Science and Technology (PCAST). This work is accomplished with approximately 34 full-time equivalent staff supported by the OSTP appropriation, which includes the OSTP Director, four Associate Directors (for Science, Technology, Environment, and National Security and International Affairs), additional technical experts, and a small administrative function. In addition, there are approximately 40 scientific and technical experts detailed to OSTP from all across the Executive Branch along with approximately a dozen other experts brought in under the Intergovernmental Personnel Act or various fellowship arrangements. This mix of personnel allows OSTP to tap a wide range of expertise and leverage all available resources to ensure that the science and technology work of the Federal Government is appropriately resourced, coordinated and leveraged.

Interagency Initiatives

A number of priority interagency S&T initiatives are highlighted in the President's 2012 Budget. These initiatives are coordinated through the NSTC, which as noted above is administered by OSTP.

Networking and Information Technology R&D

The multi-agency Networking and Information Technology Research and Development (NITRD) program plans and coordinates agency research efforts in cyber security, high-end computing systems, advanced networking, software development, high-confidence systems, information management, and other information tech-

nologies. The 2012 Budget provides $3.9 billion for NITRD, an increase of $74 million over the 2010 funding level.

Networking and computing capabilities are more critical than ever for a range of national priorities, including national and homeland security, reforming the health care system, understanding and responding to environmental stresses, increasing energy efficiencies and developing renewable energy sources, strengthening the security of our critical infrastructures including cyberspace, and revitalizing our educational system for the jobs of tomorrow. The 2012 Budget includes a focus on research to improve our ability to derive scientific insights and economic value from enormous quantities of data that heretofore would have been too large to take full advantage of, and continues to emphasize foundations for assured computing and secure hardware, software and network design, and engineering to address the goal of making Internet communications more secure and reliable.

National Nanotechnology Initiative

The 2012 Budget provides $2.1 billion for the multi-agency National Nanotechnology Initiative (NNI), an increase of $201 million over the 2010 funding level. Research and development in the NNI focuses on the development of materials, devices, and systems that exploit the fundamentally distinct properties of matter at the nanoscale. NNI-supported R&D is enabling breakthroughs in disease detection and treatment, manufacturing at or near the nanoscale, environmental monitoring and protection, energy conversion and storage, and the design of novel electronic devices. In 2012, NNI agencies will be moving forward, using close and targeted program-level interagency collaboration, on three signature initiatives in areas ready for advances: Nanoelectronics for 2020 and Beyond; Sustainable Manufacturing—Creating the Industries of the Future; and Nanotechnology for Solar Energy Collection and Conversion.

In addition, agencies continue to maintain a focus on developing nanotechnology responsibly with attention to potential human and environmental health impacts, as well as ethical, legal, and other societal issues. I will also add that I recently submitted to the Committee a revised strategic plan for the NNI reflecting the changing opportunities for frontier research at the nanoscale.

U.S. Global Change Research Program

The Budget includes an expanded commitment to global change research, with the understanding that insights derived today will pay off with interest in the years and decades ahead as our Nation works to limit and adapt to shifting environmental conditions. Investments in climate science over the past several decades have contributed enormously to our understanding of global climate. The trends in global climate are clear, as are their primary causes, and the investments in this research arena in the 2012 Budget are a critical part of the President's overall strategy to mitigate U.S. greenhouse-gas emissions and move toward a clean- energy economy even as we adapt to those changes that are inevitable. Specifically, the 2012 Budget provides $2.6 billion for the multi-agency U.S. Global Change Research Program (USGCRP)—an increase of 20.3 percent or $446 million over the 2010 enacted level—to continue its important work of improving our ability to understand, predict, project, mitigate, and adapt to climate change.

As you are no doubt aware, the USGCRP was mandated by Congress in the Global Change Research Act of 1990 (P.L. 101–606) to improve understanding of uncertainties in climate science, expand global observing systems, develop science-based resources to support policymaking and resource management, and communicate findings broadly among scientific and stakeholder communities. Thirteen departments and agencies participate in the USGCRP. OSTP and the Office of Management and Budget (OMB) work closely with the USGCRP to establish research priorities and funding plans to ensure the program is aligned with the Administration's priorities and reflects agency planning. In 2011, the USGCRP is undertaking a comprehensive process that will result in an updated strategic plan, which will be submitted to Congress later this year.

Funding in the 2012 Budget will support an integrated and continuing National Climate Assessment of climate change science, impacts, vulnerabilities, and response strategies as mandated by Congress. The Budget also prioritizes an interagency research effort for measuring, reporting, and verifying greenhouse-gas emissions.

Innovation, Entrepreneurship, and Job Creation

The President believes we must harness the power and potential of science, technology, and innovation to transform the Nation's economy and to improve the lives of all Americans. In addition to the investments in research and development (R&D) I have described, the President's 2012 Budget targets strategic investments to spur

innovation in the public and private sectors and to maximize the impact of the Federal R&D investment for innovation. Last month, the President released a revised Strategy for American Innovation, building on an earlier version released in September 2009. This strategy describes how investments in R&D work together with other Federal investments and policies to support American innovation. Let me share with you a few highlights that are reflected in the Budget.

The Budget proposes a permanent extension of the research and experimentation (R&E) tax credit to spur private investment in R&D by providing certainty that the credit will be available for the duration of the R&D investment. In December, the President and Congress worked together to extend expiring tax breaks for Americans; as part of that agreement, the current R&E tax credit was extended through the end of this year. The 2012 Budget proposes to expand and simplify the credit as part of making it permanent.

In addition, earlier this year the Administration announced Startup America, a campaign to inspire and accelerate high-growth entrepreneurship throughout the Nation. This coordinated public/private effort brings together an alliance of the country's most innovative entrepreneurs, corporations, universities, foundations, and other leaders, working in concert with a wide range of Federal agencies to increase the prevalence and success of American entrepreneurs. A broad set of Federal agencies will launch a coordinated series of policies that ensure high-growth startups have unimpeded access to capital, expanded access to quality mentorship, an improved regulatory environment, and a rapid path to commercialization of federally-funded research.

The 2012 Budget sustains the Administration's effort to promote regional innovation clusters as significant sources of entrepreneurship, innovation, and quality jobs. These efforts are taking place in several agencies working together, including the Small Business Administration (SBA), DOE, and especially the Economic Development Administration (EDA) within the Department of Commerce. EDA will be pursuing several programs in research parks, regional innovation clusters, and entrepreneurial innovation activities, as authorized recently in the America COMPETES Reauthorization Act. And as mentioned earlier, the 2012 Budget continues to increase funding for the Hollings Manufacturing Extension Partnership (MEP) in NIST to disseminate the latest advanced manufacturing techniques and innovative processes to small- and medium-sized manufacturers around the Nation. Taken together, these investments will help ensure that Federal investments in innovation, education, and infrastructure translate into commercial activity, real products, and jobs.

Science, Technology, Engineering, and Mathematics (STEM) Education

In his State of the Union address, the President said: "If we want innovation to produce jobs in America and not overseas, then we also have to win the race to educate our kids." To help win that race, the 2012 Budget emphasizes science, technology, engineering, and mathematics (STEM) education, building on two strong years of progress. Through his past budget requests and actions—including his recent hosting of the first White House science fair, his launch of the "Educate to Innovate" and "Change the Equation" initiatives, and his challenging the Nation's 200,000 Federal scientists and engineers to get more involved in STEM education—the President has shown that he is deeply committed to improving STEM education. These efforts have engaged not only the Federal Government but also the private, philanthropic, and academic sectors. The Educate to Innovate campaign has resulted in over $700 million in financial and in-kind private-sector support for STEM education programs. And the Change the Equation program has brought together over 100 corporations in a historic effort to scale up effective models for improving STEM education. The Administration has also integrated STEM education into broader education programs. For example, the Race to the Top competition provided a competitive advantage to states that committed to a comprehensive strategy to improve STEM education.

Building on these efforts, the 2012 Budget proposes an investment of $100 million as a down payment on a 10-year effort to help prepare 100,000 new highly effective STEM teachers. This coordinated effort between NSF and the Department of Education will help prepare teachers with both strong teaching skills and deep content knowledge. The Administration proposes $80 million for the Department of Education in the 2012 Budget to expand promising and effective models of teacher STEM preparation within the new Teacher and Leader Pathways program—for example, ones that provide undergraduates with early and intensive field experience in the classroom along with extensive STEM subject coverage. At the same time, NSF proposes to launch a $20 million teacher-education research program called Teacher Learning for the Future. In cooperation with the Department of Education,

this NSF program will fund research that will increase our understanding of what makes a great STEM teacher and how to best prepare, support, and retain highly effective STEM teachers in the most cost effective manner. The coordination of these two programs will ensure that there is continual innovation and improvement in teacher preparation that is grounded firmly in evidence.

This is part of a broader Administration commitment to look carefully at the effectiveness of all STEM programs and find ways to improve them. To further this goal, I have established a Committee on STEM Education under the National Science and Technology Council. The STEM Education Committee is co-chaired by OSTP's Associate Director for Science, Carl Wieman, a Nobel Prize-winning physicist renowned for his work on improving STEM education, and involves participation from the many Federal agencies involved in STEM education activities.

The work of this Committee is closely aligned with the vision for STEM education outlined by Congress in the America COMPETES Reauthorization Act and focuses on improving the coordination and effectiveness of all Federal STEM education programs. In this spirit, the Department of Education and NSF are leading an effort, with active OSTP participation, to increase the impact of the Federal STEM investments I've outlined above by: (1) developing an aligned strategy that emphasizes key agency capacities; (2) clarifying evidence standards used to assess program impact; and (3) identifying the most promising STEM efforts for further validation, testing, and suitability for scaling up.

All told, the 2012 Budget requests $3.4 billion for STEM education programs across the Federal Government. This is $200 million lower than the 2010 funding level and reflects some difficult choices. However, we feel this budget is better focused on programs that will make an impact.

OSTP looks forward to working with this Committee on our common vision of improving STEM education for all of America's students.

21st Century Infrastructure

I've talked about innovation and education, and now I would like to talk briefly about the third step in winning the future: rebuilding America. In his State of the Union address, the President established a vision of rebuilding America for the 21st century. This vision is reflected in the 2012 Budget in investments that will not only rebuild the roads and bridges of the 20th century but will also help build the new infrastructure needed for America to remain competitive in this century.

Within science and technology, the 2012 Budget proposes a Wireless Innovation and Infrastructure Initiative to help businesses extend the next generation of wireless coverage to 98 percent of the U.S. population. This Initiative will enable businesses to grow faster, students to learn more, and public safety officials to access state-of-the-art, secure, nationwide, and interoperable mobile communications. It will also foster the conditions for the next generation of wireless technology, nearly doubling the amount of wireless spectrum for mobile broadband and providing critical support for R&D in wireless innovation. The Initiative builds upon the Presidential Memorandum on spectrum released last year, which proposes to reallocate a total of 500 megahertz of Federal agency and commercial spectrum bands over the next 10 years to increase the Nation's access to wireless broadband.

As part of the Initiative, the 2012 Budget proposes the creation of a $3 billion Wireless Innovation (WIN) Fund to be funded out of receipts generated through electromagnetic-spectrum auctions. This Fund will advance our economic growth and competitiveness goals, supporting key technological developments that will enable and take advantage of the private sector's rollout of next-generation wireless services and pave the way for new technologies. The WIN Fund will support basic research, experimentation and testbeds, and applied development in a number of areas including public safety, education, energy, health, transportation, and economic development.

The 2012 Budget also proposes investments in novel, game-changing physical infrastructure systems including a national high-speed rail system, an improved civil aviation system taking advantage of the NextGen air-traffic-control innovations, and new standards for smart-grid technologies.

Conclusion

The investments in research and development, innovation, STEM education, and 21st century infrastructure proposed in the President's FY 2012 Budget reflect his clear understanding of the critical importance of science and technology, STEM education, and 21st century infrastructure to the challenges the Nation faces. Recognizing the importance of responsibly reducing projected budget deficits and holding the line on government spending, the President has made difficult choices in order to maintain and in some cases increase critical investments that will pay off by gen-

erating the American jobs and industries of the future. Indeed, the science and technology investments in the 2012 Budget are essential to keep this country on a path to revitalized economic growth, real energy security, intelligent environmental stewardship, better health outcomes for more Americans at lower costs, strengthened national and homeland security, and continuing leadership in science and in space.

As this Committee has long understood over the decades, the best environment for innovation in all technologies is a broad and balanced research program for all the sciences. Such a broad base of scientific research will provide the foundation for a cornucopia of multidisciplinary discoveries with unimagined benefits for our society. The truth is that this country's overall prosperity in the last half-century is due in no small measure to America's "innovation system"—a three-way partnership among academia, industry, and government.

One of President Obama's guiding principles is that America's present and future strength, prosperity, and global preeminence depend directly on fundamental research. Knowledge drives innovation, innovation drives productivity, and productivity drives America's economic growth. And so it logically follows that economic growth is a prerequisite for opportunity, and scientific research is a prerequisite for growth.

That is why President Obama believes that leadership across the frontiers of scientific knowledge is not merely a cultural tradition of our nation—today it is an economic and national security imperative. This Administration will ensure that America remains at the epicenter of the ongoing revolution in scientific research and technological innovation that generates new knowledge, creates new jobs, and builds new industries.

By sustaining our investments in fundamental research, we can ensure that America remains at the forefront of scientific capability, thereby enhancing our ability to shape and improve our Nation's future and that of the world around us.

I look forward to working with this Committee to make the vision of the President's FY 2012 Budget proposal a reality. I will be pleased to answer any questions the Members may have.

Senator NELSON. Dr. Suresh?

STATEMENT OF DR. SUBRA SURESH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. SURESH. Thank you, Chairman Nelson and Ranking Member Boozman. Thank you very much for this opportunity to present NSF's 2012 budget request to you this morning.

I would like to expand on what Dr. Holdren said, focusing on what NSF is planning to do for the coming fiscal year.

I came to the United States in 1977 to do science and engineering because it was the only beacon of science and engineering at that time; to do engineering research and education I did not have to think twice as to where I wanted to go. The mission of NSF is to sustain that excellence as we continue to lead the way for important discoveries and cutting edge technologies.

For 2012, NSF's budget request is $7.8 billion, which represents an increase of $894 million or 13 percent. As Dr. Holdren just mentioned, it is consistent with the President's Plan for Science and Innovation and the President's plan for doubling the budget for science agencies. It is also consistent with the America COMPETES Reauthorization Act of 2010.

The economic prosperity of our country and its global competitiveness depend on innovations that come from new technologies; new knowledge; basic research, as the Ranking Member mentioned in his opening remarks; and a highly skilled and inclusive workforce. NSF has an unparalleled track record for the past 60 years in supporting the best ideas and the most talented people. The 2012 budget request builds on these past accomplishments.

The most challenging research problems today bring together people from very different fields; fields as different as computer science, mathematics and the physical, life, and social sciences. In 2012, INSPIRE, which is a new program in the NSF portfolio, will encourage investigators to undertake multidisciplinary research which is the hallmark of much of contemporary science and engineering.

As you mentioned in your opening statement, Mr. Chairman, NSF supports basic research in all fields of science and engineering. Because of this, we are well positioned to catalyze the new fields and new research paradigms that emerge from this cross fertilization. Over the next 5 years NSF will receive a billion dollars from the Wireless Innovation Fund which was established with receipts from the spectrum auctions. In fact, NSF supported research on advanced economics that led to the identification of potential opportunities for financial gains through spectrum auctions. That led to the FCC's current system of spectrum auctions, which has netted $45 billion for the federal government since 1994. This fund will allow NSF to expand research on wireless test pads and systems such as smart sensors for buildings, roads, and bridges.

In the 1960s and 1970s, process innovation and mathematical research funded by NSF led to major innovations in an area called rapid prototyping which revolutionized American manufacturing. This came at a time when industry was not supporting this research: it was NSF-funded research that led to the revolution in manufacturing. Continuing that trend, in the 2012 budget we have identified $190 million for the area of advanced manufacturing to pursue innovations in sensor and model-based smart manufacturing and nanomanufacturing.

Additionally, an interagency National Robotics Initiative will focus on robots that will work cooperatively with people in areas such as manufacturing, space and undersea exploration, healthcare, surveillance and security, and education and training.

Dr. Holdren mentioned the National Nanotechnology Initiative. NSF has continued to play a lead role in that initiative since the beginning of that effort more than 10 years ago. As part of this, in the 2012 budget, we will explore significant initiatives in nanoelectronics, solar energy collection and conversion, and sustained nanomanufacturing. Just to illustrate the impact of NSF funded research in nanotechnology: in the past 10 years, NSF funded nanotechnology centers have led to 175 startups that have established collaborations with 1,200 companies.

U.S. leadership in science and engineering requires the most knowledgeable and skilled STEM workforce. Three new programs in STEM education, each funded at a level of $20 million, will improve teacher preparation, strengthen undergraduate STEM education and broaden participation of under represented groups in our workforce. We fully recognize that leading edge tools are also needed to advance the frontiers of science and engineering and to train students for the workforce. The budget sustains investments in major equipment and facility projects. These are very critical for creation of new knowledge and major new discoveries.

In conclusion, "one NSF" is a concept that characterizes my vision for the National Science Foundation as a model agency. NSF

will work seamlessly across organizational and disciplinary boundaries to create new basic knowledge, stimulate discovery, and address complex societal problems. NSF's investments in fundamental science and engineering have paid enormous dividends, improving the lives and livelihoods of several generations of Americans. The 2012 budget request will carry the success into the future.

Mr. Chairman, Mr. Ranking Member, this concludes my testimony and I look forward to answering your questions.

[The prepared statement of Dr. Suresh follows:]

PREPARED STATEMENT OF DR. SUBRA SURESH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Chairman Nelson, Ranking Member Boozman, 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) 2012 Budget Request. My name is Subra Suresh and I am Director of the National Science Foundation (NSF).

I hope to make a clear and compelling case for the critical value of NSF support for science and engineering research and education at a time when America faces many pressing needs and tight budget constraints. I came to the United States as a young engineering student because it was the world's beacon of excellence in science and engineering research and education. I stayed for the same reason. The mission of NSF is to sustain that excellence as we continue to lead the way for the important discoveries and cutting-edge technologies that will help keep our Nation globally competitive, prosperous, and secure.

The President's request for NSF for FY 2012 is $7.8 billion, an increase of 13 percent, or $894 million, over the FY 2010 Enacted level. *The President's Plan for Science and Innovation* calls for doubling the Federal investment in key basic research agencies. NSF's request is consistent with this plan, with the Administration's Innovation Strategy, and with the America COMPETES Reauthorization Act of 2010. The increase will support 2,000 more research awards across the Nation.

In FY 2012, NSF will strengthen support for basic research and education in all fields of science and engineering, and promote collaborations that reflect the increasingly interdisciplinary nature of modern science and engineering, while strengthening our disciplinary excellence. We will capitalize on many promising areas of investigation where new discoveries can help establish U.S. leadership in next generation technologies, and we will invest in transformational work, new fields, and novel theoretical paradigms to fuel the innovations of the future. Innovative programs to bolster world-class science, technology, engineering, and mathematics education (STEM), from coast to coast, and from north to south, are central to the success of all these activities.

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 1970s, 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 82 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 basic 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 2012 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.

The NSF FY 2012 Budget Request

The Administration's *A Strategy for American Innovation* makes clear the larger rationale for investments in science and engineering research and education. This is to put knowledge to work—to create the industries and jobs of the future, and to improve the quality of life and enhance the security and prosperity of every citizen. NSF investments support each of the three pillars of this strategy: *Invest in the Building Blocks of American Innovation, Promote Market-Based Innovation*, and *Catalyze Breakthroughs for National Priorities*.

Invest in the Building Blocks of American Innovation

A robust U.S. science and engineering research enterprise is necessary to maintain a global edge in the competition for new ideas. In FY 2012, NSF will continue to support the most promising research programs and launch several new initiatives.

Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) will support new activities to encourage investigators to undertake the interdisciplinary research that is a hallmark of much contemporary science and engineering. This effort will be in concert with disciplinary excellence. INSPIRE will catalyze interdisciplinary research by seamlessly integrating a suite of new activities with existing efforts and other NSF investments. The goal is to foster and support the transformative research that interdisciplinary research so often produces. INSPIRE is a new $12 million initiative in FY 2012, and will involve participation from all Directorates.

Science and Engineering Beyond Moore's Law (SEMBL) explores next generation computing, including quantum computing, that addresses the limits of current technology. Those limits may be reached in as few as 10 to 20 years. In FY 2012, NSF will invest $96 million to continue this multidisciplinary program.

Research at the Interface of the Biological, Mathematical, and Physical Sciences (BioMaPS) is a $76 million investment to investigate biological systems that provide architectural and operational blue prints which can guide engineering of adaptive technologies. BioMaPS will integrate research in the biological, engineering, mathematical, and physical sciences to better understand and replicate nature's ability to network, communicate, and adapt. The research will accelerate the generation of bio-based materials and sensors, and the advanced manufacturing of bio-inspired devices and platforms.

Global leadership also requires the most knowledgeable and skilled STEM workers in the world. NSF's approach is to develop the Nation's talent pool by integrating research and education. This longstanding NSF practice facilitates the direct transfer of new knowledge to the private sector. It happens every time graduate students with experience working at the frontiers of discovery enter the work force. A strong suit in U.S. competitiveness, this is one of NSF's greatest contributions to the Nation's innovation system. NSF will support three new initiatives to strengthen STEM education throughout the nation, and continue support for highly effective efforts to develop the Nation's talent and workforce.

Teacher Learning for the Future (TLF), funded at $20 million, is a new teacher-training research program that will fund innovative efforts that design, develop, implement and test new teacher-training programs in cooperation with the Department of Education.

Widening Implementation and Demonstration of Evidence-based Reforms (WIDER), a new $20 million program to support research on how to achieve widespread sustainable implementation of improved undergraduate instructional practices and student outcomes at major universities.

Transforming Broadening Participation through STEM (TBPS), a third new program, will expand support for activities to broaden participation of underrepresented groups through partnerships that match research centers with other institutions committed to broadening participation. The FY 2012 investment in TBPS is $20 million.

The Faculty Early Career Development program (CAREER) develops the future scientific and technical workforce through support of young faculty who are dedicated to integrating the excitement of research with inspired teaching and enthusiastic learning. In FY 2012, NSF will invest $222 million to support approximately 606 CAREER awards, an increase of 60 awards.

The Graduate Research Fellowship program (GRF), funded at $198 million in FY 2012, supports the development of graduate students in order to cultivate the next generation of STEM workers. In FY 2012, NSF will award 2,000 new fellowships, sustaining the doubling of new fellowship awards achieved in FY 2010. In addition, the cost of education allowance will be increased from $10,500 to $12,000, the first increase in this level since 1998. The Budget Request also includes initial funding for a stipend increase to $32,000 that will be fully implemented in FY 2013.

Community college funding continues to be a priority for NSF in FY 2012. NSF engages community colleges through several programs, including Advanced Technological Education (ATE), Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES), the Louis Stokes Alliances for Minority Participation (LSAMP), and the Tribal Colleges and Universities Program (TCUP). The total investment in community college programs is $100 million.

Promote Competitive Markets that Spur Productive Entrepreneurship.

Advances in technology, economic growth, and a prosperous society depend on the translation of fundamental discoveries into new processes, practices, and commercial products that are widely used. Many NSF activities provide incentives for scientists, engineers, and educators to undertake use-inspired research that transforms basic discoveries into applications for the benefit of society and the economy.

The Advanced Manufacturing initiative will pursue advances in sensor and model-based smart manufacturing; cyber-physical systems such as advanced robotics; smart buildings and bridges; and nano-manufacturing. This initiative holds tremendous potential for significant short-term and long-term economic impact by developing the foundation for entirely new classes and families of products that were previously unattainable. The NSF request for FY 2012 includes $190 million for these activities.

The Wireless Innovation (WIN) Fund, a component of the Administration's new Wireless Innovation and Infrastructure Initiative (WI3), will provide $1 billion to NSF over the next 5 years. WI3 proposes to reallocate a total of 500 megahertz of Federal agency and commercial spectrum bands over the next 10 years to increase the Nation's access to wireless broadband. NSF will support research on experimental wireless technology testbeds, more flexible and efficient use of the radio spectrum, and cyber-physical systems such as wireless sensor networks for smart buildings, roads, and bridges. A portion of the receipts generated through electromagnetic spectrum auctions will provide funding for WIN. NSF's FY 2012 investments will be coordinated with a number of other agencies, including the Defense Advanced Research Projects Agency and the National Institute of Standards and Technology.

Enhancing Access to the Radio Spectrum (EARS), in addition to the related research funded through the WIN, will support research into new and innovative ways to use the radio spectrum more efficiently so that more applications and services used by individuals and businesses can occupy the limited amount of available spectrum. NSF proposes an investment of $15 million in FY 2012.

Engineering Research Centers (ERCs) and Industry/University Cooperative Research Centers (I/UCRC) direct much of their basic research to problems with potential economic impact. By working closely with industry, these programs create enabling technologies for national needs, such as managing the electrical power system, improving manufacturing and biological processing, and supporting new healthcare information and telecommunications technologies. They also prepare students for innovation leadership in a globally competitive marketplace. The FY 2012 NSF investment is $96 million.

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, funded at $147 million in FY 2012, build partnerships

between the academic and industry sectors. They bolster the innovation economy by funding translational research at U.S. small businesses on topics that span the breadth of NSF scientific and engineering research and reflect national and societal priorities.

Catalyze Breakthroughs for National Priorities.

In FY 2012, NSF will focus on key national priority areas, where the expertise of physical, biological, and social scientists and engineers can help advance U.S. goals through frontier research. NSF-catalyzed research includes investments in clean energy and the advancing fields of bio- and nanotechnology, areas that are poised for innovative breakthroughs.

Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21) is a new portfolio that builds on NSF's long history of providing leadership for cyber infrastructure and computational science for the U.S. academic science and engineering community. The $117 million CIF21 will advance data-enabled science through the development of novel approaches to collect, manage, and curate the vast quantities of data generated by modern observational and computational tools. The program will also expand access to cyber infrastructure to promote collaboration, and support improved community research networks to connect people, facilities, computers, and other tools.

The Science, Engineering, and Education for Sustainability (SEES) portfolio, funded at $998 million in FY 2012, draws together NSF programs that spark innovations for tomorrow's clean energy solutions. SEES will promote a cross-disciplinary approach to sustainability science to explore the environment-energy-economy nexus in order to inform energy and environmental policies and improve our capabilities for rapid response to extreme events, such as power grid disruption, floods, or extreme weather.

Clean Energy investments, a significant component of SEES, will lead to future clean energy and energy efficiency technologies. Investments totaling $576 million are found throughout the NSF portfolio, in core research programs and in activities such as BioMaPS and SEES.

The National Nanotechnology Signature Initiatives are promising research themes that have the potential to generate applications with widespread economic benefit, as well as address national and homeland security challenges. In FY 2012, NSF will invest $117 million in three research areas: Nanotechnology for Solar Energy Collection and Conversion, Sustainable Nanomanufacturing—Creating the Industries of the Future, and Nanoelectronics for 2020 and Beyond. NSF also supports advanced manufacturing research through these investments.

The National Robotics Initiative (NRI), a new interagency initiative for FY 2012, partners NSF with the National Aeronautics and Space Administration, National Institutes of Health, and the U.S. Department of Agriculture. NRI will marshal broad science and engineering support to provide U.S. leadership in the development of next generation robotics. The focus is on robots that work beside, or cooperatively, with people in areas such as manufacturing, space and undersea exploration, healthcare and rehabilitation, military and homeland surveillance and security, education and training, and safe driving. Collaboration and coordination strengthens the research effort and also ensures that agency programs do not overlap. NSF will invest $30 million in NRI in FY 2012.

Interagency Initiatives

NSF participates in a number of interagency programs that aim to coordinate research and development activities in areas of critical national importance.

National Nanotechnology Initiative (NNI), involving 25 departments and agencies across the Federal Government, focuses on realizing the tremendous potential of nanotechnology. Investments in nanotechnology have led to the discovery and development of entirely new classes of materials. NSF will increase support for NNI research by 10.6 percent to a total of $456 million. This investment includes the National Nanotechnology Signature Initiatives.

The Networking and Information Technology Research and Development (NITRD) explores new frontiers in computer, information, and networking science, and coordinates these efforts among multiple agencies. NSF will increase its investment in these activities by 15.3 percent to $1.258 billion in FY 2012. The focus of NSF support includes human-computer interaction and information management, high-end computing infrastructure and applications, large scale networking, and cybersecurity and information assurance. Other initiatives in the NSF budget will explore new techniques in education and workforce training to exploit cutting edge networking and information technologies.

Homeland Security Activities across NSF will increase by 9.2 percent to about $426 million. The focus is on two general areas: protecting critical infrastructure and key assets and defending against catastrophic threats. Approximately 73 percent of this investment supports research in cybersecurity, emergency planning and response, and risk management, modeling, and simulation of resilient infrastructure.

Major Research Equipment and Facilities Construction

People and their ideas form the core of a robust science and engineering enterprise. But leading-edge tools are also needed in many cases to advance the frontiers and train students for the workplace. NSF provides the assets that will be central to success in the emerging "New Era of Observation," without precedent in terms of the sheer scale, scope, reach, resolution and volume of what we are able to observe. This new era has been enabled by the "Era of Data and Information" where we are now entering an emerging paradigm of data-enabled science.

NSF provides sophisticated tools to a broad population of scientists, engineers, students, and educators. All of the projects in the Major Research Equipment and Facilities Construction account undergo major cost and schedule reviews, as required by NSF guidelines. The following projects receive continued support:

- The *Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO)* is a planned upgrade of the existing Laser Interferometer Gravitational-Wave Observatory (LIGO). AdvLIGO will be ten times more sensitive, powerful enough to approach the ground-based limit of gravitational-wave detection. The FY 2012 investment is $21 million.
- The *Advanced Technology Solar Telescope (ATST)* will enable study of the Sun's magnetic fields, which is crucial to our understanding of the types of solar variability and activity that can affect communications and navigational satellites in space and power grids here on earth, and may influence climate. The FY 2012 investment is $10 million.
- The *Atacama Large Millimeter Array (ALMA)* is the world's most sensitive, highest resolution, millimeter wavelength telescope. ALMA will provide a testing ground for theories of planet formation, star birth and stellar evolution, galaxy formation and evolution, and the evolution of the universe itself. The FY 2012 investment is $3 million.
- The *National Ecological Observatory Network (NEON)* will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. The FY 2012 investment is $88 million.
- The *Ocean Observatories Initiatives (OOI)* will provide continuous, interactive access to the ocean through a network of sensors designed to collect physical, chemical, geological, and biological data. OOI will produce never-before-seen views of the ocean's depths. The FY 2012 investment is $103 million.

Terminations/Reductions

NSF continually assesses its portfolio to ensure that investments align with agency priorities and focus on the frontiers of innovative science and engineering research. NSF proposes six programs for termination or reduction in FY 2012.

- *Deep Underground Science and Engineering Laboratory (DUSEL):* NSF eliminates funding for DUSEL. Termination is based on National Science Board reviews that concluded the cost and scope of DUSEL were inconsistent with the agency's traditional strengths and its role in advancing research and education across many fields and disciplines. NSF will continue to solicit proposals for future particle physics research. No funding is required in FY 2012 for DUSEL.
- *Graduate STEM Fellows in K–12 Education:* NSF eliminates the agency-wide Graduate STEM Fellows in K–12 Education (GK–12) program. While the program has been effective in meeting its overall goals, recent evaluation findings indicate that the effects of this program's fellowship experience in improving research skills is mixed, and program design limits the ability of participants to gain in-depth experience in K–12 teaching. NSF plans to build on experiences gained during the 10-years of GK–12 funding to widen the breadth of graduate traineeship experiences through other programs.
- *National STEM Distributed Learning Program (NSDL):* NSF eliminates funding for the NSDL program (formerly the National STEM Digital Library). While NSDL has been successful in meeting its original goals, an October 2010 preliminary evaluation by the RAND Corporation, Steps Toward a Formative Evaluation of NSDL: Phase 2, noted the challenges of sustaining the collection in

the face of changing technology, and raised concerns about the currency of the collections, peer review of collections, collaboration across pathways, and lack of standardization. NSF plans to build from the substantial NSDL experience to address key areas in cyberlearning through other programs and activities, such as Cyberlearning Transforming Education (CTE). No funding is required in FY 2012 for NSDL.

- *Research Initiation Grants to Broaden Participation in Biology:* NSF eliminates funding for the Research Initiation Grants to Broaden Participation in Biology program (RIG) because it did not achieve the goal of broadening participation in biology. The number of proposals from underrepresented groups did not increase. RIG concludes in FY 2011.
- *Science of Learning Centers (SLC):* NSF proposes to reduce funding for the SLC program, which currently supports six large-scale, long-term centers that conduct science of learning research. The on-going center review process and reviews from an external May 2010 Advisory Committee both recommended that NSF phase the program down as funding for individual centers concludes and shift resources wherever possible to enhance support for the science of learning using non-center mechanisms. NSF expects there may be additional reductions to this program in future years as funding for individual centers comes to a close.
- *Synchrotron Radiation Center (SRC):* NSF eliminates funding for the Synchrotron Radiation Center facility at the University of Wisconsin. The SRC is 30 years old, and more powerful and capable facilities have come on-line since 1980.

Model Organization

The National Science Foundation aims to perform as a model organization in carrying forward its mission. Only 6 percent of the NSF annual budget is spent on management and administration. The FY 2012 request includes $494 million, an increase of $64 million, for activities to strengthen NSF's ability to manage its operations effectively and efficiently. These funds will support:

- Staff will include 40 additional full-time equivalents for a total of 1,365 FTE;
- IT investments of $86 million will include NSF financial system modernization (iTRAK), *Research.gov* expansion, and improvements to the operational IT system's reliability and security;
- Headquarters lease expiration funding is $45 million to plan and prepare for a new headquarters lease; and
- Acquisition, part of the government-wide effort to strengthen the acquisition workforce and improve capabilities in the pre-solicitation phase of major acquisitions, receives $2 million.

NSF is committed to promoting strong, independent evaluation to inform its policy decisions, program management, and performance, and to sharing publicly available findings online.

OneNSF

The concept "OneNSF" characterizes NSF efforts to perform as a model agency. The National Science Foundation will work seamlessly across organizational and disciplinary boundaries to create new knowledge, stimulate discovery and address complex societal problems and promote national prosperity.

Within this overarching context, the process of setting NSF priorities involves many considerations and results in our best view of how to advance the Nation's science, engineering, and education enterprise. Internally, NSF holds a series of retreats and planning meetings where directions are developed based on an understanding of new research frontiers, emerging fields, and opportunities to advance research and educational goals. NSF also considers opportunities to coordinate and collaborate with other agencies. Staff from all Directorates and Offices participate in these activities.

The NSF system of competitive merit review helps to bring the best ideas forward from every corner of the Nation. NSF continues to accept and review unsolicited proposals, a practice that ensures that unanticipated and novel ideas of great promise are heard.

Conclusion

President Obama has spoken of this generation's new "Sputnik moment," a reference to the challenge of meeting the Nation's economic and societal needs in the current climate of global competition for new ideas and talent. NSF's strategic in-

vestment in research and education will help the Nation meet the challenges of our times and move beyond them.

Mr. Chairman and members of the Subcommittee, I hope my testimony explains NSF's transformative role in building our Nation's future prosperity and continued leadership at the frontiers of discovery, innovation and learning. Robust NSF investments in fundamental science and engineering have paid enormous dividends, improving the lives and livelihoods of generations of Americans. The FY 2012 NSF Budget Request supports leading edge programs and activities that will continue this success in the future.

This concludes my testimony. I thank you for your leadership, and will be pleased to answer any questions you may have.

Senator NELSON. Director Gallagher?

STATEMENT OF PATRICK D. GALLAGHER, PH.D., UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY, U.S. DEPARTMENT OF COMMERCE

Dr. GALLAGHER. Great. Thank you, Chairman Nelson, Ranking Member Boozman, it is a pleasure.

Let me summarize my brief comments for you this morning informally. I think there are three things I would like to mention to set up our discussion that I am very much looking forward to.

First, the NIST budget request needs to be understood in the context of the priority setting that Dr. Holdren has already mentioned. The President has laid out a very responsible budget, but we find NIST being very well aligned with the Presidential priority to support the innovation capacity of the United States. The NIST mission to promote innovation and industrial competitive through measurement science and standards and technology is very well aligned with the President's goal and so the 2012 budget request for a billion dollars, which is approximately a 17 percent increase, really needs to be understood in this context.

Also, within the budget request, there are several major themes in the NIST budget that I wanted to highlight. One of the key themes is advanced manufacturing. The NIST budget request includes significant emphasis on promoting the capacity of U.S. manufacturers and particularly in high technology related manufacturing areas. And this is important because manufacturing is central to our capacity as a nation to innovate. This includes—the details are in the submitted testimony—nearly $85 million of increases in the NIST Laboratory programs that are to address measurement barriers that manufacturers face in emerging areas and also to support the types of technologies that enable U.S. manufacturers to compete and thrive in a very competitive international market. It includes an increase for the Manufacturing Extension Partnership Program, which is a program that works in partnership in all 50 states to provide business services to small and midsize manufacturers. It includes an increase to our Technology Innovation Program so we can sponsor grants looking at breakthrough technologies in advanced manufacturing areas, and a new program, AMTech, that is designed to stimulate the creation of industrial consortia, very much like the SEMATECH example that you gave in your opening statement. And this is critically important, this is the ability to get competing companies to work together to tackle a shared technical problem and by tackling that problem, enable the whole sector. And we think this is going to be a critical asset.

The other major theme in the budget request for NIST is in infrastructure, in particular, two types of infrastructure. What I would call cyber infrastructure, there's a very strong focus on cybersecurity and making sure that the integrity and reliability of our ability to move information, which is a key enabler and an innovation economy, is preserved. This includes core NIST functions in looking at cybersecurity research, advanced cryptography, biometrics, access control, things of that type. Also, in support of our national program office responsibilities for trusted identities in cyberspace and as our national program we are able to support cybersecurity education efforts, because humans interact with cyber infrastructure as well. And both from a workforce perspective and a participation perspective that is important.

It also addresses cyber infrastructure in the context of enabling technology infrastructure that we need to advance our goals. So whether it is smart grid or cloud computing or health information technology, NIST is working in concert with industry to support the development of the standards infrastructure that make these complex systems work and the request addresses that as well.

But it also touches on physical infrastructure. In particular, NIST is working with both industry and with state and local communities to develop technically sound model codes and standards to ensure that we can build robust and disaster resistant structures and infrastructure, something that is clearly on a lot of our minds as we look at the unfolding situation in Japan.

I mentioned the one new program which is AMTech, the Advanced Manufacturing Technology Consortia, to develop these consortia approaches to share technical challenges. The other program is in the area of wireless infrastructure. It is part of the Public Safety Innovation Fund which is part of the larger administration effort in wireless innovation. NIST has a new program funded from spectrum and set of auctions to work with the public safety community to develop a network based communication infrastructure that first responders could use. So this would enable a broadly interoperable national system of emergency communication and to enable that sort of leap ahead technology.

In spite of the sizable increases, we have also focused on realizing administrative savings wherever we could. The budget requests incorporate over $11 million in those administrative savings and offsets. And we certainly understand the context in which this takes place.

So I will leave it with that and look forward to answering any questions you may have.

[The prepared statement of Dr. Gallagher follows:]

PREPARED STATEMENT OF PATRICK D. GALLAGHER, PH.D., UNDER SECRETARY OF COMMERCE FOR STANDARDS AND TECHNOLOGY, U.S. DEPARTMENT OF COMMERCE

Chairman Nelson, Ranking Member Boozman, and members of the Subcommittee, thank you for the opportunity to appear before you today to present the President's Fiscal Year (FY) 2012 budget request for the National Institute of Standards and Technology (NIST). This budget reflects the important role that NIST plays as part of President Obama's Plan for Science and Innovation. As the President has said . . . *"We know what it takes to compete for the jobs and industries of our time. We*

need to out-innovate, out-educate, and out-build the rest of the world."[1] The NIST FY 2012 budget clearly lays out the NIST role in the Administration's priorities by making critical investments in key areas that will help preserve our Nation's economic security and strengthen American competitiveness.

Mr. Chairman, I would like to start with a quick mention of the context of this budget. Overall, this is a very difficult budget environment. The President made clear that it was important for the government to live within its means and establish some priorities within those limits. The President has focused on a number of key goals, including innovation, infrastructure and education.

Within that context, NIST finds itself with a mission that's very well aligned to those goals. Over the past few years, numerous reports have underscored the importance of a robust Federal presence in the sciences to advance technological innovation. The "*Rising Above the Gathering Storm*" report and its follow-on, "*The Gathering Storm, Revisited*," were a clarion call to action that helped to shape the America COMPETES Reauthorization Act that this Committee championed and the President signed into law earlier this year. In addition, in February of this year, the White House Office of Science and Technology Policy, National Economic Council, and Council of Economic Advisers jointly released an update to the 2009 "*Strategy for American Innovation*" that "focuses on critical areas where sensible, balanced government policies can lay the foundation for innovation that leads to quality jobs and shared prosperity."

The NIST mission is to promote U.S. innovation and industrial competitiveness through measurement science, standards and technology. The NIST mission is very well-aligned with the priority goals that the President has laid out. The FY 2012 budget for NIST reflects that alignment.

Mr. Chairman, the President's FY 2012 discretionary budget request for NIST is $1 billion, a 17 percent increase over the FY2010 enacted level. The budget maintains the President's commitment to double the NIST laboratory budget, and to support and enhance our world leadership in the physical sciences and technology.

The NIST budget is comprised of three discretionary spending accounts and one new proposed mandatory spending account.

For the NIST laboratories, the budget requests $679 million to accelerate the development of standards, technology, and measurement science in areas as diverse as advanced manufacturing technologies, cybersecurity, and infrastructure. The request reflects a net increase of $173.6 million over the FY 2011 annualized CR level. We did not continue funding $10.5 million in previous year earmarks and redirected this amount to new initiatives. Thus, the budget proposes $178.5 million in laboratory initiatives and $5.6 million in adjustments to base.

For the NIST Industrial Technology Services (ITS) account, the budget requests $238 million, an increase of $33 million over FY 2011 annualized CR levels. The account includes NIST's external programs: the Technology Innovation Program (TIP), the Hollings Manufacturing Extension Partnership (MEP), the Baldrige Performance Excellence Program (BPEP) and the newly proposed Advanced Manufacturing Technology Consortia (AMTech) program. The request includes $12.3 million for the AMTech, a new cooperative grant program with industry and academia to foster public-private partnerships to develop needed technology to support advanced manufacturing industries that will broadly benefit the Nation's industrial base. Also in the ITS line is a $1.9 million reduction to BPEP from the FY 2011 annualized CR levels.

The budget requests $84.6 million for the Construction of Research Facilities (CRF) account; representing a $62.4 million decrease from the FY 2011 annualized CR level. The request includes $25.4 million for the continued renovation of the Boulder Building 1 renovation but does not include $67 million in FY 2010 earmarks and the Construction Grant Program.

Finally, NIST requests $100 million in mandatory appropriations for the Public Safety Innovation Fund, NIST's component of the Wireless Innovation Fund, which itself is part of the President's Wireless Innovation and Infrastructure Initiative (WI3). This mandatory appropriation request will fund NIST's safety efforts in this area, with particular focus on working with industry and public safety organizations to develop new standards, technologies, and applications to advance public safety.

Let me speak in more depth about the major thematic initiatives in this request: manufacturing, infrastructure, and education. These themes directly relate to the President's stated goals to "out-innovate, out-educate, and out-build."

---

[1] *Remarks by the President in State of Union Address on January 25, 2011.*

***Out-Innovate:* Supporting Innovation for a Strong Manufacturing Base**

In order to "Out-Innovate," the U.S. must have a strong manufacturing base. With that focus innovation in manufacturing is key to the NIST 2012 budget. In the area of manufacturing, U.S. industry faces relentless competition that has trimmed the Nation's share of global manufacturing output from 25 percent in 2000 to about 20 percent today.

The U.S. manufacturing sector, still the world's largest, is the Nation's innovation engine. Manufacturers perform half of all research and development in the U.S., and they employ 17 percent of the Nation's scientists and engineers. The sector develops, builds, and supplies the advanced equipment that enables the U.S. military to maintain technological superiority over our adversaries.

Providing the measurement tools and other essential technical assistance that existing U.S. manufacturers and aspiring start-ups need to invent, innovate, and produce—more rapidly and more efficiently than their competitors—is a top NIST priority. NIST has partnered with the manufacturing sector for over a century. Today's challenges require stepping up efforts to enhance and strengthen the Nation's underlying technical infrastructure, which is integral to our innovation and advanced manufacturing capabilities.

To reap the economic benefits of our ability to innovate, our Nation's manufacturing sector must be able to renew itself by adopting new technology and developing new markets. The nation's manufacturers must respond quickly and effectively to an ever-changing mix of requirements, risks, and opportunities, from new regulations to rising energy costs to emerging technologies and markets. The revitalization of the U.S. manufacturing base is critical to driving innovation and job creation in the future and will play a major role in building an economy that can help raise the standard of living for all Americans.[2]

2012 Manufacturing Initiatives

The President's FY 2012 budget for NIST includes five manufacturing-related initiatives in NIST's scientific laboratories that will enable NIST to bolster and diversify needed research and promote proven services that will strengthen U.S. manufacturing competitiveness in high-value-added product markets.

- *Strengthening Measurement Services in Support of Industry Needs ($20.0M)* The U.S. economy depends upon a robust and reliable physical science-based measurement system. Industry is increasingly relying upon and utilizing NIST's precision time and synchronization services to drive innovation. Industries as diverse as telecommunications, electric power distribution, broadcasting, and navigation networks, as well as many crucial applications in national defense, intelligence, and homeland security rely on NIST calibrations and measurement services. In aeronautics, for example, NIST calibrations for commercial and Federal Government partners ensure the accuracy and performance of altimeters and electrical systems that enable F–18s and commercial aircraft to fly. This initiative will enhance systems for distributing NIST measurement services to meet the growing demand from industry for such services.
- *Advanced Materials for Industry ($14.2M)* The discovery and optimization of new materials is costly and inefficient. Today, U.S. researchers can design and create new materials at a rate that outpaces our ability to support the measurements to characterize and exploit these discoveries. NIST efforts in advanced materials development and measurement science can help manufacturers save millions of dollars in design costs. This initiative will help to provide that support to industry through the development of a national measurement and standards infrastructure necessary to enable computer modeling and simulation capabilities for discovering new materials and reliably optimizing structures and properties for manufacturing processes and product performance and features.
- *Innovations for 21st Century U.S. Manufacturing: Faster, Smarter and Cleaner ($13.3M)* Innovation is central to manufacturing, and in turn, to the overall growth and health of the U.S. economy. The ability to *rapidly* introduce product innovations provides a foundation for future growth in U.S. manufacturing and with it, the creation and retention of high-skill, well-paying jobs. This initiative will fund efforts to develop advanced robotics technologies that allow the U.S. to retain manufacturing competitiveness, and fund programs that will promote sustainable operations and improve energy efficiency in both the manufacturing and construction sectors of the economy.

[2] Executive Office of the President, *A Framework for Revitalizing American Manufacturing*, Dec. 2009.

- *Measurement Science and Standards to Support Biomanufacturing ($9.5M)* The high cost of biotechnology medicines is adversely impacting the U.S. healthcare system and economy. Biotechnology drugs, currently dominated by protein therapeutics, are the fastest-growing class of pharmaceuticals and the fastest growing (~20 percent/year) category of health care spending.[3] Inefficiencies in the manufacturing process contribute to the high cost of these drugs. Under this initiative, NIST will work closely with industry, the FDA, and other standards organizations to better understand the manufacturing process resulting in higher quality biologic products through continuous improvement of manufacturing processes. It will also enable the development of agile biomanufacturing processes required for next generation products such as stem cells and personalized biotherapeutics.
- *Measurements to Support the Manufacture and Production of Nanotechnology-based Products ($28.2M)* There remain significant barriers to the full commercial exploitation of nanotechnology. The lack of manufacturing and characterization tools adds significantly to the development cost of nano-based products. Rigorous measurement science is needed to characterize the environmental, health, and safety risks of engineered nanomaterials. NIST's expertise in measurement science as well as its world-class nanotechnology fabrication facilities at the Center for Nanoscale Science and Technology (CNST) in Gaithersburg, Maryland, provides industry unique resources to advance the measurement science needed to enhance our understanding of the safety of nanomaterials, and fund research on the development and manufacture of cost-competitive technologies. This initiative will position the U.S. to be globally competitive in emerging technologies through safe use of nanotechnology. It will also provide needed investments in the CNST to keep it at the cutting-edge of innovation.

The President's budget strongly supports manufacturing through the Industrial Technology Services programs.

Hollings Manufacturing Extension Partnership (MEP)

The President's 2012 Budget requests $142.6 million for the MEP program. This request is a $17.9 million increase over the FY 2011 annualized CR level. The MEP is a Federal-state partnership which requires a two-thirds financial match from non-Federal sources. Through its national network of MEP Centers located in every state, 1,400 technical experts help small and medium-sized manufacturers navigate economic and business challenges and connect to public and private resources essential for increased competitiveness and profitability.

Through competitively awarded cooperative agreements, NIST MEP will expand the capabilities of its nationwide network of centers to accelerate commercialization of technological innovations, adopt environmentally sustainable business practices, promote renewable energy initiatives, foster market diversification, and connect domestic suppliers to manufacturers to assist manufacturers in successfully competing over the long term in today's complex global manufacturing environment.

The Technology Innovation Program (TIP)

The FY 2012 request for TIP is $75 million. The proposed TIP budget represents an increase of $5.1 million above the FY 2011annualized CR level. TIP funds cutting edge, transformative research and development projects that address critical national needs and societal challenges not already being addressed by others. TIP requires a 1:1 match of funds from the private sector. In FY 2012, TIP expects to hold a funding competition in one or more of the following research areas: advanced robotics and intelligent automation, energy, healthcare, water, civil infrastructure technologies, and manufacturing.

TIP funding will incentivize innovative research and development (R&D) projects, conducted by small and medium-sized U.S. based companies, alone or as joint ventures with universities, national laboratories and other non-profit research organizations. Further, it will foster research collaborations, enable the creation of intellectual property in the United States, disseminate new knowledge, and advance the state-of-the-art in technologies that address societal challenges. In its most recent round of funding for manufacturing projects, TIP awardees included those young, small companies which are the engines of innovation and the future generators of globally competitive jobs.

[3] Biotech 2008—Life Sciences: A 20/20 Vision to 2020, Burrill and Company, 2008.

Advanced Manufacturing Technology Consortia (AMTech)

NIST is also requesting $12.3M for the Advanced Manufacturing Technology Consortia (AMTech) program, a new public-private partnership that will broadly benefit the Nation's industrial base by providing grants to form and fund industrial consortia to address industrial driven technological challenges that no one company can address alone. AMTech is modeled upon NIST's successful partnership, the Nanoelectronics Research Initiative, which in collaboration with industry, funds research consortia targeting the nanoelectronics technology sector.

AMTech will collapse the timescale of technological innovation by including partners that span the innovation lifecycle from idea to discovery, from invention to commercialization. Through cost-sharing and a common research agenda, these consortia would support the development of innovative new technologies directed at creating high-wage jobs and economic growth across the industry sector. These consortia will develop road-maps of critical long-term industrial research needs and provide support for research and equipment at leading universities and government laboratories directed at meeting these needs.

***Out-Build*: Building the Nation's Infrastructure—Cyber, Physical and Wireless**

To meet the President's challenge to "*Out-Build*" other nations, NIST is requesting funds in the FY 2012 budget to strengthen the U.S. infrastructure in three main areas: the cyber infrastructure, the physical infrastructure and the wireless infrastructure.

Cybersecurity Infrastructure. A secure cyber infrastructure is vital to the economic vitality and national security interests of the United States. In addition to enabling more than $200 billion in annual e-commerce, interconnected networks of computers are essential for critical functions such as air traffic control, electric power distribution and the GPS in our cars. The nation's cyber infrastructure is central to maintaining the timely delivery and quality of public services that are part of everyday life. Our nation's computers face ever-increasing threats from malicious individuals, organizations, and nation states. Currently, our computer security tools are manually implemented, too complex to be effectively used, and too static to respond to rapid changes in the threat environment. This allows many attacks to succeed, causing significant damage and undermining confidence in vital commercial and public information systems. The result is a large, direct economic impact—estimates show that Americans lose billions of dollars each year to cyber crime.

NIST is responsible for cybersecurity research, development of Federal cybersecurity standards, establishment of methods and metrics for determining the effectiveness of security controls, and providing technical support to public and private sector implementation of security standards and controls. The FY 2012 budget request contains $43.4 million for cybersecurity related programs and activities that will strengthen NIST's contribution to the development and promulgation of effective and usable cybersecurity standards.

The cybersecurity infrastructure request has three initiatives.

- *Scalable Cybersecurity for Emerging Technologies and Threats ($14.9M)* The request would provide improvements to NIST's core cybersecurity work in support of the Comprehensive National Cybersecurity Initiative (CNCI), the Federal Information Security Management Act (FISMA), and other national priorities. NIST will develop improved security techniques, support the creation of consensus security standards, increase the interoperability and usability of security technologies, and expedite the secure adoption of emerging information technologies.
- *National Program Office for the National Strategy for Trusted Identities in Cyberspace (NSTIC) and NSTIC Grant Program ($24.5M)* The request would support a National Program Office (NPO) to coordinate Federal activities needed to implement NSTIC. This initiative is in direct response to the recommendations of the *White House Cyberspace Policy Review* and will raise the level of trust associated with the identities of individuals, organizations, services, and devices involved in online transactions. NIST will be responsible for day to day and overall operation of the NPO. NIST will work with the private sector to identify potential funding opportunities for the delivery of NSTIC solutions. Of the $24.5 million for NSTIC, $7.0 million will support a National Program Office and $17.5 million will fund the pilot grants.
- *National Initiative for Cybersecurity Education (NICE) ($4.0M)* The request supports NICE, which expands the scope of the Comprehensive National Cybersecurity Initiative's (CNCI) Education Initiative from the training of the Federal workforce to a larger national education focus. NIST will develop a cybersecu-

rity education framework that addresses: national cybersecurity awareness, formal cybersecurity education, Federal cybersecurity workforce structure, and cybersecurity workforce training and professional development.

Interoperability of Infrastructure. Other critical emerging technologies such as the Smart Grid and national health care information systems have the potential to transform our society and revitalize the U.S. economy. To be effective, the many interconnected components in these systems must be fully interoperable to allow information to be exchanged and used seamlessly across systems. As a respected and trusted technical partner, NIST is uniquely positioned to bring together stakeholders from industry, government, academia, and standards development organizations to establish consensus-based interoperability standards and conformity tests. The President's budget request for NIST contains an initiative that will support continued efforts in these critical areas as well as provide the infrastructure necessary to address other emerging interoperability challenges.

- The *Interoperability Standards for Emerging Technologies Initiative ($23.8M),* will focus on the development of standards to enable or accelerate the successful development of new technologies such as a smart electrical grid (Smart Grid), interoperable electronic healthcare records, and cloud computing. These technologies have the potential to transform our society and galvanize U.S. industry, and provide new opportunities for exports of U.S.-developed technologies. For each technology to be effective, however, many complex interconnected components must be built to enable full interoperability and reduce the full potential of these technologies. Lack of standards for interoperability can significantly slow adoption of these emerging technologies, dampen confidence in industry, and increase the risks of stranded investments in solutions that quickly become obsolete.

Physical Infrastructure. Buildings in the U.S. consume 72 percent of all electrical energy produced in this country. Emissions associated with buildings and appliances are projected to grow faster than those from any other sector. To ensure adequate supplies of energy and curtail the projected growth of carbon dioxide emissions, it is essential to reduce building energy consumption significantly while minimizing the environmental impacts of buildings during their life cycles. In addition, many of the Nation's largest buildings and much of its infrastructure are concentrated in disaster-prone regions where hurricanes, earthquakes, floods and other hazards are common. Catastrophic failures in infrastructure as a result of natural disasters are costly and directly impact our personal and economic health. NIST is requesting funds for two initiatives that will further the development of a stronger building infrastructure.

- *Measurements and Standards to Support Increased Energy Efficiency and Reduced Environmental Impact initiative ($13.3M)* This initiative will fund research in Net-Zero Energy Building (NZEB) design. NZEB designs would use as much energy from renewable sources as they consume. Such design also doubles the service life of building materials, products, and systems in order to minimize their lifecycle impacts—this also takes indoor air quality into account. Current analysis methods are not able to assess the indoor air quality impacts of key design decisions or impacts of new technologies. This initiative will provide the measurement science required to achieve net-zero energy, high-performance buildings. It will also provide the measurement science to support gas measurement standards to ensure their accuracy and comparability.
- *Measurements and Standards to Support Advanced Infrastructure Delivery and Resilience ($10.6M)* The disaster resilience of our structures today is determined in large measure by the building codes, standards, materials, and practices used during their construction. There are gaps in the measurement science needed to improve the disaster resilience of infrastructure exposed to natural and man-made hazards. This request funds efforts to provide improvements to our Nation's physical infrastructure to damage from earthquakes, windstorms, and fire. This funding will also develop comprehensive measures of construction practices so our Nation's building infrastructure can be both more efficiently built and more resilient.

Wireless Infrastructure. The request to create the Public Safety Innovation Fund (PSIF), a mandatory account within NIST funded at $100 million ($500 million over 5 years) is part of the Administration's Wireless Innovation and Infrastructure Initiative (WI3).

President Obama called for a National Wireless Initiative to make available high-speed wireless services to at least 98 percent of Americans. The WI3 will make it

possible for businesses to achieve that goal, while freeing up spectrum through incentive auctions, spurring innovation, and supporting a nationwide, interoperable wireless network for public safety. An important element of this plan is the reallocation of the D Block for public safety, and some of the proceeds from the incentive auctions being dedicated to NIST research, experimentation and testbeds. The funds will also focus on applied development to foster the development of a next-generation Public Safety communications network.

Specifically, to spur innovation, the WI3 includes a Wireless Innovation (WIN) Fund for research and development of emerging wireless technologies and applications. NIST will focus on applied development to foster the development of a next-generation Public Safety communications network. The current systems for 4G high speed wireless services are not tailored for public safety's requirements. Developing and implementing such requirements, including capabilities to enable handsets to operate in peer-to-peer (or without the aid of a central network) will require technological leadership that NIST can help provide. NIST, in consultation with agency partners, including the National Institute of Justice at the Department of Justice and the Department of Homeland Security, will focus on developing and testing requirements, standards, wireless applications, and other wireless technologies in support of an interoperable nationwide Public Safety Broadband Network.

***Out-Educate*: Training the Next Generation of Scientists.**

In order to "*Out-Educate*," each agency must do its part. While NIST does not have a primary mission in education, the future development of the Nation's scientists is critical to the future of NIST. NIST has an important role to play in helping to identify, recruit, and retain the next generation of scientists and engineers to help drive American competitiveness. There is one initiative associated with this area:

- *The Postdoctoral Research Associateship Program ($3.0M)* This highly competitive program is very effective at attracting outstanding scientists and engineers to consider a career in science by providing opportunities to work alongside NIST researchers. I want to thank the Committee for its support in eliminating the cap on funding for the post-doc program. The elimination of this cap allows NIST to fund more associates. The requested increase will enable the program to offer at least an additional 23 positions per year and keep the pipeline of bright, new scientists flowing.
- *National Initiative for Cybersecurity Education (NICE) ($4.0M)* As mentioned earlier, the request supports NICE, which expands the scope of the Comprehensive National Cybersecurity Initiative's (CNCI) Education Initiative from the training of the Federal workforce to a larger national education focus.

Construction of Research Facilities (CRF): The FY 2012 request totals $84.6 million, a $62.4 million decrease over the FY2011 annualized level. The request contains $25.4 million to continue the renovation of the 60-year-old Building 1 on the NIST Boulder campus, which houses the majority of research and measurement laboratories on the Boulder campus. The balance of the account, $59.2 million, will provide funding for NIST to address deficiencies and maintain NIST's laboratories and facilities. The decrease reflects the elimination of congressionally-directed projects from FY 2010.

Budget Decreases: Finally, let me touch on two areas in which the budget reflects savings: The Administration's Administrative Efficiency Initiative challenged all agencies to identify savings as part of the budget development process. NIST's FY 2012 budget incorporates over $11 million in administrative savings across the agency in order to make the agency more efficient and effective in an era of tight budgets.

The Baldrige Performance Excellence Program (BPEP) requests $7.7 million, $1.9 million less than the FY 2011 annualized CR level. The FY 2012 funding supports the continued development of the Baldrige Program Criteria, dissemination of best practices, and the annual awards process. At the proposed level, BPEP will evaluate alternative sources of funding and alternative cost models consistent with the administration's goal of transitioning the program out of Federal funding.

Summary

In summary, I would like to note that for more than 100 years NIST has maintained the national standards of measurement. This role was assigned by the U.S. Constitution to the Federal Government to promote industry and ensure market fairness. The FY 2012 budget request for NIST reflects the Administration's recognition of the important role that NIST plays in innovation and the impact that the research and services NIST provides can have on moving the Nation forward by lay-

ing the foundation for long- term job creation and prosperity. By sustaining our investments in fundamental research, we can ensure that America remains at the forefront of scientific capability, thereby enhancing our ability to shape and improve our Nation's future and that of the world around us.

I look forward to working with you Mr. Chairman and members of the Committee and would be happy to answer any questions.

Biography of Dr. Patrick D. Gallagher, Under Secretary of Commerce for Science and Technology and Director

Dr. Patrick Gallagher was confirmed as the 14th Director of the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) on Nov. 5, 2009. He also serves as Under Secretary of Commerce for Standards and Technology, a new position created in the America COMPETES Reauthorization Act of 2010, signed by President Obama on Jan. 4, 2011.

Gallagher 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 2010 resources include $856.6 million from the Consolidated Appropriations Act of 2010 (Public Law 111–117), $49.9 million in service fees, and $101.5 million from other agencies. The agency employs about 2,900 scientists, engineers, technicians, support staff, and administrative personnel at two main locations in Gaithersburg, Maryland and Boulder, Colorado.

Gallagher had served as Deputy Director since 2008. Prior to that, he served for 4 years as Director of the NIST Center for Neutron Research (NCNR), a national user facility for neutron scattering on the NIST Gaithersburg campus. The NCNR provides a broad range of neutron diffraction and spectroscopy capability with thermal and cold neutron beams and is presently the Nation's most used facility of this type. Gallagher received his Ph.D. in Physics at the University of Pittsburgh in 1991. His research interests include neutron and X-ray instrumentation and studies of soft condensed matter systems such as liquids, polymers, and gels. In 2000, Gallagher was a NIST agency representative at the National Science and Technology Council (NSTC). He has been active in the area of U.S. policy for scientific user facilities and was chair of the Interagency Working Group on neutron and light source facilities under the Office of Science and Technology Policy. Currently, he serves as co-chair of the Standards Subcommittee under the White House National Science and Technology Council.

Senator NELSON. Dr. Abdalati?

STATEMENT OF DR. WALEED ABDALATI, CHIEF SCIENTIST, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. ABDALATI. Thank you, Chairman Nelson and Ranking Member Boozman. It is my privilege to be here to give NASA a seat at the table for this important conversation. I appreciate the invitation.

And I would like to preface my remarks: I actually had not expected to see my fellow NASA people, the astronauts, here this morning. But as I was looking at them it reminded me, as I am reminded almost every minute of every day that I am at NASA that they represent the ingenuity, the character, the perseverance, the integrity, the commitment, any adjective, any positive adjective you can come up with, that really is pervasive among our engineers, our astronauts, and our scientists. Our nation really is stronger and better for it.

And science is a critical element of that investment, a tremendously important one that we are proud to execute at NASA. So it really is an absolute privilege to be here and have the opportunity to have this conversation.

Party because NASA really leads the Nation on a great journey of discovery, we look for new knowledge across domains that range from right here at home on Earth to the far reaches of the uni-

verse. Our research budget, besides the missions that we develop, supports 10,000 scientists, engineers, technicians, and students throughout the nation. Students, that are a key part of your research portfolio and in fact, I am happy to say a former student of mine is sitting right behind me on the staff of Senator Mark Udall. She came to hear me talk, so she forgives me for whatever I may have done to her.

These grants and research activities support discoveries and technologies that fuel a strong economy. As the newly appointed chief scientist I view it as an honor and a privilege, not just a job, to work with agency leaders to support and ensure that our science investments bring the most value to the nation. And value, not just in terms of scientific return, but value in terms of elevating the national competence—the national literacy.

To do this, our investments are focused—rich in content, but also mindful of the current challenges facing the nation in this fiscal environment. We at NASA feel, as much as anyone, these challenges. The 2012 budget request for NASA supports a diverse science and research and development portfolio, but it also makes difficult choices. We don't like making those choices, but we recognize the need to make those choices and do our part for the good of the nation. But at the same time, our research budget allows us to continue to inspire the next generation, and even the current generation, of leaders in science, technology, engineering and math. And to ensure that our investments are really of the best quality and the best value, we develop them through a rigorous process of engagement of the scientific community through National Academy of Sciences studies called Decadal Surveys. In Earth science the view from space provides the context, scale and perspective to study Planet Earth as a complex system with diverse interacting components: the atmosphere, the ocean, the land, the ice and life. By observing their interactions we are able to understand and develop a comprehensive picture of how the Earth works, how it is changing, why it is changing and ultimately what those changes mean for life on Earth.

At the same time, with partnerships through our operational agencies, NOAA, USGS, the Environmental Protection Agency, we improve the nation's capabilities to predict climate, to assess and endure national hazards, to manage resources and to develop environmental policy. But these benefits are not only realized here at home, they are also realized abroad. And as just one example, for the recent devastating earthquakes in Japan, NASA has been collecting and analyzing—not just acquiring and "watching," data from multispectral, multiangle, and multiple resolution sensors to support damage assessment and response activities.

NASA Earth Science, as you are well aware, is an essential part of the national and international efforts to understand the Earth's system. It is of economic value, humanitarian value, and strategic value for the benefit of billions of people worldwide.

Our space endeavors look far beyond the Earth environment, in fact tonight one of our missions—the Messenger Mission—is going to enter Mercury's orbit. It has traveled 5 billion miles over the last few years, it is finally at its destination and we look forward to the knowledge it will bring us.

Our portfolio includes missions to study the sun in new ways, to explore Mars by traversing its surface with robots and to use high-energy X-rays to search for black holes and map supernova explosions. The budget also provides stable footing for the James Webb Space Telescope, which truly is a technical marvel and will be well worth the investment. In addition, through funding NASA research and analysis programs, scientists will continue to use the vast volumes of data from NASA spacecraft, rockets, balloons, and payloads on the ISS to further fuel the nation's research and advancements.

And finally, with the extension of the International Space Station operations to 2020 or beyond, we are able to expand fundamental knowledge of biological and physical processes in the microgravity environment. The astronauts talked of 130 ongoing experiments on Station now and the incredible discoveries that are being made.

NASA science is uniquely targeting not only matters of the human mind, but also matters of the human spirit, the human heart. It nourishes our need to explore the unknown. And with a balanced and diverse portfolio we diligently seek to understand the world in which we live, the sun that fuels us, our celestial neighbors and the universe beyond. These endeavors inspire and serve humankind. They are timeless and they are priceless, although I realize we do have to put a price on some of them. And they will continue to enable the United States to lead the world toward a future that will no doubt exceed what we can only imagine today.

Thank you.

[The prepared statement of Dr. Abdalati follows:]

PREPARED STATEMENT OF DR. WALEED ABDALATI, CHIEF SCIENTIST, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the Committee, it is my privilege to appear before you today to discuss NASA's portion of the President's FY 2012 Federal Research and Development and Science budgets. Maintaining our status as the world's leader in innovation, education, science and technology is directly linked to our ability as a nation to push the frontiers of human understanding in innovative and transformational ways. NASA leads the Nation on a great journey of discovery, seeking new knowledge across domains that range from right here at home to distant galaxies and everywhere in between. In collaboration with the Nation's science community, NASA's space-based and suborbital observatories conduct scientific studies of the Earth, explore the nature and behavior of the Sun and other bodies in our solar system, and peer toward the edges of the universe, back toward the beginning of time. The International Space Station, with construction complete in 2011, will serve as a fully functional and permanently crewed research laboratory and technology test bed in orbit around Earth. Work on board the International Space Station will expand scientific research opportunities in the areas of biological and physical research as well as technology development in the microgravity environment.

From space, in space, and about space, NASA's science efforts are focused on pursuing questions that are rooted at the very core of the human spirit. These range from a practical curiosity about the environment in which we live, to a wondrous fascination about what lies beyond. What child has not peered at the stars, planets and comets in the night sky and wondered—"What is it like there? How many stars are out there? Is there life out there? Can we go there someday?" That wonder carries with us through adulthood and is a part of who we are. At the same time, who cannot look at the images of the Earth from space—a beautiful blue, green, and white globe, seemingly suspended against a dark and silent backdrop, carrying the whole of human civilization abuzz on its surface—and not wonder how it works and how it is changing? There is tremendous value to understanding how and why our planet is changing and what the future Earth will look like. There is economic value; there is humanitarian value; there is political value, and there is value for ensuring our security. NASA Science inspires and serve humankind in ways that

are truly unique and in ways that are critical for ensuring that we as a society not only survive, but thrive, in whatever future the human race carves out for itself.

Recognition of NASA's remarkable science contributions comes from many places. In the simplest sense, it can be seen in the incredulous eyes of people who see images of the famous Butterfly nebula or the Martian surface for the first time. It can also be evident in the appreciation of the farmer whose crop output is increased through the use of NASA data and information. However, one of the most notable validations of the value of NASA science comes from objective assessments by scientific journals. In its report of the top ten insights of the 2000–2010 decade, the journal *Science* identifies four achievements that are directly derived from NASA science investments. *Discover Magazine*'s 100 Top Science Stories of 2010 include fifteen NASA stories. American Physical Society's counts three NASA science stories among its Top Ten Physics-related News Stories of 2010. And the list goes on.

As NASA's newly appointed Chief Scientist, it is my job, honor and privilege, to work in conjunction with the leaders of the Agency and the scientific community to ensure that the Nation's space program delivers the most valuable science for the taxpayer investment. Doing so requires that our goals remain focused, rich in content, and mindful of the resources available in our current, challenging fiscal environment. NASA's proposed FY 2012 budget request supports a diverse science and research and development (R&D) portfolio that reflects key priorities, while making some difficult choices that allow us to continue to invest in our Nation's future. This budget acknowledges that we must be good stewards of the tax payers' science and technology investments, while providing the Nation with the advancements necessary to maintain our global leadership and inspire our next generation of leaders in science, technology, engineering and math. The FY 2012 budget supports the key scientific priorities that are developed through a rigorous process of scientific community engagement by the National Academy of Sciences known as decadal surveys.

NASA's journey of scientific discovery also helps motivate, support, and prepare for human expansion into the solar system. Science missions provide critical insights into the radiation environment of deep space, the characteristics and compositions of planetary atmospheres, the terrain and geology of planetary surfaces, and the nature and origin of small bodies. They identify the hazards and resources present as humans explore space and the science questions and regions of interest that warrant detailed examination by human explorers.

The importance of NASA Science was recognized by Congress more than a half-century ago and codified in our founding document, the National Aeronautics and Space Act of 1958. The Act explicitly states:

> "The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:
>
> > (1) The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space;" [section 102(d)]

Thus establishing science as a core element of NASA's mission. The return on investments in NASA science over the years have been tremendous, and the President's FY 2012 budget request provides for continued investments that will move the Nation forward in important and inspiring scientific endeavors.

Earth Science

The view from space allows scientists to study planet Earth as a complex system with diverse interacting components: the oceans, atmosphere, land, ice, and life. NASA assets observe processes that are global in nature with local impacts, and that are local in nature with global impacts. By observing the interactions of these various components, we are able to develop a comprehensive picture of how the Earth works, how it is changing, why it is changing, and ultimately, what these changes mean for life on Earth. The knowledge we derive from this comprehensive picture, which is essential for ensuring our well-being as a society, can only be realized when the Earth is viewed in the context, scale, and perspective afforded by these space-based capabilities. From quantifying the impacts of melting ice on sea level, to understanding the inner workings of hurricanes and tropical storms, to assessing the health and amount of global vegetation, NASA Earth Science provides advances in understanding that positively benefit the lives of billions of people all over the world.

In addition to the scientific research and the new knowledge that NASA investments provide, NASA Earth Science also has real-time direct applicability to many national needs. Through our partnerships with other agencies (*e.g.,* the National Oceanic and Atmospheric Administration (NOAA), the United States Geologic Survey (USGS), the Environmental Protection Agency (EPA)) that maintain forecasting and decision support systems, we ensure complementary, not duplicative activities.

The result of these partnerships is improved national capabilities for climate predictions, weather, and natural hazards; the management of resources; and development of environmental policy. NASA's Earth Science is an essential part of the national and international efforts to understand the global environment and use Earth observations and scientific understanding in service to society.

There are too many examples of the direct societal benefits gained from NASA's Earth Science missions to list them all here today. However, I would like to highlight a few for your consideration. Once such example is the use of the Thermal Infrared Sensor (TIRS), currently flying on the Landsat 5 and 7 spacecraft and now in development for the Landsat Data Continuity Mission. TIRS plays an important role in the water management efforts in the western United States. In particular, TIRS measurements are used operationally by state agencies to monitor snowpack runoff and water consumption on a field-by-field basis in nine western states (Nevada, Idaho, Wyoming, Montana, Colorado, New Mexico, Nebraska, North Dakota and South Dakota). State water managers call TIRS's data the "gold standard" for the cost-effective administration of water transfer agreements, and an irreplaceable tool for western water managers. In 2012, NASA will begin to work with the Department of the Interior to develop successor Landsat satellites, through an operational program funded by USGS.

The Moderate Resolution Imaging Spectroradiameter, or MODIS instrument, on the Terra and Aqua spacecrafts provides data for the MODIS Rapid Response System developed to provide daily satellite images of the Earth's landmasses within a few hours of acquisition. This capability makes the system a valuable resource for organizations like the U.S. Forest Service and the international fire monitoring community, which use the images to track fires; the United States Department of Agriculture Foreign Agricultural Service, which monitors crops and growing conditions; and the United States Environmental Protection Agency and the United States Air Force Weather Agency, which track dust and ash in the atmosphere. As a final example, NASA-sponsored investigations have developed and demonstrated reliable and accurate detection of volcanic ash clouds using data from instruments on NASA Earth Science satellites, including the MODIS, MISR, OMI, and CALIOP instruments on the Terra, Aqua, Aura, and Cloudsat NASA research missions. The proven utility of these data led to their operational use by the NOAA National Weather Service to formulate Volcanic Ash Advisories. These products were used extensively during the Iceland volcano eruption in April 2010 and more recently, NASA satellite data were used to produce volcanic ash advisories for aviators across the Gulf of Mexico during the February 1 eruption of the Popocatepetl volcano in Mexico.

These practical benefits are not only realized here at home, but also abroad as is currently the case for the recent devastating earthquake in Japan. As with the previous earthquakes in Chile, Haiti, and elsewhere, NASA has been collecting and analyzing data from multispectral, multi-angle, and multiple resolution sensors to support damage assessment and response activities. We will continue the vital work to expand our abilities to observe our planet Earth and make those data available for decisionmakers and international partners.

NASA's FY 2012 budget request for Earth Science supports the development and launch of five foundational decadal missions guided by the priorities in the 2007 National Academy of Science Decadal report. We had certainly hoped to be examining and distributing new information from the Glory mission in 2012, but as is sometimes the case in the high-risk space business, the launch of Glory was unsuccessful. The FY 2012 request does, however, support exciting and high priority missions that include Aquarius, NPOESS Preparatory Project, Landsat Data Continuity Mission, and the Global Precipitation Measurement mission. In addition, the FY 2012 request supports the development and launch of the Orbiting Carbon Observatory-2, as well as the continued formulation and development of Soil Moisture Active and Passive (SMAP) and Ice Cloud and land Elevation Satellite-2 (ICESat-2), the first two Tier 1 Earth Science Decadal Survey missions, with targeted launch dates in November 2014 and January 2016, respectively.

Space Science

Robotic space probes allow us to extend humankind's presence into Earth's orbit and beyond. Through these missions we learn about our moon, the outer planets and their moons, asteroids and comets, icy bodies of the solar system, and we unravel some of the mysteries of our universe. NASA's FY 2012 budget request supports a robust space science mission portfolio including the Mars Science Laboratory (MSL), the Nuclear Spectroscopic Telescope Array (NuSTAR), the Radiation Belt Storm Probes (RBSP) and continued support for U.S. scientists through the research and analysis programs. MSL launches later this year and will arrive at Mars in August 2012. About the size of a subcompact car, MSL will assess whether Mars ever

was, or is today, an environment able to support microbial life. The Nuclear Spectroscopic Telescope Array mission will launch in early 2012 and become the first focusing hard X-ray telescope to orbit Earth. NuStar will give us new insight into how black holes are distributed through the cosmos, how heavy elements were forged in the explosions of massive stars, and what powers the most extreme active galaxies. The FY 2012 budget provides stable footing for the James Webb Space Telescope (JWST) while the Agency develops a revised program plan and a reassessment of schedule and lifecycle cost. The new plan will be reflected in the 2013 President's Budget Request; however, the FY 2012 investment puts JWST well on its way to enabling us to view further into the universe and closer to its beginnings than ever before. Through NASA's research and analysis programs, scientists will continue to use the vast volumes of data from NASA spacecraft, sounding rockets, balloons, and payloads on the ISS to further fuel the Nation's research advancements.

On March 7, 2011, the National Academy of Sciences (NAS), National Research Council (NRC) announced the results of the long-awaited decadal survey for NASA's planetary missions. In its report, *Vision and Voyages for Planetary Science in the Decade 2013–2022*, the Academy outlined the scientific priorities for planetary missions for the next decade. The committee emphasized the importance of utilizing realistic cost estimates, and recognized both the challenges we face in the current fiscal environment and the importance of capitalizing on our international partnerships to help us accomplish larger, flagship missions. The committee's two highest priority large-class missions include the Mars Astrobiology Explorer—Cacher and a Jupiter Europa Orbiter. The report also strongly endorsed the importance and fundamental contributions to planetary exploration made by NASA's competitive Discovery (small missions) and New Frontiers (medium missions) programs. As with other decadal surveys, NASA is assessing the committee's recommendations and will use them to guide the strategic planning for upcoming missions. This report follows another decadal survey in Astrophysics released in 2010, *Astrophysics 2010: New Worlds, New Horizons in Astronomy and Astrophysics* that continues to shape our astrophysics investments. A similar report for heliophysics is under way and is expected to be completed in 2012.

Life and Physical Sciences Research

With the extension of International Space Station (ISS) operations to 2020 or beyond, we are able to expand the fundamental knowledge of biological and physical processes in the microgravity environment. NASA's FY 2012 budget provides for investments in this aspect of NASA research, taking advantage of the unique environment and capabilities of the ISS research facility. Fundamental space biology research will investigate the effects of gravity and the space environment on cellular, microbial, and molecular processes and comparative responses of whole organisms and their systems. This research will help scientists better understand the molecular and cellular basis for human disease and sub-optimal performance, with potential benefits both to astronaut health and the health of the general population. Under microgravity conditions, researchers gain important insights into gene differentiation and the structures of complex macromolecules, with potential applications in the design of new drugs and the development of vaccines. Physical sciences research will explore the fundamental laws of the universe and provide a foundation for the development of advanced exploration systems that will enable humans to explore space in a more sustainable and affordable way. In April, the National Research Council will deliver to NASA the first decadal survey on life and physical sciences that will provide us with the guidance to ensure we maximize the return on our science investments in ISS and in life sciences and microgravity research.

The Human Research Program (HRP) and its associated projects will continue to develop technologies, countermeasures, diagnostics, and design tools to keep crews safe and productive on long-duration space missions. Utilizing the Bioastronautics Roadmap, a risk reduction strategy developed in conjunction with the Institute of Medicine, the HRP identifies the top priority risks to crew health and carries out research targeted at developing countermeasures to reduce these risks. The ISS is critical to validating many of these countermeasures.

The ISS as a National Laboratory is a national resource to promote opportunities for advancing science and technology to other U.S. Government agencies, university-based researchers and private firms. These other organizations will use the ISS to pursue basic and applied research in fields such as human health, energy, the environment and STEM education. NASA currently has Memoranda of Understanding with five Federal agencies and nine Space Act Agreements (SAAs) with companies and universities for use of the ISS as a National Laboratory. These organizations include:

- The National Institutes of Health (NIH), which issued a 3-yr rolling Funding Opportunity Announcement for ISS-based investigations in March 2009 to include two-phase awards of up to $1.5M per grant over 5 years. Three first-round grants for the ground-based phase totaling an estimated $1.3M were awarded in August 2010;
- The National Science Foundation, which funded a study using ISS as a platform for deploying CubeSats to study the upper atmosphere; and
- AstroGenetix Inc., which continues to make progress on their vaccine development project.

In support of the National Laboratory effort, NASA recently released a Cooperative Agreement Notice (CAN) for an independent Non-Profit Organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will: (1) act as a single entry point for non-NASA users to interface efficiently with the ISS; (2) assist researchers in developing experiments, meeting safety and integration rules, and acting as an ombudsman on behalf of researchers; (3) perform outreach to researchers and disseminate the results of ISS research activities; and (4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more. NASA plans to make an award for this organization in late spring. The NPO will oversee all research involving organizations other than NASA and transfer current NASA biological and physical research to the NPO in future years.

Linkages with Technology

Within NASA, technology and science work hand-in-hand, with technology enabling science and the science guiding technology. The Fiscal 2012 budget provides for continuation of our groundbreaking research into the next generation technologies. The investments are required to enable NASA's future Science missions as well as those in Aeronautics and Exploration. NASA invests in technology development in each of its Science areas. For Science, NASA's technology programs serve as an innovation engine, investing in the high payoff, high-risk ideas and technologies of tomorrow that industry cannot tackle today. This unique work also attracts bright minds into educational and career paths in STEM disciplines, and enhances the Nation's technological leadership position in the world.

Conclusion

NASA science contributes directly and substantially to current national priorities. As a leader in fundamental research, NASA works in and across the fields of Astrophysics, Planetary Science, Heliophysics, Earth Science, Life Sciences, Physical Sciences and technology development in ways that are unique to NASA's mission. The Science budget funds these missions as well over 3,000 competitively-selected research grants involving over 10,000 scientists, engineers, technologists, and their students across the Nation. The U.S. science community's drive for innovation is unwavering and is ready to produce the new discoveries and technologies that feed a strong economy.

NASA science is unique—targeting not only matters of the human mind, but also matters of the human spirit and nourishing our need to explore the unknown. With a balanced and diverse portfolio, we diligently seek to understand the world in which we live, the Sun that fuels us, our celestial neighbors, and the universe beyond. These endeavors both inspire and serve human kind. They are timeless and priceless. And they will continue to enable the United States to lead the world toward a future that will no doubt exceed what we can only imagine today.

SCIENCE PROGRAM SUMMARY

The President's FY 2012 request for NASA includes $5,016.8 million for Science. NASA continues to expand humanity's understanding of our Earth, our Sun, the solar system, and the universe with 56 science missions in operation and 28 more in various stages of development. The Science budget funds these missions as well as over 3,000 competitively-selected research grants involving over 10,000 scientists, engineers, technologists, and their students across the Nation. The Agency selects competed missions and research proposals based on open competition and peer review. NASA's science efforts continue to advance a robust and scientifically productive program while making difficult choices commensurate with the Government-wide priority to constrain the Federal budget.

The challenges we face have been amplified by the failed launch of the Glory satellite on March 4th. This loss underscores the challenging nature of the space business. Reliable and affordable access to space is vital to NASA's science program.

Earth Science

The FY 2012 budget request includes $1,797.4 million for Earth Science. NASA's constellation of Earth observing satellites provides many of the global environmental observations used for climate research in the United States and abroad.

In early FY 2012, NASA plans to launch the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), continuing selected climate data records and becoming an integral part of the Nation's operational meteorological satellite system for weather prediction. We also plan to select new Venture Class science instruments and small missions in FY 2012.

The Aquarius instrument on the Argentine Satélite de Aplicaciones Científicas (SAC)–D mission (launching later this year) will deliver the first global ocean salinity measurements to the science community in FY 2012. The Orbiting Carbon Observatory 2 (OCO-2), Landsat Data Continuity Mission (LDCM), and the Global Precipitation Measurement (GPM) missions will be in integration and testing in FY 2012. The first two NRC Decadal Survey missions, Soil Moisture Active/Passive (SMAP) and the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2), will both enter into development during FY 2012. This budget request also funds robust Research and Analysis, Applied Science, and Technology programs. In this climate of fiscal austerity there are some capabilities that will not be developed in order to keep the most important ones on track. Development of the second two Tier 1 Decadal Survey missions, the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI); and the Climate Absolute Radiance and Refractivity Observatory (CLARREO), has been deferred. NASA will continue pre-formulation work on the DESDynI and review international partner options. However, the FY 2012 request enables the Gravity Recovery And Climate Experiment Follow-on (GRACE–FO); the Pre-Aerosols-Clouds-Ecosystems (PACE); and the Tier 2 missions Surface Water and Ocean Topography (SWOT); and Active Sensing of CO_2 Emissions Over Nights, Days, and Seasons (ASCENDS) to go forward as planned.

Planetary Science

The Science budget request includes $1,540.7 million for Planetary Science in FY 2012. NASA and its partners consider the period from October 2010 to August 2012 (the length of a Martian year) to be the "Year of the Solar System."

The Juno mission will launch in August 2011 and arrive at Jupiter in 2016. The Gravity Recovery And Interior Laboratory (GRAIL) mission, following launch in September 2011, will enter lunar orbit and help determine the structure of the lunar interior from crust to core; the mission will advance our understanding of the thermal evolution of the Moon by the end of its prime mission in FY 2012. A webcam is giving the public an opportunity to watch technicians assemble and test NASA's MSL "Curiosity," one of the most technologically advanced interplanetary missions ever designed. More than one million people have watched assembly and testing of Curiosity via a live webcam since it went on-line in October. Curiosity will launch in early FY 2012 and arrive at Mars in August 2012; it will be two times as large and three times as heavy as the Spirit and Opportunity rovers, and will focus on investigating whether conditions on Mars have been favorable for microbial life and for preserving clues in the rocks about possible past life. The MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) spacecraft will arrive at Mercury later this evening and will complete its first year in Mercury orbit in March 2012. MESSENGER's instruments will map nearly the entire planet in color, image the surface in high resolution, and measure the composition of the surface, atmosphere and nature of the magnetic field and magnetosphere. During its nearly decade-long mission, the Dawn mission will study the asteroid Vesta and dwarf planet Ceres—celestial bodies believed to have accreted early in the history of the solar system. Dawn will enter into orbit around Vesta this summer and will depart in 2012 for its encounter with Ceres in 2015. NASA and the European Space Agency (ESA) have selected the five science instruments for the 2016 ExoMars Trace Gas Orbiter mission. The budget also supports robust Research and Analysis and Technology programs.

NASA recently received the new National Academy of Sciences Decadal Survey for Planetary Science, entitled *Vision and Voyages for Planetary Science in the Decade 2013–2022*. We are grateful to the Academy and to all the Survey participants for their hard work and thoughtful recommendations. NASA will use this Survey to prioritize ongoing programs and future mission opportunities.

Astrophysics

The FY 2012 budget request includes $682.7 million for Astrophysics (not including an additional $375 million for the James Webb Space Telescope [JWST] which is detailed below). This is a golden age of space-based Astrophysics, with 14 observ-

atories in operation. Astrophysics research, technology investments, and missions aim to understand how the universe works, how galaxies, stars and planets originated and developed over cosmic time, and whether Earth-like planets and life exist elsewhere in the cosmos.

The FY 2012 budget request reflects the scientific priorities of the new National Academy of Science Decadal Survey entitled, *New Worlds, New Horizons in Astronomy and Astrophysics*. The budget includes additional funding for the Explorer mission selection planned for 2012, sustains a vigorous flight rate of future astrophysics Explorer missions and missions of opportunity, and increases investments in recommended research and technology initiatives. Funding is also provided for pre-formulation investments in recommended large missions beyond JWST, while work on the Space Interferometry Mission (SIM) and Joint Dark Energy Mission (JDEM) has been brought to a close, consistent with the recommended Decadal Survey program. The Stratospheric Observatory for Infrared Astronomy (SOFIA) will complete its open door flight testing and conduct the first competed science observations in FY2012. The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will launch in early 2012. The NASA Astrophysics budget also supports continuing operations of the Hubble Space Telescope (HST), Chandra X-ray Observatory, and several other astrophysics observatories in space. The budget increases funding for the core Astrophysics research program, including sounding rocket and balloon suborbital payloads, theory, and laboratory astrophysics.

James Webb Space Telescope

The FY 2012 budget request includes $375 million for the James Webb Space Telescope (JWST). JWST is now budgeted as a separate theme, reflecting changes implemented in FY 2011 to improve management oversight and control over this critical project, as recommended by the Independent Comprehensive Review Panel's (ICRP) report in November 2010. The project, which was previously managed within the Science Mission Directorate's (SMD) Astrophysics Division within NASA Headquarters, and was part of the Cosmic Origins Program, is now managed via a separate program office at NASA Headquarters. The JWST Project Manager at Headquarters now reports directly to NASA's Associate Administrator and the Associate Administrator of SMD. The lead Center for JWST, Goddard Space Flight Center, has also implemented changes, with project management now reporting directly to the Center Director. JWST was the top priority large mission recommended in the previous NRC Decadal Survey and is considered a foundational element of the science strategy in the new Decadal Survey for Astronomy and Astrophysics. Cost growth and schedule issues identified during the Mission Critical Design Review led to the formation of the ICRP. The ICRP report concluded that the problems causing cost growth and schedule delays on the JWST project are associated with cost estimation and program management, not technical performance. The $375 million funding in 2012 gives the program a stable footing to continue progress while the Agency develops a revised program plan that includes a realistic assessment of schedule and lifecycle cost. The revised schedule and lifecycle cost will be reflected in the 2013 President's Budget Request.

Heliophysics

The FY 2012 budget request includes $622.3 million for Heliophysics. NASA's heliophysics satellites provide not only a steady stream of scientific data for NASA's research program, but also supply a significant fraction of critical space weather data used by other Government agencies for support of commercial and national security activities in space. Those agencies use the data to protect operating satellites, communications, aviation and navigation systems, as well as electrical power transmission grids. The spacecraft also provides images of the Sun with ten times greater resolution than high-definition television in a broad range of ultraviolet wavelengths. On February 6, 2011, the two Solar Terrestrial Relations (STEREO) spacecraft reached 180 degrees separation; when combined with the Solar Dynamics Observatory (SDO), these spacecraft will enable constant imaging of the full solar sphere for the next 8 years, as the solar cycle peaks and begins to decline again. These three spacecraft working together and in combination with NASA's other solar observatories will give us unprecedented insight into the Sun and its dangerous solar storms that could threaten both satellites and humans in space as well as electric power systems on Earth. NASA has begun development of a mission, called Solar Probe Plus, that will visit and study the Sun from within its corona—a distance only 8.5 solar radii above its surface.

The FY 2012 budget will enable completion of the Radiation Belt Storm Probes (RBSP) mission for launch in FY 2012 as well as the completion of development of the Interface Region Imaging Spectrograph (IRIS) Explorer mission. In FY 2012, the

Magnetospheric Multiscale (MMS) mission will enter its assembly and integration phase, the Solar Orbiter Collaboration with ESA will undergo Mission Confirmation Review, and the Solar Probe Plus mission will enter into the preliminary design phase. NASA has increased funding for the next Explorer mission selection planned for 2012 to enable selection of up to two full missions, as well as instruments that may fly on non-Explorer spacecraft. The budget also supports robust Research and Analysis and Sounding Rocket operations programs. The National Academy of Sciences has begun work on the next Decadal Survey for Heliophysics and we anticipate its release in the spring of 2012.

Life and Physical Sciences

The FY 2012 budget request includes $66.5 million to support research in the Life and Physical Sciences on the International Space Station (ISS), including a non-profit organization (NPO) to stimulate, develop and manage the U.S. national uses of the ISS National Lab. The ISS has transitioned from the construction era to that of operations and research, with a 6-person permanent crew, 3 major science labs, an operational lifetime through at least 2020, and a growing complement of cargo vehicles, including the European Automated Transfer Vehicle (ATV) and the Japanese H-II Transfer Vehicle (HTV). The FY 2012 budget request reflects the importance of this unparalleled research asset to America's human spaceflight program and will enable fundamental science advances in the areas of biology and physics in the little-understood space environment. These science investments will be informed by recommendations in the National Academy of Science decadal survey for life and microgravity sciences, which will be released shortly.

Many avenues of research being conducted aboard the ISS may have terrestrial applications. For example, ISS research has shown that *Salmonella* bacteria become more virulent in microgravity (*i.e.,* more aggressive in causing disease). Scientists have identified the gene responsible for this increased virulence and are developing a potential vaccine against *Salmonella*. AstroGenetix, Inc. has funded their own follow-on studies on ISS and is now pursuing approval of a vaccine as an Investigational New Drug with the Food and Drug Administration. They are now applying a similar development approach to methicillin-resistant *Staph aureus* (MRSA).

Microcapsules are tiny micro-balloons used in cancer treatment to deliver anti-cancer drugs directly to a tumor site. Microcapsules with improved cancer treatment properties developed on the ISS were reproduced on Earth and were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method are beginning.

Numerous plant growth experiments have investigated both the effects of microgravity, as well as the capability for growing regenerable food supplies for crew. Technology developed the for greenhouse flown on the ISS led to a new technology that is widely used on Earth, killing 98 percent of airborne pathogens (including Anthrax) for food preservation, doctors' offices, homes, and businesses.

Finally, as part of the ISS National Laboratory effort, the National Institutes of Health (NIH) are hosting three rounds of competition for the BioMed-ISS initiative. The first round of grants for the ground-based phase has been awarded to support the following important research topics:

- Studying bone-cells in a gravity-free environment in order to uncover new therapeutic targets for osteoporosis and related bone diseases.
- Applying lessons learned from studies of immune cells in the space environment, where the immune system is suppressed, to a new model for investigating the loss of immune response in older women and men.
- Using microgravity three-dimensional cell culture models to generate insights into how the barrier properties of the intestines, which inhibits the movement of toxins into the intestinal tract behave, and to explore how the absence of gravity affects alcohol's ability to compromise this barrier. The compromise of this barrier and the reduced resistance to toxin transport is major factor in alcohol-related disease, The microgravity environment is helping scientists understand the underlying mechanisms for this process.

Senator NELSON. Thank you, gentlemen.

Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Chairman.

Dr. Suresh, in your testimony you mentioned increasing the number of international players in the global markets for graduates STEM degrees. In your opinion what are the—some of the

short term and longer term steps we must take to encourage more high school and college students to pursue scientific and technical degrees?

Dr. SURESH. NSF for several decades has played a key role in STEM education, not just by itself, but also in concert with other agencies such as the Department of Education. The distinction between what NSF does, and what other agencies do, is NSF sponsors research into best models, ways in which our STEM education can be strengthened, and then we work with other agencies so that it can be implemented on a larger scale.

For example, Dr. Holdren mentioned, in his presentation, that recently NSTC has convened a committee on STEM education which aims to do exactly that. We have a number of programs that reach out to K through 12. We have a number of programs that reach out to undergraduate students. We have new programs that are introduced that will bring the latest science and technology into STEM education practices in the country. A lot of our programs are also aimed at supporting the President's mission of 100,000 new STEM teachers in the country. What are the best practices? What are the lessons learned?

We also try to incorporate under-represented groups. By the year 2040 we will be a country with a majority of minorities. How do we incorporate these groups into the STEM workforce?

These are all part and parcel of activities that NSF is engaged in.

Senator BOOZMAN. Do we do—do we embrace the scientific method of studying what we are doing, evaluating the programs that are working, measuring their effectiveness, and then again getting rid of the programs that aren't working?

Dr. SURESH. Absolutely. In the Fiscal Year 2012 budget, for example, in the area of education, there are several programs that are scheduled for either termination or reduction, not because these programs have not worked in the past; but we have funded them for a long time, learned a lot of lessons from them, and as we launch newer programs with new tools, new technologies, and new evidence-based research methodologies for STEM education, we try to realign them. In the area of STEM education, we have several programs that fall into that category.

By the way, I should also add, in the area of research and operations, we have eliminated several programs which will save the taxpayers more than $100 million. So the budget has been developed very responsibly.

Senator BOOZMAN. OK. Thank you.

Dr. SURESH. Thank you.

Senator BOOZMAN. Director Gallagher, there have been concerns that other nations may be using the international standards setting process to benefit their own domestic industries. Is this happening? If so, how does this sort of protective standard setting occur and what impact could it have on U.S. businesses and scientific research?

Dr. GALLAGHER. So, standards are interesting because they are a form of collective behavior among what would normally be competing companies. And they are powerful. I think that standards set the conditions for a market to take hold and they set the condi-

tions for which technologies can evolve so that you achieve the desirable goals, like interoperability.

But like any powerful collective behavior, it can be misused. And I think this is always a concern when you are looking at standards setting. Certainly there are examples of either developing countries that want to influence international standard setting to either advantage their local producers or to meet certain conditions that they feel are apparent in their markets. The most effective tool we have is actually to engage more. The truth of the matter is, even our own producers in this country are producing for a global market and it is to our own advantage that there be robust, technically sound standards that our own manufacturers can work toward.

One of the strengths of the U.S. system is we tend to bring, because we have an industry led standard setting process and not a government led standard setting process, the experts in the technologies right to the table. And I think the cases where we have seen problems have been when for some reason we are not aggressive enough in getting our perspectives there first. So there is a great first mover advantage in the fact that we bring so much technology and capacity into the discussions.

So this really just takes a careful monitoring of the various interests that are taking place and making sure that we are fully engaged.

Senator BOOZMAN. So it is a focus of the administration?

Dr. GALLAGHER. Very much so.

Senator BOOZMAN. OK. Thank you, Mr. Chairman.

Senator NELSON. And Dr. Gallagher, in those standards you are requesting 24 million for the Interoperability Standards for Emerging Technologies. Are there other emerging technologies that NIST should be working on with industry to develop interoperable standards?

Dr. GALLAGHER. The answer is yes. It would be sad if we had a shortage of emerging technologies to work on, so I think that the list of potential areas where we are being asked to engage with industry is large. The focus of the request is in three areas, in particular where the federal government has a great interest in the formation of these standards.

First, specifically looking at smart grid standardization so that the smart grid infrastructure is interoperable and secure. Second, the area of cloud computing where there is enormous advantage to federal agencies looking toward cloud services and making sure that cloud providers can still maintain the security and interoperability we still have access to our data and aren't locked in to a particular proprietary answer. And third, in the area of electronic medical records.

Two of those three efforts were actually started with Recovery Act funding transferred to NIST. And so this request basically allows us to maintain these programs where we are working and in many cases with hundreds of industries at the same time. But our core programs continue to look at evolving and emerging technology areas like nanotechnology, synthetic biology and other areas where it is just as important to work with industry to make sure we are, again, moving out forward first so we can shape the way these standards take place.

Senator NELSON. Are those standards for the electronic medical records ready to go?

Dr. GALLAGHER. Well, I always hesitate to say "ready" because the standards setting activities tend to be continuous. So what I am often looking for is you have a very clear starting point where you get the activity going but the technology continues to evolve so that—what I look for has the effort achieved a maturity where it is self sustaining. And I think we are still early, I would say, in the case of electronic medical records. There are still some key issues to address to make sure that these systems can interoperate and we can securely and reliably share patient information across systems, between different doctors.

We also want to make sure these systems are usable. I don't think doctors want to be struggling with complicated systems that they can't use. And I think patients want to understand that they can control how their medical information is used by different participants in that system. So it is a very active area but I wouldn't say we are done.

Senator NELSON. Well, they are ready to go out there in the private sector, because they are setting up these electronic medical records as we speak. So, tell me about the disconnect.

Dr. GALLAGHER. Well, this is true in all of these new technology areas. That is correct, we are deploying electronic medical records systems, they are commercially available. And in fact under the HITECH Act we are creating incentives to lower the barriers for doctors to purchase these systems.

The way you address some of these areas where we are continuing to evolve standards is largely through upgradability requirements. So we do make sure, when we are early in a standards setting process, that if a system doesn't have the full capability or we haven't reached consensus among the technical community how we are going to provide for a certain type of interoperability, there is the pathway to upgrade those investments so that we can achieve that type of interoperability.

So I think the capability of these electronic medical records systems is going to continue to evolve and it is going to continue to get better. But the road map and sort of the priority setting that we look at when we engage is to try to establish the core functionality, provide an upgradability and then make sure that the technology is moving toward the sort of the full scale interoperability that we would like to see in the end.

Senator NELSON. I would like you to provide, to the committee, a timetable with a copy to the Secretary of HHS on when you think that these standards are ready.

Dr. GALLAGHER. I would be happy to work with you.

Senator NELSON. What I would like is a report on your timetable.

Dr. GALLAGHER. Right. Right.

Senator NELSON. When you see this, because if you all are still developing these things 10 years from now that is going to be too late.

Dr. GALLAGHER. We will be happy to provide that. I don't think this is a case where the standards are not going to be ready in 10 years. There are a lot of standards that are already in place, all I am pointing out is that the technology itself is going to evolve and

you want a standards setting process that not just addresses the needs for interoperability today but is still there working on standards as the technology itself improves. We worked closely with HHS on this and we would be happy to give you that time scale.

Senator NELSON. Well, the President is requesting $24 million for this Interoperability Standards for Emerging Technologies and I take it this is one of the emerging technologies.

Dr. GALLAGHER. That is correct.

Senator NELSON. And there are others. You mentioned smart grid, you said healthcare IT, cloud computing and other technologies. Could you play a role in coordinating market participants in the mobile payment industry?

Dr. GALLAGHER. Yes, we could. In fact there are already ongoing discussions about roles that we could play in supporting standards for mobile payment interoperability. In fact within the Trusted Identity Initiative as well, some of the authentication technology that you will need to enable mobile transactions is part of that effort as well. So we certainly would see a role there.

Senator NELSON. What are you doing on U.S. leadership in international standards?

Dr. GALLAGHER. So the NIST role in standards is really a technical role. One of the ways that we work to achieve robust international standards is to make sure that the best technical work is being used as the basis for the standards. So, as I said before, I think one of the strengths of the U.S. standardization process is that we tend to put the best technology and the best technical experts around the table when these are forming.

The U.S. standards process though is interesting, because unlike most other countries it is not government setting standards in the United States, it is industry setting standards. So the key participants in the international standards bodies are private sector organizations, not government organizations. So our role is largely in support of those private sector organizations to make sure that this work is technically sound.

We also work with other federal agencies, including our trade agencies, to make sure that we are sensitive to any emerging technical barriers to trade, any concerns that these standards are creating a barrier, so we can work to address those from our technical perspective.

Senator NELSON. Senator?

Senator BOOZMAN. Along that line, Secretary Gallagher, I wish we could turn you loose on the government agencies so the DOD and VA would have the same interoperability. There is just example after example where the government just doesn't do a very good job of that at all.

Dr. Holdren, I really did enjoy our visit the other day. That was very helpful in helping me get up to speed with what you are trying to accomplish. As you know, two significant interagencies research programs are up for reauthorization, the National Nanotechnology Initiative and the Networking and Information Technology Research and Development Program. How effective do you believe the interagency research programs are at furthering transformational research in areas of national importance, such as energy independence and cybersecurity?

And then also, could you provide some examples of success resulting from interagency collaborations in either of these programs?

So we are really—you know, that—we are kind of getting back to interoperability in a way in that regard also, amongst our agencies.

Dr. HOLDREN. Well thank you, Senator Boozman. I enjoyed our conversation a great deal as well.

And let me say in starting to answer this, that the question of interoperability among the government agencies is one that the chief information officer or the chief technology officer, both of which we have for the first time in this executive branch, have really been working hard on. I think they are actually making a lot of progress. It is—it is a huge challenge, of course, but I think progress is being made there.

As for the——

Senator BOOZMAN. I think so, and yet as someone that has been on the VA committee in the House and now in the Senate—it is a huge challenge.

Dr. HOLDREN. Yes. Absolutely. I understand it, but I do know that the CTO and the CIO have been working with the VA, among others, on getting more of this right.

You mentioned both the NITRD Initiative, the Networking Information Technology R&D Initiative, and the Nanotech as interagency initiatives that are trying to promote increased cooperation, not just across the agencies but with the private sector. And both do have that thrust in trying to get better at transferring discovery out of the universities and the national laboratories and into the private sector, through partnerships. I think we are already seeing many benefits in that domain, in the nanotech area in particular, which is one in which any number, I couldn't give you the exact number, but I can try to find it, any number of new startup companies have been benefiting from these public/private interactions. And we have, I know, successful companies marketing new nano-based products that have come out of this. I think we are getting better and better at it.

We are also seeing real successes in the clean energy domain, where the national laboratories, the universities and the private sector are working more effectively on advanced batteries, for example, on improving fuel cell technology, on improving photovoltaic cell technology, as Chairman Nelson mentioned in his remarks. I think energy already provides us a rich array of examples in that domain.

The President's Council of Advisors on Science and Technology (PCAST) has, in the last year, completed major reviews of both the National Nanotechnology Initiative and the NITRD Initiative and has made a number of recommendations about how we can improve the effectiveness of both of those at doing just what you are talking about. And it is my responsibility to see that those recommendations, with the approval of the President, get implemented.

We have been doing that. We have got National Science and Technology Council subcommittees working hard in both of those domains.

Senator BOOZMAN. Thank you.

Dr. Abdalati, in the America COMPETES Authorization of 2010, NASA was directed to utilize their resources to create and support professional development for STEM teachers and STEM educators at all educational levels. We have had concerns in the past that NASA has not fully embraced this opportunity and direction. How does NASA plan on implementing this directive going forward? And then also, what commitment can you make that we will see NASA aggressively engage in this area?

Dr. ABDALATI. Well, first I think the level of NASA commitment is coupled to the leadership at NASA, and Administrator Bolden has made it very clear that this is a very high priority of his. He has made that clear publicly and he has certainly made that clear internally. One of the reasons he wanted a chief scientist, and in particular a chief scientist who understands NASA but is from academia, was for this purpose, to have this kind of link, someone who lives and breaths in the STEM world.

So, the first and most important step is the Agency's commitment. When you couple that with the commitment of the President, I think there is great potential for what NASA can and will do.

We have an Office of Education, and I believe you had the opportunity to speak with the Associate Administrators from NASA earlier in the week, and undoubtedly heard about the great things that our Office of Education is doing in STEM education. I am personally working to develop a strong relationship with Mr. Melvin, the lead of that office.

At NASA, There are also education experts embedded within each of the directorates to ensure that the detailed activities within the directorates propagate into the educational domain, leaving the Education Office to manage education activities from an agency perspective.

So, the biggest issue is the commitment—at the top from Administrator Bolden, to myself as Chief Scientist, to the Associate Administrator of Education. I can take, for the record, your question as to specific actions that will be undertaken at NASA on STEM education and I can also assure you that the commitment and support, which is really what makes it a success, from the President to the administrator on downward is there.

[The information requested follows:]

In January 2011, President Barack Obama stated that, "over the next 10 years, nearly half of all new jobs will require education that goes beyond a high school education. And yet, as many as a quarter of our students aren't even finishing high school. The quality of our math and science education lags behind many other nations. America has fallen to ninth in the proportion of young people with a college degree. And so the question is whether all of us 'as citizens and as parents' are willing to do what's necessary to give every child a chance to succeed." This speech echoes findings and calls-to-action by numerous committees, reports, professionals in education, and leaders in American industry. In response, the Department of Education has identified several strategies to improve science, technology, engineering and mathematics (STEM) education and ways in which Federal agencies can contribute to the Nation's STEM improvement efforts. NASA is a strong contributor to the national plan.

Consistent with Section 202 of the America COMPETES Reauthorization Act of2010, NASA works with professional organizations, academia, and state/local education providers to identify and address needs in STEM education. Quality professional development for STEM educators is a prevalent need. Through the education staff at NASA's Centers, NASA works cooperatively with states and school districts to identify content needs and opportunities, and with university partners to ensure that NASA investments will be effective in improving teaching practice. NASA also

works through communities of practice to identify content areas and special events that supplement informal education programming offered by museums and science centers. NASA higher education efforts increasingly target community colleges, which generally serve a high proportion of minority students. NASA programs build student STEM ability, preparing students for study at a four-year institution. Competitive opportunities support initiatives like the President's "Race to the Top" and the Department of Education's "Star Project," which promote state-based education reform and identify replicable strategies for improving K–12 education.

NASA's education programs aim to increase the number of students who are proficient in, choose to major in, and pursue careers in STEM fields. Improving STEM ability, increasing public scientific literacy, increasing the talent pool of future STEM workers, and developing the STEM skills of the future workforce are imperatives if the Nation is to remain globally competitive and sustain a strong economy. NASA actively works through mutually beneficial relationships with over 500 colleges and universities, hundreds of K–12 schools and districts, and over 400 museums and science centers to provide education experiences, so that all students can learn deeply and think critically in STEM disciplines. NASA supports cutting-edge undergraduate student research that contributes to NASA missions while training the next generation of scientists, engineers, and innovators. NASA targets recruitment and retention of underserved and underrepresented students, including women and girls, Hispanics, and students with disabilities.

NASA is committed to providing equal access to its education activities by providing any student with the opportunity to contribute to the future STEM work force. NASA is responding by focusing its education investments on areas of greatest national need and ensuring that the Agency's education programs support national STEM priorities. With its wealth of science and technology content and its expansive network of education professionals, NASA is well equipped to address national needs such as meeting state requirements for educator professional development. NASA provides practical experience and skills development for those who will become the future workforce through internships, fellowships, and student research opportunities. NASA is especially qualified to attract students to pursue STEM study and careers. It also is able to engage these future workers through inspiring NASA missions, fostering collaborative relationships between students and the current workforce and offering students opportunities to work in ,.out of this world" facilities. Hands-on challenges with expert mentors generate increased interest in STEM study.

NASA has engaged students and teachers in its engineering challenges and scientific discoveries since its inception. From school presentations to seeds flown in space, from filmstrips and posters to podcasts and virtual tours through the galaxies, NASA's education programs have fostered inquiry, built curiosity, and encouraged innovation. Generations of Americans have participated in NASA's STEM education programs, and thereby learned basic skills, discovered new career paths, and developed interests in emerging academic disciplines.

NASA is actively engaged in collaborations with other Federal agencies to ensure the Agency's programs are supportive of national STEM priorities. The NASA Associate Administrator for Education represents the Agency on the National Science and Technology Council (NSTC) Committee on STEM Education (CoSTEM). It was established pursuant to the requirements of Sec. 101 of the America COMPETES Reauthorization Act of2010. The NASA Office of Chief Scientist is also participating in the CoSTEM by providing the CoSTEM Executive Secretary, who works in close coordination with the Office of Education.

NASA's Earth and space science missions have an essential role in NASA's education mission. The discoveries and new knowledge from our missions and research programs consistently engage people's imaginations, inform teachers, and excite students about science and exploration. We are committed to utilizing our resources to foster the broad involvement of the Earth and space science communities in education and public outreach with the goal of enhancing the Nation's formal education system and contributing to the broad public understanding of science, mathematics and technology. NASA's Science Mission Directorate creates education products using NASA's results in Earth-Sun system science, solar system research, universe exploration, and the development of new technologies to support learning. Through a "Train the Trainer" model the SMD programs train master teachers, who reach their peers via in person and online professional development opportunities that range from one day to week-long workshops. Another aspect of Teacher Professional development includes providing summer research opportunities for in-service teachers.

In 2010, NASA chartered an Education Design Team (EDT) to develop a strategy to improve NASA's education offerings, assist in establishing goals, structures, proc-

esses, and evaluative techniques to implement new sustainable and innovative STEM education programs. EDT has completed its task, and its recommendations are reflected in the FY 2012 education budget for NASA's Office of Education.

The FY 2012 budget provides NASA with the resources necessary to continue this rich tradition in STEM education through support for the Nation's students and educators, the leveraging of cutting-edge education technologies, and partnerships with industry. The budget proposal will:

- Increase NASA's impact on STEM education by further focusing K–12 efforts on middle-school pre- and in-service educator professional development;
- Increase emphasis on providing experiential opportunities for students, internships, and scholarships for high school and undergraduate students;
- Increase NASA's role in national and state STEM policy discussions;
- Emphasize evaluation and assessment, including external independent evaluation, to ensure that investments are providing desirable STEM impacts;
- Engage strategic partners with common objectives and complementary resources; and
- Use NASA's unique missions, discoveries, and assets (*e.g.,* people, facilities, education infrastructures) to inspire student achievement and educator teaching ability in STEM fields.

Senator BOOZMAN. Thank you.

Thank you, Mr. Chairman.

Senator NELSON. Well, contrary to Administrator Bolden's emphasis on STEM education, the President's budget cuts $200 million from the 2010 levels across the Federal Government in STEM education. So Dr. Holdren, why this philosophy? What performance metrics was your office using when deciding to make these reductions?

Dr. HOLDREN. Well, first of all Chairman Nelson, as I have said, we had to make some very hard choices in this budget. We all know that we don't have the money to do everything we would like to do and in this budget we reduced funding or cut funding for a wide variety of programs across a wide variety of domains that we would have preferred, under better circumstances, to be able to more fully fund.

In the education domain, one of the things that I think needs to be recognized is the extent to which education activities are spread across a large number of R&D categories, in which education and training occurs without that particular label. I know Dr. Suresh could talk about this in greater detail, in terms of how it works at NSF where you have an education directorate and it does very important work. But I would say an even larger part of the education work at NSF goes on in connection with the research grants across the whole range of fields and those are going up.

In other cases, we cut programs that seemed to have been on the metric of cost per student, or cost per new teacher to be extremely expensive even if successful by some other metrics. We are looking for ways to get the most bang for the taxpayer's buck in this domain and in this fiscal climate. We made some choices based on looking for ways to get more for our money than some of the more expensive programs on that per teacher or per student basis.

Senator NELSON. Well, the information that I have is contrary to that. Dr. Suresh, it says that in your bailiwick of NSF, that you are actually reducing the funding requested for K through 12 educational activities. Why do that?

Dr. SURESH. I'm happy to answer that and also provide some additional information on the point that Dr. Holdren made. If you

look at graduate level funding, for example, one of our signature programs, which is also a Presidential priority, is the Graduate Research Fellowships. In 2012, we will have 2,000 more graduate research fellows. Since 1952, NSF has funded 46,000 graduate research fellows.

We are not only increasing the number and funding 2,000 new fellows in 2012, we are also increasing the cost of the education allowance from $10,500 to $12,000 because it is long overdue. What is reflected in the education budget is just a little more than half of it. The other part of it comes from research directorates. So this is what Dr. Holdren was referring to.

Another program like that is the IGERT program which is also interdisciplinary activities for graduate students. Fifty percent of the IGERT program support also comes from entities other than the education directorate within NSF.

With respect to K through 12 education, we have other activities within the National Science Foundation that pick up aspects of this. We are also, at this point, strategically examining, based on evidence, programs that work, have done well, and that we can share through a variety of directorates within NSF. In fact, I have charged the head of our EHR directorate to look at two possibilities: how to engage all of the research directorates in educational activities, and also how to make sure that all of the best practices of the various research directorates are incorporated into the education activities.

Senator NELSON. Well, following on that, it is true that the President's budget has a 3.8 percent increase for STEM education, in NSF. But when you get down into the weeds you see that Kindergarten through 12th grade is reduced by 15 percent. And I just heard the President give a speech about how important it is to get kids turned on to science and technology and education and mathematics. And I hear the Secretary of Education saying this all along. So I am wondering, if the policy is being set by the President, why is it being implemented by this 15 percent reduction and this cancellation of the NSF graduate and Kindergarten through 12th programs. Tell us about that.

Dr. HOLDREN. Mr. Chairman, if I could say a word about the priorities and then I will turn it back to Dr. Suresh for some of the details. But one of the things that we are doing to implement the President's priorities is getting the private sector and the philanthropic sector much more heavily engaged in supporting K through 12 STEM education. The President's Educate to Innovate Initiative, which he first rolled out in November, 2009, with something over a quarter of a billion dollars in private sector and philanthropic support for improving K through 12 STEM education, now has over $700 million in philanthropic and private sector support and has a new component called Change the Equation, which has a 100 leading high tech CEOs contributing expertise and person power from their companies to work with teachers in classrooms, to provide role models and to provide more realistic and more hands-on experience for science and math and engineering students in K through 12.

So one of the things we are doing, we are being creative here in getting more of the society engaged in this effort and more of the society engaged in paying for it.

Senator NELSON. Is that filling this 15 percent cut to STEM education for K through 12?

Dr. HOLDREN. Well, I can provide you an analysis of the extent to which the specific functions are being covered. I can't do that off the top of my head, but I think—even as we are forced in a time of great fiscal constraint, to economize in our federal budget—we are succeeding in bringing in resources for these very purposes, from the philanthropic and private sectors, I think is significant.

Senator NELSON. Senator?

Senator BOOZMAN. Thank you, Mr. Chairman.

Director Gallagher, the—can you tell us in regard to nanotechnology, can you discuss some of the standard setting challenges that we face there?

And then also, as we reauthorize the National Nanotechnology Initiative, can you tell us how you feel that perhaps we could improve the current situation? You know, what do we need to do to improve the bill as we go forward, in other words improve the authorization?

Dr. GALLAGHER. Thank you. So the NIST program, the NIST portion of the NNI includes our mission to advance measurement science and provide measurement capability. In the realm of standard setting, one of the key areas for any new emergent technology, and nanotechnology is a classic example, is as we move from the science realm into the technology development realm, in particular commercial technology development, is the acceptability in the market of these products that contain nanotechnology.

And for this technology, it centers around questions of environment and health and safety. So a key part of the NIST effort and part of our request is to develop the supporting measurement capabilities so that we can assess risk of engineered nanoparticles so that you can determine whether there has been an environmental release, how do you characterize whether environmental samples contain nanoparticles. And it is really important, in fact it is imperative that this effort be very strong and move quickly because if public concerns about the safety of nanoparticles get ahead of where our science is, in terms of being able to articulate this, we will see a very significant barrier, through fear of these—and you will certain see that. So I think that is one of the most urgent standards needs in the area of nanotechnology.

I think the NNI has reflected this very effectively in their strategy. From my perspective, the most important ingredient in the NNI initiative was the fact that you talked about the difficulty of many different agencies participating in something. This is one of those success stories where we have had a very broad interagency effort that is working extremely well together with really an integrated strategy approach. And, from my perspective, that is what I would like to see in any reauthorization effort.

Senator BOOZMAN. Very good.

Just one more thing. Dr. Suresh, the—it is my understanding the National Science Board is beginning a review of modification to the merit review criterion at the NSF, specifically the intellectual merit

and broader impacts criterion. What changes are being considered to ensure proposals that have received excellent reviews are funded?

Dr. SURESH. Thank you for the question, Mr. Ranking Member.

As you know, NSF funds proposals based on two criteria. The first and primary criterion is that it has scientific excellence. Then the additional criterion, the second criterion, is the broader impact, which encompasses a lot of different aspects, from translation to the marketplace to broadening participation and a variety of other factors.

In the America COMPETES Reauthorization Act of 2010 there was language requesting the director of the National Science Foundation to provide a report to Congress within 6 months of the enactment of the America COMPETES Reauthorization Act. So that is due to Congress in June of this year.

Almost in parallel with that, the National Science Board had established a task force to look into this. Because these two happened in parallel they were initially out of synch. So what we have done recently, since the passage of the America COMPETES Act, is to align the two together so that we will have one synergized version of the sentiments that develop from the study, that will be communicated broadly.

In addition to that, we have launched outreach to the entire scientific community in the U.S. seeking their input on broader impact. This is currently on the National Science Foundation website, and a lot of letters have gone out. We have also sought input from the broader community. So we have had a number of teleconferences, joint teleconferences, between the Foundation and the Board. It is our expectation that we will have a cohesive set of recommendations ready by about early May or so, so that the report will be submitted to Congress on time.

Senator BOOZMAN. Thank you.

Thank you, Mr. Chairman.

Senator NELSON. Dr. Holdren, the President's budget had a considerable increase in NIST as well as the National Science Foundation, but it kept NASA flat-lined for the next several years. You want to explain that philosophy?

Dr. HOLDREN. Well, first of all Chairman Nelson, the President had been clear from early in the administration about the importance he ascribed to investing in fundamental research as the foundation for advances all across the spectrum of applications. And that spectrum of applications of course includes space. But the President said, look what I think we need to do is get NSF, the DOE Office of Science and the NIST Laboratories on a doubling trajectory. And he has remained committed to that even through these budget difficulties.

I would add that it is less expensive to do that than to expand the NASA budget by enough to do everything we would all like to do. And I think you and I share an appreciation for the importance of space and a desire to do more there. But in this budget environment the President felt that NASA could not be exempt and that we needed to try to meet the goals of the 2010 NASA Authorization Act with a budget that did not go up overall compared to the 2010 appropriation.

The division of the investments in NASA included, again, some difficult cuts that I would have preferred not to make, the President would have preferred not to make. We cut Earth Science research. I would have preferred not to do that, as the President would have preferred not to do it. We cut some of the investments in robotic missions, robotic precursor missions for the Human Exploration Program. I would have preferred not to do that.

We don't have as much money for some of the major elements, including the heavy lift vehicle where we asked for a substantial amount of money but not as much as was authorized. Part of that difficulty, as you know, is that we have still not been freed from the constraints of the 2010 appropriation language. I know you have introduced a bill to do that, we very much appreciate it. But in order to be ready to spend as much in 2010 as one might have liked to spend, one needed to have done certain things in 2011 which we have not been able to do, because of the constraints of being under a continuing resolution which keeps those—the 2010 constraints on the Constellation Program in place.

So these were tough choices, there is no question about it. And I for one would have been happy had we been able to do more across a wide range of government programs, but fiscal responsibility is a big part of the message that we are all working with at this juncture.

Senator NELSON. Are you aware that we had all the Associate Administrators of NASA here last Tuesday and they testified that the language that you just referred to, requiring the investment in Constellation, which by the way will be stricken in this continuing resolution, but that NASA has not spent very little if any additional money, that it would not be spending in the development of the new heavy lift rocket?

Dr. HOLDREN. I haven't had a chance to review that particular testimony. There have been a few other issues on my plate in the last week, as I know you will understand.

Senator NELSON. Well, fine but I bring it——

Dr. HOLDREN. But——

Senator NELSON.—to your attention, because it has been the conventional wisdom of what—and talked about in the press, what you just said and what we are told in practice is exactly the opposite, that the language which required—it was Richard Shelby putting in the language to protect Constellation back a year ago and it is obsolete language that needs to be stricken, and it will be in this coming CR. However, when asked that question the two Associate Administrators involved in this said that very little additional money had been spent because of that requirement that would not have been otherwise spent.

Dr. HOLDREN. Well, there is the question of what was spent that what—that otherwise wouldn't have been and there is also the question of what was not spent that otherwise would have been. I would want to look at that testimony and talk to those folks. It is my impression there have been some constraints. I think they probably said, well the constraints perhaps have not been all that bad. But my bottom line, Senator, is I am delighted that you are getting rid of that restriction in the continuing resolution going forward. And I thank you for that.

Senator NELSON. Well, my bottom line is that I want a space program that is robust.

Now, the President originally had come forth with a NASA budget a couple of years ago that was a $6 billion increase. It was one of the few agencies that was getting a substantial increase. And now with it being flat-lined, as with regard to the President's recommendation, flat-lined at the 2010 level, that $6 billion is evaporating. And yet the President's request lessens the heavy lift capability development and increases the commercial. Can you explain that?

Dr. HOLDREN. I can certainly try. First of all, as Administrator Bolden has made clear and we agree, we have to continue to make the International Space Station and our capacity to get U.S. astronauts to it and back from it, a continuing backbone of our human space exploration program. And in our judgment, and I think in yours too, Senator, the duration of the gap during which we have to rely entirely on the Soyuz for the transport of our astronauts back and forth after the retirement of the shuttle, is a matter of concern. We think it is very important to reduce that gap and we think that commercial crew provides the best opportunity for doing that and that we need to make those investments in order to keep that gap to a minimum and to be able to use the International Space Station as the superb scientific and technology development platform that it is.

Again, on the question of the heavy lift and on the question of the $6 billion increase over 5 years that we thought previously we would be able to get, I think it is a shame that the budget constraints under which we are now functioning make it impractical to get that increase. We are going to do absolutely the best we can to pursue all of the goals of the 2010 NASA Authorization Act with the money that we think is prudent and likely to be available.

I am personally very much hoping that the President's proposal gets fully funded. And I know you are going to try to help us with that. But my bigger worry is what difficulty we will be in if we can't get the $18.7 billion through in the 2012 budget.

Senator NELSON. Well, let's talk reality now, because we are now facing the situation that the President's request for flat-lining NASA is in peril. We are facing, in the House position, significant cuts. Cuts that we had testimony the other day that would mean 4,500 people immediately laid off by NASA. I am talking about the additional cuts as enacted by the House. Over 800 of those would come from Goddard, about 800 of those would come from Kennedy, about a little more than over 800 would come from Johnson. And then you can go around to all the centers and you could see what would add up to the 4,500 immediate job cuts from those centers, the bulk of which is coming from those three centers that I just mentioned.

What we are going to vote on at three o'clock today is another continuation for 3 weeks, and it is not going to have these cuts. But we are coming down to the moment of truth in another 3 weeks on enacting a budget for the remaining 6 months that not only is going to affect NASA but it is going to affect every one of your two other agencies, NIST as well as NSF. NSF would be down 4.4 per-

cent, if you followed the House position, and NIST would be down 18.6 percent.

So why don't you, the three of you share with us, and Dr. Holdren first, what those kind of gargantuan cuts would do to these various programs.

Dr. HOLDREN. Chairman Nelson, first of all, you and I and the President and I am sure the colleagues here to my left are all on the same page in this. We don't favor those cuts, those cuts are not what the President proposed, either in his 2011 budget or in his 2012 budget. And again, as I said when we were talking about NASA in particular, my worry is what happens if we don't get the $18.7 billion. I want to get that $18.7 billion because I think we can keep the most important stuff going, I think we can move a robust space program forward, which you and I and the President all want.

But if we experience these deep cuts that have been proposed by some in the House, it is going to be devastating. I think it is going to be devastating across the whole domain of investment in science, engineering, mathematics, innovation, which we have agreed have been the sources of our economic strength, the sources of our global leadership, the sources of our national security, the sources of our environmental equality. These cuts are a bad idea.

Senator NELSON. I would love to get $18.7 billion for NASA. The House position is $18.1 billion, that is $600 million less and that would do what I just outlined. And of course additionally it would have those cuts that I just talked about for your two agencies.

Dr. Suresh, you want to tell us what it would do to you?

Dr. SURESH. Quite substantial damage, if you will. Let me just give you some numbers. Last year, in 2010, Fiscal Year 2010, we received 55,000 proposals for funding at the National Science Foundation and we could have funded a lot more than we actually ended up funding, but we funded 13,000. There are so many outstanding young people out there whom we could not fund.

Let me get specifically to the current House language and where we are and what damage it will do to NSF. The overall NSF cut will mean, if the House position passes, 900 fewer awards with a potential loss of 12,630 people from the Fiscal Year 2010 enacted level. If we compare that to the Fiscal Year 2011 request, there will be 2,075 fewer awards and a potential loss of nearly 30,000 people. This is for all of NSF.

I can give you some numbers just for research. If we compare that to the 2011 request, there will be 20,200 fewer people who will be supported for research in the country.

You mentioned STEM education earlier. 4,500 people will be lost from NSF support for STEM education. Yesterday I read the research funding in China is increasing 50 percent over the next few years, and that is the competition that we are facing at this point.

Senator NELSON. OK. Dr. Gallagher?

Dr. GALLAGHER. Thank you, Mr. Chairman.

For NIST, to understand the impact of H.R. 1 or what it would have on the agency, it is important to point out that NIST has two types of programs. The NIST Laboratory program is an intramural program that are employees working in the laboratories. The MEP and TIP programs are extramural, that is they fund extramural re-

search grants and cooperative programs. And that changes the impact on the two.

At the proposed levels that were in that bill, for the intramural laboratory program the impact would be substantial. It was not deep enough, in our initial analysis, that we believe we would have to furlough employees, but the reduction to our other object accounts was significant enough that it would prevent us from renewing any new agreements. It would certainly result in a freeze. It would result in a curtailing of a number of our programs. Two of the most impacted programs are the ones that were being supported through other agency transfers under the Recovery Act; specifically smart grid and health IT would be very strongly impacted.

In the extramural programs the Technology Innovation Program would not be able to fund any awards this year and the MEP program would have enough funding for the basic centers but none of the new services that—in the Next Generation MEP Program would be funded.

Senator BOOZMAN. Again, I've been very supportive of NASA and will. I think as our astronauts demonstrated, you know, it has been a great success story through the years, it is something that our Nation can be very, very proud of. I think the concern is, is that with a proposed one and a half trillion dollar deficit that over a period of 10 years, one and a half trillion dollar deficits as far as the eye can see, that an additional $13 trillion debt after 10 years, that's a real problem.

Admiral Mullen testified a couple of months ago that our greatest threat to national security wasn't al Qaeda or Afghanistan or any of those threats, but was the debt. And so as we are wrestling around with this, you know, we do have to keep that in mind.

My commitment is to, again this is something that, you know, this is something that only the government can do. You know, I think we all agree with that and I think, you know, Senator Nelson also agrees with, you know, the magnitude of the problem that we face. My concern, though, is as we look at the budget and things is that you have an authorization that is in regard to NASA. Money is being authorized in various programs and I think as the testimony or the—in listening to the senators, you know, as we have heard testimony, expressed feedback back, I think that we are pretty unanimous that those dollars need to be spent as they were authorized, as opposed to going in a different direction with the intent of the authorization that was really diligently worked out and worked out in good faith where, you know, we felt like we had reached a deal and now there is some concern that perhaps there is some variation from that.

Thank you, Mr. Chairman.

Senator NELSON. We are going to wrap up here. And we have got a number of other questions to submit for the record.

I just want to say this. We had talked earlier about the need for clean energy, therefore the reduction of our dependence particularly on foreign oil. And one of you had commented in response to me commenting about this competition on photovoltaic which is another good example, that if we are successful in designing a better photovoltaic cell we could surely help ourselves in that realm.

I just want to put into the record here, that China is investing up to $660 billion over the next decade in clean energy research. And South Korea is planning to invest $85 billion over the next 5 years in clean energy research. So Dr. Suresh, we will let you be the clean up hitter here. Why don't you tell us what role NSF can play in increasing research and development of clean energy?

Dr. SURESH. We have requested in excess of $550 million in the Fiscal Year 2012 budget for clean energy research, which will involve every office and directorate in the National Science Foundation. And this forms part and parcel of an umbrella that we call SEES: Science, Engineering and Education for Sustainability. As you mentioned in your opening remarks Mr. Chairman, and as my colleagues here have pointed out, this is an area where from NSF's perspective there are significant opportunities for new basic discoveries, which in concert with other agencies will lead to major economic benefits and society impact for the country.

NSF is very committed to clean energy. We are looking at every aspect of clean energy. And this will really tap into the innovative spirit of the scientific workforce in the country.

Senator NELSON. Gentlemen, we thank you for your public service. We thank you for your testimony today.

The hearing is adjourned.

[Whereupon, at 12:15 p.m., the hearing was adjourned.]

A P P E N D I X

PREPARED STATEMENT OF HON. JOHN D. ROCKEFELLER IV,
U.S. SENATOR FROM WEST VIRGINIA

America's expertise in science, technology and innovation has made us a leader in the global economy. But our role as a global leader is being challenged, and we need to be smart about how to maintain our competitive edge.

Realizing the danger of inaction, this Committee worked to pass the *America COMPETES Reauthorization Act of 2010*, which cleared both the Senate and the House with overwhelming bipartisan support.

But we still have a long way to go. Countries, like China and India, are devoting far more resources into research and development. They are finding new ways to use technology to deliver cleaner energy, cleaner water, cleaner air and more economic opportunity.

And that's what brings us here today.

I think in some ways we have become too comfortable in our previous success. We still remember our potential—and forget where we are today. Our future depends on the investments we make to keep this Nation competitive. Without a strong, bold and daring vision, we risk falling behind.

For me this takes particular urgency in my state of West Virginia. West Virginia is in the midst of transitioning from a more industrial economy to one that, in the future, I hope is based more on technology. Our universities are thriving but we need to do more. We need the infrastructure for that. We are headed in the right direction but still have steps to take.

America COMPETES offers a blueprint for our innovation infrastructure. It puts science and research investments on a doubling path over 10 years and strengthens science, technology, engineering and mathematics (STEM) education.

However, in light of today's fiscal debate, we find our commitment to an innovative America in danger. This is despite the fact that the President's Deficit Commission itself called for an increase in government support for science R&D as a long-term gain for the budget.

The President's FY 2012 budget proposal—with its call for increases in science at the National Science Foundation and the National Institute of Standards and Technology—sets the right agenda for the future. However, we must first take action in this fiscal year. We simply cannot afford to continue jeopardizing our Nation's future by failing to invest today.

This hearing is an opportunity to identify the hurdles we must overcome on the path toward a more competitive America. I am pleased to welcome to this Committee a group of witnesses who have tremendous insight into the challenges we face.

Dr. Holdren, President Obama's chief science advisor, is responsible for the broad Federal science portfolio as the Director of the Office of Science and Technology Policy.

Dr. Suresh, the new Director of the National Science Foundation, is in charge of directing funding to the most innovative researchers in the country—people who seek to solve our most difficult scientific problems.

Dr. Gallagher, the Under Secretary of Commerce for Standards and Technology, leads the agency best equipped to bring government and the private sector together, conducting cutting-edge measurement research for new technologies.

And, last but not least, we have Dr. Abdalati. As NASA's Chief Scientist, Dr. Abdalati works to integrate science across the space portfolio.

I want to thank our witnesses again for being here today. I look forward to their testimony.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO JOHN P. HOLDREN

Question. One R&D subject requiring significant improvement is the field of forensic science. As I'm sure you know, the National Research Council studied the forensic science system in the United States and found scientific deficiencies as described in their February 2009 report, "Strengthening Forensic Science in the United States: A Path Forward." That report recommended, "removing all public forensic laboratories and facilities from the administrative control of law enforcement agencies or prosecutors' offices." On March 9, 2009, the President issued a memorandum on scientific integrity, which was followed by your memorandum on December 17, 2010, with more specific guidance to the executive branch. How can the standards you outlined in your memo be applied to protect the integrity of forensic science regardless of where/why it's conducted?

Answer. First of all, a subcommittee of the National Science and Technology Council has been developing recommendations regarding how best to implement the changes called for in the National Research Council (NRC) report on forensic sciences. Approximately half of the NRC issues have been addressed by the Subcommittee in draft form to date, and recommendations relating to the rest of the NRC's findings—including the one relating to the independence of forensic laboratories—are expected by this fall.

A number of elements from my December 17, 2010, Memorandum to the Heads of Departments and Agencies are relevant to the issue of ensuring scientific independence for forensic laboratories. For example, my Memorandum notes in Section I that the integrity of scientific information generally is important "both to ensure the validity of the information itself and to engender public trust in government." That is especially true when the science is linked to the criminal justice system, given that individuals' freedoms are directly at stake in such cases.

Second, my memorandum also calls for the "setting of clear standards governing conflicts of interest." Again, this is relevant to the issue of laboratory independence raised by the NRC, which found in its report that conflicts can arise when forensic laboratories are in fact—or are perceived to be—too closely affiliated with law enforcement or prosecutors' offices.

A third area of relevance is my Memorandum's emphasis on the accurate conveyance of scientific and technological information. The NRC report noted that overly close relationships between forensic laboratories and law enforcement or prosecutors' offices can bias the reporting of results—a problem potentially exacerbated by another problem raised by the NRC: non-standardized forms and tools for reporting results. My Memorandum addresses the issue of how best to report scientific findings generally, calling for "a clear explication of underlying assumptions; accurate contextualization of uncertainties; and a description of the probabilities associated with both optimistic and pessimistic projections, including best-case and worst-case scenarios where appropriate."

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. BILL NELSON TO JOHN P. HOLDREN

Question. Basic research is the foundation of our economy; however, basic R&D only creates jobs when innovations are commercialized. What actions is the Administration taking to facilitate technology transfer and commercialization? Please provide specific examples of agency efforts in this regard. A recent report in the *Wall Street Journal* indicated that the percentage of organizations off-shoring R&D in the next 5 years is expected to double. How does OSTP see this impacting future U.S. innovation? What is the administration doing to keep that R&D spending in the United States?

Answer. The Administration's recently revised A Strategy for American Innovation (February 2011) describes many of the Administration's actions to facilitate technology transfer and commercialization. For example:

- The Department of Commerce's Office of Innovation and Entrepreneurship promotes innovation-based, high-growth entrepreneurship in pursuit of job creation and economic growth. The Office plays a leading role in developing policy recommendations and implementing initiatives to increase the efficiency and effectiveness of efforts to commercialize technology through university and federally-funded research.
- The Small Business Administration's Innovation Fund will support up to $1 billion in private-sector financing over the next 5 years by matching private cap-

ital raised by investment funds that are seeking to deploy capital in early-stage innovative small businesses.

- The U.S. Department of Agriculture's Agricultural Research Service (ARS) established the Agricultural Technology Innovation Partnership Program (ATIP) to provide opportunities for the private sector to commercialize research outcomes arising from USDA R&D investments.

In addition, the Department of Energy (DOE) established a new policy on technology transfer and commercialization of innovations from the DOE National Laboratories, with the goal of reducing barriers to working with the DOE National Labs, increasing interactions with the private sector, communicating opportunities, and communicating outcomes.

The Administration also announced a program as part of Startup America to facilitate start-up companies in identifying and obtaining a low-cost option to license Lab technologies. These options facilitate a startup in its first-year activities to raise capital and establish itself before facing the deferred costs of a license to commercialize the technology.

OSTP is concerned about increased off-shoring of R&D investments by U.S. companies. If these trends continue and are not matched by strong R&D investments in the United States, there could be negative impacts on our Nation's capacity to innovate and compete in the global economy. Encouragingly, data show that, in recent years, off-shoring of R&D has been more than offset by increased "on-shoring" of R&D by foreign-owned companies investing in R&D capabilities in the United States and by increased U.S. R&D investments by U.S.-owned companies (National Science Board, Science and Engineering Indicators 2010). The Administration has proposed several policies designed to keep R&D spending by both U.S.-owned and foreign-owned companies here in the United States. A leading example is the 2012 Budget's proposal to simplify, expand, and make permanent the Research and Experimentation (R&E) Tax Credit. The Treasury Department recently released an analysis showing that, if implemented, this proposal could leverage more than $100 billion in U.S. private-sector R&D over the next 10 years. The R&E Tax Credit can only be claimed for R&D performed in the United States and thus provides an incentive for companies to perform R&D in the United States rather than abroad. It is important to note that virtually all nations have R&D tax incentives. Many nations have tax incentive structures that are stronger than the current U.S. credit. Therefore, the proposal to improve and expand the U.S. R&E tax credit is essential to compete effectively for domestic and foreign corporate R&D capital.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARK WARNER TO JOHN P. HOLDREN

Question 1. In the coming months the Senate and House will debate the FY 2012 Federal budget. In light of the Nation's current fiscal situation, there is a potential for budget cuts to programs throughout OSTP. Could you prioritize the programs that you would allocate the most resources to should cuts occur? If not, why not? Can you merge existing research programs? If not, why not?

Answer. In the spirit of shared sacrifice to address the fiscal situation, the 2012 Budget for OSTP requests $6.65 million, a 5 percent reduction from the $7.0 million 2010 enacted funding level. Sustaining the capabilities of OSTP's staff is a top priority in the Budget, and therefore resources for OSTP personnel and staff support are preserved. In the 2012 Budget, OSTP has proposed to reduce spending on other contractual services, resulting in fewer reports and technical analyses from the President's Council of Advisors on Science and Technology (PCAST). Because OSTP does not itself fund research, Federal research program mergers are not an appropriate strategy in the search for reductions in OSTP's 2012 Budget.

Question 2. The National Science Foundation manages a small stream of Federal funding which helps to support the Industry-University Cooperative Research Centers and Engineering Research Centers. These programs appear to be significant in that they help to bridge the gap known as the "valley of death," which many new companies and technologies face in their growth cycles. These programs are a relatively small investment of Federal resources, leveraged by private sector contributions and they reaffirm the strong comparative value of industry financial support.

a. Is OSTP engaged in any assessment of the strengths and weaknesses of these types of programs, in comparison with other types of research programs offered by NSF, to determine whether or not our current mix of Federal R&D spending is optimal? If not, why not?

b. Is OSTP engaged in any assessment of these types of programs, in comparison with programs such as Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR), Engineering Research Centers (ERC), Grant Opportunities for Academic Liaison with Industry (GOALI) Industry/University Cooperative Research Centers (I/UCRC), Materials Research Science & Engineering Centers (MRSEC), National Nanotechnology Infrastructure Network (NNIN), Nanoelectronics Research Initiative (NRI), Nanoscale Science & Engineering Centers (NSEC), Partnerships for Innovation (PFI), and Science and Technology Centers (STC) to determine which programs are the most effective? If not, why not?

c. Has OSTP begun considering which programs are the most valuable in terms of future U.S. competitiveness? Do these assessments account for the need to consolidate and reduce duplicative programs and to get more value out of Federal research dollars? If not, why not?

Answer. OSTP is well aware of and supportive of NSF's I/UCRC program and related efforts to improve the commercialization of promising ideas arising from NSF support of university-based research. I defer to NSF to provide details of its assessments of I/UCRC and other programs. OSTP is briefed regularly on both NSF-supported external assessments and NSF in-house assessments of programs in the NSF portfolio, and we work cooperatively with OMB and NSF as part of the annual budget process to optimize NSF and other Federal R&D investments based on the results of these assessments. In these ongoing discussions with OMB and NSF, we do not look at assessments of individual programs in isolation; rather, we look at the entire portfolio of programs organized around similar goals—for example commercialization of Federal research or Federal support of STEM education. These ongoing discussions consider which Federal programs are the most valuable in terms of future U.S. competitiveness and also consider the fiscal environment in which tough choices have to be made, including potential terminations or reductions in Federal programs, to maximize the impact of Federal research dollars.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER F. WICKER TO JOHN P. HOLDREN

Question 1. I recognize the contributions NSF, NIST, and NASA have made to society and American innovation, but we are in dire economic times. Non-defense discretionary outlays grew 5.6 percent over the last decade. The continued deficits of our Federal Government are not sustainable and our country's growing debt is a threat to national security. With our current fiscal condition in mind, can you tell me how many jobs your budget proposal will create for Americans?

Answer. We do not have precise, prospective estimates for the job-creation impacts of the 2012 Budget although, as we describe in the answer to Question 3 below, we are working to improve impact measures for Federal R&D funding.

Question 2. Is the creation of jobs a top priority for funding R&D at your respective agency?

Answer. Because OSTP does not itself fund research, Federal R&D programs would not be affected by the proposed reductions in OSTP's 2012 Budget.

Question 3. How do you measure the impact Federal R&D funding has on job creation?

Answer. The Federal Government relies on numerous metrics to measure the impact of Federal R&D funding on important national goals including job creation. Under OSTP's leadership, the National Science and Technology Council's Interagency Task Group on the Science of Science Policy released a report in November 2008 (The Science of Science Policy: A Federal Research Roadmap) that assesses existing impact measures for Federal R&D and sets out a research agenda for improving these measures. Since then, we have been working with the Federal research agencies to make progress on the roadmap's research agenda, with special attention to developing more real-time impact measures and to building a data infrastructure (STAR METRICS) for collecting better impact measures.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO PATRICK D. GALLAGHER

Question 1. One R&D subject requiring significant improvement is the field of forensic science. As I'm sure you know, the National Research Council studied the forensic science system in the United States and found scientific deficiencies as described in their February 2009 report, "Strengthening Forensic Science in the United States: A Path Forward." That report called out several areas where NIST

could significantly contribute to needed improvements, such as "to develop tools for advancing measurement, validation, reliability, information sharing, and proficiency testing in forensic science and to establish protocols for forensic examinations, methods, and practices." What do you see as NIST's role in improving forensic science overall and how would you specifically propose to address the above recommendation?

Answer. NIST is aware of the National Research Council report, and is committed to addressing the important issues in forensic science in part by serving as co-chair (with Department of Justice's Bureau of Alcohol, Tobacco, Firearms, and Explosives) of the interagency Subcommittee on Forensic Science in the Committee on Science of the National Science and Technology Council. This Subcommittee is currently working to respond to the report's 13 recommendations.

NIST has a mission-oriented focus on measurement science that is well-matched to the needs of the forensic science community (*e.g.,* determining accuracy, efficacy, and quality assurance of measurements). NIST also provides measurement services in many areas such as reference materials, reference databases, and calibration services for a wide range of customers.

NIST has a long history of providing innovative solutions to technological forensic science challenges like those described in the 2009 NRC report. One example is the development at NIST of truncated DNA polymerase chain reaction primers to accurately detect and identify DNA short tandem repeats (STRs) in highly decomposed and partially incinerated human remains recovered from Ground Zero at the World Trade Center in 2001.

The current efforts at NIST in forensic science-related areas are largely driven by funding from other agencies (*e.g.,* DOJ, DHS, and DOD) on a short-term directed task basis. This has allowed NIST to establish some competency in certain forensic science areas. For example, NIST research in human identity and forensic DNA testing, developed in collaboration with the National Institute of Justice (NIJ/DOJ), has resulted in the development of standard reference materials, new testing methods, inter-laboratory validations, and the creation of training materials.

Question 2. That report also described the importance of nationwide interoperability for Automated Fingerprint Identification Systems (AFIS) and the difficulty in achieving that goal. NIST has a history of working on AFIS interoperability issues. Can you please describe the technical challenges and legal barriers preventing interoperability of the multitude of systems that comprise AFIS, the role of NIST in addressing these issues, and specific actions that NIST might take to enhance interoperability?

Answer. While NIST participates in the National Science and Technology task force on AFIS Interoperability, the bulk of NIST's work in this area is targeted at addressing the technical challenges to AFIS interoperability.

Some of the key technical challenges to AFIS interoperability are linked to the identification and recognition of features in latent fingerprints.

- The issue of AFIS interoperability arises in the latent fingerprint forensic application. Because latent images can be of arbitrarily poor quality, a successful recognition requires human assistance. Typically, a trained latent examiner will mark the minutia points and other features that appear in images, and submit the markup, and sometimes the image, to a remote AFIS identification server. A list of zero or more possible candidates will be returned by an AFIS machine, and the examiner will adjudicate the latent against the "exemplar" candidate images (*e.g.,* collected in a prior arrest).
- AFIS interoperability is defined as the ability of AFIS A to be able to correctly find matching fingerprints when the examiner used a latent workstation intended for AFIS B.
- The interoperability issue arises because the fingerprint examiner will use a vendor-supplied "latent workstation" which embeds graphical user interface tools to assist the examiner. More importantly, the workstation also embeds vendor-specific encodings of the minutia points, and there are semantic differences in the way the coordinates and angles of minutiae are computed even if that information is transmitted in a standardized format (the generic fields of Type 9 of ANSI/NIST ITL 1–2007).
- A second challenge is that different AFIS minutia extraction algorithms report different numbers of minutiae from the same input image because some minutiae are missed, and others are detected erroneously. The differences are influential on the core AFIS matching algorithms.

To address these AFIS interoperability issues, NIST has been active in research and standardization in three areas:

1. NIST has conducted tests of latent fingerprint technology in its ELFT (Evaluation of Latent Fingerprint Technologies) program. In its recent phase, the new standardized Extended Feature Set (EFS, proposed for the 2011 ANSI/NIST standard) was implemented by the major AFIS vendors, and evaluated at NIST. Those tests also tested image-only searches, which do not require examiner markup. As stated above, interoperability is assured at the image-level.

2. In addition, NIST runs the Minutia Exchange (MINEX) test which measured the recognition accuracy available from standardized minutia records generated by vendors A and B when matched with an algorithm (AFIS core) from vendor C.

3. NIST is the standards development body for the ANSI/NIST ITL standard. It includes Type 9 for fingerprint features, including minutiae and EFS. NIST also serves in the ISO/IEC SC 37 committee which is developing a standardized conformance test for the correct placement semantics of minutiae. That standard will become part of ISO/IEC 29109–2.

Looking forward, NIST's participation in other appropriate standards bodies and technical scientific working groups will help to realize AFIS interoperability. Further engagement with the AFIS industry and the consolidation of technical findings into standards will also further this objective.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO PATRICK D. GALLAGHER

Question 1. Basic research is the foundation of our economy; however, basic R&D only creates jobs when innovations are commercialized. What actions is NIST taking to facilitate technology transfer and commercialization? Please provide specific examples of agency efforts in this regard.

Answer. The President has made investment in R&D, and the resulting economic growth that comes through innovation, a cornerstone of his economic policy. I want to applaud this Committee for its foresight and leadership in advancing the America COMPETES Reauthorization Act of 2010 which continued the doubling path for NIST and the National Science Foundation and the Department of Energy's Office of Science. This Committee and the Administration agree that such investments in R&D are fundamentally important to accelerating technological innovations which, when commercialized, can have transformational impacts.

NIST's critical role in this effort 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. NIST's programs from the laboratories to the extramural programs provide a "tool kit" that addresses unique needs and gaps spanning the entire innovation and technology development cycle. From incentivizing and supporting long-term industry-led directed basic research to accelerating technology deployment and adoption by America's manufacturers, the NIST extramural programs along with the NIST laboratories, provide a critical infrastructure that supports the type of high-tech innovation, development, and manufacturing that is critical for our Nation's long-term sustainable economic growth and job creation.

- The NIST laboratories provide measurement solutions to innovators and manufacturers that increase efficiency and facilitate the use and adoption of advanced technology. For example the NIST work in advanced sensors, robotics, and modeling and simulation will provide the infrastructure that facilitates the adoption of new technology systems that will help manufacturers:
  - transform a new idea into production easily
  - reconfigure a factory to produce multiple types of products using the same facility
  - adapt to changes in production while maintaining high quality and minimizing waste
  - organize subcontractors, OEMs, and customers into efficient and dynamic supply chains
- The new AMTech will collapse the timescale of technological innovation by including partners that span the innovation lifecycle from idea to discovery, from invention to commercialization. Through cost-sharing and a common research agenda, these consortia would support the development of innovative new technologies directed at creating high-wage jobs and economic growth across the industry sector. These consortia will develop road-maps of critical long-term in-

dustrial research needs and provide support for research and equipment at leading universities and government laboratories directed at meeting.

- TIP funds small companies and consortia of small companies and universities to support high-risk transformational Research and Development. TIP funding helps small companies develop and demonstrate new high-risk, cutting edge technologies, when no other sources of funding are available.
- MEP helps small and medium manufacturers strengthen their competitive positions by accelerating the adoption of technological innovations, facilitating the adoption of environmentally sustainable business practices, promoting renewable energy initiatives, fostering market diversification, and connecting domestic suppliers to manufacturers to assist manufacturers in successfully competing over the long term in today's complex global manufacturing environment.

Question 2. Please provide to the Committee and the Secretary of HHS a timetable for the development of the electronic medical records standards.

Answer. Based on industry and national needs, NIST anticipates the need for standards in emerging areas and plays a critical role by participating early in the development process and by helping ensure that the requisite infrastructural standards and associated tests are robust, complete, and unambiguous.

Timeline for Electronic Health Records (EHRs) Standards

Standards, implementation specifications, and certification criteria for EHRs are scheduled to be adopted through rulemaking by HHS every 2 years consistent with its proposed sequence for the stages of meaningful use. This sequence will indicate needs over time for standards development, where NIST will likely play an important role.

Standards for Stage 1 Meaningful Use: complete

Electronic Health Records that satisfy Stage 1 Meaningful Use standards and certification criteria are already available for physicians' practices and many hospitals. Recent surveys show that more than 80 percent of all hospitals and 40 percent of all office-based physicians intend to achieve meaningful use and qualify for incentive payments by using certified EHRs in a meaningful way. We anticipate that these numbers will increase in time, especially as the private sector continues to embrace the opportunity to innovate with less expensive and more user friendly EHRs.

Standards for Stage 2 Meaningful Use: operational by 2013

Stage 2 Meaningful Use may stipulate additional and enhanced standards and certification criteria that could lead to more robust interoperable EHRs and greater adoption rates.

The two Federal Advisory Committees (FACAs) established by the HITECH Act, namely, the HIT Policy Committee and the HIT Standards Committee, are advising the National Coordinator for Health Information Technology within the Department of Health and Human Services (HHS) on the priorities for Stage 2 and, subsequently, the requisite standards. NIST is represented on the HIT Standards Committee as well as on its workgroups.

Based on the advice of these advisory committees, as well as on broad public input, ONC implements its Standards and Interoperability (S&I) Framework to: establish use cases; identify and harmonize standards; prepare implementation specifications, reference implementations, and pilot demonstrations; develop tests procedures; and, implement the certification process. It is anticipated that the proposed standards and certification criteria for Stage 2, will be published in the 4th quarter of CY 2011.

Standards for Stage 3 Meaningful Use: operational by 2015

Stage 3 Meaningful Use activities will follow the same sequence as those for Stage 2. It is anticipated that Stage 3 requirements will be more stringent than those of Stage 2.

The above timeline and work plan will result in operational EHRs by the deadline of 2014.

Question 3. Last year you testified that the Technology Innovation Program (TIP) had the right ingredients for innovative research, but at the current level of funding, we wouldn't see a large national impact. The FY 2012 request of $75 million for this program is $4.9 million less than last year's request. What metrics are you using to evaluate the performance of this program? Are we making progress on the research in areas of critical national need targeted by the program? How long does NIST intend to maintain TIP in a pilot phase before deciding whether or not to expand the program?

Answer. Measurement of program performance is a top priority for TIP. TIP measures outputs as short-run indicators of progress toward program goals. TIP measures outcomes in the longer run to assess the program's impact.

Each year, TIP estimates the following performance results as measures of key outputs and indicators of progress in meeting short-run program goals:

- Number of TIP projects funded
- Evidence of fostering research collaborations
- Patents, papers, and publications developed through the TIP projects that accelerate the creation and dissemination of knowledge

A full description of TIPs performance measurement practices can be found in the TIP Annual report (*http://www.nist.gov/tip/upload/tip_2009_annual_report.pdf*)

Since its authorization, the program has awarded 38 grants during the period FY 2008–2010, representing a TIP investment of approx $136 million, for a total investment of about $280 million in new high-risk, high-reward research:

- In 2008, $42.5 million from TIP funds supported nine projects in advanced sensor technologies for civil infrastructure such as roads, bridges, and water systems, for a total of $88.2 million in new research (TIP + awardee cost share).
- In 2009, TIP funded twenty projects at $71M, for a total potential new research investment of $145.6M, to address critical national needs in manufacturing and civil infrastructure.
- In 2010, TIP provided more than $22.2 million for nine projects for advanced manufacturing research in electronics, biotechnology and nanotechnology, for a total of $45.9 million in new research.

Despite being a young program, results from the R&D are already being shared and tested, which is indicative of the impact of the program. Technologies in civil infrastructure have been tested in state highway facilities and several of the projects have agreements with state transportation authorities (*e.g.,* California, Michigan, and Massachusetts) to serve as test beds for this next generation of technologies.

The scientific findings from these projects are also being actively shared within the scientific community, enabling these efforts to benefit R&D in areas beyond the organizations partnering with TIP. In March 2011, organizations working with TIP in the 17 civil infrastructure projects presented 47 research papers at a smart structures conference hosted by SPIE. This interaction across scientific disciplines allows TIP participants to share important R&D findings that can subsequently be used by other researchers. These early research results and strong partnering relationships suggest the research currently underway has laid the foundation for transforming today's research into tomorrow's solutions.

The FY12 request supports the Administration's priorities of promoting technological innovation and providing support for manufacturing.

Question 4. How is the AMTech (Advanced Manufacturing Technology Consortia) Program different from existing activities at NIST, such as the TIP and Manufacturing Extension Partnership (MEP) programs?

Answer. AMTech will collapse the timescale of technological innovation by including partners that span the innovation lifecycle from idea to discovery, from invention to commercialization. Through cost-sharing and a common research agenda, these consortia would support the development of innovative new technologies directed at creating high-wage jobs and economic growth across the industry sector. These consortia will develop roadmaps of critical long-term industrial research needs and provide support for research and equipment at leading universities and government laboratories directed at meeting these needs. This approach deepens industrial involvement in determining how to best leverage government resources to promote technological innovation.

TIP funds small companies and consortia of small companies and universities to support high-risk transformational Research and Development toward targeted and immediate needs. The cost-share provisions of TIP enable TIP to leverage significant non-Federal investment for high-risk, cutting edge technologies, and serves as an important source of funding when no other sources are reasonably available. In contrast to TIP funds, which are given to single institutions or small groups of awardees, AMTech provides a framework for entire industry sectors to address pre-competitive research needs. Participants in an AMTech consortium include both large industry players, with acknowledged expertise in the critical needs facing a par-

ticular sector, as well as small and medium enterprises, whose smaller organization may allow for increased agility and innovation.

NIST's MEP program complements AMTech by helping small and medium manufacturers strengthen their competitive positions through assistance provided by a nationwide network of centers and field staff consisting of over 1,400 technical experts. MEP helps small and medium manufacturers by accelerating the adoption of technological innovations, facilitating the adoption of environmentally sustainable business practices, promoting renewable energy initiatives, fostering market diversification, and connecting domestic suppliers to manufacturers to assist manufacturers in successfully competing over the long term in today's complex global manufacturing environment.

RESPONSE TO QUESTIONS SUBMITTED BY HON. ROGER F. WICKER TO PATRICK D. GALLAGHER

Question 1. I recognize the contributions NSF, NIST, and NASA have made to society and American innovation, but we are in dire economic times. Non-defense discretionary outlays grew 5.6 percent over the last decade. The continued deficits of our Federal Government are not sustainable and our country's growing debt is a threat to national security. With our current fiscal condition in mind, can you tell me how many jobs your budget proposal will create for Americans?

Answer. As the President has said, "The first step in winning the future is encouraging American innovation." The Administration in February proposed a record $66.8 billion investment in civilian research and development reflecting its firm belief that investment in civilian research is a key ingredient for cultivating the innovation that is so important to growing the American economy of the future.

NIST's mission is to promote U.S. innovation and industrial competitiveness through advances in measurement science, standards and technology to enhance U.S. economic security and improve the quality of life of U.S. citizens. The foundational nature of measurements have a multiplier effect on job creation. While NIST does not directly count the number of jobs created, NIST programs have a direct and measurable impact on the number of jobs created and retained. A 2009 survey of NIST's Manufacturing Extension Partnership (MEP) clients indicated that as a direct result of the MEP program, the MEP clients had created 17,721 jobs, and retained 54, 354 jobs.

Similarly, we know from anecdotal data that grants made by NIST's Technology Innovation Program (TIP) or the Small Business Innovation Research (SBIR) program awards are often the key resource that enable the continued existence of small businesses involved in very technical and specialized R&D and innovation related research or commercialization activities. In its 3 years of existence, TIP has awarded 38 grants covering civil infrastructure and manufacturing. These 38 projects have supported 88 small and medium-sized businesses.

As yet another example, NIST research in developing measurement techniques and instrumentation at the nanoscale to examine an exciting new form of carbon, graphene, has resulted in the commercialization of a new breakthrough product, an ultra-high vacuum compatible dilution refrigerator. A manufacturer of specialty scientific instrumentation is now manufacturing this refrigerator for commercial sales, thereby creating and supporting jobs in manufacturing and service.

Question 2. Is the creation of jobs a top priority for funding R&D at your respective agency?

Answer. Creation and preservation of high quality U.S. jobs is a key priority for the Administration. NIST does its part by enabling job creation through the development and dissemination of its products and services such as new measurement technologies, improving existing measurements, supporting manufacturing and innovation related programs, cyber security awareness, education and practices, etc. These products and services underpin numerous industries such as manufacturing, healthcare, automotive, financial services, etc. NIST developed technologies and services enable manufacturers to improve their products, processes and efficiency thereby making their companies more competitive.

The effort to design, develop, and implement a "smart" electrical grid is one such example. One estimate by the GridWise Alliance, a Smart Grid industry group, anticipates up to 280,000 new jobs (*http://gigaom.com/cleantech/smart-grid-could-create-280000-smart-jobs/*) related to the realization of a Smart Grid. Next generation photo-voltaic panels are another example of where NIST's foundational efforts can lead to significant job growth in a high tech sector. The advanced photo-voltaic industry already counts 93,000 solar-panel related positions in the U.S. (*http://*

www.pv-magazine.com/news/details/beitrag/solar-jobs-in-the-us-on-the-rise__10000 1376/). Further technological advancements are anticipated to grow that number.

Question 3. How do you measure the impact Federal R&D funding has on job creation?

Answer. Measuring the impact of Federal R&D funding on job creation is a complex problem that NIST cannot address on its own. However, as the President has stated, we need to ensure that the Nation out-innovates, out-educates, and out-builds the rest of the world in the years ahead.

NIST participates in the Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness and Science (STAR METRICS) project, a multi-agency project led by the National Institutes of Health, the National Science Foundation (NSF) and the White House Office of Science and Technology Policy, in partnership with research institutions. STAR METRICS is developing a common framework that can be used to assess the impact of Federal R&D investments including number of jobs created through Federal R&D funding.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO DR. SUBRA SURESH

Forensics

Question. One R&D subject requiring significant improvement is the field of forensic science. As I'm sure you know, the National Research Council studied the forensic science system in the United States and found scientific deficiencies as described in their February 2009 report, "Strengthening Forensic Science in the United States: A Path Forward." That report indicated, "Research is needed to address issues of accuracy, reliability, and validity in the forensic science disciplines." Does NSF have any current grant programs that would address this need? If yes, how many awards have been made over the past year in these areas of research? How could these programs be expanded to more specifically target this need? If no, how could NSF address this recommendation? This report also commented that "to correct some of the existing deficiencies, it is crucially important to improve undergraduate and graduate forensic science programs." How could NSF improve the education and training in forensic science?

Answer. NSF does not have a specific program focused on forensic sciences. However, the Foundation supports basic scientific research in dozens of scientific fields, and some of this research is useful in forensic settings. In FY 2010, it is estimated that 85 awards, for a total of $22.5 million, were made for programs relevant to forensic research.

NSF recommends that to address the issues mentioned, practitioners and basic scientists should be brought together to look at areas of mutual interest. Improvements could be made in areas such as how basic scientists could better communicate results to practitioners, how practitioners could better communicate needs to basic scientists, how to develop collaborations, or how to assess the quality of a piece of scientific research. In addition, workshops, advanced training partnerships, or research coordination networks might be useful to focus on areas of specific interest to both groups, such as neural aspects of pattern matching. These interactions would also be essential to improving education and training in the forensic sciences.

EPSCoR

Question. The EPSCoR Interagency Coordinating Committee was established in FY 1993 to coordinate Federal EPSCoR and EPSCoR-like programs to maximize the program's impact and minimize duplication in states receiving EPSCoR support from more than one agency. NSF chairs the committee. This coordination mandate was expanded in the 2010 America COMPETES Reauthorization. The committee is designed to ensure the EPSCoR programs are effectively addressing their missions, and we would like to be kept informed of its activities. Please provide specifics on how often this committee meets, what agencies have attended, and what business has been conducted. What could be done to improve the effectiveness of the coordination mandate?

Answer. The EPSCoR Interagency Coordinating Committee (EICC) meets annually. Recurrent agenda topics include eligibility criteria by agency, current priorities, budget, key program thrusts, and synergistic partnerships for investment, evaluation, and communication. In addition to these meetings, EICC members are invited to participate in NSF EPSCoR national conferences and annual project directors and project administrators meetings; committee members and agency representatives routinely participate in these meetings.

Five agencies currently fund EPSCoR or EPSCoR-like programs: the Department of Energy, the National Institutes of Health, the National Aeronautics and Space Administration, the U.S. Department of Agriculture, and the National Science Foundation.

The last meeting of EICC took place on May 9, 2011 and the discussions focused on the EPSCoR specific items in Section 517 of Public Law 111–358, the America COMPETES Reauthorization Act of 2010. The next meeting is targeted for mid-August, 2011 and will also focus on of the issues listed in this Act and action plans expected to improve effectiveness of cross-agency coordination.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO DR. SUBRA SURESH

Research Funding Activities

Question 1. Basic research is the foundation of our economy; however, basic R&D only creates jobs when innovations are commercialized. What actions is NSF taking to facilitate technology transfer and commercialization? Please provide specific examples of agency efforts in this regard.

Answer. Although NSF awards to individual investigators frequently result in innovations that are commercialized, we recognize that the road from discovery to commercialization is challenging. Several types of NSF awards provide opportunities to speed technology transfer and commercialization. For example, many of NSF's Centers programs require a plan for knowledge transfer and encourage partnerships with industry. Centers programs that encourage partnerships with industry include the Science and Technology Centers (STC) program, the Engineering Research Centers (ERC) program, and the Centers for Chemical Innovation (CCI). A recent American Association for the Advancement of Science (AAAS) review of the Science and Technology Centers program found that a majority of the STCs served as a springboard for start-up companies.

Centers also provide a rich student training environment that encourages innovation. Many of the students involved in center research activities obtain jobs working for industry partners. The National Center for Innovation Education program (a collaborative effort of the Engineering Directorate and the Directorate for Education and Human Resources) funds a comprehensive and coordinated set of activities to address the challenge of educating engineers to be innovators.

In addition to the integration of knowledge transfer into these programs from across the foundation, there are also specific targeted programs that facilitate technology transfer and commercialization. The Division of Industrial Innovation and Partnerships (IIP), within the Directorate for Engineering, has several programs that support these goals: the Small Business Innovation Research (SBIR) program, the Small Business Technology Transfer (STTR) program, the Partnerships for Innovation (PFI) program, the Industry/University Cooperative Research Centers (I/UCRC) program, and the Grants Opportunities for Academic Liaison with Industry (GOALI) program.

Question 2. There has been discussion that NSF should implement blind proposal review to avoid institutional bias in grant awards. Please provide NSF's views on blind proposal review. How is NSF encouraging fair competition among all colleges and universities in the review of research proposals?

Answer. Program officers at the National Science Foundation come from a broad range of colleges and universities and understand that high-quality research is conducted at both small and large institutions. Program officers also recruit reviewers and panelists from diverse types of institutions. Thus, a broad range of perspectives are brought to bear throughout the review process. Program officers also receive training on the importance of building a robust portfolio, which includes funding diverse types of institutions as one element. One of the examples of representative activities provided in NSF's guidance on broader impacts is the involvement of faculty and students at community colleges, colleges for women, undergraduate institutions, and EPSCoR institutions. NSF considers the ability to recognize these broader impacts related to institutional type to be extremely important. If proposal review were blind to the identity of the institution we would lose our ability to recognize these important characteristics. Another important disadvantage to blind review is that it would limit our ability to evaluate information about the availability of specific facilities necessary to conduct the proposed research.

Question 3. What is NSF doing to raise awareness of its programs among all colleges and universities, including community colleges?

Answer. The National Science Foundation regularly makes outreach presentations to diverse institutions across the country in an effort to help increase their awareness and participation in NSF programs. Program Officers conduct outreach when visiting academic institutions (including community colleges) or participating in scientific meetings. NSF hosts informational booths at scientific meetings such as the annual meeting of the AAAS. In 2010, two Regional Grants Conferences were organized by the Office of Budget, Finance, and Award Management, and hosted by Jackson State University and Case Western Reserve University. The Office of Legislative and Public Affairs also organizes "NSF Days" held at various locations throughout the country. In 2010, the foundation hosted "NSF Days" in Arizona, California, Florida, Georgia, Idaho, Iowa, Missouri, Ohio, and Tennessee. Representatives from most of NSF's directorates and offices attended each of these conferences.

An NSF Day hosted by a research or masters level institution includes presentations on NSF's history, proposal and merit review process, Foundation-wide programs, and international programs. Breakout sessions are held by directorate and on proposal preparation. These provide excellent networking opportunities and allow informal conversations with NSF program officers. NSF Days at community colleges are focused on programs of interest to two-year institutions. In addition to a general introduction to NSF, workshops include presentations on the Advanced Technological Education (ATE) program and other programs in the Division of Undergraduate Education. Additionally, there is a proposal presentation and usually a panel of local principal investigators who have previously won NSF awards talking about their experiences.

NSF began conducting Community College NSF Days in 2003. A total of seven events have taken place, all at the invitation of the community colleges themselves. Examples from 2010 include a workshop at Rio Hondo Community College in Whittier, California, where 75 people from 22 different institutions participated, and a workshop at Clark College in Vancouver, Washington, where 33 people attended from 7 community colleges in Oregon and Washington. In addition, NSF has held 67 regular NSF Day events, which included attendees from community colleges. In total, over 730 community colleges representatives have attended either Community College NSF Days or NSF Days.

Outreach workshops are sponsored by individual directorates, as well as EPSCoR, the Small Business Innovation Research (SBIR) program, and other NSF-wide programs. The ATE program regularly sponsors a workshop for the Council for Resource Development (CRD) which includes grants officers from community colleges. NSF outreach to scientists and engineers from underrepresented groups includes efforts such as workshops for tribal colleges and minority-serving institutions, including historically black colleges and universities.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARK WARNER TO DR. SUBRA SURESH

Wireless Technologies

Question 1. In its March 2010 National Broadband Plan, the Federal Communications Commission (FCC) recommended that NSF should fund a "wireless testbed for promoting the science underlying spectrum policymaking." As stated in the FCC's plan, "Wireless testbeds can permit empirical assessment of radio systems and the complex interactions of spectrum users, which are nearly impossible to assess through simulation or analytical methods. As a result, they can reveal a great deal about how sharing can best be facilitated, how spectrum rights might be established, and the impact of dynamic spectrum access radios on existing and future communications services." The President's FY12 budget request for the NSF includes a plan to invest a large portion of the receipts from spectrum auctions in targeted research and experimental wireless technologies that expect to improve spectrum efficiency. Of the $150 million investment from the new Wireless Innovation (WIN) Fund proposed for FY12, how much would be made available for wireless technology testbeds, including those recommended by the FCC?

Answer. $65 million is proposed for developing wireless technology testbed research and experimentation in FY12.

Question 2. How would these testbed funds be made available to small business entrepreneurs to test their innovative, spectrum efficient wireless technologies?

Answer. NSF provides grants to small businesses through its Small Business Innovation Research & Small Business Technology Transfer programs, as well as through many of its core programs in all the science and engineering directorates. If WIN funding becomes available to NSF, competitions will be organized to specifi-

cally target small business entrepreneurs who are interested in trying out their new ideas on the wireless testbed.

NSF is piloting the use of prizes through *Challenge.gov* in an effort to go beyond NSF's traditional grantee pool and to reach out to small businesses and entrepreneurs. Two competitions are under development with prizes to be given during the course of the next year.

More generally, a suite of wireless testbeds will be made available for pre-commercial, open use by small business entrepreneurs across the country.

Question 3. How would these testbed funds potentially be combined with additional amounts from the WIN Fund to be distributed to other agencies such as the Defense Advanced Research Projects Agency (DARPA) and the National Institute for Standards and Technology (NIST)?

Answer. The Director of the National Science Foundation will consult with the Secretary of Defense, the Secretary of Commerce, the Secretary of Energy, and the Attorney General in carrying out the wireless testbed research and experimentation.

NSF plans to sponsor workshops with these mission agencies to explore areas of mutual research interest and to foster collaboration. As these agencies carry out the research and exploratory development of wireless applications and services related to their missions, the wireless testbed will be made available for testing their new ideas.

In addition, NSF co-chairs (with the National Telecommunications and Information Administration) the Wireless Spectrum R&D (WSRD) Senior Steering Group of the National Information Technology R&D (NITRD) program. Through WSRD, NSF consults and collaborates on a regular basis with all Federal agencies that have active interests in wireless R&D, including testbeds. WSRD is presently conducting an inventory of all Federal testbed activities, and we expect that WSRD will play a key role in coordinating Federal testbeds going forward.

Question 4. What would be the necessary steps for NSF to coordinate with the National Telecommunications and Information Administration (NTIA) to use portion of these testbed funds to support NTIA's existing "Spectrum Sharing Innovation Testbed" program?

Answer. The Institute for Telecommunications Sciences (ITS), the research and engineering laboratory of the NTIA, in Boulder, CO has very specific goals. It uses a spectrum sensor van to carry out spectrum surveys or measurements of the radio spectrum and analysis of spectrum interference, which feed back into improved Federal management of the spectrum. Their experiences will be invaluable to NSF as it moves forward with the development of its national-scale wireless testbed. NSF plans to work with ITS in at least two different ways: 1) to foster investments in the tools and techniques used to carry out spectrum measurement; and 2) to foster investments in new models of propagation and detection. NSF would take these steps early on to ensure that ITS becomes a true partner in these endeavors.

Question 5. What steps have been taken to coordinate these NSF initiatives with the FCC?

Answer. NSF has worked closely with several of the authors of the FCC Broadband Plan in the development of its testbed plans. The FCC is represented on the NITRD WSRD Senior Steering Group, through which coordination on testbed activities is being facilitated. In August 2010, NSF held a spectrum-focused workshop (the EARS workshop) that included presentations by FCC Commissioner Meredith Atwell-Baker and Commerce Secretary Gary Locke, which helped set the stage for close collaboration among the regulatory agencies and NSF. NSF is also in routine contact with the FCC Chief Technology Officer, Dr. Doug Sicker, and he recently participated in an early review of the next stage of development in the wireless testbed at NSF.

Question 6. In what other ways could NSF ensure a more rapid return on these proposed innovation investments from the new WIN fund?

Answer. NSF has a long history of investing in networking testbeds at university campuses across the United States. NSF is currently funding the federation of these testbeds to provide interoperability and to increase accessibility. Testbed resources (*e.g.,* sensor and bus networks, cloud computing) that were previously available only to local researchers will now be available more broadly across the country via the new wireless testbed.

NSF's testbed activities to date have focused on networking technologies, which are a very important part of many wireless technologies. At this point, cognitive radios are part of the testbed as well as data obtained from some radars and remote sensing devices. There are other wireless devices and services, such as, radio and television broadcasts, navigation beacons, point-to-point links, many unlicensed devices (including white space devices and ultrawideband systems), and related appli-

cations that need to be included, and that operate outside of network models. With WIN funds, NSF would be able to expand its investments to include a wider variety of wireless testbed capabilities. Their use would speed the time-to-market of new concepts and new technologies that can make more efficient and more innovative use of the radio spectrum, or that expand access to the radio spectrum to traditionally underserved populations and areas.

In developing the wireless testbed, NSF will deploy a spiral development methodology that over a short period of time will increase the scale, novelty, and types of technologies that are deployed in a comprehensive national-scale wireless testbed.

A series of workshops and prize competitions are already being planned; which will allow NSF several ways to reach beyond the principal investigator research community to the entrepreneurs and small businesses that normally do not submit proposals to NSF. First, it will facilitate the development of partnerships across academia, industry, and government. Second, it will enable NSF and others to showcase and broadly advertise the types of new ideas developed through these competitions and demonstrate what might be possible with innovative new wireless technologies. Third, it will allow for more rapid technology transfer from prototype, to testbed, to business models; especially for wireless gigabit applications and services in areas of national interest, including health, education, transportation, energy, and advanced manufacturing.

University-Industry Partnerships

Question 1. A recommendation from the 2008 study called Encouraging Industry-University Partnerships: Report from the Engineering Advisory Committee, Subcommittee on Industry-University Partnerships was as follows, "The Engineering Advisory Committee's Subcommittee on Industry-University Partnerships (EAC–UIP) was convened in the Spring of 2007. The group first conducted a workshop to study the landscape of partnership programs at NSF (plus DARPA and NASA) and identify best practices. This was followed by an analysis of NSF's current portfolio of partnership programs, which examined funding levels, the relative roles of small and large industry, and where partnerships fit along the "innovation supply chain" (discovery-to-commercialization process). We also reviewed the National Science Board's decision to discontinue industry cost-sharing as part of a larger moratorium on cost-sharing, and submitted a recommendation to them that industry investment be reinstated by the Foundation.

All members of the Subcommittee believe that industry investment in NSF-funded research is of long-term strategic importance and should be encouraged. Requiring or endorsing industry contributions helps incentivize academics to form partnerships outside the academic environment. It also sends an important message to the public about the project's relevance—and that industry and government are both vested in R&D.

Our discussions identified several issues that make university-industry partnerships challenging. From these, the Subcommittee formulated the following recommendations to the Engineering Director:

1. Expand existing partnership programs so as to better fill the university-industry landscape.

2. Pilot new partnering programs that address the remaining gaps in the university industry landscape.

3. Expand mechanisms to motivate/reward industry financial investment in NSF sponsored projects, by extending matching-funds supplements to other ENG programs.

4. Continue participating on the National Academies' UIDP, and do whatever possible to expedite the release of software to assist in negotiating partnership IP.

5. Take a more proactive role in making companies more aware of the benefits of investing and participating in NSF-sponsored research projects.

6. Mount an awareness campaign with the goal of helping companies understand NSF's partnership programs.

7. Take a proactive role in making faculty aware of the benefits of seeking and participating in partnerships with industry.

8. Mount an awareness campaign with the goal of helping university administrators and faculty understand NSF's partnership programs.

9. Champion, within NSF, the need to offer many different types of university-industry partnership mechanisms—and encourage the broader adoption of partnership mechanisms so that they are available to a much wider cross-section of faculty researchers.

10. Continue monitoring the progress of all university-industry partnership mechanisms, Foundation-wide, and periodically re-assess them to ensure that the number and type of opportunities meet the diverse needs of academic and industry constituencies.

Question A. How many of these recommendations have been implemented at NSF?

Question B. Which recommendations have not and what are the reasons why not?

Question C. Based on these recommendations, what is NSF doing to increase funding for these types of partnership programs?

Answer. In order to answer this question, we have chosen to address each of the individual recommendations separately and then provide specific answers to a, b, and d at the end. In addition to the specific details below, it is important to note that the Engineering Directorate has made these recommendations a focus of directorate presentations to professional societies, universities, etc., to emphasize the portfolio of partnerships with industry we support, and the role of translational research in our investments.

Recommendation 1: Expand existing partnerships programs so as to better fill the university-industry landscape.

- The Industry/University Cooperative Research Centers (I/UCRC) program's Fundamental Research Program (FRP) funds centers to embark into new areas of discovery ripe for exploration and innovation. The I/UCRC has modified the FRP to require industry inspired proposals, thus building upon and expanding the existing partnerships of the center.
- The I/UCRC program has extended its membership duration from a maximum of 10 to 15 years (Phase III) with decreased NSF funding in the third phase. This allows for continued building of partnerships on the NSF brand.
- Small Business Innovation Research (SBIR) firms are joining the I/UCRC and increasing small business memberships in the center Industry Advisory Boards (IABs).

Recommendation 2: Pilot new partnering programs that address the remaining gaps in the university-industry landscape.

- Both the Translational Research in the Academic Community (TRAC) and Accelerating Innovation Research (AIR) programs seek to leverage existing partnerships to advance innovative capacity. I/UCRCs have had the highest response among center programs to the AIR Program Solicitation.
- The Partnerships for Innovation (PFI) program's ultimate goal is to enable business partners to grow and radically change how businesses are doing what they do and thereby contribute to U.S. competitiveness.

Recommendation 3: Expand mechanisms to motivate/reward industry financial investment in NSF sponsored projects, by extending matching-funds supplements to other ENG programs.

- The concept of extending matching funds is prohibited by current National Science Board policy. The I/UCRC and ERC programs are the only partnership programs eligible for matching funds.
- The I/UCRC program contains a component entitled Cooperative Opportunities for Research between I/UCRCs (CORBI) where industry members of two separate centers allocate money to fund collaborative research between the centers. NSF matches the amount committed by both centers' Industrial Advisory Boards (up to $50,000 for each center pair collaborating).

Recommendation 4: Continue participating on the National Academies' UIDP, and do whatever possible to expedite the release of software to assist in negotiating IP.

- NSF is continuing to support the UIDP effort and has provided focused support through various program initiatives within ENG's Industrial Innovation and Partnerships (IIP) division.
- NSF is actively participating with UIDP's release of their "TurboNegotiator" software and assisting in organizing negotiating workshops on selected technology areas using 'TurboNegotiator' as a tool.

Recommendation 5: Take a more proactive role in making companies more aware of the benefits of investing and participating in NSF-sponsored research projects.

- NSF program directors play a significant active role in marketing I/UCRC concepts to member companies at planning grant meetings for the formation of new

centers and IAB meetings for existing centers. Program directors also have discussions with companies off-line.

- NSF personnel have created awareness within 30 industries during UIDP annual meeting presentations.
- IIP has joined the Industrial Research Institute (IRI), composed of approximately 200 Fortune 500 companies, and participated in their External Technology and Innovation Leadership networks.
- NSF has presented at both American Society of Mechanical Engineers (ASME) and Council for Chemical Research (CCR) meetings.

Recommendation 6: Mount an awareness campaign with the goal of helping companies understand NSF's partnership programs.

- This is a current practice with SBIR companies through such activities as the I/UCRC membership supplemental Dear Colleague Letter. IIP personnel also routinely talk to various large companies and other agencies at various I/UCRC meetings.
- The responses to recommendation #5 also addresses this recommendation.

Recommendation 7: Take a proactive role in making faculty aware of the benefits of seeking and participating in partnerships with industry.

- This is an on-going effort with all potential faculty and faculty within existing centers.
- The new PFI solicitation requires collaboration with two or more small businesses. The generous lead time, use of Letters of Intent (LOI), and program director's interactions with potential principal investigators (PIs) represent aggressive attempts to promote partnerships.
- NSF personnel participate in approximately eight "NSF Days" annually across the country.

Recommendation 8: Mount an awareness campaign with the goal of helping university administrators and faculty understand NSF's partnership programs.

- The I/UCRC program has not separately mounted an awareness campaign for university administrators; however, the I/UCRC program staff takes every opportunity to discuss the Center model with university tech transfer offices and others.
- The PFI program requires the participation of a senior university administrator by requiring them to lead the research effort.
- Several senior administrators were made aware of the PFI solicitation and served on PFI review panels.
- NSF personnel presented partnership program information at the American Society for Engineering Education (ASEE) annual conference and conducted a UIDP webinar. IIP personnel participated in UIDP panels.

Recommendation 9: Champion, within NSF, the need to offer many different types of university-industry partnership mechanisms—and encourage the broader adoption of partnership mechanisms so they are available to a much wider cross-section of faculty researchers.

- The new/recent AIR, TRAC, and i6 Challenge solicitations are good examples of the different types of university-industry partnership mechanisms and their availability to a larger pool of researchers.
- The NSF Director has articulated partnership mechanisms in his recent FY 2012 budget press conference and in other venues.

Recommendation 10: Continue monitoring the progress of all university-industry partnership mechanisms, Foundation-wide, and periodically re-assess them to ensure that the number and type of opportunities meet the diverse needs of academic and industry constituencies.

- The I/UCRC program has made evaluation a cornerstone of the program since its inception over 30 years ago. Each center has an appointed evaluator that provides information to the I/UCRC Program on the center structure and operations. Data is aggregated on an annual basis for use in case studies and longitudinal studies of center impact and program effectiveness.
- NSF is looking to develop mechanisms for measurement through STAR METRICS and the Data Information Management System (DIMS) that are ongoing approaches.

Question A. How many of these recommendations have been implemented at NSF?

Answer. NSF has implemented 9 out of 10 recommendations.

Question B. Which recommendations have not and what are the reasons why not?

Answer. Implementing recommendation #3 would require a change in NSF policy.

Question C. Based on these recommendations, what is NSF doing to increase funding for these types of partnership programs?

Answer. The NSF FY 2012 Budget Request includes a total $19.50 million for Accelerating Innovation Research (AIR). These funds will expand on the AIR 2011 launch and will build stronger university industry collaboration by engaging industry in defining high risk fundamental research that has the potential to overcome scientific/engineering barriers to innovation and thus impact on its innovation readiness for third party investment.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. KAY BAILEY HUTCHISON TO DR. SUBRA SURESH

STEM Education

Question. During the reauthorization of the America COMPETES Act, the Senate Commerce, Science and Transportation Committee created a STEM-Training grant program at the National Science Foundation. As you know, this program is designed to increase the number of qualified STEM teachers in America's classrooms and was a recommendation in the Gathering Storm report and its many follow-up reports.

Could you please provide the Committee with a timeline for implementation of this program? Specifically, what role does the NSF intend to have in implementing this STEM-Training grant program? How soon will the NSF begin funding the programs first class of STEM teachers in training?

Answer. The NSF has a long-standing history of investing in the improvement of STEM teacher preparation and continuing professional development, and is committed to the President's goal of preparing 100,000 STEM teachers. The FY 2012 Budget Request includes Teacher Learning for the Future (TLF) within the Directorate for Education and Human Resources. TLF is focused on building understanding, through research and demonstration, about what it takes to prepare truly great STEM teachers. NSF's Office of Integrative Activities, in conjunction with the Directorate for Education and Human Resources, will convene a stakeholders' workshop early in FY 2012 to focus on best practices in STEM teacher preparation. In preparation for the workshop, NSF will engage in planning and mapping of current programs concerned with teacher preparation (including the Noyce Scholars program, the Math and Science Partnership Program, and the proposed TLF program). These programs already incorporate key elements of teacher preparation programs that have demonstrated success in terms of pupil learning, including attention to replication of effective programs, and could be expanded or reconfigured to address new expectations.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER F. WICKER TO DR. SUBRA SURESH

Budget Priorities and Performance

Question 1. I recognize the contributions NSF, NIST, and NASA have made to society and American innovation, but we are in dire economic times. Non-defense discretionary outlays grew 5.6 percent over the last decade. The continued deficits of our Federal Government are not sustainable and our country's growing debt is a threat to national security. With our current fiscal condition in mind, can you tell me how many jobs your budget proposal will create for Americans?

Answer. It is not possible to provide accurate and reliable, prospective estimates for the number of jobs that will be created by investing in basic research, or for the proportion of created jobs which will go to American citizens. The Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness and Science (STAR METRICS) collaboration project, currently in Phase I, will measure the impact of science spending on job creation in the academic sector.

Question 2. Is the creation of jobs a top priority for funding R&D at your respective agency?

Answer. Stimulating long-term economic growth and job creation is a long-standing priority for NSF. As the only Federal agency specifically dedicated to the sup-

port of basic research and education across all fields of science and engineering, NSF connects forefront science and engineering with potential economic, societal, and educational benefit. NSF's high-risk, potentially transformative investments enable important discoveries and cutting-edge technologies that help to keep the Nation globally competitive, prosperous, and secure.

Question 3. How do you measure the impact Federal R&D funding has on job creation?

Answer. NSF co-leads the STAR METRICS collaboration. STAR METRICS is a Federal and research institution collaboration to create a repository of data and tools that will be useful to assess the impact of Federal R&D investments. In the project's first phase, it is developing uniform, auditable and standardized measures of the impact of science spending (ARRA and non-ARRA) on job creation, using up-to-date data from research institutions' existing database records.

Clean Energy

Question. NSF has requested a 13 percent increase in overall funding compared to 2010 enacted levels. Within this request is a substantial increase for programs related to climate change—including $576 million for Clean Energy Investments. The Department of Energy's Office of Science also supports areas of basic energy science, climate change, and science education. To what degree do increases for research related to clean energy by NSF overlap or duplicate the efforts by the Department of Energy's Office of Science?

Answer. In FY 2012, NSF will continue to strengthen its long-standing investments in basic clean energy related research. In FY 2010, the clean energy portfolio was $324 million, which grows to $576 million in the FY 2012 request. The portfolio is quite diverse, including research related to fuel cells, biofuels, solar and wind power, process efficiencies for vehicles and electrical transmission, and many other topics. Research is supported in nearly all NSF directorates and offices through both existing core programs and in the newer investment areas, such as Science, Engineering and Education for Sustainability (SEES) and Research at the Interface of the Biological, Mathematical and Physical Sciences and Engineering (BioMaPS).

Avoiding overlap of effort across agencies is important to NSF. In order to leverage, not duplicate, Federal investments, the Foundation's activities in the energy arena are developed in consultation with the Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the U.S. Department of Agriculture (USDA), and other Federal agencies. NSF provides research support to the academic community and focuses on early stage to pre-competitive programs that complement DOE's activities. An example of this synergy is the Foundational Program to Advance Cell Efficiency (F–PACE), which is a DOE/NSF joint program in photovoltaics. DOE picks up support for clean energy research at the pre-competitive through commercialization stage. Other existing NSF programs focusing on innovation (such as Engineering Research Centers, the Industry-University Cooperative Research Centers Program, the Accelerating Innovation Research program, and supplements for Translational Research in the Academic Community) are excellent examples of programs where NSF's strength at the most basic end of the innovation and education chain benefits and could increasingly benefit both agencies in meeting national needs for energy security. There are many examples where NSF–DOE complementarity has benefited discovery and innovation, for example, current leaders of a number of DOE energy research centers got their start with NSF Research Initiation Awards and/or CAREER awards.

In expanding research related to clean energy, NSF will make unique contributions to the pursuit of energy efficiency and new energy sources. NSF's mission to pursue fundamental basic research makes us ideally situated to investigate important questions outside the interests of other agencies. Further, in FY 2012, NSF has proposed increased funding for an approach to clean energy using a "pathways" approach that integrates research on topics that range from resource characterization, to the technology needed to develop and efficiently utilize a resource, to the social and environmental impact of widespread adoption of that energy source. The span of NSF's interests in natural and social sciences, engineering, and science education differentiates us from other agencies and enables us to take on such a complex topic in such a comprehensive manner. It also enables NSF to target resources at educating graduate, postdoctoral, and early career scientists who will be able to use interdisciplinary knowledge and skills to address a critical scientific and societal challenge and collaborate adeptly with private and public partners.

EPSCoR

Question. Funding for the Experimental Program to Stimulate Competitive Research (EPSCoR) has received a modest increase in NSF's FY2012 budget request.

This is a long-standing, successful program that helps institutions from smaller states, such as Mississippi, compete for merit-based research funding. Can you explain the reasoning for your request for substantial increases in climate change funding while successful programs such as EPSCoR only receive modest support?

Answer. The FY 2012 Request for EPSCoR funding is consistent with the NSF growth trend for the Research and Related Activities account for FY 2009 through FY 2012.

Climate change and its associated impacts on energy, environment, and water are important to many EPSCoR jurisdictions. One objective of the EPSCoR program is to catalyze fuller participation of EPSCoR researchers in all of the Foundation's activities. EPSCoR jurisdictions are also eligible to submit proposals to the Foundation's climate change programs.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO DR. WALEED ABDALATI

Question 1. Basic research is the foundation of our economy; however, basic R&D only creates jobs when innovations are commercialized. What actions is NASA taking to facilitate technology transfer and commercialization? Please provide specific examples of agency efforts in this regard.

Answer. Since its inception, NASA has worked to find ways to facilitate the transfer of its cutting-edge technologies to the public sector. NASA has a long and successful history of transferring its technology for public good, with long-standing efforts involving NASA's field centers dedicated to patenting and licensing new technology.

NASA's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STIR) programs tap the innovative potential of hundreds of small businesses around the country; the products of those efforts serve specific NASA mission needs as well as those of customers in the private sector and other government agencies. The SBIR and STIR programs are the foundation ofNASA's investment in early stage technology development, and often serve as technology pathfinders for larger efforts that are adopted by prime contractors and the NASA centers.

In addition, NASA has developed a program to foster the release of NASA software for a wide range of applications; and also uses Space Act Agreements for many ofNASA's innovative partnerships. In terms of volume, NASA executed over 1,000 new collaborative R&D relationships in 2010 and has over 4,000 that are currently active. These numbers reflect a close alliance between R&D development at NASA's field centers and the commitment by the field center technology transfer professionals to foster application of that technology for commercial development and other objectives.

Many NASA technologies are transferred to existing companies, or to new companies that are created to take advantage of NASA's inventions. These inventions and technologies provide more than just an economic benefit: many of them improve the environment, make us healthier and safer, and improve our quality of life.

Several recent examples of successful NASA technology transfer are highlighted below and represent a fraction of the wide range of technology transfer efforts undertaken at the NASA field centers.

- A ground-based inflatable antenna based on a design developed for space communication is now providing high-bandwidth communication in remote areas and after emergencies such as the 2010 earthquake in Haiti.
- A technique for strengthening metal engine components that undergo extreme heat and stress is being applied to completely eliminate a common failure in modular hip implants.
- Light sensors invented by NASA researchers provide imaging capabilities for digital cameras, web cameras, automotive cameras, and one of every two cell phone cameras on the planet.
- NASA funding supported the development of a whole aircraft parachute system that is now standard equipment on many of the world's top-selling general aviation aircraft and is credited with saving 246 lives to date.
- Fuel cell technology originally devised for generating oxygen and fuel for missions to Mars has been adapted to generate clean energy on Earth, providing an environmentally friendly, scalable power source for a host of Fortune 500 businesses.

- Bacteria isolated for use in water-purifying technology for the International Space Station is providing a safe, environmentally sound method for oil spill cleanup and for cleansing municipal and industrial wastewater.

Each year NASA documents 40–50 of the top recent technology transfer successes such as the ones listed above, in its annual *Spinoff* publication (http://spinoff.nasa.gov). More than 1,700 of these top successes have been published in *Spinoff* and are documented online and available via a searchable database at this website.

Feeding this pipeline of innovation are new technologies developed by NASA. In FY 2010, NASA documented the development of 1,647 new technologies through new technology reports (NTRs). NASA seeks to make these technologies available to industry, academia and other agencies for further development and application. Each month 40–50 recent NTRs are published in NASA TechBriefs, the largest circulation design engineering magazine in the country, reaching over a quarter of a million technologists in all industries. The monthly magazine features exclusive reports of innovations developed by NASA and its industry partners/contractors that can be applied to develop new and improved products and solve engineering or manufacturing problems. In addition to the print edition, TechBriefs is also available online at *http://www.techbriefs.com/*.

In addition to these longstanding technology transfer efforts, NASA is engaged in new and exciting ways to push its innovations out to the public.

The Agency is an active participant in the Federal Laboratory Consortium, a national organization chartered by Congress to foster technology transfer from Federal laboratories to the private sector. NASA currently has several individuals serving on FLC planning committees, and NASA researchers have also played an active part presenting their technologies at various FLC forums and encouraging private sector collaboration/partnership development, such as a nanotechnology partnership forum held at the National Institute of Standards and Technology last September, and a recent forum at the College of William and Mary dedicated to energy technology partnerships, energy efficiency, and energy conservation.

In addition to conducting research in support of future human missions into deep space, astronauts aboard the ISS will carry out experiments anticipated to have terrestrial applications in areas such as biotechnology, bioengineering, medicine, and therapeutic treatment as part of the National Laboratory function of the Station.In support of this effort, in February 2011, NASA released a Cooperative Agreement Notice (CAN) for an independent Non-Profit Organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will: (1) act as a single entry point for non-NASA users to interface efficiently with the ISS; (2) assist researchers in developing experiments, meeting safety and integration rules, and act as an ombudsman on behalf of researchers; (3) perform outreach to researchers and disseminate the results of ISS research activities; and (4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more.

NASA has also initiated several innovative approaches to licensing, such as one through collaboration between NASA's Goddard Space Flight Center and Ocean Tomo, to use live auctions as a means to broadcast a range of NASA technologies available for licensing. NASA also recently published a Request For Information (RFI) seeking ideas from industry for innovative ways to inform the public of available NASA licenses and for new ways to create these licenses.

NASA is also actively engaged in several initiatives to bring NASA technology to areas traditionally not associated with the civilian space program. For example, a recent partnership with the Colorado Association for Manufacturing and Technology (CAMT) has resulted in the development of a regional economic cluster aimed at bringing NASA technology, high tech jobs, and small businesses together to focus on accelerating the process for bringing advanced aerospace and environmental technologies to market. NASA intends to look for additional regional opportunities and partners across the country to strengthen the U.S. economy by partnering technology developed for the space program with other industrial and research sectors, such as bio-agriculture, robotics, and alternative energy.

Additionally, NASA is constantly seeking new ways to use its technology for public benefit. Recent partnerships have NASA providing medical, engineering, and psychological support for the rescue of the trapped Chilean miners; providing space-based remote sensing as well as ground-based remediation technology for the oil spill cleanup in the Gulf Coast; and launching aerial support of wildfire management along the West coast. NASA-derived robots have even been deployed to analyze the damaged Fukushima nuclear reactor following the recent earthquake and tsunami in Japan.

To help communicate to the public the linkage between NASA's research and technology and benefits from resulting commercialized products, NASA created a web feature called *NASA @ Home and City* which is available online at *http://www.nasa.gov/city*. This website makes it easy to see how space technology improves our everyday lives, from the bedroom, bathroom or kitchen to the hospital, grocery store, firehouse, or sports arena.

NASA technologies make a difference in our lives every day. Knowledge provided by weather and navigational spacecraft, efficiency improvements in both ground and air transportation, super computers, solar- and wind-generated energy, the cameras found in many of today's cell phones, improved biomedical applications including advanced medical imaging and even more nutritious infant formula, as well as the protective gear that keeps our military, firefighters and police safe, have all benefited from our Nation's investments in aerospace technology. By investing in space and aeronautics technology, NASA will continue to make a difference in the world around us.

Question 2. Your testimony indicated that your goal is to deliver the most valuable science for the taxpayer investment. How will you determine what the most valuable science is? What metrics are used to evaluate the performance of current investments?

Answer. NASA science provides value in several ways that include, but are not limited to: (a) increasing basic knowledge, as we gain new insights into our ever changing universe, (b) inspiring future generations to pursue science and engineering professions through our performance of incredible technical and scientific feats such as sending rovers to explore the surface of Mars, and (c) directly improving the human condition, for example through critical insights into the behavior of our changing planet with continual and improving Earth observations.

While the intrinsic value of these pursuits may be clear in a qualitative sense, ensuring that we deliver the most valuable science for the taxpayers' investments requires that we develop means of objectively assessing relative value of and returns on our investments. This is challenging, because in science, the importance of a theory, observation, or discovery may not be fully realized until long after its occurrence.

Nonetheless, there are means by which we can increase the likelihood that our investments are of the greatest value, and at NASA we employ a number of such strategies. These include the following:

- Widely advertising our funding opportunities

By reaching as broad an audience as possible, we ensure the greatest likelihood of receiving the most creative ideas, and the highest quality proposals. We advertise funding opportunities through the NASA Solicitation and Proposal Integrated Review and Evaluation System (our online database of potential investigators) as well as through our website and other mechanisms.

- Relying on competition and peer review for the vast majority of our investments

Except in a few instances that require results on very short time scales, or specific expertise that exists in-house, our research is selected through competition and rigorous peer-review. Even the few direct-funded activities are subject to peer review prior to award. By relying on this process, we ensure that the scientific investigations and the missions we support are of the highest quality as judged by experts in the relevant areas.

- Relying on recommendations from the external scientific community

NASA has a long history of seeking advice from the National Research Council (NRC) to help us develop priorities for our investments. The most visible are our decadal surveys, which lay out science priorities and mission priorities which we at NASA work diligently to follow. By relying on these recommendations for our largest, multi-billion-dollar science investments, we ensure that we are investing our resources in the highest-priority science as indicated by the broader scientific community. This advice extends to establishing priorities for infrastructure investments and reviewing our strategic plans.

- Seeking advice through our Federal Advisory Committees

In addition to the NRC recommendations, we also rely on recommendations on scientific matters from the NASA Advisory Council and in particular its Science Committee, and discipline-specific subcommittees. These groups, comprised of scientific leaders who have a comprehensive understanding of NASA, provide advice on the execution ofNASA science programs. NASA carefully considers their advice

and implements it according as commensurate with broader NASA and national objectives, availability of resources, and capabilities of the agency.

- Reviewing annual progress reports of individual scientists. and making funding renewal contingent on satisfactory progress

Scientists are required to demonstrate measurable progress in their scientific investigations in order to continue to receive funding under multi-year grant proposals. These annual gates provide opportunities to terminate unproductive projects or to provide guidance on projects that are not fully living up to their promise.

NASA also has established metrics for evaluating the returns from our science investments. We submit with our annual budget requests an Annual Performance Plan that outlines the annual performance goals we intend to achieve in science with the budget requested; at the end of each fiscal year we report our success in achieving those goals in our Performance and Accountability Report. The annual performance goals cover the breadth of NASA's science research, and we rely on the subcommittees of the NASA Advisory Council Science Committee to evaluate our progress in our many research areas.

In addition, NASA uses several other indicators to assess the value of the science we fund. While these measures do not report the annual progress of our research as our annual performance goals do, they serve as informal markers of the utility of our research results.

- Tracking the number and quality of publications and citations in the peer-reviewed scientific literature of NASA funded investigations, projects or missions.

The currency of many scientific endeavors is the peer-reviewed literature. Citation indices make it very easy to track the publications associated with particular grants or research topics, as well as particular investigators and how often these are cited by other publications. Moreover, journal impact factors provide a means of assessing the quality of the publications in which these papers appear, and thus provide some insight into the significance of the publications themselves. While the numbers themselves are not a sole metric for scientific quality, they do provide a useful tool as part of a broader assessment strategy.

- The use of research results by partner agencies

The employment of NASA research results by other agencies within the U.S. Government is an indication that the science undertaken has produced a capability to support other national objectives and is of direct value to the Nation. This is primarily the case with our Earth Science investments, and past examples include the use of ocean altimetry and ocean surface winds in weather forecasts, algorithms for forest fires detection and associated products now in use by the U.S. Forest Service, and the continuity of Landsat measurements for use by the U.S. Geological survey.

- Tracking the number and quality of various awards and recognitions made to NASA sponsored researchers

When the achievements of scientists in the NASA community are recognized as making profound contributions to the body of knowledge, such recognition is an indication of the significance and value of the research supported. These awards can include scientific achievement (*e.g.,* Nobel prizes, professional society awards), or fellowships to scientific organizations (such as the National Academies and professional societies).

- The amount of and nature of media coverage of our research and findings.

While this is not typically a very good measure of science quality, it is an indication of relevance and interest in the research and missions being pursued, and is an appropriate element of our value-assessment portfolio.

Question 3. One of NASA's largest scientific investments is arguably the International Space Station (ISS). With final assembly now complete, the program is shifting its focus toward the research opportunities afforded by the ISS's microgravity environment. The FY 2012 budget request proposes a 70 percent increase in the ISS research budget to utilize this investment. How are ISS research activities improving life here on Earth? What is NASA doing to ensure that this facility is effectively utilized as a National Lab?

Answer. The ISS has transitioned from the construction era to that of operations and research, with a 6-person permanent crew, 3 major science labs, an operational lifetime through at least 2020, and a growing complement of cargo vehicles, including the European Automated Transfer Vehicle (ATV) and the Japanese H-II Transfer Vehicle (HTV).

The Station is the largest crewed spacecraft ever assembled, representing a unique research capability aboard which the United States and its partner nations can conduct a wide variety of research in biology, chemistry, physics and engineering fields which will help us better understand how to keep astronauts healthy and productive on long-duration space missions.

In addition to conducting research in support of future human missions into deep space, astronauts aboard the ISS will carry out experiments anticipated to have terrestrial applications:

- ISS research has shown that bacteria can become more virulent in microgravity (*i.e.,* more aggressive in causing disease). In several cases, scientists have successfully identified the genes responsible for this increased virulence and are now developing vaccine candidates. AstroGenetix, Inc. has funded its own follow-on studies on ISS and is now preparing to submit Investigational New Drug applications to the Food and Drug Administration for the treatment of both *salmonella*-induced food poisoning and methicillin-resistant *Staph aureus* (MRSA).
- Microcapsules are tiny micro-balloons used in cancer treatment to deliver anti-cancer drugs directly to a tumor site. Microcapsules with improved cancer treatment properties developed on the ISS were reproduced on Earth and were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method are planned at M.D. Anderson Cancer Center and the Mayo Clinic.
- A Japanese scientist crystallized the HQL–79 protein (human prostaglandin D2 synthase inhibitor protein) on the ISS, producing an improved structure that identified the location of critical hydrogen bonds that were not previously known. This allowed drug design for a candidate treatment to inhibit the progression of Duchenne muscular dystrophy. Continuing work is examining other proteins and viruses.
- Numerous plant growth experiments have investigated both the effects of microgravity, as well as the capability for growing regenerable food supplies for crew. Technology developed for a greenhouse flown on the ISS is now widely used on Earth, killing 98 percent of airborne pathogens (including Anthrax) for food preservation, doctors' offices, homes, and businesses.

The ISS will also serve as an incubator for growth of the low-Earth orbit space economy. NASA is counting on its Commercial Resupply Services (CRS) suppliers to carry cargo to maintain the Station. It is hoped that these capabilities, initially developed to serve Station, may find other customers as well, and encourage the development of further space capabilities and applications.

Non-NASA research into areas such as biotechnology, bioengineering, medicine, and therapeutic treatment will be enabled by the National Laboratory function of the Station. NASA has 5 Memoranda of Understanding (MODs) with other U.S. Government agencies, and 9 agreements with non-government organizations to conduct research aboard the ISS. NASA will pay for the transportation and ISS infrastructure costs (*i.e.,* use of power, thermal control systems, communications, etc.) associated with National Laboratory research, and provide some grant funding for experiments conducted by research institutions. However, experiments sponsored by private firms will be funded by the National Laboratory partners—not by NASA. On February 14, 2011, NASA released a Cooperative Agreement Notice (CAN) for an independent non-profit organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will: (1) act as a single entry point for non-NASA users to interface efficiently with the ISS; (2) assist researchers in developing experiments, meeting safety and integration rules, and acting as an ombudsman on behalf of researchers; (3) perform outreach to researchers and disseminate the results of ISS research activities; and (4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more. The Agency anticipates making a selection in late spring with final award by mid-summer.

As a tool for expanding knowledge of the world around us; advancing technology; serving as an impetus for the development of the commercial space sector; demonstrating the feasibility of a complex, long-term, international effort; and, perhaps most importantly, inspiring the next generation to pursue careers in science, technology, engineering, and mathematics, the ISS is without equal.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO DR. WALEED ABDALATI

Question 1. Could you provide an example of the type of content and outreach activities you expect to participate in?

Answer. As a scientist and a teacher of science, I have always valued the opportunities I've had to reach out to students, other educators, and members of the public. As NASA Chief Scientist, I have the opportunity to serve as the face of NASA's incredible science capabilities to a wide range of audiences, and I intend to make full use of that opportunity. From giant distant galaxies to molecules of air and water here on Earth, I believe that science plays a critical role in our Nation's future, and I plan to communicate that as broadly and effectively as I can through as many channels as possible. It is for this reason that I have working with me an experienced communications officer who works directly with our Office of Communications and is developing a multi-faceted public communications strategy, which will emphasize the importance of science in the agency's and the Nation's future.

I plan to partner with the NASA Office of Education on science projects designed for K–12 STEM students and educators that use the inspirational nature of our pursuits and discoveries. I plan to speak at events that reach large numbers of science teachers. In an effort to target higher education, I also plan to visit universities around the country where I will reach out directly to undergraduate, graduate and post-graduate students and faculty through seminars and academic lectures to encourage them to seek and find opportunities to thrive in science careers. My office is actively engaged in OSTP's Committee on STEM Education.

I will reach out directly to members of the American public through events such as science festivals, lectures at museums and science centers, television, radio, print media, and social media. I look forward to taking advantage of NASA's web-based interactive programs such as science casts and web chats and will encourage participants to pursue careers in science, technology, engineering and math. I have a long history of public outreach through channels such as these, and I look forward to using my position as Chief Scientist and the NASA communication infrastructure to expand the reach of the agency. Through NASA's Open Government initiatives, I will interact directly with citizen scientists and encourage them to take an active role in the Nation's space program and in doing so rediscover its magic and wonder and practical value.

Question 2. In the America COMPETES Authorization of 2010, NASA was directed to utilize their unique resources to create and support professional development for STEM teachers and STEM educators at all levels. We have had concerns in the past that NASA has not fully embraced this opportunity and direction. How does NASA plan on implementing this directive going forward? Could you provide a timeline and status update on implementing this directive?

Answer. In January 2011, President Barack Obama stated that, "over the next 10 years, nearly half of all new jobs will require education that goes beyond a high school education. And yet, as many as a quarter of our students aren't even finishing high school. The quality of our math and science education lags behind many other nations. America has fallen to ninth in the proportion of young people with a college degree. And so the question is whether all of us 'as citizens and as parents' are willing to do what's necessary to give every child a chance to succeed." This speech echoes findings and calls-to-action by numerous committees, reports, professionals in education, and leaders in American industry. In response, the Department of Education has identified several strategies to improve science, technology, engineering and mathematics (STEM) education and ways in which Federal agencies can contribute to the Nation's STEM improvement efforts. NASA is a strong contributor to the national plan.

Consistent with Section 202 of the America COMPETES Reauthorization Act of 2010, NASA works with professional organizations, academia, and state/local education providers to identify and address needs in STEM education. Quality professional development for STEM educators is a prevalent need. Through the education staff at NASA's Centers, NASA works cooperatively with states and school districts to identify content needs and opportunities, and with university partners to ensure that NASA investments will be effective in improving teaching practice. NASA also works through communities of practice to identify content areas and special events that supplement informal education programming offered by museums and science centers. NASA higher education efforts increasingly target community colleges, which generally serve a high proportion of minority students. NASA programs build student STEM ability, preparing students for study at a four- year institution. Competitive opportunities support initiatives like the President's "Race to the Top" and

the Department of Education's "Star Project," which promote state-based education reform and identify replicable strategies for improving K–12 education.

NASA's education programs aim to increase the number of students who are proficient in, choose to major in, and pursue careers in STEM fields. Improving STEM ability, increasing public scientific literacy, increasing the talent pool of future STEM workers, and developing the STEM skills of the future workforce are imperatives if the Nation is to remain globally competitive and sustain a strong economy. NASA actively works through mutually beneficial relationships with over 500 colleges and universities, hundreds ofK–12 schools and districts, and over 400 museums and science centers to provide education experiences, so that all students can learn deeply and think critically in STEM disciplines. NASA supports cutting-edge undergraduate student research that contributes to NASA missions while training the next generation of scientists, engineers, and innovators. NASA targets recruitment and retention of underserved and underrepresented students, including women and girls, Hispanics, and students with disabilities.

NASA is committed to providing equal access to its education activities by providing any student with the opportunity to contribute to the future STEM work force. NASA is responding by focusing its education investments on areas of greatest national need and ensuring that the Agency's education programs support national STEM priorities. With its wealth of science and technology content and its expansive network of education professionals, NASA is well equipped to address national needs such as meeting state requirements for educator professional development. NASA provides practical experience and skills development for those who will become the future workforce through internships, fellowships, and student research opportunities. NASA is especially qualified to attract students to pursue STEM study and careers. It also is able to engage these future workers through inspiring NASA missions, fostering collaborative relationships between students and the current workforce and offering students opportunities to work in "out of this world" facilities. Hands-on challenges with expert mentors generate increased interest in STEM study.

NASA has engaged students and teachers in its engineering challenges and scientific discoveries since its inception. From school presentations to seeds flown in space, from filmstrips and posters to podcasts and virtual tours though the galaxies, NASA's education programs have fostered inquiry, built curiosity, and encouraged innovation. Generations of Americans have participated in NASA's STEM education programs, and thereby learned basic skills, discovered new career paths, and developed interests in emerging academic disciplines.

NASA is actively engaged in collaborations with other Federal agencies to ensure the Agency's programs are supportive of national STEM priorities. The NASA Associate Administrator for Education represents the Agency on the National Science and Technology Council (NSTC) Committee on STEM Education (CoSTEM). It was established pursuant to the requirements of Sec. 101 of the America COMPETES Reauthorization Act of 2010. The NASA Office of Chief Scientist is also participating in the CoSTEM by providing the CoSTEM Executive Secretary, who works in close coordination with the Office of Education.

NASA's Earth and space science missions have an essential role in NASA's education mission. The discoveries and new knowledge from our missions and research programs consistently engage people's imaginations, inform teachers, and excite students about science and exploration. We are committed to utilizing our resources to foster the broad involvement of the Earth and space science communities in education and public outreach with the goal of enhancing the Nation's formal education system and contributing to the broad public understanding of science, mathematics and technology. NASA's Science Mission Directorate creates education products using NASA's results in Earth-Sun system science, solar system research, universe exploration, and the development of new technologies to support learning. Through a "Train the Trainer" model the SMD programs train master teachers, who reach their peers via in person and online professional development opportunities that range from one-day to week-long workshops. Another aspect of teacher professional development includes providing summer research opportunities for in-service teachers.

In 2010, NASA chartered an Education Design Team (EDT) to develop a strategy to improve NASA's education offerings, assist in establishing goals, structures, processes, and evaluative techniques to implement new sustainable and innovative STEM education programs. EDT has completed its task, and its recommendations are reflected in the FY 2012 education budget for NASA's Office of Education.

The FY 2012 budget provides NASA with the resources necessary to continue this rich tradition in STEM education through support for the Nation's students and

educators, the leveraging of cutting-edge education technologies, and partnerships with industry. The budget proposal will:

- Increase NASA's impact on STEM education by further focusing K–12 efforts on middle-school pre- and in-service educator professional development
- Increase emphasis on providing experiential opportunities for students, internships, and scholarships for high school and undergraduate students;
- Increase NASA's role in national and state STEM policy discussions;
- Emphasize evaluation and assessment, including external independent evaluation, to ensure that investments are providing desirable STEM impacts;
- Engage strategic partners with common objectives and complementary resources; and
- Use NASA's unique missions, discoveries, and assets (*e.g.,* people, facilities, education infrastructures) to inspire student achievement and educator teaching ability in STEM fields.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER F. WICKER TO DR. WALEED ABDALATI

Question 1. I recognize the contributions NSF, NIST, and NASA have made to society and American innovation, but we are in dire economic times. Non-defense discretionary outlays grew 5.6 percent over the last decade. The continued deficits of our Federal Government are not sustainable and our country's growing debt is a threat to national security. With our current fiscal condition in mind, can you tell me how many jobs your budget proposal will create for Americans?

Answer. The number of jobs created depends on many factors and assumptions making a specific number challenging to defend. However we have regularly observed that NASA's investments have immediate direct effects, as well as long term and indirect effects on jobs and economic growth. NASA's research and development work has been shown to stimulate new business lines that create future jobs. This is validated in the National Research Council (NRC) report "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future" by the Committee on Prospering in the Global Economy ofThe 21st Century, chaired by Norman R. Augustine. NASA has provided numerous achievements in the fields of aeronautics, electronics, computers, aerospace systems, health technology, imaging detectors, telescopes, and high performance materials, for example. These technologies for NASA's science and engineering achievements are transferred into the Nation's economy through industries that apply them in innovative ways. The NRC reported Research and Development (R&D)investments, like those that NASA's missions require, have "social rates of return of from 20–100 percent, with an average of 50 percent."

In the near-term, NASA will facilitate the growth of the commercial space industry through its commercial cargo and crew development Space Act Agreements and with launch vehicle demands from its science and human exploration missions. These emerging commercial space industries have the potential to help drive the Nation's economy in the 21st century. Already, we see growth with Space Exploration Technologies (SpaceX) which was founded in 2002. Working on NASA and other contracts, SpaceX has grown from 150 employees in 2005 to over 1,100 employees today. The advances made through aeronautics research will expand airspace capacity, enable fuel-efficient flight planning, reduce the overall environmental footprint of aviation, diminish delays on the ground and in the sky, and improve the ability of aircraft to operate safely in all weather conditions. NASA will continue architecture planning for a Multi-Purpose Crew Vehicle (MPCV) capable of taking human explorers to distant locations throughout the inner solar system. The Space Launch System (SLS) Program will develop the heavy lift vehicle that will launch the MPCV, other modules, and cargo for these missions. The ISS is the centerpiece of NASA's planning for extended space missions, as it serves as a research laboratory and technology test bed for basic and advanced studies in life sciences, human health, material sciences, Earth science, and fundamental physics. A new independent non-profit organization is being established to coordinate and oversee all of the ISS research and technology efforts and extends the reach of the ISS as a National Lab to further encourage the Nation's investments in R&D.

NASA technology investments are of benefit to more than the Agency's missions and the aerospace industry. As one example, consider the case of Bloom Energy. In 2000, NASA and the University of Arizona developed the Mars Oxygen Generator, a two-pound experiment designed to generate oxygen for life support and fuel pro-

duction on Mars. The device used solid oxide electrolysis cells to convert carbon dioxide and water into oxygen and fuel. When operated in reverse as a fuel cell, this device has been shown to produce clean, reliable electricity here on Earth. Development and commercialization of this technology as a NASA spin-off began with the founding ofBloom Energy in 2001 with a team of8 people, and now supports a direct and contracted workforce of around 1,000 people. Largely supported by the private sector, Bloom has moved their "Bloom Box" beyond the early demonstration phase, generating electricity at prices lower than traditional methods while producing half the amount of greenhouse gases. They expect to add 1,000 cleantech jobs as they quadruple their manufacturing capacity.

NASA's investments in the Small Business Innovation Research program helped Dr. John Langford grow Aurora Flight Sciences. Created in 1989 with two employees in two small rented offices, today, Aurora is home to over 750 employees. Aurora Flight Sciences has grown to support a corporate headquarters in Manassas, VA and operates production plants in Bridgeport, WV and Columbus, MS and a Research and Development Center in Cambridge, MA. The firm's annual revenues exceed $75 million. Aurora is a worldwide leader in the design of unmanned air vehicles (UAV's), robotic aircraft that can fly a variety of missions from research on the planet Mars to defense reconnaissance. Over the years, Aurora has been the recipient of numerous Small Business Innovative Research (SBIR) grants with NASA and Defense Advanced Research Projects Agency (DARPA).

Question 2. Is the creation of jobs a top priority for funding R&D at your respective agency?

Answer. The top priority for R&D funding at NASA is creating capability and providing knowledge. Funding R&D leads not only to direct employment opportunities, but innovations that create new products, services and industries, which in turn expands employment, creating the jobs that make our Nation great and make our Nation competitive in the world. By fueling the imagination and creativity of the national spirit, NASA is a major player in developing interest in science, technology and engineering fields.

As NASA explores space and our planet, it stimulates U.S. economic growth in numerous ways. NASA's Aeronautics program performs the mid- and long-term research that provides the technologies that keep the U.S. aerospace industry competitive in the global marketplace. NASA's development programs provide demand for workers who are best in the world at what they do, further supporting the competitiveness of our aerospace industry. The challenge of living and working in space—either with people or robots—drives the continual improvement of technologies, many of which are then applied to the day-to-day life of the taxpayers through the marketplace. The agency's competitive, peer-reviewed basic research programs support the education and training of the aerospace workforce of tomorrow. By providing demand for scientists and engineering professionals, promoting technology innovation, and preparing the workforce of the future, NASA strives to enhance the health, growth, and long-term competitiveness of the Nation.

A further example of the priority NASA places on job creation is in the Agency's Space Technology Implementation Plan. NASA's plan emphasizes partnering, small business innovation, and technology development; all elements that support job creation. NASA also will use novel approaches to facilitate technology transfer, ensuring its technologies are infused into commercial applications, to promote the creation of new jobs and to advance new products and services that will benefit the Nation and the world. This was an important element of the 2010 NASA Authorization Act and appropriating the President's 2012 budget request will enable the implementation of these space technology plans.

Question 3. How do you measure the impact Federal R&D funding has on job creation?

Answer. NASA does not currently collect quantitative data on the impact of its R&D funding on job creation.

Each year NASA documents 40–50 of the top recent technology transfer successes in its annual *Spinoff* publication (*http://spinoff.nasa.gov*). More than 1,700 of these top successes have been published in *Spinoff* and are documented online and available via a searchable database at this website. The Agency is also an active participant in the Federal Laboratory Consortium, a national organization chartered by Congress to foster technology transfer from Federal laboratories to the private sector. NASA technology transfer activities are reported annually through an FLC collected report.

There are many organizations, both within the U.S. and internationally that are working to improve measurement of R&D funding on job creation. For example, the Organization for Economic Co-operations and Development (OECD) has defined sev-

eral metrics related to science and technology impacts. Some examples are Gross Domestic Expenditure on R&D (GERD), GERD as a percentage of GDP, Total researchers, Government researchers, Business Enterprise researchers, total R&D personnel, and many others. (see the following link: *http://www.oecd.org/dataoecd/30/35/34250656.pdf*).

○