NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

NATIONAL TECHNICAL INFORMATION SERVICE

FISCAL YEAR 2016
BUDGET SUBMISSION TO CONGRESS

National Institute of Standards
and Technology

Exhibit 1

Department of Commerce
National Institute of Standards and Technology
BUDGET ESTIMATES, FISCAL YEAR 2016
CONGRESSIONAL SUBMISSION

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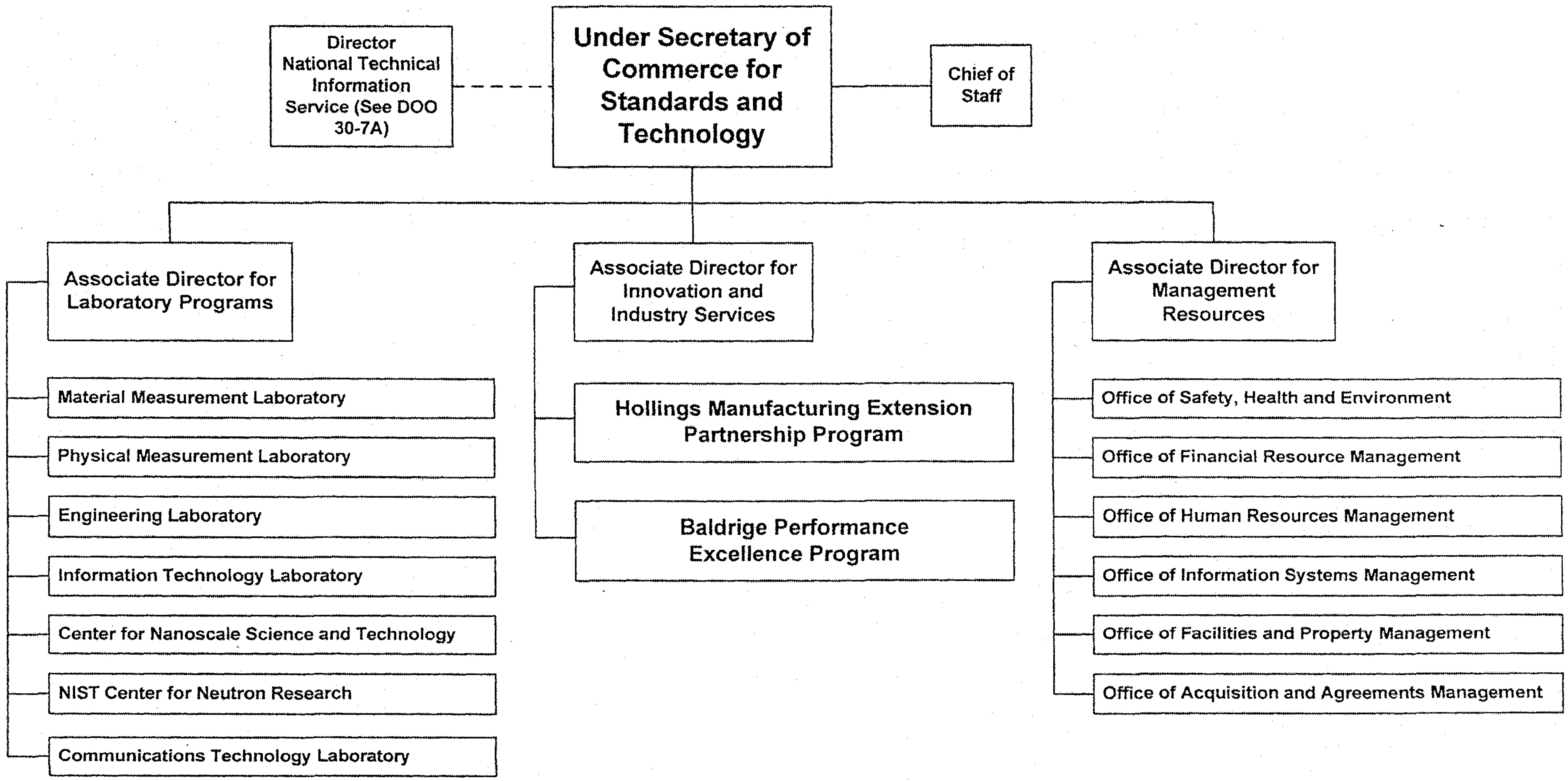
U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology



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EXECUTIVE SUMMARY

General Statement

The mission of the National Institute of Standards and Technology (NIST) 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. For more than 110 years, NIST has maintained the national standards of measurement, a role that the U.S. Constitution assigns to the Federal government to ensure fairness in the marketplace. Today, the NIST Laboratories, funded by the Scientific and Technical Research and Services (STRS) and Construction of Research Facilities (CRF) appropriations, address increasingly complex measurement challenges. For example, NIST develops measurements focusing on the very small (e.g., nanotechnology devices) and the very large (e.g., skyscrapers), the physical (e.g., methods for characterizing strands of DNA for forensic testing) and the virtual (e.g., methodologies and best practices for securing cyberspace). As new technologies develop and evolve, NIST's measurement research and services remain central to innovation, productivity, trade, and public safety. NIST promotes the use of measurements based on the international system of units (SI). The measurement science research at NIST is useful to all science and engineering disciplines.

NIST's portfolio also includes the Hollings Manufacturing Extension Partnership (MEP), funded by the Industrial Technology Services (ITS) appropriation. MEP is a Federal-state-industry partnership that provides U.S. manufacturers with access to technologies, resources, and industry experts. The MEP program consists of Manufacturing Extension Partnership Centers located across the country that work directly with their local manufacturing communities to strengthen the competitiveness of our Nation's domestic manufacturing base. Funding for the MEP Centers is a cost-sharing arrangement consisting of support from the Federal government, state and local government/entities, and fees charged to the manufacturing clients for services provided by the MEP Centers. The ITS appropriation also includes the Advanced Manufacturing Technology Consortia (AMTech) to enable industry-led consortia to identify and prioritize directed basic research projects supporting long-term industrial research needs, and the recently authorized National Network for Manufacturing Innovation (NNMI) which will serve to create an effective manufacturing research infrastructure for U.S. industry and academia to solve industry-relevant problems.

As part of the National Wireless Initiative included in the American Jobs Act, NIST also has resources through the Wireless Innovation (WIN) Fund to help develop cutting-edge wireless technologies for public safety users. The WIN Fund contains $300.0 million in mandatory funds for NIST from the spectrum auction proceeds in FY 2015 to help industry and public safety organizations conduct research and develop new standards, technologies and applications to advance public safety communications in support of the initiative's efforts to build an interoperable nationwide broadband network for first responders.

NIST is a critical agency for implementing the Department's "Innovation" strategic goal and objectives. As stated in the Department of Commerce (DoC) Strategic Plan for FY 2014- 2018, "Innovation is the key driver of U.S. competitiveness. The Department is well-positioned to address many of the challenges the country faces in the manufacturing sector. Through the NIST, the Department houses foundational research capabilities that accelerate the development and adoption of technological breakthroughs that help grow the economy. Increasingly the Department uses its unique convening power to promote public-private partnerships among universities and businesses. These partnerships provide scientific and technical resources to manufacturing firms, and support a skilled workforce to fill the manufacturing jobs of the 21st century." NIST also contributes to the Environment and Data strategic goals and objectives of the Department's strategic plan.

For FY 2016, NIST is submitting a total discretionary request level of $1,119.7 million, $255.8 million above the FY 2015 enacted level.

The following is a comparison of NIST's FY 2016 request level with the FY 2015 enacted levels.

(Dollar amounts in millions)						
Appropriation	FY 2015 Enacted		FY 2016 Request		Change from FY 2015	
	FTE	Amount	FTE	Amount	FTE	Amount
Scientific and Technical Research and Services	2,391	675.5	2,507	754.7	116	79.2
Industrial Technology Services	86	138.1	91	306.0	5	167.9
Construction of Research Facilities	76	50.3	76	59.0	0	8.7
Working Capital Fund	700	0.0	700	0.0	0	0.0
TOTAL RESOURCES	**3,253**	**863.9**	**3,374**	**1,119,7**	**121**	**255.8**

Goals of the Program and Statement of Objectives

DISCRETIONARY APPROPRIATIONS

Scientific and Technical Research and Service (STRS) Appropriation

The objectives of the STRS programs are to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology that drive technological change. NIST resources are devoted to meeting today's economic and societal challenges and to laying the foundation for future success. NIST activities help address a broad range of critical science and innovation challenges for the Nation. NIST's Laboratories funded by STRS play a unique role in the Nation's scientific, industrial, and business communities. NIST anchors the national measurement and standards system that is the language of research and commerce. NIST's presence and leadership in the Nation's measurement and standards system enables companies, researchers, government agencies, and universities to work with each other more easily, thereby improving the Nation's economic security and quality of life. NIST also supports enacted legislation such as the America COMPETES Act, which outlines major roles for NIST in promoting national competitiveness and innovation, and DoC priorities as described in the FY 2014–2018 Strategic Plan.

The NIST laboratory programs funded by STRS appropriations provide industry, academia, and other Federal agencies with:

• Scientific underpinnings for basic and derived measurement units, international standards, measurement and calibration services, and certified reference materials;

• Impartial expertise and leadership in basic and applied research to enable development of test methods and verified data to support the efficient commercialization and exchange of goods and services in industry and commerce;

• Expertise and support for the development of consensus-based standards and specifications that define technical and performance requirements for goods and services, with associated measurements and test methods for conformity; and

• Unique, cutting-edge user facilities that support innovation in materials science, nanotechnology discovery and fabrication, and other emerging technology areas through the NIST Center for Neutron Research (NCNR), which provides world-class neutron measurement capabilities to the U.S. research community, and the NIST Center for Nanoscale Science and Technology, which supports the U.S. nanotechnology enterprise from discovery to production by providing access to world-class nanoscale measurement and fabrication methods and technology.

FY 2016 STRS

NIST's FY 2016 request continues to support NIST's laboratory programs in creating the conditions for economic growth and opportunity by requesting $754.7 million for the STRS appropriation, an increase of $79.2 million over FY 2015.

Construction of Research Facilities (CRF) Appropriation

This appropriation supports the construction of new facilities and the renovation and maintenance of NIST's current buildings and laboratories to comply with scientific and engineering requirements and to keep pace with Federal, State, and local health and safety regulations. The CRF request totals $59.0 million, an $8.7 million increase from FY 2015.

FY 2016 CRF

This request will increase the Safety Capacity, Maintenance and Major Repair (SCMMR) program to restore NIST Construction of Research Facilities funding that was reduced in the FY 2015 appropriation and fund the next phase of the planned multiyear critical renovations. Aging and deteriorating buildings and infrastructure threaten NIST's ability to meet its mission. NIST's leading-edge measurement science requires adequate and safe facilities. Without the funds to maintain, repair, and improve facilities, NIST would fail to meet its mission, reducing its ability to create the conditions for economic growth and opportunity.

Industrial Technology Services (ITS) Appropriation

NIST requests $306.0 million for the ITS appropriation, which consists of three extramural programs, the Advanced Manufacturing Technology Consortia program (AMTech), the Hollings Manufacturing Extension Partnership (MEP), and the recently authorized National Network for Manufacturing Innovation (NNMI). The total request is a $167.9 million increase from FY 2015.

FY 2016 ITS

Advanced Manufacturing Technology Consortia (AMTech)

The budget requests $15.0 million for AMTech, an increase of $6.9 million over FY 2015. Industry consortia are known to be extremely effective in identifying technology needs and roadblocks, yet often need a catalyst to enable consortium formation. The AMTech grants program enables industry-led consortia to identify and prioritize directed late basic to early applied research projects supporting long-term industrial research needs. AMTech creates the incentive for multiple industry stakeholders to share financial and scientific resources, together with state and local government interests, as well as technical innovators at universities and government laboratories. The program provides funding to industry-led consortia for the development of detailed roadmaps of long-term research challenges. Further, the program aims to seed industry-led consortia establishment by awarding project grants to support the research needed to help them achieve future desired technology developments. The AMTech program supports the Administration's priorities to invest in advanced manufacturing to foster innovation, create high-quality jobs, and enhance global competitiveness. By supporting consortia, the AMTech program will address multiple components of the innovation cycle, from discovery and pre-competitive technology development to accelerate the pace of innovation through various industry sectors.

Hollings Manufacturing Extension Partnership (MEP)

The request includes $141.0 million for MEP, an $11.0 million increase over FY 2015. MEP is a Federal-State-industry partnership that provides U.S. manufacturers with access to technologies, resources, and industry experts. The program consists of 60 MEP Centers that work directly with their local manufacturing communities to strengthen the competitiveness of our Nation's domestic manufacturing base. MEP supports the mission of NIST and the DoC to promote U.S. innovation and competitiveness and enable economic growth for American industries, workers, and consumers. Across the country, MEP Centers serve as trusted advisors to their manufacturing clients. MEP helps companies navigate economic and business challenges, and provides an innovation framework to enable them to capitalize on opportunities and develop pathways leading to profitable growth. Services provided by MEP are grounded in technology-related activities, sustainability, efficiencies through continuous improvement, and the integration of supply chains. In FY 2014, MEP began a systematic recompetition of the national system of MEP centers. By the end of FY 2015 nearly one-third of all the States will have undergone recompetition, with more than half of the States to be recompeted by end of FY 2016. This nation-wide renewal will be completed by 2017.

National Network for Manufacturing Innovation (NNMI)

The request provides funds for Federal investment in the National Network for Manufacturing Innovation (NNMI), which will serve to create an effective manufacturing research infrastructure for U.S. industry and academia to solve industry-relevant problems. The newly authorized NNMI will consist of linked Institutes for Manufacturing Innovation (IMIs) with common goals, but unique concentrations. In an IMI, industry, academia, and government partners leverage existing resources, collaborate, and co-invest to nurture manufacturing innovation and accelerate commercialization. As sustainable manufacturing innovation hubs, IMIs will create, showcase, and deploy new capabilities, new products, and new processes that can impact commercial production. They will build workforce skills at all levels and enhance manufacturing capabilities in companies large and small. Institutes will draw together the best talents and capabilities from all the partners to build the proving grounds where innovations flourish and to help advance American domestic manufacturing. The request includes $150.0 million for the program to fund two Institutes for five years and also fund coordination efforts.

Summary of Proposed Changes

STRS

1. <u>Ensuring a World Class Neutron Research Facility (+$11.0 million and +1 FTE)</u>

NIST requests an increase of $11.0 million and 1 FTE to ensure that NIST continues to provide a world-class neutron research facility, providing access to sophisticated measurement tools that can be used by industry. Growing the economy, improving industrial competiveness, and developing the products of tomorrow require providing industry with access to sophisticated measurement tools enabling researchers to find solutions to problems quickly. Neutrons have been enormously successful as a unique probe of the structure and dynamics of materials for researchers from many different backgrounds, including academia and industry. Neutrons can provide information that simply cannot be obtained using more conventional methods available in the researchers' own laboratories. Worldwide, the demand for access to neutron measurement capabilities far exceeds the supply, and the NCNR is the only U.S. neutron research facility with a focus on enhancing industrial competitiveness. It is therefore essential to U.S. industry, and the long-term economic growth of the U.S., that the NCNR is optimally equipped to provide state-of-the-art measurement tools to the U.S. scientific and engineering community.

The NCNR will maintain and grow its high quality facility to address the neutron supply-demand mismatch by investing in a lifetime extension of the source facility to maintain reliable operations and high availability to the end users. The investment will ensure the high reliability and availability of the facility through strategic enhancements of the reactor source (including obtaining an adequate supply of reactor fuel) and supports NIST's capacity to grow innovation-intensive economic sectors.

2. <u>Materials Genome Initiative (+$10.0 million and +16 FTE)</u>

NIST requests an increase of $10.0 million and 16 FTE to enable NIST to create advanced materials discovery tools and data for industry, in support of the Administration's Materials Genome Initiative (MGI). The proposed increase provides the resources to accelerate NIST's progress in its key role in the MGI, an interagency effort to dramatically influence the pace for bringing new materials to market. NIST is underway in developing an advanced materials innovation infrastructure, including data assessment and validation, data standards, and modeling and simulation tools. This increase is necessary to enable NIST to meet the ambitious timelines demanded by industry and other stakeholders to provide this interoperability and accessibility of materials information. By leveraging resources and partnerships, NIST will assist U.S. manufacturers in achieving materials by design for high-tech products in a range of industrial sectors.

3. <u>Disaster Resilient Buildings and Infrastructure (+$10.0 million and +13 FTE)</u>

NIST requests an increase of $10.0 million and 13 FTE to develop science-based building codes and standards to improve disaster resilience of communities impacted by natural and man-made hazards. The request would fund efforts to develop and accelerate the adoption and use of the underlying measurement science to improve predictive capabilities, and improve codes, standards and practices for cost-effective improvement of disaster resilience, including life-safety and reduction of property loss, due to natural and man-made hazards.

4. <u>Advanced Communications – Addressing the Spectrum Crunch (+$9.0 million and +16 FTE)</u>

NIST requests $9.0 million and 16 FTE to develop the measurement science and tools necessary to improve spectrum sharing and increase spectrum efficiency of commercial wireless radio-frequency communication systems and to accelerate the deployment of future wireless communications systems that operate at millimeter-wave frequencies. With the requested funds, NIST will focus its efforts on research that supports industry to develop and deploy advanced communication technologies for both the existing and future frequency spectrum bands allocated for wireless communication systems. These areas include Increased Spectrum Efficiency, Improved Spectrum Sharing, and Millimeter-wave Communications Systems.

5. <u>Strengthening NIST Cryptographic Capabilities to Address the Cybersecurity Concerns of Today and Tomorrow (+$7.0 million and +10 FTE)</u>

NIST requests an increase of $7.0 million and 10 FTE to strengthen the Nation's cybersecurity posture by providing strong cryptographic solutions and the development of privacy enhancing solutions and tools. Cybersecurity is a strategic priority that is vital to the economic and national security interests of the United States. In addition to the obvious financial ramifications with nearly $262.0 billion of e-commerce transactions in the U.S. alone for 2013, interconnected networks of computers have become essential for critical functions that affect every aspect of our lives including air traffic control, factory operation, and electric power distribution. A day does not go by without a new story of consumer data stolen, government networks attacked, or peoples personal data being used against them in acts of intimidation or humiliation. While NIST activities target these cybersecurity challenges such as the development of cybersecurity standards for Federal information systems, the newly released Cybersecurity Framework to reduce cybersecurity risk to critical infrastructure, and the launch of the National Cybersecurity Center of Excellence have helped to improve our overall cybersecurity awareness and posture. However, NIST's core technical capabilities cannot stagnate if NIST is to keep pace in what has become a rapidly escalating arms race to protect our individual, corporate, and public sector data, information, and systems from attacks from individual actors, criminal organizations, and nation-states. NIST must immediately build out its technical talent in cryptography to effectively address the rapidly emerging threats in this field. Simultaneously, with more citizens using web-based tools for everyday activities ranging from holiday shopping to online bill payment to using social media tools to stay connected with friends and family there is a pressing need for robust tools that provide users assurance about the privacy of their information and their online transactions.

6. <u>Advanced Sensing for Manufacturing (+$5.0 million and +10 FTE)</u>

NIST requests an increase of $5.0 million and 10 FTE to support U.S. competitiveness in advanced manufacturing by filling sensing and measurement gaps in the areas of advanced sensors used for process control. The long-term competitiveness of the U.S. economy relies heavily on the ability of the manufacturing sector to establish and maintain itself as a global leader. Advanced manufacturing technologies will revitalize this sector and ensure that it continues to be the engine of innovation and job creation that the U.S. needs for a secure and sustainable future. NIST will support advanced manufacturing in key areas in electronics, optics, and photonics identified in several seminal reports from the National Academies and other groups, including the one from the National Science and Technology Council Fast Track Action Committee co-chaired by NIST that produced an April 2014 report *Building a Brighter Future with Optics and Photonics*. Specifically, NIST will assist industry by developing sensors and methods for diagnostics and process control in advanced manufacturing.

<u>7. Smart Cities Cyber Physical Systems (+$5.0 million and +14 FTE)</u>

NIST requests an increase of $5.0 million and 14 FTE to develop the measurement science foundations for advanced smart city technologies that improve the livability, workability, safety, and resilience of communities across the Nation. The request funds efforts to develop and accelerate the adoption and use of measurement science foundations that enhance innovation in smart city technologies and increase the market size for and accessibility to markets for U.S. industry. Standards that enable innovation and entrepreneurship in smart city technologies can increase the economic competitiveness of U.S. industry by opening markets in the rapidly growing global smart city market. Facing rapid population growth, inefficient and aging infrastructures, and the needs of an increasingly digital society, communities across the Nation and around the world, from small towns to megacities, look to harness the power of emerging cyber physical systems and Internet of Things (IoT) technologies to improve livability, workability, resilience, and sustainability. These communities also seek access to advanced technologies for their residents, businesses, and institutions to catalyze jobs growth and create new businesses by enhancing the way people work, learn, and interact. Among the largest barriers to meeting these goals through commercial innovation are limitations in the interoperability and scalability of many of today's smart city solutions. These barriers mean that today's smart city systems are often custom implementations that are costly and inefficient, work in only one city or one infrastructure, create stranded systems that cannot readily be upgraded or extended, prevent meaningful comparisons for informed acquisition decisions, and stifle innovation and growth in the smart city technologies market. This initiative creates the measurement science and technical standards required for the design and performance measurement of scalable, extensible, and interoperable smart city solutions that empower U.S. communities and ensure American companies can be competitive in the rapidly growing global smart city market.

8. Manufacturing Entrepreneurship (+$5.0 million and +1 FTE)

NIST requests an increase of $5.0 million and 1 FTE as part of the Administration's efforts to strengthen the U.S. manufacturing sector by reducing barriers for new entrepreneurs to enter the manufacturing marketplace.

In recent years a trend has emerged where a growing number of individuals are self-identifying as Makers, or manufacturing entrepreneurs. Much of this trend has been driven by a mixture of new technologies and grass roots organizations. Examples of these drivers include:

- large number of "shared spaces" (Fab Labs, TechShops, makerspaces, LabCentral) that allow entrepreneurs access to manufacturing tools and the skills needed to use them;
- emergence of accelerators, incubators, and seed stage funds that are focused on hardware and manufacturing startups, such as Bolt and Dragon Innovation;
- ability of entrepreneurs to raise funding and gauge the level of customer interest in their products using crowdfunding sites like KickStarter and IndieGoGo;
- multi-channel retailers that are providing access to markets for entrepreneurs, such as the GE-Quirky-Target and Nordstrom-Etsy collaborations; and
- new conferences such as MakerCon which convene the otherwise isolated makers to form collaborative communities.

These entrepreneurs are seeking to capitalize on the small-batch industrial revolution. Many aspects of the digital revolution are accessible to new entrepreneurs. Numerous resources and tools exist to help individuals create new businesses. But it is much more difficult when that new business is manufacturing. Advanced, small batch manufacturing technologies can seem inaccessible to an entrepreneur new to manufacturing. Much manufacturing knowledge is not readily available and manufacturing technologies are evolving rapidly. Independent entrepreneurs, or "Makers," who want to produce their designs in small production runs encounter cost and technical barriers.

The following objectives will be addressed by this initiative through focused actions:

- Access to manufacturing knowledge that increases the value and variety of what manufacturing entrepreneurs can design and manufacture
- A robust manufacturing eco-system that provides full support for new manufacturing entrepreneurs
- Effective collaboration between new manufacturing entrepreneurs and Federal government programs.

9. Quantum-Based Sensors and Measurements -- Developing the Measurement Infrastructure for Tomorrow's Industry (+$5.0 million and +11 FTE)

NIST requests an increase of $5.0 million and 11 FTE to support forward looking research programs in areas that will revolutionize and transform future U.S. economic competitiveness. The requested funding provides resources to support the measurement science and standards necessary to maintain U.S. leadership in quantum information science. Quantum information science is an emerging research field with the potential to revolutionize computation, communication, precision measurement, and fundamental quantum science. This field seeks to harness the fundamental laws of physics to dramatically improve information acquisition, transmission, and processing. This proposed increase supports NIST's key role in quantum information science, which will lead to improved information security and assurance, improved and cheaper standards, and more sensitive sensors for a variety of applications. NIST's success will ensure U.S. leadership in quantum information science, improving U.S. competitiveness in advanced manufacturing, and strengthening national security, all while keeping NIST at the cutting edge of future standards development. This mission-driven effort also supports a large portion of NIST's world-class basic research effort that has led to four NIST Nobel Prizes.

10. Biomanufacturing/Engineered Biology: Developing Engineering Principles for Efficient Biomanufacturing (+$4.0 million and +4 FTE)

NIST requests an increase of $4.0 million and 4 FTEs to ensure quality and predictability in the design of synthetic biological systems for efficient production of fuels, chemical feedstocks, pharmaceuticals, and medical therapies. Biomanufacturing has the potential to usher in the next Industrial Revolution into many U.S. manufacturing sectors. Biomanufacturing is the use of living organisms to produce a commodity, including fuels, chemicals, pharmaceuticals and medical therapies. There is increasing interest with the Federal government to help incentivize the creation of a bio-based economy. The requested funds would allow NIST to coordinate, develop and assess measurement infrastructure for biological systems; develop robust design and testing tools for biological systems, and develop and deploy predictive models for biological systems.

11. Lab to Market/Technology Transfer (+$4.0 million and +10 FTE)

NIST requests an increase of $4.0 million and 10 FTE to expand lab to market and technology transfer activities through the development and deployment of data sharing and collaborative tools and services. The U.S. invests more than $135.0 billion annually in research and development. A wide range of life-changing commercial technologies were nurtured by such federally funded R&D. Federally-funded R&D has historically led to dramatic economic growth, and there is potential to increase the public's return on this investment in terms of innovation, job creation, societal impact, and economic prosperity. To fully realize this impact, the transfer of technology resulting from this investment to U.S. businesses must be accelerated. Through efforts under the Presidential Memorandum, Accelerating Technology Transfer and Commercialization of Federal Research in Support of H gh-Growth Businesses and the Lab to Market Cross Agency Priority Goal, great progress is being made. However, there remains work to be done to implement cross-agency solutions and develop interagency tools that support these activities. Such a coordinated approach will better leverage the entire research portfolio than the current piecemeal approach. Specifically, NIST will lead the development of infrastructures for information sharing, data dissemination, and increase collaborations to address national priorities and enhance business competitiveness. The America COMPETES Reauthorization Act of 2010 created the position of Under Secretary for Standards and Technology that included Federal government-wide responsibilities for technology transfer. These include analysis, planning, coordination, reporting and general oversight of technology transfer responsibilities under Section 5 of the Federal Technology Transfer Act of 1986, the Bayh-Dole Act of 1980, and Executive Orders 12591 and 10096. These duties include coordinating Federal agency activities for the commercialization of technology developed at Federal laboratories, monitoring of agency use of cooperative agreements as a means of increasing the efficiency of transferring federally funded technology to the private sector, and the preparation of related reports. This initiative will strengthen NIST and Federal Technology Transfer activities.

12. <u>STRS Programmatic Decrease: (-$12.7 million, 0 FTE)</u>

The NIST request includes a decrease of $12.7 million to adhere to the prescribed FY 2016 funding levels. NIST would minimize negative impact on newly funded Administration initiatives and priorities (e.g., Advanced Manufacturing). With the proposed reduction, NIST does not plan on utilizing Reduction-In-Force (RIF) authority to meet funding targets to fund current programs.

To meet its science and commerce mission, NIST relies on effective partnerships with universities, industry, and consortia partners as a vehicle to leverage their expertise to help NIST meets its measurement science and technology mission. This leveraging occurs in the form of grants and contracts, both of which may include funding of research associates, postdocs, graduate students and equipment, awarded to these partners at various times of the year and depending on current measurement science needs. To preserve NIST's core programs in our laboratories, NIST would reduce grants and contracts with partners. While this reduction preserves core laboratory programs at NIST, it would degrade these partnerships that NIST relies on to keep pace with emerging measurement science, technology, and innovations offered by these partners through grants and contracts.

CRF

<u>1. Safety Capacity, Maintenance and Major Repair (SCMMR) (+$7.9 million and +0 FTE)</u>

NIST requests an increase of $7.9 million in the SCMMR program to restore NIST Construction of Research Facilities funding that was reduced in the FY 2015 appropriation and fund the next phase of the planned multiyear critical renovations. The increase will expedite the maintenance and repair of facilities and reduce the impact of facility deficiencies on laboratory projects. The planned renovation projects, to include the Building 1 Renovation, will address the deterioration of critical facilities by accomplishing specific SCMMR-type improvements. These renovations will reduce the backlog of maintenance, repair and replacement issues identified in the recent facility condition assessments. Executing major renovation projects within the SCMMR program will also allow flexibility to fund the most critical facilities requirements to fulfill the NIST mission.

ITS

1. National Network for Manufacturing Innovation (NNMI) (+$150.0 million and +7 FTE)

The request provides funds for Federal investment in the NNMI, which will serve to create an effective manufacturing research infrastructure for U.S. industry and academia to solve industry-relevant problems. The newly authorized NNMI will consist of linked Institutes for Manufacturing Innovation (IMIs) with common goals, but unique concentrations. In an IMI, industry, academia, and government partners leverage existing resources, collaborate, and co-invest to nurture manufacturing innovation and accelerate commercialization. As sustainable manufacturing innovation hubs, IMIs will create, showcase, and deploy new capabilities, new products, and new processes that can impact commercial production. They will build workforce skills at all levels and enhance manufacturing capabilities in companies large and small. Institutes will draw together the best talents and capabilities from all the partners to build the proving grounds where innovations flourish and to help advance American domestic manufacturing. The request includes $150.0 million for the program to fund two Institutes for five years and also fund coordination efforts.

As part of its efforts to revitalize U.S. manufacturing, the Administration is proposing mandatory funding to complete the build out of the National Network of Manufacturing Innovation (NNMI), consisting of 45 institutes where researchers, companies, and entrepreneurs can come together to develop new manufacturing technologies with broad applications. The $1.93 billion one-time mandatory funding proposal will support 29 institutes, building on the nine institutes already funded through 2015 and the Budget's support of seven new manufacturing institutes in the Departments of Commerce, Agriculture, Defense, and Energy. The Administration proposes to transition this program from discretionary funds to a mandatory appropriations account, to be executed from FY 2017 to FY 2024 to complete the network of 45 Institutes.

2. MEP Programmatic Increase (+$9.7 million and 0 FTE)

The proposed budget increase will enable MEP to execute the Action Plans identified in the DoC Strategic Plan (FY 2014 – FY 2018): "America is Open for Business".

MEP is identified as a central agent in achieving the following Strategic Objectives in the Innovation Strategic Goal:

- Growing a productive, agile and high value manufacturing sector,
- Increasing the capability of U.S. regional economies to accelerate the production of value-added goods and services, and
- Accelerating the development of industry-led skills strategies.

In addition, MEP's successfully proven ExporTech Program, in a partnership with the International Trade Administration, advances the Trade and Investment Strategic Objective of increasing U.S. exports by broadening and deepening the U.S. exporter base.

The funding increase will also allow the MEP system to play a robust role in transferring to the small manufacturing sector the results of the R&D activities of the new Institutes for Manufacturing Innovation, whose establishment is a priority of the Administration, the Congress, and NIST. MEP is explicitly identified in the proposed authorizing legislation as the vehicle for small and medium-sized enterprises (SME) engagement; however, the mission-driven agency funded NNMI model of the first eight Institutes does not explicitly provide resources for a nation-wide mechanism for SME engagement. MEP's deep experience in technology transition and acceleration, its 60 Center network in every State, now informed by the Manufacturing Technology Acceleration Center pilot program, enhances this capability. Additional funding will enable the Centers to execute the full mission of the NNMI program.

3. <u>AMTech Increase (+$6.8 million and 0 FTE)</u>

The Advanced Manufacturing Technology Consortia (AMTech) program establishes industry-led consortia, which will identify and prioritize research projects supporting long-term industrial research needs. AMTech creates the incentive for multiple industry stakeholders to share financial and scientific resources, together with state and local government interests, as well as technical innovators at universities and government laboratories. The AMTech model demonstrates how the Federal government may leverage resources for a greater societal and commercial outcome by producing research that fits into industry roadmaps. The AMTech program fills a critical gap by providing resources for directed basic and measurement research that is seen as too long-term and has too much market uncertainty for industry to invest in on its own. Research challenges addressed by an AMTech consortium are pre-competitive: all industry members will benefit from the R&D outcomes and the partnerships are built on open access to intellectual property. AMTech provides a mechanism to leverage agency investment in order to launch breakthrough technologies that will collapse the timescale of innovation. This funding request continues to allow the AMTech program to more closely leverage the increased investment in Advanced Manufacturing at NIST, and ensure that the consortium building and roadmapping goals of AMTech can have a positive impact on industry.

<u>Working Capital Fund</u>

The Working Capital Fund finances research and technical services performed for other Government agencies and the public. These activities are funded through advances and reimbursements. The Fund also finances the acquisition of equipment, standard reference materials, and storeroom inventories until issued or sold.

<u>Reimbursable Program</u>

NIST's reimbursable services consist of technical work performed for other Federal agencies, state and local governments, and the private sector. These services include calibrations and special tests, advisory services, and the sale of Standard Reference Materials. The unique measurements and standards expertise developed with appropriated funding gives NIST the capability to perform these services on a reimbursable basis. NIST accepts other agency work based on an established set of criteria which include: the need for traceability of measurements to national standards; the need for work that cannot or will not be addressed by the private sector; work supported by legislation that authorizes or mandates certain services; work that would result in an unavoidable conflict of interest if carried out by the private sector or regulatory agencies; and requests by the private sector for NIST action or services. NIST's reimbursable program is estimated to be $151.7 million in FY 2015 and $143.1 million in FY 2016.

FY 2016 Annual Performance Plan / FY 2014 Annual Performance Report

National Institute of Standards and Technology

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Part 1: Agency and Mission Information

Section 1.1: Overview

Since 1901, NIST (known as the National Bureau of Standards until 1988) has developed and maintained key standards for the Nation, a role that the U.S. Constitution assigns to the Federal government, and has been supplying the measurements and tools to help U.S. industry compete. As a non-regulatory agency in the U.S. Department of Commerce (DOC), an experienced partner of industry, and the Federal research agency specifically focused on promoting U.S. economic competitiveness, NIST is well-positioned to accelerate and promote innovation and advanced technologies through its laboratory programs and its Innovation and Industry Services Programs.

NIST employs about 3,000 scientists, engineers, technicians, and support and administrative personnel and carries out its technical work at its two main research campuses in Gaithersburg, Md., and in Boulder, Colo. At these campuses, NIST also hosts about 2,700 associates and facility users from academia, industry, and other government agencies who collaborate with NIST staff. NIST also participates in seven external institutes in basic physics, quantum physics, biology/biotechnology, biomedical measurement science, advanced materials, cybersecurity, and marine science, located in Boulder, Colo., College Park, Md., Palo Alto, Calif., Chicago, Ill, Rockville, Md., and Charleston, S.C., respectively. In addition, NIST partners with nearly 1,300 manufacturing specialists and staff at about 400 Hollings Manufacturing Extension Partnership (MEP) service locations around the country.

Section 1.2: Mission Statement

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.

Section 1.3: Organizational Structure

NIST Organizational Structure

Director
Under Secretary of Commerce for Standards and Technology
Willie E. May (acting)

Chief of Staff
Kevin Kimball

Executive Officer for Administration
Management and Organization
Program Coordination
Public Affairs Office
International and Academic Affairs
Congressional and Legislative Affairs

Associate Director for Laboratory Programs/ Principal Deputy
Richard Cavanagh (acting)

Staff Offices
Standards Coordination
Special Programs

Material Measurement Laboratory
Laurie E. Locascio

Communications Technology Laboratory
Kent Rochford

Physical Measurement Laboratory
James Olthoff (acting)

Engineering Laboratory
Howard Harary

Information Technology Laboratory
Charles Romine

Center for Nanoscale Science and Technology
Robert Celotta

NIST Center for Neutron Research
Robert Dimeo

Associate Director for Innovation & Industry Services
Phillip Singerman

Staff Offices
Advanced Manufacturing
Economic Analysis
Technology Innovation
Technology Partnerships

Baldrige Performance Excellence Program
Robert Fangmeyer

Hollings Manufacturing Extension Partnership
Phillip Singerman (acting)

Associate Director for Management Resources
Mary Saunders

Staff Offices
Civil Rights and Diversity
Research Support Services

Office of Acquisition and Agreements Management
Cecelia Royster

Office of Safety, Health and Environment
Richard Kayser

Office of Financial Resource Management
George Jenkins

Office of Human Resources Management
Susanne Porch

Office of Information Systems Management
Delwin Brockett

Office of Facilities and Property Management
Steve Salber

Part 2: Cross-Agency Priority Goals

Section 2.1: Overview

Per the GPRA Modernization Act requirement to address Cross-Agency Priority Goals in the agency strategic plan, the annual performance plan, and the annual performance report, please refer to www.Performance.gov for the agency's contributions to those goals and progress, where applicable. NIST currently contributes to the following CAP Goals: Cybersecurity, Job-creating investment, STEM Education, and Economic Growth: lab-to-market.

Lab-to-Market

Agency Official: Phillip Singerman, Associate Director Innovation and Industry Services

A sub-team from the Interagency Working Group met to draft a roadmap white paper addressing collaborations. The two main components will be 1) an analysis of CRADA language across agencies, to identify areas of commonality that could be used to create a standard template backbone, streamlining the negotiation process for outside partners; and 2) an analysis of agency-specific technology transfer authorities, how they are used at those agencies, and how other agencies envision using them for their own partnerships, with the goal of making recommendations for the expansion of certain authorities to additional agencies. NIST also made contributions towards two additional white papers on entrepreneurial training for researchers, and Entrepreneur-In-Residence programs at federal agencies. The Interagency Working Group is discussing using prize competitions to address questions about effective metrics. Future topics to be addressed at upcoming meetings include evaluating best practices in licensing, and discussing the promulgation of new regulations for improved personnel exchange. The Bayh-Dole working group is moving forward with university groups to begin discussing the state of Bayh-Dole and areas that may need to be addressed. NIST is reviewing, via the Federal Laboratory Consortium, best practices in incentivizing government researchers to participate in the technology transfer process, identifying opportunities for cross-agency training, and reviewing the consistency of data between FLCBusiness and GSA records.

Cybersecurity

Agency Official: Delwin Brockett, Office of Information Systems Management

Strong Authentication

During FY 2014, a NIST internal directive was issued requiring use of assigned PIV cards to authenticate to PIV enabled information systems. NIST has also proactively contributed to the development of a DOC directive on the use of PIV authentication. NIST has also enabled several of its internal applications to accept PIV card authentication.

Trusted Internet Connection
NIST completed implementation of these capabilities at its Gaithersburg, Maryland facilities in FY 2013 through the acquisition of AT&T Managed Trusted Internet Protocol Service (MTIPS) through the General Services Administration (GSA) Networx program. NIST Boulder, Colorado facilities rely on Internet services provided by National Oceanic and Atmospheric Administration (NOAA). NOAA anticipates their TIC implementation will be operational in FY 2015.

Continuous Monitoring
The DoC strategy for meeting this requirement is through the implementation of the DoC Enterprise Cybersecurity Monitoring and Operations (ECMO) initiative. DoC selected the IBM Tivoli Endpoint Manager (TEM) software platform for implementation of ECMO. On behalf of DoC, NIST implemented and provides TEM information system services for all DoC Operating Units.

Part 3: Strategic Goals and Objectives

Section 3.1: Corresponding DoC Strategic Goals, and Objectives

Goal	Objective Number	Objective Name	Leader
Innovation	2.1	Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization.	Willie May, Acting Under Secretary for Standards and Technology, Acting NIST Director
Innovation	2.2	Increase the capacity of U.S. regional economies to accelerate the production of value-added goods and services by providing services to and investments in businesses and communities.	Willie May, Acting Under Secretary for Standards and Technology, Acting NIST Director
Innovation	2.3	Strengthen the Nation's digital economy by championing policies that will maximize the potential of the Internet, expanding broadband capacity, and enhancing cybersecurity to provide a robust environment for innovation.	Larry Strickling, Assistant Secretary for Communications and Information, National Telecommunications and Information Administration (NTIA)
Innovation	2.4	Accelerate the development of industry-led skills strategies that result in a productive workforce for employers and high-quality jobs for workers.	Matt Erskine, Deputy Assistant Secretary, Economic Development Administration (EDA)
Innovation	2.5	Accelerate growth of innovation-intensive economic sectors by building public and private capacity to invent, improve, and commercialize new products and services.	Willie May, Acting Under Secretary for Standards and Technology, Acting NIST Director

Environment	3.1	Advance the understanding and prediction of changes in the environment through world class science and observations.	Kathy Sullivan, Under Secretary of Commerce for Oceans and Atmosphere and National Oceanic and Atmospheric Administration (NOAA) Administrator
Environment	3.3	Strengthen the resiliency of communities and regions by delivering targeted services to build capacity.	Kathy Sullivan, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator
Data	4.1	Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.	Mark Doms, Under Secretary for Economic Affairs, Economics & Statistical Administration (ESA)

Objective 2.1: Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization.

Strategies:

Establish the National Network for Manufacturing Innovation (NNMI). There is a gap in the U.S. innovation infrastructure that hinders the transition of new manufacturing processes and technologies from the lab bench to the manufacturing floor. The NNMI, a proposed national network of up to 45 institutes, will bring together companies, universities and community colleges, and government to develop world-leading technologies and capabilities that U.S.-based manufacturers can apply in production. As self-sustaining hubs, these institutes will create, showcase, and deploy new capabilities, new products, and new processes that can impact commercial production. They will build workforce skills at all levels and enhance manufacturing capabilities in companies large and small.

Support industry consortia to identify and address shared technical challenges. A common vision of long-term technology challenges can spur innovation across an industry. NIST's Advanced Manufacturing Technology (AMTech) program will provide grants to industry-led consortia to identify and prioritize research projects critical to long-term industrial advances. These technology roadmaps and related outputs will help guide applied research to meet industry's needs, some of which AMTech will support through university and government laboratory research funding.

Collaborate with industry on measurement science and standards to solve technical challenges. Rejuvenating U.S. manufacturing will require the development of measurements that support new, advanced manufacturing techniques. NIST will enhance partnerships with the U.S. manufacturing sector to develop and disseminate test methods, measurement tools and know-how, and scientific data that are embedded in the processes, products, and services of nearly every U.S. manufacturing industry.

Progress Update:

As part of the AMTech program, NIST in May 2014 awarded 19 advanced manufacturing technology planning awards totaling $9 million to new or existing industry-driven consortia. These grants will help the consortia develop research plans that address high-priority challenges impeding the growth of advanced manufacturing in the United States. Technology roadmapping is a key component of the projects. Each consortium will engage manufacturers of all sizes, university researchers, trade associations and other stakeholders in an interactive process to identify and prioritize research projects that reduce shared barriers to the growth of advanced manufacturing. In July 2014 NIST announced a new competition for a second round of planning grants totaling $5.6 million in two year grants, the funding opportunity closed in October 2014 and NIST is now reviewing the proposals.

Working with federal agencies including the Department of Defense (DOD), the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF), the NIST-hosted Advanced Manufacturing National Program Office (AMNPO) is working to establish Institutes for Manufacturing Innovation and to develop a network of the institutes for exchanging best practices. AMNPO coordinated a successful meeting of institute leaders in 2014, and is planning additional opportunities to reinforce relationships across institutes. As part of these efforts, NIST has provided $19.5M to support research efforts at the various institutes. In addition, AMNPO has been developing guidance documents on important institute topics such as institute performance metrics and intellectual property rights. The AMNPO continues to coordinate with Hill staff to convey the importance and success of the institutes, for example through a Hill Day event on September 18, 2014. Bicameral legislation to establish the NNMI, the Revitalize American Manufacturing and Innovation Act is being considered in both the House of Representatives (H.R. 2996) and the Senate (S.1468).

Next Steps:

The NIST-hosted AMNPO is continuing to provide critical guidance for the networking and establishment of Institutes for Manufacturing Innovation, and to support meetings than bring together leadership from the various institutes. NIST is preparing for a DOC role in establishing future institutes upon authorization of NNMI. This planning will utilize recommendations from the recently released *Accelerating U.S. Advanced Manufacturing* report the President's Council of Advisors on Science and Technology, a federal advisory committee.

NIST laboratory programs will continue to expand their mechanisms for partnership with industry to accelerate innovation in advanced manufacturing. For example, the Material Genome Initiative (MGI) is strengthening ties with the materials Center of Excellence, the Center for Hierarchical Materials Design, and with a number of industry partners to address priority materials design needs. In addition, the NIST Center for Automotive Lightweighting recently commissioned a unique Next-Generation Formability System, which investigates the effect of multi-dimensional stress and strain. The NCAL is using this unique instrument to test industry-submitted samples, the results of which are shared with the Center's industry and academic partners.

Objective 2.2: Increase the capacity of U.S. regional economies to accelerate the production of value-added goods and services by providing services to and investments in businesses and communities.

Strategies:

Support small and mid-sized manufacturing by restoring robust supply chains. Small and mid-sized manufacturers are central to regional economic growth and innovation, but they can face unique challenges in deploying advanced manufacturing technologies. Through its national network of centers, the NIST Hollings Manufacturing Extension Partnership (MEP) will expand its efforts to strengthen the competitive position of small and mid-sized manufacturers through new efforts and partnerships focused on supply chain technology areas to speed the adoption of technology and commercialization.

Progress Update:

MEP funded five Manufacturing Technology Acceleration Center (MTAC) pilot projects in 2014 to accelerate technology adoption across US supply chains. In addition, MEP Centers are implementing a Center-developed supply chain optimization set of tools and materials focused on establishing a coaching and mentoring partnership between the MEP Center's subject matter experts and participating manufacturers to address barriers to effective supply chains. MEP centers help to improve supply chain performance by quantifying the needs of the supply chain and focusing on the points in the process that are impeding throughput. Total cost of ownership is one element on which the centers provide guidance, along with executive and partner engagement and risk management.
In June 2014, NIST MEP hosted the Grantee Regional Collaboration Meeting for the 53 grantee teams from four multiagency initiatives: the Jobs and Innovation Accelerator Challenge, the Rural Jobs Accelerator, the Advanced Manufacturing Jobs and Innovation Challenge and the Make It In America. These four initiatives are the result of the collaborative work of 8 federal entities: EDA, DOE, DOL, NIST MEP, SBA, USDA, ARC, DRA. The 150 attendees included representatives from the grantee teams from the 30 states such as Workforce Investment Boards, State Economic Development Agencies, MEP Centers, Universities, Community Colleges, regional councils, non-profits, chambers of commerce. The day and a half event provided a venue for information and peer knowledge exchange on the latest practices that will accelerate cluster and industry development in urban and rural regions for small and medium sized manufacturers, worker training, job creation and business investments in the United States.

The MEP program continues to provide valuable services to America's small and medium manufacturers. For every one dollar of federal investment, the MEP generates nearly $19 in new sales growth and $21 in new client investment. This translates into $2.2 billion in new sales annually. For every $1,978 of federal investment, MEP creates or retains one manufacturing job.

Next Steps:

In 2014, MEP, working with the MEP Advisory Board, developed a Strategic Plan that outlines a number of steps the Program will take over the next few years focused on supporting partnerships, enhancing competiveness and developing expanded capabilities to support the needs of U.S. manufacturers. More information is available here: http://www.nist.gov/mep/strategic-plan.cfm. NIST MEP launched a competition in FY2014 to fund Centers in 10 states. The competition is the first in a multiyear effort to update the funding structure to better match needs with resources in MEP's network of centers. This first competition will serve as a demonstration of the process to re-compete the full network. Additional competitions are planned for FY2015.

Objective 2.3: Strengthen the Nation's digital economy by championing policies that will maximize the potential of the Internet, expanding broadband capacity, and enhancing cybersecurity.

Strategies:

Foster advanced communications technologies. Spectrum sharing and other innovations in advanced communications will drive economic growth and development. The Department will leverage the key research and engineering expertise and capabilities of NIST and NTIA by establishing the CAC. This unique national asset will provide both research and testing capabilities. NIST and NTIA will partner with industry, academia, and government agencies to foster the invention, development, and deployment of future advanced communications technologies.

Create a standards framework to reduce cyber risks to critical infrastructure. The national and economic security of the United States depends on the reliability of critical infrastructure, including the electric grid, financial sector, and communications system. Taking full advantage of existing cross-sector security standards and guidelines, NIST is leading the development of a Cybersecurity Framework that will help critical infrastructure owners and operators to identify, assess, and manage cyber risk. NIST will support future private sector implementation of this framework.

Progress Update:

The new Center for Advanced Communications will implement a key provision of a memorandum President Obama issued on June 14, 2013, on "Expanding America's Leadership in Wireless Innovation" (http://www.whitehouse.gov/the-press-office/2013/06/14/presidential-memorandum-expanding-americas-leadership-wireless-innovatio). In support of the new CAC, NIST has established a new Communications Technology Laboratory at the Boulder campus. NIST has procured an initial set of advanced instrumentation necessary to develop required new metrology capability at NIST to support the CAC.

Cybersecurity Framework -- Under Executive Order 13636, *Improving Critical Infrastructure Cybersecurity,* NIST was charged with the responsibility to develop a voluntary framework – based on existing standards, guidelines, and practices – for reducing cyber risks to critical infrastructure. The Framework seeks to promote the wide adoption of practices to increase cybersecurity across all sectors and industry types. It seeks to provide owners and operators a flexible, repeatable and cost effective risk-based approach to implementing security practices while allowing organizations to express requirements to multiple authorities and regulators. The first version of the framework was released on February 12, 2014 (http://www.nist.gov/cyberframework/upload/cybersecurity-framework-021214.pdf). The framework is not a static document and will continue to evolve over time. Updates on framework progress can be found at: http://www.nist.gov/itl/cyberframework.cfm.

In the fall of 2013, former NIST Director requested that NIST's primary advisory committee, the Visiting Committee on Advanced Technology (VCAT) review NIST's cryptographic standards and guidelines development process, in response to community concerns that a cryptographic algorithm in a NIST standard had been deliberately weakened. The findings, part of NIST's broader review in this area, called for the Bureau to increase its staff of cryptography experts and implement more explicit processes for ensuring openness and transparency to strengthen its cryptography efforts.

Next Steps:

As part of the initial efforts of the CAC, NIST and NTIA are working to finalize a partnership with DOD and other Federal agencies to ensure that the government has timely access to spectrum testing capabilities in order to help facilitate the development of new spectrum sharing technologies and to streamline their deployment.

NIST is continuing to update the Cybersecurity Framework, improving it based on feedback from users' experiences, while new standards, guidelines, and technology assist with implementation and future versions of the Framework. In addition, NIST is continuing significant industry engagements to ensure the Framework's adoption by critical infrastructure and other companies. NIST provided an update to the VCAT on the progress of their specific recommendations during their October 2014 meeting. Additional information is available from the presentations provided to the VCAT available at: http://www.nist.gov/director/vcat/upload/Cyber-VCAT-2014-10_final.pdf.

Objective 2.4: Accelerate the development of industry-led skills strategies that result in a productive workforce for employers and high-quality jobs for workers.

Strategies:

Implement industry-driven initiatives that provide U.S. workers with in-demand skills. Many unemployed or underemployed workers lack the skills that businesses need to fill the millions of open jobs across the Nation. NIST will capitalize on its relationships with businesses and state and local governments to champion and support employer-aligned skills programs. Through MEP's national system of centers, NIST will support and promote programs that identify the future hiring needs of small manufacturers and expose young people to STEM (science, technology, engineering, mathematics) fields.

Progress Update:

NIST MEP, in collaboration with MEP centers, is developing a talent management system - Strategic Management Acquisition and Retention of Talent (SMARTalent). SMARTalent is intended to help manufacturers operationalize their workforce development strategies. As manufacturers focus on workforce planning and investment, this resource, in combination with the expertise of the local MEP center, can help most effectively operationalize investments with the objective to enable manufacturers to eliminate task redundancies and streamlines processes.

MEP also supports industry efforts to respond to a long-standing issue for recruiting new talent for small manufacturers – public image of manufacturing. To help re-brand manufacturing and inform education providers and the general public about advanced manufacturing, MEP is reaching out through social media, publications, conferences, presentations, partnerships and direct Center involvement to change the image of manufacturing. All workforce initiatives and activities are shared across the MEP network.

MFG Day (http://www.mfgday.com/), co-produced by NIST MEP, Fabricators and Manufacturers Association, National Association of Manufacturers, The Manufacturing Institute, along with the Science Channel and Shell Oil, showcases a nation-wide number of activities, open houses and events to interest the public in manufacturing and the importance the industry plays in the U.S. economy. On October 3, 2014, more than 1600 events took place across the county in support of MFG day and providing manufacturers an opportunity to highlight their industry.

Next Steps:

NIST MEP has a number of initiatives that enable small and medium-sized manufacturers to improve their workforce development strategies. These include, in addition to SMARTalent, strategic consulting, training and education partnerships, workforce readiness, and business stabilization. More information on MEP's workforce strategies is available here: http://www.nist.gov/mep/workforce-initiatives.cfm.

NIST MEP along with the co-producers are working to address common misperceptions about manufacturing by supporting MFG Day. By working together during and after MFG DAY, manufacturers will begin to address the skilled labor shortage they face, connect with future generations, take charge of the public image of manufacturing, and ensure the ongoing prosperity of the whole industry.

Objective 2.5: Accelerate growth of innovation-intensive economic sectors by building public and private capacity to invent, improve, and commercialize new products and services.

__Strategies:__

Develop and provide next-generation measurement tools and standards. Precise measurements and robust standards are critical for an innovative high-technology economy and provide the foundations for interoperability between products and systems, enabling global trade. In close cooperation with industry, academia, and other federal agencies, NIST will advance measurement science, develop standard protocols and test methods, and evaluate and generate data supporting innovative areas of the economy. NIST's connections with private sector standards developing organizations will help ensure that new and updated standards have strong technical underpinning.

Build research capacity in emerging areas of research to meet tomorrow's challenges. Technological innovation is accelerating at a pace unprecedented in human history, and the continued competitiveness of U.S. industries will require breakthroughs in measurement science in all disciplines. Through the Centers of Excellence Program, NIST will partner with leaders in academia and industry to augment internal research programs and develop access to leading talent, ensuring that the Agency can meet future measurement science needs.

Accelerate rate of lab-to-market commercialization. A wide range of life-changing commercial technologies were nurtured by federally funded R&D, from the Internet, to the global positioning system (GPS), to leading-edge vaccines. The federal R&D enterprise must continue to support fundamental research and diffuse this knowledge through open data and publications. Through streamlined processes and increased engagement with entrepreneurs, DOC will facilitate industry access to federal laboratories and federally funded research.

__Progress Update:__

Investments to grow and strengthen the NIST Laboratory Programs have been the top priority of the agency for the past several years and as a result funding for the NIST Laboratory Programs has increased by 37% from FY 2010 through FY 2014. These increased resources have enabled NIST to launch a number of key programs to further accelerate innovation in a number of critical priority areas. Highlights include:

- NIST on a Chip -- NIST is developing a next-generation plan for advancing measurement services, called NIST on a Chip. NIST on a Chip is an integrated program to develop and deploy NIST-traceable measurements and physical standards that are deployed in the customer's lab, factory floor, device, or system; are easily used and integrated; are rugged, yet small in size and weight; and have low power consumption. As the reference standard is integrated into the device or process, many of the difficulties of the traditional measurement service model can be overcome, including minimal down time and recalibration, as well as improved flexibility for innovation. Measurement technologies include force, fluid flow, pressure, length, voltage, current, magnetic field, time and frequency, optical power, displacement, and electric field. Examples of work in this area can be found at: http://www.nist.gov/pml/newsletter/

- Centers of Excellence -- In FY 2013, NIST launched the NIST Centers of Excellence (COE) Program. The NIST Centers of Excellence will provide an interdisciplinary environment where researchers from NIST, academia, and industry will collaborate on emerging areas of basic and applied research and innovations in measurement science. These centers will focus on:
  - Fostering expanded development of expertise in measurement science and its role in innovation through the education and training of scientists and engineers;
  - Providing greater opportunities for NIST to engage with industry and entrepreneurs; and
  - Enhancing technical innovation through earlier alignment of measurement science with emerging and innovative fields of research.

  In FY2014 NIST established the COE in advanced materials, the Center for Hierarchical Materials and Design (CHiMaD), a partnership between Northwestern University, University of Chicago, and Argonne National Laboratory. The new center will focus on developing the next generation of computational tools, databases and experimental techniques to enable "Materials by Design*," one of the primary goals of the administration's Materials Genome Initiative (MGI). "Materials by design" employs physical theory, advanced computer models, vast materials properties databases and complex computations to accelerate the design of a new material with specific properties for a particular application.

  NIST also launched two federal funding opportunities for a COE in Community Resilience, and on focused on Forensic Science. More information about NIST's Center of Excellence Program can be found here: http://www.nist.gov/coe/

- Technology Transfer -- NIST, with its government-wide responsibilities for the analysis, planning, coordination, reporting, and general oversight of Federal technology transfer responsibilities is ideally positioned to support an Administration-wide effort in this area. NIST is strengthening its Federal tech transfer activities through developing human capital, empowering effective collaborations, opening access to tangible and intangible assets, and evaluating impact.

Next Steps:

In early FY2015 NIST will award two new Centers of Excellence in Community Resilience and Forensic Science. NIST will leverage these COEs to build technical capabilities in areas of national need at a scale and pace not available through traditional means.

NIST is part of an administration-wide Cross-Agency Priority Goal on technology transfer. For updates and plans on that goal, see www.performance.gov.

The National Research Council conducts technical assessments of the scientific impact of selected NIST laboratories on a yearly basis. For FY 2014, the NRC conducted technical assessments of the scientific impact of the Engineering Laboratory and the Material Measurement Laboratory with a focus on the following criteria: the technical quality and merit of the laboratory programs relative to the state-of-the-art worldwide, the effectiveness with which the laboratory programs are carried out and the results disseminated to customers, the relevance of the laboratory programs to the current and future needs of stakeholders, and the adequacy of the facilities and laboratory equipment to perform the program functions. In FY 2015, the NRC will assess the scientific impact of the Information Technology Laboratory and the Physical Measurement Laboratory. These assessments can be found here: http://nist.gov/director/nrc/

NIST also works with its Visiting Committee on Advanced Technology to identify priority areas and to help shape and define the NIST role in those areas. The current VCAT report can be found at: http://www.nist.gov/director/vcat/.

Objective 3.1: Advance the understanding and prediction of changes in the environment through world class science and observations.

Strategies:

Improve the understanding of greenhouse gas processes. As the effects of increased greenhouse gas become more apparent, there is a growing need for a better understanding of the processes that cause the increase. The National Oceanic and Atmospheric Administration (NOAA) and NIST will work cooperatively to link measurements and standards supporting the atmospheric and emissions monitoring communities. The efforts of both bureaus will advance measurement capabilities of the monitoring networks and improve measurements of greenhouse gas emissions on scales ranging from the global to metropolitan areas and cities.

Progress Update:

NIST has funded cooperative agreements furthering research efforts to sustain and expand greenhouse gas (GHG) measurements test beds in the U.S. currently located in Indianapolis, Ind. and Los Angeles, Calif. The Indianapolis testbed, begun in 2011, is a greenhouse gas observing network within and around the city with 12 real-time observing locations on communications, 6 of which are capable of collecting samples for later analysis, as well as other instrumentation. The research testbed in Los Angeles was started in 2012 and is ramping up an operation network of up to 15 observing stations in and around the South Coast Air Basin with unique challenges in population density and geographic topography.

Next Steps:

NIST Greenhouse Gas and Climate Science Measurements Program will develop advanced measurement tools and standards to improve the accuracy and capability for remote observations of greenhouse gas, both satellite and surface-based with an emphasis on cities and metropolitan areas. The program will independently verify greenhouse gas emissions inventories, and extend measurement science to better understand and describe the Earth's climate. The program will also enable international measurement standards and protocol developments that ensure accuracy, confidence, and reliability of local and global assessments of GHG emissions.

Objective 3.3: Strengthen the resiliency of communities and regions by delivering targeted services to build capacity.

Strategies:

Lead the development of a Disaster Resilience Framework. To protect critical infrastructure and public resources, NIST will lead the development of a Disaster Resilience Framework for building and infrastructure resilience. The framework will apply to many types of hazards (e.g., tornadoes in the Midwest and earthquakes on the West Coast). A Disaster Resilience Standards Panel convened by NIST will further refine the framework and identify model resilience guidelines to put the framework into action. This national effort will require significant engagement with stakeholders and federal agencies, including NOAA, the Department of Homeland Security (DHS), the Federal Emergency Management Agency, the U.S. Geological Survey (USGS), the Department of Transportation (DOT), the Department of Housing and Urban Development, and the National Science Foundation (NSF).

Progress Update:

The President's Climate Action Plan (issued in June 2013) directs NIST to convene a panel on disaster-resilience standards to develop a comprehensive, community-based resilience framework and provide guidelines for consistently safe buildings and infrastructure—products that can inform the development of private-sector standards and codes. To accomplish this, NIST is convening a series of regional workshops engaging the broad network of stakeholders on the role that buildings and infrastructure lifelines play in ensuring community resilience. In FY 2014, NIST held workshops in Washington, DC and Hoboken, NJ with plans to hold several more in FY2015. Based on the initial workshop results, NIST has starting developing a working draft Disaster Resilience Framework to establish the overall performance goals; assess existing standards, codes, and practices; and identify gaps that must be addressed in order to bolster community resilience.

Next Steps:

NIST plans to release the Disaster Resilience Framework for public comment in April 2015. This document will be the starting point to establish a Disaster Resilience Standards Panel (DRSP). The DRSP will be a self-governing body, supported by NIST, which will meet regularly to put the framework into action.

In FY 2014, the NIST VCAT was briefed on the NIST Resilience Initiative program to help shape and define the NIST role in this national priority area. The Committee will be developing specific recommendations to position NIST to best respond to different priority areas. These recommendations will be provided in the VCAT's 2014 Annual Report. The current report can be found at: http://www.nist.gov/director/vcat/.

The National Construction Safety Team (NCST) Advisory Committee advises NIST on carrying out investigations of building failures conducted under the authorities of the NCST Act. Members are selected based on their technical expertise and experience, established records of distinguished professional service, and their knowledge of issues affecting NIST studies. The NCST Advisory Committee submits a report to Congress annually.

Objective 4.1: Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.

Strategies:

Expand data interoperability across Commerce, and expand open data access and dissemination. The Department will use a standards approach to develop an interoperable Commerce Data Infrastructure. Adherence to a set of common standards and architecture would result in a powerful data platform that provides universal access to data in usable form. Improving discovery and analysis by enhancing access will make data produced by Commerce more effective. Usable open data will promote economic growth and energize a data-as-a-service marketplace for entrepreneurs, new businesses, and the public. This infrastructure and its enabling standards will be developed in a close collaboration between the public and private sectors.

Drive the development of Big Data standards and measurement science. The availability of vast data resources carries the potential to answer questions previously out of reach. There is also broad agreement that Big Data will overwhelm traditional approaches. The rate at which data volumes, speeds, and complexity are growing is outpacing scientific and technological advances in data analytics, management, transport, and more. A lack of consensus on some important, fundamental questions will confuse potential users and hold back progress. What are the attributes and characteristics that define Big Data environments? What are the central scientific, technological, and standardization challenges that need to be addressed to accelerate the deployment of robust Big Data solutions? NIST will drive advancements in Big Data standards by forming communities of interest from industry, academia, government, and other standards bodies, with the goal of developing consensus definitions, taxonomies, secure reference architectures, and a technology roadmap.

Progress Update:

In response to the Office of Management and Budget (OMB) Memorandum M-13-13 "*Open Data Policy- Managing Information as an Asset*" and Office of Science and Technology Policy (OSTP) Memo Feb. 2013 "*Increasing Access to the Results of Federally-Funded Scientific Research,* NIST has established a Scientific Data Committee[1] (SDC) to serve as a resource to NIST laboratories and the NIST Director's office on data preservation and access standards, technologies, metadata issues, and implementation priorities, processes, performance measures, and strategies for the preservation of and access to digital scientific data at NIST. As of October 1, 2014, NIST will create data management plans for scientific data generated at NIST. Additionally, an Interagency Technical Advisory Group (iTAG) with members from NIST, the Census Bureau, DOE, the Department of Treasury, the National Archives and Records Administration, and the Smithsonian has been established to provide a forum for Federal agency and entity coordination on operational requirements and insights on how to maximize access to scientific and technical data.

[1] http://inet.nist.gov/pao/upload/NIST-Scientific-Data-Committee-Charter.pdf

On June 19, 2013, the NIST Big Data Public Working Group (NBD-PWG) was launched with participation from industry, academia, and government across the nation. The NBD-PWG will form a community of interest from all sectors including industry, academia, and government, with the goal of developing a consensus in definitions, taxonomies, secure reference architectures, and a technology roadmap. The NBD-PWG has created five subgroups: Definitions and Taxonomies, Use Case and Requirements, Security and Privacy, Reference Architecture, and Technology Roadmap. These subgroups have developed a set of consensus working drafts.

Next Steps:

The NIST/SDC Open Data Plan has three elements. The first element is to develop and pilot an extensible data registry that describes data sets using common metadata and uses persistent identifiers to provide access to those NIST digital objects regardless of their physical location; the second element is to develop and pilot a tool to help NIST-funded researchers plan for data management at the beginning of each project; and the third is to conduct training and outreach to make data providers aware of their responsibilities and data consumers aware of available data assets. NIST has established a Data Coordinator and a Data policy group to oversee these efforts.

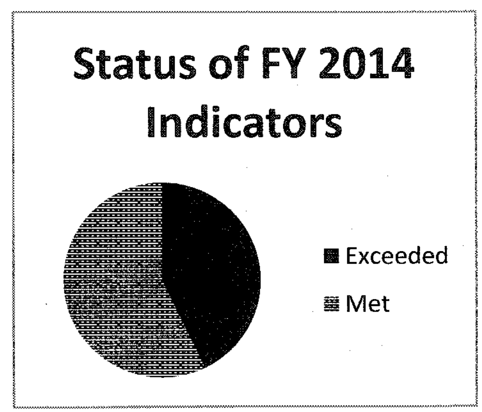
NIST will lead the NBD-PWG to create a vendor-neutral, technology and infrastructure agnostic framework which would enable Big Data stakeholders to pick-and-choose best analytics tools for their processing and visualization requirements on the most suitable computing platform and cluster while allowing value-added from Big Data service providers.

Part 4 Performance Goals / Indicators

Section 4.1: Summary of Performance

Status of indicators

For FY 2014, NIST has met or exceeded all the targets set for its performance indicators. NIST will not have data on one indicator, Citation Impact of NIST–Authored Publications, until March 2015. This indicator is not included in the chart to the right.



Trends of Indicators

In FY 2014, NIST adopted a set of performance indicators that better reflect NIST's role in responding to national priorities, the current research agenda and support for DOC strategic goals and objectives. NIST does not have historical data on these new measures and therefore cannot provide trend indicators.

Section 4.2: Summary of Indicator Performance

Objective 2.1: Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization

Indicator	Target	Actual	Status	Trend
Industry use of NIST research facilities	215	375 (partial data)	Exceeded	Not enough data

Objective 2.2: Increase the capacity of U.S. regional economies to accelerate the production of value-added goods and services by providing services to and investments in businesses and communities

Indicator	Target	Actual	Status	Trend
Number of firms receiving in-depth technical assistance from MEP centers	8340	8353	Exceeded	Not enough data
Percentage of MEP clients receiving in-depth technical assistance that increase their competitiveness	60%	58%	Met	Not enough data

Objective 2.3: Strengthen the nation's digital economy by championing policies that will maximize the potential of the Internet, expanding broadband capacity, and enhancing cybersecurity

Indicator	Target	Actual	Status	Trend
Number of products integrating the Cybersecurity Framework	10	10	Met	Not enough data
Number of citations of the Cybersecurity Framework	10	10	Met	Not enough data

Objective 2.4: Accelerate the development of industry-led skills strategies that result in a productive workforce for employers and high-quality jobs for workers

Indicator	Target	Actual	Status	Trend
Number of MEP centers partnering with skills training providers (e.g., community colleges) to link manufacturing firms with skills training resources.	50	54	Exceeded	Not enough data

Objective 2.5: Accelerate growth of innovation-intensive economic sectors by building public and private capacity to invent, improve, and commercialize new products and services

Indicator	Target	Actual	Status	Trend
Citation impact of NIST-authored publications	1.5	Available March 2015	N/A	Positive
Milestones completed for Commerce interoperability framework	Complete CIF/CAP and prototype and pilot at NIST	Complete	Met	Not enough data

Section 4.3 Detailed Indicator Plans and Performance

Objective 2.1: Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization

Indicator	**Level of co-investment by non-federal sources in DOC-supported NNMI institutes (millions)**							
Description	This indicator reflects how well the focus area of the National Network for Manufacturing Innovation (NNMI) Institutes matches a real national need and is intended to measure the extent to which the industrial partners perceive that they are receiving value from the existence of the Institute. Non-federal partners dedicate resources when they believe that there will be economic benefit. Non-federal sources include industry partners of all sizes, state and local governments, economic development entities, institutions of higher education, private organizations and individuals. Investment includes cash and in-kind resources provided.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	$0	$0	$6
Actual	N/A	N/A	N/A	N/A	N/A	$0		
Status	N/A	N/A	N/A	N/A	N/A	Met		
Trend	Not Enough Data							
Actions to be taken /	Continue to track proposed NNMI legislation. Adjustments will be made to targets if the program receives							

Future Plans	authorization and appropriated funding.
Adjustments to targets	FY2015 target reduced from $6M to $0 to reflect the lack of a Congressionally authorized and appropriated program in FY14.

Validation and Verification	
Data Source	Proposal letters of commitment and project reporting
Frequency	Annual
Data Storage	Electronic and paper at NIST Advanced Manufacturing Program Office
Internal Control Procedures	Data reflects direct and verifiable counts. Internal controls include verification and review by NIST Advanced Manufacturing Program Office and Grants Management Division personnel.
Data Limitations	Data will likely not reflect all non-federal contributions to the institute
Actions to be Taken	None

Indicator	Industry use of NIST research facilities
Description	This indicator reflects the value, relevance, and usefulness of NIST research facilities to industry users. NIST research facilities are unique capabilities that can be leveraged through partnerships with businesses, especially manufacturers, to accelerate discovery and commercialization of innovative products. This indicator counts the number of Cooperative Research and Development Agreements (CRADAs) between industry and NIST laboratories, as well as the number of industrial institutions that use the NIST user facilities (NIST Center for Neutron Research and the Center for Nanoscale Science and Technology).

	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	215	225	250
Actual	N/A	N/A	N/A	N/A	N/A	375*		
Status	N/A	N/A	N/A	N/A	N/A	Exceeded		
Trend	Not Enough Data							

Notes	Data from the NIST Center for Neutron Research (NCNR) and the Center for Nanoscale Science and Technology (CNST) lag due to the time it takes for industry participants to publish in peer-reviewed publications. *Partial FY2014 data. Final data will be available in March 2015.
Information Gaps	Data may not include all instances of industry use of NIST research facilities indirectly through support of academic research.

Validation and Verification	
Data Source	NIST Technology Partnerships Office, NIST Center for Neutron Research, Center for Nanoscale Science and Technology
Frequency	Ongoing
Data Storage	NIST Technology Partnerships Office, NIST Center for Neutron Research, Center for Nanoscale Science and Technology
Internal Control Procedures	Data represents direct and verifiable counts. Internal controls include verification and review by NIST Technology Partnerships Office, NIST Center for Neutron Research, Center for Nanoscale Science and Technology, and the NIST Program Coordination Office
Data Limitations	Data does not reflect scope of partnership (i.e., whether one experiment or an ongoing, multifaceted investigation). NCNR data reflects a period of August – July 2014.
Actions to be Taken	None

Objective 2.2: Increase the capacity of U.S. regional economies to accelerate the production of value-added goods and services by providing services to and investments in businesses and communities

Indicator	**Number of firms receiving in-depth technical assistance from MEP centers**							
Description	Number of client firms receiving services from MEP centers where those services were substantial and essential and therefore could reasonably be assumed to have directly or entirely led to the impacts reported through the MEP client survey.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	8340	8750	9187
Actual	N/A	N/A	N/A	7614	8140	8353		
Status	N/A	N/A	N/A	N/A	N/A	Exceeded		
Trend	Not Enough Data							
Notes	FY 2013 data was preliminary and has been updated.							

Validation and Verification	
Data Source	MEP center project reporting
Frequency	Quarterly
Data Storage	Manufacturing Extension Partnership office
Internal Control Procedures	Review and verification by Manufacturing Extension Partnership office personnel
Data Limitations	Output measure only
Actions to be Taken	None

Indicator	**Percentage of MEP clients receiving in-depth technical assistance that increase their competitiveness**							
Description	Percentage of MEP clients receiving in-depth technical assistance that reported increasing sales, reducing costs, or making new investments as a result of the services received.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	60%	62%	64%
Actual	N/A	N/A	N/A	61%	58.5%	58%		
Status	N/A	N/A	N/A	N/A	N/A	Met		
Trend	Not Enough Data							
Notes	FY 2013 data was preliminary and has been updated.							

Validation and Verification	
Data Source	The client impact survey is administered by a private firm, Fors Marsh Group, located in Arlington, Va.
Frequency	The survey is conducted four times per year, and clients are selected based on when they completed the first project with a MEP Center in the previous year.
Data Storage	Survey data is sent directly to MEP for analysis. MEP reviews and stores survey data received from Fors Marsh Group.
Internal Control Procedures	Internal controls include verification and significant review of the client responses by MEP staff. Criteria are in place for identifying outliers in the data. Centers verify the outlier and if necessary the data are revised based on the Center review.

Data Limitations	As with similar survey instruments, sources of uncertainty include variation in interpretation of specific questions; in the estimation techniques used in response to specific questions; in the quality of industry data, missing values; and other common survey problems.
Actions to be Taken	None

Objective 2.3: Strengthen the nation's digital economy by championing policies that will maximize the potential of the Internet, expanding broadband capacity, and enhancing cybersecurity.

Indicator	**Number of critical infrastructure sectors with work products integrating the Cybersecurity Framework**							
Description	This indicator demonstrates that NIST consistently produces useful and relevant cybersecurity publications and reference materials that organizations representing or participating in a diverse set of the sixteen total critical infrastructure sectors can use. The Cybersecurity Framework may be cited in professional journals; international/national/industry standards, guidelines, and practices; sector-specific federal agency guidance to industry; and commercial/government-off-the-shelf software.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	10	12	13
Actual	N/A	N/A	N/A	N/A	N/A	9		
Status	N/A	N/A	N/A	N/A	N/A	Met		
Trend	Not Enough Data							

Validation and Verification	
Data Source	Information Technology Laboratory research and stakeholder outreach
Frequency	Ongoing
Data Storage	Information Technology Laboratory
Internal Control Procedures	Definition of critical infrastructure and specification of the 16 critical infrastructure sectors from in Presidential Policy Directive (PPD) 21, *Critical Infrastructure Security and Resilience* (http://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil).
Data Limitations	With a focus on the specified critical infrastructure sectors, this measure does not include cross-sector work products, non-critical infrastructure sectors (eg, retail), international entities, or government agencies (beyond government facilities).
Actions to be Taken	None

Objective 2.4: Accelerate the development of industry-led skills strategies that result in a productive workforce for employers and high-quality jobs for workers

Indicator	**Number of MEP centers partnering with skills training providers (e.g., community colleges) to link manufacturing firms with skills training resources.**
Description	This indicator reflects the number of MEP centers involved in activities supporting the development of a workforce with industry-aligned skills. MEP is working with partners throughout the national network of centers to provide the tools, services, and connections necessary

	to develop a workforce with industry-aligned skills.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	50	55	55
Actual	N/A	N/A	N/A	N/A	N/A	54		
Status	N/A	N/A	N/A	N/A	N/A	Exceeded		
Trend	Not Enough Data							
Notes	All Centers currently partnered with a 1) workforce investment board, 2) community college, 3) technical college, 4) university, or 5) state workforce agency are included in this count.							

Validation and Verification	
Data Source	MEP center project reporting
Frequency	Annual
Data Storage	Manufacturing Extension Partnership office
Internal Control Procedures	Review and verification by Manufacturing Extension Partnership office personnel
Data Limitations	Output measure only
Actions to be Taken	None

Objective 2.5: Accelerate growth of innovation-intensive economic sectors by building public and private capacity to invent, improve, and commercialize new products and services

Indicator	**Citation impact of NIST-authored publications**							
Description	This indicator demonstrates that NIST consistently produces useful and relevant scientific and technical publications and is outcome-oriented. The "relative citation impact" indicator is the ratio of the average number of citations per publication (citation rate) for all NIST publications in a year to the average citation rate for a large group of peer institutions in the world. Publications typically lag by a minimum of two years due to the time needed for research, writing, journal peer review, and publication processes.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	1.1	1.1	1.1	1.1	1.1	1.5	1.5	1.5
Actual	1.7	1.7	2.0	1.8	2.3	*		
Status	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	*		
Trend	Positive							
Notes	* The FY 2014 actual for this measure will lag at least six months.							
Information Gaps	Due to the ever-changing nature of research and publication, and continual updating of the dataset used to generate these metrics, the actuals for any given year are subject to change.							

Validation and Verification	
Data Source	Thomson Reuters InCites™
Frequency	Annual

Data Storage	NIST
Internal Control Procedures	Internal controls include verification and review by NIST Information Services Office and the NIST Program Coordination Office
Data Limitations	Factors such as self-citations, citation circles, and multiple authorship may affect the reliability of any data of this nature.
Actions to be Taken	None.

Indicator	**Milestones completed for Commerce interoperability framework**							
Description	NIST will, in collaboration with other agencies, develop an interagency reference architecture and Commerce Interoperability Framework (CIF) or Common Access Platform (CAP).							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	N/A	N/A	N/A	N/A	N/A	Complete CIF/CAP and prototype and pilot at NIST.	Expand CIF/CAP pilot to include additional bureaus/ agencies	Extend CIF/CAP pilot to enable datasets communication and access among identified agencies
Actual	N/A	N/A	N/A	N/A	N/A	Complete		
Status	N/A	N/A	N/A	N/A	N/A	Met		
Trend	Not Enough Data							
Notes	The CIF prototype is complete at NIST. NIST is piloting the CIF at the Census Bureau instead of NIST because Census has more mature data streams and more well-defined needs. NIST is on-track to meet 2015 milestones.							

Validation and Verification	
Data Source	NIST Information Technology Laboratory
Frequency	Ongoing
Data Storage	NIST Information Technology Laboratory
Internal Control Procedures	Internal controls include review by Information Technology Laboratory personnel
Data Limitations	Data provides information on output levels only.
Actions to be Taken	None.

Part 5: Other Indicators

None.

Part 6: Agency Priority Goals

None

Part 7: Resource Requirements Table

NIST Resource Requirements Table*

NIST Resource Requirements (obligations in M)										
	FY 2009 Actual	**FY 2010 Actual**	**FY 2011 Actual**	**FY 2012 Actual**	**FY 2013 Actual**	**FY 2014 Actual**	**FY 2015 Estimate**	**FY 2016 Base**	**Increase/ Decrease**	**FY 2016 Request**
Objective 2.1: Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization.										
TIP	$50.2	$77.2	$74.2	$4.4	1.4	1.6	5.6	-	-	-
AMTech	-	-	-	-	3.0	12.6	15.0	8.2	6.8	15.0
NNMI									143.6	143.6
Labs									20.0	20.0
User Facilities	74.5	72.9	74.2	83.0	89.5	85.5	87.9	86.9	8.9	95.8
Recovery Act funds	3.9	20.1	-	-	-	-	-	-	-	-
Subtotal Funding	**128.6**	**170.2**	**148.4**	**87.4**	**93.9**	**99.7**	**108.5**	**95.1**	**179.3**	**274.4**
Direct	123.8	167.3	144.5	78.4	78.2	93.2	102.6	91.1	179.3	270.4
Reimbursable	4.8	2.9	3.9	9.0	15.7	6.5	5.9	4.0	-	4.0
Total	128.6	170.2	148.4	87.4	93.9	99.7	108.5	95.1	179.3	274.4
Subtotal FTE	**311**	**329**	**332**	**285**	**262**	**282**	**292**	**290**	**35**	**325**
Objective 2.2: Increase the capacity of U.S. regional economies to accelerate the production of value-added goods and services by providing services to and investments in businesses and communities.										
Objective 2.4: Accelerate the development of industry-led skills strategies that result in a productive workforce for employers and high-quality jobs for workers.										
MEP	112.6	126.8	129.3	130.9	118.2	122.6	154.0	131.2	9.8	141.0
Direct	111.0	124.9	128.6	129.1	117.9	122.5	154.0	131.2	9.8	141.0
Reimbursable	1.6	1.9	0.7	1.8	0.3	0.1	-	-	-	-
Total	112.6	126.8	129.3	130.9	118.2	122.6	154.0	131.2	9.8	141.0
Subtotal FTE	**70**	**78**	**83**	**89**	**74**	**71**	**80**	**80**	**-**	**80**
Objective 2.3: Strengthen the Nation's digital economy by championing policies that will maximize the potential of the Internet, expanding broadband capacity, and enhancing cybersecurity to provide a robust environment for innovation.										
Cybersecurity Framework	-	-	-	16.5	21.7	28.0	36.4	36.4	19.0	55.4

Direct	-	-	-	16.5	21.7	28.0	36.4	36.4	19.0	55.4
Reimbursable	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	16.5	21.7	28.0	36.4	36.4	19.0	55.4
Subtotal FTE	**-**	**-**	**-**	**6**	**18**	**22**	**44**	**46**	**40**	**86**
Objective 2.5: Accelerate growth of innovation-intensive economic sectors by building public and private capacity to invent, improve, and commercialize new products and services.										
Labs	555.5	583.7	584.0	621.4	625.9	679.5	728.2	688.0	8.9	696.9
BPEP	13.0	10.8	9.1	2.1	-	-	0.1	-	-	-
Construction and SCMMR	161.7	169.8	91.0	35.6	75.0	64.8	63.2	51.1	7.9	59.0
Recovery Act funds	121.1	455.5	4.4	7.0	1.4	-	-	-	-	-
Subtotal Funding	**851.3**	**1,219.8**	**688.5**	**666.1**	**702.3**	**744.3**	**791.5**	**739.1**	**16.8**	**755.9**
Direct	683.6	1,053.7	524.4	505.1	544.9	588.5	636.4	600.8	15.3	616.1
Reimbursable	167.7	166.1	164.1	161.0	157.4	155.8	155.2	138.3	1.5	139.8
Total	851.3	1,219.8	688.5	666.1	702.3	744.3	791.6	739.1	16.8	755.9
Subtotal FTE	**2,486**	**2,566**	**2,575**	**2,554**	**2,556**	**2,656**	**2,799**	**2,807**	**25**	**2,832**
Objective 3.1: Advance the understanding and prediction of changes in the environment through world class science and observations.										
Greenhouse Gas	2.3	8.8	9.1	9.0	8.8	11.9	13.9	13.9	-	13.9
Direct	2.3	8.8	9.1	9.0	8.8	11.9	13.9	13.9	-	13.9
Reimbursable	-	-	-	-	-	-	-	-	-	-
Total	2.3	8.8	9.1	9.0	8.8	11.9	13.9	13.9	-	13.9
Subtotal FTE	**7**	**18**	**22**	**23**	**19**	**20**	**21**	**21**	**-**	**21**
Objective 3.3: Strengthen the resiliency of communities and regions by delivering targeted services to build capacity.										
Disaster Resilience	5.4	4.2	4.3	7.2	7.1	5.7	10.4	10.4	10.0	20.4
Direct	5.4	4.2	4.3	7.2	7.1	5.6	9.6	9.6	10.0	19.6
Reimbursable	-	-	-	-	-	0.1	0.8	0.8	-	0.8
Total	5.4	4.2	4.3	7.2	7.1	5.7	10.4	10.4	10.0	20.4
Subtotal FTE	**7**	**8**	**9**	**16**	**12**	**16**	**16**	**16**	**13**	**29**

Objective 4.1: Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.										
Big Data standards	-	-	-	-	0.2	2.0	0.5	0.8	-	0.8
Direct	-	-	-	-	0.2	2.0	0.5	0.8	-	0.8
Reimbursable	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	0.2	2.0	0.5	0.8	-	0.8
Subtotal FTE	**-**	**-**	**-**	**-**	**1**	**3**	**1**	**1**	**-**	**1**

Total Funding	**1,100.2**	**1,529.8**	**979.6**	**917.1**	**952.2**	**1,014.2**	**1,115.2**	**1,026.9**	**234.9**	**1,261.8**
Direct	926.1	1,358.9	810.9	745.3	778.8	851.7	953.4	883.8	233.4	1,117.2
Reimbursable	174.1	170.9	168.7	171.8	173.4	162.5	161.9	143.1	1.5	144.6
Total	1,100.2	1,529.8	979.6	917.1	952.2	1,014.2	1,115.3	1,026.9	234.9	1,261.8
Total FTE	**2,881**	**2,999**	**3,021**	**2,973**	**2,942**	**3,070**	**3,253**	**3,261**	**113**	**3,374**

* Dollars reflect obligations for all fund sources and exclude $1,930M National Network for Manufacturing Innovation and $300M Wireless Innovation Fund (mandatory appropriations).

Part 8: Other Information

Section 8.1: Major Management Priorities, Challenges, and Risks

NIST has had multiple actions that impact top DOC management challenges.

Challenge 1: Strengthen Commerce Infrastructure to Support the Nation's Economic Growth

Responsible Bureau Official: Under Secretary for Commerce for Standards and Technology and NIST Director

- NIST has taken a number of actions to mitigate the challenge of implementing the National Network for Manufacturing Innovation. Congress continues to make progress on the NNMI legislation. NIST has conducted planning exercises to ensure that the agency is prepared to manage the program if Congress passes authorization legislation.

Challenge 3: Continue Enhancing Cybersecurity and Management of Information Technology Investments.

Responsible Bureau Official: Under Secretary for Commerce for Standards and Technology and NIST Director

- NIST is assisting in establishing a robust capability to respond to cyber incidents. As a member of the DOC Federation of Computer Incident Response Teams, NIST participates in meetings, weekly teleconference calls, and email discussions. NIST also provides advice, consultations, and incident response assistance to other parts of DOC upon request.
- NIST is helping to continue sustainable implementation of enterprise cybersecurity initiatives by implementing Trusted Internet Connection (TIC) requirements, purchasing MTIPS services using the GSA Networx contract. NIST has also implemented the DOC Enterprise Cyber Security Monitoring and Operations infrastructure, providing enterprise continuous monitoring capabilities for all DOC OUs. Also, NIST participates in all of the planning activities and working groups involved with the implementation of the DOC Enterprise Security Oversight Center.
- NIST is maintaining momentum in consolidating commodity IT to cut costs by sharing procurement vehicles – NIST uses Department-wide contracts, such as the Microsoft and McAfee contracts, for its IT commodity purchases whenever possible. NIST has also been an active participant in DOC-wide efforts to put additional shared procurement vehicles into place. A NIST employee was a member of the team that developed the Network Equipment strategic sourcing vehicles. NIST tests new Dell desktop and laptop devices for inclusion in the DOC-wide PCs and Accessories Custom User Purchasing Agreement. Also, in FY2012 NIST established the MS Office 365 contract, which several other bureaus are using today for their migrations to Office 365.

- In addition, NIST hosts the DOC Enterprise Cyber Security Monitoring and Operations infrastructure, providing enterprise continuous monitoring capabilities for all DOC operating units.

Challenge 3: Continue Enhancing Cybersecurity and Management of Information Technology Investments.

Responsible Bureau Official: Under Secretary for Commerce for Standards and Technology and NIST Director

- NIST has been responsive to the President issued Executive Order 13636, *Improving Critical Infrastructure Cybersecurity* in February 2013. It directed the National Institute of Standards and Technology (NIST) to work with stakeholders to develop a voluntary framework in one year – based on existing standards, guidelines, and practices - for reducing cyber risks to critical infrastructure.
- NIST released the *Framework for Improving Critical Infrastructure Cybersecurity* on February 12, 2014. The Framework, created through collaboration between industry and government, consists of standards, guidelines, and practices to promote the protection of critical infrastructure. The prioritized, flexible, repeatable, and cost-effective approach of the Framework helps owners and operators of critical infrastructure to manage cybersecurity-related risk. http://www.nist.gov/cyberframework/index.cfm

Challenge 5: Continue to Foster a Culture of Management Accountability to Ensure Responsible Spending.

Responsible Bureau Official: Under Secretary for Commerce for Standards and Technology and NIST Director

- NIST's Office of Acquisitions and Agreements Management (OAAM) has made a concerted effort to improve controls over the use of Federal funds by recipients. These efforts include, but are not limited to the hiring of a Grants Division Chief; procurement of six on-site training courses for grants staff; and the completion of an internal compliance file review. In addition, NIST has created an internal task force to identify process improvement solutions for acquisitions and agreements. NIST/OAAM is confident that these multifaceted activities will improve the controls over the use of Federal funds.
- NIST/OAAM has developed comprehensive draft closeout SOPs, utilizing lessons learned from internal award closeout administration and findings and recommendations identified in the September 23, 2013 memorandum *Closeout Procedures Needs Strengthening for the Broadband Technology Opportunities Program (BTOP)*. The draft closeout SOP will be issued in Final by the end of the fiscal year. With respect to closeout activities, NIST/OAAM has closed 54.3% (57 of 105) expired BTOP awards.
- NIST has been an active participant in DOC-wide planning for migration from the DOC legacy financial systems to a Business Application Solution (BAS).

NIST Internal Management Challenge: Achieve Operational Efficiency and Economy to Support a World-class Research Program.

Responsible Bureau Official: Under Secretary for Commerce for Standards and Technology and NIST Director

- Safety management -- NIST is continuing a long process of improving safety management practices and developing a robust safety culture at the laboratories. This effort has made significant progress, but still requires management focus and priority.
- Integrating program and support functions -- NIST is undertaking a significant effort to improve how we procure goods and services. This effort will improve NIST scientific staff's ability to do their mission-critical work by focusing on timeliness, value, effort, and responsiveness. As a part of this effort, NIST managers and staff are defining processes and methodologies that will refine and streamline acquisitions.
- Budget uncertainties and travel ceilings --Current budget uncertainties pose significant risk to NIST's ability to maintain programs that improve U.S. competitiveness, particularly when other countries are increasing investments in measurements, standards, and technology development. Similarly, travel caps are reducing NIST scientists' participation in technical meetings, standards development activities, etc. Participation in these activities supports technology transfer from NIST laboratories and provides NIST staff critical insights about external competition and the science and technology landscape.
- Access to a world class workforce -- NIST's ability to perform best-in-the-world research is dependent on our ability to attract and work with world-class researchers. Foreign researchers working with NIST staff at NIST facilities are an integral part of this dynamic. Collaboration with these experts enables NIST researchers to better understand and stay on the cutting-edge of scientific developments around the world. Also, restrictions on incentives and pay increases along with general negative impressions about Federal employees continue to be a challenge in recruiting the best and brightest scientific minds in the U.S. to work at NIST and contribute to our important mission.

Section 8.2: *Cross-Agency Collaborations*

Cross-Agency Collaborations

NIST has a key coordination role in working with other agencies to help achieve its objective aimed at strengthening U.S. advanced manufacturing through partnerships and collaborations that accelerate technology development and commercialization.

- **Advanced Manufacturing** --The Nation's long-term competitiveness relies heavily on global leadership in advanced manufacturing capabilities. In support of this effort, NIST maintains key relationships with OSTP, the National Economic Council, NSF, NASA, DOE, and DOD. NIST hosts the Advanced Manufacturing National Program Office (AMNPO) which is working closely with NSF, DOD, DOE, NASA, and other agencies to coordinate federal advanced manufacturing programs and create the necessary foundation for the proposed National Network for Manufacturing Innovation (NNMI).

NIST is working closely with a number of other agencies to develop and provide measurement tools and standards to promote industrial competitiveness, enable innovation, and increase efficiency. Key examples include:

- **National Nanotechnology Initiative** -- NIST actively participates in and leads many activities within the National Nanotechnology Initiative (NNI). For example, NIST and OSTP co-chair the Nanoscale Science, Engineering, and Technology Subcommittee which is the interagency convening group of the NNI. The NNI consists of the individual and cooperative nanotechnology-related activities of 27 Federal agencies with a range of research and regulatory roles and responsibilities.
- **Materials Genome Initiative** -- NIST is a lead agency in the Administration's effort to build a materials innovation infrastructure in the U.S. This interagency activity is leveraging expertise at NIST, DOE, DOD, NSF, and other agencies to develop computational approaches that will dramatically reduce the development time of new materials for more effective and cheaper products.
- **Cybersecurity** -- NIST is playing a critical role in implementing a framework for reducing cyber risks to critical infrastructure, per the Presidential Executive Order "Improving Critical Infrastructure Cybersecurity" issued in February 2013. OMB, DHS, and the National Security Agency are key government stakeholders in this effort and are working with NIST to create a public-private partnership to develop a standards-based framework to identify and mitigate cybersecurity risks to the nation's critical infrastructure.
- **Advanced Communications** -- NIST and NTIA recently signed a Memorandum of Understanding to establish a national Center for Advanced Communications at the DOC Boulder facilities. The Center will leverage the unique NIST and NTIA technical expertise in communication technologies and will work closely with the private sector and other federal agencies, including DOD and the Federal Communications Commission. The Center will address measurement and standards challenges in the rapidly evolving communication technologies.
- **Measurement Science and Standards in Forensic Science** -- NIST works with the Department of Justice (DOJ) and forensic science practitioners to establish practices that will enable greater transparency and rigor in the use of forensic evidence within the criminal justice system. For example, NIST and DOJ recently signed a Memorandum of Understanding to create a National Commission on Forensic Science to help address important issues identified in a National Academies' report that studied the nation's forensic science approach.
- **Standards and Trade Policy** -- NIST partners with the Office of the U.S. Trade Representative on significant issues relating to trade policy and standards-related issues that impact trade policy.
- **Interoperability of Electronic Health Records (EHR)** -- NIST is working in close collaboration with the Department of Health and Human Services Office of the National Coordinator for Health IT to promote interoperability of electronic health records.
- **Biosciences** -- Ongoing collaborations between NIST and the Food and Drug Administration range from the reliability of active implanted medical devices, to biological drugs and stem cell-based therapies, to certified reference materials for dietary supplements.

Through the MEP, NIST collaborates with a number of other agencies in support of its objective to improve the competitiveness of small and medium-sized businesses. Most recently, MEP has collaborated actively with multiple other agencies (including the Economic Development Administration, the Department of Labor (DOL), the Small Business Administration (SBA), the U.S. Department of Agriculture, DoE, and the Delta Regional Authority) on priority Administration initiatives to grow the economy and create jobs. In some cases, such as with the Advanced Manufacturing Jobs and Innovation Accelerator Challenge and the Make it in America competition, MEP has been a full partner, providing funding and leadership to help shape and implement the initiatives for maximum impact. In others, MEP has been a supportive non-funding partner, bringing our expertise and insights regarding US manufacturing to the initiatives. These recent activities are in addition to the long-standing relationships NIST MEP has had with a number of agencies and programs, including:

- **E3: Economy, Energy, and Environment** -- MEP is collaborating with DOE, the Environmental Protection Agency, DOL, SBA, and USGS on E3, a coordinated federal and local technical assistance initiative that is helping manufacturers across the nation adapt and thrive in a new business era focused on sustainability.
- **ExporTech** -- Deployed nationally as a collaboration between MEP, U.S. Export Assistance Centers, and other partners including District Export Councils, State Trade Offices, Ex-Im Bank and SBA, ExporTech helps companies enter or expand in global markets.
- **Supplier Scouting** -- In partnership with DOT, DOE, DOD, and other NIST programs, MEP has been using its extensive network of manufacturers and suppliers to help American companies meet the requirements of the Buy America and Buy American standards.

Section 8.3: *Evidence Building*

NIST continually collects information on major national issues, shifting trends in science and technology, and the performance of key operational processes through a variety of mechanisms including meetings, workshops, industry visits, and objective peer review of its programs. This input is viewed in the context of the NIST mission to make decisions on where NIST needs to develop specific capabilities, how to best marshal existing resources to address current issues, and how to continually optimize the organization for improved performance.

The NRC provides expert assessments of the NIST Laboratory programs. The NRC assessments assure decision-makers within the Federal government that NIST maintains the highest standards of effort, performance, and relevance. The assessments also help NIST respond to recommendations and advice as provided to NIST by its advisory body, the Visiting Committee on Advanced Technology. In addition, the process of bringing expert NRC panelists to the NIST campus creates an opportunity for NIST scientists to obtain direct feedback and to foster professional relationships with experts in their field. For FY 2014, the NRC conducted technical assessments of the scientific impact of the Engineering Laboratory and the Material Measurement Laboratory on the following criteria: the technical quality and merit of the laboratory programs relative to the state-of-the-art worldwide, the effectiveness with which the laboratory programs are carried out and the results disseminated to customers, the relevance of the laboratory programs to the current and future needs of stakeholders, and the adequacy of the facilities and laboratory equipment to perform the program functions. The most recent NRC reports are available here: http://nist.gov/director/nrc/

The NIST Visiting Committee on Advanced Technology (VCAT) assessed NIST's programs and priorities, with specific focuses on NIST's portfolio of manufacturing programs, as well as NIST's cybersecurity efforts. Their recommendations are included in the *2013 Annual Report,* as well as their report on *NIST Cryptographic Standards and Guidelines Process* at: http://www.nist.gov/director/vcat/. In addition to the VCAT, NIST has other federal advisory committees that provide critical advice for other key NIST programs, including Advisory Committee on Earthquake Hazards Reduction, the Board of Overseers for the Malcolm Baldrige Award, the Information Security and Privacy Advisory Board, and the Manufacturing Extension Partnership Advisory Board.

NIST MEP uses a broad array of research and reports to shape its program direction. These include client surveys, Federal Advisory Committee reports, and National Academy of Sciences reports. For more information, see the MEP website at http://nist.gov/mep/.

Section 8.4: Hyperlinks

The NRC Assessment Reports for NIST are available at: http://www.nist.gov/director/nrc/index.cfm.
A variety of performance evaluation and economic studies are available at: http://nist.gov/director/planning/impact_assessment.cfm

Section 8.5: Data Validation and Verification

The FY 2014 Summary of Performance and Finance Information includes in the Secretary's Statement, an assessment of the reliability and completeness of the Department's performance data.

Section 8.6: Lower-Priority Program Activities

The President's Budget identifies the lower-priority program activities, where applicable, as required under the GPRA Modernization Act, 31 U.S.C. 1115(b)(10). The public can access the volume at: http://www.whitehouse.gov/omb/budget.

Exhibit 5

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
SUMMARY OF RESOURCE REQUIREMENTS
(Dollar amounts in thousands)

	Positions	FTE	Budget Authority	Direct Obligations	Appropriation
2015 Enacted	2,412	2,391	$681,900	$716,451	$675,500
less: Unobligated balance from prior year	0	0	0	(33,551)	0
less: Transfers from DoJ	0	0	(4,500)	(4,500)	0
less: Transfer from EAC	0	0	(1,900)	(1,900)	0
2016 Adjustments to base:					
Annualization of positions financed in FY 2015	0	10			
plus: Restoration of 2015 deobligation offset	0	0	1,000	0	1,000
plus: Uncontrollable cost changes	0	0	16,834	16,834	16,834
less: Estimated recoveries, 2016	0	0	(1,000)	0	(1,000)
2016 Base Request	2,412	2,401	692,334	693,334	692,334
plus: 2016 Program changes	146	106	60,827	60,827	62,327
plus: Transfer from DoJ			2,599	2,599	0
plus: Transfer from EAC			1,900	1,900	0
2016 Estimate	2,558	2,507	757,660	758,660	754,661

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Comparison by program/sub-program:		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Measurement science, services, and programs											
Laboratory programs	Pos./Approp	2,163	$578,012	2,185	$591,305	2,185	$606,423	2,316	$661,535	131	$55,112
	FTE/Obl.	2,078	578,380	2,166	610,327	2,171	607,283	2,266	662,795	95	55,512
Corporate services	Pos./Approp	48	17,312	48	17,311	48	17,624	48	16,906	0	(718)
	FTE/Obl.	46	17,313	47	17,456	47	17,727	47	17,009	0	(718)
Standards coordination and special programs	Pos./Approp	155	55,676	179	66,884	179	68,287	194	76,220	15	7,933
	FTE/Obl.	150	55,872	178	88,668	183	68,324	194	78,856	11	10,532
TOTALS	Pos./Approp	2,366	651,000	2,412	675,500	2,412	692,334	2,558	754,661	146	62,327
	FTE/Obl.	2,274	651,565	2,391	716,451	2,401	693,334	2,507	758,660	106	65,326

Comparison by program/sub-program:	2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Adjustments for:										
Recoveries		(6,014)		(1,000)		(1,000)		(1,000)		0
Unobligated balance, start of year		(29,408)		(33,551)		0		0		0
Unobligated balance, end of year		33,551		0		0		0		0
Unobligated balance, expired account		6		0		0		0		0
Unobligated balance transfer to other accounts		3,700								
Budget Authority		653,400		681,900		692,334		757,660		65,326
Financing from transfers:										
Transfers to other accounts		4,000		0		0		1,500		1,500
Transfers from DoJ for forensic sciences and OLES		(4,500)		(4,500)		0		(2,599)		(2,599)
Transfer from Election Assistance Commission		(1,900)		(1,900)		0		(1,900)		(1,900)
Appropriation		651,000		675,500		692,334		754,661		62,327

Exhibit 6

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
PROGRAM AND PERFORMANCE: REIMBURSABLE OBLIGATIONS
(Dollar amounts in thousands)

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Comparison by program/sub-program:		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Measurement science, services, and programs											
Laboratory programs	Pos./BA	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	0	0	0	0	0	0	0

Exhibit 7

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
SUMMARY OF FINANCING
(Dollar amounts in thousands)

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Total Obligations	$651,565	$716,451	$693,334	$758,660	$65,326
Offsetting collections from:					
Federal funds	0	0	0	0	0
Non-Federal sources	0	0	0	0	0
Total offsetting collections	0	0	0	0	0
Adjustments for:					
Recoveries and refunds	(6,014)	(1,000)	(1,000)	(1,000)	0
Unobligated balance, start of year	(29,408)	(33,551)	0	0	0
Unobligated balance, end of year	33,551	0	0	0	0
Unobligated balance, expired	6	0	0	0	0
Unobligated balance transfer to WCF	3,700	0	0	0	0
Budget Authority	653,400	681,900	692,334	757,660	65,326
Financing:					
Transfer to other accounts	4,000	0	0	1,500	1,500
Transfers from other accounts	(6,400) [1/]	(6,400) [1/]	0	(4,499) [1/]	(4,499)
Appropriation	651,000	675,500	692,334	754,661	62,327

[1/] Actual transfers of $1,900K from EAC and $4,500K from DoJ in FY 2014; planned $1,900K from EAC and $4,500K from DoJ in FY 2015; and planned $1,900K from EAC and $2,599K from DoJ in FY 2016.

Adjustments to Base

Exhibit 9

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
JUSTIFICATION OF ADJUSTMENTS TO BASE
(Dollar amounts in thousands)

	FTE	Amount
Adjustments:		
Restoration of FY 2015 deobligation offset	0	1,000

In FY 2015, NIST's STRS budget authority was reduced by $1,000,000 based on an estimated level of prior year deobligations. This adjustment would restore the reduction in FY 2016.

	FTE	Amount
Financing:		
Recoveries of prior year deobligations	0	(1,000)

NIST's FY 2016 STRS budget authority is reduced by the estimated level of prior year deobligations in FY 2016.

Other Changes:

Annualization of 2015 pay raise		0	664

A pay raise of 1.0 percent is assumed to be effective January 1, 2015.

Total cost in FY 2016 of 2015 pay raise	$3,114,000
Less amount requested in FY 2015	(2,450,000)
Less amount absorbed in FY 2015	0
Amount requested in 2016 to provide full-year cost of 2015 pay raise	664,000

2016 Pay increase and related costs	0	3,059

A general pay raise of 1.3 percent is assumed to be effective January 1, 2016.

Total cost in FY 2016 of pay increase	$3,059,000
Less amount absorbed in FY 2016	0
Amount requested for FY 2016 pay increase	3,059,000
Payment to Departmental Management Working Capital Fund	0
Total adjustment for FY 2016 pay increase	3,059,000

Annualization of positions financed in FY 2015	10	0

NIST requires an additional 10 FTE to staff FY 2015 requested increases at their full operating level in FY 2016.

New positions in 2015	46
Less 5 percent lapse	(2)
Full-Year FTE	44
Less FTE Funded in 2015	(34)
Annualization of Positions/FTE in 2016	10

Change in compensable days	0	1,178

The increased cost of one more compensable day in FY 2016 compared to FY 2015 is calculated by dividing the FY 2015 estimated personnel compensation ($961,996,000) and applicable benefits ($215,510) by 261 compensable days. The cost increase of one compensable day is $1,177,506.

Personnel benefits		$2,291
Civil Service Retirement System (CSRS)..	($298)	
Federal Employees' Retirement System (FERS)	1,581	
Thrift Savings Plan (TSP)..	221	
Federal Insurance Contribution Act (FICA) - OASDI..	321	
Health Insurance	556	
Employees Compensation Fund..	(90)	

Civil Service Retirement System (-$298,000) – The number of employees covered by the Civil Service Retirement System (CSRS) continues to drop as positions become vacant and are filled by employees who are covered by the Federal Employees' Retirement System (FERS). The estimated percentage of payroll for employees covered by CSRS will decrease from 5 percent in FY 2015 to 3.3 percent in FY 2016. The contribution rate will remain at 7.0 percent in FY 2016.

Payroll subject to retirement systems ($250,829,919)	
Cost of CSRS contributions in FY 2016 ($250,829,919 x .033 x .07).....................	$579,417
Cost of CSRS contributions in FY 2015 ($250,829,919 x .050 x .07).....................	877,905
Total adjustment to base	(298,488)

Federal Employees' Retirement System ($1,581,000) – The number of employees covered by FERS continues to rise as employees covered by CSRS leave and are replaced by employees covered by FERS. The estimated percentage of payroll for employees covered by FERS will increase from 95.0 percent in FY 2015 to 96.7 percent in FY 2016. P.L. 112-240 enacted in January 2013 modified the federal retirement annuity establishing a Revised Annuity Employee (RAE) reducing the amount of government FERS contribution percentage for those employees hired after January 1, 2013 with less than five years of creditable service.

Payroll subject to retirement systems ($239,655,647) (non-RAE employees)	
Basic benefit cost in FY 2016 ($239,655,647 x .967 x .137)	$31,749,340
Basic benefit cost in FY 2015 ($239,655,647 x .950 x .132)	30,052,818
Increase (FY 2015-FY 2016)	1,696,522
Payroll subject to retirement systems ($11,174,272) (RAE employees)	
Basic benefit cost in FY 2016 ($11,174,272 x .967 x .119)	$1,285,857
Basic benefit cost in FY 2015 ($11,174,272 x .950 x .132)	1,401,254
Increase (FY 2015-FY 2016)	(115,397)
Total adjustment to base	1,581,125

Thrift Savings Plan ($221,000) – The cost of agency contributions to the TSP will also rise as FERS participation increases. The contribution rate will increase from 4.61 percent to 4.62 percent in FY 2016.

Thrift plan cost in FY 2016 ($250,829,919 x .967 x .0462)	$11,205,927
Thrift plan cost in FY 2015 ($250,829,919 x .950 x .0461)	10,985,096
Total adjustment to base	220,831

Federal Insurance Contributions Act (FICA) - OASDI ($321,000) – As the percentage of payroll covered by FERS rises, the cost of OASDI contributions will increase. In FY 2016, the maximum salary subject to OASDI tax is $122,100 in FY 2016. The OASDI tax rate for employers also remains at 6.2 percent in FY 2016.

FERS payroll subject to FICA tax in 2016 ($250,829,919 x .967 x .909 x .062).........	$13,669,776
FERS payroll subject to FICA tax in 2015 ($250,829,919 x .950 x .904 x .062).........	13,355,590
Increase (FY 2015-FY 2016)	314,186
OTP payroll subject to FICA tax in FY 2016 ($5,680,081 x .967 x .909 x .062)	309,554
OTP payroll subject to FICA tax in FY 2015 ($5,680,081 x .950 x .904 x .062)	302,439
Increase (FY 2015-FY 2016)	7,115
Total adjustment to base	321,301

Health insurance ($556,000) – Effective January 2014, NIST's contribution to Federal employees' health insurance premiums increased by 3.1 percent. Applied against the FY 2015 estimate of $17,921,000, the additional amount required is $555,551.

Employees' Compensation Fund (-$90,000) – The Employees' Compensation Fund bill for the year ending June 30, 2013, is $90,000 less than for the year ending June 30, 2012.

Per Diem...	0	173

Effective January 1, 2014, the General Services Administration raised per diem rates resulting in an average increase of 4 percent to NIST. This percentage was applied to the FY 2015 estimate of $4,332,000 to arrive at an increase of $173,280.

Rental Payments to GSA	0	1

GSA rates are projected to be 1.5 percent in FY 2016 after economic adjustments. This percentage was applied to the FY 2015 estimate of $89,000 to arrive at an adjustment to base of $1,335.

Communications, utilities, and miscellaneous charges		0	4,602
Postage	2		
Electricity rate decrease	4,918		
Natural Gas rate decrease	(318)		

Effective January 26, 2014, the Governors of the Postal Service implemented a rate increase for shipping services. The overall price change is 5.3 percent. When applied to the FY 2015 postage estimate of $47,000, this results in an increase of $2,491.

The electricity ATB amount was derived using a year to year comparison of the cost per kilowatt hour. In analyzing the 12 months ended February 2014 and 2013, the per kilowatt hour rate increased 26.3 percent (from .095 to .120) for Gaithersburg, Maryland; increased 1.8 percent (from .434 to .442) for Kauai, Hawaii; increased 14.7 percent (from .067 to .077) for Boulder, Colorado; and increased 16.3 percent (from .091 to .106) for Ft. Collins, Colorado for a net increase of $4,918,000.

The natural gas ATB amount was derived using a year to year comparison of the average cost per therm. In analyzing the 12 months ended February 2014 and 2013, the per therm rate decreased 5.6 percent (from .483 to .456) and decreased .9 percent (from .603 to .597) for Gaithersburg and Boulder respectively resulting in a net decrease of $318,000.

Other Services		0	1,612
Working Capital Fund (Departmental Management)	1,626		
National Archives and Records Administration (NARA) storage costs	(14)		

Working Capital Fund (Departmental Management) ($1,626,000) – The amount of $1,626,000 is to fund inflationary costs within the Departmental Working Capital Fund.

National Archives and Records Administration (NARA) storage costs (-$14,000) - NARA estimates reflect a decrease of $14,000 in FY 2016 for records storage and maintenance costs.

Supplies and Materials		0	255
Scientific journal subscriptions	$183		
Helium	72		

Scientific journal subscriptions ($183,000) - This adjustment to base addresses the FY 2013 to FY 2014 inflationary increase in costs for NIST's subscriptions journals which exceed the inflationary increases provided through the regular general pricing level deflator. The application of the 5.9 percent deflator results in an increase of $182,605 when applied to the FY 2015 estimate of $3,095,000.

Helium ($72,000) – This adjustment to base addresses the increase in the market cost of Helium used in NIST research from March FY 2012 to February of FY 2014. The application of the 6.7 percent deflator results in an increase of $72,325 when applied to the FY 2015 estimate of $1,079,478.

General pricing level adjustment	0	2,999

This request applies the OMB economic assumption of 1.6 percent for FY 2016 where the prices that the government pays are established through the market system. Factors are applied to sub-object classes that result in the following adjustments to base: transportation of things $17,840; rental payments to others $28,656; communications, utilities, and miscellaneous charges $50,928; printing and reproduction $9,456; other services $1,677,344; supplies and materials $451,440; and equipment $764,352.

Subtotal, Other changes	10	16,834
Total, Adjustments to base	10	16,834

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STRS

APPROPRIATION ACCOUNT: Scientific and Technical Research and Services (STRS)

The STRS account contains the Measurement Science, Services, and Programs, which contains three budget sub-programs: Laboratory Programs, Corporate Services, and Standards Coordination and Special Programs. These three sub-programs are described in further detail in this section of the budget.

BUDGET PROGRAM: Measurement Science, Services, and Programs

Measurement Science, Services, and Programs Overview

The NIST Measurement Science, Services, and Programs work at the frontiers of measurement science to ensure that the U.S. system of measurements is firmly grounded on a sound scientific and technical foundation. NIST promotes the use of measurements based on the international system of units (SI). The measurement science research at NIST is useful to all science and engineering disciplines. The NIST Laboratories directly support U.S. innovation and industrial competitiveness by developing new measurement instruments and facilities to address critical barriers to innovation; disseminating validated measurement methods and protocols; providing reference data, reference materials, and calibration services to ensure that industry-performed measurements are traceable to NIST standards; and developing testing protocols and supporting laboratory accreditation programs. NIST works actively with other metrology institutes from around the world to ensure that the global marketplace is supported with sound measurements and standards.

The NIST Laboratories also support the development of written standards and specifications that define technical and performance requirements for goods and services. These standards, also known as documentary standards, are often developed collaboratively with the private sector through an open, consensus-based process. NIST scientists and engineers lend their expertise to these efforts in order to promote standards that are based on sound science and to ensure that the standards are supported by effective measurements and testing for conformity to the standards.

Primary areas being researched with the program's base resources include the following:

- maintaining and disseminating national measurement standards;
- developing new measurement technologies and ways to tie needed measurements to fundamental national standards;
- developing, maintaining, and improving existing measurement science, services, references, and standards; and
- pursuing basic and applied research in measurement areas within NIST's mission.

The work performed by the NIST Laboratories affects many aspects of daily life in the U.S. Examples include:

- **Manufacturing** – NIST programs in Advanced Manufacturing are developing the tools to enable new more competitive ways to manufacture current generation products and that support the manufacture of new products that are emerging from advanced technologies.

- **Cybersecurity** – NIST programs focus on information technology and cybersecurity, and enabling the adoption of a robust and secure cyber infrastructure that will increase productivity and foster continued innovation.

- **Interoperability** – Critical emerging technologies such as the Smart Grid and National healthcare information systems have the potential to transform our society and revitalize the U.S. economy. NIST programs are helping to accelerate the development of standards needed to ensure that the many interconnected components in these systems can fully function and exchange information seamlessly across systems.

Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Measurement science, services, and programs
Sub-program: Laboratory programs

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) over 2016 Base	
Line Item		Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount
Strategic and emerging	Pos./Approp	26	$12,553	26	$15,598	26	$15,772	26	$15,231	0	($541)
research initiative fund	FTE/Obl.	25	11,348	26	16,850	26	15,772	26	15,231	0	(541)
National measurement and	Pos./Approp	1,773	476,225	1,795	484,289	1,795	496,187	1,924	543,038	129	46,851
standards laboratories	FTE/Obl.	1,704	476,709	1,780	500,307	1,785	496,835	1,879	544,086	94	47,251
User facilities	Pos./Approp	261	78,206	261	80,390	261	82,767	263	91,615	2	8,848
	FTE/Obl.	250	78,928	259	82,014	259	82,965	260	91,813	1	8,848
Postdoctoral research	Pos./Approp	103	11,028	103	11,028	103	11,697	103	11,651	0	(46)
associateship program	FTE/Obl.	99	11,395	101	11,156	101	11,711	101	11,665	0	(46)
Total	Pos./Approp	2,163	578,012	2,185	591,305	2,185	606,423	2,316	661,535	131	55,112
	FTE/Obl.	2,078	578,380	2,166	610,327	2,171	607,283	2,266	662,795	95	55,512

BUDGET SUB-PROGRAM: Laboratory Programs

BASE JUSTIFICATION:

Laboratory Programs Overview

The objectives of the Laboratory Programs are to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology which drive technological change. NIST's Laboratories play a unique role in the Nation's scientific, industrial, and business communities. NIST anchors the national measurement and standards system that is the language of research and commerce. Maintaining the national standards of measurement is a role that the U.S. Constitution assigns to the Federal government to ensure fairness in the marketplace. NIST's presence and leadership in the Nation's measurement and standards system enables companies, researchers, government agencies, and universities to work with each other more easily, improving the Nation's economic security and quality of life.

NIST resources are devoted to meeting today's economic and societal challenges and to laying the foundation for future success. NIST activities help address a broad range of critical challenges for the Nation. Current Administration priority areas targeted within our base programs include ongoing work funded in FY 2015 for cybersecurity, forensic science, Cyber Physical Systems, Synthetic Biology, and the Lab-to-Market initiative. NIST also supports enacted legislation such as the America COMPETES Act which outlines major roles for NIST in promoting national competitiveness and innovation, and the National Technology Transfer Advancement Act (NTTAA), which designates NIST as the coordinator for all Federal agencies using documentary standards.

The individual descriptions of the activities under NIST's Laboratory Programs are described below.

1. NIST Center for Neutron Research (NCNR)

Program Description

The NCNR safely and reliably operates a national-user facility providing neutron-based measurement capabilities to U.S. researchers from industry, academia, other NIST laboratories, and other government agencies in support of materials research, neutron imaging, chemical analysis, neutron standards, dosimetry, and radiation metrology. Neutrons, uncharged particles from the nucleus of atoms, have unique properties that make them ideal probes of the structure and motion of materials at the scale of atoms and molecules in a material. The NCNR provides an intense source of neutron beams that are used to probe the molecular and atomic structures and dynamics of a wide range of materials. The facility also boasts a unique, large-volume, liquid hydrogen cold source, that produces the largest number of "cold" (or low-energy) neutron beams in the country. Cold neutrons are used to probe the underlying structures and slow dynamics in advanced materials such as plastics, magnetic films, chemical catalysts, biological materials, and composites. With such state-of-the-art measurement capabilities, the NCNR plays an essential role in broad sectors of nano-science and technology. In a wide range of applications, neutron beam measurement techniques are on a par with x-rays or microscopes in their ability to probe materials that are the focus of today's most important research areas, including materials, biotechnology, and nanotechnology. The NCNR operates as a national-user facility that provides merit-based access to all qualified researchers. The NCNR also supports critical NIST research in materials research, chemistry, physics, nanoscale science, and other related fields. Use of the NCNR facilities for proprietary research is possible on a full-cost recovery basis. As a result, researchers from industry, academia, and other Federal agencies depend on NCNR's unique research capabilities to work on cutting edge science. The capabilities of the NCNR are further leveraged through a variety of cost-sharing partnerships with other agencies, industries, and universities to expand specific measurement capabilities and to broaden the access to unique neutron instrumentation. The NCNR is significantly expanding its collaboration with the Nation's industrial and academic researchers with new instrumentation and analysis methods for macromolecular structure and dynamics, elemental trace analysis, determination of magnetic nano-structures, neutron imaging, and neutron spectroscopy.

Examples of Accomplishments

Research and Facility Performance:

- National Research Facility/Neutrons: The NCNR has operated with high availability for decades and provides, on average, 250 days of reactor operation annually to support scientific research. During FY 2014, 2,271 researchers directly benefited from access to NCNR capabilities, which accounted for over one-half of all neutron research done in the U.S. These researchers also represent 163 U.S. universities and other academic institutions, 46 corporations, and 32 U.S. government organizations and laboratories.

- High-Impact Research: Research performed at the NCNR resulted in 340 publications in FY 2014. With a significant fraction of these papers published in prominent journals, the NCNR ranks as one of the highest impact neutron facilities in the world.

Priority Objectives for FY 2016

The 2012 cold neutron expansion project resulted in five new measurement capabilities at the NCNR. This expansion also resulted in additional capacity for new, advanced neutron measurement capabilities, the design and development of which are now underway. An Advanced Measurements Technology initiative funded in FY 2014 will support a major upgrade to the Residual Stress Diffractometer that allows profiling of mechanical stress in components fabricated by advanced manufacturing processes. By 2015 the NCNR will have made significant progress in the design and development of two world-class cold neutron instruments that will be made available to the U.S. scientific community upon completion. The expanded facility allowed NIST to provide new neutron-measurement capabilities to the U.S. research community. Examples of research the expanded NCNR continues to support include:

- Energy Efficiency and Alternative Energy: Studying nanomaterials for the structure and behavior of new materials at the nano-scale, making it possible to improve process technologies and develop new materials applications in areas ranging from lighter weight advanced materials for the auto industry to new nanocomposites for polymer-based solar cells to new materials and approaches for the efficient storage of energy.

- Fuel Cell and Battery Design: Imaging the interior of complex devices and materials non-destructively to "see" how they function under various operating conditions. NCNR neutron imaging has made it possible to look through the steel casings of operating fuel cells and watch the flow and movement of water molecules as the cell functions, leading to better designs and performance.

- Drug and Vaccine Development: Improving the study of the structure and motions of very large biological molecules such as proteins. Neutrons can see detailed protein structure such as bending or folding which helps identify the protein's function. The insights gained could lead to the development of new drug therapies, new anti-toxins, and improved vaccines.

- Environment: Studying chemical interactions with porous or other complex structured materials. The unparalleled penetration and imaging power of neutrons is being used to develop new, more efficient industrial catalysts and better ways to remove toxins from the environment, as well as to achieve a better understanding of complex biological systems at the cellular level.

- Advanced Computer Technology: Studying advanced new materials that can be used to advance computer technology beyond the integrated circuit. As the size of transistors reaches fundamental limits, further advances in the computation power of computer chips will require new materials that can exploit other electronic properties, such as electronic spin, to carry information in the device.

- Materials Performance: Probing the internal stresses in materials such as pipelines, turbine blades, railroad rails, and shock absorbers, which are essential to understanding and improving the performance of products used in industry, transportation, and national defense.

- Data Storage: Increasing the density of stored information. The advance of information technology requires a concomitant increase in the density of stored information. This required the development of new nanostructured-magnetic materials. Neutrons allow researchers to develop a detailed understanding of the magnetism to develop these new data-storage systems.

2. Center for Nanoscale Science and Technology (CNST)

Program Description

In the seven years since its inception, the CNST has become a major national resource for nanoscale science and the development of nanotechnology, and the only national nanocenter with a focus on commerce. Unique in its mission to provide the measurement infrastructure that underlies all progress in this critically important 21st century technology, the CNST serves the U.S. industrial and scientific research communities by providing a venue for highly-collaborative, multidisciplinary research and direct access to state-of-the-art nanoscale measurement and fabrication tools. The continued development of nanotechnology is key to firmly establishing U.S. leadership in such diverse fields as manufacturing, healthcare, electronics, information technology, biotechnology, and energy. For example, for the case of energy, nanoscale phenomena lie at the heart of a great many energy production, storage, and transmission processes. Research in CNST's NanoLab aimed at providing measurement solutions that enable the optimization of the nanostructure of photovoltaic devices can therefore have a profound impact by enhancing the conversion of the sun's energy to electricity. Such research demands a multidisciplinary approach and the development and ready availability of advanced tools, which manipulate and measure the properties of structures - where size can be counted in atoms. The CNST was purposely built to satisfy these demands and offer many unique measurement capabilities in an open, collaborative, multi-disciplinary research environment. This is where innovative research takes place that advances state-of-the-art of measurement and fabrication ("fab"). A critical component of the CNST, the NanoFab, is available through a simple, merit-based application process. Users can economically access expensive state-of-the-commercial-art fabrication and measurement tools, and processes. Proprietary research can be performed on a full-cost recovery basis. Having now completed its initial ramp up in staff, equipment, facilities, and processes, the CNST continues to expand its strategic relationships and collaborations with industrial and academic partners. In an effort to keep up with increasing demand, the CNST is engaged in a new program to recapitalize and update its equipment and instrumentation and thereby meet the needs of its stakeholders. In FY 2014, the NanoFab added significant capacity in electron-beam lithography technology, wet-chemical processing tools, and advanced metrology tools capable of keeping pace with the ever-increasing requirements for improved accuracy and resolution. The effort continues in FY 2015 with the addition of laser surface scanning, reactive ion etching, and improved chemical processing. Continuing a program first started in FY 2014, we will be ensuring compatibility with industrial process by scaling tool capabilities to accommodate 200 mm substrates.

Examples of Accomplishments

CNST research focuses on industry and government priorities, as demonstrated by these recent examples:

- National User Facility: In the few years since its inception, both the capabilities and the associated impact of the CNST have grown rapidly. In FY 2013 alone, almost 1,900 researchers representing over 400 institutions from 39 states and the District of Columbia participated in projects at the CNST. CNST projects resulted in 145 publications and patents in FY 2013, and helped more than 130 companies meet their measurement and fabrication needs.

- Nanomanufacturing: In support of nanomanufacturing efforts in the semiconductor industry and academia, the CNST has developed transmission electron microscope imaging and tomography techniques that provide quantitative information on the morphology of diblock copolymers undergoing directed self-assembly. This information is used to validate the models used to predict block copolymer structure, accelerating the deployment of these novel materials into manufacturing.

- Nanomanufacturing: Nanoparticles synthesized and used in liquids have applications ranging from drug-delivery to water-splitting. The CNST is leading a cross-NIST program, in collaboration with industry, to develop experimentally and theoretically validated, high-throughput, measurements for quality- and process-control for nanoparticles. These metrology tools are designed to overcome the "nanoparticle characterization bottleneck" and enable the manufacture of high-quality nanoparticles.

- Nanomanufacturing: Identifying the active sites on catalyst nanoparticles is essential for developing more efficient, lower-cost catalysts. The CNST is working to create a unique fluorescence microscope that uses individual molecules to measure the surface activity of nanoparticles in order to optimize the synthesis conditions and composition of new generations of catalysts.

- Nanoscale Fabrication: To help enable innovation, the CNST NanoFab's new tool acquisitions have put a strong emphasis on advanced, research scale tools that are based on platforms that have been scaled to high volume production. This has accelerated the prototyping process enabling industrial users to reduce their new product development cycle times.

- Nanomanufacturing: With an eye toward the development of more efficient catalysts for the synthesis of nanomaterials, the CNST has developed a unique environmental transmission electron microscope system, incorporating *in situ* Raman spectroscopy. This enables both atomic-scale resolution of active catalysis processes and precise local temperature and chemistry measurements that permit accurate kinetic studies. The information obtained will enable rational catalyst design.

- Energy Conversion, Storage, and Transport: In collaboration with several U.S. companies and national labs, the CNST developed a new technique for the functional, nanoscale characterization of thin-film photovoltaic materials which utilizes a focused electron beam to produce a nanoscale photon source. The technique can be applied to optimize photovoltaic technologies and devices based on emerging materials.

- Energy Conversion, Storage, and Transport: To advance solar fuel generation, the CNST and its academic collaborators developed measurement methods, modelling tools and overall guidelines that predict the potential performance enhancement from advanced light management approaches based on the use of surface plasmons.

- Energy Conversion, Storage, and Transport: In collaboration with Sandia National Laboratory, the CNST developed characterization methods and demonstrated pathways toward enabling high electrical conductivity in metal-organic frameworks, a broad class of new materials with potential applications in catalysis, gas capture, storage and sensing, and drug delivery. Such developments accelerate the integration of these promising materials into practical devices.

- Future Electronics: Using state-of-the-art, CNST-developed instrumentation, researchers advanced new electronic devices based on two-dimensional materials; such materials are being hotly pursued by the U.S. electronics industry as a replacement for silicon in its pursuit of faster, smaller, and more energy-efficient electronic devices. Measurements of the electronic and mechanical properties of graphene demonstrated new properties that can be exploited for novel device architectures while atomic-scale measurements of crystalline topological insulators enabled deeper understanding of these new materials that will lead to new designs for high speed digital switches.

- Nanomanufacturing and Characterization: To support nanomanufacturing characterization needs ranging from defect analysis to battery electrode development, CNST researchers demonstrated a new form of ion microscopy based on CNST's patented cold atom ion source technology. Using imaging modalities based on secondary electron and backscattered ion detection, the researchers established unique measurement capabilities in surface compositional analysis and the detection of thin resist layers in nanoimprint lithography, solving two important nanomanufacturing problems.

Priority Objectives for FY 2016

- Nanofabrication: Enable U.S. industry to develop myriad novel nanostructures for use in diagnostic and distributed sensing in applications, ranging from targeted drug delivery to enhancing oil recovery, by providing new self-assembly methods and associated metrology techniques that will accelerate research on new multifunctional nanoparticles.

- Nanomanufacturing: Support the rapid development of scalable nanomaterial production processes with applications in the high-performance materials, healthcare, and energy sectors. Advance the development of high-throughput metrology techniques to enable rapid, precise, and accurate measurements of nanoparticle size and shape in manufacturing, using integrated opto-nanofluidic devices to enable process control of engineered nanomaterials.

- Nanofabrication: Work with scientists in NIST's Physical Measurement Laboratory to develop compact and portable length and frequency standards that take advantage of recent advances in nanofabrication technology and nanophotonics research. These portable metrology tools have the potential to bring precise measurements out of the lab and into deployment in a variety of scenarios, including manufacturing facilities, field instrumentation, and navigation systems.

- Future Electronics: Help the U.S. electronics industry retain leadership in next-generation device realization by developing new measurement capabilities that combine atomic force microscopy with scanning tunneling microscopy to yield unprecedented, detailed, atomic scale electronic property information on a wide range of potential future electronic materials.

- Nanoscale Characterization and Manufacturing: Develop innovative nanoscale focused ion beam applications, working with industrial partners to fully integrate CNST-developed technology with state-of-the-art ion beam systems. Explore new imaging modalities and nanomachining opportunities that promise technological solutions to key nanomanufacturing needs in integrated circuit editing, failure analysis, nanoscale sample analysis, and the development of new nanomaterials for the electronics and energy sectors.

- Solar Energy/Photovoltaics: In collaboration with academia and national labs, correlate nanoscale property maps of thin-film photovoltaic devices with high-throughput contactless measurement methods transferable to manufacturing facilities to enable inline process control.

- Solar Energy/Photovoltaics and Storage: Develop techniques for nanoscale characterization of buried interfaces in photovoltaic and battery devices correlating electron beam injection methods and X-ray tomography. In collaboration with U.S. companies and national labs, apply these methods to optimize existing and emerging technologies for energy generation and storage.

- Energy Storage: Provide critical new measurement capabilities to U. S. battery development efforts by building on CNST's recently realized, unique lithium ion microscope platform to enable implantation of lithium ions with nanometer scale resolution in battery electrode and electrolyte materials. Coupled with new in situ electrical measurement tools this permits detailed measurements of important microscopic behavior of lithium ions in cathode, anode, and solid electrolyte materials.

- New Generation of Nanotechnologists: Help educate a new generation of nanotechnologists by providing hundreds of young scientists and engineers with the ability to use some of the world's most advanced instrumentation to address the challenge of measuring the subtle phenomena of nature that occur only on the nanometer scale. Through two-year-long postdoctoral appointments and visiting fellowships available to scientists from academia, industry, and government laboratories, CNST will provide in depth, post-graduate training in nanotechnology for more than 50 researchers. In cooperation with the National Science Foundation, the CNST will provide internship opportunities for community college students preparing for careers in nanotechnology, who will gain hands-on experience with state-of-the-art nanofabrication tools.

- Fluidic Devices for Synthetic Biology: Design and fabricate micro- and nanofluidic devices that enable precise control over biological systems and components for imaging and manipulation. These will be capable of handling live cells and will be compatible with existing and newly-developed measurement platforms.

3. Physical Measurement Laboratory (PML)

Program Description

The PML develops and disseminates the national standards of length, mass, force and shock, acceleration, time and frequency, electricity, temperature, humidity, pressure and vacuum, liquid and gas flow, and optical, acoustic, ultrasonic, and ionizing radiation. Its activities range from fundamental measurement research to the provision of measurement services, standards, and data.

PML applies its measurement capabilities to problems of national significance through collaborations with industry, universities, professional and standards setting organizations, and other government agencies. It supports the research community in such areas as communication, defense, electronics, energy, environment, health, lighting, manufacturing, microelectronics, radiation, remote sensing, space, and transportation. PML establishes spectroscopic methods and standards for infrared, visible, ultraviolet, x-ray, and gamma-ray radiation; investigates the structure and dynamics of atoms, molecules, and biomolecules; develops the electrical, thermal, dimensional, mechanical, and physical metrology for measuring the properties of precision-measurement devices and exploratory semiconductor, quantum electronic, nanoelectronic, bioelectronic, biooptical, optoelectronic, and quantum-information devices and systems; and examines the thermophysical and interfacial properties of streams of flowing fluids, fluid mixtures, and solids. It develops and disseminates national standards by means of calibrations, measurement quality assurance, standard reference materials, technology transfer, education/training, and a comprehensive weights and measurement program to promote uniformity and accuracy at the international, Federal, state, and local levels. It generates, evaluates, and compiles atomic, molecular, optical, ionizing radiation, electronic, and electromagnetic data in response to national needs; measures and improves accuracy of the fundamental physical constants; and develops and operates major radiation sources for measurement science and metrology.

NIST's base activities within PML support a broad range of scientific, technological, commercial, and consumer needs.

- Time and Frequency: NIST maintains the Nation's standards for time and frequency measurement, an increasingly important field that supports advanced communications, electronic systems, power grids, and high-speed commerce. NIST focuses on developing the highest accuracy standards and methods of disseminating time and frequency, through the Internet, radio broadcasts, and satellites. The Internet service alone provides official time to the public several billion times each day.

- Medical Radiation and Imaging Technology: NIST calibrations underlie the safety and efficacy of diagnostic procedures (such as mammography) and therapeutic procedures (such as for cancer treatment). Well in excess of 22 million therapeutic radiation procedures[1] and nearly 39 million x-ray mammograms[2] annually are traced to NIST standards. NIST researchers have a robust program in a broad range of medical imaging technologies.

- Electrical and Electronics Metrology: Electronics are highly dependent on measurements enabled by NIST programs. NIST supports the electronics industry in many ways in its drive to develop ever smaller and more functional semiconductor products. The accuracy of every electricity revenue meter in the U.S. relies on standards provided by NIST. NIST is currently developing new techniques to support increasing complex, smaller, and more integrated devices, where feature sizes continue to be reduced and the role of defects and imperfections become increasingly important. In addition, NIST is developing techniques to support state variables other than charge for future electronic logic.

- Optoelectronics and Optical Technology: According to a report by the National Research Council, "public companies active in optics and photonics generated an estimated 10 percent of all public-company revenues within the U.S. in 2010. These 282 unique public companies account for $3 trillion

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[1] *All therapeutic radiation procedures performed in the United States must be traceable to NIST standards. According to the American Cancer Society (http://www.cancer.org), there will be over 1.6 million newly diagnosed cancers in the United States in 2014. Approximately 60 percent of cancer patients are treated with radiation therapy during the course of the disease. An estimate of the number of cancer patients treated annually using radiation therapy is, therefore, about 900,000. Each patient will have a total of between 25 and 30 fractionated dose procedures (between 22 million and 27 million individual procedures performed annually). Therapeutic radiation procedures are also used for diseases other than cancers. However, statistics on these are not available.*

[2] *All mammograms performed in the United States must be traceable to NIST standards. As of December 1, 2014, almost 39 million mammograms were being performed annually. See* http://www.fda.gov/Radiation-EmittingProducts/MammographyQualityStandardsActandProgram/FacilityScorecard/ucm113858.htm.

in revenues and 7.4 million high-value U.S. jobs."[3] These companies require accurate and trusted standards in areas such as lighting, communications, photography, color and appearance, spectroscopy, and imaging. Work at NIST is important for environmental monitoring instruments used to measure temperature, atmospheric composition, and other aspects important in large-scale climate studies.

- Mechanical and Dimensional Metrology: NIST leads the development of new measurement standards to support U.S. manufacturing and harmonize the U.S. with international standards, removing impediments to U.S. competitiveness. NIST activities in this area promote lower costs for U.S. manufacturers, assure quality and interchangeability of parts, and achieve acoustical standards for the safety of workers in noisy environments.

- Fluid Dynamics: NIST maintains, improves, and disseminates the national measurement standards for gas flow, liquid flow, air speed, pressure, temperature, and humidity. Such measurements underlie process chemistry and manufacturing, equitable commerce in natural gas and liquid fuels, wind turbine performance, aircraft altimeter accuracy, and atmospheric monitoring.

- Public Health and Safety: NIST expertise in radiation detection and measurement supports critical needs of first responders, homeland security surveillance, medical sterility, and nuclear energy. Optical measurement systems support needs in highway and aviation safety, missile defense, and medical diagnosis. NIST aids the law-enforcement community with performance standards for bullet forensics.

- Weights and Measures: NIST promotes uniformity in U.S. weights and measures laws, regulations, and standards to achieve equity between buyers and sellers in the marketplace nationwide and internationally. This enhances consumer confidence, enables U.S. businesses to compete fairly at home and abroad, and strengthens the U.S. economy. NIST works with state and local officials and business, industry, and consumer groups, to achieve these goals.

- Advanced Training and Technology Transfer: Through NIST's joint institutes with the University of Colorado (JILA) and the University of Maryland (Joint Quantum Institute), NIST helps train graduate students and postdoctoral fellows in advanced science and technology, who support research and innovation in industry, academia, and government laboratories. Many NIST-supported trainees have gone on to establish high-technology companies; and create new jobs and products for the U.S. economy.

Examples of Accomplishments

- Manufacturing: NIST has launched a new calibration service for high-power lasers of the sort used by manufacturers for applications such as cutting and welding metals, as well as by the military for more specialized applications like defusing unexploded land mines. NIST is the only national metrology institute in the world to offer calibrations for laser power and power meters above 1.5 kilowatts (kW). The new service is offered for power levels up to 10 kW. Light focused from a 10 kW laser is more than a million times more intense than sunlight reaching the Earth.[4]

[3] *See* http://www.nap.edu/catalog.php?record_id=13491. *See also* http://spie.org/Documents/AboutSPIE/PDF/HLII-OpticsandPhotonics.pdf.
[4] *See* http://www.nist.gov/pml/div686/20141029_laser_cal.cfm

- Quantitative Medical Imaging: Image-calibration technology, designed and developed by NIST scientists in collaboration with the National Cancer Institute and the Radiological Society of North America, has been adopted for use in multi-site clinical trials in the United States and Europe to study traumatic brain injury (TBI). About two dozen of the units—which were brought from conceptualization to commercialization in only a year—were distributed to trial participants in an effort to bring uniform quality control to brain imaging. The principal diagnostic tool for detecting and monitoring microscopic changes caused by TBI is magnetic resonance imaging (MRI). This work will help ensure that brain and other scans are not only accurate but also consistent over time and between different MRI facilities. Recent publicity about concussions and other head injuries in the National Football League and among soldiers exposed to explosions has raised awareness of TBI, but the condition is by no means limited to sports and military service. TBI is a major cause of death and disability in the United States, contributing to about 30 percent of all injury deaths, according to the Centers for Disease Control and Prevention.[5]

- Quantum Computing: A team of NIST researchers has created what may be the most highly enriched silicon currently being produced. The material is isotopically more than 99.9999 percent pure silicon-28. Many quantum-computing schemes require isotopically pure silicon, for example to act as a substrate in which qubits—the quantum bits that store information—are embedded. Indeed, since silicon processing has become such an advanced technology within the semiconductor industry, such schemes hold promise for being able to leverage commercial manufacturing techniques to realize a practical quantum computer.[6]

- Remote Sensing: SURF III, a unique NIST synchrotron facility, was used by NASA to calibrate two experimental instruments that launched last July. SURF III is a key standard for extreme ultraviolet (EUV) radiation. EUV radiation from the sun creates "space weather" on Earth, which affects global communications and other infrastructure. It is also a component of global climate models, so proper measurement is important in the application of the models. However, there is so much energy in EUV radiation that the instruments that measure it are prone to degradation, and substantial calibration drift over time. For NASA, it is an expensive process to determine the drift so satellite data can be correctly interpreted. This motivated new, innovative designs for EUV instruments that should be degradation free. They were tested and calibrated at SURF III prior to launch.[7]

- Health Care: NIST made measurements on sample hearing aids provided by the Department of Veterans Affairs (VA) to assist them in making decisions regarding multiyear contract awards. The testing focused on the performance characteristics of two important features of modern hearing aids, feedback suppression and adaptive directionality. Hearing loss is a major medical issue for millions of Americans, and it is the second most prevalent service connected disability among veterans. Hearing aids help to alleviate the problems associated with this disability, and the VA purchases about 20 percent of the hearing aids sold in the U.S.[8]

Priority Objectives for FY 2016

- Advanced Communications: Develop technology and metrology for long-path free-space optical communications using frequency combs. This will help enable deployment of free-space optical communications as a secure, broadband, ground- or satellite-based communication technology that is not constrained by availability of radio spectrum.

[5] *See* http://www.nist.gov/pml/electromagnetics/magnetics/phantoms-for-traumatic-brain-injury.cfm
[6] *See* http://www.nist.gov/pml/div684/grp02/six-nines-081114.cfm
[7] *See* http://www.nist.gov/pml/div685/grp07/euv-calibration-for-solar-studies.cfm
[8] *See* http://www.nist.gov/pml/div683/hearing_aids.cfm

- Large-Scale Dimensional Metrology: Further develop a new multilateration technique using laser trackers to provide world-class measurement accuracy on large, complex three-dimensional (3-D) structures, such as airplanes. Applications include construction and advanced manufacturing.

- Better Microscopy for Nanomanufacturing: Further develop innovative approaches to solving vibration and drift problems in production line, scanned particle beam microscopy by utilizing super-fast image capture and a NIST-developed alignment program to improve image sharpness.

- Medical Imaging Technology: Design and calibrate "phantoms" to better calibrate PET-CT scanners, and use them to monitor scanner performance during clinical trials. Calibrated phantom standards will assist in evaluating the instrumental effects on clinical data. Additionally, continue development and validation of a phantom to calibrate magnetic resonance imaging (MRI) scanners. Together, these will improve the accuracy of medical diagnostic imaging, lead to more effective treatments, and speed the discovery and validation of new drugs and therapies.

- Energy and the Environment: Develop neutron-imaging methods to quantify shale structure and the efficiency of fossil fuel extraction processes from shale deposits. We will quantify the efficiency of supercritical CO_2 extraction methods. This approach to oil recovery allows for CO_2 sequestration and greater utilization of natural resources.

- Environmental Protection: Demonstrate a new capability based on a horizontal smokestack simulator to determine the accuracy of sensors measuring the mass flow of gas from power plants and other sources of greenhouse gas emissions. The simulator will allow an improved quantification of the complex flow patterns observed in industrial smokestacks.

- Electronics and Information Technology: Research low-power consumption technologies for data processing and data storage, including the use of spintronics. This will potentially reduce the rapidly growing energy demand of devices and systems from hand held to large server centers.

- Photonics: Perform research and development for new, ultraprecise laser technologies that will eventually outperform current best lasers by a factor of 100 or more in precision, with impacts on better atomic clocks, improved communications, new forms of quantum computing and quantum communications, and improvements to a wide range of precision measurements. These advances leverage NIST's pioneering of new types of laser technologies, including "super-radiant lasing," new ultrastable laser cavity systems, and continuing advances in laser frequency combs.

- Measurement Science: Continue to develop new "NIST on a chip" technologies, to provide a broad range of NIST-traceable embedded standards for use almost anywhere e.g., on the factory floor to support advanced manufacturing, in operating aircraft and vehicles to improve efficiency and safety, in the home to support improved, cost-effective health care. This research will build on NIST's pioneering research on chip-scale atomic clocks, magnetometers, and related devices to support a wide range of measurements. This program will broadly disperse NIST traceable precision measurements, and will build new means of technology transfer from NIST to industry partners.

- Measurement Science: Demonstrate an integrated chip-scale, photonic device for the accurate measurement of temperature, based on the temperature-dependent optical properties of micro-ring resonators. Such devices will allow manufacturers to fully integrate temperature measurement into manufacturing processes and instrument systems to improve quality and performance.

- Measurement Science: Develop a fully automated intrinsic alternating current (AC) voltage standard source, based on quantized pulses from superconducting circuit arrays for frequencies up to 2 megahertz (MHz). This will enable higher precision and accuracy of AC voltage measurements in electrical and electronics products across a wide range of industries.

- Measurement Services: Strengthen the Nation's precision timing and synchronization infrastructure through a new official U.S. standard for time, based on the second-generation laser-cooled atomic fountain clock. Timing and synchronization are a critical part of our modern technology, supporting such applications as GPS, communications, and electric power distribution.

- Measurement Services: Strengthen NIST's programs in the delivery of calibration services by furthering the development of the *mise en pratique* for the electronic kilogram. This will allow an international redefinition of the kilogram, to be based on fundament constants of nature, and improve the method of delivering services. Develop new, dynamic measurement techniques in both force and length metrology to support real-time measurements for advanced manufacturing.

4. Material Measurement Laboratory (MML)

Program Description

The MML serves as the national reference laboratory for measurements in the material, biological, and chemical sciences through activities ranging from fundamental and applied research on the composition, structure, and properties of industrial, biological, and environmental materials and processes, to the development and dissemination of certified reference materials, critically evaluated data, and other programs to enable measurement quality.

MML serves a very broad range of industry sectors ranging from transportation to biotechnology by conducting research, and providing its output in the form of measurement services and measurement quality assurance tools to address problems of national importance, such as greenhouse gas emissions measurements; renewable energy; the Nation's aging infrastructure; environmental quality; food safety and nutrition; forensics and homeland security; healthcare measurements; and manufacturing ranging from advanced materials to photovoltaics to biologic drugs.

Specifically, MML conducts research in:

- Materials Science and Engineering to provide the measurement science, standards, technology, and data required to support the Nation's need to design, develop, manufacture, and use materials. In partnership with U.S. industry, other government agencies and other scientific institutions, we develop and disseminate measurement methods, theories, models, tools, critical data, reference materials, reference data, standards, and science underpinning the Nation's materials science and engineering enterprise. These activities foster innovation and confidence in measurements needed to advance technology and facilitate manufacturing in industrial sectors, such as energy, electronics, transportation and the environment.

- Materials Measurement Science to provide the measurement science, measurement standards, and measurement technology required to enable world-leading characterization of materials in support of the Nation's needs for the determination of the composition, structure, and properties of materials. In partnership with U.S. industry, government agencies and other stakeholders, we develop state-of-the-art instrumentation, methods, models and software to accurately and precisely measure materials over a range of length and time scales. We provide benchmarking and validation of emerging materials analysis methods, and disseminate reference materials, standards and scientific data to foster innovation and advance a wide range of technologies, such as those for public safety, forensics, homeland security and nanomanufacturing.

- Biosystems and Biomaterials to address the Nation's needs for measurement science, standards, data, methods and technology in the quantification of complex biological systems, materials and processes, from the nano- to the macro-scale. In partnership with U.S. industry, other government agencies and other scientific institutions, we develop and disseminate infrastructure supporting quantitative biology and biomaterial measurements with the intent of fostering innovation and confidence for stakeholders in biomedicine and healthcare, manufacturing, food safety, environmental health, and national security. We enable the U.S. to maximize the return on our national investment in the bioscience enterprise through interdisciplinary research drawing from expertise in the physical, information, and biological sciences.

- Biomolecular Measurement to provide the measurement science, standards, technology, and data required to support the Nation's needs in determining the composition, structure, quantity, and function of biomolecules. In partnership with U.S. industry, government agencies, and scientific institutions, we perform fundamental and applied research on the measurement of macromolecules such as proteins and nucleic acids, as well as peptides, glycans, metabolites, lipids, and natural products. We provide measurement science, reference materials, reference data, and technologies to foster innovation and confidence in measurements needed to advance biotechnology, deoxyribonucleic acid (DNA) forensics, biomedical and bioscience research, and health care.

- Chemical Sciences to provide the measurement science, standards, technology, data and chemical informatics required to support the Nation's needs in the determination of chemical composition and chemical structure of gases, organic, and inorganic species and in the measurement of a wide variety of chemical properties and processes, including chemical reactivity and mechanisms, and thermochemical properties. In partnership with U.S. industry, government agencies, and academic scientific institutions, we perform fundamental and applied research to advance and create state-of-the-art chemical measurement capabilities, theoretical and computational methods for quantitative measurements, and sensing of solids, liquids, gases, plasmas, transient species, and multicomponent matrices. We also formulate and disseminate reference materials and measurement standards, and critically evaluate reference data. These activities support the chemical science, technology, and engineering enterprise with the intent of fostering innovation and confidence in measurements and technologies used in a wide range of applications, including chemical analysis, environmental and climate assessment, clinical health assessment, food and nutritional assessment, sensing, manufacturing, and energy transformation.

- Applied Chemicals and Materials to provide the measurement science, standards, technology, instrumentation, models and data required to support the Nation's needs for design, production, and assessment of chemical and material products. In partnership with U.S. industry, other government agencies and other scientific institutions, we provide thermophysical and mechanical properties; analysis of reliability and performance of materials and structures; and information systems for chemical and materials engineering, with the intent of fostering innovation and confidence in the Nation's physical and energy infrastructures, enabling advances in chemical manufacturing and in electronics, and promoting sustainability.

MML is also responsible for coordinating the NIST-wide Standard Reference Materials (SRM) and Standard Reference Data (SRD) programs. NIST SRMs and SRD are key technology transfer mechanisms that enable U.S. industry to achieve traceability of their measurements to NIST's fundamental standards and best-in-the-world measurements, and to the SI. This traceability enables industry to more easily address international comparability and compliance, which is necessary for the U.S. to export its products worldwide.

In order to address the growing challenges of data and informatics in the chemical, biological and materials sciences, and to meet objectives of recent Administrative directives related to public data availability, MML has established an Office of Data and Informatics (ODI). The ODI is charged with coordinating and building capabilities within MML to better analyze, condition, and properly store the large data sets inherent to contemporary chemical, biological and materials experimentation and simulation and modeling. In addition, the ODI will build capabilities and best practices in data validation and provenance, as well as interchange standards needed to serve large datasets to the public, and to make them available for complex scientific endeavors. As such, it will serve national initiatives related to Big Data, as well as the Materials Genome Initiative (MGI). In addition, the ODI shapes the next generation of innovative SRDs produced by MML.

Examples of Accomplishments

Accomplishments (and continuing activities) include research and measurement service delivery focus on industry and government priorities, as described below:

- Advanced Materials: Provided the underpinning measurement science, standards and leading-edge measurement tools needed to establish quantitative processing-structure-property relationships of advanced materials, in ways that enable U.S. industry and other government agencies to discover, develop and optimize advanced materials and to harness their properties for technology innovations. Advanced materials include ceramics, metals, polymers, semiconductors, composites, fluids, and some biomaterials, in bulk, particulate, and multilayer forms, that have new or improved properties. MML provides the tools and standards for accurate measurements of material composition, structure, and properties for sustainable and safe manufacture, use and recycling of products that contain advanced materials.

- Bioscience and Healthcare: Increased the accuracy, comparability, and efficacy of measurements used in medical diagnostics and advanced therapeutics in ways that enabled reduced U.S. healthcare costs and improve quality of life through more informed medical decision-making. For more than 25 years, NIST has maintained standards for electrolytes, organic biomarkers (such as cholesterol, creatinine and glucose), drugs of abuse and toxic metals. NIST provides needed measurements and standards to support the measurement of health status markers in serum, urine, and tissue; the development of innovative biologic medicines such as protein therapeutics, cell-based regenerative products, and vaccines; the development of advanced dental materials, tissue engineering scaffolds, nanoparticle-based therapies for cancer; and safe and reliable implanted medical devices.

- Electronics: Quantified the composition, structure, properties and dimensions of current and emerging electronic materials and devices, and assessed electronics fabrication routes in ways that enabled development and manufacture of advanced electronics by U.S. industry. This work enables industrial development and commercialization of next-generation semiconductor devices, magnetic materials for low-noise sensors and next generation computer logic, and flexible organic electronic devices; as well as tests and standards to ensure the safe and reliable long-term use of these products.

- Energy: Supported the development, production and reliability of materials and devices related to advanced energy sources, renewable energy, energy storage and energy-harvesting, as well as the safe and effective use of petroleum, in ways that enabled the Nation to adopt new energy technologies and to ensure energy security. MML measurement methods, reference materials and data are essential for a cleaner fossil fuel economy, and support the development, manufacture and quality control of biofuels, next generation photovoltaics, advanced batteries and heat-harvesting thermoelectric devices.

- Environment and Climate: Verified assessments of soil, air, and water, as well as environmental threats, and supported environmental remediation strategies, in ways that enabled our Nation to protect its environmental resources and develop science-based environmental policy. MML measurement methods, certified reference materials, reference data, and measurement quality assurance programs are central to environmental contaminant measurement and monitoring programs, provide needed improvements to the reliability and comparability of measurements and assessments of environmental quality and climate. In addition, MML has developed an advanced specimen banking program that enables retrospective analyses and determination of trends of contaminants in the environment and animals.

- Food Safety and Nutrition: Underpinned measurements of the composition of food and water in ways that enabled the Nation to prevent contaminated food and water from entering supply streams, ensured the reliability of nutrition information on product labels, and enabled consumers to make well-informed dietary choices. MML reference materials enable food manufacturers and distributors to accurately assess the nutritional content of their products. MML also has expertise in chemical analysis supports new methods to detect contamination.

- Manufacturing: Supported the industrial production of finished goods from raw chemicals, raw materials and biological sources, and facilitated the design of materials for manufactured products in ways that promote innovation, U.S. industrial competitiveness, and job creation. MML research and standards products provide essential support to a large number of U.S. manufacturing sectors, including automotive, electronics, materials and chemicals production, and biopharmaceuticals.

- Physical Infrastructure: Provided measurement science and test methods, including non-destructive evaluation techniques, needed to assess the health of aging physical infrastructure components and materials, to predict their lifetime and failure, and to gauge their performance under extreme environmental conditions in ways that enabled the Nation to prioritize infrastructure remediation, and to manufacture more resilient infrastructure components. These include reference materials and standards for assessing material strength and hardness, standards for fuel pipeline safety, methods to assess the performance of plastic pipes for water and gas, and methods to test and predict the heath of critical connections and join-ends in bridges and buildings.

- Safety, Security, and Forensics: Advanced threat detection, improve the accuracy of forensics measurements and helped ensure the reliability of protective technologies and materials, in ways that foster homeland security, the safety of public servants, and effective law enforcement. These include advanced instrumentation and reference materials that enable the accurate and reliable detection of chemical, biological, radiological, nuclear and explosive threats; standards and reference materials that support DNA-based human identity testing for forensics and biometrics; and measurement methods that ensure the reliability of soft body armor.

Priority Objectives for FY 2016

Advanced Materials: To enable innovation, manufacture, use and recycling of high priority advanced materials in a range of industry sectors, MML will develop and deploy:

- instruments, measurement methods, and standards to determine the composition and structure of advanced materials with the unprecedented resolution and accuracy needed by industry to advance the development of products that contain such materials; for example, semiconductors, engineered nanomaterials, and catalysts. These measurement tools include microscopy and spectroscopic methods to image materials at the atomic and molecular scales, and a suite of NIST-developed synchrotron spectroscopy instrumentation to be installed at the world's premiere synchrotron user facility, NSLS-II (Brookhaven National Laboratory).

- a new industry consortium, nSoft, established in 2013, will help a wide range of industry partners (currently leading U.S. chemical, materials and pharmaceutical firms) leverage advanced neutron-based measurement methods housed at NIST needed to accelerate the development and commercialization of new "soft materials", including polymers, colloidal materials, complex fluid formulations, petroleum based products, consumer products, and pharmaceuticals.

- instruments, measurement methods, standards and validated data to determine the properties of advanced materials for myriad industries. For example, reference materials to calibrate instruments for nanoscale measurements, including reference flexural cantilever arrays for force measurements in scanning probe microscopes, which are ubiquitous in industrial laboratories.

- cutting edge and scalable methods to separate Carbon Nanotubes (CNT) by length, chirality and electronic structure needed to measure their intrinsic added-value in CNT-enabled products, and to produce nanotube reference materials needed to assess potential environmental, health, and safety (EHS) risks of CNTs.

- databases of critically evaluated crystal structure, diffusion rates, interatomic potentials, and phase equilibrium diagrams needed by industry to design, develop, and process advanced materials without expensive brute-force empiricism.

- transferable instruments, validated protocols and assays, standards, and validated data to determine the physico-chemical and toxicological properties of engineered nanomaterials and nanotechnology-enabled products, essential to assess and manage EHS risks, with a focus on industry-relevant advanced materials such as carbon-based nanomaterials and nanoparticles of titanium dioxide, silver, and silicon dioxide. A specific thrust area is the detection, quantification, and characterization of the release of silver nanoparticles from treated textiles and CNTs from polymer-based nano-composites.

<u>Bioscience and Healthcare</u>: MML will develop and disseminate reference methods, SRMs, measurement quality assurance programs, and new instrumentation, needed to increase the accuracy and comparability of healthcare assessments and to advance biomedical technologies. Research activities will include:

- programs aimed at advancing engineering biology and addressing the grand challenge of understanding the underlying principles that direct biological systems response. This includes the production of sufficient highly-qualified data to permit hypothesis-independent selection of mathematical models that describe the biological response. NIST will provide the mechanism for community engagement, bringing together academics, industry and other agencies, and the fundamentals of measurement assurance, to create a data/analysis pipeline that will enable discovery of biological principles.

- protocols and reference materials for blood protein health status marker detection (such as those used for detection of heart attack, kidney function, and prostate cancer).

- DNA and Ribonucleic acid (RNA) measurement methods and standards that support whole genome sequencing, early detection and diagnosis of disease such as cancer, and genetics-based diagnostics for detection of chromosomal disorders such as Huntington's Disease and Fragile X Syndrome.

- measurement protocols, reference data, and reference materials to support the development, manufacturing and regulatory approval of innovative biopharmaceuticals such as protein therapeutics.

- advanced bioimaging techniques that will enable label-free, information rich, 3D imaging of cells and tissues needed to improve early detection of disease (such as cancer) and significantly advance understanding of the structure and function of complex biosystems.

- documentary standards and best-practice protocols for measuring key attributes of stem cells linked to their safety and efficacy as requested by the cell therapy industry and the Federal Drug Administration (FDA).

- measurements and data needed to ensure the reliability of implanted medical devices non-destructive in-line means to detect faulty capacitors and leads in active medical devices like pacemakers.

- measurement protocols and reference materials for improving the design and reliability of new dental materials, such as mercury-free polymer composite filling materials.

Electronics: In support of the U.S. semi-conductor and electronics industry and the users of advanced electronic materials in a number of industries, MML will develop and disseminate:

- measurement methods and instrumentation needed to accelerate the commercialization of devices based on emerging electronic technologies, including organic flexible electronics, enabling industry to determine the source of materials performance variations that hinder reliable manufacture of innovative products such as flexible displays.

- measurement methods, instruments and reference materials needed by the U.S. semiconductor industry to produce the nanoscale structures, and to employ the novel materials, inherent to the manufacture of next-generation microelectronic devices. These include dimensional metrologies to ensure the quality of manufactured structures and films, and 3D chemical imaging and depth profiling techniques to gauge the reliability of emerging materials deposition and doping routes for manufacturing multi-layered devices and interconnects.

Energy: To keep abreast of current measurement needs of U.S. industry as they design, manufacture, and deploy renewable energy resources, MML will develop and disseminate:

- measurement methods and reference materials to accelerate the commercialization of solar devices made from thin-film semiconductors, and organic photovoltaics. These include measurement tools requested by the budding U.S. solar industry to benchmark material performance, optimize processing and design, monitor manufacturing processes, and determine failure mechanisms that shorten lifetime.

- measurement methods, data, and reference materials that enable our Nation to develop and use alternative and renewable fuels. These include needed fundamental physical property data and the production of data and reference materials needed for the reliable manufacturing and quality control of biofuels such as ethanol and biodiesel, alternative aviation and motor fuels, and pinene and terpene based fuels. In addition, a new program will assess corrosion and other failure mechanisms specific to alternative fuels that can threaten the Nation's ability to use its existing petroleum pipeline infrastructure to transport these newer energy sources.

- measurement methods and reference materials to accelerate the industrial development of energy harvesting and energy storage devices. These include instrumentation and reference materials needed by the U.S. automotive industry to test the performance of thermoelectric devices that recover waste-heat, and measurements that will help industry to commercialize better batteries and fuel cells.

Environment and Climate:

MML will develop and disseminate:

- measurement methods, data, chemical informatics tools, and reference materials to allow precise measurements of key greenhouse gases, including carbon dioxide, methane, and reactive species. This will include two reference materials for calibrating atmospheric levels of Chlorofluorocarbons (CFCs) as well as very accurate measurements of optical properties of methane.

- measurement methods and data necessary to design and evaluate candidate sorbent materials for industrial scale carbon capture and sequestration systems. This includes a new laboratory, the NIST Facility for Adsorbent Characterization and Testing (FACT), which was for built by leveraging ARPA-E funds. The laboratory houses instrument characterizing the pore architecture and evaluating the fundaments sorption properties of advanced materials, which will be used to establish best practices and comparable test methods for new sorbents.

- reference materials, data and a comprehensive marine specimen repository, needed to ground assessments of environmental events, such as the Deep Water Horizon Oil spill, as well as related and remediation efforts, including means to better monitor oil and other residues in marine sediments and animal tissues. In 2015, the marine specimen repository will have expanded to include specimens from Pacific waters.

- reference materials, data, and measurement methods to enable sound scientific assessment of the state of aquatic and soil environments when impacted by contaminants attributed to chemical releases from industrial activities, including hydrocarbons in marine environments, and heavy metals, such as hexavalent chromium, in soil.

- measurement methods, data, and reference materials to allow precise measurements of the optical properties of environmental aerosols, such as so-called black and brown carbon species that will enable substantially better models for predicting atmospheric warming phenomenon.

- reference data and thermophysical property values to needed to predict candidate compounds that can be used as more environmentally benign refrigeration fluids with lower green-house warming potential and ozone depletion potential.

- reference materials, measurement methods, data, and technologies to support a secure and sustainable water future including testing, treating and transporting water.

Food Safety and Nutrition: In this area, reference measurement methods and reference materials or data will be developed and disseminated for underpinning measurements made for determining:

- folate species, vitamin B12, vitamin B6, and vitamin D metabolites to support human nutrition assessment studies being conducted by the Centers for Disease Control (CDC) and National Institutes of Health (NIH).

- accurate levels of iodine and other key nutrients in baby foods, breakfast cereals and table salt, in partnership with the NIH Office of Dietary Supplements.
- identity and properties of bacterial foodborne pathogens by coupling emerging genomic methods with mass spectrometry techniques.

Manufacturing: Enabled by new funding provided in FY 2013 and FY 2014 appropriations and the reprioritizing of current resources, MML will grow priority measurement science and standards programs that will enhance the competitiveness of U.S. manufacturers. Priority program development will include:

- Additive Manufacturing (AM): In concert with the NIST-wide program in additive manufacturing, MML will develop state-of-the-art measurement, characterization, and modeling methods for understanding how processing variables determine the resistance of AM processed materials to mechanical failure. This program will examine methods for measuring and characterizing the chemistry and microstructure of the bonding interface of both polymeric and metallic materials and the quantification of the influence of precursor materials and processing variables on the integrity of the bonds between the voxels of material and the resistance of AM processed materials to fracture.

- Automotive Light-Weighting: In partnership with the Nation's leading automotive manufacturers, The NIST Center for Automotive Light-Weighting will deploy data, measurement protocols and models that enable the automotive industry to rapidly design and produce vehicle components from advanced light-weight alloys, which promise to radically improve fuel efficiency. Starting in 2014, a new NIST-led industry consortium will be formed to leverage a suite of ARRA-funded instrumentation built at NIST that will be used to radically reduce the time and cost needed to introduce lightweight aluminum, high-strength steel and magnesium alloys into vehicle parts, and to ensure the crashworthiness of these parts. In 2015, this partnership will include mechanical and lifetime assessments of lightweight composites proposed for use in vehicles.

- Synthetic Biology: Rapid advances in the ability to modify biological systems at the genetic level have created a new engineering discipline, commonly referred to as synthetic biology, which has the potential to revolutionize manufacturing. Synthetic biology relies on the ability to make and assemble biological machinery in organisms, such as bacteria, or mammalian cells to perform as "factories" with specific and desired functions, for example, the production of fuels, specialty chemicals, novel materials, and drugs. The over-arching challenge to the manufacturing potential of synthetic biology is the lack of quantitative, basic knowledge of how biological systems work and how they can be manipulated with precision through genetics. To address this challenge NIST will establish measurement assurance tools and qualified datasets needed to unlock and quantify the fundamental principles that direct biological systems. As part of this effort, NIST has established a new partnership with Stanford University and a collection industry start-ups in the Stanford region, called the Joint Institute for Making, Measuring and Modelling Biology (JIMMMB).

- Biomanufacturing: The MML program in biomanufacturing will develop measurement methods, protocols, and standards for improved measurement of biologic products. Biotechnology drugs, currently dominated by protein therapeutics, are the fastest-growing class of pharmaceuticals and one of the fastest growing categories of health care spending. MML will work closely with industry, the FDA, and other standards organizations with the goal of developing new measurement science and tools for improved physical/chemical characterization of biologic products. Improved measurement infrastructure will enable greater manufacturing flexibility, the development of biosimilars and new innovative products, and ultimately, safer, more effective biologic medicines. With initiative funds provided previously, MML will establish a new mass spectrometer facility to accelerate development of a monoclonal antibody SRM. This SRM will be used to assess the ability of industry laboratories nationwide to reliably determine the structure and function of a model biologic drug. In addition, MML will establish a mammalian cell culture facility at the Institute for Bioscience and Biotechnology Research, a collaborative NIST-University of Maryland Institute, to support host cell proteomic and metabolomics studies.

- Materials Genome Initiative (MGI): MML expertise in materials measurements and modeling is an essential component to this interagency effort aimed at accelerating industrial innovation by significantly reducing the time from discovery to commercialization for new materials. The MGI will integrate modeling and simulation tools with experimental tools and digital data/informatics in ways that enable rapid prediction and optimization of materials properties. To support this revolutionary approach, MML, in collaboration with NIST's Information Technology Laboratory, will continue to develop the key infrastructure to enable data and models to be exchanged between researchers and integrated in real time, and provide the critical quality metrics (validation, verification, sensitivity, and uncertainty quantification) for these data and models to allow realization of advanced, new materials. To achieve these ends, NIST will continue to assess and implement the best technical modalities for materials data exchange, develop digital repositories of materials data and models, and work with its stakeholders to establish additional repositories, using shared, consensus-based, materials metadata standards. In response to ongoing assessments (drawn from four interagency/industry workshops during FY 2012 and FY 2013 as well as continuous engagement with NIST stakeholders), MML has significantly enhanced its investment efforts to improve materials data exchange, determining best practices for exchange of materials information for a number of targeted materials applications, including thermodynamic, diffusive and mechanical properties. These new efforts will enable true "integration" of computation and experiment to realize new metrologies and "big data" driven materials research. Additionally, MML has developed substantial new efforts in combinatorial materials research, which will be the "big data" experimental feedstock for newly developed models, as well as new exemplars of the MGI approach in functional and biological materials to complement the existing efforts in structural alloys and polymers. Also, in support and MGI and other data-driven enterprises in the materials sciences, MML has begun a significant staffing-up, including the hiring of the founding director, for its Office of Data and Informatics, which will provide expertise, coordination and infrastructure needed for data driven research enterprises in the Laboratory.

- Nanomanufacturing: In collaboration with the NIST CNST, MML will contribute to a nanoparticle manufacturing metrology program to include efforts in separation, synthesis, integration, performance and baseline measurement validation. MML scientists will contribute to the development of tools and methodologies to characterize engineered nanoparticle concentration, size and size distribution, shape and shape distribution, surface functionalization, electronic/optical properties, behavior in complex fluid environments, scalable synthesis processes and the underlying theory.

- Process Measurements for Manufacturing with Advanced Materials: In partnership with industry, MML will develop measurement tools capable of monitoring advanced high-volume manufacturing processes used to produce technologies, such as flexible electronics, organic photovoltaics and carbon-nanotube based composites. The work will focus on techniques for monitoring processes, such as interface formation, film formation, nanotube growth, deposition distribution and structure formation at the speeds needed for high-volume manufacturing, and often with nanometer-level resolution.

Physical Infrastructure: MML will focus its measurement science base in areas critical to maintenance and assessment of our Nation's physical infrastructure. MML will develop, validate, and disseminate:

- measurement techniques that will establish the safety of gusset plate connections in fracture-critical bridges, and that support the establishment of standards for non-destructive bridge condition assessments, in collaboration with the FHWA Turner-Fairbank Research Center.

- measurements and SRMs needed to improve our Nation's ability to detect hidden flaws due to corrosion and fatigue.

- test methods and standards to qualify steels used in fuel pipelines, and measurements that foster the repurposing of pipelines for alternative fuels like hydrogen, ethanol and biofuels, that are needed by the Department of Transportation and Department of Energy to determine the safety rating of these materials for alternative fuels, and are needed to assess biodegradation mechanisms that can degrade pipelines in the presence of new fuels.

- measurements to foster robust U.S. water infrastructure, including means to evaluate next generation plastic water pipelines used in nuclear plant cooling, test the mechanical integrity and fouling resistance of water filtration membranes, and to detect emerging contaminants including nanomaterials and drug metabolites.

Safety, Security, and Forensics:

In this area, MML will develop and deploy:

- measurement methods, reference materials, and data to ensure that the Nation has reliable and effective detection capabilities for Chemical, Biological, Explosive, and Nuclear threat materials, including new test protocols for the efficient sampling of contraband residues requested by the Transportation Security Administration, and control and calibration systems for assessing the performance of biothreat assays.

- new methods for collecting and analyzing contraband residues from fingerprints, credit cards, and clothing using advanced chemical imaging and aerodynamic techniques.

- reference materials and methods of DNA profiling for consistent genetic typing within the forensics and biometrics communities, including new tests to evaluate prototype rapid DNA typing equipment.

- new imaging and mechanical testing protocols for evaluating the performance of soft body armor materials at high strain rates.

- new methods for through-barrier and concealed threat imaging.

- standards and guidelines to improve the quality and consistency of forensic science through participation in the Organization of Scientific Area Committees.

- sound and accurate methods to reliably identify and provide purity analysis of drugs-of-abuse to address the emergence of legalized marijuana.

- new measurement methods, technologies and non-hazardous proxy materials to better train canines to detect contraband substances, such as military explosives, homemade explosive components such as peroxides, and illicit drugs.

5. Engineering Laboratory (EL)

Program Description

The EL provides the measurement science and standards needed for the technology-intensive manufacturing, construction, and cyber-physical infrastructure communities. EL carries out mission functions in fire prevention and control; national earthquake hazards reduction; national windstorm impact reduction; national construction safety teams; building materials and structures; engineering and manufacturing materials, products, processes, equipment, technical data, and standards; sustainable manufacturing and construction; manufacturing enterprise integration; and smart grid devices and systems. EL also carries out other engineering research and services to support mission functions as may be necessary, including systems integration and engineering; intelligent systems and control; robotics and automation; cyber-physical systems; sustainability and energy efficiency; economic analysis and life cycle assessment; productivity measurement; and safety, resilience, and environmental performance.

The EL's measurement science research and services include the development of performance metrics, measurement and testing methods, predictive modeling and simulation tools, knowledge modeling, protocols, technical data, and reference materials and artifacts; the conduct of inter-comparison studies and calibrations; the evaluation of technologies, systems, and practices, including uncertainty analysis; and the development of the technical basis for standards, codes, and practices—in many instances via testbeds, consortia, standards and codes development organizations, and/or other partnerships with industry and academia.

The impacts of EL's mission programs are focused on four strategic goals in areas of critical national priority: Disaster-Resilient Buildings, Infrastructure, and Communities; Sustainable and Energy-Efficient Materials and Buildings; Smart Manufacturing; and Cyber-Physical Systems. EL achieves these end-use impacts by serving as an authoritative source of (1) critical solution-enabling measurement science and (2) critical technical contributions underpinning emerging standards, codes, and regulations that are used by the U.S. manufacturing, construction, and infrastructure industries to strengthen leadership in domestic and international markets. The programs described below support EL's strategic goals; they all develop and deploy advances in measurement science with the specific objectives listed.

Smart Manufacturing

- Smart Manufacturing Systems Design and Analysis: To enable composable, integrated systems architectures, predictive models and real-time data analytics, and system assurance tools for smart manufacturing systems.

- Smart Manufacturing Operations Planning and Control: To enable performance, quality, interoperability, wireless and cybersecurity standards for real-time prognostics and health management, control, and optimization of smart manufacturing systems.

- Robotic Systems for Smart Manufacturing: To safely increase the versatility, autonomy, and agile re-tasking of collaborative robot systems with humans-in-the-loop for next-generation smart manufacturing systems.

- Measurement Science for Additive Manufacturing: To enable rapid design-to-product transformation through characterization, sensing, control, and assurance of materials, processes, and parts using additive manufacturing systems.

Cyber-Physical Systems

- Smart Grid: To enable integration of interoperable and secure real-time sensing, control, communications, information and power technologies to increase the efficiency, reliability, resiliency, and sustainability of the Nation's electric grid.

- Cyber Physical Systems: To enable predictive co-design and robust performance measurement of advanced cyber physical systems that integrate engineered and information technology capabilities.

Sustainable and Energy-Efficient Materials and Buildings

- Sustainable Engineered Materials: To enable sustainable use of engineered materials in manufacturing and construction, including cementitious, polymeric, and composite materials.

- Net-Zero Energy, High-Performance Buildings: To move the Nation toward net-zero energy, high-performance buildings while maintaining a healthy indoor environment.

- Embedded Intelligence in Buildings: To improve building operations to achieve energy efficiency, occupant comfort, and safety through the use of intelligent building systems.

Disaster-Resilient Buildings, Infrastructure, and Communities

- Disaster Resilience: To enable communities to implement measures to improve the resilience of buildings and infrastructure lifelines.

- Structural Performance Under Multi-Hazards: To enhance the community-centric resilience of buildings and infrastructure to natural and manmade hazards.

- Fire Risk Reduction in Communities: To improve the resilience of communities and structures to unwanted fires through innovative fire protection and response technologies and tactics.

- Fire Risk Reduction in Buildings: To increase the safety of building occupants and the performance of structures and their contents by enabling innovative, cost-effective fire protection technologies.

- Earthquake Risk Reduction in Buildings and Infrastructure: To improve safety and enhance resilience of buildings, infrastructure, and communities against the effects of earthquakes.

Examples of Accomplishments

- Smart Manufacturing Systems Design and Analysis: Developed an architecture framework to model, assure, and predict the performance of a smart manufacturing system in real-time. Incorporated data analytics for manufacturing and enable industry standards. Evaluated the architecture framework for quantifying uncertainty, and modeling and composing systems in the context of a manufacturing challenge problem across industry sectors.

- Smart Manufacturing Operations Planning and Control: Completed a major update of the *Guide to Industrial Control System (ICS) Security* (Special Publication 800-82 (Revision 2)) encompassing ICS risk management, recommended practices, security architectures, security capabilities and technologies, and security control baselines tailored to risk levels. The guidance will enable improved ICS security in manufacturing and critical infrastructure industries, while addressing the demanding performance, reliability, and safety requirements of these systems.

- Robot Systems for Smart Manufacturing: Developed a knowledge representation to support robotic kitting operations in manufacturing assembly. The knowledge representation provides the technical basis for standards that enable more rapid deployment and re-tasking of robotic systems in kitting applications, leading to more agile and productive assembly processes.

- Measurement Science for Additive Manufacturing: Developed powder bed density measurement methods and completed associated measurements, providing reference data to improve predictive modeling of powder bed fusion additive manufacturing processes. Developed and submitted a draft Standard Guide for evaluating properties of metal powders used in additive manufacturing processes.

- Cyber Physical Systems: Completed the SmartAmerica Challenge that brought together more than 100 universities and companies in 24 teams to demonstrate the ability of advanced cyber physical systems to save lives, grow the economy, and create jobs in areas ranging from intelligent transportation to smart health care and emergency response. Launched the first ever CPS Public Working Group to develop consensus reference architectures, technical use cases, and cybersecurity frameworks to enable interoperable platforms for innovation.

- Smart Grid: Completed the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0, designed to reflect the most recent progress in the smart grid and enable advances for a future grid. Through the Green Button Initiative, enabled utilities to provide more than 42 million U.S. customers with access to their energy usage data and completed a standards platform that supports innovators and entrepreneurs in creating consumer tools and applications for efficient and sustainable energy usage. Promoted the transition to independence of the Smart Grid Interoperability Panel, providing a forum for public/private partnerships.

- Sustainable Engineered Materials: Developed a measurement protocol to quantify nanofiller release from commercial polymeric products due to physical abrasion or weather exposure. This protocol has been presented to ASTM E56.06 as a standardized measurement protocol. The standardized test method will ultimately inform stakeholders and enable scientifically-based decision-making on impacts of the nanofiller release.

- Net-Zero Energy, High-Performance Buildings: Completed software tool to integrate modeling of airflow and contaminant transport in buildings with overall building energy simulations. Conventional approaches for quantifying the airflow, ventilation, contaminant concentrations, and energy consumption of buildings require separate simulations that are pieced together, a process that is cumbersome and can lead to errors. The new tool overcomes this challenge and will be valuable to the building industry to ensure that it maintains or improves the indoor environment as the Nation strives to improve the energy efficiency of its building stock.

- Embedded Intelligence in Buildings: Completed the design and awarded contracts for the construction of a new laboratory facility to study the use of intelligent agents for control and optimization of complex interacting building systems. This laboratory will enable NIST researchers and industry collaborators to conduct reproducible, carefully controlled tests of intelligent agent control technology resulting in a new generation of optimization techniques for the energy performance of commercial building systems.

- Structural Performance Under Multi-Hazards: Completed and published the final report of the NIST's NCST Technical Investigation of the May 22, 2011, Joplin, MO tornado. The Joplin tornado report outlines 47 major findings and 16 recommendations calling for development of nationally accepted standards and changes to building codes to account for tornadic wind and debris loads, provide storm sheltering options, and improvement of emergency warnings and communications that can significantly reduce deaths and the steep economic costs of property damage caused by tornadoes. NIST is continuing to work with key stakeholders to implement the 16 Joplin tornado recommendations.

- Fire Risk Reduction in Communities: Developed an electronic data collection system for post fire analysis of WUI fires- standardized data collection system for characterizing the impact of fire on wildland-urban interface (WUI) communities. Application of the standardized data collection system will provide needed data to inform the development of standards and codes to improve the fire resistance of WUI structures and communities.

- Fire Risk Reduction in Buildings: Developed and released major updates to the Fire Dynamics Simulator and Smokeview companion computational fire modeling and visualization software tools, including significant advances and improved accuracy for the modeling of hydrodynamics and turbulence, combustion, solid phase heat transfer, pyrolysis, and radiation. The software tools will improve the quality of fire safety practice, fire investigations, planning costly large-scale fire experiments, and design of fire protection systems.

- Earthquake Risk Reduction in Buildings and Infrastructure: Completed a study of costs of compliance with earthquake provisions of national model building codes in Memphis/Shelby County, TN, that influenced local governments there to adopt national model building codes, thus improving earthquake resilience of future construction in that area.

Priority Objectives for FY 2016

- Smart Manufacturing Systems Design and Analysis: Develop a framework for characterizing the performance of a smart manufacturing system incorporating data analytics, architecture requirements, industry standards, methods for including uncertainty quantification and compositional modeling for different manufacturing applications. This framework will enable the performance of a smart manufacturing system to be modeled and predicted in real-time.

- Smart Manufacturing Operations Planning and Control: Develop a digital information-modeling standard for exchanging manufacturing product quality statistics, encompassing all types of quality measurement data. The quality statistics standard will reduce manufacturing costs, increase production efficiency, and improve product quality, eliminating barriers to effective communication of quality statistics information within the manufacturing enterprise.

- Robot Systems for Smart Manufacturing: Design and develop a testbed that instantiates the calibration and related challenges for robot sensors, grippers, and arms in small and medium-sized enterprise (SME) workcells. This testbed will provide an environment in which to develop and validate models and tools for calibration of the robot systems, enabling ease of use of these systems in SME environments.

- Measurement Science for Additive Manufacturing: Establish key performance indicators (KPIs) for metal-based additive manufacturing processes, and develop a prototype implementation of the sensing, diagnostics, and analytics to monitor and adjust these KPIs and enable real-time process control. Real-time control of additive processes will ensure consistent quality of additively manufactured products and an effective response to production changes and disturbances, enhancing the usability of additive manufacturing technology for mission critical applications.

- Cyber Physical Systems: Launch the Global Cities Initiative that brings together smart city implementers with technology innovators to demonstrate the ability of standards for interoperability and performance measurement to reduce the time and cost of smart city deployments, promote entrepreneurship, and enhance benefits to citizens.

- Smart Grid: Complete smart grid test bed modules supporting research on microgrid components for energy management, resilience, efficiency, and reliability. These initial modules will enable measurement science focused on microgrid management and operations, grid sensors and communications, timing, smart meters, and cybersecurity.

- Net-Zero Energy, High-Performance Buildings: Complete publicly available software tool for screening new refrigerants with low global warming potential for use in air conditioners, heat pumps, and refrigeration systems. This tool, which accounts for refrigerant thermodynamic and transport properties, will be used by manufacturers of such systems to transition to more environmentally benign substances while maintaining the energy efficiency of their equipment.

- Embedded Intelligence in Buildings: Assess the energy and economic impact of common building system faults and use the results to develop and implement a fault prioritization capability for the NIST-developed Automated Fault Detection and Diagnostic Expert Assistant (FDD-EA). This feature will provide users with guidance on the most likely cost-effective order in which to address multiple fault cases and can significantly increase the industry acceptance of FDD technology.

- Sustainable Engineered Materials: Deliver a concrete rheology SRM for calibrating science-based rheometers as a replacement for existing empirical flow tests. This is the culmination of three SRMs (paste, mortar, and concrete) that have been delivered to the concrete construction industry, which will enable calibration of cement rheometers and scientifically-based characterization of concrete flow properties.

- Disaster Resilience: Develop and disseminate first generation Model Resilience Guidelines for critical buildings and infrastructure lifelines. These guidelines will assist communities in implementing measures to enhance the resilience of their critical buildings and lifeline systems based on existing standards, codes, and best practices

- Structural Performance Under Multi-Hazards: Complete development of new wind hazard maps designed for incorporation into building codes and standards. The maps are based on more sophisticated analysis techniques and more climatological data than the existing maps, and provide better representation of the regional variations in extreme wind climate, leading to safer and more economical structures.

- Fire Risk Reduction in Communities: Develop standard test methods to evaluate the performance of emergency response robots used by fire fighters and search and rescue teams. Standard test methods will improve the safety and effectiveness of emergency responders during urban and wildland fires, significant accidents, and catastrophic natural disasters.

- Fire Risk Reduction in Buildings: Develop a computational simulation to estimate the fire environment created by burning residential furniture. Characterization of the fire environment will provide a design basis to improve the fire performance of residential upholstered furniture.

- Earthquake Risk Reduction for Buildings and Infrastructure: Recommend changes to model building code provisions based on laboratory testing and analysis of slender reinforced concrete walls subject to ground motion induced uplift phenomena first seen in the 2010 Maule, Chile, earthquake. Adoption and use of updated model building codes will improve the safety of buildings with slender reinforced concrete wall elements in major earthquakes.

6. Information Technology Laboratory (ITL)

Program Description

The ITL enables the future of the Nation's measurement and standards infrastructure for information technology by accelerating the development and deployment of information and communication systems that are interoperable, secure, reliable, and usable; advancing measurement science through innovations in mathematics, statistics, and computer science; and conducting research to develop the measurements and standards infrastructure for emerging information technologies and applications. We accomplish these goals through collaborative partnerships with our customers and stakeholders in industry, government, academia, and consortia. Based on input from these customers and stakeholders, we have focused our research and development agenda on these broad program areas.

- Advanced Networking: ITL's Advanced Networking initiative focuses on measurement science for robust, scalable, and advanced networking technologies and innovative trustworthy methods for dynamically provisioning resources that are critical for such National initiatives as Health IT, telemedicine, Smart Grid, environmental monitoring, and mobile and cloud computing.

- Advanced Materials: As part of the multi-agency Materials Genome Initiative (MGI), ITL is working with the Material Measurement Laboratory to apply our expertise in the development and use of materials modeling and simulation for manufacturing, and to collaborate in the creation of a national informatics infrastructure that will substantially lower the cost of both design and manufacturing for industries seeking to realize the benefits of computer-based materials discovery and optimization.

- Big Data and Data Science: The NIST Big Data and Data Science program seeks to enable foundational improvements in data science and analytics, knowledge discovery, information understanding and visualization across areas of high priority to NIST, DoC and Federal agencies, through rigorous measurement, testing and evaluations.

- Cloud Computing: NIST's role in cloud computing is to promote the effective and secure use of the technology by providing technical guidance and promoting standards that enable cloud users to benefit from increased efficiency for cost savings and enhanced capabilities for applications such as Big Data and mobile computing.

- Cyber Physical Systems (CPSs): NIST is working with industry, academia and other stakeholders to develop a consensus definition, taxonomy and reference architecture to identify and address core CPS design, interoperability, cybersecurity, networking and timing requirements via the development of standards, guidelines, and measurements.

- Cybersecurity Automation: NIST develops the underlying essential standards to enable automating cybersecurity vulnerability discovery, configuration management, and security metrics. These standards allow for the design of machine readable cybersecurity policies that can be automatically disseminated, enforced, audited and remediated by commercial tools in near real time as well as tool based, standardized cybersecurity vulnerability management at enterprise scale.

- Cybersecurity Framework: Recognizing that the national and economic security of the United States depends on the reliable functioning of critical infrastructure, the President issued Executive Order 13636, Improving Critical Infrastructure Cybersecurity, in February 2013. It directed NIST to work with stakeholders to develop a voluntary framework – based on existing standards, guidelines, and practices - for reducing cyber risks to critical infrastructure.

- Cybersecurity Research and Development: NIST's focus is to improve the cybersecurity assurance posture of current and future information technologies and to improve the trustworthiness of IT components such as claimed identities, data, hardware, software for networks and devices, mobile device security, and information analytics. This includes research and analysis of cryptographic technologies including hash algorithms, symmetric and asymmetric cryptographic techniques, key management, random number generation and cryptographic metrics and tests.

- Cybersecurity Standards: NIST's role in the standardization of cybersecurity technologies is exercised by the deep technical expertise held by NIST personnel in areas such as cryptography and key management. NIST cybersecurity experts and cryptographers engage with a variety of national and international standards bodies to help accelerate the standardization and adoption of other U.S. information and critical infrastructure technologies.

- Health Information Technology: NIST collaborates with the Health and Human Services (HHS) Office of the National Coordinator, major standards development organizations, professional societies and the public sector in fostering interoperable, secure, reliable, and usable standards-based solutions for the exchange of health information.

- Metrology for Computation: The Metrology for Computation Program focuses on developing a measurement and standards infrastructure for scientific computation that will lead to predictive computing with quantified reliability and result in a solid foundation for the use of scientific computing as a measurement and decision-making tool.

- National Cybersecurity Center of Excellence (NCCoE): By working collaboratively with the Information Technology industry, the NCCoE tackles industry's most significant cybersecurity challenges by reducing barriers to adoption of more secure technologies. The NCCoE and its technology partners demonstrate example solutions that are standards-based, practical, open and usable.

- National Strategy for Trusted Identities in Cyberspace (NSTIC): NSTIC was established in direct response to the White House Cyberspace Policy Review, which called for an effort to raise the level of trust associated with the identities of individuals, organizations, services, and devices involved in online transactions. The crux of these activities has taken place in the privately-led Identity Ecosystem Steering Group, with support from the NSTIC National Program Office at NIST to develop a framework of standards, policies and accreditation processes necessary to implement NSTIC and develop, in collaboration with stakeholders, a standards roadmap for credential issuers, relying parties and service providers.

- Next Generation Internet Technologies: Today's Internet provides critical infrastructure to almost every aspect of our society, yet many of the Internet's core protocols and services are vulnerable to attack and misconfiguration and are reaching critical scaling limits due to the growth of the Internet. The Internet Infrastructure Protection program focuses on evolving the current Internet's core protocols for naming, addressing and routing to be more robust and secure and to support continued viability of the current Internet architecture.

- Quantum Information: As part of the larger NIST Quantum Information Program, ITL aims to understand the potential for quantum-based technology to transform computing and communications, and to develop the measurement and standards infrastructure necessary to exploit this potential.

- Smart Grid: NIST works nationally and internationally with industry, other government agencies, academia, and other stakeholders on cybersecurity, and communication requirements, performance metrics, measurement methods, and standards. ITL leads NIST Smart Grid activity in cybersecurity and the use of wireless and power line communication infrastructures. ITL provides smart grid users and stakeholders with guidance and tools to help them make informed decisions about smart grid information infrastructures.

- Synthetic Biology: To ensure quality and predictability in the design of synthetic biological systems for efficient production of fuels, chemical feedstocks, pharmaceuticals and medical therapies, ITL will develop novel image analysis methods to identify dynamic behaviors in experimental data and connect them to DNA sequences. Further, ITL will develop a computational framework to evaluate data and predictive models, and develop a resource repository of data and theoretical models.

- Uncertainty Measurement: NIST develops and applies best practices for the characterization of measurement uncertainty, in particular to enable the intercomparison of measurements in the context of interlaboratory studies and calibrations.

Examples of Accomplishments

- Advanced Materials: NIST provided the materials research community with a 3D tool for studying the relationship between the microstructure of a material and its overall mechanical, dielectric, or thermal properties. The tool, OOF3D, enables scientists to improve the testing of materials while saving considerable amounts of time by analyzing and predicting the behavior of materials under various conditions of stress and strain.

- Big Data and Data Science: NIST issued Big Data Reference Architecture Version 1 and Big Data Technology Roadmap Version 1. These documents provide a basis for defining and prioritizing requirements for interoperability, portability, reusability, and extendibility for big data analytic techniques and technology infrastructure in order to support secure and effective adoption of Big Data. These documents are the basis for the initial activities of a new international standards working group on Big Data.

- Cloud Computing: NIST released for public comments the Usability Cloud Framework and a white paper on Cloud and Accessibility. The Usability Cloud Framework will be the foundation for developing usability metrics for organizations interested in measuring the user experience when adopting the cloud. The Cloud and Accessibility white paper details the activities of the Public Working Group on Cloud and Accessibility as it addresses the topics facing cloud computing with respect to accessibility, standards and usage.

- Cybersecurity Framework: In February, 2014, NIST released the "Framework for Improving Critical Infrastructure Cybersecurity," which was created through collaboration between industry and government, and consists of standards, guidelines, and practices to promote the protection of critical infrastructure. The prioritized, flexible, repeatable, and cost-effective approach of the Framework helps owners and operators of critical infrastructure to manage cybersecurity-related risk. The Framework is already being implemented by industry, adopted by infrastructure sectors and is reducing cyber risks to our critical infrastructure, including the finance industry.

- Cybersecurity Standards: The SHA 3 Cryptographic Hash Algorithm and Modes of Use has been issued as a Federal Information Processing Standard and introduced into the International Organization for Standardization for processing as an international standard.

- National Cybersecurity Center of Excellence (NCCoE): NIST awarded the National Cybersecurity Center of Excellence Federally Funded Research and Development Center (FFRDC). The FFRDC is addressing an urgent national requirement that scientific and engineering talent be rapidly assembled and put to work to enhance the trustworthiness of our Nation's government and private sector information systems. The confidentiality, integrity, and assured service shortcomings of these information systems pose a serious risk to national security, public safety and economic prosperity. Widespread adoption of components and systems designed to address threats to our information technologies is inhibited by shortcomings in usability, affordability, and performance impacts. The FFRDC is enhancing the NCCoE's ability to address these shortcomings.

- Next Generation Internet Architectures: NIST released to the Internet industry, protocol specifications, rapid prototypes and measurement/monitoring systems for emerging secure inter-domain routing technologies. These are helping industry measure and characterize the completeness, correctness and robustness of emerging global information infrastructures for BGP security.

- Quantum Information: In cooperation with the University of Maryland (UMD) and the National Security Agency (NSA), NIST has established a new Center for Quantum Information and Computer Science on the campus of UMD. The goal of the center is to realize the full vision of the existing Joint Quantum Institute by bringing in new partners within the University and NIST to perform foundational research in quantum information theory. Such work will prepare NIST to develop the necessary measurement and standards infrastructure for future computing and communication systems based on radically different architectures that exploit the computational power of quantum mechanics.

Priority Objectives for FY 2016

- Advanced Networking: To develop advanced test and measurement techniques to characterize and improve promising "clean slate" designs for fundamentally new architectures and protocols for core Internet services, including: new routing and addressing paradigms, information centric networking architectures and software defined networks. NIST's initial focus will address characterizing the robustness and security properties of emerging Software-Defined Networking (SDN) technologies. NIST will develop techniques to predict catastrophic run-time events in distributed systems. The resulting measurement science will provide a rigorous foundation for industrial methods to signal the onset of catastrophic events on the basis of measurable precursor behaviors.

- Advanced Materials: Working closely with the Materials Measurement Laboratory to achieve the goals of the inter-agency Materials Genome Initiative, ITL will develop techniques and tools for the quality assessment of computational tools and materials data, as well as the development of standards, protocols and related tools for the seamless interchange of data among computational platforms.

- Big Data and Data Science: To develop standards, guidelines, and best practices to enable reliability, security, and privacy-protection that facilitate innovative big data approaches for storage and access, analytics, knowledge extraction, fusion/integration, usability and visualization that are generalizable across multiple sectors. NIST will also create a cloud-compatible computational cluster to support data science R&D in measurement, test and evaluation through understanding reconfigurable hardware approaches and various Big Data benchmarking methods and data management.

- Cloud Computing: To address the high priority interoperability, security and portability requirements identified in the "USG Cloud Computing Technology Roadmap" to accelerate USG adoption of cloud computing.

- Cyber Physical Systems (CPS): As part of a public-private partnership, NIST will develop a consensus definition, taxonomy, and reference architecture for CPS. NIST will develop a technology road map that identifies CPS standards, measurements, and research gaps to inform ongoing industry, academia and government research, development, measurement, and standards activities. NIST will leverage its extensive cybersecurity, networking, and timing expertise in the CPS domain – for example by exploring the application of the NIST cybersecurity risk management framework, and other guidance, to the CPS domain.

- Cybersecurity Automation: To work with industry through standards development organizations to transition cybersecurity automation technologies into IT commercial products. Develop and demonstrate prototypes and deployment to confirm existing capabilities and standards gap areas and continue efforts in security taxonomies to facilitate cybersecurity information sharing.

- Cybersecurity Research and Development: To conduct research and development into security design principles for systems engineering, privacy engineering and security of small sensor networks and the "internet of things". Continue public-private engagement to address areas identified during the development of the Cybersecurity Framework directed by Executive Order 13636. To conduct research into quantum resistant cryptography, usable security, privacy enabling encryption, constrained encryption and formal proofs for cryptography.

- Cybersecurity Standards: To participate in and provide contributions for national and international voluntary consensus standards efforts in support of elliptical curve cryptography, identity, security automation, communication protocols, smart grid, and risk management as well as emerging areas where standards needs are identified and correspond to mission and stakeholder needs.

- Health Information Technology: To promote interoperability and adoption of Health IT by applying NIST expertise in standards development, harmonization, and testing; security; usability; and certification processes. This will enable broader applications of electronic health records and health IT through telehealth and mobile devices.

- Metrology for Computation: To research and develop metrology constructs – standard reference computations, uncertainty quantification techniques, and traceability procedures – for scientific computation and computer-assisted measurement technologies. These will be applied in a variety of areas, including medical imaging and materials discovery.

- National Cybersecurity Center of Excellence (NCCoE): Within the Health IT Use Case, launch a new project focused on the security of wireless medical infusion pumps and increase the number of simultaneous cybersecurity use cases and active participants at the Center.

- National Strategy for Trusted Identities in Cyberspace (NSTIC): To work with the Identity Ecosystem Steering Group to improve the Identity Ecosystem Framework, coordinate Federal government adoption of NSTIC, as well as award additional pilots to advance implementation of the NSTIC.

- Next Generation Internet Technologies: To develop and promulgate standards and test methodologies for new ubiquitous trust infrastructures based upon secure Domain Name System (DNS) technologies to improve the trustworthiness and robustness of Internet email and web services.

- Quantum Information: To develop experimental protocols and statistical analysis procedures to assess the capability of particular physical realizations of quantum computation. In addition, NIST will continue to evaluate algorithms that may provide the basis for future public key cryptography systems that are resistant to attack by adversaries with quantum resources.

- Smart Grid: To develop and disseminate methods and guidelines for assessing the suitability of network communication technologies and architectures and their use for Smart Grid applications. NIST will also research the most common platforms used in the Smart Grid in order to further extend the security content automation protocol which can decrease the cost of cybersecurity implementation in the smart grid. Additionally, NIST will explore the application of resource constrained cryptography for processing platforms that are applicable for the Smart Grid.

- Uncertainty Measurement: To identify and develop new statistical methods for improved analysis of forensic evidence.

7. Strategic and Emerging Research Initiative (SERI)

Program Description

The SERI program provides the NIST Director with the programmatic flexibility to seed the development of new competencies that enable NIST to contribute to the solution of future national needs and goals by investing in high-risk, high-payoff innovative research. SERI supports the DoC and NIST's mission of promoting U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology that drive technological change.

The primary activities being conducted with the program's base resources are the development of new competencies necessary to develop and maintain knowledge related to measurement techniques that solve problems in areas of national need that NIST has identified. The SERI program gives NIST the flexibility to quickly develop capabilities to solve new measurement problems for emerging national needs. Examples of past national need areas that had related measurement and standards competencies addressed through SERI include Smart Grid, physical infrastructure, advanced manufacturing, and reduction of greenhouse gas (GHG) emissions. SERI allows NIST to develop these measurement and standards competencies more quickly, which enables emerging problems to be addressed much more efficiently and effectively, leading to even greater economic benefits.

Current Objectives and Examples of Accomplishments

Redefinition of the Kilogram (kg)

SERI funding is being utilized by NIST to support the international efforts to prepare for a future redefinition of the unit of mass - the kg - the last remaining International System of Units (SI) basic unit defined by an artifact. NIST initiated two efforts to redefine the kilogram with an invariant of nature, the Watt-Balance Project and the Avogadro Project. The Watt-Balance Project measures the force required to balance a one kg mass artifact against the pull of earth's gravity by monitoring the voltage and current (hence the name "watt") involved in doing so. The Avogadro Project involves the determination of Planck's constant, requiring "counting" the number of atoms (via unit cell volume of a crystal) in each of two highly pure one kg single-crystal enriched silicon spheres about 94 millimeters (mm) in diameter to define their molar mass. The result provides a determination of the Avogadro constant, which in turn can be used to obtain Planck's constant using the well-known values of other constants. Specifically, SERI funding has accomplished the following:

- Setup of the multicollector inductively coupled plasma mass spectrometer (MC-ICPMS) for the Avogadro Project;
- Performing repeated molar mass measurements using optimized design to evaluate reproducibility and ensure it meets the goal of the project;
- Recalibrated components of the previous watt balance to enable the redefinition; and
- Initiated the development of a new, robust watt balance capable of routine mass dissemination after the redefinition

National Strategy for Trusted Identities in Cyberspace (NSTIC)

SERI funding was utilized in FY 2011 to initiate the NIST effort in support of NSTIC, which President Obama signed in April 2011. This strategy charts a course for the public and private sectors to collaborate to raise the level of trust associated with identities of individuals, organizations, networks, services, and devices in online transactions. The vision is a future in which "Individuals and organizations utilize secure, efficient, easy-to-use, and interoperable identity solutions to access online services in a manner that promotes confidence, privacy, choice, and innovation." SERI funding enabled the initiation of the NIST effort and building of a platform to maximize initiative funding received for FY 2012. Specifically, SERI funding accomplished the following:

- Laid the groundwork for the NSTIC National Program Office that will lead the implementation of NSTIC and coordinate activities with the private sector stakeholders;

- Worked with industry, academia, advocates, non-profits and governments to develop a comprehensive view of the problem space and inform the NSTIC vision, objectives, and guiding principles; and

- Issued grants to advance the NSTIC vision, objectives, and guiding principles. In FY 2012, NIST awarded more than $9.0 million for pilot projects to five U.S. organizations. In January 2013, NIST released the Federal Funding Opportunity (FFO) for the second round of pilots.

Climate Research/GHG Monitoring

SERI funding was utilized to develop competence across NIST in development and validation of novel methodologies and procedures for remote monitoring and measurement of greenhouse gas emissions.

This competence forms the basis of a recently-funded effort in which NIST will:

- provide the measurement science basis for accurate and comparable quantitative measurements of GHG emissions;

- ensure measurement capabilities for accurate and reliable assessment of current GHG baselines, verification of GHG emissions, and quantification of GHG sinks that absorb GHGs through quantitative measurements; and

- enable development of international measurement standards to ensure the accuracy of global assessments of GHG emissions.

Biomanufacturing

SERI funding was utilized to jump start NIST's ability to address inefficiencies and stimulate innovation in healthcare by addressing challenges associated with the development and manufacture of biologic drugs. NIST used SERI funding to develop competence in the measurement needs and techniques in biomanufacturing and to procure instruments used to characterize proteins/biologic drugs. NIST will use these competencies and accomplish the NIST role in the development of a suite of fundamental measurement science, reference standards and reference data to enable more accurate and confident characterization of key attributes of protein drugs that are directly linked to their safety and efficacy. Specifically, these competencies form the basis of a recently-funded effort in which NIST will focus on three measurement challenge areas related to 1) the characterization of protein therapeutics and their manufacture; 2) protein stability/protein structure; and 3) protein cell variability. These tools will facilitate the development of the Biomanufacturing industry and offer the possibility of lower cost biosimilars, thereby allowing U.S. citizens affordable access to these innovative and life-saving biopharmaceutical medicines.

8. Innovations in Measurement Science (IMS)

Program Description

IMS program provides funds to explore high-risk, leading-edge research concepts that anticipate future measurement and standards needs of industry and science. These funds are a principal mechanism for initiating the new programs and research directions necessary for NIST to keep pace with and respond quickly to the increasingly complex nature, and the shorter time frame, of technology development.

Since its inception in 1979, the IMS Program has: 1) funded over 100 research projects that have evolved into core activities within the NIST Laboratories, 2) formed the cutting edge of NIST's research programs, and 3) attracted some of the Nation's top scientific talent to NIST. Four NIST Nobel Prize winners in Physics (Dr. William Phillips, 1997; Dr. Eric Cornell, 2001; Dr. Jan Hall, 2005; and Dr. David Wineland, 2012) each conducted projects that were funded by the IMS program. Other program achievements include the development of a cold-neutron small-angle scattering facility, a bold concept that ultimately led to the NIST Center for Neutron Research (NCNR), now a premier research program that attracts almost 2,300 affiliated researchers annually from industry, government, and academia.

One current research effort funded through the IMS program is addressing fundamental problems with the essential links between electrical and mechanical units from the International System of Units (SI). The calculable capacitor, a device that realizes the capacitance unit (farad) from the meter, was originally created 40 years ago after many years of research and has been used ever since. With the availability of new technologies, such as modern lasers and digital electronics, it is now possible to build the next generation of calculable capacitors with improved reliability, accessibility, and accuracy. In this project, NIST will use femtosecond laser frequency comb technology to create a new calculable capacitor that would, for the first time, realize an SI electrical unit based directly on an atomic clock. NIST's goal is for its new calculable capacitor to have measurement uncertainties roughly a factor of two lower than those of other calculable capacitors currently being developed around the world.

9. Postdoctoral Research Associateship Program

Program Description

NIST supports a nationally competitive Postdoctoral Research Associateship Program which is administered in cooperation with the National Research Council (NRC). The NIST NRC postdoctoral program recruits outstanding research scientists and engineers to work on NIST research projects, strengthens communications with university research, and provides a valuable mechanism for the transfer of research results from NIST to the scientific and engineering communities.

The NIST NRC postdoctoral program is an important part of NIST's efforts to support industry through advancing measurement, standards, and technology, and represents a highly cost-effective means of technology transfer to and from NIST of the latest measurement sciences and technologies. Incoming associates bring the most recent advances in university research to NIST, while actively contributing to NIST projects. The program increases technology transfer from NIST to industry, academia, and other government agencies, contributing to the employment pool of highly-qualified scientists and engineers for these sectors. NIST's mission to support U.S. industry with measurements, standards and technology depends on a constant infusion of new ideas and expertise to address the rapidly advancing needs of a technology-driven economy. Skilled and motivated people are the most effective source of technology and knowledge transfer. The highly competitive NIST NRC postdoctoral program ensures a continuing infusion of postdoctoral associates who bring to NIST the benefits of the latest academic research.

Examples of Accomplishments

NIST NRC postdoctoral associates carry out state-of-the-art research which supports industry through advancing measurements, standards, and technology throughout the core programs of NIST. Each of the projects advances measurement and standards research areas in some way, but a few examples of areas of research by recent postdoctoral associates include such projects as:

- Characterized carbon dioxide adsorption with neutron/X-ray diffraction in several types of zeolites for possible application to flue and natural gases;

- Developed custom software for thermal imaging calibration and measurement procedures, towards applications in metal-based additive manufacturing;

- Constructed optoelectronic instruments to measure charge characteristics and efficiency in organic photovoltaic devices;

- Developed and constructed a prototype optical nanocalorimeter using bilayer microcantilevers to investigate nanoparticles (e.g. Sn, Zn, Ag) to develop a temperature calibration curve for supporting the ITS-90, themodynamic temperature scale;

- Developed and implemented a novel camera using microwave superconducting quantum interference devices (SQUID's) to multiplex an array of transition edge sensors (TES) bolometers;

- Developed a standard method for human plasma metabolite analyses using Liquid Chromatography/Mass Spectrometry to identify more than 95 common metabolites; and

- Development of methods for the modeling of nucleic acids using scattering and nuclear magnetic resonance (NMR) restraints.

Priority Objectives for FY 2016

The priority objectives for FY 2016, for the NIST NRC postdoctoral program, are to continue to recruit the best applicants for the program and to make best use of the available resources to bring on as many highly-qualified postdoctoral associates as possible. NIST scientists and engineers, acting as mentors/advisers for the program, are constantly refining and proposing new research areas in which to interest applicants. The program is a very flexible and responsive way to focus new NIST activities to address critical national priorities including those in energy, environment, information technology security, and physical infrastructure. NIST continues to improve the focus of the program to ensure a continuing infusion of motivated postdoctoral associates into the NIST measurement science laboratories, ensuring mutually-beneficial technology and knowledge transfer between NIST and the postdoctoral associates. Across all NIST laboratories, the program strongly supports the goals of the NIST Three Year Programmatic Plan. The postdoctoral program addresses NIST priorities to meet critical national needs, strengthening and focusing NIST's laboratories and research to ensure U.S. leadership in measurement science and standards in these areas.

<u>10. Communications Technology Laboratory (CTL)</u>

In FY 2014, through a reprogramming request to Congress, NIST established a new Organizational Unit (OU), CTL, under the Associate Director for Laboratory Programs. The CTL is headquartered at the NIST facility in Boulder, Colorado and will be part of the joint NIST/NTIA Center for Advanced Communications (CAC), which will serve as a hub for collaboration with other government agencies, and industry.

CTL promotes the development and deployment of advanced communications technologies, through the conduct of leading edge R&D on both the metrology and understanding of physical phenomena, materials capabilities, complex systems relevant to advanced communications; and research targeted at supporting a multi-level testbed facility, including the development of precision instrumentation, validated test-protocols, models, and simulation tools necessary to support the testing and validation of new communications technologies. CTL is working to address critical needs in public safety communications, and well as increasing the efficiency scarce spectrum use to meet the demands from the exponential growth of wireless data.

Both NIST and NTIA possess world-class advanced communications capabilities in the areas of spectrum sharing, testing, standards coordination, public safety communications, electromagnetics and quantum electronics, among others. As stand-alone efforts, the work of the two agencies has effectively addressed the needs of sponsors and improved the overall understanding of communications technology in the marketplace. By finding synergies within the agencies' respective authorized areas of activity and taking advantage of and leveraging the critical mass of NIST and NTIA research and engineering capabilities concentrated in Boulder, Colorado through the formation of the CAC, the Department of Commerce will create a unique national asset that will provide the infrastructure necessary for effective engagement and collaboration with industry, academic and government partners necessary to effectively and efficiently address current and future advanced communications challenges.

Examples of Accomplishments

- Advanced Communications: NIST and NTIA have signed an MOA to establish the Center for Advanced Communications. The CAC has begun engagement with the Department of Defense (DoD) to address spectrum sharing measurements, and is creating the National Advanced Spectrum and Communication Test Network (NASCTN) to facilitate the coordinate their respective spectrum sharing efforts and engineering capabilities. NASCTN will be a network of government, academic and commercial capabilities to facilitate and coordinate the use of intellectual capacity, modeling and simulation, laboratory, and test ranges to meet national spectrum interests and challenges.

- Public Safety: Developed a multivendor Public Safety Broadband network to characterize Quality of Service, Priority, and Pre-emption for 700 MHz band 14 Long-Term Evolution (LTE) wireless networking equipment.

- Public Safety: Advanced the development of standards for mission-critical voice-over-Internet Protocol in LTE wireless standards to support next-generation first responder communications.

- Public Safety: Developed and executed a test plan to characterize the expected in-building penetration of LTE radio signals and researched the effects of using cost effective in-building small cells to enhance in-building penetration.

Priority Objectives for FY 2016

- Advanced Communications: Develop measurement methods to enable the implementation of spectrum sharing. NIST will develop test systems and protocols to validate the performance of wireless systems and spectrum-sharing technologies.

- Advanced Communications: Lead the National Advanced Spectrum and Communication Test Network (NASCTN) to coordinate spectrum sharing efforts with DoD entities. Establish practices and processes that provide a fused federal capability to hasten, promote and enable federal, academic, and industrial users to work together to address pressing spectrum sharing and co-existence challenges.

- Advanced Communications: Develop calibrated signal sources for high-speed modulated signals that will help enable deployment of advanced communication systems that use higher frequency spectrum than that generally commercialized today. Opening up this frontier of spectrum will enable expanded use of broadband (high-data rate) devices and applications. Measurement methods to be developed by NIST will enable the engineering of advanced devices and the implementation of spectrum management policy. NIST will develop free field test systems to verify the performance of wireless systems and spectrum-sharing technologies.

- Public Safety: Develop equipment and network measurements and standards that support the development and launch of the First Responders Network Authority (FirstNet).

- Public Safety: Design and build a test network to research the impacts of transferring the Government's Wireless Priority Services from older cellular technologies to advanced LTE networks.

- Public Safety: Characterize the impact of loud noise environments on Voice-over-LTE (VoLTE) and its effects on public safety speech intelligibility.

PROGRAM CHANGE(S):

1. Ensuring a World Class Neutron Research Facility (Base Funding: $46.8 million and 171 FTE; Program Change: +$11.0 million and +1 FTE)

NIST requests an increase of $11.0 million and 1 FTE to ensure that NIST continues to provide a world-class neutron research facility, providing access to sophisticated measurement tools that can be used by industry.

Enhancing industrial competitiveness with a world-class neutron research facility ($11.0 million)

Growing the economy, improving industrial competiveness, and developing the products of tomorrow require providing industry with access to sophisticated measurement tools enabling researchers to find solutions to problems quickly. Neutrons have been enormously successful as a unique probe of the structure and dynamics of materials for researchers from many different backgrounds, including academia and industry. Neutrons can provide information that simply cannot be obtained using more conventional methods available in the researchers' own laboratories. Worldwide, the demand for access to neutron measurement capabilities far exceeds the supply, and the NIST Center for Neutron Research (NCNR) is the only U.S. facility with a focus on enhancing industrial competitiveness. It is therefore essential to U.S. industry, and the long-term economic growth of the U.S., that the NCNR is optimally equipped to provide state-of-the-art measurement tools to the U.S. scientific and engineering community.

The NCNR will maintain and grow its high quality facility to address the neutron supply-demand mismatch by investing in a lifetime extension of the source facility to maintain reliable operations and high availability to the end users. The investment will ensure the high reliability and availability of the facility through strategic enhancements of the reactor source (including obtaining an adequate supply of reactor fuel) and supports NIST's capacity to grow innovation-intensive economic sectors in support of DoC Strategic Plan Objective 2.5 and supports the development of partnerships and collaborations as identified in DoC Strategic Plan Strategic Objective 2.1.

Action: Lifetime extension of the source facility to maintain reliable operations and high availability to the end users

The NCNR uses a 20 MW research reactor as a neutron source. The reactor operates 24 hours a day, seven days a week for approximately 250 days of the year to support experiments by over 2,000 research participants annually. It is critical that the research reactor operates safely and reliably in order to support the NCNR mission to develop and provide advanced neutron measurement techniques and instrumentation for research. Costs to maintain, upgrade or replace reactor systems as well as costs for reactor fuel have increased significantly. For example, the cost to procure an individual reactor fuel element rose from $32,500 in 2002 to $94,060 a decade later in 2013, and it is estimated to be over $150,000 in 2015. Due to these rising costs as well as needed maintenance and upgrades, NIST is requesting funds for reactor facility enhancements in three areas in order to maintain the high availability and reliability of the source for the NCNR users:

- *Reactor fuel manufacturing and shipping*: $6.0 million per year is requested to enable NIST to ensure the availability of reactor fuel for sustained operations. At its current capacity NCNR uses 28 fuel elements annually. These funds will enable NIST to continue to support domestic fuel production and ensure that the NCNR can continue operations for the foreseeable future.

- *Primary cooling system upgrade*: The primary cooling system is essentially all original equipment and is operating beyond the original design lifetime of 40 years. Replacement parts for many of the components that wear out over time are unavailable and require fabrication from original drawings. NIST requests $2.0 million per year for upgrades that will systematically replace the main components (pumps and isolation valves).
- *Heavy water replacement*: The 46 metric tons of heavy water that cools the reactor via the primary cooling system must be replaced every ten years because it becomes radioactive over time as tritium builds up during normal operations. NIST is requesting a one-time investment of $3.0 million for this cost in FY 2016. In the out-years these funds will be applied to maintain and upgrade reactor infrastructure.

Statement of Need and Economic Benefits

Investments in neutron science at NIST will enable industry researchers to study and develop new materials and products. Neutrons have been enormously successful as a unique probe of the structure and dynamics of materials under a broad range of such conditions including stress, shear, flow, high and low temperatures, and magnetic field. Paint, a $25.0 billion industry in the U.S., is an example of a material that has been engineered to exhibit specific properties under shear and neutrons have been essential in developing the understanding leading to improved performance. Pharmaceutical companies, a $340.0 billion industry in the U.S., use neutron scattering as an essential tool for the development of biopharmaceuticals, requiring more varied processing equipment (e.g. for complex flow conditions) to be available for beam-line research. In each case neutrons provide industry with information that simply cannot be obtained using more conventional methods.

Unfortunately the demand for access to neutron measurement capabilities far exceeds the supply. In the U.S. there are only three remaining sites that provide such measurement capabilities. One of the Nation's facilities is scheduled to be de-funded in FY 2015, which will further reduce the U.S. measurement capacity and significantly exacerbate the supply-demand mismatch.

Base Resources Assessment

The NCNR is the only U.S. facility with a focus on enhancing industrial competitiveness. It is therefore essential to U.S. industry, and the long-term economic growth of the U.S., that the NCNR is optimally equipped to provide state-of-the-art measurement tools to the U.S. scientific and engineering community. With the recent completion of a major expansion, about two dozen instruments are available at the NCNR alongside a high quality technical staff. The 2013 National Research Council assessment identified the NCNR as a premier neutron science user facility and noted "NCNR's high scientific productivity is due, in part, to effective communication between the management and staff and with the internal and external user communities." The NCNR provides several access modes for neutron research, ranging from peer-reviewed proposals to industry partnerships, proprietary research, and through consortia – such as nSoft that is providing access to leading companies such as Dow, Kimberly-Clark, and Medimmune. Over 2,000 research participants annually produce 300 publications based on research conducted at the NCNR, which also results in about 40 PhDs annually and a number of summer students who spend time on the NIST site learning about neutron science.

Schedule and Milestones

Lifetime extension of the source facility to maintain reliable operations and high availability to the end users.

- Purchase of reactor fuel to enable sustained NCNR operations (FY 2016 - FY 2020).
- Reactor system upgrades including fabrication of replacement parts for the primary cooling system (FY 2016 - FY 2020).
- Replacement of heavy water that cools the reactor via the primary cooling system (FY 2016).

Deliverables

Lifetime extension of the source facility to maintain reliable operations and high availability to the end users.

- High availability and reliability of the neutron facility for NCNR users through enhancements to the reactor facility.

Performance goals and Measurement Data

Performance Goal: Replace aging parts of the reactor primary cooling system with new parts	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	**5%**	**20%**	**25%**	**50%**	**100%**
Without increase	**0**	**0**	**0**	**0**	**0**
Description:	**The original equipment and components of the reactor's primary cooling system will be replaced over the course of five years, thus maintaining the high availability and reliability of the facility to the scientific community. The measure is percentage completion replacement.**				

PROGRAM CHANGE PERSONNEL DETAIL

(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs

Subprogram: Laboratory Programs

Program Change: Ensuring a World Class Neutron Research Facility

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Mechanical engineer	Gaithersburg	ZP III	1	$76,377	$76,377
Mechanical engineer	Gaithersburg	ZP II	1	52,667	52,667
Total			2		129,044
Less Lapse		25%	(1)		(32,261)
Total full-time permanent (FTE)			1		96,783
FY 2016 Pay Adjustment (1.3%)					1,258
TOTAL					98,041

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	1
Other than full-time permanent	0
Total	1
Authorized Positions:	
Full-time permanent	2
Other than full-time permanent	0
Total	2

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Ensuring a World Class Neutron Research Facility

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	98	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	98	247,260
12	Civilian personnel benefits	31	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	23	8,821
22	Transportation of things	2	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous	1,280	32,994
24	Printing and reproduction	4	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	634	60,486
25.3	Purchases of goods & services from Gov't	6,338	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	315	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	140	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	497	31,505
31	Equipment	1,638	49,978
32	Lands and structures	0	0
33	Investments and loans	0	0
41	Grants, subsidies and contributions	0	90,571
42	Insurance claims and indemnities	0	0
43	Interest and dividends	0	0
44	Refunds	0	0
99	Total obligations	11,000	662,795

2. Materials Genome (Base Funding: $18.9 million and 34 FTE; Program Change: +$10.0 million and +16 FTE)

NIST requests an increase of $10.0 million and 16 FTE to enable NIST to create advanced materials discovery tools and data for industry, in support of the Administration's Materials Genome Initiative (MGI).

Proposed Actions

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

Action 1: Integrated Computational Tools, Databases, and Experimental Techniques ($2.0 million)

NIST will invest in key competence enhancement in integrated computational materials engineering with the proposed increase in funds. This expertise in computation will augment existing NIST competence in experimental materials science, enabling critical co-designed measurement science methods and infrastructure tools, such as standards. This increased technical capacity will enable NIST to pursue new programmatic thrusts using advanced computational and experimental techniques, to achieve Administration targets in materials design in important domains including big data for materials, high throughput approaches to materials discovery, biomaterials, functional electronic materials, and additive manufacturing.

Action 2: Develop a robust infrastructure to support the sharing of materials data ($3.0 million)

As the leadership of the public-private partnership Materials Project (one of the inspirations for the MGI) noted recently, "data is only useful if it is accessible, characterized (e.g. through its metadata), contains uncertainty quantification, and if an ontology exists to connect diverse data items. This is a particularly difficult problem for materials, as the complexity of real materials requires characterization on many levels through different techniques, making comparison and integration of data items often non-existent." The proposed increase will enable NIST to build off of the pilot effort in standing up the Materials Data Repository (MDR), initiated in FY 2014. NIST can play an important role in the materials informatics challenges associated with the MGI. NIST will reach out to key stakeholders in the government, private sector, and academia to share data in the MDR. These relationships will be essential to ensure that the MDR becomes a central resource for both depositing and accessing materials data. The requested funding will also provide the NIST Office of Data and Informatics (ODI), a new office within the Material Measurement Laboratory, with needed resources to address these challenges by supporting community-developed standards and other data intensive projects. Ultimately, the ODI efforts in support of tools to share materials data could have the same impact that the Protein Data Bank has had, in structural biology, and the Virtual Observatory has had, in astronomy. As part of this action, NIST will collaborate with other Federal agencies, non-profit organizations, and other stakeholders to host materials data from a variety of sources.

Action 3: Ensure integration with NIST Advanced Materials Center of Excellence ($2.0 million)

NIST will put in place the critical resources to sustain and enhance its relationship with the Chicago-based Center for Hierarchical Materials Design (CHiMaD). Initiated in FY 2014, CHiMaD is a NIST-sponsored Center of Excellence funded in part by a $25.0 million award from NIST over five years. The CHiMaD consortium is led by Northwestern University and also includes the University of Chicago, the Northwestern-Argonne Institute of Science and Engineering (a partnership between Northwestern and the Department of Energy's Argonne National Laboratory) and the Computation Institute (a partnership between the University of Chicago and Argonne). The consortium also plans to work closely with QuesTek Innovations, a small business spin-off of Northwestern; ASM International, a well-known professional society of materials scientists; and Fayetteville State University. As a NIST Center of Excellence, CHiMaD is a new alliance between NIST and these organizations, which is intended to leverage and extend NIST's capability in the area of advanced materials design and data tools. Maximum success of this joint partnership with CHiMaD requires NIST investment in the laboratory research program. Beyond the initial external award to CHiMaD, as part of the NIST Center of Excellence Program, the resources requested here are essential to enable NIST to invest in staff and research programs that align and integrate with CHiMaD activities.

Action 4: Accelerate the prediction of new materials using high-throughput techniques ($3.0 million)

The MGI has, to date, focused on enabling materials design and discovery through advances in integrated computational materials science. As these tools and capabilities come on line, another element of MGI will move into sharper focus, specifically the need for large amounts of the high quality experimental data that are required to validate these models, and thereby improve predictive power and identify the best candidates for advanced materials. Over the last decade, revolutionary high-throughput experimental methodologies have been developed that are uniquely suited to rapidly generate a high volume of quality data. These funds will allow NIST to develop the next generation of new high-throughput experimental and simulation tools. In addition, NIST will make critical technical contributions to the development of standards for synthesis, characterization, and informatics, in partnership with stakeholders from industry and academia. As a respected technical organization, NIST will enable broad access to these new high-throughput tools and support high-throughput experiments to improve device design and performance.

Statement of Need and Economic Benefits

Advanced materials are essential to economic security and human well-being, with applications in clean energy, national security, and human welfare. Today, the discovery and optimization of new materials for innovative products is a time-consuming and laborious process. Expensive trial-and-error-based experimentation results in highly inefficient exploration of the potential candidates for a desired new material system. This is in part because the materials design space is highly complex. For example, in metals, whether high strength steel for automobiles or lightweight aluminum for airplanes, a few percent change in composition or slight modification in manufacturing processes can make such a large difference that performance metrics, such as strength, can vary by 50 percent or more. In another example, composite materials such as those used in advanced inks and new concrete formulations may include dozens of components, each of which can profoundly affect the material's properties. Identical arguments can be made for such diverse applications as solar cells, advanced batteries, catalytic materials, and next-generation electronics. The result is much lost opportunity for the discovery and optimization of new materials on which new higher performance products can be based.

However, a powerful new paradigm for materials discovery and optimization has begun to emerge: materials by design. The possibilities and opportunities were outlined in the 2008 National Research Council study *Integrated Computational Materials Engineering (ICME): A Transformative Discipline for Improved Competitiveness and National Security.*[9] This approach, championed by the Administration in the MGI, stands in contrast to traditional trial-and-error-based approaches. The MGI aims to support U.S. institutions in the effort to discover, manufacture, and deploy advanced materials twice as fast, at a fraction of the cost, a goal crucial to achieving global competitiveness in the 21st century. Indeed, computational approaches based on physics-based material models, when integrated with carefully chosen experiments, can lead to hugely reduced development time, materials of higher performance, and far more effective and cheaper products. For example, General Electric has cut their jet engine alloy development cycle from fifteen years to nine years by using computational approaches and Procter and Gamble has saved about 17 years of design time in 2009 alone through their commitment to virtual computing in product design and development. A variety of other products, ranging from automobile engines to computer chips, are ripe to benefit from such modern methods of materials engineering -clearly a major enabler for the future of manufacturing and American industry.

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

Base Resource Assessment

The ongoing effort at NIST is a significant part of the multi-agency Materials Genome Initiative[10] (MGI), whose other major partners include the National Science Foundation and the Departments of Energy and Defense. The goal of the MGI is to significantly reduce the time and cost needed to discover, develop, manufacture, and deploy advanced materials. NIST has a leading role in the National Science and Technology Council's MGI Subcommittee under the Committee on Technology.

The generation and evaluation of physical reference data and the development of databases that can be widely used by industry is mandated by the NIST mission. NIST has expertise in data generation, collection, assessment, and dissemination, as well as model design and validation from atomic scale to the device scale. This expertise has provided a theoretical underpinning for NIST's efforts in measurement science and standards for advanced materials for some time. Specific linkages between modeling and simulation methods (e.g. those that focus at different length scales) must work in the intended manner in order to predict, assess, and validate material properties. NIST initiated in FY 2012 two use cases in structural metallic alloys and advanced composites to elucidate best practices, help identify and develop needed standards, focus integration efforts, and expose challenges that inhibit success.

Addressing MGI challenges is part of the remit of NIST's new Office of Data and Informatics, which is actively pursuing data curation and preservation mechanisms for materials science that will enable data discovery, interoperability, and re-use. From its inception, the ODI has vigorously supported the MGI, developing and deploying the essential materials data infrastructure required to meet the goals of the Initiative.

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[9] National Research Council. (2008). Integrated Computational Materials Engineering: A Transformational Discipline for Improved Competitiveness and National Security. Washington, D.C.: The National Academies Press. (available online at http://www.nap.edu/catalog.php?record_id=12199).
[10] http://www.whitehouse.gov/mgi

In FY 2014, NIST embarked on a five-year collaboration with the Chicago-based CHiMaD, a NIST Center of Excellence. CHiMaD is specifically focused on collaborating with NIST to help NIST achieve its goals within the MGI. The CHiMaD program is complementary to NIST's existing efforts and the requested increase in funds will enable NIST to maximize the impact and integration of this fledgling collaboration.

Besides the crucial collaboration with CHiMaD, other partners and stakeholders in this initiative include government agencies, namely DoE, DoD, and NSF, via the MGI Subcommittee of the NSTC. Also essential are the industry stakeholders that develop, model, and use advanced materials (e.g., including GE, Dow, DuPont, Procter and Gamble, Ford, and GM). NIST has relationships with the Materials Research Society, TMS, and ASM International, all professional societies that have initiated broad MGI related activities among their 60,000 members, and who provide a substantial resource for collaboration with universities and industry.

Schedule and Milestones

Action 1: Integrated Computational Tools, Databases, and Experimental Techniques

- Build up NIST expertise in state-of-the art computational tools and experimental techniques (FY 2016 – FY 2020).
- Develop and publish new methods and data to accelerate materials by design in structural metallic alloys and advanced composites (FY 2016 – FY 2018).
- Develop new tools and techniques to accelerate materials by design in biomaterials and organic electronics (FY 2017 – FY 2020).
- Develop new tools and techniques to accelerate materials discovery using high throughput experimental and computational techniques (FY 2016 – FY 2020).

Action 2: Develop a robust infrastructure to support the sharing of materials data

- Transition MDR to an open model, with registered participants who are eligible based on NIST criteria (e.g., materials scientists, laboratory researchers, and product engineers working in materials development) (FY 2016).
- Develop, release, and refine a Materials Data Curator, to enable advanced search and increased utility for reposed data (FY 2016 – FY 2018).
- Convene workshops and other meetings to engage with industry, government, non-profit organizations, and other stakeholders to continually ensure that the MDR and subsequent iterations of its essential functionality, meet community needs (FY 2016 – FY 2020).
- Develop partnerships to integrate and leverage MDR and its successors with other advanced materials databases (FY 2016 – FY 2019).
- Develop and implement new modalities of curation, storage, search, and dissemination of materials data, in concert with the NIST office of Data and Informatics (FY 2017 – FY 2020).

Action 3: Ensure integration with NIST Advanced Materials Center of Excellence, CHiMaD

- Expand NIST capabilities in areas in advanced materials computational and experimental tools that best complement CHiMaD research programs to ensure long-term knowledge gain at NIST (FY 2016 – FY 2018).
- Promote coordination between NIST and CHiMaD through site exchanges and joint research projects (FY 2016 – FY 2018).

- Foster new collaborations between the CHiMaD and other US and international institutions with significant mission overlap or synergy (FY 2016 – FY 2018).

Action 4: Accelerate the prediction of new materials using high-throughput techniques

- Develop new capabilities in high throughput experimental techniques and associated "big data" analytics to supply the MGI infrastructure with critically evaluated data (FY 2016 – FY 2019).
- Develop and disseminate new best practices for high throughput modeling and simulation. (FY 2016 – FY 2019).

Deliverables

Action 1: Integrated Computational Tools, Databases, and Experimental Techniques

- Demonstration of dramatically reduced design times for new advanced materials using fully-integrated computational materials engineering in a set of use cases covering several types of materials. NIST-developed models, simulations, and experimental data will be integrated to enable a "materials by design" approach for new industry-relevant materials with desired properties.
- Creation and dissemination of modeling and simulation tools, experimental data sets and protocols, and data standards via peer-reviewed publications, qualified databases, and other appropriate sharing mechanisms.

Action 2: Develop a robust infrastructure to support the sharing of materials data

- NIST curated repositories of materials data including modeling and simulation results, standard reference data, critically evaluated data sets and associated models for materials development use by industry, academia, and other stakeholders.
- Partnerships with private sector and government data repository providers that ensure the maximum utility of the NIST MDR and materials data curation tools, and their integration with other relevant materials data streams outside of NIST.
- Development of new analytical tools to optimize industry's use of MDR and its successors to accelerate the deployment of advanced materials in high-tech products and processes.

Action 3: Ensure integration with NIST Advanced Materials Center of Excellence, CHiMaD

- Complementary expertise at NIST and partner consortium CHiMaD to address critical materials challenges in both "hard" (inorganic) and "soft" (organic) advanced materials in fields as diverse as self-assembled biomaterials, smart materials for self-assembled circuit designs, organic photovoltaic materials, advanced ceramics and metal alloys.
- New relationships between NIST staff and technical experts at CHiMaD member organizations, including academic and industry connections, that strengthen and broaden the dissemination of NIST measurement science and standards for advanced materials.
- Deeper integration of CHiMaD with the National portfolio of materials genomic research.

Action 4: Accelerate the prediction of new materials using high-throughput techniques

- Broad access by the entire materials science industry and academic community to new high-throughput approaches that enable faster discovery of new advanced materials.
- Demonstrated integration of high-throughput data into the materials design workflow.

Performance Goals and Measurement Data

Performance Goal: Cumulative number of integrated computation and experimental materials design demonstration projects	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	4	8	10	12	18
Without increase	2	3	3	4	4

Performance Goal: Number of non-NIST participating organizations in the NIST Materials Data Repository	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Increase	12	24	48	80	100
Without Increase	8	10	12	14	16

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Materials Genome

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Physicist	Gaithersburg	ZP IV	2	$107,326	$214,651
Materials Scientist	Gaithersburg	ZP IV	4	$107,326	$429,303
Statistician	Gaithersburg	ZP IV	1	$107,326	$107,326
Data Scientist	Gaithersburg	ZP IV	3	$107,326	$321,977
Physicist	Gaithersburg	ZP III	2	$76,377	$152,754
Applied Mathamatician	Gaithersburg	ZP III	1	76,377	76,377
Materials Scientist	Gaithersburg	ZP III	3	76,377	229,132
Data Scientist	Gaithersburg	ZP III	2	76,377	152,754
Chemical Engineer	Gaithersburg	ZP III	2	76,377	152,754
Administrative/technical support	Gaithersburg	ZA II	2	52,667	105,335
Total			22		1,942,363
Less Lapse		25%	(6)		(485,591)
Total full-time permanent (FTE)			16		1,456,772
2016 Pay Adjustment (1.3%)					18,938
TOTAL					1,475,710

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	16
Other than full-time permanent	0
Total	16
Authorized Positions:	
Full-time permanent	22
Other than full-time permanent	0
Total	22

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Materials Genome

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$1,476	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,476	247,260
12	Civilian personnel benefits	461	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	45	8,821
22	Transportation of things	22	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous charges	1,121	32,994
24	Printing and reproduction	14	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	1,799	60,486
25.3	Purchases of goods & services from Gov't accounts	1,066	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	1,200	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	221	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	856	31,505
31	Equipment	719	49,978
41	Grants, subsidies and contributions	500	90,571
44	Refunds	0	0
99	Total obligations	9,500	662,795
	Transfer to NIST Working Capital Fund	500	0
	Total increase requested	10,000	662,795

3. Disaster Resilient Buildings and Infrastructure (Base Funding: $10.4 million and 13 FTE; Program Change: + $10.0 million and +13 FTE)

NIST requests an increase of $10.0 million and 13 FTE to develop science-based building codes and standards to improve disaster resilience of communities impacted by natural and man-made hazards.

Proposed Actions

Develop and accelerate the adoption and use of the underlying measurement science to improve predictive capabilities, and improve codes, standards and practices for cost-effective improvement of disaster resilience, including life-safety and reduction of property loss, due to natural and man-made hazards. (+$10.0 million)

Natural and other disasters in the United States are estimated to be responsible for $57.0 billion (and growing) in average annual costs in terms of lives lost, disruption of commerce and financial networks, properties destroyed, and the cost of mobilizing emergency response personnel and equipment.[11] Major catastrophes such as Superstorm Sandy (2012), Hurricane Katrina (2005) and earthquakes like the ones that struck Tohoku and Kobe, Japan in 2011 and 1995, respectively, can cause mega-losses ($80 billion - $300 billion[12]) in a single event. Preventing hazard events from becoming debilitating disasters requires resilient buildings and infrastructure. As discussed in the Hurricane Sandy Rebuilding Strategy,[13] disaster resilience can be enhanced by ensuring that state and local entities adopt the latest model building codes and standards; however, critical gaps exist in code/standard requirements which directly address extreme wind (tornado, e.g.) and wildfire events. Additionally, there are opportunities to significantly enhance future building codes and standards by translating advanced scientific understanding of hazards and building performance into science-based building codes and standards (both prescriptive, as well as performance-based). The development of improved building codes will first require a robust capability to predict the effects of hazards on the performance of complex structural systems, including: data to characterize the hazard, validated physics-based models to predict performance, metrics for measuring performance, acceptance criteria for differing levels of performance objectives, and mitigation strategies based on performance evaluation. This initiative proposes to develop the measurement science required to achieve disaster resilient buildings and infrastructure in a timely and cost-effective manner. The scope of the proposed measurement science research focuses on enabling disaster-resilient buildings and infrastructure by addressing the following four technical goal areas through focused actions:

- Disaster and Failure Event Technical Studies
- Windstorm and Storm Surge Reduction
- Earthquake Risk Reduction
- Wildland-Urban Interface Fire Protection

These actions directly support the Department of Commerce's Strategic Goal to ensure that communities and businesses have the necessary information, products, and services to prepare for and prosper in a

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[11] *Disaster Resilience: A National Imperative.* The National Academies Press, Washington, D.C. 2012.

[12] Risk Management Solutions estimated total economic losses due to the Great Tohoku Earthquake and Tsunami to be $200-300B. http://www.rms.com/Publications/2011TohokuReport_041111.pdf

[13] From *Hurricane Sandy Rebuilding Strategy.* A report presented to the President of the United States by the Hurricane Sandy Task Force. August 2013: "Recommendation 25 - States and localities should adopt and enforce the most current version of the IBC and the IRC."

changing environment. These actions will provide important tools needed to prepare the Nation for the impacts of climate change as highlighted in the 2013 Climate Action Plan and the 2014 National Climate Assessment, providing support to local, state, and tribal communities.[14]

Action 1: Disaster and Failure Event Technical Studies

NIST will provide the measurement science to improve codes, standards, and practices based on collection and analysis of data on real-world performance of buildings and infrastructure during disaster and failure events.

Disaster and Failure Event Technical Studies and Prototype Data Repository Development: NIST will develop new measurement science to collect and archive disaster field data into a prototype disaster and failure database, i.e., a National Disaster and Failure Events Data Repository. Technical challenges of collecting post-disaster field data include the perishable nature of evidence and artifacts, the scale of many affected areas, and the lack of reliable local infrastructure. Through a trained lead investigator and small field teams of hazard and engineering experts, NIST will collect and analyze data and artifacts to improve the understanding of hazards, the real-world performance of buildings and infrastructure during disaster and failure events at both the component and the system levels, associated emergency response and evacuation procedures, and social and economic factors that affect pre-disaster mitigation activities and post-disaster response efforts. The results of disaster and failure studies will lead to recommendations to provide disaster-resilience at the structure and community levels through improvements to building codes, standards and practices, and the identification of gaps in current knowledge about buildings, infrastructure, emergency response, and human behavior. NIST will create and maintain the database to facilitate disaster and failure studies and widely disseminate the data, findings, and recommendations from these studies. Other Federal agencies, research institutions, and industry organizations that are engaged in parallel efforts that can provide input for the data repository will be engaged in the development of the database. The database domains will include: earthquake, hurricane, tornado, wildfires, storm surge, tsunami, and building fires. For example, developing the earthquake module of the data repository will involve the participation of FEMA, NSF, and USGS, in addition to NIST.

Action 2: Windstorm and Storm Surge Impact Reduction

Develop the measurement science to improve the design, construction, and retrofit of buildings, structures, and lifelines under extreme wind and coastal flooding loads from hurricanes, tornadoes, and other windstorms.

Methods, Tools and Standards for Design to Resist Windstorm and Storm Surge Hazards: NIST will develop the measurement science needed to create new computational fluid dynamics (CFD) based analytical tools that will substantially improve the accuracy of wind loads used in the design of buildings and building envelopes, and analyze the combined effects of storm surge velocity, depth, waves, and flood-borne debris on coastal buildings and critical infrastructure to improve building codes and standards.[15] NIST will develop a suite of experimentally-validated software tools that will be used to significantly improve wind loading codes and standards, and reduce industry dependence on expensive and time consuming wind tunnel testing. NIST will develop a probability-based methodology for quantification of storm surge hazards, along with methods and tools for estimation of forces due to these hazards.

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[14] Such as the 2014 Tribal Climate Resilience Program.

[15] The NIST effort will leverage ongoing efforts in coastal resilience at NOAA and other Federal agencies by focusing on the translation of the science of storm surge and building response into improved building codes and standards.

Action 3: Earthquake Risk Reduction

Develop the measurement science to facilitate constructing earthquake-resilient lifelines and provide cost-effective technologies for enhanced earthquake performance in existing buildings.

NIST will provide the technical basis for guidelines, tools, and techniques for new construction and evaluation of the current stock of the Nation's buildings and infrastructure. Consideration of lifeline resilience at both the component (strength) and system-wide levels will lead to strong earthquake resilience. While ongoing efforts to provide performance-based tools, standards, and guidelines for new building design will lead to enhanced resilience in new construction, the existing building stock (particularly pre-1980's construction) remains extremely vulnerable to earthquake activity. NIST will provide the measurement science for more accurate evaluation of existing building vulnerabilities and for cost-effective performance-based risk mitigation in existing buildings, including consideration of the application of innovative new materials.

Action 4: Wildland-Urban Interface (WUI) Fire Mitigation

Provide the measurement science to develop a national WUI fire rating system, complementary standard fire test methods, and the technical basis for WUI fire mitigation technologies.

NIST will develop the technical basis for WUI fire mitigation technologies, addressing both existing and new construction through consideration of 1) structural fire prevention, 2) structural fire protection, and 3) post-fire recovery. The technical basis for WUI fire mitigation will consider WUI fire hazards, including the role of structure and landscape attributes such as building and community design and materials, residential and wildland vegetation, topography, and local weather. NIST will develop standard test methods and the technical basis for application of innovative WUI fire mitigation technologies, including innovative building materials and assemblies, fire resistant vegetation, fire protection strategies for hardening buildings and communities, and tools for the design of fire resistant WUI communities.

Statement of Need and Economic Benefits

Natural disasters in the U.S. continue to be responsible for a significant cost on the Nation's economy. These events are estimated to cost approximately $57.0 billion (and growing) in average annual costs when factoring in lives lost, disruption of commerce and financial networks, properties destroyed, and the cost of mobilizing emergency response personnel and equipment. Natural hazards[16] are a continuing and significant threat to U.S. communities. Major catastrophes such as Superstorm Sandy, Hurricane Katrina (2005) and earthquakes like the ones that struck Tohoku and Kobe, Japan in 2011 and 1995, respectively, can cause mega-losses ($80 billion-$300 billion[17]) in a single event. Unfortunately, critical gaps exist in current model codes and standards that address extreme wind (tornado, e.g.) and wildfire events. There are opportunities to significantly enhance the Nation's disaster resilience by translating advanced scientific understanding of hazards and building performance into cost-effective science-based building codes and standards both prescriptive, as well as performance-based. Human activities that are accidental, criminal, or terrorist can also lead to disastrous losses. The risk across large, disaster-prone regions of the Nation is substantially greater now than ever before due to the combined

[16] Hazards include earthquakes, wind-related hazards (hurricanes, tornadoes, windstorms), fire-related hazards (community-scale fires in the wildland-urban interface, structural fires), water-related hazards (storm surge, flood) and human-made hazards (accidental, criminal, or terrorist).

[17] Risk Management Solutions estimated total economic losses due to the Great Tohoku Earthquake and Tsunami to be $200-300B. http://www.rms.com/Publications/2011TohokuReport_041111.pdf

effects of urban development and population growth. [18, 19] In addition, much of the Nation's physical infrastructure is located in parts of the country that are susceptible to natural hazards (e.g., along coastlines, in the wildland-urban interface, and in earthquake-prone regions) and significant parts of this infrastructure is aging, diminishing its capacity to resist hazards.

Disaster resilience, the ability to withstand the impacts of natural or man-made hazards and recover quickly to pre-disaster societal functions, is at once a local and a national issue. Just as the effects of a natural disaster cascade locally through impacted infrastructure and society, they can also cascade across entire regions and even nationally. Regional and national disaster resilience is impacted by pre-event mitigation, immediate response, and long-term recovery. As projected losses continue to rise, there is increasing recognition of the need to minimize response and recovery by proactively identifying hazards that pose threats and acting to mitigate their potential impact. Preventing hazards (e.g., earthquakes, hurricanes, and community-scale fires) from becoming disasters depends upon the disaster resilience of our buildings and infrastructure. This, in turn, depends upon the capacity to prepare for and mitigate the impacts of hazards, preventing them from becoming disasters. This initiative focuses on specific measurement science solutions to:

1. Provide hazard and disaster information where and when it is needed;
2. Understand the natural processes that produce hazards;
3. Develop hazard mitigation strategies and technologies;
4. Recognize and reduce vulnerability of interdependent critical infrastructure;
5. Assess disaster resilience using standard methods; and
6. Promote risk-wise behavior.

The specific measurement science solutions to be realized from this effort also directly address five of the six Grand Challenges identified by the National Science and Technology Council[20] for advancing the science and technology to enhance the Nation's disaster resilience. These challenges arise due to a lack of adequate: (1) understanding of the natural hazards that create risks in the built environment and information relative to such hazards for use by design professionals, standards developers, and emergency managers; (2) predictive technologies and mitigation strategies to improve the performance of complex structural and infrastructure systems and means to transfer the results of research into practice and promote risk-wise behavior; and (3) standard methods to predict and assess the disaster resilience of buildings and infrastructure for use in planning and response efforts.

The disaster resilience of our buildings and infrastructure today is determined in large measure by the building codes, standards, and practices used when they were built. With few exceptions, these legacy codes, standards, and practices, which have evolved over several decades, are prescriptive, oversimplified, and inconsistent with respect to risk. There is a serious lack of validated tools and metrics to evaluate the performance of buildings and infrastructure and associated risks. It is critical to fill the science and technology gaps underpinning these codes, standards, and practices if the disaster resilience of our buildings and infrastructure are to be enhanced significantly in the future.

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[18] *Improved Seismic Monitoring – Improved Decision Making: Assessing the Value of Reduced Uncertainty*, National Academies Press, 2006.
[19] Economic Statistics for NOAA – May 2005 – Fourth Edition.
[20] *Grand Challenges for Disaster Reduction.* National Science and Technology Council Subcommittee on Sisaster Reduction. 2005.

Base Resource Assessment

NIST requests $10.0 million to develop the scientific basis to enable technology innovations, improve prediction capabilities, and improve codes and standards for cost-effectively reducing loss of life and property damage due to natural and man-made hazards. The NIST role is well-established in the building, materials, fire safety industries, and standards arena. NIST has significant statutory responsibilities in these areas, including:

- NIST is directed by Congress to be the Lead Agency for the National Earthquake Hazards Reduction Program, NEHRP (P.L. 108-360) and to promote the implementation of earthquake hazard reduction measures for buildings and lifelines, support the development of performance-based seismic engineering (PBSE) tools, and promote the commercial application of those tools.
- NIST is directed to conduct basic and applied research that enables protection of life and property from fire under the Federal Fire Prevention and Control Act of 1974.
- NIST is directed to conduct structure failure investigations through the National Construction Safety Team Act of 2002.
- NIST is directed to conduct wind research under the National Windstorm Impact Reduction Act of 2004.
- NIST supports the materials, building, and fire engineering fields with measurement science results that enable the development of science-based standards and codes.

The program leverages NIST core competencies in performance of buildings and infrastructure under extreme conditions. NIST has in-depth technical expertise in materials, wind, earthquake, structural, and fire protection engineering. It has unique laboratory capabilities (such as the National Fire Research Laboratory[21]) that are needed to develop the required measurement science. It has strong relationships with other government agencies (such as the U.S. Fire Administration, FEMA, NSF, NOAA, USGS and DOT), industry, academia, and standards development organizations that will be needed to transfer research to actual practice. NIST has extensive experience over the last 30 years conducting field studies and analyses of disasters and failures, developing measurement science tools to address materials and structural performance issues, and making recommendations to improve the standards and codes that impact building and infrastructure performance.

NIST provides the measurement science to enable the development of science-based standards and codes, standard reference materials, predictive models, evaluated data, and advanced instrumentation and methods. NIST is uniquely positioned to help address the challenges proposed in this initiative. Private sector organizations generally lack the resources to carry out the research required to develop the technical basis for improved codes and standards. NIST works closely with private sector organizations through the voluntary consensus process to enable science-based codes and standards. NIST also works closely with private sector organizations to develop and disseminate technical guidelines, tools, and best practices. In the earthquake area, NIST works closely with FEMA to support the development of recommended earthquake provisions for national model building codes and, as the NEHRP Lead Agency, works directly with FEMA, NSF, and USGS in all NEHRP activities.

[21] NIST has just completed construction of a $25 million expansion to the National Fire Research Laboratory on its Gaithersburg campus. The expanded laboratory will provide the capability to test real-scale structural systems under realistic structural and fire loads

Schedule and Milestones

Action 1: Disaster and Failure Event Technical Studies

- Create and implement a National Disaster and Failure Events Data Repository to serve as a public archival repository on hazard characteristics, the performance of buildings and infrastructure, associated emergency response and evacuation procedures, and social and economic factors that affect pre-disaster mitigation activities and post-disaster response efforts (Complete Phase I in FY 2016).
- Develop new measurement science to collect and archive disaster field data into prototype National Disaster and Failure Studies Repository that leverages recent advancements in geolocation, imaging, and information technology (Complete in FY 2017).
- Conduct field studies in the aftermath of disaster and failure events to collect data and artifacts related to the performance buildings and infrastructure, associated emergency response and evacuation procedures, and social and economic factors that affect pre-disaster mitigation activities and post-disaster response efforts. (This will be an on-going effort with a frequency of approximately once per year or less.)
- Conduct technical studies to interpret and analyze the data and artifacts, build and analyze models, perform laboratory experiments, determine findings and promote implementation of recommendations for changes to codes, standards, and practices, address knowledge gaps in the prevention, mitigation, or fundamental understanding of physical performance and human behavior. (This will be an on-going effort with a frequency of approximately once per year or less.)
- Populate the Data Repository with carefully analyzed historical information from previous NIST studies on disaster and failure events. (Complete in FY 2018).
- Partner with other agencies and organizations to input historical data for the National Disaster and Failure Events Data Repository (Complete in FY 2018).
- Disseminate and provide technical assistance, outreach, and education to codes, standards, and practitioner communities on disaster and failure event information, outcomes, and recommendations (Complete in FY 2019).

Action 2: Windstorm and Storm Surge Impact Reduction

- Methodologies to enable application of CFD to wind load analysis on buildings (Complete in FY 2017).
- Probability-based methodology for quantification of storm surge hazards with consideration for variations in local topography (Complete in FY 2017).
- Methodology and guidelines for risk-consistent estimation of design forces due to storm surge velocity, waves, and impact of flood-borne debris for design of coastal infrastructure and buildings (Complete in FY 2018).
- Suite of integrated and experimentally validated software tools for CFD-based determination of wind loads on low- and mid-rise buildings (Complete in FY 2018).
- Guidelines and a Pre-standard for application of CFD tools for wind load determination, and improved low-rise building wind load provisions for inclusion in U.S. wind loading codes and standards (Complete in FY 2019).
- Computational Fluids Dynamics (CFD)-based methods and tools for determining storm surge forces, and pre-standards for structural design criteria on buildings and infrastructure (Complete in FY 2019).

Action 3: Earthquake Risk Reduction

- Improved techniques, tools, and guidelines for evaluating existing buildings and mitigating their risks in a performance-based engineering based on analytical and experimental studies, to be accomplished by working with national model building code organizations to incorporate those products in appropriate model building codes (Complete in FY 2019).
- Guidelines for constructing earthquake-resilient lifeline components and systems based on analytical and experimental studies, to be accomplished by working with standards development organizations to incorporate the guidelines in appropriate standards (Complete in FY 2020).

Action 4: Wildland-Urban Interface (WUI) Fire Mitigation

- Develop measurement science to quantify fire and ember exposure during experimentally controlled fires (Complete in FY 2017).
- Develop the measurement science to quantify fire and ember exposure in actual WUI events (Complete in FY 2018).
- Develop standard test methods using realistic fire and ember exposures (Complete in FY 2019)
- Develop mitigation guidelines for buildings and communities based on realistic fire and ember exposures (Complete in FY 2020).

Deliverables

Action 1: Disaster and Failure Event Technical Studies

- New measurement science to efficiently and rigorously collect and archive data during field investigations of post-disaster buildings and communities.
- A National Disaster and Failure Events Data Repository on natural and man-made hazard events, the performance of the built environment during hazard events, associated emergency response and evacuation procedures, and pre-disaster mitigation studies specific to hazard events.
- Data, models, guidelines, and improved standards, codes, and practices for the built environment.

Action 2: Windstorm and Storm Surge Impact Reduction

- Methodologies, software tools, guidelines, and pre-standards for application of CFD-based analysis to wind loads, and load analysis due to storm surge hazards.
- Improved wind and storm surge load provisions in U.S. building codes and standards.
- Tools to enable the transformation of wind load analysis on buildings from physical-based modeling in wind tunnels to computational-based modeling.

Action 3: Earthquake Risk Reduction

- Comprehensive guidelines for construction of earthquake-resilient lifelines.
- Condition assessment and evaluation tools for existing buildings and complete guidelines and standards for cost-effective seismic strengthening of older buildings.

Action 4: Wildland-Urban Interface (WUI) Fire Mitigation

- Database from experimental measurements that will guide cost-effective fire protection for WUI communities.

- Characterization of WUI fire hazards, providing the technical basis for building and landscaping standards and codes, and best practices for WUI communities.
- Recovery guidelines for re-building with advanced new materials and fire resistant community design.
- Model standards and codes to harden WUI buildings and communities.

Performance Goals and Measurement Data

Disaster and Failure Event Technical Studies

Performance Goal: Number of published disaster studies from NIST and partners available in repository.	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target	FY 2021 Target
With increase	0	1	5	10	15	20
Without increase	0	0	0	0	0	0
Description: Public accessibility of data from disaster and failure studies will maximize use of disaster and failure data and artifacts and ensure findings from disaster events are disseminated.						

Windstorm and Storm Surge Impact Reduction

Performance Goal: Number of publications documenting methodologies, software tools, guidelines, and pre-standards available for win surge impact reduction.	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target	FY 2021 Target
With Increase	0	2	5	8	8	8
Without Increase	0	0	0	0	0	0
Description: Publications will document the methodologies, software tools, guidelines, and pre-standards which establish the technical basis for engineering tools and documentary standards that reduce property and life-loss due to wind and storm surge events.						

Earthquake Risk Reduction

Performance Goal: Number of guidelines published which improve seismic resilience of infrastructure lifelines and existing buildings.	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target	FY 2021 Target
With Increase	0	1	2	3	3	3
Without Increase	0	0	0	0	0	0
Description: Guidelines for construction of earthquake-resilient lifelines and existing buildings will support building codes and standards for the cost-effective seismic strengthening of the built environment.						

Wildland-Urban Interface (WUI) Fire Mitigation

Performance Goal: Number of published studies and guidelines, which improve the resilience of WUI communities.	**FY 2016 Target**	**FY 2017 Target**	**FY 2018 Target**	**FY 2019 Target**	**FY 2020 Target**	**FY 2021 Target**
With Increase	0	1	2	3	3	3
Without Increase	0	0	0	0	0	0
Description: Science-based WUI fire mitigation guidelines will inform the development of effective building codes and standards and improve community resilience.						

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Disaster Resilient Buildings and Infrastructure

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Economist/Physical Scientist	Gaithersburg	ZP IV	5	$107,326	$536,628
Engineers	Gaithersburg	ZP IV	5	107,326	536,628
Social Scientists	Gaithersburg	ZP IV	1	107,326	107,326
Computer Scientists	Gaithersburg	ZP IV	3	107,326	321,977
Technicians	Gaithersburg	ZT III	1	58,000	58,000
Business Specialists	Gaithersburg	ZA III	1	76,377	76,377
Administrative/Technical Support	Gaithersburg	ZA II	2	52,667	105,335
Total			18		1,742,271
Less Lapse		25%	(5)		(435,568)
Total full-time permanent (FTE)			13		1,306,703
2016 Pay Adjustment (1.3%)					16,987
TOTAL					1,323,690

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	13
Other than full-time permanent	0
Total	13
Authorized Positions:	
Full-time permanent	18
Other than full-time permanent	0
Total	18

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Disaster Resilient Buildings and Infrastructure

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$1,324	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,324	247,260
12	Civilian personnel benefits	413	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	40	8,821
22	Transportation of things	14	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous charges	1,141	32,994
24	Printing and reproduction	16	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	2,209	60,486
25.3	Purchases of goods & services from Gov't accounts	316	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	900	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	172	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	936	31,505
31	Equipment	1,119	49,978
41	Grants, subsidies and contributions	1,400	90,571
44	Refunds	0	0
99	Total obligations	10,000	662,795

4. Advanced Communications – Addressing the Spectrum Crunch (Base Funding: $12.8 million and 44 FTE; Program Change: + $9.0 million and +16 FTE)

NIST requests $9.0 million and 16 FTE to develop the measurement science and tools necessary to improve spectrum sharing and increase spectrum efficiency of commercial wireless radio-frequency communication systems and to accelerate the deployment of future wireless communications systems that operate at millimeter-wave frequencies. This initiative will accelerate the Department's ability to achieve the strategy "Foster advanced communications technologies" in Strategic Objective 2.3 in the DoC 2014-2018 Strategic Plan.

Proposed Actions

The availability of secure, reliable, high-speed wireless communications is essential for the United States' future economic health and security. Consumers and industry are becoming increasingly reliant on wireless devices to conduct their daily business. In addition, wireless systems are necessary for the development of new technologies in areas as diverse as public safety communications, electrical power grid management, medical devices communications, and advanced manufacturing. According to the 2013 Cisco VNI Mobile Forecast, global mobile data traffic will increase by thirteen times and the number of connected mobile devices is estimated to be over 10 billion by 2018. As a result, the radio-frequency spectrum allocated for wireless devices is becoming increasingly congested, making it more difficult for devices to perform efficiently and reliably.

In response to this problem, NIST established the Communications Technology Laboratory (CTL) in 2014 to develop a focused research program for developing the measurement science and standards in support of the communications industry and government agencies as they contend with the spectrum crunch. CTL supports the development of spectrum-efficient and spectrum-sharing wireless technologies for industry and the public-safety sector and helps prepare U.S. industry to develop products that take advantage of spectrum made available by NTIA and the FCC.

With the requested funds, NIST will focus its efforts on research that supports industry to develop and deploy advanced communication technologies for both the existing and future frequency spectrum bands allocated for wireless communication systems. These areas include Increased Spectrum Efficiency, Improved Spectrum Sharing, and Millimeter-wave Communications Systems.

Action 1: Increased Spectrum Efficiency ($2.0 million)

In the short term, it is imperative for Federal and commercial users of the radio-frequency spectrum to use the currently-allocated frequency bands more efficiently until new spectrum is made available and new spectrum-sharing technologies are developed. One method for improving spectrum efficiency is to develop higher-performance wireless components, such as digital transmitters and receivers, which are incorporated into a wireless device. To this end, industry needs improved measurement tools in order to accurately measure the electrical performance of these components. By providing these measurement tools and standardizing test methods, NIST can help the communications industry improve spectrum efficiency in the following areas.

Frequency-agile antennas, multiple-antenna arrays, and beam-steering antennas are all forms of adaptive antennas, which are a promising technology for increasing spectrum efficiency. With these new antenna systems, signals can be accurately focused in real time to areas of high wireless usage, which also reduces potential interference caused by nearby radiating wireless devices and systems. In order to accurately measure the performance and electrical characteristics of wireless systems that incorporate these new adaptive antenna systems, NIST will extend its current antenna measurement capability by constructing a new multi-purpose, fully-anechoic test chamber. With this new capability, NIST will develop new standardized test methods for characterizing the performance characteristics of adaptive antennas and provide a facility where industry can test the next generation of adaptive antenna systems prior to their deployment.

Spectrum efficiency can also be improved by maximizing the amount of data transmitted over a finite bandwidth. In particular, complex, high-fidelity, digitally-modulated waveforms are necessary for high-quality communications and error-free, high-speed data exchange. NIST will develop the capability to produce signal-generation electronics from the device to the system level and produce calibrated, traceable waveforms that can be used to validate the accuracy of vector receivers widely used by the communications industry.

Another approach to improving spectrum efficiency is to ensure that digital transmitters and receivers, which are the backbone of mobile wireless communication systems, operate effectively over a very well-defined frequency band. The performance of digital transmitters and receivers can be determined through measurement techniques such as bit-error rate and error-vector magnitude, which can quantify the effects of noise, distortion and interfering signals that impair the efficiency of digital transmitters and receivers. However, standards do not exist for these important measurement methods, so NIST will develop accurate, traceable measurement techniques and will work with standards development organizations to have these methods adopted as standards so that the key performance metrics of digital transmitters and receivers can be accurately determined.

Action 2: Improved Spectrum Sharing ($3.0 million)

New and improved spectrum sharing technologies are promising technologies that can address the spectrum scarcity due to strict, exclusive, and static allocation of frequency bands. These technologies range from access databases that allow sharing on a weekly and daily basis to more dynamic sharing on a millisecond basis. Regardless of the time granularity envisaged the assumptions for sharing are as follows. Primary users (PUs) are the licensed (or intended) users of the spectrum. In addition to the PUs, secondary users (SUs) can dynamically use the same spectrum as long as they do not cause significant performance degradation for the PUs. Spectrum sharing technologies could benefit many applications, such as in the case of unlicensed devices operating in the TV broadcast bands (white spaces), device to device communications in mobile cellular networks, and sensor networks. Spectrum sharing can also play an important role in unlicensed spectrum as the means to prioritize traffic.

Researchers have worked on various aspects of this relatively new technology and have generated important results. However, despite the impressive theoretical research output, there has been a slow industry adoption, due to a lack of prototype implementations, mature standards and test environments to validate proposed solutions.

NIST has been developing an evaluation framework for spectrum sharing to investigate its benefits. The requested funds would bolster the development of performance metrics, measurement methods and tools and their successful implementation in a test and evaluation environment. The performance metrics and measurement methods will be used to fully characterize the overall spectrum efficiency and the quality of service measures for the primary and secondary users. Additionally, NIST will work on innovative approaches to spectrum sensing and sharing. As part of this effort, NIST will develop and disseminate simulation models and prototype implementations of key spectrum sharing components. This includes spectrum sensing, control channel architecture, access protocols, and sharing policies. The dissemination of simulation models and software building blocks of key spectrum sharing functions will facilitate R&D of innovative spectrum sharing technologies by others and expedite product development.

The requested funds would also extend NIST's capabilities to measure the potential electromagnetic interference between commercial wireless communication devices and system that operate in the radio-frequency spectrum. NIST will build a multi-purpose test facility that can replicate a variety of complex electromagnetic environments to accurately determine the interference, coexistence, and electromagnetic compatibility of these wireless devices and systems and develop accurate channel propagation models. These channel propagation models are used by industry in the early design and development phases of next generation products. Thus, in addition to determining the interference issues with currently-available wireless systems, this NIST facility will provide industry a way to identify potential issues with the next generation of wireless systems before they are commercialized and deployed. These funds would also support NIST's work with standards development organizations to revise outdated standards in the areas of electromagnetic immunity, electromagnetic compatibility, and coexistence so that they would be applicable to the next generation of wireless devices and systems.

Action 3: Millimeter-wave Wireless Communications ($4.0 million)

Another potential solution to the spectrum crunch is the development of communications systems that operate at the recently-released millimeter-wave portions of the frequency spectrum that are well above the current cell-phone bands. Communication systems that operate at these high frequencies offer the promise of much higher data rates but many measurement challenges remain that are hindering the development and deployment of these communications systems. With the requested funds, NIST can address the following issues.

Although test and measurement equipment exists for generating, receiving, and characterizing radio signals used by today's mobile wireless systems, manufacturers have only recently begun to provide test equipment that operates at higher, millimeter-wave frequencies. In order to ensure the accuracy of this next generation of test and measurement equipment, NIST will develop traceable sources, new calibration techniques, and standardized test methods that could be used by test equipment manufacturers to improve the accuracy of instruments such as vector signal analyzers and real-time sampling oscilloscopes, which are critical for characterizing the components and devices that make up a millimeter-wave communication system.

Quantifying the over-the-air performance of millimeter-wave communications devices is another measurement-related challenge. In particular, accurate techniques are needed to measure the total radiated power, receiver sensitivity, and data throughput of these wireless devices. Conventional methods, such as anechoic chambers, are difficult to extend to higher frequencies, so NIST will develop new, reverberation-chamber-based measurement techniques that can mimic complex electromagnetic environments and can accurately characterize the key over-the-air performance of millimeter-wave communications devices.

Another barrier is the availability of accurate propagation data at millimeter-wave frequencies, which is critical to the development of channel models. These models are needed by industry so that they can design, simulate and evaluate potential wireless networks and interfaces before a communications system is deployed. To address this issue, NIST will develop new mobile channel-sounding methods that can accurately characterize the propagation characteristics, such as multi-path interference and path loss, of millimeter-wave channels and use this data to develop improved channel models that industry can use to identify those frequency bands that are candidates for commercial millimeter-wave communication systems.

Additionally, NIST will develop a system evaluation platform to test channel propagation models and develop novel communication technologies at higher frequencies. NIST will also work with industry to develop network protocols and transmission formats and standards for operation at millimeter-wave frequencies.

Statement of Need and Economic Benefits

Like the interstate highway system or the electrical power grid, the mobile wireless communications system is a critical infrastructure that is an important driver for increasing productivity and accelerating the growth of the Nation's economy. In addition, the wireless industry is a source of jobs in the U.S - estimated to be 3.8 million in 2011 - and it also contributed nearly $150.0 billion to the Nation's GDP in 2011.

Businesses and consumers are becoming increasingly dependent on wireless devices that require reliable, fast and secure access to broadband data as well as voice and video services. The variety of wireless devices that access mobile network continues to rapidly increase. In addition to the many tablets, laptops, and smartphones already connected to the network, additional wireless devices now include machine-to-machine connections that are key enablers of applications in the navigation, health-care, electric utilities, manufacturing, and transportation sectors. The proliferation of these wireless connections, numbered at 7 billion in 2013, is estimated to grow to over 10 billion by 2018, placing a strain on the already congested frequency spectrum that is allocated to mobile wireless networks.

In its initial response to this future "spectrum crunch", the Administration directed Federal agencies in a 2010 Presidential Memorandum to make additional radio-frequency spectrum available for commercial applications through spectrum auctions and/or reallocation of portions of the Federal spectrum. Although this has the potential of reducing spectrum congestion in the short term, the Administration recognized that additional measures were needed to ensure spectrum availability for future wireless systems. Consequently, the Administration released a Presidential Memorandum (2013) and a PCAST report (2012), directing Federal agencies to investigate new technologies for reducing spectrum congestion.

In response to these Administrative directives, NIST and NTIA established the Center for Advanced Communications in 2014 to promote interdisciplinary research, development and testing in radio frequency technology and spectrum sharing for public safety and commercial broadband applications.

Schedule and Milestones

Action 1: Increased Spectrum Efficiency

- FY 2016 – FY 2017: Design and construct a multi-purpose, fully-anechoic test chamber that would enable the characterization of the next-generation of adaptive antennas, such as frequency-agile antennas, multiple-antenna arrays, and beam-steering antennas.

- FY 2017 – FY 2020: Develop novel measurement techniques for accurately characterizing the electrical characteristics of adaptive antenna systems used to increase spectrum efficiency.

- FY 2016 – FY 2017: Develop the capability to design, fabricate, and calibrate waveform sources up to 200 GHz that can be used by industry to validate the performance vector sources and receivers used by the communications industry.

- FY 2017 – FY 2019: Identify key performance metrics and develop measurement techniques for accurately characterizing the electrical performance of digital receivers and transmitters.

Action 2: Improved Spectrum Access

- FY 2016 – FY 2017: Develop metrics and measurement methods and tools for assessing the performance of spectrum sharing technologies and validate their use in a testing environment.

- FY 2017 – FY 2019: Research and develop novel spectrum sharing techniques and components including spectrum sensing, channel control, spectrum management policy, and network access protocols;

- FY 2017 – FY 2020: Test and evaluate emerging proposals for spectrum sharing technologies; disseminate evaluation results and measurements methods and tools.

- FY 2017 – FY 2020: Work with industry to define and promulgate consensus standards for spectrum sharing technologies and to ensure the rapid adoption and deployment of these standard technologies into commercial networks.

- FY 2016 – FY 2018: Develop a new semi-anechoic chamber that can accurately mimic a wide variety of complex electromagnetic devices that wireless device and systems are subjected to.

- FY 2018 – FY 2020: Research and develop new measurement techniques and standards for accurately determining the electromagnetic compatibility, electromagnetic immunity and coexistence of wireless devices and systems.

Action 3: Millimeter-wave Wireless Communications

- FY 2016 – FY 2017: Conduct research to develop a traceable, modulated-signal source at millimeter-wave frequencies that will enable test equipment manufacturers to characterize millimeter-wave vector sources and vector receivers.

- FY 2017 – FY 2019: Develop new calibration methods and uncertainty analyses for the next-generation of broadband, millimeter-wave vector signal analyzers and other modulated-source receivers.

- FY 2017 – FY 2020: Develop new over-the-air test methods, based on reverberations chambers, which would determine key figures of merit, such as total radiated power, receiver sensitivity, and data throughput for millimeter-wave devices and systems.

- FY 2016 – FY 2018: Assemble, test and calibrate millimeter-wave channel sounder systems that would operate at 28, 38, and 83 GHz and use this data to develop new channel simulation models.

- FY 2017 – FY 2020: Develop a system simulation platform to evaluate new channel propagation models and enable the development of novel communication technologies at higher frequencies; work with standard developing organizations for the development of communication protocols at millimeter-wave frequencies.

Deliverables

Action 1: Increased Spectrum Efficiency

- Publications and standards for improved electrical characterization of adaptive antenna systems used in advanced wireless devices and systems.

- Standards and best practice guides that document how to accurately measure the high-frequency electrical performance of broadband digital receivers and transmitters.

- Measurement methods for waveform metrology that industry could use to access the accuracy of vector receivers used in the communications industry.

Action 2: Improved Spectrum Access

- Metrics and measurement methods for assessing the performance of spectrum sharing.

- Modeling tools that enable researchers to accurately characterize the behavior and performance of spectrum sharing technologies.

- Software building blocks of key components of spectrum sharing technologies to enable rapid prototype implementation and to expedite the product development cycle and the commercial deployment.

- Published analyses and improved standards for emerging spectrum sharing technology specifications.

- Measurement tools and published standards for accurately determining the electromagnetic computability, electromagnetic immunity and coexistence of wireless systems that employ complex, digital-modulation schemes.

Action 3: Millimeter-wave Wireless Communications

- Published standards that define performance metrics and develop best practice guides for performing calibrations and calculating measurement uncertainties for millimeter-wave vector signal sources and receivers.

- Traceable, precision modulated-signal source that would provide test equipment manufacturers a way to verify the performance of vector sources and receivers that operate at millimeter-wave frequencies.

- Measurement tools for characterizing the over-the-air performance of millimeter-wave wireless devices and systems.

- Improved channel models that would enable industry to accurately predict the propagation characteristics of communications channels at millimeter-wave frequencies.

- Accurate channel data that would aid standards development organizations in their efforts to develop the network protocols for millimeter-wave communication systems.

Performance Goals and Measurement Data:

Performance Goal: Publications	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	16	19	21	25	30
Without increase	10	10	10	10	10
Description:	Number of new NIST Special Publications, Internal Reports, Professional conference and journal articles, standard technical contributions annually.				

Performance Goal: Test & Measurement Tools	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	15	18	21	24	27
Without increase	5	5	5	5	5
Description:	Number of models, test and measurement tools released to public use annually.				

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Advanced Communications

Title:	Grade	Number of Positions	Annual Salary	Total Salaries
Electrical Engineer	ZP III	3	$76,414	$229,242
Electrical Engineer	ZP IV	2	107,378	214,756
Electronics Engineer	ZP III	3	76,414	229,242
Electronics Engineer	ZP IV	2	107,378	214,756
Mathematical Statistician	ZP III	1	76,414	76,414
Mathematical Statistician	ZP IV	1	107,378	107,378
Computer Scientist	ZP III	3	76,414	229,242
Computer Scientist	ZP IV	2	107,378	214,756
Information Technology Specialist	ZP III	3	76,414	229,242
Administrative/technical support	ZA II	2	52,693	105,386
Total		22		1,850,414
Less Lapse	25%	(6)		(462,604)
Total full-time permanent (FTE)		16		1,387,811
FY 2016 Pay Adjustment (1.3%)				18,042
TOTAL				1,405,852

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	16
Other than full-time permanent	0
Total	16
Authorized Positions:	
Full-time permanent	22
Other than full-time permanent	0
Total	22

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Advanced Communications

Object Class	Increase	Total Program
Personnel compensation		
Full-time permanent	$1,406	$225,785
Other than full-time permanent	0	19,571
Other personnel compensation	457	1,904
Special personnel services payments	0	0
Total personnel compensation	1,863	247,260
Civilian personnel benefits	0	75,676
Benefits for former personnel	0	0
Travel and transportation of persons	34	8,821
Transportation of things	11	1,212
Rental payments to GSA	0	90
Rental Payments to others	0	1,602
Communications, utilities and miscellaneous	1,262	32,994
Printing and reproduction	3	612
Advisory and assistance services	0	3,900
Other services	1,486	60,486
Purchases of goods & services from Gov't	105	33,253
Operation and maintenance of facilities	0	0
Research and development contracts	1,348	9,841
Medical care	0	0
Operation and maintenance of equipment	108	14,994
Subsistence and support of persons	0	0
Supplies and materials	383	31,505
Equipment	107	49,978
Grants, subsidies and contributions	1,290	90,571
Refunds	0	0
Total obligations	8,000	662,795
Transfer to the NIST Working Capital Fund	1,000	0
Total Increase Requested	9,000	662,795

5. Strengthening NIST Cryptographic and Privacy Capabilities to Address the Cybersecurity Concerns of Today and Tomorrow (Base Funding: $6.2 million and 21 FTE; Program Change: +$7.0 million and +10 FTE)

NIST requests an increase of $7.0 million and 10 FTE to strengthen the Nation's cybersecurity posture by providing strong cryptographic solutions and the development of privacy enhancing solutions and tools. This initiative is critical to the Department's ability to answer the questions posed in Strategic Objective 2.3 in the DoC 2014-2018 Strategic Plan.

Cybersecurity is a strategic priority that is vital to the economic and national security interests of the United States. In addition to the obvious financial ramifications with nearly $262.0 billion of e-commerce transactions in the U.S. alone for 2013, interconnected networks of computers have become essential for critical functions that affect every aspect of our lives including air traffic control, factory operation, and electric power distribution. A day does not go by without a new story of consumer data stolen, government networks attacked, or peoples personal data being used against them in acts of intimidation or humiliation. While NIST activities targeting these cybersecurity challenges such as the development of cybersecurity standards for Federal information systems, the newly released Cybersecurity Framework to reduce cybersecurity risk to critical infrastructure, and the launch of the National Cybersecurity Center of Excellence have helped to improve our overall cybersecurity awareness and posture, NIST's core technical capabilities cannot stagnate if NIST is to keep pace in what has become a rapidly escalating arms race to protect our individual, corporate, and public sector data, information, and systems from attacks from individual actors, criminal organizations, and nation-states. NIST must immediately build out its technical talent in cryptography to effectively address the rapidly emerging threats in this field. Simultaneously, with more citizens using web-based tools for everyday activities ranging from holiday shopping to online bill payment to using social media tools to stay connected with friends and family there is a pressing need for robust tools that provide users assurance about the privacy of their information and their online transactions.

Action 1: Ensuring the continued delivery of robust and independent cryptography capabilities ($5.0 million)

Cryptography is the backbone of effective cybersecurity. To remain an effective contributor to the development of cybersecurity solutions NIST must maintain a strong independent technical capability in cryptography in order to continue to identify, design, develop and standardize effective cryptographic algorithms, modes, key-management and protocols to provide foundational protection for the processes, information, and systems needed to deliver essential services and achieve mission and business objectives. This need is even more critical in the face of quantum computing, which, when available, will break all commonly used public key cryptographic algorithms. To ensure that NIST can continue to provide strong and independently verified cryptography solutions, and to begin to build the quantum resistant public-key architectures and systems that will take more than 15 years to fully develop and deploy, NIST must increase both its cadre of Federal cryptographers and its access to top academic talent. With this initiative, NIST will:

- Expand its cryptographic team;
- Identify and analyze quantum resistant security technologies; and
- Develop and promulgate standards, guidelines, tests, and measurements to support a post quantum security market.

Action 2: Development of privacy-enhancing technologies and architectures ($2.0 million)

Privacy risks are not well understood in complex online data ecosystems. Users should not be expected to manage such complexity themselves and engineers currently lack many reusable, standards-based tools and practices to mitigate privacy risks and integrate appropriate privacy controls into data systems. This action will help to accelerate the deployment and use of commercially available products that provide privacy protecting capabilities that are easy to use, design, and deploy by system users and developers. NIST's objective is to make significant contributions to address these challenges by creating privacy frameworks, reference architectures, guidelines, and best practices and by supporting industry standards. With this initiative NIST will:

- Provide tools and techniques to assist users in understanding and effectively managing privacy risks when interacting with a data ecosystem to improve customer trust and preserve their privacy;
- Provide practices, tools, and techniques to assist industry and government in understanding and managing privacy risks;
- Assist system designers, architects and developers to identify effective mitigations to address privacy risks; and
- Provide guidelines to create privacy controls that reflect Fair Information Practice Principles (FIPPs) when building a data ecosystem.

Statement of Need and Economic Benefits

The Nation's dependence on information technologies continues to deepen quickly, and cybersecurity efforts must expand accordingly to keep pace. Strong cryptographic solutions provide a necessary foundational element to combat the cybersecurity threats that increasingly exploit essential systems and services that place the Nation's security, economy, and public safety and health at risk. Failure to increase investment in cryptography and privacy research and standards activities will delay progress in mitigating existing cybersecurity threats and leave the U.S. even more vulnerable to future threats. The result is a continued loss of personal data and intellectual property, disruption to the delivery of essential services. A widely cited study released in early 2014 estimated the annual cost to the global economy from cybercrime at more than $445.0 billion, including both the gains to criminals and the costs to companies for recovery and defense. The same study also quoted an estimated 800 million individuals' records being compromised in 2013 alone, and the associated cost at approximately $160.0 billion per year. And these numbers do not include the impact from the highly publicized data breaches at major U.S. commercial retailers in 2014. Investments in cybersecurity and the development of privacy tools are critical to prevent further expansion in the gap between attackers' capabilities and defenders' ability to prevent attacks from succeeding and limit the impact of those attacks that do succeed. Delays in conducting this work will also delay corresponding improvements in the efficiency of cybersecurity operations, thus wasting significant resources at a cost much higher than the cost to develop these improvements.

Base Resources Assessment

In the area of cryptography, NIST invested a total of $5.375 million in base STRS funds in FY 2014, and $75.8 million in cybersecurity related efforts as a whole.

NIST collaborates with industry, consortia, and other Federal agencies to resolve critical cybersecurity issues for the Nation's cyber infrastructure. NIST's activities in support of cybersecurity cover the full range of the research lifecycle, from conducting fundamental research, such as improved techniques for measuring elements of security, to disseminating the results of that research in many forms.

This includes the following:

- Developing and reviewing standards, and coordinating the development of large sets of standards.
- Writing guidelines on securing technologies for agencies and other organizations to follow.
- Developing tools, procedures, and testing environments for evaluating cybersecurity technologies and the security of emerging information technologies.
- Establishing validation programs to confirm the proper implementation of standards in IT products and services.
- Conducting outreach to make the cybersecurity and IT communities aware of NIST activities and outputs.

NIST has a proven track record in the research and development of standards and guidelines for information and communications infrastructure protection, security automation, continuous monitoring, identity management, and other information security focus areas. Critical to cybersecurity research is improving the protection of data and identity information and NIST has extensive expertise in the development of related standards. NIST has a leading role in the Department of Commerce program of cybersecurity and privacy initiatives that support realizing the potential for e-commerce to foster innovation, bolster U.S. industrial competitiveness, and enhance our economic prosperity and security.

NIST is responsible for the development of Federal cryptographic standards for non-national security information systems. NIST's standards, guidelines and testing programs provide strong interoperable cryptography that are not only used throughout the Federal government, but also provide the foundation for cryptography throughout the world. For example, *Federal Information Processing Standard 197, Advanced Encryption Standard*, and *Federal Information Processing Standard 140 -2, Security Requirements for Cryptographic Modules*, are two globally recognized and used cryptographic standards produced by NIST. NIST has also led the development of and authored standards in support of Homeland Security Presidential Directive 12, *Federal Information Processing Standard 201-2, Personal Identity Verification (PIV).* HSPD-12 mandated the use of secure identity credentials for all Federal government employees and certain contractors. To date, over three million FIPS 201-PIV credentials have been issued, with significant consequent adoption of the standard occurring at the state and local level to meet regional cybersecurity and identity management requirements, a testimonial that the NIST work in cybersecurity is addressing real national needs.

Schedule and Milestones

Action 1: Ensuring the continued delivery of robust and independent cryptography capabilities

- Double NIST's cryptographic team (FY 2016 – FY 2017).
- Research quantum-resistant cryptographic mechanisms (FY 2017 – FY 2020).

Action 2: Development of privacy-enhancing technologies and architectures

- Develop outcome-based objectives, best practices, methodologies, and standards for assessing and mitigating design-level privacy risks in context (FY 2016 – FY 2017).
- Research and develop privacy-enhancing tools and technologies (FY 2017 – FY 2020).
- Develop methods for assessing conformance to created privacy standards, guidelines and best practices (FY 2018 – FY 2020).

- Perform outreach and education to assist technology developers and the public in making informed practical privacy-related decisions with regard to their interactions with the data ecosystem (FY 2016 – FY 2020).

Deliverables

Action 1: Ensuring the continued delivery of robust and independent cryptography capabilities

- A strong and independent NIST cryptography team.
- A pool of 5-10 NIST supported cryptographers at academic institutions around the U.S. to ensure a continued domestic critical mass of cryptographic expertise.
- New effective cryptographic algorithms that resist classical and quantum threats.
- Key management and communications protocols that support the new cryptographic algorithms.
- Conformance testing mechanisms to validate the adherence of products and services to associated standards and guidelines.

Action 2: Development of privacy-enhancing technologies and architectures

- Outcome-based objectives, best practices, and methodologies and standards for assessing and mitigating design-level privacy risks.
- Practices and methodologies for privacy engineering, and automatic data- and context-informed privacy risk assessment methods and technologies.
- Privacy risk analysis guidelines and practices integrated into industry and government applications, services, and devices.
- Privacy tools that will allow users, organizations and developers to understand systems and applications and their related capabilities that use, call or invoke personal data.

Performance Goals and Measurement Data:

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	2	4	8	9	10
Without increase	0	0	0	0	0
Description:	Number of new NIST Special Publications, Internal Reports, scientific and technical journal articles, technical specifications, guidelines, conference articles or reports related to cryptography.				

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	0	1	2	1	2
Without increase	0	0	0	0	0
Description:	Number of new NIST Special Publications, Internal Reports, scientific and technical journal articles, technical specifications, guidelines, conference articles or reports related to privacy-enhancing technologies				

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	0	1	2	1	2
Without increase	0	0	0	0	0
Description:	Test procedures, mechanisms and environments; software tools, and models/simulations				

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Strengthening NIST Cryptographic and Privacy Capabilities to Address the Cybersecurity Concerns of Today and Tomorrow

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Cryptographer	Gaithersburg	ZP V	1	$126,245	$126,245
Cryptographer	Gaithersburg	ZP IV	4	107,326	429,304
Cryptographer	Gaithersburg	ZP III	3	76,377	229,131
IT Specialist	Gaithersburg	ZP V	1	126,245	126,245
IT Specialist	Gaithersburg	ZP IV	2	107,326	214,652
IT Specialist	Gaithersburg	ZP III	2	76,377	152,754
Administrative/technical support	Gaithersburg	ZA II	1	52,667	52,667
Total			14		1,330,998
Less Lapse		25%	(4)		(332,750)
Total full-time permanent (FTE)			10		998,249
2016 Pay Adjustment (1.3%)					12,977
TOTAL					1,011,226

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	10
Other than full-time permanent	0
Total	10
Authorized Positions:	
Full-time permanent	14
Other than full-time permanent	0
Total	14

PROGRAM CHANGE DETAIL BY OBJECT CLASS

(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Strengthening NIST Cryptographic and Privacy Capabilities to Address the Cybersecurity Concerns of Today and Tomorrow

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	1,011	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,011	247,260
12	Civilian personnel benefits	316	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	30	8,821
22	Transportation of things	7	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous	789	32,994
24	Printing and reproduction	13	612
25.1	Advisory and assistance services	5	3,900
25.2	Other services	1,690	60,486
25.3	Purchases of goods & services from Gov't	772	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	350	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	91	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	241	31,505
31	Equipment	185	49,978
32	Lands and structures	0	0
33	Investments and loans	0	0
41	Grants, subsidies and contributions	1,500	90,571
42	Insurance claims and indemnities	0	0
43	Interest and dividends	0	0
44	Refunds	0	0
99	Total obligations	7,000	662,795

6. Advanced Sensing for Manufacturing (Base Funding: $5.0 million and 16 FTE; Program Change: +$5.0 million and +10 FTE)

NIST requests an increase of $5.0 million and 10 FTE to support U.S. competitiveness in advanced manufacturing by filling sensing and measurement gaps in the areas of advanced sensors used for process control.

Proposed Action: Advanced Sensing for Manufacturing

The long-term competitiveness of the U.S. economy relies heavily on the ability of the manufacturing sector to establish and maintain itself as a global leader. Advanced manufacturing technologies will revitalize this sector and ensure that it continues to be the engine of innovation and job creation that the U.S. needs for a secure and sustainable future. The challenge of revitalizing our economy through advanced manufacturing is clearly expressed in the original President's Council of Advisors on Science and Technology Advanced Manufacturing Partnership (AMP) report published in 2012, Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing. Since then, the U.S. Government has made major advances in implementing the recommendations the original report. In 2014, the follow-up committee issued the Report to the President Accelerating U.S. Advanced Manufacturing (AMP 2.0), which made further recommendations. In the report, the AMP 2.0 Recommendation #4 specifically states the need for "standards enabling exchange of manufacturing process information". This new NIST initiative directly addresses the challenges raised in the AMP 2.0 (Annex 1 and 2) and will help position U.S. manufacturers as leaders in advanced materials and manufacturing technologies.

A nationwide infrastructure that includes the scientific measurement tools and standards that industry needs to develop and advance their manufacturing methods is imperative. Ensuring that U.S. industry has the scientific and technical tools needed to stay competitive is the goal of the NIST laboratory research programs – as industry innovates, develops new technologies, and evolves, so must the work done at NIST. The investment requested here will support NIST so that it can continue to meet needs identified by industry in the area of advanced technology products and processes, thus adding to a strong portfolio of manufacturing investment that is already in place but covers other critical areas in advanced manufacturing.

A highly integrated effort across NIST laboratories in measurement science and standards will accelerate the design, development, and manufacturability of advanced electronic and photonic devices - those that require new concepts, architectures, materials, and manufacturing methods. The future of the U.S. manufacturing industry hinges on a few key decisions that need addressed now, and the pending paradigm shifts require that NIST programs adapt to address the challenges facing this community. NIST will address a rapidly emerging trend in the industry today: the need for advanced sensing using non-invasive sensing and real-time process analysis to reduce the rejection rate during the manufacture of high-value added products that involves multiple complex steps. Our industries need breakthrough technologies, novel device architectures, and next-generation logic to realize necessary future sensor performance. Electronic components in 20 years will look vastly different than those of today, with new device concepts and means of computing and sensing (spin, quantum, optical) that incorporate a diversity of new materials (e.g., nanowires, 2D-layers), but, we do not yet know the path forward. NIST will provide measurement science and standards to support the development of distributed and ubiquitous devices that can be integrated everywhere by consumers and manufacturers, to meet diverse needs.

NIST will support advanced manufacturing in key areas in electronics, optics, and photonics identified in several seminal reports from the National Academies and other groups, including the one from the

National Science and Technology Council Fast Track Action Committee co-chaired by NIST that produced an April 2014 report Building a Brighter Future with Optics and Photonics. Specifically, NIST will assist industry by developing sensors and methods for diagnostics and process control in advanced manufacturing.

Statement of Need and Economic Benefits

Manufacturing continues to play an essential role in the U.S. economy and is tied intimately to our Nation's capacity to innovate. The importance of advanced manufacturing, in general, and the components described in this initiative, specifically, have been recognized by leading industry and Federal advisory groups, including, the President's Council of Advisors on Science and Technology, the NIST Visiting Committee of Advisors on Technology, the Institute for Defense Analyses and the National Academies. This importance was clearly stated in the original AMP report in 2012, and again in 2014 with the AMP 2.0 report. A 2012 study by the Institute for Defense Analyses[22] also identified a number of emerging manufacturing trends including new manufacturing methods and manufacturing with less labor-intensive and more information-technology intensive processes.

The future of U.S. advanced manufacturing will involve new paradigms, which will require fundamental measurement infrastructure and standards to invent new electronic components, reliably evaluate new materials and electronic performances, and benchmark various technologies. The semiconductor manufacturing industry is already a $300.0 billion industry supporting a $2.0 trillion electronic products industry and growth in both areas is expected. Advances in electronics components and sensors are critical for future process technologies and device components, for applications including photolithography for device fabrication, and precision lasers for materials processing. Reliable, low-cost discrete electronic and photonic parts manufacturing will require non-invasive real-time process monitoring sensors with quantified measurement uncertainties.

Base Resources Assessment

This initiative builds upon many programs across NIST in measurement science and standards development, but targets those manufacturing areas that are in critical need of investment to maintain pace in the international marketplace. The NIST laboratories have a long tradition of developing and delivering measurement science tools that support advanced manufacturing technologies. Existing capabilities that will be leveraged to achieve the goals of this initiative include NIST's expertise in materials modeling and simulation, in support of the Administration's Materials Genome Initiative, as well as expertise in nanomanufacturing, digital design, chip-scale measurement technologies, robotics, additive manufacturing, and cyber physical systems. A recent assessment of the NIST manufacturing-related programs conducted by the National Research Council found that NIST programs are "highly qualified and comparable to the best in the world."[23] Measurement science and standards services developed at NIST provide the basic and applied research underpinnings to support advances in manufacturing.

NIST laboratories have a long history of providing measurement science and standards to support the semiconductor manufacturing industry. Current research focus includes "Beyond CMOS,"[24] defect characterization, reliability studies, and dimensional metrology. The research proposed in this initiative is

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[22] S. S. Shipp *et al.*, "Emerging Global Trends in Advanced Manufacturing," Institute for Defense Analysis, Mar. 2012.

[23] National Research Council. *A Review of the Manufacturing-Related Programs at the National Institute of Standards and Technology: Fiscal Year 2012.* Washington, DC: The National Academies Press, 2012.

[24] Complementary Metal-Oxide-Semiconductor. CMOS is the current technology used to construct integrated circuits for today's electronics

based on knowledge gained through leadership roles in international road-mapping efforts and standards developing organizations.

NIST has built a scientifically strong base of excellence in electronic and photonic measurements and this initiative will enable NIST to focus additional resources on providing American manufacturers with a competitive advantage in critical, future areas that support advanced technology products and processes. NIST is historically strong in the area of calibration and quantification of data uncertainties of sensors. These new, innovative and complex advanced sensors for manufacturing will all require calibrations so that their signal outputs can be converted to physically relevant quantities manufacturers can then utilize. Furthermore, the physical quantities measured by the sensors need to be validated for their procession and accuracy if the sensors are to be made interchangeable and interoperable.

Schedule and Milestones

Action: Advanced Sensing for Manufacturing

- Advance multidimensional and multispectral imaging and scattering measurements of surface, subsurface, and bulk structure for the specification, optimization, and quality control of manufactured components and products.

- Develop in-process and post-process sensing and imaging of surface and subsurface micro and nanostructure, associated defects and interfaces, and surface properties to enable improvements in the reliability and efficiency of advanced manufacturing processes.

- Develop in-process, real-time, high spatial and temporal resolution sensing platforms to control and optimize laser materials processing of semiconductors, metals, and ceramics.

- Develop measurement methods and test artifacts to enable the in-place calibration and validation of complex imagers and sensors and networks of imagers and sensors used in real-time process monitoring and control.

Deliverables

Action: Advanced Sensing for Manufacturing

- High-sensitivity, high-throughput inspection methods for nanoscale inspection in microelectronics and optoelectronics manufacturing processes to enable improved process performance, defect detection and quality control, and counterfeit product detection.

- Three-dimensional, non-contact laser imaging methods for the real-time, automated assembly and inspection of product parts in an advanced manufacturing environment.

- In-process and post-process physical and chemical imaging measurements and data on laser materials processing to improve process development and reliability, reduce materials waste, and enable real-time control and optimization.

- Standard reference materials; reference data on bulk materials, interfaces, and test artifacts; and standardized measurement and calibration methods to enable the in-place calibration of multidimensional and multispectral imaging systems, sensors, and sensor networks in an advanced manufacturing environment.

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	10	12	13	15	16
Without increase	4	5	7	4	6
Description:	Number of new NIST Special Publications, Internal Reports, scientific and technical journal articles, and conference articles and reports.				

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	4	5	5	4	4
Without increase	1	2	2	1	2
Description:	Number of new technical specifications and guidelines developed and published.				

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	5	6	5	7	5
Without increase	2	2	3	3	2
Description:	Number of standard reference materials, test artifacts, and reference data sets developed and disseminated.				

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Advanced Sensing for Manufacturing

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Physicist	Gaithersburg	ZP IV	6	$107,326	$643,954
Physicist	Boulder	ZP IV	6	107,326	643,954
Administrative/Technical Support	Gaithersburg	ZA II	1	52,667	52,667
Total			13		1,340,575
Less Lapse		25%	(3)		(335,144)
Total full-time permanent (FTE)			10		1,005,431
2016 Pay Adjustment (1.3%)					13,071
TOTAL					1,018,502

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	10
Other than full-time permanent	0
Total	10
Authorized Positions:	
Full-time permanent	13
Other than full-time permanent	0
Total	13

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Activity: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Advanced Sensing for Manufacturing

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$1,019	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,019	247,260
12	Civilian personnel benefits	318	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	35	8,821
22	Transportation of things	26	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous charges	573	32,994
24	Printing and reproduction	12	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	602	60,486
25.3	Purchases of goods & services from Gov't accounts	1,059	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	83	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	613	31,505
31	Equipment	660	49,978
41	Grants, subsidies and contributions	0	90,571
44	Refunds	0	0
99	Total obligations	5,000	662,795

7. Smart Cities/Cyber-Physical Systems (Base Funding: $6.7 million and 12 FTE; Program Change: +$5.0 million and +14 FTE)

NIST requests an increase of $5.0 million and 14 FTE to develop the measurement science foundations for advanced smart city technologies that improve the livability, workability, safety, and resilience of communities across the Nation. This initiative addresses the goals of the DoC 2014-2018 Strategic Plan to strengthen the Nation's digital economy (Objective 2.3) and the resiliency of U.S. communities and regions (Objective 3.3).

Proposed Actions: Develop and accelerate the adoption and use of measurement science foundations that enhance innovation in smart city technologies and increase the market size for and accessibility to markets for U.S. industry

Standards that enable innovation and entrepreneurship in smart city technologies can increase the economic competitiveness of U.S. industry by opening markets in the rapidly growing global smart city market. Facing rapid population growth, inefficient and aging infrastructures, and the needs of an increasingly digital society, communities across the Nation and around the world — from small towns to megacities — look to harness the power of emerging cyber physical systems and Internet of Things (IoT) technologies to improve livability, workability, resilience, and sustainability. These communities also seek access to advanced technologies for their residents, businesses, and institutions to catalyze jobs growth and create new businesses by enhancing the way people work, learn, and interact. Among the largest barriers to meeting these goals through commercial innovation are limitations in the interoperability and scalability of many of today's smart city solutions. These barriers mean that today's smart city systems are often custom implementations that are costly and inefficient, work in only one city or one infrastructure, create stranded systems that cannot readily be upgraded or extended, prevent meaningful comparisons for informed acquisition decisions, and stifle innovation and growth in the smart city technologies market. This initiative creates the measurement science and technical standards required for the design and performance measurement of scalable, extensible, and interoperable smart city solutions that empower U.S. communities and ensure American companies can be competitive in the rapidly growing global smart city market.

The foundations of smart city solutions lie in the convergence of information technology with manufactured products, engineered systems of products, and associated services that enable a new generation of "smart" systems. Examples include a smart electricity grid, intelligent vehicles, and smart buildings. These integrated, hybrid networks of cyber and engineered physical elements, or Cyber Physical Systems (CPS), are the basic engine of innovation for a broad range of industries. The President's Council of Advisors on Science and Technology (PCAST) has noted that CPS "are a national priority for Federal R&D" and that dramatic improvements in the systems engineering, integration and testing process for complex CPS are needed to meet safety, security, reliability and performance requirements. NIST has deep expertise in a number of CPS domains and is uniquely positioned to adapt measurement science solutions that enable integration of infrastructures and systems across domains at city-scale for powerful new services and capabilities. This initiative mobilizes NIST's CPS expertise and draws on powerful concepts from cyber physical systems and the Internet of Things to promote economic growth and enable communities across the Nation to enhance the quality of life for their residents.

Action 1: Measurement science principles for smart city systems (+$1.5 million)

An essential requirement for achieving smart city goals is the ability to reliably design and safely manage smart city solutions across multiple city-scale infrastructures. For example, enhancing community resilience to natural disasters requires integrating the design and management of communications, emergency response, health care, transportation, energy, water, food supply, and other infrastructures. NIST's smart cities initiative focuses on the measurement science for an integration infrastructure that unites engineered systems and infrastructures around community goals. The components of a smart city integration infrastructure include an interface (connections to domain platforms and components), core systems (networking, data analytics, etc.), and integration and management capabilities (modeling and simulation, design, control, visualization, communications; etc.). The first action item focuses on the foundations for predictive design and effective performance measurement for integration infrastructures suitable for at-scale smart city systems, focusing on:

- Designing for scalability;
- Real-time sensing, modeling, and feedback; and
- Methods for validation and verification for at-scale smart city solutions.

This work provides the measurement science foundations for city planners and commercial technology innovators to design and develop platforms that reliably and demonstrably meet smart city requirements; enables solutions that meet today's needs while evolving to accommodate new technologies and expanded requirements in the future; and ensures that complex smart city systems are safe, secure, and reliable.

Action 2: Standards and guidelines for interoperability (+$1.0 million)

A second requirement for meeting smart city goals is the ability to connect multiple domains, diverse infrastructures, and a range of engineered and IT components. This includes the ability to integrate information across domains, coordinate management of multiple infrastructures, and compose new services and capabilities from diverse components. Consensus standards are needed to provide the basis for achieving the needed level of interoperability and this action item focuses on standards for:

- Multi-domain data access, integration, and analysis;
- Application interfaces for interoperability across city-scale infrastructures; and
- Communication technologies and protocols that provide for flexible and agile interconnection of sensors, systems, and infrastructures.

This work provides the foundations of technical standards and guidelines that enable the development of smart city solutions that are platforms for innovation and entrepreneurship in creating new services and capabilities; allow efficient integration of multiple infrastructures into smart city solutions without costly redesign and renovation; and provide the basis for modularity and composability in assembling new and expanded services from existing systems.

Action 3: Smart city test beds for science-based design (+$1.3 million)

The third action area focuses on creating capabilities for experimental analyses to test and refine the measurement science concepts and interoperability foundations that emerge from the first two action items. The ability to conduct experiments at scale can both inform and validate the development of measurement science principles for design and operation of smart city systems. The incorporation of standards alone is insufficient to achieve full interoperability. Foundations for third party testing and certification capabilities are also needed to support innovators and entrepreneurs in developing effective smart city technologies.

This action item focuses on:

- Modular, composable test beds for smart city research, including integrating existing, domain-specific test beds and facilities; and
- Instrumenting city-scale infrastructures for experiment and testing.

This work provides the foundations for experimental research into new generations of smart city technologies; enables the development of a testing and certification community that promotes reliable and cost-effective smart city deployments; and allows data-enabled decision making by those responsible for planning and designing smart city projects.

Action 4: IT building blocks for smart city solutions (+$1.2 million)

Requirements common to all smart city solutions are that systems must be secure, privacy-protecting, reliable, and resilient. Meeting these requirements requires designing-in the appropriate capabilities rather than bolting-on various fixes after the fact. This action item focuses on approaches for integrating the required capabilities throughout the relevant design, development, deployment and operations phases. These basic capabilities are:

- Integrated cyber and physical security at all smart city system layers;
- Privacy engineering for privacy by design; and
- Wireless communications, including dynamic wireless spectrum, that provide for reliable and resilient interconnection of sensors, systems, and infrastructures.

This work enables smart city systems that can be protected against cyber threats; protects the privacy of residents while ensuring they can benefit from smart city services and resources; and provides for reliable systems that function under stress or crisis situations.

Statement of Need and Economic Benefits

Communities across the Nation are facing significant challenges. These include:

- Managing an aging infrastructure while reducing overall costs – America's infrastructure was recently assigned a grade of D+ with $3.6 trillion in investments needed[25] at a time when 88 percent of city and county leaders expect reduced or flat budgets[26];
- Meeting the demands of population growth and increasing urbanization, which will add 2.5 billion people to the urban population by 2050[27];
- Protecting against the risks of an increasingly uncertain climate future; and

[25] American Society of Civil Engineers, http://www.infrastructurereportcard.org/

[26] http://americancityandcounty.com/gpn/keating-report-mid-year-2014-forecast-government-budgets-and-spending-part-2

[27] United Nations, World Urbanization Prospects 2014, http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

- Meeting the needs of an increasingly digital society in which connectivity and access to digital information, e-commerce, and the industrial internet are engines for progress.

To meet these challenges, communities are increasingly turning to smart city strategies that integrate digital and physical infrastructures to improve performance, increase efficiency, and create new opportunities for citizens and businesses. Examples include:

- Reduced energy consumption in commercial and residential buildings and city infrastructures;
- Business growth and new jobs through IT-enabled commerce and industry;
- Increased environmental sustainability and an improved quality of life;
- Reduced traffic congestion, accidents, pollution, and energy costs;
- Better health care;
- Increased resilience to natural disasters; and
- Improved public safety and reduced crime.

It is estimated that today 15 percent of cities worldwide are pursuing smart city opportunities[28] driving growth in a global market for smart city technologies that is predicted to reach $408 billion by 2020[29]. The rapidly increasing number of smart city projects and the associated market expansion represent significant growth opportunities for U.S. businesses if a framework of open and transparent standards is put in place to enable an open, globally competitive market. This initiative focuses on the measurement science research and standards development to create an open framework for a globally competitive smart city technologies market.

It is estimated that the deployment of next-generation cyber physical systems across the transportation, energy, and health sectors alone has the potential to boost U.S. productivity growth by as much as 1.5 percent and increase per capita GDP by 25-40 percent by 2030[30]. The implementation of new cyber physical systems at scale to achieve just a one percent improvement in efficiency can save over 66 billion dollars in power generation and 63 billion dollars in health care over a 15 year period. Future CPS technologies could eliminate 93 percent of the six million automotive crashes caused each year by human error and reduce by half the current 80 billion dollars per year cost of traffic congestion[31]. With a projected global population exceeding nine billion people by 2050, an uncertain climate future, and up to 50 percent food loss between production and consumption, the application of advanced CPS technologies to the entire food chain is critical to meet the needs of future generations. Smart city technologies embrace all of these goals and more. The goal of this initiative is to ensure that communities nationwide are able to take advantage of these technologies in meeting their needs through smart city projects that are cost-effective, safe, secure, privacy-enhancing, reliable and resilient.

[28] IDC Corporation, http://www.idc.com/getdoc.jsp?containerId=prUS24641314
[29] UK Dept. Business Innovation & Skills, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249423/bis-13-1217-smart-city-market-opportunties-uk.pdf
[30] http://files.gereports.com/wp-content/uploads/2012/11/ge-industrial-internet-vision-paper.pdf
[31] https://www.nitrd.gov/nitrdgroups/images/6/6a/Cyber_Physical_Systems_(CPS)_Vision_Statement.pdf

Base Resources Assessment

In the area of Cyber Physical Systems, NIST invested a total of $6.7 million in base STRS funds and 12 FTE in FY 2014. NIST has deep expertise in a number of CPS domains including advanced manufacturing, smart grid, transportation, civil infrastructure, buildings and structures, defense, health technologies, emergency response, materials science, physical measurements, networking and communications technologies, cybersecurity, and others. Through this initiative, this domain expertise can be translated into all-domain smart cities progress by adapting measurement science solutions across domains and developing cross-domain and domain-independent solutions. NIST's activities cover the full research cycle, from fundamental research to disseminating the results of that research. This includes:

- Developing and reviewing standards;
- Providing technical guidelines on measurements and other processes for use by agencies and industry;
- Developing tools, tests, and test beds for evaluating technologies, including the security of emerging information technologies;
- Establishing validation tools, methods, and other resources that can be used to confirm the proper implementation of standards; and
- Conducting outreach across sectors and domains to increase awareness of NIST activities and outputs.

This initiative leverages the combined expertise of the Engineering Laboratory, Information Technology Laboratory, Physical Measurement Laboratory, Communications Technology Laboratory, Materials Measurement Laboratory, and Standards Coordination Office. Work on standards and measurements will be carried out in coordination with public and private stakeholders, including relevant stakeholder groups and national and international standards organizations. Work on experiment and testing capabilities will be carried out in partnership with academic researchers, commercial sector innovators, and city/community leaders.

This initiative builds on the expertise and current activities of NIST, including:

- Measurement science for cyber physical systems;
- Research, development, and standards for city-scale infrastructures, including smart grid, building controls, advance manufacturing, health systems, resilience, and disaster response; and
- Active engagement with cities, communities and innovators through the SmartAmerica and Global City Teams challenges.

Schedule and Milestones

Action 1: Measurement science principles for smart city systems

- Build up NIST expertise for city-scale cyber physical systems measurement science, including capabilities for interoperable design and performance measurement (FY 2016 – FY 2020).

- Develop and publish new methods for measuring the performance of cyber physical systems at city scale (FY 2016 – FY 2018).
- Develop and disseminate new tools for city-scale cyber physical systems design and performance measurement suitable for use by smart city solution designers and operators (FY 2018 – FY 2020).
- Develop methods and guidelines for validation and verification for at-scale smart city solutions based on the tools and concepts developed under this action item (FY 2018 – FY 2020).
- Conduct workshops on concepts for smart city integration infrastructure (FY 2016 – FY 2017).

Action 2: Standards and guidelines for interoperability

- Conduct workshops on current and future concepts for smart city standards for interoperability (FY 2016).
- Convene a public working group to develop smart city reference architecture, taxonomy, and supporting use cases (FY 2016 – FY 2017).
- Develop and publish methods for multi-domain data access, integration, and analysis and use the resulting concepts to inform and support NIST work with standards bodies (FY 2016 – FY 2020).
- Develop and publish analyses of application interfaces for interoperability across city-scale infrastructures and use the resulting insights to inform and support NIST work with standards bodies (FY 2016 – FY 2020).
- Develop and publish analyses of communication technologies and protocols for integration of smart city sensors, systems, and infrastructures and use the resulting information to inform and support NIST work with standards bodies (FY 2016 – FY 2020).

Action 3: Smart city test beds for science-based design

- Conduct workshop on smart city test bed design, including composability and modularity (FY 2016).
- Develop and publish an inventory and best practices analysis for current smart city test beds (FY 2016).
- Develop and publish analyses of conceptual design principles for modular, composable smart city test beds (FY 2017 – FY 2018).
- Develop and publish best practices for smart city applications testing and certification based on test bed capabilities (FY 2018 – FY 2020).
- Working with cities and researchers, promote pilot deployments of smart city instrumentation concepts for interoperable, cross-domain at-scale cyber physical systems (FY 2016 – FY 2018).
- Build on smart city instrumentation pilots to develop and publish new measurement science concepts for next generation smart city technologies (FY 2018 – FY 2020).

Action 4: IT building blocks for smart city solutions

- Conduct two workshops on integrated cyber and physical security and privacy engineering for smart city solutions (FY 2016).

- Develop and publish a technology roadmap for integrating cyber and physical security at all smart city system layers (FY 2017).
- Develop and publish new NISTIR providing a framework and guidelines for integrated smart city cyber and physical security (FY 2018 – FY 2020).
- Develop and publish new concepts for privacy engineering in smart city solutions (FY 2017 – FY 2020).
- Conduct workshop on wireless communications for resilient smart city solutions (FY 2017).
- Develop and publish new concepts for wireless communications for resilient smart cities (FY 2018 – FY 2020).

Deliverables

Action 1: Measurement science principles for smart city systems

- NIST publications on at-scale CPS performance measurement
- Tools for CPS design and performance measurement
- NIST publications on methods and guidelines for smart city systems validation and verification
- Workshop reports on smart city integration infrastructures

Action 2: Standards and guidelines for interoperability

- Workshop reports on smart city standards for interoperability
- NIST smart city reference architecture, taxonomy and supporting use cases
- NIST publications on multi-domain data access integration and analysis
- NIST contributions to standards development in smart city data access, integration and analysis, application interfaces, and communication technologies and protocols
- NIST publications on smart city application interfaces for interoperability
- NIST publications on smart city communications technologies and protocols

Action 3: Smart city test beds for science-based design

- Workshop reports on smart city test bed design
- NIST publication on current smart city test bed concepts and best practices
- NIST publications on conceptual design principles for next-generation, modular smart city test beds
- NIST publications on foundations for smart city testing and certification
- NIST publications on next generation smart city technologies based on instrumented-cities analyses

Action 4: IT building blocks for smart city solutions

- Workshop reports on smart city cyber and physical security, privacy engineering, and wireless communications for resilient smart cities
- NIST technology roadmap for integrated cyber and physical security for smart cities

- NISTIR on framework for smart city cyber and physical security
- NIST publications on privacy engineering for smart cities
- NIST publications on wireless communication for resilient smart cities

Performance Goals and Measurement Data

Performance Goal: Publications	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	4	4	5	5	6
Without increase	2	2	2	2	2
Description:	Number of new NIST scientific and technical journal articles, special publications, interagency and internal reports, and conference articles and reports				

Performance Goal: Guidelines and Standards Contributions	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	3	4	4	5	5
Without increase	2	2	2	2	2
Description:	Number of new technical specifications and guidelines published and number of contributions to standards efforts				

Performance Goal: Measurement tools for smart city systems	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With increase	0	2	4	4	6
Without increase	0	1	1	1	1
Description:	Number of models and simulations, test, and measurement tools released for public use annually				

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Smart Cities/Cyber-Physical Systems

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Program manager	Gaithersburg	ZP V	1	$126,245	$126,245
Electronics engineer	Gaithersburg	ZP V	1	126,245	$126,245
Systems engineer	Gaithersburg	ZP V	1	126,245	$126,245
Computer scientist	Gaithersburg	ZP V	1	126,245	$126,245
Physical scientist	Gaithersburg	ZP V	1	126,245	126,245
Economist	Gaithersburg	ZP V	1	126,245	126,245
Mathematician	Gaithersburg	ZP V	1	126,245	126,245
Materials scientist	Gaithersburg	ZP V	1	126,245	126,245
Mechanical engineer	Gaithersburg	ZP IV	1	107,326	107,326
Electronics engineer	Gaithersburg	ZP IV	1	107,326	107,326
Systems engineer	Gaithersburg	ZP IV	1	107,326	107,326
Computer scientist	Gaithersburg	ZP IV	1	107,326	107,326
Physical scientist	Gaithersburg	ZP IV	1	107,326	107,326
Materials scientist	Gaithersburg	ZP IV	1	107,326	107,326
Economist	Gaithersburg	ZP IV	1	107,326	107,326
Stakeholder coordinator	Gaithersburg	ZP IV	1	107,326	107,326
IT specialist	Gaithersburg	ZP II	1	52,667	52,667
Administrative/technical support	Gaithersburg	ZA II	2	52,667	105,334
Total			19		2,026,569
Less Lapse		25%	(5)		(506,642)
Total full-time permanent (FTE)			14		1,519,927
FY 2016 Pay Adjustment (1.3%)					19,759
TOTAL					1,539,686

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	14
Other than full-time permanent	0
Total	14
Authorized Positions:	
Full-time permanent	19
Other than full-time permanent	0
Total	19

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Smart Cities/Cyber-Physical Systems

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	1,540	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,540	247,260
12	Civilian personnel benefits	481	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	59	8,821
22	Transportation of things	11	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous	536	32,994
24	Printing and reproduction	17	612
25.1	Advisory and assistance services	6	3,900
25.2	Other services	792	60,486
25.3	Purchases of goods & services from Gov't	355	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	400	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	66	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	120	31,505
31	Equipment	137	49,978
32	Lands and structures	0	0
33	Investments and loans	0	0
41	Grants, subsidies and contributions	480	90,571
42	Insurance claims and indemnities	0	0
43	Interest and dividends	0	0
44	Refunds	0	0
99	Total obligations	5,000	662,795

8. Quantum-Based Sensors and Measurements -- Developing the measurement infrastructure for tomorrow's industry (Base Funding: $21.6 million and 42 FTE; Program Change: +$4.997 million and +11 FTE)

NIST requests an increase of roughly $5.0 million and 11 FTE to support forward looking research programs in areas that will revolutionize and transform future U.S. economic competitiveness. Maintaining a strong investment in forward looking basic research is a critical component to maintaining the technical infrastructure required in innovation-intensive economies as called for in the DoC Strategic Objective 2.5.

Proposed Actions: Develop and deploy cutting edge quantum-based measurement capabilities (+$5.0 million)

NIST's ability to continue to push the envelope of measurement science has regularly demonstrated the potential to open up new fields of technology and provide the technical infrastructure necessary to grow new industries. Scientific progress in a single discipline typically finds myriad applications, and often in seemingly unrelated areas. Take for example laser frequency combs. Originally developed by NIST to support ultra-precise atomic clocks, the technology has contributed to breakthroughs in a number of areas including communications and GPS technologies. Additionally, NIST investments in the ability to measure and characterize materials at the nanoscale have helped to usher in a new era of nanoengineered materials. Quite rapidly, such nanomaterials have become essential components in semiconductor electronics and lightweight materials, which are used in everything from airplanes to athletic gear. The proposed increase will strengthen ongoing NIST efforts and help expand NIST's internal and external research capacity in quantum science and will accelerate NIST's ability to deliver the measurement solutions needed to support continued U.S. leadership in this critical space.

The requested funding provides resources to support the measurement science and standards necessary to maintain U.S. leadership in quantum information science. Quantum information science is an emerging research field with the potential to revolutionize computation, communication, precision measurement, and fundamental quantum science. This field seeks to harness the fundamental laws of physics to dramatically improve information acquisition, transmission, and processing. This proposed increase supports NIST's key role in quantum information science, which will lead to improved information security and assurance, improved and cheaper standards, and more sensitive sensors for a variety of applications. NIST's success will ensure U.S. leadership in quantum information science, improving U.S. competitiveness in advanced manufacturing, and strengthening national security, all while keeping NIST at the cutting edge of future standards development. This mission-driven effort also supports a large portion of NIST's world-class basic research effort that has led to four NIST Nobel Prizes. NIST Research will be targeted to:

- ***Engineer robust quantum systems for improved sensing and better and/or cheaper quantum standards.*** Over the next decade quantum systems will be used to revolutionize sensor technology both for state-of-the-art sensors and for less sensitive and more ubiquitous environmental applications. The NIST program will explore applications such as rotation sensors, gyroscopes, gravimeters, magnetometers, gravity gradiometers, photonic sensors for thermodynamic quantities and electromagnetic field sensors, accelerometers, and standard based devices for realization of base and applied quantities of the metric system. NIST will develop the measurement science for these devices, explore their sensitivities to various environmental parameters, and explore technologies that are commercially viable whether on the factory floor or as a ubiquitous sensor in the environment. The program will explore technologies that work at room temperature as well as those requiring very low temperature and ultra-high vacuum.

- ***Create, develop, and characterize robust and efficient hybrid quantum systems*** that enable efficient transformation of quantum information from one modality to another. Such transformations are essential to the creation of practical quantum devices. NIST will focus on the measurement science that will enable these more complex technologies. Hybrid quantum systems can be used to efficiently convert rf-photons to optical photons and can be used to create low noise, near quantum-limited amplifiers, parametric amplifiers and detectors.
- ***Develop tools for understanding, manipulating, controlling and measuring complex quantum systems*** to create the measurement science and scientific knowledge needed for future technologies and innovation. One early application is to explore and develop sources of squeezed light or atoms that could be used for precision metrology and low noise amplification for improved quantum based sensing.
- ***Develop and explore quantum materials and solid state qubits for future advanced quantum devices*** including more robust and better integrable quantum standards and quantum sensors. This effort will focus on creating solid-state qubits that are identical, uniform and/or atomically precise, and amendable to mass fabrication.

Statement of Need and Economic Benefits

Improvements in both basic and applied quantum information science have far-reaching industrial applications, national security implications, and economic benefits. For example, in the area of computing, quantum algorithms offer remarkable improvements in efficiency when compared to traditional methods, enabling computers to run exponentially faster than classical computers. The quantum properties of light provide privacy assurance and security that are guaranteed by the laws of physics, which has substantial applications in both cyber and telecommunications security. Finally, quantum sensors have much higher precision and faster acquisition compared current technologies, improvements that could be applied to almost any industry or process. Indeed, the National Research Council of the National Academies identified both quantum engineering and quantum information science among the grand challenges in atom, molecule and photon science.[32] The economic impact of improvements in quantum information science is enormous. Considering only quantum computing, which will eventually replace current computers and therefore translate into off-the-chart economics: for every one computer electronics manufacturing job, 16 others are created as a result and the quantum computing industry is projected to grow nearly 140 percent between 2017 and 2022.[33] Foreign governments have partnered with industry to make substantial investments (> $500 million in the past four years) to make advancements in quantum computing.[34] The primary stakeholders are U.S. high-tech industries, research universities, and other government agencies, each of which realize that strong participation in the "second quantum revolution" is essential to future U.S. economic and national security.

Base Resource Assessment

In the areas of quantum science NIST invested a total of $21.6 million in base STRS funds in FY 2014. Controlling and manipulating quantum systems is the foundation for NIST's capabilities in time, electrical metrology, and cryogenic electronics, and is the basis of research of NIST's four Nobel Laureates. NIST is widely recognized as a world leader in this area and has been at the forefront

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[32] Controlling the Quantum World: The Science of Atoms, Molecules, and Photons. Committee on AMO 2010, National Research Council.
[33] Capturing an Industry: Quantum Computers. Recommendations for California to maximize its share of the emerging quantum computer industry. www.makingitincalifornia.com. September 16, 2013.
[34] Federal budget supports quantum research at Waterloo. www.exchangemagazine/morningpost/2014/week6/Wednesday/14021.

of research in demonstrating and characterizing quantum gates, in demonstrating and understanding the limitations of quantum key distribution, in some of the first experiments in quantum transduction, and in the earliest experiments in quantum simulation. The advances in quantum information science is both mentioned and the foundation for NIST's most recent Nobel Prize in Physics to David Wineland in 2012. Quantum based standards are currently the basis for most electrical quantities and for our most precise standard – time. Research is underway and active in creating quantum basis for temperature and luminosity. But even where we have world class quantum standards there exist hopes for building more robust and integrable quantum standards including quantum hall resistance standards based on grapheme or other materials that would operate at higher temperatures and lower magnetic fields than the present standards; a quantum logic clock that provides the most precise and accurate single atom clock today; and two efforts to use qubit technologies as the basis for a quantum current standard based on electron counting. These competencies exist as a result of NIST's world class leadership in building atomic clocks and quantum electrical standards and builds on the past decade of competence building through budget initiatives in quantum information and NIST IMS program.

Schedule and Milestones

Develop and deploy cutting edge quantum-based measurement capabilities

- Create the characterizing tools necessary for robust and efficient quantum transducers production (FY 2016 - 2019).
- Develop tools for understanding, manipulating, controlling, and measuring complex quantum systems (FY 2016 - 2019).
- Engineer robust small quantum systems for improved sensing and better/cheaper quantum standards (FY 2018 - 2021).
- Develop and explore quantum materials and solid state qubits for future integrateable advanced quantum devices (FY 2018 - 2021).
- Coordinate with stakeholders at universities and the private sector to identify and integrate best practices in industrial application of quantum science (FY 2016 - 2017).

Deliverables

Develop and deploy cutting edge quantum-based measurement capabilities

- Develop both primary and (slight less efficient) commercially viable single photon detectors that surpass current commercially available technology by at least one order or magnitude.
- Improve quantum simulation capabilities to better understand and harness the power of complex many-body quantum systems.
- Determine the types of sensors (e.g., rotation sensors, gyroscopes, gravimeters, and electromagenic field sensor) that can benefit from miniature quantum systems and provide the necessary science to enable these technologies to become commercially viable.
- Create the tools, processes, materials, and characterization capabilities required for the mass production of identical interconnected solid-state qubits.
- Develop a roadmap for addressing the scientific/technical aspects of wide-spread quantum science adoption in specific business sectors.

Performance Goals and Measurement Data

Performance Goal:	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target	FY 2021 Target
With increase	0	1	2	3	3	3
Without increase	0	0	0	0	0	0
Description: Production of improved quantum standards with industrial applications.						

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Quantum-based Sensors and Measurements

Title:	Grade	Number of Positions	Annual Salary	Total Salaries
Physicist	ZP V	3	$126,245	$378,735
Physicist	ZP IV	6	107,326	643,956
Theoretical Physicist	ZP III	2	76,377	152,754
Program Manager	ZP V	1	126,245	126,245
Computer Scientist	ZP IV	1	107,326	107,326
Administrative Assistant	ZA II	1	52,667	52,667
Administrative/technical support	ZA II	1	52,667	52,667
Total		15		1,514,350
Less Lapse	25%	(4)		(378,588)
Total full-time permanent (FTE)		11		1,135,763
FY 2016 Pay Adjustment (1.3%)				14,765
TOTAL				1,150,527

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	11
Other than full-time permanent	0
Total	11
Authorized Positions:	
Full-time permanent	15
Other than full-time permanent	0
Total	15

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Quantum-based Sensors and Measurements

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$1,151	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	359	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,510	247,260
12	Civilian personnel benefits	0	75,676
13	Benefits for former personnel	0	8,821
21	Travel and transportation of persons	21	0
22	Transportation of things	12	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous	588	32,994
24	Printing and reproduction	5	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	493	60,486
25.3	Purchases of goods & services from Gov't	61	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	693	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	64	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	68	31,505
31	Equipment	450	49,978
41	Grants, subsidies and contributions	1,032	90,571
44	Refunds	0	0
99	Total obligations	4,997	662,795

9. Biomanufacturing/Engineered Biology: Developing Engineering Principles for Efficient Biomanufacturing (Base Funding: $15.0 million and 25 FTE; Program Change: +$4.0 million and +4 FTE)

NIST requests an increase of $4.0 million and 4 FTEs to ensure quality and predictability in the design of synthetic biological systems for efficient production of fuels, chemical feedstocks, pharmaceuticals, and medical therapies. Maintaining a strong investment in forward looking basic research is a critical component to maintaining the technical infrastructure required in innovation-intensive economies as called for in the DoC Strategic Objective 2.5.

Proposed Actions: Developing engineering principles for efficient biomanufacturing

Biomanufacturing has the potential to usher in the next Industrial Revolution into many U.S. manufacturing sectors. Biomanufacturing is the use of living organisms to produce a commodity, including fuels, chemicals, pharmaceuticals and medical therapies. There is increasing interest with the Federal government to help incentivize the creation of a bio-based economy, and in 2012, Senate legislation was introduced to allow more biomanufacturing companies to participate in Farm Bill Programs.[35] Medical therapies, also called biologics when produced via a biomanufacturing process and probably the products with the greatest biomanufacturing presence, already account for 50 percent of the revenue from the top 100 drugs in 2014. For biomanufacturing to reach a sustainable maturity in all sectors, however, there are three main hurdles that need to be overcome: reducing the risk of contamination; maintaining high productivity/efficiency, and; reducing product variability among different manufacturing runs. Unlike traditional manufacturing modalities, which often have a number of well-developed, specific process controls and verification steps already integrated into the process, today's biomanufacturing is still using a costly and uncertain trial-and-error approach. This uncertainty also causes a rather unique issue in the regulatory process; biologics cannot be approved by the Food and Drug Administration without concomitant approach of the manufacturing process. This two-phase approval process is implemented because of public safety concerns but creates the unanticipated consequence of restricting future process improvements. A paradigm shift of creating a more reliable, even predictable biomanufacturing process would address all the technological hurdles and help to reduce the uncertainty causing that currently hampers the regulatory process, most immediately for biologics.

Creating efficient, predictable biomanufacturing processes will require the development of tools to explore, manipulate and ultimately explain the intricate complexities of biological cells. Research in the biological sciences has traditionally relied on a reductionist approach, which suggests that all complex phenomenon can be explained by measuring the most basic components involved. Many recent biological disciplines, such as synthetic biology and systems biology, are still based on such an approach. While reductionism has proved to be quite powerful under certain circumstances, this approach of simplification can obfuscate critical, often fundamental, behavior. In an effort to overcome this issue, a new paradigm in the life sciences, commonly referred to as Engineering Biology, has been developed. Instead of measuring individual components, Engineering Biology focuses on the behavior of the whole organism. For example, Engineering Biology would answer how the genetic circuits interact with all of the cellular machinery whereas synthetic biology would focus on how much product these circuits can produce. Engineering Biology seeks to understand, and therefore predict, the rules that govern biological function, and therefore can be used to develop highly stable, calculable biomanufacturing processes.

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[35] https://www.bio.org/media/press-release/bio-applauds-senator-stabenow%E2%80%99s-proposed-legislation-supporting-creation-biobase

Relying on the ability to synthesize, assemble and ultimately understand the relationships between different types of biological machinery, Engineering Biology seeks to bypass the less predictable and lengthy process of evolution to streamline the creation of organisms capable of performing a specific function. This initiative addresses the technical challenges faced by the biomanufacturing industry by developing a suite of quantitative methods for accurate measurement of biological systems, creating the necessary tools to methodically design and test engineered organisms, and, by engaging relevant stakeholders, develop and evaluate predictive models where engineered biological systems first be examined *in silico*. Ultimately, a data/analysis system consisting of a community-fed pipeline of highly qualified data and data-driven approaches will be created, thereby enabling a platform for world-wide collaboration. This pipeline will result in rapid examination of experimental parameter space with large, highly qualified datasets to produce experimentally testable predictive theories that constitute the fundamental principles controlling biological organisms. This approach has the potential to revolutionize not only biology and biomanufacturing, but all aspects of biomedical science and medicine.

Action 1: Coordinate, develop and assess measurement infrastructure for biological systems

The trial-and-error approach, which is commonly employed in biomanufacturing, is a typical yet ineffectual response when techniques to provide accurate, quantitative measurements are not available. Such measurements, however, are critical for understanding how biological systems are controlled on a genetic level. Unfortunately, these types of measurements are quite difficult. By their very nature, biological cells are inherently "noisy" and interact with the environment in unexpected ways. The biomanufacturing and Engineering Biology research communities have requested NIST's help in measurement and standards development in an effort to provide confidence in the measurements and to establish robustness and harmonization of results. Consequently, NIST is needed to coordinate the strategic development and implementation of accurate and quantitative measurements of engineered biological systems. New, robust measurement technologies will be developed and benchmarking tools for existing techniques will be disseminated. While data generation is important, assessing the data quality is equally critical. Therefore, methods for data validation, including relevant reference data and standards, will be developed. It is envisioned that these efforts will help lead to the generation of sufficient highly qualified dataset, and NIST will assist these communities develop a suitable framework that can help them address their larger (and currently unforeseen) challenges. NIST will also develop a technical roadmap for NIST metrology as it relates to the intersection of biomanufacturing and Engineering Biology.

Action 2: Develop robust design and testing tools for biological systems

The bedrock of Engineering Biology is the ability to manipulate and modify a specific region of genetic material, and then understand how that modification influences the biological organism. Manipulation and modification relies on a detailed understanding what genetic material is present, in what configuration (what is being produced, commonly referred to as the gene or DNA sequence) and how actively that sequence is expressed (how much material is being produced). For example, two DNA sequences may produce different amounts of the same protein. While there are several well-established methods for DNA sequencing, methodologies to accurately quantify DNA expression are currently lacking. This may lead to less-than-optimal design of engineered organisms via the trial-and-error approach and loss of inter-operability among different laboratories. Based on established expertise in gene sequencing, NIST will develop and test standards for DNA modification and synthesis, including assessing the results of DNA modification on gene expression. Such rigorous genetic characterization accompanied by a quantitative functional activity descriptor will enable a better understanding of how biosynthetic pathways function. NIST will also provide high quality data on biological systems engineered with systematic genetic modifications, which can serve as gene expression references for the synthetic biological community to better standardize reporting and promote inter-operability. Further, NIST will focus on robust, high throughput methods for generating large volumes of validated data on gene expression for engineered biological systems. These large data volumes will be available to synthetic biology community for both input and export of genetic designs, which will further assure inter-operability of methods and comparability of results.

Action 3: Develop and deploy predictive models for biological systems

Computational tools are just as important to the development of Engineering Biology as validated lab-based measurement and testing protocols. Such tools allow the Engineering Biology community to investigate any and all genetic combinations at computer terminals (*in silico*) rather than *in vitro* at the lab bench, thus saving both time and money. Through collaborations, NIST will develop and critically evaluate theoretical models that allow prediction of a desired biological response. These models will connect DNA sequences and enzymatic activity, for example, to dynamic behaviors, and will likely require collaboration from a number of different fields, including physics, mathematics, statistics, biology, and computer science. NIST will work with the community to collate and evaluate data and predictive models. NIST will also engage the community to develop a shared resource of data, theoretical models, and modular modeling component repository to allow critical assessment of model performance models. Early and wide-spread adoption of modeling codes, including units of measure and data validation protocols, will promote world-wide collaboration and standardization.

Statement of Need and Economic Benefits

Innovations in the biomanufacturing industry are traditionally incremental in nature and often driven by slight refinements to existing technologies.[36] Yet with a potential market share of $1 trillion[37], disruptive technologies and inventions for the biomanufacturing sector are warranted. The intersection of biomanufacturing and Engineering Biology is nascent enough that roadmapping efforts have not yet occurred. Related fields, such as synthetic biology, have begun this effort and are therefore informative of ongoing activities. The United Kingdom's Royal Society and Royal Academy of Engineering, the United States' National Academy of Sciences and National Academy of Engineering, and the Chinese Academy of Science and Chinese Academy of Engineering, collectively organized a series of international symposia on the scientific, technical, and policy issues associated with synthetic biology.[38] During the two-year period when the three symposia were taking place, the governments of the United Kingdom and China made investments in synthetic biology a priority (by comparison, the United States invests roughly $140.0 million annually in this area). The United Kingdom and China also advanced formal strategies and benchmarks for funding allocation purposes. Additionally, in Europe, the European Commission and the Organization for Economic Co-operation and Development (OECD) have taken an active interest in the field. During the course of the symposia series, representatives from China, the United Kingdom, the United States, and the OECD discussed national plans, as well as planned and ongoing international collaborations, for stimulating progress in synthetic biology. The United States Congress has established a bipartisan caucus on synthetic biology, and the House of Representatives included provisions on synthetic biology in the recently passed Manufacturing Competitiveness Act.

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[36] Gottschalk et al. 2012. The need for innovation in biomanufacturing. Nature Biotechnology. 30, 489-492.
[37] https://www.bio.org/media/press-release/bio-asks-senate-committee-target-tax-credits-advanced-biofuel-and-renewable-chem
[38] UK Synthetic Biology Roadmap Coordination Group. A synthetic biology roadmap for the UK [Internet]. Technology Strategy Board (UK): 2012. 33 p. Requested by UK Department for Business Innovation and Skills. Available from: http://www.innovateuk.org/_assets/tsb_syntheticbiologyroadmap.pdf

Base Resource Assessment

NIST currently invests about $15.0 million specifically targeted at addressing the measurement challenges in the area of Engineering Biology. These current efforts are largely centered in measurement assurance of DNA sequence. NIST has established close and fruitful connections with DARPA, NSF, and academic and industrial collaborators in this arena, and has been active in road-mapping efforts with the synthetic biology community. The proposed program would add capacity in systematic design and measurement of engineered biological response, which in turn would support theoretical work and development of predictive models.

Schedule and Milestones

Action 1: Coordinate, develop and assess measurement infrastructure for biological systems

- Develop advanced measurement methods based on NIST-invented technologies to measure small molecule products from engineered organisms (FY 2016).
- Convene the synthetic biology community to determine requirements for standards and metrology (FY 2016 – FY 2020).
- Develop measurement methods at NIST for evaluating sequence fidelity (FY 2016).
- Develop protocols, reference materials and benchmarking methods and materials for assuring high quality measurements of cell function and products (FY 2016 – FY 2020).

Action 2: Develop robust design and testing tools for biological systems

- Increase NIST capacity for high content analysis of cell function and cellular products with state of the art equipment and newly recruited personnel (FY 2016 – FY 2017).
- Design, construct and deploy biological components that allow testing of desired response characteristics and response function in engineered cells (FY 2017 - FY 2020).

Action 3: Develop and deploy predictive models for biological systems

- Develop and test new thermodynamic and statistical mechanical models of cell population responses (FY 2016 – FY 2018).
- Work with and engage the community to contribute, along with NIST, data and models for engineered biological systems via an interactive Web presence (FY 2016 – FY 2020).
- Model complex adaptive responses (emergence) across multiple scales of biological organization (FY 2017 – FY 2019).
- Develop and test models to describe and predict the effects of organization and complexity on the function of single cells and cell communities (FY 2019 – FY 2020).

Deliverables

Action 1: Coordinate, develop and assess measurement infrastructure for biological systems

- Coauthor publication on the use of gradient elution moving boundary electrophoresis (GEMBE) on detecting morphine produced by an engineered organism (FY 2016).
- Host an *Engineering Biology Standards Consortium* with existing partners (BioBricks Foundation, DARPA Living Foundries, SynBERC) to guide, foster, and develop metrology products (FY 2017).
- Develop a technical roadmap for NIST metrology for Engineered Biology for publication in the peer-reviewed literature (FY 2017).
- Conduct inter-laboratory study of synthesis fidelity (FY 2017).
- Hold workshop to engage regulatory agencies and stakeholders to identify standards needs for release of engineered organisms (FY 2018).
- Publish recommendations/guidance for gene synthesis quality (FY 2018).
- Disseminate relevant benchmarking tools for fluorescence microscopy and flow cytometry to the community (FY 2018).
- Provide reference data on characteristics and functional activity of selected engineered organisms (FY 2019 – FY 2020).

Action 2: Develop robust design and testing tools for biological systems

- Perform collaborative research on systematic refactoring of gene clusters (FY 2016).
- Develop a robust engineering platform that allows assessment and control of directed evolutionary response in engineered biological systems (FY2016 – FY 2017).
- Demonstrate a reliable method for inserting large DNA constructs into engineered cells (FY 2017).
- Develop a platform compatible with microscopy for cell and gene manipulation (FY 2016 – FY 2017).
- Establish robust high throughput methods for generating large volumes of validated data on engineered systems (FY 2017 – FY 2020).

Action 3: Develop and deploy predictive models for biological systems

- Organize a workshop on quantitative biology with academic and industrial participants (FY 2016).

- Provide a mathematical description of cell system performance with 1 and 2-dimensional landscapes (FY 2018).
- Develop a model to describe evolution of microbial systems and effect on production. (FY 2018 – FY 2020).
- Demonstrate the ability to predict the output of an engineered system according to the class of engineered components (FY 2020).
- Predict fundamental performance limits of natural and engineered biosystems for design and optimization (FY 2020).
- Establish an interactive Web presence that allows users to submit high quality data, and/or models, and to assemble a selection of resulting mathematical kernels to analyze their data (or the data of others) (FY 2017 – FY 2020).
- Hold a Critical Assessment of Model Performance study to evaluate performance of models across biomanufacturing stakeholders (FY 2020).

Performance Goals and Measurement Data

Performance Goal: Develop measurement tools for biological systems	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Increase	6	9	12	15	15
Without Increase	3	3	3	3	3

Performance Goal: Develop widely-adopted testing tools for biological systems	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Increase	4	18	24	50	70
Without Increase	2	2	6	12	15

Performance Goal: Deploy predictive model for biological systems	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Increase	0	0	5	10	15
Without Increase	0	0	0	0	0

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Biomanufacturing/Engineered Biology

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Biochemist	Gaithersburg	ZP IV	1	$107,326	$107,326
Biological Engineer	Gaithersburg	ZP IV	1	107,326	107,326
Computational Biologist	Gaithersburg	ZP IV	1	107,326	107,326
Biomedical Engineer	Gaithersburg	ZP IV	1	107,326	107,326
Biologist	Gaithersburg	ZP IV	1	107,326	107,326
Computer Scientist	Gaithersburg	ZP IV	1	107,326	107,326
Total			6		643,954
Less Lapse		25%	(2)		(160,988)
Total full-time permanent (FTE)			4		482,966
2016 Pay Adjustment (1.3%)					6,279
TOTAL					489,245

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	4
Other than full-time permanent	0
Total	4
Authorized Positions:	
Full-time permanent	6
Other than full-time permanent	0
Total	6

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: Biomanufacturing/Engineered Biology

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$489	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	489	247,260
12	Civilian personnel benefits	153	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	23	8,821
22	Transportation of things	16	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous	474	32,994
24	Printing and reproduction	8	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	283	60,486
25.3	Purchases of goods & services from Gov't	89	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	500	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	71	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	244	31,505
31	Equipment	550	49,978
41	Grants, subsidies and contributions	1,100	90,571
44	Refunds	0	0
99	Total obligations	4,000	662,795

10. <u>STRS Programmatic Decrease: (-$10.885 million and 0 FTE)</u>

To adhere to the prescribed FY 2016 funding levels, NIST would minimize negative impact on newly funded Administration initiatives and priorities (e.g., Advanced Manufacturing). With the proposed reduction, NIST does not plan on utilizing Reduction-In-Force (RIF) authority to meet funding targets to fund current programs.

To meet its science and commerce mission, NIST relies on effective partnerships with universities, industry, and consortia partners as a vehicle to leverage their expertise to help NIST meets its measurement science and technology mission. This leveraging occurs in the form of grants and contracts (both of which may include funding of research associates, postdocs, graduate students and equipment) awarded to these partners at various times of the year and depending on current measurement science needs. To preserve NIST's core programs in our Laboratories, NIST would reduce grants and contracts with partners. While this reduction preserves core Laboratory programs at NIST, it would degrade these partnerships that NIST relies on to keep pace with emerging measurement science, technology, and innovations offered by these partners through grants and contracts.

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollars in thousands)

Budget Program: Measurement Science, Services, and Programs
Subprogram: Laboratory Programs
Program Change: STRS Programmatic Decrease

	Object Class	FY 2016 Decrease	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	0	$225,785
11.3	Other than full-time permanent	0	19,571
11.5	Other personnel compensation	0	1,904
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	0	247,260
12	Civilian personnel benefits	0	75,676
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	($170)	8,821
22	Transportation of things	0	1,212
23.1	Rental payments to GSA	0	90
23.2	Rental Payments to others	0	1,602
23.3	Communications, utilities and miscellaneous	-	32,994
24	Printing and reproduction	0	612
25.1	Advisory and assistance services	0	3,900
25.2	Other services	(3,793)	60,486
25.3	Purchases of goods & services from Gov't	0	33,253
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	9,841
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	0	14,994
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	(1,821)	31,505
31	Equipment	(1,068)	49,978
32	Lands and structures	0	0
33	Investments and loans	0	0
41	Grants, subsidies and contributions	(4,033)	90,571
42	Insurance claims and indemnities	0	0
43	Interest and dividends	0	0
44	Refunds	0	0
99	Total obligations	(10,885)	662,795

Department of Commerce
National Institute of Standards and Technology
Laboratory Programs
REIMBURSABLE PROGRAM AND WORKING CAPITAL FUND INVESTMENTS
(Dollar amounts in thousands)

	FY 2014 Actual	FY 2015 Enacted	FY 2016 Estimate
Department of Defense			
Air Force	$9,228	$6,017	$5,813
Army	746	817	835
Navy	1,385	1,232	1,290
Other, Department of Defense	16,906	17,029	15,564
Subtotal, Department of Defense	28,265	25,095	23,502
Department of Agriculture	30	25	25
Department of Commerce	16,026	16,551	16,080
Department of Energy	4,725	5,674	4,445
Dept. of Health & Human Services	4,252	5,560	4,871
Dept. of Homeland Security	13,682	19,742	17,745
Department of the Interior	210	0	0
Department of Justice	4,863	7,586	7,669
Department of Transportation	326	297	298
Department of the Treasury	0	649	400
Department of Veterans Affairs	200	200	210
Environmental Protection Agency	75	85	85
General Services Administration	38	201	97
National Aeronautics & Space Admin.	2,317	2,771	2,717
National Science Foundation	2,949	2,833	2,500
Nuclear Regulatory Commission	2,347	2,500	2,500
Other	5,317	6,558	5,304
Subtotal, Other Agency	85,622	96,327	88,448
Calibrations & Testing	8,325	8,128	8,150
Technical & Advisory Services	18,247	19,778	19,102
Standard Reference Materials	17,853	18,906	18,649
Subtotal, Other Reimbursables	44,425	46,812	45,901
Total, Reimbursable Program	130,047	143,139	134,349
Equipment Transfers	7,700	0	1,500
Subtotal, WCF transfer	7,700	0	1,500
Equipment Investments	13,225	23,631	14,897
IE Amortization	(19,801)	(15,862)	(14,897)
WCF Operating Adjustments	19,734	0	0
Total, WCF Investments	13,158	7,769	0
Total, Reimbursable Program and WCF Investments	150,905	150,908	135,849

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Corporate Services

Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Measurement science, services, and programs
Sub-program: Corporate services

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) over 2016 Base	
Line Item		Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount
Corporate services	Pos./Approp	48	$17,312	48	$17,311	48	$17,624	48	$16,906	0	($718)
	FTE/Obl.	46	17,313	47	17,456	47	17,727	47	17,009	0	(718)
Total	Pos./Approp	48	17,312	48	17,311	48	17,624	48	16,906	0	(718)
	FTE/Obl.	46	17,313	47	17,456	47	17,727	47	17,009	0	(718)

BUDGET SUB-PROGRAM: Corporate Services

BASE JUSTIFICATION:

Corporate Services Overview

This program includes the NIST central IT support for NIST's technical programs which provides secure, centrally managed IT infrastructure resources supporting NIST's technical mission leading to improved measurement methods, standards advances, reference data, and research results benefiting numerous sectors of the U.S. economy. This program also provides the necessary resources to operate and maintain administrative and financial management systems at NIST that satisfy the requirements established by the Department of Commerce; Office of Management and Budget; Government Accountability Office; Department of Treasury; General Services Administration; and Congress.

1. Computer Support

The scope of this effort includes: securely deploying and managing computing, software, and networking resources as well as distributed, redundant storage for NIST data; and, management of the central computing facilities to meet Federal IT security requirements and the specialized requirements of the IT equipment located therein. These resources enable NIST laboratories and programs to meet mission-specific needs, disseminate NIST results to the public, and collaborate with NIST partners.

Examples of Accomplishments

- Piloted a Virtual Desktop Infrastructure to allow NIST business and scientific users to access their data and applications anytime, anywhere, from any device, so that ideas, collaboration, and innovation aren't limited to business hours or office buildings.

- Implemented Enterprise Cybersecurity Monitoring and Operations in the NIST environment, enabling continuous monitoring and real-time reporting for Windows, Linux, Unix and Mac OS.

Priority Objectives for FY 2016

- Manage the IT infrastructure including computing systems, software, data storage, networking, and security capabilities to support all NIST programs including in new research buildings.

- Optimize the portfolio of computing platforms, data storage and backup, network interconnects, system security mechanisms including network access control, and software components to meet the unique requirements of NIST users and programs.

- Migrate services to cloud providers in cases where it would provide optimal benefit to NIST.

2. Business Systems

The DoC and the Administration have undertaken major modernization initiatives of various business systems, functions, and processes. DoC envisions common, Department-wide, user-friendly, and flexible systems to support financial management, procurement management, travel management, grants management, property management, and other administrative functions. New business systems or upgrades to existing systems will be implemented over the next several years. Any new systems acquired will be integrated within the Department's

Framework for business systems modernization. They will also interface with other internal and external administrative and management systems. NIST's business systems are an integral part of the vision for the administrative and financial management systems formulated by the DoC.

Example Accomplishments

- Used incremental upgrades and performance tuning to keep the financial system and associated business systems at NIST operating smoothly.

- Implemented system modifications to ensure continued compliance with OMB and Treasury directives and mandates.

Priority Objectives for FY 2016

- Implement, operate, and maintain administrative management systems that support the delivery of administrative services to NIST and its cross serviced customers.

- Operate and maintain CBS and the NIST CBS Portal that supports delivery of services to NIST and its cross-serviced customers.

- In conjunction with the Department and NIST's customers, plan for the successor to the Commerce Business System architecture.

PROGRAM CHANGE(S):

1. <u>STRS Programmatic Decrease (-$0.718 million and 0 FTE).</u>

To adhere to the prescribed FY 2016 funding levels, NIST proposes to reduce IT and business systems efforts in support of NIST's scientific and technical research programs. With the proposed reduction, NIST does not plan on utilizing Reduction-In-Force (RIF) authority to meet funding targets to fund current programs. Rather this programmatic decrease will focus on equipment and contractual services specific to NIST's business systems and centrally managed IT infrastructure and support services.

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollars in thousands)

Budget Program: Measurement Science, Services, and Programs
Subprogram: Corporate Services
Program Change: STRS Programmatic Decrease

Object Class	FY 2016 Decrease	FY 2016 Total Program
Personnel compensation		
Full-time permanent	0	$3,727
Other than full-time permanent	0	265
Other personnel compensation	0	856
Special personnel services payments	0	0
Total personnel compensation	0	4,848
Civilian personnel benefits	0	1,436
Benefits for former personnel	0	0
Travel and transportation of persons	($4)	23
Transportation of things	0	0
Rental payments to GSA	0	0
Rental Payments to others	0	10
Communications, utilities and miscellaneous charges	0	1,293
Printing and reproduction	0	2
Advisory and assistance services	0	306
Other services	(461)	5,067
Purchases of goods & services from Gov't accounts	0	1,941
Operation and maintenance of facilities	0	0
Research and development contracts	0	0
Medical care	0	0
Operation and maintenance of equipment	0	1,196
Subsistence and support of persons	0	0
Supplies and materials	(26)	(2)
Equipment	(227)	889
Lands and structures	0	0
Investments and loans	0	0
Grants, subsidies and contributions	0	0
Insurance claims and indemnities	0	0
Interest and dividends	0	0
Refunds	0	0
Total obligations	(718)	17,009

Department of Commerce
National Institute of Standards and Technology
Corporate Services
REIMBURSABLE PROGRAM AND WORKING CAPITAL FUND INVESTMENTS
(Dollar amounts in thousands)

	FY 2014 Actual	FY 2015 Enacted	FY 2016 Estimate
Department of Defense			
Department of Commerce	$3,088	$3,776	$3,796
General Services Administration	7	9	9
Subtotal, Other Agency	3,095	3,785	3,805
Total, Reimbursable Program	3,095	3,785	3,805
Equipment Investments	2,524	2,387	1,992
IE Amortization	(1,818)	(1,912)	(1,992)
Total, WCF Investments	706	475	0
Total, Reimbursable Program and WCF Investments	3,801	4,260	3,805

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Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Measurement science, services, and programs
Sub-program: Standards coordination and special programs

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) over 2016 Base	
Line Item		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Standards coordination and special programs	Pos./Approp	155	$55,676	179	$66,884	179	$68,287	194	$76,220	15	$7,933
	FTE/Obl.	150	55,872	178	88,668	183	68,324	194	78,856	11	10,532
Total	Pos./Approp	155	55,676	179	66,884	179	68,287	194	76,220	15	7,933
	FTE/Obl.	150	55,872	178	88,668	183	68,324	194	78,856	11	10,532

BUDGET SUB-PROGRAM: Standards Coordination and Special Programs

BASE JUSTIFICATION:

Standards Coordination and Special Programs Overview

Standards Coordination and Special Programs houses two cross NIST activities managed by the Associate Director for Laboratory Programs that deal with coordinated high-profile R&D programs, documentary standards coordination and policy development.

1. Office of Special Programs (OSP)

The OSP serves as the project and program management office for the Associate Director for Laboratory Programs, enhancing management oversight, planning, and resource coordination for high-profile programs that critically depend on the expertise and capabilities of two or more NIST laboratories.

The OSP currently consists of the following four programs:

- Forensic Sciences: In cooperation with the Department of Justice, the Department of Defense, the Department of Homeland Security and the National Science Foundation, develops performance standards, measurement tools, operating procedures and equipment guidelines that help criminal justice agencies make informed procurement, deployment, applications, operating, and training decisions. Provides unique expertise on performance standards for critical technologies in forensic science such as firearms and toolmark analysis, pattern and impression analysis including latent friction ridge analysis, footprint, tread and tire analysis, trace evidence including paint and coatings, fiber, hair, glass, metals and plastics analysis, geological evidence analysis, questioned document analysis, crime scene analysis, fire scene and fire debris analysis, explosives analysis, controlled substance and toxicology analysis, computer forensics, multi-media, digital and image analysis, voice spectral analysis, serology and DNA analysis, and medicolegal and death investigation. Works with law enforcement, universities, professional and scientific organizations, and other government agencies, to solve difficult technical forensic science standards challenges.

- Energy Research Program: As a new program in 2014, provides the measurement science and technical underpinnings for standards related to energy research that requires expertise and capabilities of more than one NIST organizational unit (OUs). Works closely with the Department of Energy (DoE) and its laboratories to identify and prioritize the evolving metrology needs for which NIST research is required. Establishes the measurement service portfolios (reference materials, reference data, and calibrations) essential to DoE programs and the relevant stakeholder communities, when these cross the boundaries of individual OUs. Works primarily in the sector associated with renewable and sustainable energy, including the fields of transportation and fuels, energy efficiency, electric power generation, and energy storage.

- Greenhouse Gas Measurements and Climate Research Program: Provides the measurement science basis for accurate and comparable quantitative measurements of greenhouse gas emissions. Ensures measurement capabilities for accurate and reliable assessment of current greenhouse gas baselines, validation of greenhouse gas emission sources, and quantification of greenhouse gas sinks through improved quantitative measurements. Enables development of international measurement standards to ensure the accuracy of global assessments of greenhouse gas emissions.

- National Security Standards Program: Provides an intra and interagency coordinated approach to the development of technical standards and conformity assessment activities, related to national security, through federal, state, local, private sector, and international engagement. The focus is on measurement science and standards for Chemical/Biological/Radiological/Nuclear/Explosive (CBRNE) detection, personal protective equipment (PPE), and physical infrastructure resilience and security. Efforts in this program support the 2011 *National Strategy for CBRNE Standards* through improved interagency collaboration for standards development.

Examples of Accomplishments

- Forensic Sciences: Designed a national framework for the development, approval and adoption of standards to support the Forensic Sciences in the U.S. This key standards infrastructure was designed to provide a national uniform organized framework to address technology and standards development needs for the highly diverse and fragmented universe of forensic science disciplines. Working with stakeholders from Federal, state and local government criminal justice and forensic science practitioners, academic researchers, measurement science and statistics subject matter experts, the organizational infrastructure was established to develop standards for the methods and protocols used in crime laboratories across the U.S., to ensure scientific rigor and to conduct research to validate new and existing methods, and develop standards for forensic science terminology, report wording and expert testimony.

- Forensic Sciences: Created a standard reference material that has globally standardized forensic firearms examinations and propelled the next generation of ballistic imaging software and instrumentation. The standard bullet was pivotal in the creation of algorithms for data collection and is the basis of uniform image capture for the National Integrated Ballistics Information Network, a national system utilized to associate firearms used in crimes to evidentiary fired bullets and casings.

- Greenhouse Gas Measurements and Climate Research Program: Completed the development of the spectral reference data for carbon dioxide at unprecedented levels of accuracy that directly support the observing instruments to be employed in NASA's Orbiting Carbon Observatory. Demonstrated a robust, low component cost, observing instrument technology prototype for carbon dioxide and methane intended for widespread use in surface-based observing networks.

- National Security Standards Program: Sponsored a National Academy of Science Workshop on "An All-Government Approach to Increase Resilience for International CBRNE Events" which brought together Federal and International response and military agencies to discuss consequence management and the U.S. government's role during international CBRNE disaster events (e.g., Fukushima).

- Office of Law Enforcement Standards: Leveraged the 700 MHz Public Safety Broadband Demonstration Network to conduct mission critical research, development, testing, and evaluation for public safety broadband communications features such as indoor/in-building coverage, extended cell coverage, and priority, quality of service, and pre-emption. Worked with the program's more than 70 Cooperative Research and Development Agreement (CRADA) partners to upgrade to network's $70+ million worth of equipment to the most advanced feature sets and standards releases. The 700 MHz Public Safety Broadband Demonstration Network continues to be one of the most vendor-diverse LTE networks in the world; test results are consumed by program sponsors such as the Department of Homeland Security's Office for Interoperability and Compatibility and the agency responsible for creating the nationwide public safety broadband network (NPSBN), FirstNet.

Priority Objectives for FY 2016

- Forensic Sciences: 1) Establish the administration of the Organization of Scientific Area Committees and be responsible for managing five Scientific Area Committees, a Forensic Science Standards Board, Quality Infrastructure Committee, Legal Resource Committee, Human Factors Committee and subcommittees to promulgate national standards, guidelines, and best practices throughout the forensic science community. In collaboration with the Department of Justice, prepare a report of the National Commission on Forensic Science and provide recommendations to the Attorney General. 2) Establish a Forensic Science Center of Excellence to rapidly build expertise in areas where measurement science gaps exist.

- Greenhouse Gas Measurements and Climate Research Program: Extend urban greenhouse gas measurements testbeds to three urban areas in the U.S. as a means of assessing the performance of advanced measurement methodologies advancing measurement capabilities for independent diagnosis of emissions inventory accuracy. The three urban areas selected cover a broad range of urban and atmospheric conditions.

- National Security Standards Program: Coordinate efforts with the Department of Defense (DoD) Test and Evaluation Capabilities and Methodologies Integrated Process Team (TECMIPT). Coordinate standards development and knowledge sharing with the European Union's Joint Research Centre specific to national security. Establish a method for information/personnel sharing, for the support of national security standards development efforts, with the European Union Joint Research Centre.

- Energy Research: Establish and coordinate research efforts with the National Renewable Energy Laboratory and NIST (Physical Measurement Laboratory, Material Measurement Laboratory, NIST Center for Neutron Research): on second generation sustainable biofuels with a primary focus on understanding fundamental interactions at the molecular level and their impact on the composition and usability of the finished fuel; and on materials issues with advanced electrodes to improve efficacy, manufacturability, and quality.

2. Standards Coordination Office (SCO)

The SCO advises NIST leadership on policy and strategy as they relate to NIST's statutory role and responsibilities in standardization and serves as a normative standards and conformity assessment related multi-functional resource for NIST and U.S. government staff. In particular, the SCO addresses issues at the intersection of technology, standards, trade and innovation.

The Standards Coordination Office carries out the following programmatic functions:

- Standards Policy Coordination: Formulates and implements NIST policy regarding standards and conformity assessment, including product testing, certification practices, and laboratory accreditation to promote U.S. technology and support international competitiveness; cooperates with domestic organizations in the private sector, state and local governments, Federal agencies, and with domestic foreign, and international organizations in matters related to standardization and conformity assessment; carries out standards policy and information functions established by Congress or as otherwise directed; recommends Federal policies regarding the development, approval, and use of voluntary standards, and the development and implementation of conformity assessment policy; chairs the Interagency Committee on Standards Policy (ICSP) which coordinates actions by which Federal agencies implement standards-related policies; coordinates domestic and international standards-related activities; monitors the global standards and conformity assessment landscape and represents NIST at relevant domestic and international fora; administers and reports on the quality system for NIST measurement services; conducts training for NIST assessors and quality managers; oversees and reviews NIST divisions' quality systems assessments; and represents the U.S. and NIST at the SIM Quality System Task Force.

- Standards Guidance: Provides standards and conformity assessment related technical support to other U.S. government agencies to assist with both technical and policy issues. Provides early warning about emerging standards and conformity assessment related issues that can help NIST managers make decisions about preparing for and addressing these issues. Assists NIST staff in bridging the technical, standards and trade policy aspects in issues with the potential to impact U.S. competitiveness and ability to innovate. Provides unique standards and conformity assessment policy expertise relating to key trading partners. Assists U.S. government agencies and private sector organizations with the implementation of Mutual Recognition Agreements (MRAs) such as the APEC Tel, CITEL, and U.S. - EU MRAs.

- Standards and Information Dissemination and Outreach: Operates the World Trade Organization, Technical Barriers to Trade related Inquiry Point and Notification Authority and Standards Information Center providing unique standards, conformity assessment and technical regulations related information to NIST staff, U.S. government employees, U.S. exporters, and foreign trading partners. Provides standards and conformity assessment related outreach and training to stakeholders, and manages standards education efforts for NIST including the Standard Services curriculum development grant program. Analyzes impact and effectiveness of NIST participation in standards and conformity assessment related activities.

- Laboratory Accreditation: Operates the National Voluntary Laboratory Accreditation Program (NVLAP) for the U.S.; provides accreditation to testing and calibration laboratories based on evaluation of their technical qualifications and competence to perform certain types of tests in specified fields using internationally accepted guides and standards; designs and implements procedures for accrediting laboratories for their capability to provide calibrations traceable to national standards and for ability to conduct such important tests as those for asbestos fibers and electromagnetic telecommunications; provides evaluation and recognition of testing performance, especially in response to Congressional mandates and requirements of other Federal agencies, to domestic and foreign laboratories, state and local governments, and commercial interests.

Examples of Accomplishments

- Standards Policy Coordination: Coordinated the development and publication of a report by the National Science and Technology Council's Subcommittee on Standards, on Federal Engagement in Standards Activities to Address National Priorities, and supported the development of a memorandum from the White House on the principles for Federal Engagement in Standards. The report included proposed policy recommendations currently under consideration in the Executive Office of the President. Serves as the Chair of the Interagency Committee on Standards Policy (ICSP).

- Standards Guidance: Designed and implemented the inspection and provisional authorization (certification) system used by the General Services Administration (GSA) for cloud service providers as part of the cloud first policy. This program has accredited more than 31 third party assessment organizations (inspection bodies) that assess the implementation of security controls in cloud service providers systems and granted provisional authorization to several cloud service providers. The program leverages private sector resources to provide a sustainable and competitive market for inspection services and reduces the resources needed by Federal agencies to use cloud services in their information systems.

- Homeland Security: Worked with the Department of Homeland Security to develop, ASTM E2885 – 13, and ASTM E2933 - 13 Standard Specifications for Chemical Vapor Detectors for Homeland Security Applications. This first of their kind standards will allow first responders and other users of detection equipment for toxic industrial chemicals and chemical warfare agents to make more informed procurement decisions.

- Conformity Assessment: Provided advice and guidance to the Occupation Safety and Health Administration's (OSHA) to review, revise and publish new recognition requirements for OSHA Nationally Recognized Testing Laboratory program. OSHA's revised requirements are designed to be compatible with international conformity assessment standards resulting increased trade of electrical products worldwide. Advised the NIST Special Program Office on standards, conformity assessment, and quality infrastructure related to the development of the newly established Organization of Scientific Area Committees to strengthen forensic science in the United States. Provided input on standards and conformity assessment to the NIST Information Technology Laboratory-led Cybersecurity Framework effort.

- Standards and Information Dissemination and Outreach: Provided training on documentary standards, conformity assessment and related topics to over 2700 Federal agency staff, including 950 in FY14, from more than 34 government agencies. This effort supports NIST's role under the National Technology Transfer and Advancement Act.

- Laboratory Accreditation: In response from a request from the Office of the National Coordinator for Health IT, NVLAP expanded its program to accredit laboratories that perform functional and conformance testing of electronic health record (EHR) technology products to encompass additional requirements. Also, NVLAP expanded its Energy Efficient Lighting Products program to meet the needs of the EPA ENERGY STAR program.

Priority Objectives for FY 2016

- Standards Policy Coordination: Coordinate implementation of White House-issued principles for enhancing Federal engagement in standards activities with the private sector to address national priorities. Continue to work with OMB's Office of Information and Regulatory Affairs on supplementary guidance for agency use of standards to enhance the efficiency and effectiveness of government programs. SCO will support OMB's revision of Circular A-119 and support Federal agencies implementation of the revised guidance on participation and use of standards.

- Standards Guidance: Issue updated guidance to agencies on conformity assessment and coordinate agency implementation. Further explore identification of external standards needs and priorities for NIST, examining standards needs and priorities in the context of potential impacts in specific priority technology areas, such as cyber-physical systems, nanotechnology, cybersecurity and forensics; and the organization and execution of opportunities for technology leaders to relate their future standards-related challenges. Work with the Department of Justice on the development and implementation of a documentary standards based quality infrastructure for forensic science. Work with the Department of Health and Human Services, National Personal Protective Technology Laboratory in developing approaches to optimize their testing and certification activities for respiratory protective equipment and a develop a framework to carry out their responsibilities for nonrespiratory personal protective equipment. Work with the Environmental Protection Agency and the General Services Administration on standards and ecolabelling issues related to green products.

- Standards and Information Dissemination and Outreach: Operate the National Center for Standards and Certification Information, and the World Trade Organization, Technical Barriers to Trade related Inquiry Point and Notification Authority providing unique standards, conformity assessment and technical regulations related information to NIST staff, U.S. government employees, U.S. exporters, and foreign trading partners. Provide standards and conformity assessment related outreach and training to stakeholders. Analyze impact and effectiveness of NIST participation in standards and conformity assessment related activities. Develop a plan in collaboration with the National Archives and Record Administration and the Government Printing Office to streamline the process to provide public access and increase the utility of a data base identifying standards incorporated by reference in the Code of Federal Regulations.

- Laboratory Accreditation: Continue to provide fee supported laboratory accreditation services to testing and calibration laboratories in support of Federal agency regulation, mandates, and industry needs.

PROGRAM CHANGE(S):

1. Manufacturing Entrepreneurship (Base Funding: $0 million and 0 FTE; Program Change: +$5.0 million and +1 FTE)

NIST requests an increase of $5.0 million and 1 FTE as part of the Administration's efforts to strengthen the U.S. manufacturing sector.

Proposed Actions: Strengthen the U.S. manufacturing sector by reducing barriers for new entrepreneurs to enter the manufacturing marketplace.

In recent years a trend has emerged where a growing number of individuals are self-identifying as "Makers", or manufacturing entrepreneurs. Much of this trend has been driven by a mixture of new technologies and grass roots organizations. Examples of these drivers include:

- Large number of "shared spaces" (Fab Labs, TechShops, makerspaces, LabCentral) that allow entrepreneurs access to manufacturing tools and the skills needed to use them;
- Emergence of accelerators, incubators, and seed stage funds that are focused on hardware and manufacturing startups, such as Bolt and Dragon Innovation;
- Ability of entrepreneurs to raise funding and gauge the level of customer interest in their products using crowdfunding sites like KickStarter and IndieGoGo;
- Multi-channel retailers that are providing access to markets for entrepreneurs, such as the GE-Quirky-Target and Nordstrom-Etsy collaborations; and
- New conferences such as MakerCon which convene the otherwise isolated makers to form collaborative communities

These new entrepreneurs are seeking to capitalize on the small-batch industrial revolution. Many aspects of the digital revolution are accessible to new entrepreneurs. Numerous resources and tools exist to help individuals create new businesses. But it is much more difficult when that new business is manufacturing. Advanced, small batch manufacturing technologies can seem inaccessible to an entrepreneur new to manufacturing. Much manufacturing knowledge is not readily available and manufacturing technologies are evolving rapidly. Independent entrepreneurs, or "Makers," who want to produce their designs in small production runs encounter cost and technical barriers.

The revitalization of U.S. manufacturing will require an innovation capacity and new entrepreneurs that can take advantage of new software solutions, service integration strategies, new technologies such as additive manufacturing, and the effective utilization data. These trends will allow entrepreneurs to capture new business opportunities and compete in the global manufacturing economy.

New manufacturing entrepreneurs are, however, encountering barriers to taking advantage of these new trends. Manufacturing entrepreneurs need help understanding new technologies and how they apply. The U.S. must facilitate a culture of innovation by fostering R&D in manufacturing; build bridges between industry and the public sector, and strengthen the manufacturing workforce by making manufacturing knowledge more accessible.

NIST has the potential to foster and expand upon this early growth in manufacturing entrepreneurship by providing infrastructure needed to promote knowledge transfer among the maker community, and facilitate experimentation on new models of collaboration between entrepreneurs, commercial manufacturers, and government agencies.

The following objectives will be addressed by this initiative through focused actions:

- Access to manufacturing knowledge that increases the value and variety of what manufacturing entrepreneurs can design and manufacture,
- A robust manufacturing eco-system that provides full support for new manufacturing entrepreneurs, and
- Effective collaboration between new manufacturing entrepreneurs and Federal government programs.

The objectives in this initiative directly support the Department of Commerce's Strategic goals for manufacturing. This initiative would make progress on the Innovation Pillar of the Department of Commerce's 2014 - 2018 Strategic Plan, specifically addressing Strategic Objective 2.1: "Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization." The following actions will provide new manufacturing innovation needed to enable new manufacturing entrepreneurs and the U.S. manufacturing supply chain as highlighted in the "Accelerating U.S. Advanced Manufacturing" Report from the President's Council of Advisors on Science and Technology.[39]

Action 1: Establish an Accessible Manufacturing Knowledgebase

NIST will organize efforts to capture, curate, and disseminate knowledge about key manufacturing processes critical to the Maker movement for the benefit of individuals who are new to manufacturing and often lack this knowledge. The effort will leverage existing experts and other sources to focus on both the organization and accessibility manufacturing knowledge and information for maximum impact.

1a. Manufacturing Information and Knowledge Libraries - Content Generation

NIST will work with the private sector to begin to identify, capture, and classify manufacturing informational content related to:

- Manufacturing technologies (including Computer Numeric Control (CNC) machining, additive manufacturing, and casting); and
- Parameters to guide the selection of manufacturing technologies and materials appropriate for small batch manufacturing applications.

[39] Executive Office of the President-President's Council of Advisors on Science and Technology. (2014) *Report to the President on Accelerating U.S. Advanced Manufacturing*, Washington, DC. Accessed at http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf

Manufacturing information and knowledge libraries will be developed for entry-level and intermediate users' consumption and presented in a variety of formats including instructional videos, on-line course content, and guides. Sources for the libraries will include manufacturing trade associations; diverse manufacturing-related consortia; and openly-available methodologies, data sets, and technologies originating from national labs, universities and other research institutes. NIST may fund private organizations through competitively selected awards to gather initial content for manufacturing information and knowledge libraries.

1b. Manufacturing Information and Knowledge Libraries - Accessibility

NIST will work with private sector partners to determine the most appropriate methods to make libraries available to the widest audiences while ensuring their reliability.

NIST may fund private organizations through competitively selected awards to architect and host the manufacturing knowledge resources and materials described above. The competitively selected awards will enable the creation of architecture for manufacturing information and promote an open-source approach to the aggregation of libraries of manufacturing-related information.

1c. Manufacturing Information and Knowledge Libraries – Content Management

It will be necessary to update libraries as new manufacturing information and technologies are developed and made available for manufacturing entrepreneurs' use. The open platform architecture for manufacturing information libraries will be configured so as to allow the continuous development and inclusion of new content and materials. NIST may fund private organizations through competitively selected awards to investigate protocols and ascertain best approaches to manage manufacturing information sourced through the manufacturing community.

This two-step approach of first "seeding" the platform with manufacturing information and instruction materials and then fostering a monitored, open-sourcing of its further development ensures that the content will be widely accessible and responsive to new manufacturing applications. NIST will develop metrics for program evaluation based on the quantity and quality of the manufacturing information, and its utilization and preservation.

Action 2: Provide Support for Manufacturing Entrepreneurs through the Manufacturing Extension Partnership

Manufacturing entrepreneurs may not necessarily be aware of the breadth and depth of public and public-private resources available to support their efforts. While collaboration often helps overcome technical barriers, support for other types of assistance (e.g., cost-effectively scaling from prototype to full production, obtaining certifications to sell in certain markets, building a supply chain, and learning to pursue export opportunities) could accelerate entrepreneur success.

The Manufacturing Entrepreneurship Initiative will engage the NIST Manufacturing Extension Partnership (MEP) network in support of the manufacturing entrepreneur movement. MEP centers already have productive collaborations with organizations that serve the manufacturing community. For example, organizations such as SFMade and Arkansas Regional Innovation Hub have formalized partnership agreements with their respective local MEP Centers. Typically, these organizations work to address the wide range of needs of the individual entrepreneurs in a specific geographic locale. The intermediaries refer Makers to MEP Centers and partners for services needed as they grow or identify opportunities for growth. The MEP Centers and partners can provide services of scale-up, certification, supply chain, and export assistance and connect manufacturing entrepreneurs to other public resources that can help realize the potential opportunities.

Action 3: Enable Effective Collaboration between Entrepreneurs and Government Agencies

The high transaction costs of processing small grants or contracts to individuals or small teams are a barrier for new entrepreneurs. This is further complicated by the fact that today's entrepreneurs are embracing a "lean startup" methodology and exploring "product-market fit" prior to startup launch. Governmental product demand is often low-volume by nature and, as such, could challenge manufacturing entrepreneurs. Production runs in the low thousands are cost-prohibitive because they are too large to be done by hand but not large enough for high-volume manufacturing processes.

New manufacturing technologies are needed to reduce the time and cost associated with low-volume production runs. NIST will work through MEP Centers and/or NIST may fund private organizations through competitively selected awards to:

- Identify advances in low-cost manufacturing technologies (e.g., desktop CNC machining, 3D printing, composites, or other technologies) that could increase the variety and value of what an individual or a small team can design and prototype;
- Develop methodologies to support cost-effective small batch manufacturing.

These services could be initially tested via a limited set of pilot programs that match government agency manufacturing requirements with manufacturing entrepreneurs.

Statement of Need and Economic Benefits

U.S. competitive advantage in manufacturing requires continual innovation - a regular refreshing of the industrial knowledge-base, capital stock, and daily practices of organizations and workers. Manufacturers who are not innovating with new processes, materials and technologies for new and improved products risk commoditization, which can quickly migrate to low-cost locations in the global economy. Advanced manufacturing capabilities based on continual innovation are much more difficult to move or replicate. However, even these capabilities are increasingly dispersed and mobile globally, requiring even greater emphasis on speed and novelty, that is, innovation acceleration. Innovation is unpredictable and risky yet essential to the creation of new and improved products to remain globally competitive.

A trend is emerging where other countries are increasingly adept at technology transfer and scaling to production. They have focused on creating a more structured technology development process by partnering with industry. Partnerships that bring diverse organizations together to accelerate innovation for advanced manufacturing create a stronger innovation system and link those innovations more directly to domestic production capabilities.

Innovation system gaps lead to market failures and these failures are magnified in advanced manufacturing. U.S. manufacturers individually are challenged to fund these technology development functions, and small manufacturers especially struggle with individually investing in prototyping and scale up of new technologies and potential products. This initiative would help provide the critical mass and knowledge base necessary to address these challenges.

Base Resource Assessment

The program leverages NIST core competencies in manufacturing and information science. NIST has in-depth technical expertise in manufacturing systems interoperability, materials science, robotics, sensors, and nano-technology. It has strong relationships with other government agencies industry, academia, and standards development organizations that will be needed to transfer research to actual practice.

NIST is uniquely positioned to help address the challenges proposed in this initiative. Private sector organizations generally lack the resources to carry out the research required to develop the technical knowledge base.

Schedule and Milestones

Action 1: Establish an Accessible Manufacturing Knowledgebase

- Identify and classify manufacturing information content sources and a providers for manufacturing information critical to additive manufacturing (Complete in FY 2016).
- Issue Federal Funding Opportunity announcement for library design architecture and accessibility methods (Complete in FY 2016).
- Identify and classify manufacturing information content sources and a providers for additional manufacturing information critical to small batch manufacturing (Complete in FY 2017).
- Issue Federal Funding Opportunity announcement for library management (Complete in FY 2017).
- Library resources available on-line (FY 2018 – FY 2021).

Action 2: Provide Support for Manufacturing Entrepreneurs

- Identify opportunities for Manufacturing Extension Partnership centers to provide services to new manufacturing entrepreneurs. Initial focus on manufacturing technologies critical to small batch manufacturing, such as additive manufacturing (Complete in FY 2016).
- Develop funding opportunities for potential service providers (Complete in FY 2017).
- Implement services for manufacturing entrepreneurs (FY 2017 - FY 2018).
- Expand services to include additional manufacturing technologies such as CNC machining and casting (Complete in FY 2018).
- Implement additional services for manufacturing entrepreneurs (FY 2019 – FY 2021).

Action 3: Enable Effective Collaboration between Entrepreneurs and Government Agencies

- Identify opportunities for collaborations between government agencies and manufacturing entrepreneurs focusing on small batch manufacturing (Complete in FY 2016).
- Develop pilot programs to demonstrate how agencies can collaborate with manufacturing entrepreneurs for small batch manufacturing (Complete in FY 2017).
- Execute pilot programs (FY 2018 - FY 2021).

Deliverables

Action 1: Establish an Accessible Manufacturing Knowledgebase

- Library and knowledgebase content development award (Complete in FY 2017)
- Library design and management award(s) (Complete in FY 2017)
- Library web page content available (FY 2018 – FY 2021)

Action 2: Provide Support for Manufacturing Entrepreneurs

- Manufacturing services opportunities report (Complete in FY 2016)
- Manufacturing services development awards (Complete in FY 2017)
- Manufacturing services for entrepreneurs (FY 2018 – FY 2021)

Action 3: Enable Effective Collaboration between Entrepreneurs and Government Agencies

- Collaboration opportunities report (Complete in FY 2016)
- Collaboration demonstration pilot programs (FY 2017 – FY 2021)

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Standards Coordination and Special Programs
Program Change: Manufacturing Entrepreneurship

Title:	Location	Grade	Number of Positions	Annual Salary	Total Salaries
Project manager	Gaithersburg	ZP IV	1	107,326	107,326
Secretary	Gaithersburg	ZS II	1	31,069	31,069
Total			2		138,395
Less Lapse		25%	(1)		(34,599)
Total full-time permanent (FTE)			1		103,796
2016 Pay Adjustment (1.3%)					1,349
TOTAL					105,145

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	1
Other than full-time permanent	0
Total	1
Authorized Positions:	
Full-time permanent	2
Other than full-time permanent	0
Total	2

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Standards Coordination and Special Programs
Program Change: Manufacturing Entrepreneurship

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$105	$15,221
11.3	Other than full-time permanent	0	989
11.5	Other personnel compensation	0	2,832
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	105	19,042
12	Civilian personnel benefits	33	5,770
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	27	1,391
22	Transportation of things	25	72
23.1	Rental payments to GSA	0	0
23.2	Rental Payments to others	0	206
23.3	Communications, utilities and miscellaneous	147	5,430
24	Printing and reproduction	15	95
25.1	Advisory and assistance services	0	310
25.2	Other services	76	12,438
25.3	Purchases of goods & services from Gov't	156	2,205
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	39	2,548
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	313	1,409
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	64	2,937
31	Equipment	0	2,016
32	Lands and structures	0	300
41	Grants, subsidies and contributions	4,000	22,687
44	Refunds	0	0
99	Total obligations	5,000	78,856

2. Lab to Market/Technology Transfer: Expand technology transfer activities to leverage existing authorities to promote data sharing efforts (Base Funding $6.0 million and 10 FTE; Program Change: +$4.0 million and +10 FTE)

NIST requests an increase of $4.0 million and 10 FTE to expand lab to market and technology transfer activities through the development and deployment of data sharing and collaborative tools and services.

Proposed Actions: Enable the Development of Laboratory to Market/Technology Transfer Tools to Enhance and Promote Data Sharing

The U.S. invests more than $135.0 billion annually in research and development. A wide range of life-changing commercial technologies were nurtured by such federally funded R&D. Federally-funded R&D has historically led to dramatic economic growth, and there is potential to increase the public's return on this investment in terms of innovation, job creation, societal impact, and economic prosperity. To fully realize this impact, the transfer of technology resulting from this investment to U.S. businesses must be accelerated. Through efforts under the Presidential Memorandum -- Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses and the Lab to Market Cross Agency Priority Goal, great progress is being made. However, there remains work to be done to implement cross-agency solutions and develop interagency tools that support these activities. Such a coordinated approach will better leverage the entire research portfolio than the current piecemeal approach. Specifically, NIST will lead the development of infrastructures for information sharing, data dissemination, and increase collaborations to address national priorities and enhance business competitiveness. The America COMPETES Reauthorization Act of 2010 created the position of Undersecretary for Standards and Technology that included Federal government-wide responsibilities for technology transfer. These include analysis, planning, coordination, reporting and general oversight of technology transfer responsibilities under Section 5 of the Federal Technology Transfer Act of 1986, the Bayh-Dole Act of 1980, and Executive Orders 12591 and 10096. These duties include coordinating Federal agency activities for the commercialization of technology developed at Federal laboratories, monitoring of agency use of cooperative agreements as a means of increasing the efficiency of transferring federally funded technology to the private sector, and the preparation of related reports. This initiative will strengthen NIST and Federal Technology Transfer activities through the following efforts:

Action 1: Develop Interagency Platform for Complementary Technology

NIST will work with the Federal Laboratory Consortium (FLC) and offices within the Executive Office of the President (EOP), including the use of the EOP Presidential Innovation Fellows program to lead the development of digital platforms to enhance cross-agency collaborations on technology transfer and development. Building on efforts to streamline access to tangible and intangible assets from the federally funded R&D enterprise, these digital platforms will increase visibility of and connectivity between those assets. They will promote collaboration between agencies on specific national priority technology areas, enabling stakeholders to identify available, complementary technology components, thus accelerating development of new technological systems. Such an infrastructure would also enable large-scale dissemination of information while providing advanced capabilities to collect and organize information in ways that better address national priorities and business needs. Such organization, searching, and collaborative capabilities are necessary, since advanced products are often not the result of a single technology, but are rather a combination of often dozens of technologies. As they develop, these platforms will expand to enable data sharing and synchronization across government, non-profit, and for-profit platforms.

Action 2: Share and Collaborate with Other Sources

NIST will work with other content delivery sources to better connect Federal and private sector technologies and needs. Leveraging interagency work to make relevant data about federally-funded intellectual property and Federal R&D open and machine-readable, NIST will work to ensure this important information is available via other databases. NIST will coordinate efforts to build upon the FLC's "Available Technologies" database to help make information available to third party systems and coordinate with other stakeholders and technology-focused organizations. There are numerous organizations nationally that need to understand and use information on research results from our investments in Federal research. These include both inventions resulting from our direct funding to Federal laboratories and federally funded research and development centers, as well as federally funded research activities performed by others, such as universities. Similarly, solutions for many national problems are likely to come from sources outside the Federal government that need a way to make it to the marketplace. NIST will work with the myriad of platforms developed by outside sources to connect technologies to the marketplace to both push out knowledge of Federal technologies and potential solutions as well as pull outside solutions that may address government problems.

Statement of Need and Economic Benefits

A wide range of life-changing commercial technologies were nurtured by federally funded research and development (R&D), from the Internet, to the global positioning system (GPS), to leading-edge vaccines. The Federal R&D enterprise must continue to support fundamental research that is motivated primarily by our interest in expanding the frontiers of human knowledge, and diffusing this knowledge through easy to access data and publications. At the same time, federally funded R&D has historically led to dramatic economic growth, and there is significant potential to increase the public's return on this investment in terms of innovation, job creation, societal impact, competitiveness, and economic prosperity. The U.S. Federal approach has been to typically support pre-commercialization and early stage research and leverage the strength and expertise of the private sector to commercialize and deploy many of these research, science and technology outcomes into real world and daily life applications. Thus, while the Federal government has forged an effective partnership with the private sector, there is still significant scope for improving and further enhancing this relationship to further strengthen U.S. competitiveness and provide economic benefit to the U.S.

These actions will be taken to accelerate and improve the transfer of new technologies from the laboratory to the commercial marketplace, building on the Administration's Startup America initiative to promote high-growth entrepreneurship, as well as the ongoing implementation of the Presidential Memorandum of October 28, 2011 (Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses), which directed agencies to establish goals, measure performance, streamline administrative processes, and facilitate local and regional partnerships to facilitate R&D commercialization.

Actions will require coordination across all Executive departments and agencies that fund research and development, both intramurally and extramurally consistent with each agency's mission. Implementation, includes the preparation of government-wide plans and will be coordinated with Executive offices and the Interagency Workgroup on Technology Transfer, established pursuant to Executive Order 12591 of April 10, 1987.

Base Resource Assessment

This effort will expand upon base resources provided in FY 2015 to fund lab to market activities. Existing funding across agencies is dispersed and there is a need to centralize the development of cross-agency solutions to address these issues. NIST currently chairs interagency workgroups to develop and coordinate policies in technology transfer across government agencies for both intramural and extramural programs and has authority to develop regulations in the area of Federal technology transfer. NIST also serves as the host agency for the Federal Laboratory Consortium for Technology Transfer. This leadership position makes NIST the ideal place to implement these programs and to further strengthen NIST's role in enabling coordination and cooperation across the Federal enterprise.

There is a greater need than ever to diffuse new and best practices across Federal agencies to fully benefit from the roughly $135.0 billion annual Federal government investment in R&D. Transfer of technology requires the transfer and sharing of data and information across multiple platforms to allow potential users to gain information from familiar and trusted sources. Although significant efforts are being implemented under the previous initiative, funding the development of systems and synchronization with external systems requires dedicated funding and a focused effort. This includes working with multiple government agencies and external partners to move information across systems.

Schedule and Milestones

Action 1: Develop Platform for Complementary Technologies

- Coordinate cross-agency system requirements.
- Identify initial candidates of national issues to serve as system pilot.
- Coordinate with agency and laboratory technology transfer offices to identify potential technology solutions linked to the problem and build tools to link data.
- Coordinate with stakeholders at universities and the private sector to identify and integrate best practices.

Action 2: Share and Collaborate with Other Sources

- Identify existing platforms and system requirements.
- Work with universities and external organizations to share data and information across systems.
- Evaluate ways to pull external solutions into national solutions platform.

Deliverables

Action 1: Develop Platform for Complementary Technologies

- Deploy platform that allows for agencies to connect technologies and solutions to identified technology problems.
- Allow for the connection of complementary technology solutions across agencies to deliver a package of technologies that addresses an identified technology problem.

Action 2: Share and Collaborate with Other Sources

- Deploy tools to share government information with external systems.
- Implement tools to allow for external solutions to be identified as solutions to national problems and other identified specific needs of agencies.

Performance Goals and Measurement Data

Performance goal: Number of technology areas addressed	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Increase	5	5	5	5	5
Without Increase	0	0	0	0	0
Description: Development of complementary technology system and populate problems and technologies					

Performance goal: Number of external systems reached	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Increase	5	5	5	5	5
Without Increase	0	0	0	0	0
Description: Improve cross platform data sharing by synchronizing information with other platforms					

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Standards Coordination and Special Programs
Program Change: Lab to Market/Technology Transfer

Title:	Grade	Number of Positions	Annual Salary	Total Salaries
Economist/Physical Scientist	ZP IV	7	$107,326	$751,282
Supervisory Scientist	ZP IV	1	126,245	126,245
Business Specialist	ZA IV	1	107,326	107,326
Business Specialist	ZA III	2	76,337	152,674
Administrative/technical support	ZA II	1	52,667	52,667
Administrative Assistant	ZS III	1	38,747	38,747
Total		13		1,228,941
Less Lapse	25%	(3)		(307,235)
Total full-time permanent (FTE)		10		921,706
FY 2016 Pay Adjustment (1.3%)				11,982
TOTAL				933,688

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	10
Other than full-time permanent	0
Total	10
Authorized Positions:	
Full-time permanent	13
Other than full-time permanent	0
Total	13

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Measurement Science, Services, and Programs
Subprogram: Standards Coordination and Special Programs
Program Change: Lab to Market/Technology Transfer

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$934	$15,221
11.3	Other than full-time permanent	0	989
11.5	Other personnel compensation	291	2,832
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	1,225	19,042
12	Civilian personnel benefits	0	5,770
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	28	1,391
22	Transportation of things	4	72
23.1	Rental payments to GSA	0	0
23.2	Rental Payments to others	0	206
23.3	Communications, utilities and miscellaneous	0	5,430
24	Printing and reproduction	5	95
25.1	Advisory and assistance services	1,466	310
25.2	Other services	0	12,438
25.3	Purchases of goods & services from Gov't	0	2,205
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	1,272	2,548
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	0	1,409
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	0	2,937
31	Equipment	0	2,016
32	Lands and structures	0	300
41	Grants, subsidies and contributions	0	22,687
44	Refunds	0	0
99	Total obligations	4,000	78,856

3. STRS Programmatic Decrease (-$1.067 million and 0 FTE).

To adhere to the prescribed FY 2016 funding levels, NIST proposes to reduce the mission related work of its standards coordination efforts to encompass policy, guidance, outreach, and information dissemination. With the proposed reduction, NIST does not plan on utilizing Reduction-In-Force (RIF) authority to meet funding targets to fund current programs.

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollars in thousands)

Budget Program: Measurement Science, Services, and Programs
Subprogram: Standards Coordination and Special Programs
Program Change: STRS Programmatic Decrease

	Object Class	FY 2016 Decrease	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	0	$15,221
11.3	Other than full-time permanent	0	989
11.5	Other personnel compensation	0	2,832
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	0	19,042
12	Civilian personnel benefits	0	5,770
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	($14)	1,391
22	Transportation of things	0	72
23.1	Rental payments to GSA	0	0
23.2	Rental Payments to others	0	206
23.3	Communications, utilities and miscellaneous charges	0	5,430
24	Printing and reproduction	0	95
25.1	Advisory and assistance services	0	310
25.2	Other services	(238)	12,438
25.3	Purchases of goods & services from Gov't accounts	0	2,205
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	2,548
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	0	1,409
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	(42)	2,937
31	Equipment	(31)	2,016
32	Lands and structures	0	300
33	Investments and loans	0	0
41	Grants, subsidies and contributions	(742)	22,687
42	Insurance claims and indemnities	0	0
43	Interest and dividends	0	0
44	Refunds	0	0
99	Total obligations	(1,067)	78,856

Department of Commerce
National Institute of Standards and Technology
Standards Coordination and Special Programs
REIMBURSABLE PROGRAM AND WORKING CAPITAL FUND INVESTMENTS
(Dollar amounts in thousands)

	FY 2014 Actual	FY 2015 Enacted	FY 2016 Estimate
Department of Defense			
Other, Department of Defense	0	0	$200
Subtotal, Department of Defense	0	0	200
Department of Commerce	$618	0	0
Department of Energy	56	0	0
Dept. of Health & Human Services	0	$75	50
Dept. of Homeland Security	1,369	200	200
Department of Justice	205	423	300
Subtotal, Other Agency	2,248	698	750
Technical & Advisory Services	4,125	4,033	4,170
Subtotal, Other Reimbursables	4,125	4,033	4,170
Total, Reimbursable Program	6,373	4,731	4,920
Equipment Investments	0	1,000	0
IE Amortization	0	(20)	0
Total, WCF Investments	0	980	0
Total, Reimbursable Program and WCF Investments	6,373	5,711	4,920

Object Class

Exhibit 16

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
SUMMARY OF REQUIREMENTS BY OBJECT CLASS
(Dollar amounts in thousands)

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
11	Personnel compensation					
11.1	Full-time permanent	$217,392	$229,446	$234,180	$244,733	$10,553
11.3	Other than full-time permanent	20,505	20,505	20,825	20,825	0
11.5	Other personnel compensation	5,592	5,592	5,592	5,592	0
11.9	Total personnel compensation	243,489	255,543	260,597	271,150	10,553
12.1	Civilian personnel benefits	72,174	75,954	79,570	82,882	3,312
13	Benefits for former personnel	0	0	0	0	0
21	Travel and transportation of persons	9,773	10,235	10,049	10,235	186
22	Transportation of things	1,072	1,115	1,133	1,284	151
23.1	Rental payments to GSA	88	80	90	90	0
23.2	Rental payments to others	1,770	1,774	1,818	1,818	0
23.3	Communications, utilities, and miscellaneous charges	24,099	26,718	31,370	39,717	8,347
24	Printing and reproduction	516	591	600	709	109
25.1	Advisory and assistance services	4,200	4,386	4,505	4,516	11
25.2	Other services	75,942	108,889	66,409	77,991	11,582
25.3	Purchases of goods and services from Government accounts	24,208	25,201	27,035	37,399	10,364
25.5	Research and development contracts	3,248	6,131	6,229	12,389	6,160
25.7	Operation and maintenance of equipment	15,887	16,236	16,496	17,599	1,103
26	Supplies and materials	30,610	31,310	32,016	34,440	2,424
31	Equipment	43,488	45,407	48,536	52,883	4,347
32	Land and structures	0	150	150	300	150
41	Grants, subsidies, and contributions	100,971	106,731	106,731	113,258	6,527
42	Insurance claims and indemnities	1	0	0	0	0
43	Interest and dividends	29	0	0	0	0
99	Total Obligations	651,565	716,451	693,334	758,660	65,326

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
99	Total Obligations	651,565	716,451	693,334	758,660	65,326
	Less Prior Year Recoveries	(6,014)	(1,000)	(1,000)	(1,000)	0
	Less Prior Year Unobligated Balance	(29,408)	(33,551)	0	0	0
	Plus Unobligated Balance, End of Year	33,551				
	Plus Unobligated Balance, Expired	6				
	Unobligated Balance Transfer to WCF	3,700				
	Total Budget Authority	653,400	681,900	692,334	757,660	65,326
	Transfer to NIST Working Capital Fund	4,000	0	0	1,500	1,500
	Transfer from Election Assistance Commission	(1,900)	(1,900)	0	(1,900)	(1,900)
	Transfers from DoJ for forensic sciences and Office of Law Enforcement Standards	(4,500)	(4,500)	0	(2,599)	(2,599)
	Appropriation	651,000	675,500	692,334	754,661	62,327

Personnel Data

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Full-time equivalent employment:					
Full-time permanent	1,988	2,105	2,115	2,221	106
Other than full-time permanent	286	286	286	286	0
Total	2,274	2,391	2,401	2,507	106
Authorized Positions:					
Full-time permanent	2,302	2,348	2,348	2,494	146
Other than full-time permanent	64	64	64	64	0
Total	2,366	2,412	2,412	2,558	146

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
APPROPRIATION LANGUAGE AND CODE CITATIONS

1. For necessary expenses of the National Institute of Standards and Technology,

15 U.S.C. 272; 273; 278b-j; p
15 U.S.C. 290b-f
15 U.S.C. 1151-52
15 U.S.C. 1454(d-e)
15 U.S.C. 1511, 1512
15 U.S.C. 3710a-d
15 U.S.C. 3711a
15 U.S.C. 7301-7313
15 U.S.C. 7406
15 U.S.C. 7506(a)

15 U.S.C. 272; 273; 278b-j; p provides basic authority for the performance of the functions and activities of the National Institute of Standards and Technology, authorizes appropriations for these purposes to be provided to the general public and specific institutions, governments, firms, and individuals, and requires the notification of Congress of a reprogramming of funds that exceeds a limit specified in public law.

15 U.S.C. 290b-f directs the Secretary of Commerce to provide for the collection, compilation, critical evaluation, publication, and dissemination of standard reference data and the authority to establish a non-agricultural technology office.

15 U.S.C. 1151-1152 establishes within the Department of Commerce, a central clearinghouse for technical information useful to American business and industry and provides for the dissemination of this technical, scientific information via the National Technical Information Service.

15 U.S.C. 1454(d-e) provides NIST with the authority to request that manufacturers and distributors of a commodity participate in voluntary product standards when there is undue proliferation of weights, measures, and quantities. Reports and recommendations to Congress are to be made upon industry failure to adopt these standards.

15 U.S.C. 1511, 1512 specifies that all bureaus of the Department of Commerce come under the authority of the Secretary of Commerce and that such bureaus including NIST shall be subject to the authority of the Secretary of Commerce.

15 U.S.C. 3710a-d provides the authority to enter into CRADAs, to make cash awards to scientific personnel for inventions, to retain royalties and to distribute royalties for inventions, and to communicate and coordinate for the Offices of Research and Technology Applications in Federal laboratories.

15 U.S.C. 3711a provides the authority for the Baldrige National Quality award.

15 U.S.C. 7301-7313 establishes National Construction Safety Teams within NIST to respond to building and structural emergencies.

15 U.S.C. 7406 provides authority for NIST to conduct Cyber Security Research and Development to minimize security risks associated with computer systems used by the Federal government.

15 U.S.C. 7506(a) provides for the establishment of a nanotechnology research and development program within NIST.

P.L. 110-143 121 STAT 1809 provides NIST to assist in developing a research program to establish guidelines for the remediation of former methamphetamine laboratories in the United States as well as developing new detection technologies and appropriate Standard Reference Materials for methamphetamine detection testing.

2. $754,661,000, to remain available until expended,

   no specific authority

3. of which not to exceed $9,000,000 may be transferred to the "Working Capital Fund." 15 U.S.C. 278b

   15 U.S.C. 278b provides in part: "The National Institute of Standards and Technology is authorized to utilize in the performance of its functions the Working Capital Fund".

4. Public Law 110-69, America Competes Act, 121 Stat 572, passed August 9, 2007 reauthorizes the Scientific and Technical Research and Services appropriation through 2010. Public Law 111-358, America Competes Reauthorization Act, 2010, 124 Stat 3982, passed January 4, 2011 reauthorized the Scientific and Technical Research and Standards appropriation through 2013. In addition, an Emergency Communication and Tracking Technologies Research initiative and a Green Manufacturing and Construction initiative were authorized to develop advanced technologies in these areas.

5. Public Law 111-5 American Recovery and Reinvestment Act of 2009 appropriates $220,000,000 for the Scientific and Technical Research and Services appropriation from FY 2009 to FY 2010 and makes available by reimbursable agreement $10,000,000 from the Department of Energy for the development of Smart Grid Technology by reference to Public Law 110-140, the Energy Independence and Security Act of 2007, and makes available by reimbursable agreement $2,230,186 for a service level agreement with the National Telecommunications and Information Administration. In addition, $20,000,000 is transferred from the Department of Health and Human Services for continued work on advancing health care information enterprise integration.

6. Public Law 113-274 Cybersecurity Enhancement Act of 2014 amended Section 2c of the National Institute of Standards and Technology Act (15 U.S.C. 272(c) and established a Public-Private collaboration on Cybersecurity by designating the Director of the Institute activities that facilitate and support on an ongoing basis the development of a voluntary, consensus-based, industry-led set of standards, guidelines, best practices, methodologies, procedures, and processes to cost-effectively reduce cyber risks to the critical infrastructure of the United States.

Exhibit 34

Department of Commerce
National Institute of Standards and Technology
Scientific and Technical Research and Services
ADVISORY AND ASSISTANCE SERVICES
(Obligations in thousands of dollars)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Estimate
Management and professional support services	$1,609	$1,722	$1,782
Studies, analyses, and evaluations	255	294	300
Engineering and technical services	2,336	2,370	2,434
Total	4,200	4,386	4,516

Significant Activities

Advisory and assistance services funded by the STRS appropriation include the review and evaluation of the technical functions and operations of NIST by the Board on Assessment of the National Academy of Sciences. The Evaluation Panels consider the importance and relative priority of projects, quality of staff, equipment needs, and finances, and the relation of the programs to the mission of NIST.

Need for Advisory and Assistance Services:

The need for advisory and assistance services stems from the NIST role in dealing with the private sector, professional organizations, and the public sector. Inputs must be obtained from consultants who can bring their individual expertise to bear and help NIST in assessing its program plans to meet the needs of its customers. The alternative to utilizing these services is to make no attempt to have expertise from sources outside NIST and risk degradation of the working and professional relationship with those in the business of using the products and services offered by NIST.

Exhibit 5

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
SUMMARY OF RESOURCE REQUIREMENTS
(Dollar amounts in thousands)

	Positions	FTE	Budget Authority	Direct Obligations	Appro-priation
2015 Enacted	85	86	$138,100	$174,595	$138,100
less: Unobligated balance from prior year			0	(33,495)	0
2016 Adjustments to base:					
TIP shutdown	0	(2)	0	0	0
plus: Uncontrollable cost changes	0	0	1,341	1,341	1,341
less: Estimated recoveries 2015	0	0	0	(3,000)	0
2016 Base Request	85	84	139,441	139,441	139,441
plus: 2016 Program changes	9	7	166,559	166,559	166,559
less: Unobligated balances at EOY	0	0	0	(6,398)	0
2016 Estimate	94	91	306,000	299,602	306,000

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Comparison by program/sub-program:		Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount
Technology innovation program											
Technology innovation program	Pos./Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	5	$1,571	2	$5,587	0	0	0	0	0	0
Advanced manufacturing technology consortia											
Advanced manufacturing technology consortia	Pos./Approp	4	15,000	4	8,100	4	$8,174	4	$15,000	0	$6,826
	FTE/Obl.	3	12,626	4	14,987	4	8,174	4	15,000	0	6,826
Hollings manufacturing extension partnership											
Hollings manufacturing extension partnership	Pos./Approp	81	128,000	81	130,000	81	131,267	81	141,000	0	9,733
	FTE/Obl.	71	122,450	80	153,960	80	131,267	80	141,000	0	9,733
National network for manufacturing innovation											
National network for manufacturing innovation	Pos/Approp	0	0	0	0	0	0	9	150,000	9	150,000
	FTE/Obl.	0	0	0	0	0	0	7	143,602	7	143,602
Baldrige performance excellence program											
Baldrige performance excellence program	Pos./Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	61	0	0	0	0	0	0
TOTALS	Pos./Approp	85	143,000	85	138,100	85	139,441	94	306,000	9	166,559
	FTE/Obl.	79	136,647	86	174,595	84	139,441	91	299,602	7	160,161

Comparison by program/sub-program:	2014 Actual Personnel	2014 Actual Amount	2015 Enacted Personnel	2015 Enacted Amount	2016 Base Personnel	2016 Base Amount	2016 Estimate Personnel	2016 Estimate Amount	Increase/(Decrease) Over 2016 Base Personnel	Increase/(Decrease) Over 2016 Base Amount
Adjustments for:										
Recoveries		(7,945)		(3,000)		0		0		0
Refunds		(241)		0		0		0		0
Unobligated balance, start of year		(18,956)		(33,495)		0		0		0
Unobligated balance, end of year		33,495		0		0		6,398		6,398
Budget Authority/Appropriation		143,000		138,100		139,441		306,000		166,559

Adjustments
to Base

Exhibit 9

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
JUSTIFICATION OF ADJUSTMENTS TO BASE
(Dollar amounts in thousands)

	FTE	Amount
Other Changes:		
Annualization of 2015 pay raise	0	21

A pay raise of 1.0 percent is assumed to be effective January 1, 2015.

Total cost in FY 2016 of 2015 pay raise	$ 99,142
Less amount requested in FY 2015	(78,000)
Less amount absorbed in FY 2015	0
Amount requested in 2016 to provide full-year cost of 2015 pay raise	21,142

	FTE	Amount
2016 Pay increase and related costs	0	98

A general pay raise of 1.3 percent is assumed to be effective January 1, 2016.

Total cost in FY 2016 of pay increase	$ 98,000
Less amount absorbed in FY 2016	0
Amount requested for FY 2016 pay increase	98,000
Payment to Departmental Management Working Capital Fund	0
Total adjustment for FY 2016 pay increase	98,000

Annualization of positions reduced in FY 2015	(2)	0

The Technology Innovation Program is shutting down and there is a reduction of 2 FTE in FY 2016.

Positions reduced in 2015	(8)
Less 5 percent lapse	(0)
Full-Year FTE	(8)
Less FTE reduced in 2015	(6)
Annualization of Positions/FTE reduced in 2016	(2)

Change in compensable days	0	35

The increased cost of one more compensable day in FY 2016 compared to FY 2015 is calculated by dividing the FY 2015 estimated personnel compensation ($7,397,000) and applicable benefits ($1,793,000) by 261 compensable days. The cost increase of one compensable day is $35,211.

Personnel benefits.	0	74

Civil Service Retirement System (CSRS)	(10)
Federal Employees' Retirement System (FERS)	57
Thrift Savings Plan (TSP)	7
Federal Insurance Contribution Act (FICA) – OASDI	10
Health Insurance	18
Employees Compensation Fund	(8)

Civil Service Retirement System (-$10,000) – The number of employees covered by the Civil Service Retirement System (CSRS) continues to drop as positions become vacant and are filled by employees who are covered by the Federal Employees' Retirement System (FERS). The estimated percentage of payroll for employees covered by CSRS will decrease from 5 percent in FY 2015 to 3.3 percent in FY 2016. The contribution rate will remain at 7.0 percent in FY 2016.

Payroll subject to retirement systems ($8,023,968)	
Cost of CSRS contributions in FY 2016 ($8,023,968 x .033 x .07)	$ 18,535
Cost of CSRS contributions in FY 2015 ($8,023,968 x .050 x .07)	28,084
Total adjustment to base	(9,549)

Federal Employees' Retirement System ($57,000) – The number of employees covered by FERS continues to rise as employees covered by CSRS leave and are replaced by employees covered by FERS. The estimated percentage of payroll for employees covered by FERS will increase from 95.0 percent in FY 2015 to 96.7 percent in FY 2016.

Payroll subject to retirement systems ($8,023,968)	
Basic benefit cost in FY 2016 ($8,023,968 x .967 x .137)	$1,063,007
Basic benefit cost in FY 2015 ($8,023,968 x .95 x .132)	1,006,206
Total adjustment to base	56,801

Thrift Savings Plan ($7,000) – The cost of agency contributions to the Thrift Savings Plan will also rise as FERS participation increases. The contribution rate increased from 4.61 percent in FY 2015 to 4.62 percent in FY 2016.

Thrift plan cost in FY 2016 ($8,023,968 x .967 x .0462)	$ 358,474
Thrift plan cost in FY 2015 ($8,023,968 x .95 x .0461)	351,410
Total adjustment to base	7,064

Federal Insurance Contributions Act (FICA) - OASDI (10,000) – As the percentage of payroll covered by FERS increases, the cost of OASDI contributions will increase. In FY 2015, the maximum salary subject to OASDI tax was $119,100 and will increase to $122,100 in FY 2016. The OASDI tax rate for employers remains at 6.2 percent in FY 2016.

FERS payroll subject to FICA tax in 2016 ($8,023,968 x .967 x .909 x .062)	$ 437,292
FERS payroll subject to FICA tax in 2015 ($8,023,968 x .95 x .904 x .062)	427,241
Increase (FY 2015-FY 2016)	10,051

OTP payroll subject to FICA tax in 2016 ($151,032 x .967 x .909 x .062)	8,231
OTP payroll subject to FICA tax in 2015 ($151,032 x .95 x .904 x .062)	8,042
Increase (FY 2015-FY 2016)	189
Total adjustment to base	10,240

Health insurance ($18,000) – Effective January 2014, NIST's contribution to Federal employees' health insurance premiums increased by 3.1 percent. Applied against the FY 2015 estimate of $571,000, the additional amount required is $17,701

Employees' Compensation Fund (-$8,000) – The Employees' Compensation Fund bill for the year ending June 30, 2013, is $8,000 less than for the year ending June 30, 2012.

Per Diem	0	8

Effective January 1, 2014, the General Services Administration raised per diem rates resulting in an average increase of 4 percent to NIST. This percentage was applied to the FY 2015 estimate of $199,000 to arrive at an increase of $7,960.

Communications, utilities, and miscellaneous charges	0	439

Electricity rate increase	469
Natural Gas rate decrease	(30)

The electricity ATB amount was derived using a year to year comparison of the cost per kilowatt hour. In analyzing the 12 months ended February 2014 and 2013, the per kilowatt hour rate increased 26.3 percent (from .095 to .120) for Gaithersburg, Maryland; increased 1.8 percent (from .434 to .442) for Kauai, Hawaii; increased 14.7 percent (from .067 to .077) for Boulder, Colorado; and increased 16.3 percent (from .091 to .106) for Ft. Collins, Colorado for a net increase of $469,000.

The natural gas ATB amount was derived using a year to year comparison of the average cost per therm. In analyzing the 12 months ended February 2014 and 2013, the per therm rate decreased 5.6 percent (from .483 to .456) and decreased .9 percent (from .603 to .597) for Gaithersburg and Boulder respectively resulting in a net decrease of $30,000.

HMEP Center Salaries	0	410

This request funds salary and benefit inflationary cost increases for non-federal employees of the Hollings Manufacturing Extension Centers using employment cost indices provided by the Bureau of Labor Statistics (BLS) to maintain a high level of service to the public.

General pricing level adjustment	0	256

This request applies the OMB economic assumptions of 1.6 percent for FY 2016 where the prices that the government pays are established through the market system. Factors are applied to sub-object classes that result in the following adjustments to base: communications, utilities, and miscellaneous charges $5,728; printing $1,296; other services $237,920; supplies $7,376; and equipment $4,080.

Subtotal Other changes	(2)	1,341
Total Adjustments to base	(2)	1,341

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ITS

APPROPRIATION ACCOUNT: Industrial Technology Services (ITS)

NIST requests for the ITS appropriation, which consists of three extramural programs, the Advanced Manufacturing Technology Consortia program (AMTech), Hollings Manufacturing Extension Partnership (MEP), and the National Network for Manufacturing Innovation (NNMI).

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Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Technology innovation program
Sub-program: Technology innovation program

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Program Activity		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Technology innovation program	Pos./Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	5	$1,571	2	$5,587	0	0	0	0	0	0

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Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Advanced manufacturing technology consortia
Sub-program: Advanced manufacturing technology consortia

Program Activity		2014 Actual Personnel	2014 Actual Amount	2015 Enacted Personnel	2015 Enacted Amount	2016 Base Personnel	2016 Base Amount	2016 Estimate Personnel	2016 Estimate Amount	Increase/(Decrease) Over 2016 Base Personnel	Increase/(Decrease) Over 2016 Base Amount
Advanced manufacturing technology consortia	Pos./Approp	4	$15,000	4	$8,100	4	$8,174	4	$15,000	0	$6,826
	FTE/Obl.	3	12,626	4	14,987	4	8,174	4	15,000	0	6,826

BUDGET PROGRAM: Advanced Manufacturing Technology Consortia (AMTech)

For FY 2016, NIST requests $15.0 million for AMTech, an increase of $6.9 million from the FY 2015 level.

BASE JUSTIFICATION:

AMTech Overview

The Advanced Manufacturing Technology Consortia (AMTech) program establishes industry-led consortia, which will identify and prioritize research projects supporting long-term industrial research needs. AMTech creates the incentive for multiple industry stakeholders to share financial and scientific resources, together with state and local government interests, as well as technical innovators at universities and government laboratories.

In June 2011, the President launched the Advanced Manufacturing Partnership (AMP), a national effort that brings together industry, universities, and the Federal government to invest in emerging technologies that will create high-quality manufacturing jobs and enhance our global competitiveness. The Advanced Manufacturing Technology Consortia (AMTech) program is an example of the kind of public-private partnership envisioned by AMP to address common technological needs. Specifically, AMTech provides cost shared funding to create new consortia or support existing consortia that are focused on developing advanced technologies to address major technical problems that inhibit the growth of advanced manufacturing in the U.S. AMTech consortia develop detailed road maps of long-term technology needs. The AMTech program provides incentives for addressing multiple components of the innovation cycle, from discovery to commercialization, stimulating industry funding to address the precompetitive R&D needs identified by the consortia members in order to accelerate the pace of innovation throughout various industrial sectors.

The AMTech model demonstrates how the Federal government may leverage resources for a greater societal and commercial outcome by stimulating consortium research that fits into industry roadmaps. The AMTech program fills a critical gap by catalyzing industry-led consortia to identify and tackle basic and measurement research that is seen as too long-term and has too much market uncertainty for individual companies to invest in on its own. Research challenges addressed by an AMTech consortium are pre-competitive: all industry members will benefit from the R&D outcomes and the partnerships are built on open access to intellectual property. AMTech provides a mechanism to leverage agency investment in order to launch breakthrough technologies that will collapse the timescale of innovation.

AMTech creates the incentive for multiple industry stakeholders to share financial and scientific resources, together with state and local government interests, as well as technical innovators at universities and government laboratories. The Advanced Manufacturing Technology Consortia (AMTech) program is an important element of the Administration's emphasis on advanced manufacturing. A number of studies point to industry-led consortia as a meaningful tool to drive directed basic research in areas of critical need. The AMTech program was singled out in the President's Council of Advisors on Science and Technology (PCAST) "Report to the President on Ensuring American Leadership in Advanced Manufacturing" (June 2011) as a public-private partnership model that is needed to catalyze American excellence in advanced manufacturing. AMTech provides a framework to support the Advanced Manufacturing Partnership (AMP), an initiative that was launched by the President in response to PCAST recommendations. AMP is a national effort bringing together industry, universities, and Federal agencies, including NIST, to invest in the emerging technologies that will create high quality manufacturing jobs and enhance global competitiveness. The AMTech program provides cost shared funding to consortia to plan developing advanced technologies to address major technical problems that inhibit the growth of advanced manufacturing in the U.S. AMTech consortia develop detailed road maps of long-term technology needs. The AMTech program provides incentives for addressing multiple components of the innovation cycle, from discovery to commercialization, to accelerate the pace of innovation throughout various industrial sectors.

The funding request continues to allow the AMTech program to more closely leverage the increased investment in Advanced Manufacturing at NIST, and ensure that the research focus of AMTech can have a positive impact on industry.

Priority Objectives for FY 2016:

Schedule & Milestones:

- In FY 2016 planning awards to existing or established consortia will be made for consortium enhancement and technology roadmap development. In FY 2016 - FY 2018, NIST will support and continually monitor newly established research consortia to track outputs and progress. Effectiveness with regard to R&D outputs of the consortia will be assessed for relevance to the long-term roadmap created by the consortia at its inception.

Deliverables/Outputs:

- In FY 2016, each planning awardee is expected to produce a technology roadmap (or be on short term track to complete) which reflects the needs of consortia members representing industry, small business, and other stakeholder groups.

PROGRAM CHANGE(S):

1. AMTech (Base Funding: $8.1 million and 4 FTE; Program Change: +$6.8 million and +0 FTE).

NIST requests an increase of $6.8 million and 0 FTE.

The Advanced Manufacturing Technology Consortia (AMTech) program establishes industry-led consortia, which will identify and prioritize research projects supporting long-term industrial research needs. AMTech creates the incentive for multiple industry stakeholders to share financial and scientific resources, together with state and local government interests, as well as technical innovators at universities and government laboratories. The AMTech model demonstrates how the Federal government may leverage resources for a greater societal and commercial outcome by producing research that fits into industry roadmaps. The AMTech program fills a critical gap by providing resources for directed basic and measurement research that is seen as too long-term and has too much market uncertainty for industry to invest in on its own. Research challenges addressed by an AMTech consortium are pre-competitive: all industry members will benefit from the R&D outcomes and the partnerships are built on open access to intellectual property. AMTech provides a mechanism to leverage agency investment in order to launch breakthrough technologies that will collapse the timescale of innovation. The funding request continues to allow the AMTech program to more closely leverage the increased investment in Advanced Manufacturing at NIST, and ensure that the consortium building and road mapping goals of AMTech can have a positive impact on industry.

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Advanced Manufacturing Technology Consortia
Subprogram: Advanced Manufacturing Technology Consortia
Program Change: The Advanced Manufacturing Technology Consortia (AMTech)

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$0	$436
11.3	Other than full-time permanent	0	0
11.5	Other personnel compensation	0	5
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	0	441
12	Civilian personnel benefits	0	133
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	0	119
22	Transportation of things	0	0
23.1	Rental payments to GSA	0	0
23.2	Rental Payments to others	0	0
23.3	Communications, utilities and miscellaneous	0	1,868
24	Printing and reproduction	0	68
25.1	Advisory and assistance services	0	0
25.2	Other services	1,651	2,960
25.3	Purchases of goods & services from Gov't	0	266
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	0
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	0	334
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	0	346
31	Equipment	0	92
41	Grants, subsidies and contributions	5,175	8,373
44	Refunds	0	0
99	Total obligations	6,826	15,000

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Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Hollings manufacturing extension partnership
Sub-program: Hollings manufacturing extension partnership

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Program Activity		Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount
Hollings manufacturing	Pos./Approp	81	$128,000	81	$130,000	81	$131,267	81	$141,000	0	$9,733
extension partnership	FTE/Obl.	71	122,450	80	153,960	80	131,267	80	141,000	0	9,733

BUDGET PROGRAM: Hollings Manufacturing Extension Partnership Program (MEP)

For FY 2016 NIST requests $141.0 million for MEP.

BASE JUSTIFICATION:

Hollings Manufacturing Extension Partnership Program (MEP) Overview

The Hollings Manufacturing Extension Partnership Program (MEP) is a Federal-state-industry partnership that provides U.S. manufacturers with access to technologies, resources, and industry experts. The MEP program consists of Manufacturing Extension Partnership Centers located across the country that work directly with their local manufacturing communities to strengthen the competitiveness of our Nation's domestic manufacturing base. Funding for the MEP Centers is a cost-sharing arrangement consisting of support from the Federal government, state and local government/entities, and fees charged to the manufacturing clients for services provided by the MEP Centers.

MEP's mission is to act as a strategic advisor to promote business growth and connect manufacturers to public and private resources essential for increased competitiveness and profitability. In doing so, MEP supports NIST's mission of promoting U.S. innovation and industrial competitiveness, while also advancing the goals of the U.S. Department of Commerce to maximize U.S. competitiveness and enable economic growth for U.S. industries, workers, and consumers.

A strong domestic manufacturing base is essential to supporting our Nation's middle class, our national security, and our economy. To continue to foster the economic resurgence, we need strong, innovative manufacturing businesses that are expanding markets and creating good jobs. With Centers in every state and in Puerto Rico, MEP is positioned to connect manufacturers with the opportunities being made available through Federal and state governments to invest in environmentally sustainable manufacturing practices, develop innovative products, and diversify into new markets. MEP Centers know their communities and understand their local manufacturing industries. Across the country, they serve as trusted advisors to their manufacturing clients and help them navigate economic and business challenges, capitalize on opportunities and develop pathways leading to profitable growth.

- In FY 2016 MEP will maintain its national network, continuing to serve as a resource for manufacturing and innovation by leveraging resources to couple cost reduction strategies with profitable client company growth through new product development, technology adoption, and market expansion. MEP will continue to expand efforts to help manufacturers develop innovative practices designed to create ideas for new products, processes and services necessary to grow business opportunities. MEP will leverage the knowledge, information and connections from across the MEP system of centers and partner organizations. MEP will continue to identify areas for future investment and expansion across the MEP network to support the diverse needs of U.S. manufacturers, including workforce development, technology transfer, supplier development, and manufacturing scale-up. MEP will work to support the tools, services and trained MEP Center field staff who are equipped to help firms innovate and create new sales, enter into new markets and adopt new technologies that build competitive advantage.

- The MEP program has a strong culture of partnership. At the state and local level, MEP Centers are often closely tied to state universities, community colleges, government economic development offices, as well as workforce development organizations. MEP Centers collaborate with third party resources and partner organizations to ensure clients receive the most effective advice and assistance. At the Federal level, MEP has ongoing partnerships with several agencies including the Department of Energy, the Environmental Protection Agency, Department of Transportation, Department of Defense, National Aeronautics and Space Administration, the Small Business Administration and the Department of Labor. Within the Department of Commerce, MEP works closely with the International Trade Administration, the Economic Development Administration and the U.S. Patent and Trademark Office.

Examples of Accomplishments:

Each year the program tracks the impact of the MEP system. The most recent data represents MEP impacts based on surveys conducted in FY 2014 including:

• New Sales	$2.5 billion
• Retained Sales	$4.2 billion
• Cost Savings	$1.1 billion
• New Client Investment	$2.7 billion
• Jobs Created	17,833
• Jobs Retained	46,069

The MEP network continues to use and expand partnerships and connections to work with companies to stabilize operations, diversify their customers, and create new business plans for moving towards a stronger future – saving jobs and helping firms identify new strategies for innovation and growth. The MEP continues to play an important role in the Administration's efforts to strengthen U.S. manufacturing in the areas of export assistance and workforce development.

Priority Objectives for FY 2016:

The broad reach and extensive manufacturing knowledge of the MEP network puts the program in the position to strategically disseminate and implement Federal level initiatives and priorities throughout the country. MEP's connection to local manufacturing communities is unique and far-reaching. MEP will work to further leverage its network of Centers to focus on innovation and export opportunities for manufacturers, connect U.S. manufacturers to new technologies and commercialization opportunities, and lay the foundation for a clean energy economy that would keep jobs in the U.S., strengthen national security, and revitalize American communities. Priorities in FY 2016 include:

- Recompetition of the MEP system: MEP will build on the pilot effort started in FY 2014 to begin a systematic refresh of the MEP centers. Through this process, MEP will review cooperative agreement award amounts to take into account variations in the number of target manufacturing firms in a region (as well as other factors), to ensure that Centers are adequately equipped and funded to address the needs of their manufacturing communities.

- Manufacturing Technology Acceleration Centers (M-TAC): MEP will focus on disseminating the results and lessons learned from the pilot M-TAC programs started in FY 2014. MEP will work to deploy these tools and techniques through the existing national network of Centers to address critical national needs in manufacturing among small and medium enterprises (SMEs) including supply chain competitiveness.

- Business-to-Business (B2B) Networks: MEP will build on efforts stared in FY 2015 focused on supporting industry collaboration through B2B networks. In December 2014, MEP announced a set of awards for a new set of B2B networks to provide virtual, regional marketplaces with appropriate technology frameworks supported by face-to-face interactions in FY 2015 -2016. The projects will involve real-time business opportunity matching, business and technology needs, and supplier capabilities and capacities. In FY 2017, MEP will work to disseminateate the lessons learned and best practices in the pilot projects across the full MEP system for adoption and deployment

- Environmental Sustainability: MEP will continue to support its partnership with the Department of Energy and the Environmental Protection Agency focused on implementing sustainable manufacturing business practices through the Economy, Energy, and Environment (E3) community activities that result from a partnership between five Federal agencies and the Green Supplier Network (GSN).

- Technology Acceleration and Deployment: MEP program's strategic focus on technology acceleration and technology scouting through universities and Federal labs enables MEP Centers to work with manufacturing firms to innovate and increase business opportunities to address new markets, develop new products and expand services. Identifying and accelerating technology development and deployment for and with manufacturing firms is a key element of MEP's innovation strategy.

- Export: MEP will support the Administration's export goals outline in the National Export Initiative (NEI) / NEXT through partnerships with the International Trade Administration and other organizations focused on helping manufacturers expand into overseas markets.

- Partnerships: MEP will continue to identify partnership opportunities, at all levels of government, to leverage the Federal investment in support of the tools, services, and information needed by the manufacturing industry. Through these partnerships, MEP will continue to support the "Make it in America" activities by identifying manufacturers with current or future capabilities to address the procurement opportunities of the Federal government and original equipment manufacturers.

The MEP network has proved, through client reported impact metrics and long-standing Federal, state, and local partnerships, to be a valuable resource to America's manufacturers. As investments are being made in workforce, technology innovation, and export programs initiatives - investments in MEP programmatic resources will ensure that these initiatives reach the targeted manufacturing community and that these firms are connected with the opportunities at the Federal and state level. In a number of ways, investing in MEP increases the effectiveness of multiple Federal initiatives, programs, and investments.

PROGRAM CHANGE(S):

1. MEP Programmatic Increase (Base Funding: $131.267 million and 82 FTE; Program Change: +$9.733 million and +0 FTE).

NIST requests an increase of $9.7 million and 0 FTE.

A strong manufacturing base is critical to the financial and national security of the U.S. and to the maintenance of the world leading innovation ecosystem. Manufacturers are facing new and significant challenges. Technology and globalization have fundamentally changed many manufacturing companies and products. Manufacturing increasingly depends on access to customers and the infrastructure needed to support the constant reinvention of the manufacturers' products and processes. The challenge is clear: increasing global competition, coupled with the changing nature of innovation and exacerbated by the economic downturn of late, demands that the U.S. proactively support its domestic manufacturing base through the development, acceleration, and deployment of manufacturing technologies.

Sustaining and strengthening the U.S. manufacturing industry requires an efficient and progressive Federal role, partnering with state and local governments, to supply high-quality unbiased information, advice, and assistance that help firms respond to new challenges. For over 25 years, MEP has successfully provided services that reduce manufacturers' bottom-line expenses, increase efficiencies, build capacity, develop new products, and attract new customers, both domestic and global. Through strategies built upon expert competencies, the MEP program works to provide services to support the diverse needs of the U.S. manufacturing industry.

Proposed Actions:

NIST MEP's plan for increased capabilities to be able to assist all growth oriented SMEs respond to critical national needs is based upon adherence to a comprehensive strategic plan, a focus on operational excellence, system-wide renewal through formal organizational recompetition, and progressive growth in funding to serve all innovative manufacturing firms.

In FY 2013, MEP began a broad based strategic planning process and developed an operational reform agenda intended to optimize program effectiveness, enhance administrative efficiency, and provide greater financial accountability. The strategic planning process was guided by the MEP [National] Advisory Board and informed by the comprehensive 476 page September 2013 report from the National Academies of Science (NAS), "21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program of the National Institute of Standards and Technology." The report compared the level of expenditures of competitor trading nations – Canada, France, Germany, Taiwan, United Kingdom – and the independent advisory panel identified as its first "Core Recommendation":

"Funding for MEP should be commensurate with the importance of manufacturing to the growth of the economy and the program's proven ability to contribute to improved firm performance and adapt to the changing needs of the manufacturing sector. The current level of funding is not adequate to maintain the program's focus on small firms, build new services around Next Generation Strategy, and provide the resources required to drive the improvements recommended by this assessment."

In FY 2014 NIST management directed MEP to initiate a carefully planned, systematic, multi-year re-competition of the national system of Centers.

In support of these reforms, the Administration urged Congress to consider the potential benefits of adjusting the cost share requirement from the current 2:1 ratio of non-federal to federal funds, in order to provide greater flexibility and incentives to develop innovative tools, increase service to small, entrepreneurial, and rural firms, and secure greater impact and accountability. Positive Congressional action was taken by the House of Representatives in 2014.

In FY 2014, the Government Accountability Office (GAO) carefully examined expenditures and investments of the MEP program. Congress had targeted a threshold of 13 percent for administrative expenses. The GAO report recognized that NIST MEP determined that 88.5 percent of the Federal MEP program expenditures in FY 2013 were for direct support of MEP centers, and that only 11.5 percent was spent by NIST MEP for administrative expenses. In FY 2014 administrative expenses were even lower. MEP carefully scrutinizes all expenses to maximize the investments in MEP Center services to the manufacturing community, which includes holding Federal FTE's constant at the national program office and evaluating all third party program development activities.

Further, in accordance with recommendations provided in GAO's audit, in FY 2014 the MEP program reviewed cooperative agreement award amounts to take into account variations in the number of target manufacturing firms in a region (as well as other factors), to ensure that Centers are adequately equipped and funded to address the needs of their manufacturing communities.

To implement the strategic plan and readjust the funding levels of Centers, in FY 2014 MEP began a systematic recompetition of the national system of MEP centers. By the end of FY 2015 nearly one-third of all the States have undergone recompetition, with more than half of the States to be recompeted by end of FY 2016. This nation-wide renewal will be completed by 2017.

The strategic planning process, attention to operational excellence, Congressional action on cost share adjustment, and the competitive federal grant process provides the basis for the FY 2016 funding request.

Statement of Need and Economic Benefits:

The combination of administrative reforms and increased funding enables the flexibility to develop and provide innovative services and technologies, and the funding to reach a critical mass of SMEs.

The proposed budget increase will enable MEP to execute the Action Plans identified in the Department of Commerce's Strategic Plan (FY 2014 – FY 2018): "America is Open for Business".

MEP is identified as a central agent in achieving the following Strategic Objectives in the Innovation Strategic Goal:

- Growing a productive, agile and high value manufacturing sector
- Increasing the capability of U.S. regional economies to accelerate the production of value-added goods and services
- Accelerating the development of industry-led skills strategies.

In addition, MEP's successfully proven ExporTech Program, in a partnership with ITA, advances the Trade and Investment Strategic Objective of increasing U.S. exports by broadening and deepening the U.S. exporter base.

The funding increase will also allow the MEP system to play a robust role in transferring to the small manufacturing sector the results of the R&D activities of the new Manufacturing Innovation Institutes, whose establishment is a priority of the Administration, the Congress, and NIST. MEP is explicitly identified in the proposed authorizing legislation as the vehicle for SME engagement; however, the mission-driven agency funded NNMI model of the first 8 Institutes does not explicitly provide resources for a nation-wide mechanism for SME engagement. MEP's deep experience in technology transition and acceleration, its 60 Center network in every State, now informed by the MTAC (Manufacturing Technology Acceleration Center) pilot program, enhances this capability. Additional funding will enable the Centers to execute the full mission of the NNMI program.

The MEP program is also explicitly identified in the 2014 recommendations of the Advance Manufacturing Partnership (AMP 2.0), particularly by the work stream priorities in manufacturing scale up, supply chain optimization, and manufacturing image (which embraces MEP's nationally recognized annual Manufacturing Day).

Building upon the Department of Commerce's strategic plan, the MEP Advisory Board, after a yearlong process of stakeholder engagement and consultation with manufacturing representatives, approved the following three year strategic plan:

MEP Mission:

To enhance the productivity and technological performance of U.S. manufacturing.

MEP Role:

MEP's state and regional centers facilitate and accelerate the transfer of manufacturing technology in partnership with industry, universities and educational institutions, state governments, and NIST and other federal research laboratories and agencies.

Strategic Goals:

Enhance competitiveness of U.S. manufacturers, with a particular focus on small and medium sized companies.
Serve as a voice to and a voice for manufacturing and manufacturers in engaging policy makers, stakeholders and clients.
Support national, state, and regional manufacturing eco-systems and partnerships.
Develop MEP's capabilities as a learning organization and high performance system.
With this growth in its Federal resources as part of a process of systematic recompettion, matched by State and private funding, MEP can focus on providing targeted services to reach additional U.S. manufacturers and increase the impact on the nation's manufacturing sector.

This investment supports a robust MEP system that is positioned to:

Provide additional manufacturers with the tools and services needed to rrespond to the rapid global change of technology and business systems advances to create opportunities for growth;

respond to manufacturers' workforce challenges;

accelerate the adoption of technologies into commercialized products;

improve manufacturers' competitive advantage through reduced environmental costs and impact;

help manufacturers build strong, stable businesses that provide good, middle class jobs; and

foster innovative partnerships with industry, academia, and local, state, and Federal governments that are focused on meeting the increased challenges facing U.S. manufacturers.

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: Hollings Manufacturing Extension Partnership Program
Subprogram: Hollings Manufacturing Extension Partnership Program
Program Change: Hollings Manufacturing Extension Partnership Program

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$0	$7,072
11.3	Other than full-time permanent	0	645
11.5	Other personnel compensation	0	155
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	0	7,872
12	Civilian personnel benefits	0	2,420
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	0	525
22	Transportation of things	0	7
23.1	Rental payments to GSA	0	3
23.2	Rental Payments to others	0	0
23.3	Communications, utilities and miscellaneous	50	1,173
24	Printing and reproduction	0	14
25.1	Advisory and assistance services	0	3,050
25.2	Other services	26	9,984
25.3	Purchases of goods & services from Gov't	5	348
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	0
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	5	166
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	5	253
31	Equipment	5	172
41	Grants, subsidies and contributions	9,637	115,013
44	Refunds	0	0
99	Total obligations	9,733	141,000

Department of Commerce
National Institute of Standards and Technology
Hollings Manufacturing Extension Partnership
REIMBURSABLE PROGRAM AND WORKING CAPITAL FUND INVESTMENTS
(Dollar amounts in thousands)

	FY 2014 Actual	FY 2015 Enacted	FY 2016 Estimate
Department of Transportation	$104	0	0
Subtotal, Other Agency	104	0	0
Total, Reimbursable Program	104	-	-
Equipment Investments	20	0	0
IE Amortization	(10)	($12)	0
Total, WCF Investments	10	(12)	0
Total, Reimbursable Program and WCF Investments	114	(12)	0

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: National network for manufacturing innovation
Sub-program: National network for manufacturing innovation

Program Activity		2014 Actual Personnel	2014 Actual Amount	2015 Enacted Personnel	2015 Enacted Amount	2016 Base Personnel	2016 Base Amount	2016 Estimate Personnel	2016 Estimate Amount	Increase/ (Decrease) Over 2016 Base Personnel	Increase/ (Decrease) Over 2016 Base Amount
National network for manufacturing innovation	Pos./Approp	0	0	0	0	0	0	9	$150,000	9	$150,000
	FTE/Obl.	0	0	0	0	0	0	7	143,602	7	143,602

BUDGET PROGRAM: National Network for Manufacturing Innovation (NNMI)

This budget program is new in FY 2016, pursuant to the Revitalize American Manufacturing and Innovation (RAMI) Act of 2014. This new funding is established as part of the Administration's efforts to strengthen the U.S. manufacturing sector.

As part of its efforts to revitalize U.S. manufacturing, the Administration proposed to establish a National Network for Manufacturing Innovation (NNMI), which would consist of a network of institutes where researchers, companies, and entrepreneurs can come together to develop new manufacturing technologies with broad applications. Each institute would have a unique technology focus with the objective of creating self-sustaining regional manufacturing hubs that have national impact. These institutes will help support an ecosystem of manufacturing activity in local areas. The Manufacturing Innovation Institutes would support manufacturing technology commercialization by helping to bridge the gap from the laboratory to the market and address core gaps in scaling manufacturing process technologies. The FY 2016 request includes $150.0 million for the program to fund two Institutes for five years and coordination efforts.

The budget request also proposes to transition this program in FY 2017 from this discretionary account to a mandatory appropriations account beginning in FY 2017. The budget proposes a $1.930 billion one-time mandatory appropriations amount for this program to be executed from FY 2017 to FY 2024 to complete the network.

BASE JUSTIFICATION FOR FY 2016:

The NNMI is a new program and no base funding exists.

PROGRAM CHANGE(S):

1. National Network for Manufacturing Innovation (NNMI) Base Funding: $0.0 million and 0 FTE; Program Change: +$150.0 million and +7 FTE).

NIST requests an increase of $150.0 million and 7 FTE.

Proposed Actions: Strengthen the U.S. manufacturing sector through collaborative investments in a network of manufacturing innovation institutes to address manufacturing challenges with broad applications and mature emerging technologies and their manufacturing readiness.

Prior to Congressional authorization of the NNMI in December 2014, eight pilot institutes were awarded or competed. The first pilot institute on the topic of additive manufacturing or "3D printing" was announced in August 2012. Located in Youngstown, Ohio and known as America Makes, the center currently has 120 members, including universities, community colleges and nonprofits, along with manufacturers, large and small, such as the global leader in additive manufacturing 3-D Systems.

Following the launch of this successful pilot institute, the administration announced the selection of three new pilot institutes – in North Carolina, Chicago and Detroit – in the areas of power electronics manufacturing, digital manufacturing and design innovation, and lightweight modern metals manufacturing in early 2014. This was followed in 2015 by a competition for four additional institutes by DoE and DoD.

With the passage of the RAMI Act, each of these pilot institutes becomes centers within the national network. To ensure individual institutes achieve their full potential to advance American domestic manufacturing, the National Network for Manufacturing Innovation will work to expand the impacts of individual Institutes, develop crosscutting metrics and methods for evaluating impact, and promulgate best practices and standards. Each Institute will participate in the broader Network. The Institutes are not directly competitive, as they will have diverse goals, but rather they will share the broad mission of improving U.S. manufacturing competitiveness.

This initiative would create a National Network for Manufacturing Innovation (NNMI) that will promote direct collaboration on industry-relevant research and development to address emerging technology areas where market failures are causing U.S. innovations to be scaled and manufactured by other countries. Institutes will facilitate the adoption of new manufacturing technologies, tools, and methodologies that will make U.S. manufacturers more competitive. The NNMI will emphasize outreach and engagement with small and medium-sized manufacturing enterprises, including women and minority owned manufacturing enterprises. Institutes will provide shared state-of-the-art facilities for workforce training, including the education and training of veterans and individuals with disabilities. The following goals will be addressed through focused actions:

- In accordance with the RAMI Act, NIST has the authority to establish and manage the NNMI network in an efficient manner including developing network governance processes to support productive interactions among institutes.

  Specifically NIST will work with other agencies, such as DOE and DOD, as well as the prior pilot institutes to establish frameworks for performance evaluation, risk management, communication and operations, and to support coordination among them.

- The RAMI Act authorizes NIST to run open competitions for additional institutes on topics proposed by industry, beyond government needs in defense and energy. As additional institutes are created, NIST will contribute its unique expertise to the coordination of issues, opportunities and practices to ensure that mutually established frameworks are consistent.

These actions will provide critical manufacturing innovation infrastructure needed to advance U.S. manufacturing as highlighted in the "Accelerating U.S. Advanced Manufacturing" Report from the President's Council of Advisors on Science and Technology.[1]

The actions in this initiative directly support the Department of Commerce's Strategic goals for manufacturing. This initiative would make progress on the key strategy "Establish the National Network for Manufacturing Innovation" in the Innovation Pillar of the Department of Commerce's 2014-2018 Strategic Plan, specifically addressing Strategic Objective 2.1: "Grow a more productive, agile, and high-value manufacturing sector through partnerships and collaborations that accelerate technology development and commercialization."

Action 1: Establish and Manage the NNMI Network

To ensure the NNMI institutes fully leverage their potential to advance American domestic manufacturing, NIST will support and expand the impacts of individual Institutes, develop crosscutting metrics and methods for evaluating impact, and offer best practices and standards. Each Institute will participate in the broader National Network. The purpose and functions of the Network are to foster inter-institute collaboration and maximize institute impact.

To the extent possible, the Institutes should work collaboratively, sharing best practices, and research and development results. The Institutes are not directly competitive, as IMIs will have diverse goals, but rather they will share the broad mission of improving U.S. manufacturing competitiveness. To support these goals, NIST will organize an NNMI Network Leadership Council composed of

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[1] Executive Office of the President-President's Council of Advisors on Science and Technology. (2014) *Report to the President on Accelerating U.S. Advanced Manufacturing*, Washington, DC. Accessed at http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf

representatives of the Institutes, Federal agencies, and other appropriate entities. The Network Leadership Council will actively look for opportunities to leverage existing resources between Institutes.

Action 2: Establish an Operational Framework for Existing and New Institutes

NIST will convene meetings of the network of existing and new institutes, and will facilitate interagency processes to develop policies for efficient operation of Institutes. The Network will will facilitate interaction with small and medium manufacturers, promote collaboration and movement within the Network, and allow Institutes to share services such human resource management. While recognizing the differing needs of various manufacturing sectors, clusters, and ecosystems, the Network will strive, as far as is practical, to maintain common policies with regard to intellectual property, contract research, operations, accountability, and marketing and branding.

Action 3: Establish Additional Institutes through Open Competitions

NIST will manage two new institute solicitations in FY 2016 using an open competition process on any topic proposed by industry. The institute selection process will be managed by the NIST Advanced Manufacturing Office. NIST AMO will be responsible for managing an open, competitive selection process and for executing the award process. Solicitations for Institute proposals may be staged, and the design and number of solicitations will depend on the availability and timing of funds. Proposals received in response to the solicitation(s) will be evaluated competitively by a review team. The review team will include NIST staff, agency partners, and outside industry experts. The merit based selection process may include pre-proposals, site visits, and economic and business plan analyses. This broad, deliberative review process can best balance the most essential U.S. industrial needs and promising opportunities and support the goals of enhancing American industrial competitiveness on regional, national and global bases.

Statement of Need and Economic Benefits:

U.S. competitive advantage in manufacturing requires continual innovation, for which the U.S. is known as the world's leader. U.S. inventions and innovations are commonly adopted for manufacturing in other countries who provide government support, because of the high cost and risk of development of new manufacturing processes by individual companies. Manufacturers who are not innovating with new processes, materials and technologies for new and improved products risk commoditization. Advanced manufacturing capabilities based on continual innovation are much more difficult to move or replicate. However, even these capabilities are increasingly dispersed and mobile globally, requiring even greater emphasis on speed and novelty, that is, innovation acceleration. Innovation is unpredictable and risky yet essential to the creation of new and improved products to remain globally competitive.

A trend is emerging where other countries are increasingly adept at technology transfer and scaling to production. They have focused on creating a more structured technology development process by partnering with industry. Partnerships that bring diverse organizations together to accelerate innovation for advanced manufacturing create a stronger innovation system and link those innovations more directly to domestic production capabilities.

Innovation system gaps lead to market failures and these failures are magnified in advanced manufacturing. U.S. manufacturers individually are challenged to fund these technology development functions, and small manufacturers especially struggle with individually investing in prototyping and scale up of new technologies and potential products. This initiative would help provide the critical mass and knowledge base necessary to address these challenges.

Base Resource Assessment:

The program leverages NIST core competencies in manufacturing, information science, standards, and materials. NIST has in-depth technical expertise in manufacturing systems interoperability, materials science, robotics, sensors, and nano-technology. It has unique laboratory capabilities needed to develop the required measurement science. It has strong relationships with other government agencies industry, academia, and standards development organizations that will be needed to transfer research to actual practice. NIST has extensive experience in conducting large competitive awards.

NIST provides the measurement science to enable the development of science-based standards and codes, standard reference materials, predictive models, evaluated data, and advanced instrumentation and methods. NIST is uniquely positioned to help address the challenges proposed in this initiative. Private sector organizations generally lack the resources to carry out the research required to develop the technical basis for improved codes and standards. NIST works closely with private sector organizations through the voluntary consensus process to enable science-based codes and standards.

Schedule & Milestones:

Action 1: Establish and Manage the NNMI Network

- Establish and convene NNMI Network Leadership Council (Complete in 2016)
- Ascertain and document best practices (Version 1 Complete in 2016)
- Complete documentation and reporting as required by RAMI Legislation (2016 - 2021)

Action 2: Establish an Operational Framework

- Develop policies needed for efficient network management (Complete in 2016)
- Convene annual meeting of NNMI Institute network representatives (2016 - 2021)
- Report on NNMI network activities (2016 - 2021)

Action 3: Establish Additional Institutes through Open Competition

- Develop internal NIST policy documents necessary for institute competition and management. (Complete in 2016)
- Hold first competition for awards for planning for institute awards with open topics consistent with and required by RAMI (Complete in 2016)
- Hold competition for institute awards with topics recommended by industry-led consortia (Complete in 2017)
- Award funding for new institute(s) (Complete by 2018)

Deliverables:

Action 1: Establish and Manage the NNMI Network

- Governance documents (Complete in 2016)
- Best practices document for agency and NIST funded institutes (Complete by 2018)
- Report to Congress and assessment by GAO (2016 - 2021)

Action 2: Establish an Operational Framework

- Policy documents issued on branding, data infrastructure and performance measures, intellectual property practices, legislative reporting requirements, network structure and communication, coordination and collaboration. (Complete in 2016)
- Policy documents issued on open data, technology transfer, and network participation by other entities (Complete in 2017)
- NNMI Network report (2016 - 2021)

Action 3: Establish Additional Institutes through Open Competition

- NIST award policy documents covering cost share approach, external evaluators, academic and industry fellows, and program income. (Complete in 2016)
- NIST award policy documents covering cost post-award management. (Complete in 2017)
- Federal Funding Opportunity to determine industry input and planning for institutes via open topic competition (Complete in 2016)
- Federal Funding Opportunity for manufacturing institutes consistent with topics selected by industry (Complete in 2017)
- Cooperative agreements in place to establish two manufacturing institutes (Complete by 2018)

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Program: National Network for Manufacturing Innovation (NNMI)
Subprogram: National Network for Manufacturing Innovation (NNMI)
Program Change: National Network for Manufacturing Innovation (NNMI)

Title:	Grade	Number of Positions	Annual Salary	Total Salaries
Project Managers	ZP V	2	$126,245	$252,490
Engineer/Scientist	ZP V	1	126,245	126,245
Engineer/Scientist	ZP IV	1	107,326	107,326
Computer/IT specialist	ZP IV	1	107,326	107,326
Grant Specialist	ZP IV	1	107,326	107,326
Administrative Specialist	ZA III	1	76,377	76,377
Secretary	ZS IV	1	47,684	47,684
Administrative/technical support	ZA II	1	52,667	52,667
Total		9		877,441
Less Lapse	25%	(2)		(219,360)
Total full-time permanent (FTE)		7		658,081
FY 2016 Pay Adjustment (1.3%)				8,555
TOTAL				666,636

Personnel Data	Number
Full-Time Equivalent Employment	
Full-time permanent	7
Other than full-time permanent	0
Total	7
Authorized Positions:	
Full-time permanent	9
Other than full-time permanent	0
Total	9

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Program: National Network for Manufacturing Innovation (NNMI)
Subprogram: National Network for Manufacturing Innovation (NNMI)
Program Change: National Network for Manufacturing Innovation (NNMI)

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	$667	$667
11.3	Other than full-time permanent	0	0
11.5	Other personnel compensation	0	0
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	667	667
12	Civilian personnel benefits	208	208
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	113	113
22	Transportation of things	51	51
23.1	Rental payments to GSA	0	0
23.2	Rental Payments to others	0	0
23.3	Communications, utilities and miscellaneous	940	940
24	Printing and reproduction	103	103
25.1	Advisory and assistance services	0	0
25.2	Other services	742	742
25.3	Purchases of goods & services from Gov't	206	206
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	0
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	181	181
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	161	161
31	Equipment	230	230
41	Grants, subsidies and contributions	140,000	140,000
44	Refunds	0	0
99	Total obligations	143,602	143,602

MANDATORY APPROPRIATIONS ACCOUNT: NATIONAL NETWORK FOR MANUFACTURING INNOVATION (NNMI)

BUDGET PROGRAM: National Network for Manufacturing Innovation (NNMI)

As part of the Administration's efforts to revitalize U.S. manufacturing, the Budget proposes follow-on one-time funding of $1.930 billion in FY 2017 to be executed from FY 2017 – FY 2024. The $1.930 billion request would complete the establishment of the National Network for Manufacturing Innovation (NNMI), a network of up to 45 institutes where researchers, companies, and entrepreneurs can come together to develop new manufacturing technologies with broad applications, nurturing innovation and accelerating commercialization.

Each institute would be industry-led, have a unique technology focus, and would leverage ecosystems of manufacturing activity in local and regional communities. The institutes would support manufacturing technology commercialization and productivity by creating a shared "industrial commons" bridging the gap from R&D to product development and manufacturing here in the U.S. A network leadership council will disseminate best practices and facilitate collaboration among the institutes. Program coordination will be led by a NIST-hosted, inter-agency Advanced Manufacturing National Program Office. The program is designed to support institutes that would be financially self-sustaining after a period of initial Federal co-investment.

A more detailed description of the NNMI's goals and objectives is available in the National Science and Technology Council (NSTC) January 2013 report, "National Network for Manufacturing Innovation: A Preliminary Design."

PROGRAM CHANGES FOR FY 2017:

National Network for Manufacturing Innovation (NNMI) ($1.930 billion one-time funding from FY 2017-FY 2024)

The FY 2016 President's Budget includes an increase of $1.930 billion in mandatory appropriations from FY 2017-FY 2024 to strengthen the U.S. manufacturing sector through collaborative investments in a network of manufacturing innovation institutes to address industrially-relevant manufacturing challenges with broad applications and mature emerging technologies and their manufacturing readiness.

Proposed Actions:

This initiative would create a National Network for Manufacturing Innovation (NNMI) that will:

- Induce industry and non-federal co-investment to rapidly seize innovation opportunities that lead to industrial capabilities, bridging the gap between fundamental technical discoveries in the U.S. and manufactured products.
- Promote direct collaboration on industry-relevant research and development to address emerging technology areas where market failures are causing U.S. innovations to be scaled and manufactured elsewhere.

- Facilitate the adoption of new manufacturing technologies, tools, and methodologies that will make U.S. manufacturers more competitive, especially recognizing the role of small and medium manufacturers in supply chains and innovation.

- Build workforce skills and enhance education needed in advanced manufacturing.

- Support identification and diffusion of "best practice" approaches to governance structure, IP management, partnering, facilities access, etc.

Statement of Need and Economic Benefits:

U.S. competitive advantage in manufacturing requires continual innovation – a regular refreshing of the industrial knowledge base, capital stock, and daily practices of organizations and workers. Manufacturers who are not innovating with new processes, materials and technologies for new and improved products risk commoditization - which can quickly migrate to low-cost locations in the global economy. Advanced manufacturing capabilities based on continual innovation are much more difficult to move overseas or replicate. However, even these capabilities are increasingly dispersed and mobile globally, requiring even greater emphasis on speed and novelty, that is, innovation acceleration. Innovation is unpredictable and risky yet essential to the creation of new and improved products to remain globally competitive.

Innovation system gaps lead to market failures and these failures are magnified in advanced manufacturing. U.S. manufacturers individually are challenged to fund these technology development functions, and small- and medium-manufacturers especially struggle with individually investing in prototyping and scale up of new technologies and potential products. This initiative would help provide the critical mass and knowledge base necessary to address these challenges.

Partnerships that bring diverse organizations together to accelerate innovation for advanced manufacturing create a stronger innovation system and link those innovations more directly to domestic production capabilities. This proposal builds on the success of models deployed in other countries.

Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Baldrige performance excellence program
Sub-program: Baldrige performance excellence program

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Program Activity		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Baldrige performance excellence program	Pos./Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	$61	0	0	0	0	0	0

Department of Commerce
National Institute of Standards and Technology
Baldrige Performance Excellence Program
REIMBURSABLE PROGRAM AND WORKING CAPITAL FUND INVESTMENTS
(Dollar amounts in thousands)

	FY 2014 Actual	FY 2015 Enacted	FY 2016 Estimate
Technical & Advisory Services	$30	$50	$35
Subtotal, Other Reimbursables	30	50	35
Total, Reimbursable Program	30	50	35
Total, Reimbursable Program and WCF Investments	30	50	35

Object Class

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
SUMMARY OF REQUIREMENTS BY OBJECT CLASS
(Dollar amounts in thousands)

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
11	Personnel compensation					
11.1	Full-time permanent	$7,870	$7,397	$7,508	$8,175	$667
11.3	Other than full-time permanent	794	879	645	645	0
11.5	Other personnel compensation	172	160	160	160	0
11.9	Total personnel compensation	8,836	8,436	8,313	8,980	667
12.1	Civilian personnel benefits	2,633	2,524	2,553	2,761	208
13	Benefits for former personnel	0	0	0	0	0
21	Travel and transportation of persons	438	644	644	757	113
22	Transportation of things	7	8	7	58	51
23.1	Rental payments to GSA	2	3	3	3	0
23.2	Rental payments to others	0	0	0	0	0
23.3	Communications, utilities, and miscellaneous charges	748	3,115	2,991	3,981	990
24	Printing and reproduction	14	84	82	185	103
25.1	Advisory and assistance services	197	3,910	3,050	3,050	0
25.2	Other services	7,750	19,152	11,267	13,686	2,419
25.3	Purchases of goods and services from government accounts	378	730	609	820	211
25.5	Research and development contracts	0	0	0	0	0
25.7	Operation and maintenance of equipment	166	583	495	681	186
26	Supplies and materials	256	678	594	760	166
31	Equipment	174	304	259	494	235
32	Land and structures	0	0	0	0	0
41	Grants, subsidies, and contributions	115,046	134,424	108,574	263,386	154,812
42	Insurance claims and indemnities	0	0	0	0	0
43	Interest and dividends	2	0	0	0	0
99	Total Obligations	136,647	174,595	139,441	299,602	160,161

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
99	Total Obligations	$136,647	$174,595	$139,441	$299,602	$160,161
	Less Prior Year Recoveries	(7,946)	(3,000)	0	0	0
	Less Prior Year Refunds	(240)	0	0	0	0
	Less Prior Year Unobligated Balance	(18,956)	(33,495)	0	0	0
	Plus Unobligated Balance End of Year	33,495	0	0	6,398	6,398
	Total Budget Authority/Appropriation	143,000	138,100	139,441	306,000	166,559

Personnel Data

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Full-time equivalent employment:					
Full-time permanent	72	79	78	85	7
Other than full-time permanent	7	7	6	6	0
Total	79	86	84	91	7
Authorized Positions:					
Full-time permanent	81	80	79	88	9
Other than full-time permanent	4	5	6	6	0
Total	85	85	85	94	9

Exhibit 33

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
APPROPRIATION LANGUAGE AND CODE CITATIONS

1. For necessary expenses of the Industrial Technology Services appropriation of the National Institute of Standards and Technology,

   15 U.S.C. 271 et seq.
   15 U.S.C. 272(b)(1) and (b)(4)
   15 U.S.C. 278b
   15 U.S.C. 278k
   15 U.S.C. 278l
   15 U.S.C. 278n
   15 U.S.C. 7506(a)(2)

   15 U.S.C. 271 et seq. provides NIST's organic authorities.

   15 U.S.C. 272(b)(1) authorizes the Secretary, through the Director of NIST, to assist industry in the development of technology and procedures needed to improve quality, to modernize manufacturing processes, to ensure product reliability, manufacturability, functionality, and cost-effectiveness, and to facilitate more rapid commercialization, especially by small- and medium-sized companies throughout the United States, of products based on new scientific discoveries in fields such as automation, electronics, advanced materials, biotechnology, and optical technologies.

   15 U.S.C. 272(b)(4) authorizes the Secretary, through the Director of NIST, to enter into contracts, including cooperative research and development arrangements and grants and cooperative agreements, in furtherance of the purposes of the NIST Act.

   15 U.S.C. 278b provides for a Working Capital Fund to support NIST activities.

   15 U.S.C. 278k directs the Secretary, through the Director of NIST, to provide assistance for the creation of Regional Centers for the Transfer of Manufacturing Technology.

15 U.S.C. 278l provides authority for technical assistance to State technology programs.

15 U.S.C. 278n established the Advanced Technology Program within NIST to assist U.S. businesses in applying generic technology and research results to commercialize scientific discoveries and refine manufacturing technologies. Public Law 110-69 signed on August 9, 2007 has now abolished the Advanced Technology Program (ATP).

15 U.S.C. 7506(a)(2) instructs the NIST Director to utilize the Manufacturing Extension Partnership program to the extent possible to ensure that basic research on issues related to the development and manufacture of nanotechnology, including metrology; reliability and quality assurance; processes control; and manufacturing best practices reaches small- and medium-sized manufacturing companies.

2. $141,000,000 is provided for the Hollings Manufacturing Extension Partnership to remain available until expended.

$15,000,000 is provided for the Advanced Manufacturing Technology Consortia Program to remain available until expended.

$150,000,000 is provided for the National Network for Manufacturing Innovation Program NNMI to remain available until expended.

3. Public Law 110-69, America Competes Act, 121 Stat 572, enacted August 9, 2007 reauthorized the Industrial Technology Services appropriation through 2010. In addition, it eliminated the Advanced Technology Program (ATP) and established the Technology Innovation Program (TIP) which provides grants to eligible companies or joint ventures whose proposed technology has strong potential to address critical national needs. It also amended 15 U.S.C. 3711 by changing the name of the National Medal of Technology from "Technology Medal" to "Technology and Innovation Medal".

4. Public Law 111-358, America Competes Reauthorization Act, 2010, 124 Stat 3982, enacted January 4, 2011 reauthorized the Industrial Technology Services appropriation through 2013 to include the Manufacturing Extension Partnership Program (MEP) and the Malcolm Baldrige National Quality Award program. In addition, authorization is provided for an Innovative Services Initiative to assist small and medium-sized manufacturers within the MEP program.

5. Public Law 112-55, Consolidated and Further Continuing Appropriations Act, 2012, 125 Stat 552, enacted November 18, 2011 did not contain funding for the Technology Innovation Program (TIP) and the Baldrige Performance Excellence Program (BPEP).

6. Public Law 113-235, Consolidated and Further Continuing Appropriations Act, 2015, 128 Stat 2130, enacted December 16, 2014 amends 15 U.S.C. 271 et seq by establishing the Network for Manufacturing Innovation Program within the Industrial Technology Services appropriation to facilitate access to capital-intensive infrastructure in order to transition innovative technologies into scalable, cost-effective, and high-performing manufacturing capabilities thereby stimulating U.S. leadership in advanced manufacturing research, innovation, and technology. As part of the program, the Secretary shall establish a network of centers for manufacturing innovation. Funding for the program is as follows: "to the extent provided for in advance by appropriations Acts the Secretary may use not to exceed $5,000,000 for each of the fiscal years 2015 through 2024 to carry out this section from amounts appropriated to the Institute for Industrial Technical Services" and, "to the extent provided for in advance by appropriations Acts, the Secretary of Energy may transfer to the Institute not to exceed $250,000,000 for the period encompassing fiscal years 2015 through 2024 from amounts appropriated for advanced manufacturing research and development within the Energy Efficiency and Renewable Energy account for the Department of Energy."

Exhibit 34

Department of Commerce
National Institute of Standards and Technology
Industrial Technology Services
ADVISORY AND ASSISTANCE SERVICES
(Obligations in thousands of dollars)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Estimate
Management and professional support services	$197	$3,660	$2,800
Studies, analyses, and evaluations	0	250	250
Engineering and technical services	0	0	0
Total	197	3,910	3,050

Significant Activities

Advisory and assistance services funded by the Industrial Technology Services appropriation are used to conduct evaluations of the programmatic outcomes, service delivery efficiency, and internal infrastructure requirements of the Hollings MEP Program.

Need for Advisory and Assistance Services:

The need for advisory and assistance services stems from the role of NIST's extramural programs with its outside partners and small businesses to relate to the private sector, professional organizations, and the public sector. Inputs must be obtained from consultants who can bring their individual expertise to bear and help NIST in assessing its program plans to meet the needs of its customers. The alternative to utilizing these services is to make no attempt to have expertise from sources outside NIST and risk having a poorer working and professional relationship with those in the business of using the products and services offered by NIST. These services provide for economic assessment and external evaluation of NIST's extramural programs.

Construction of
Research Facilities

Exhibit 5

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
SUMMARY OF RESOURCE REQUIREMENTS
(Dollar amounts in thousands)

	Positions	FTE	Budget Authority	Direct Obligations	Appropriation
2015 Enacted	76	76	$50,300	$62,316	$50,300
less: Unobligated balance from prior year	0	0	0	(12,016)	0
2016 Adjustments to base:					
plus: Uncontrollable cost changes	0	0	822	822	822
2016 Base Request	76	76	51,122	51,122	51,122
less: 2016 Program changes	0	0	7,878	7,878	7,878
2016 Estimate	76	76	59,000	59,000	59,000

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Comparison by program/sub-program:		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Construction and major renovations											
Construction and major renovations	Pos/Approp	76	$56,000	76	$50,300	76	$51,122	76	$59,000	0	$7,878
	FTE/Obl.	65	$63,410	76	62,316	76	51,122	76	59,000	0	7,878
Adjustments for:											
Prior year recoveries			(1,899)		0		0		0		0
Unobligated balance, start of year			(17,527)		(12,016)		0		0		0
Unobligated balance, end of year			12,016		0		0		0		0
Appropriation			56,000		50,300		51,122		59,000		7,878

Exhibit 6

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
PROGRAM AND PERFORMANCE: REIMBURSABLE OBLIGATIONS
(Dollar amounts in thousands)

		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Comparison by program/sub-program:		Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount	Per-sonnel	Amount
Construction and major renovations											
Safety, Capacity, Maintenance and Major Repairs	Pos./BA	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	$1,371	0	$892	0	0	0	0	0	0

Exhibit 7

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
SUMMARY OF FINANCING
(Dollar amounts in thousands)

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Total Obligations	$64,781	$63,208	$51,122	$59,000	$7,878
Financing:					
Offsetting collections from:					
Federal funds	0	0	0	0	0
Non-Federal sources	(892)	0	0	0	0
Total offsetting collections	(892)	0	0	0	0
Adjustments for:					
Prior year recoveries (Direct)	(1,899)	0	0	0	0
Unobligated balance, start of year (Direct)	(17,527)	(12,016)	0	0	0
Unobligated balance, start of year (Reimbursable)	(1,371)	(892)	0	0	0
Unobligated balance, end of year (Direct)	12,016	0	0	0	0
Unobligated balance, end of year (Reimbursable)	892	0	0	0	0
Budget Authority	56,000	50,300	51,122	59,000	7,878
Financing:					
Transfer to other accounts	0	0	0	0	0
Transfer from other accounts	0	0	0	0	0
Appropriation	56,000	50,300	51,122	59,000	7,878

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Adjustments
to Base

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
JUSTIFICATION OF ADJUSTMENTS TO BASE
(Dollar amounts in thousands)

		FTE	Amount
Other Changes:			
Annualization of 2015 pay raise		0	16

A pay raise of 1.0 percent is assumed to be effective January 1, 2015.

Total cost in FY 2016 of 2015 pay raise	$ 76,263
Less amount requested in FY 2015	(60,000)
Less amount absorbed in FY 2015	0
Amount requested in 2016 to provide full-year cost of 2015 pay raise	16,263

		FTE	Amount
2016 Pay increase and related costs		0	82

A general pay raise of 1.3 percent is assumed to be effective January 1, 2016.

Total cost in FY 2016 of pay increase	$ 82,000
Less amount absorbed in FY 2016	0
Amount requested for FY 2016 pay increase	82,000
Payment to Departmental Management Working Capital Fund	0
Total adjustment for FY 2016 pay increase	82,000

Change in compensable days	0	31

The increased cost of one more compensable day in FY 2016 compared to FY 2015 is calculated by dividing the FY 2015 estimated personnel compensation ($6,722,000) and applicable benefits ($1,487,000) by 261 compensable days. The cost increase of one compensable day is $31,452.

Personnel benefits	0	58

Civil Service Retirement System (CSRS)	($8)
Federal Employees' Retirement System (FERS)	48
Thrift Savings Plan (TSP)	6
Federal Insurance Contribution Act (FICA) - OASDI	9
Health Insurance	15
Employees Compensation Fund	(12)

Civil Service Retirement System (-$8,000) – The number of employees covered by the Civil Service Retirement System (CSRS) continues to drop as positions become vacant and are filled by employees who are covered by the Federal Employees Retirement System (FERS). The estimated percentage of payroll for employees covered by CSRS will decrease from 5 percent in FY 2015 to 3.3 percent in FY 2016. The contribution rate will remain at 7.0 percent in FY 2016.

Payroll subject to retirement systems ($6,715,278)	
Cost of CSRS contributions in FY 2016 ($6,715,278 x .033 x .07)	$ 15,512
Cost of CSRS contributions in FY 2015 ($6,715,278 x .050 x .07)	23,503
Total adjustment to base	(7,991)

Federal Employees' Retirement System ($48,000) – The number of employees covered by FERS continues to rise as employees covered by CSRS leave and are replaced by employees covered by FERS. The estimated percentage of payroll for employees covered by FERS will increase from 95 percent in FY 2015 to 96.7 percent FY 2016.

Payroll subject to retirement systems ($6,715,278)	
Basic benefit cost in FY 2016 ($6,715,278 x .967 x .137)	$ 889,633
Basic benefit cost in FY 2015 ($6,715,278 x .95 x .132)	842,096
Total adjustment to base	47,537

Thrift Savings Plan ($6,000) – The cost of agency contributions to the Thrift Savings Plan will also rise as FERS participation increases. The contribution rate increased from 4.61 percent in FY 2015 to 4.62 percent in FY 2016.

Thrift plan cost in FY 2016 ($6,715,278 x .967 x .0462)	$ 300,008
Thrift plan cost in FY 2015 ($6,715,278 x .95 x .0461)	294,096
Total adjustment to base	5,912

Federal Insurance Contributions Act (FICA) - OASDI ($9,000) – As the percentage of payroll covered by FERS increases, the cost of OASDI contributions will increase. In FY 2015, the maximum salary subject to OASDI tax was $119,100 and will increase to $122,100 in FY 2016. The OASDI tax rate for employers will remain at 6.2 percent in FY 2016.

FERS payroll subject to FICA tax in 2016 ($6,715,278 x .967 x .909 x .062)	$ 365,970
FERS payroll subject to FICA tax in 2015 ($6,715,278 x .95 x .904 x .062)	357,559
Increase (FY 2015-FY 2016)	8,411
OTP payroll subject to FICA tax in FY 2016 ($96,722 x .967 x .909 x .062)	5,271
OTP payroll subject to FICA tax in FY 2015 ($96,722 x .95 x .904 x .062)	5,150
Increase (FY 2015-FY 2016)	121
Total adjustment to base	8,532

Health insurance ($15,000) – Effective January 2014 NIST's contribution to Federal employees' health insurance premiums increased by 3.1 percent. Applied against the FY 2015 estimate of $475,000, the additional amount required is $14,725.

Employees' Compensation Fund (-$12,000) – The Employees' Compensation Fund bill for the year ending June 30, 2013, is $12,000 less than for the year ending June 30, 2012.

Per Diem	0	1

Effective January 1, 2014, the General Services Administration raised per diem rates resulting in an average increase of 4 percent to NIST. This percentage was applied to the FY 2015 estimate of $20,000 to arrive at an increase of $800.

General pricing level adjustment	0	634

This request applies the OMB economic assumptions of 1.6 percent for FY 2016 where the prices that the government pays are established through the market system. Factors are applied to sub-object classes that result in the following adjustments to base: communications, utilities, and miscellaneous $2,832; other services $601,744; supplies and materials $25,040; and equipment $4,192.

Subtotal, Other changes	0	822
Total Adjustments to base	0	822

Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
PROGRAM AND PERFORMANCE: DIRECT OBLIGATIONS
(Dollar amounts in thousands)

Program: Construction and major renovations
Sub-program: Construction and major renovations

Program Activity		2014 Actual Personnel	2014 Actual Amount	2015 Enacted Personnel	2015 Enacted Amount	2016 Base Personnel	2016 Base Amount	2016 Estimate Personnel	2016 Estimate Amount	(Increase/ Decrease) Over 2016 Base Personnel	(Increase/ Decrease) Over 2016 Base Amount
Construction and major renovations	Pos/Approp	5	$11,800	0	0	0	0	0	0	0	0
	FTE/Obl.	4	9,023	0	$7,358	0	0	0	0	0	0
Safety, Capacity, Maintenance and Major Repairs	Pos/Approp	70	44,200	76	50,300	76	$51,122	76	$59,000	0	$7,878
	FTE/Obl.	60	54,186	76	52,828	76	51,122	76	59,000	0	7,878
External Projects	Pos/Approp	1	0	0	0	0	0	0	0	0	0
	FTE/Obl.	1	201	0	2,130	0	0	0	0	0	0
Total	Pos/Approp	76	56,000	76	50,300	76	51,122	76	59,000	0	7,878
	FTE/Obl.	65	63,410	76	62,316	76	51,122	76	59,000	0	7,878

APPROPRIATION ACCOUNT: CONSTRUCTION OF RESEARCH FACILITES (CRF)
BUDGET PROGRAM: CONSTRUCTION AND MAJOR RENOVATIONS

For FY 2016, NIST requests a total of $59.0 million and 76 FTE for Construction and Major Renovations.

BASE JUSTIFICATION:

CRF Overview

The CRF program funds new construction, as well as NIST's base Safety, Capacity, Maintenance, and Major Repairs (SCMMR) program. The SCMMR program includes funding for the maintenance, repair, improvements, and major renovation of facilities occupied or used by NIST in Gaithersburg, Maryland; Boulder and Fort Collins, Colorado; and Kauai, Hawaii to meet current and future measurement and research needs for the Nation.

Aging and deteriorating buildings and infrastructure threaten NIST's ability to meet its mission. Failure to properly maintain, repair, improve, renovate and construct facilities used by NIST will cause reductions in measurement capabilities, impairing NIST's ability to meet its measurement and standards missions, and thus reducing U.S. innovation and industrial competitiveness. Other negative impacts include possible damage to staff and visitor safety and health, and reductions in staff productivity.

State-of-the-art facilities are essential to the capabilities of NIST's laboratories. NIST measurement capabilities must be maintained at the highest levels of precision and accuracy to meet the increasingly stringent needs of their users. Also, facilities must be compliant with various health and safety regulations. Other major considerations for facilities are to increase the capacity of facilities, to improve access for people with disabilities, and to safeguard the utility infrastructure of existing buildings.

NIST prioritizes its efforts to improve and upgrade its facilities to address its highest priority SCMMR projects. If major facilities-related emergency situations arise, previously planned facilities work is reprioritized as appropriate.

SUB-PROGRAM: SCMMR

The objectives of the SCMMR sub-program are to:

- continue the repair and upgrade of facilities that have a high impact on staff and visitor safety;
- continue abatement of hazardous materials from site buildings and structures;
- continue facilities modifications to comply with the Access to Federal Buildings Act and the Americans with Disabilities Act;
- continue repairs/replacements of utility systems, exhaust and air filtration systems, mechanical-electrical systems, and site alarm fire safety systems that are failing at an accelerated rate because they are over 40 to 50 years old;
- continue site infrastructure upgrades and repairs, to include roads, loading docks, pedestrian walk areas, and storm water drainage;
- enable or maintain building environmental conditions required for meeting scientific requirements;

- continue to reduce the backlog of deferred maintenance projects including major renovation projects; and
- intensify targeted energy conservation, water efficiency, and building system upgrades to facilitate meeting sustainability requirements stipulated in Executive Orders 13423 and 13514.

PROGRAM CHANGES:

1. Safety, Capacity, Maintenance and Major Repair Increase (+$7.878 million, 0 FTE):

NIST requests an increase of $7.878 million in the Safety Capacity, Maintenance and Major Repair (SCMMR) program to restore NIST Construction of Research Facilities funding that was reduced in the FY 2015 appropriation and fund the next phase of the planned multiyear critical renovations. Reinstating total CRF funding to $59.0 million will expedite the maintenance and repair of facilities and reduce the impact of facility deficiencies on laboratory projects. The planned renovation projects will address the deterioration of critical facilities by accomplishing specific SCMMR-type improvements. These renovations will reduce the backlog of maintenance, repair and replacement issues identified in the recent facility condition assessments. Executing major renovation projects within the SCMMR program will also allow flexibility to fund the most critical facilities requirements to fulfill the NIST mission.

Major planned renovation projects within the SCMMR funding request for the 2016:

Building 3 Renovation (B3R) ($3.0 million) – This funding provides for construction support during FY 2016 for the major renovation of Building 3, awarded in FY 2015, to support existing and expanding Boulder research functions.

Building 1 Renovation (B1R) ($12.0 million) – During the course of FY 2016, the B1R projects for Wing 3 and Wing 6 will be completed. These projects will provide critical space for relocation of existing research operations, enabling the vacating of Wing 5 for its proposed renovation/rebuilding. This funding supports the Wing 5 project, including concept development, design documents and initial relocation efforts for Wing 5. NIST intends to request funding in future budgets to allow the Wing 5 construction award to be made. Including FY 2016 funding, the total funding needed for the B1R Wing 5 project is $60.0 million.

Multi-Year Budget Information ($ in thousands)*

Major Cost Categories	FY 2015 and Prior	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
B1R Design and Limited Renovation of Building 3	$12,000						
B1R Exterior Renovations	14,876						
B1R Wing 3	15,000						
B1R Wing 6	15,700						
B1R Swing Space	3,900						
B3R	15,000	$3,000					
B1R Wing 5		12,000					

* *These projects will be completed with existing SCMMR as well as future additional CRF funding requests.*

Statement of Need and Economic Benefits – Cost Benefit Analysis

In the 1950s and 1960s, the United States recognized its need to invest in science and technology. The Boulder campus was built during this period and the Bureau of Standards was relocated from its collection of aging, obsolete, and temporary buildings in downtown Washington DC to a new state-of-the-art site in Gaithersburg. Construction of Building 1 in Boulder began in 1952 with its dedication by President Eisenhower in 1954. With FY 1961 funding authorized by Congress, the original Gaithersburg buildings were constructed between 1961 and 1969. Once again, more than half a century later, the aging and deteriorating buildings and infrastructure threaten NIST's ability to meet its mission. While some improvements have been made, the current state of facilities remains a serious impediment to the NIST mission – "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 research is critical to advances in vital fields such as nanotechnology, semiconductor technology, bioscience, and many other high impact areas. Deterioration of NIST's buildings and infrastructure makes the mission harder to achieve. For example, poor vibration control, poor temperature control, and low air quality due to 50-year old air conditioning and heating systems increase the difficulty of conducting research and even the most basic measurement calibrations such as for precision pressure gages.

Examples of critical facility and infrastructure investments to support the needs of this modern research institution include:

- replacement of aging, obsolete, failed mechanical systems, to include heating and cooling coils, chillers, condenser units, exhaust fans, condensate receivers, vacuum pumps, steam traps;
- upgrade heating, ventilation, and air conditioning control systems from 1960's pneumatic to current-day direct digital to address building supply/return/exhaust air rebalancing issues;

- roof replacements;
- elevator refurbishments;
- replacement of motor control centers, transformers, switchgear, network protectors, buss ducts, panels, UPS systems, fire alarm systems, variable frequency drives;
- address building envelope exterior and interior architectural systems' degradations – energy inefficient and/or leaking windows and doors, rollup doors, below grade water infiltration through foundation cracks, and worn out ceilings and flooring;
- address leaks and deterioration of underground potable water, sewer, electrical feeder, and compressed air systems;
- asbestos abatement; and
- deteriorating road, parking lot, and sidewalk surfaces.

Building 3 Renovation (B3R): The establishment of the Communication Technology Laboratory (CTL) has created an increase in need for research space. NIST reviewed utilization of existing built space and determined that space currently used as an instrument fabrication shop could be repurposed and expanded to create the space needed for the new mission, which includes meeting critical needs in public safety communications. As a result, the design and construction project for Building 3 was proposed in the FY 2015 plan.

Building 1 Renovation (B1R): Aging laboratory facilities at NIST Boulder substantially hinder NIST's mission of fostering innovation and ensuring U.S. competitiveness. The B1R in Boulder is a phased project to modernize this 60-year-old facility that is no longer meeting the needs of the research community. The facility houses approximately 50 percent of NIST laboratory space in Boulder, most of which supports below Level 1 (L1) performance capability. The project is the continuation of the long-range revitalization plan for the NIST laboratories at Boulder to improve space performance following the completion of construction of the high-performance (L4) Precision Measurement Laboratory (PML).

In planning for the B1R, NIST identified infrastructure projects related to capacity, control of air cleanliness, temperature, vibration, humidity, plumbing systems, electrical distribution, and life safety systems. Examples of areas affected by existing inadequate facility conditions include research to enable next generation optical atomic clocks for improved timekeeping, advanced spectroscopies for non-invasive medical diagnostics and chemical detection, and development of "NIST-on-a-chip" technologies to bring ultraprecise NIST measurements into end user applications. Failures and poor performance of the building infrastructure severely impact this research in these critical technologies.

Base Resources Assessment

An ever-pressing issue for NIST is the aging and obsolescence of the facilities and infrastructure at all NIST sites. These aging facilities and their extensive backlog of deferred maintenance have become serious impediments to the efficient completion of the NIST mission in all areas of research. While some progress has been made by strategically applying available SCMMR resources against the most critical repair and renovation needs, NIST still faces a large backlog of urgent SCMMR projects. Some of NIST's most serious facility deterioration directly affects the welfare and safety of the 5,700 NIST employees and associates/guest researchers who are present on the two major sites at any given time. Each site still suffers from severe systems capacity problems, including antiquated electrical systems (transformers, switchgear, and motor starters) and non-existent or inadequate delivery of chilled water to the laboratories. Based on the independent architectural and engineering reviews and in conjunction with the need to maintain world class research, the proposed funding will be prioritized to address the projects most critical to the continued success of the NIST mission.

Schedule and Milestones:

- FY 2016 and beyond – Award SCMMR projects that focus on reducing the overall backlog of maintenance projects and improve the overall Facility Condition Index (FCI) for all NIST sites.
- FY 2016 – B1R – Complete the renovation of Wings 3 and Wing 6.
- FY 2016 – B1R – Award an architect/engineering (A/E) contract for the planning, programming and design of the Wing 5 project.

Deliverables:

- FY 2016 – Updated Facility Replacement Value for all NIST facilities.
- FY 2016 – B1R – Restore 34,340 usable square feet of upgraded research space to the NIST facility inventory with completion of Wing 3 and Wing 6 renovation projects.
- FY 2016 – B1R – Elimination of all deficiencies for Wing 3 and Wing 6 and Facility Condition ranking of these wings change from "poor" to "excellent."
- FY 2017 – B3R project – Estimated additional 16,000 usable square feet of laboratory and office space added to the NIST facilities inventory.
- FY 2017 – B1R – Completed design documents for the Wing 5 project.

Performance Goals & Measurement Data:

Performance Goal: Deferred Maintenance Reduction	FY 2016 Target	FY 2017 Target	FY 2018 Target	FY 2019 Target	FY 2020 Target
With Change	Approximately $8 million reduction each year. [1]				
Without Change	Continue to fall further behind in the execution of the deferred maintenance backlog.				

[1] $8 million equates to 0.3% of the current estimate of the replacement value of the NIST owned facilities. For every year this funding is not provided, the FCI will deteriorate by an additional amount: 0.3% in FY 2016, 0.6% in FY 2017, 0.9 % in FY 2018, 1.2% in FY 2019, and 1.5% in FY 2020.

PROGRAM CHANGE PERSONNEL DETAIL
(Dollar amounts in thousands)

Budget Program: Construction and Major Renovations
Sub-program: Construction and Major Renovations
Program Change: Safety, Capacity, Maintenance, and Major Repairs Increase

Existing staff will be used to manage the SCMMR program and therefore no new FTE are required for this initiative.

PROGRAM CHANGE DETAIL BY OBJECT CLASS
(Dollar amounts in thousands)

Budget Program: Construction and Major Renovations
Sub-program: Construction and Major Renovations
Program Change: Safety, Capacity, Maintenance, and Major Repairs Increase

	Object Class	FY 2016 Increase	FY 2016 Total Program
11	Personnel compensation		
11.1	Full-time permanent	0	$6,827
11.3	Other than full-time permanent	0	0
11.5	Other personnel compensation	0	90
11.8	Special personnel services payments	0	0
11.9	Total personnel compensation	0	6,917
12	Civilian personnel benefits	0	2,094
13	Benefits for former personnel	0	0
21	Travel and transportation of persons	0	29
22	Transportation of things	0	17
23.1	Rental payments to GSA	0	7
23.2	Rental Payments to others	0	0
23.3	Communications, utilities and miscellaneous charges	$40	1,998
24	Printing and reproduction	0	9
25.1	Advisory and assistance services	0	0
25.2	Other services	7,821	44,658
25.3	Purchases of goods & services from Gov't accounts	4	206
25.4	Operation and maintenance of facilities	0	0
25.5	Research and development contracts	0	0
25.6	Medical care	0	0
25.7	Operation and maintenance of equipment	5	1,201
25.8	Subsistence and support of persons	0	0
26	Supplies and materials	4	1,594
31	Equipment	4	270
32	Lands and structures	0	0
33	Investments and loans	0	0
41	Grants, subsidies and contributions	0	0
42	Insurance claims and indemnities	0	0
43	Interest and dividends	0	0
44	Refunds	0	0
99	Total obligations	7,878	59,000

Object Class

Exhibit 16

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
SUMMARY OF REQUIREMENTS BY OBJECT CLASS

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
11	Personnel compensation					
11.1	Full-time permanent	$6,722	$6,722	$6,827	$6,827	0
11.3	Other than full-time permanent	0	0	0	0	0
11.5	Other personnel compensation	90	90	90	90	0
11.9	Total personnel compensation	6,812	6,812	6,917	6,917	0
12.1	Civilian personnel benefits	2,017	2,012	2,094	2,094	0
13	Benefits for former personnel	0	0	0	0	0
21	Travel and transportation of persons	52	29	29	29	0
22	Transportation of things	17	17	17	17	0
23.1	Rental payments to GSA	6	7	7	7	0
23.2	Rental payments to others	0	0	0	0	0
23.3	Communications, utilities, and miscellaneous charges	1,925	1,955	1,958	1,998	$40
24	Printing and reproduction	9	9	9	9	0
25.1	Advisory and assistance services	0	0	0	0	0
25.2	Other services	40,352	40,328	36,837	44,658	7,821
25.3	Purchases of goods and services from government accounts	194	199	202	206	4
25.5	Research and development contracts	0	0	0	0	0
25.7	Operation and maintenance of equipment	1,173	1,177	1,196	1,201	5
26	Supplies and materials	1,562	1,565	1,590	1,594	4
31	Equipment	261	262	266	270	4
32	Land and structures	9,023	7,301	0	0	0
41	Grants, subsidies, and contributions	0	643	0	0	0
43	Interest and dividends	7	0	0	0	0
99	Total Obligations	63,410	62,316	51,122	59,000	7,878

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
99	Total Obligations	$63,410	$62,316	$51,122	$59,000	$7,878
	Less Prior Year Recoveries	(1,899)	0	0	0	0
	Less Prior Year Unobligated Balance	(17,527)	(12,016)	0	0	0
	Plus Unobligated Balance End of Year	12,016	0	0	0	0
	Total Budget Authority/Appropriation	56,000	50,300	51,122	59,000	7,878
	Plus Transfers from Other Accounts	0	0	0	0	0
	Appropriation	56,000	50,300	51,122	59,000	7,878

Personnel Data

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Full-time equivalent employment:					
Full-time permanent	64	76	76	76	0
Other than full-time permanent	1	0	0	0	0
Total	65	76	76	76	0
Authorized Positions:					
Full-time permanent	75	76	76	76	0
Other than full-time permanent	1	0	0	0	0
Total	76	76	76	76	0

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
APPROPRIATION LANGUAGE AND CODE CITATIONS

1. For construction of new research facilities, including architectural and engineering design, and for renovation and maintenance of existing facilities, not otherwise provided for the National Institute of Standards and Technology, as authorized by 15 U.S.C. 278c-278e.

   15 U.S.C. 278c authorizes that the Secretary of Commerce to acquire land for such field sites as are necessary for the proper and efficient conduct of the activities authorized.

   15 U.S.C. 278d authorizes that the Secretary of Commerce to undertake such construction of buildings and other facilities and to make such improvements to existing buildings, grounds, and other facilities as are necessary for the proper and efficient conduct of authorized activities.

   15 U.S.C. 278e provides that in the performance of the functions of the National Institute of Standards and Technology the Secretary of Commerce is authorized to undertake: the care, maintenance, protection, repair, and alteration of Institute buildings and other plant facilities, equipment, and property.

2. $59,000,000 to remain available until expended.

3. Public Law 110-69, America Competes Act, 121 Stat 572, passed August 9, 2007 reauthorizes the Construction of Research Facilities appropriation through 2010. It also provided for the Retention of Fees to the Construction of Research Facilities account. "The Director is authorized to retain all building use and depreciation surcharge fees collected pursuant to OMB Circular A-25. Such fees shall be collected and credited to the Construction of Research Facilities Appropriation Account for use in maintenance and repair of the Institute's existing facilities". Public Law 111-358, America Competes Reauthorization Act, 2010, 124 Stat 3982, passed January 4, 2011 reauthorized the Construction of Research Facilities appropriation through 2013.

4. Public Law 111-5, American Recovery and Reinvestment Act of 2009 appropriated $360,000,000 to the Construction of Research Facilities appropriation from FY 2009 to FY 2010.

Exhibit 34

Department of Commerce
National Institute of Standards and Technology
Construction of Research Facilities
ADVISORY AND ASSISTANCE SERVICES
(Obligations in thousands of dollars)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Estimate
Management and professional support services	$0	$0	$0
Studies, analyses, and evaluations	0	0	0
Engineering and technical services	0	0	0
Total	0	0	0

Significant Activities

Professional support and engineering and technical services are obtained when required to support the construction and major repairs and renovations of NIST's physical infrastructures in Gaithersburg, Maryland, and Boulder, Colorado. Strategies and action plans are also developed to further ensure structural building safety when the need arises.

Need for Advisory and Assistance Services

NIST uses outside professional support and engineering and technical services whenever necessary expertise is not available in-house to ensure the safety of NIST staff and visitors.

Working
Capital Fund

Exhibit 5

Department of Commerce
National Institute of Standards and Technology
Working Capital Fund
SUMMARY OF RESOURCE REQUIREMENTS
(Dollar amounts in thousands)

	Positions	FTE	Budget Authority	Obligations
2015 Enacted	682	700	0	0
Reduction in transfers from prior STRS program changes	0	0	0	0
2016 Base	682	700	0	0
Transfer from STRS program changes for equipment investments	0	0	$1,500	$1,500
2016 Estimate	682	700	1,500	1,500

Exhibit 6

Department of Commerce
National Institute of Standards and Technology
Working Capital Fund
SUMMARY OF REIMBURSABLE OBLIGATIONS
(Dollar amounts in thousands)

	2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
Comparison by activity:	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount
Laboratory programs										
WCF transfer		$7,700		0		0		$1,500		$1,500
Reimbursables	585	130,047	627	$143,139	627	$134,349	627	134,349	0	0
WCF investments	0	13,158	0	7,769	0	0	0	0	0	0
Subtotal	585	150,905	627	150,908	627	134,349	627	135,849	0	1,500
Corporate services										
WCF transfer		0		0		0		0		0
Reimbursables	0	3,095	0	3,785	0	3,805	0	3,805	0	0
WCF investments	0	706	0	475	0	0	0	0	0	0
Subtotal	0	3,801	0	4,260	0	3,805	0	3,805	0	0
Standards coordination and special programs										
WCF transfer		0		0		0		0		0
Reimbursables	45	6,373	49	4,731	49	4,920	49	4,920	0	0
WCF investments	0	0	0	980	0	0	0	0	0	0
Subtotal	45	6,373	49	5,711	49	4,920	49	4,920	0	0
Hollings manufacturing extension partnership										
WCF transfer		0		0		0		0		0
Reimbursables	0	104	0	0	0	0	0	0	0	0
WCF investments	0	10	0	(12)	0	0	0	0	0	0
Subtotal	0	114	0	(12)	0	0	0	0	0	0
Baldrige performance excellence program										
WCF transfer		0		0		0		0		0
Reimbursables	22	30	24	50	24	35	24	35	0	0
WCF investments	0	0	0	0	0	0	0	0	0	0
Subtotal	22	30	24	50	24	35	24	35	0	0
Total, National Institute of Standards and Technology										
WCF transfer		7,700		0		0		1,500	0	1,500
Reimbursables	652	139,649	700	151,705	700	143,109	700	143,109	0	0
WCF investments	0	13,874	0	9,212	0	0	0	0	0	0
Grand Total	652	161,223	700	160,917	700	143,109	700	144,609	0	1,500

Department of Commerce
National Institute of Standards and Technology
Working Capital Fund
SUMMARY OF FINANCING
(Dollar amounts in thousands)

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Total Obligations	$161,223	$160,917	$143,109	$144,609	$1,500
Offsetting collections from:					
Federal funds	(153,413)	(100,810)	(93,003)	(93,003)	0
Non-Federal sources	(3,836)	(60,107)	(50,106)	(50,106)	0
Total offsetting collections	(157,249)	(160,917)	(143,109)	(143,109)	0
Unobligated balance, start of year	(93,574)	(88,058)	(88,058)	(88,058)	0
Unobligated balance transferred	(3,700)	0			
Unobligated balance, end of year	88,058	88,058	88,058	88,058	0
Change in uncollected customer payments - Federal	9,242	0	0	0	0
Budget Authority	4,000	0	0	1,500	1,500
Financing:					
Transfer from other accounts	(4,000)	0	0	(1,500)	(1,500)
Appropriation	0	0	0	0	0

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Department of Commerce
National Institute of Standards and Technology
Working Capital Fund

This Working Capital Fund (WCF) reflects the full-time equivalent (FTE) employment and reimbursable obligations associated with the reimbursable work performed by NIST for other agencies and the public, and WCF investments. NIST's reimbursable services consist of technical work performed for other Federal agencies, state and local governments, and the private sector, including calibrations and special tests, advisory services, the sale of Standard Reference Materials (SRMs) and Baldrige Performance Excellence Program (BPEP) fees. The unique measurement and standards expertise developed with appropriated funding gives NIST the capability to perform these services on a reimbursable basis. NIST accepts other agency work based on an established set of criteria which include: (1) the need for traceability of measurements to national standards; (2) the need for work which cannot or will not be addressed by the private sector; (3) work supported by legislation that authorizes or mandates certain services; (4) work which would result in an unavoidable conflict of interest if carried out by the private sector or regulatory agencies; and (5) requests by the private sector for NIST action or services.

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Object Class

Department of Commerce
National Institute of Standards and Technology
Working Capital Fund
SUMMARY OF REQUIREMENTS BY OBJECT CLASS
(Dollar amounts in thousands)

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
11	Personnel compensation					
11.1	Full-time permanent	0	0	0	0	0
11.3	Other than full-time permanent	0	0	0	0	0
11.5	Other personnel compensation	0	0	0	0	0
11.9	Total personnel compensation	0	0	0	0	0
12.1	Civilian personnel benefits	0	0	0	0	0
13	Benefits for former personnel	0	0	0	0	0
21	Travel and transportation of persons	0	0	0	0	0
22	Transportation of things	0	0	0	0	0
23.1	Rental payments to GSA	0	0	0	0	0
23.2	Rental payments to others	0	0	0	0	0
23.3	Communications, utilities, and miscellaneous charges	0	0	0	0	0
24	Printing and reproduction	0	0	0	0	0
25.1	Advisory and assistance services	0	0	0	0	0
25.2	Other services	0	0	0	0	0
25.3	Purchases of goods and services from Government accounts	0	0	0	0	0
25.5	Research and development contracts	0	0	0	0	0
25.7	Operation and maintenance of equipment	0	0	0	0	0
26	Supplies and materials	0	0	0	0	0
31	Equipment	$7,700	0	0	$1,500	$1,500
32	Land and structures	0	0	0	0	0
41	Grants, subsidies, and contributions	0	0	0	0	0
99	Total Obligations	7,700	0	0	1,500	1,500

Personnel Data	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Full-time equivalent employment:					
Full-time permanent	597	645	645	645	0
Other than full-time permanent	55	55	55	55	0
Total	652	700	700	700	0
Authorized Positions:					
Full-time permanent	663	663	663	663	0
Other than full-time permanent	19	19	19	19	0
Total	682	682	682	682	0

Exhibit 34

Department of Commerce
National Institute of Standards and Technology
Working Capital Fund
ADVISORY AND ASSISTANCE SERVICES
(Obligations in thousands of dollars)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Estimate
Management and professional support services	$142	$172	$177
Studies, analyses, and evaluations	109	111	102
Engineering and technical services	132	133	134
Total	383	416	413

Significant Activities

Advisory and assistance services funded by the Working Capital Fund represent services funded by reimbursable funds in support of reimbursable work conducted at NIST.

Need for Advisory and Assistance Services

Advisory and Assistance services have been necessary to obtain additional expertise for conducting activities like the technical evaluation of the World Trade Center collapses, for example.

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Exhibit 5

Department of Commerce
National Institute of Standards and Technology
Wireless Innovation Fund
SUMMARY OF RESOURCE REQUIREMENTS - MANDATORY APPROPRIATION
(Dollar amounts in thousands)

	Positions	FTE	Budget Authority	Direct Obligations	Appro-priation
2015 Enacted	0	0	0	0	0
2016 Adjustments to base	0	0	0	0	0
2016 Base Request	0	0	0	0	0
plus: 2016 Offsetting Collections	0	0	0	0	0
2016 Estimate	0	0	0	0	0

Comparison by program/sub-program:		2014 Actual Per-sonnel	2014 Actual Amount	2015 Enacted Per-sonnel	2015 Enacted Amount	2016 Base Per-sonnel	2016 Base Amount	2016 Estimate Per-sonnel	2016 Estimate Amount	Increase/(Decrease) Over 2016 Base Per-sonnel	Increase/(Decrease) Over 2016 Base Amount
Wireless Innovation Fund											
Wireless Innovation Fund	Pos/Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	0	0	0	0	0	0	0
Total: Wireless Innovation Fund	Pos/Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	0	0	0	0	0	0	0

	2014 Actual FTE	2014 Actual Amount	2015 Enacted FTE	2015 Enacted Amount	2016 Base FTE	2016 Base Amount	2016 Estimate FTE	2016 Estimate Amount	Increase/(Decrease) Over 2016 Base FTE	Increase/(Decrease) Over 2016 Base Amount
Total Obligations	0	0	0	0	0	0	0	0	0	0
Adjustments for:										
Prior year recoveries	0	0	0	0	0	0	0	0	0	0
Prior year refunds	0	0	0	0	0	0	0	0	0	0
Unobligated balance from offsetting	0	0	0	0	0	0	0	0	0	0
Unobligated balance, expired account collections, end of year	0	0	0	0	0	0	0	0	0	0
Budget Authority/Appropriation - Mandatory Account	0	0	0	0	0	0	0	0	0	0

[1/] WIN Mandatory Budget Authority of $300 million (from offsetting collections) will obligate over several fiscal years beginning in FY 2015.

Department of Commerce
National Institute of Standards and Technology
Wireless Innovation Fund
PROGRAM AND PERFORMANCE: REIMBURSABLE OBLIGATIONS
(Dollar amounts in thousands)

Comparison by program/sub-program:		2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) Over 2016 Base	
		Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount	Personnel	Amount
Wireless Innovation Fund	Pos./Coll.	0	0	3	278	10	22	10	22	0	0
	FTE/Obl.	0	0	3	10	10	30	10	30	0	0

Exhibit 7

Department of Commerce
National Institute of Standards and Technology
Wireless Innovation Fund
SUMMARY OF FINANCING - MANDATORY APPROPRIATION
(Dollar amounts in thousands)

	2014 Actual	2015 Enacted[1/]	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Total Obligations	0	$10	$30	$30	0
Offsetting collections from:					
Trust funds		(278)	(22)	(22)	0
Adjustments for:					
Unobligated balance, start of year (Mandatory)	0	0	(268)	(268)	0
Unobligated balance from offsetting collections, end of year	0	268	260	260	0
Budget Authority/Appropriation - Mandatory Account	0	0	0	0	0

[1/] WIN Mandatory Budget Authority of $300 million (from offsetting collections) will obligate over several fiscal years beginning in FY 2015.

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Exhibit 10

Department of Commerce
National Institute of Standards and Technology
Wireless Innovation Fund
PROGRAM AND PERFORMANCE: MANDATORY APPROPRIATION
(Dollar amounts in thousands)

Program: Wireless Innovation Fund
Sub-program: Wireless Innovation Fund

Program Activity		2014 Actual Personnel	2014 Actual Amount	2015 Enacted [1/] Personnel	2015 Enacted [1/] Amount	2016 Base Personnel	2016 Base Amount	2016 Estimate Personnel	2016 Estimate Amount	(Increase/ Decrease) Over 2016 Base Personnel	(Increase/ Decrease) Over 2016 Base Amount
Wireless Innovation Fund	Pos/Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	0	0	0	0	0	0	0
Total	Pos/Approp	0	0	0	0	0	0	0	0	0	0
	FTE/Obl.	0	0	0	0	0	0	0	0	0	0

[1/] WIN Mandatory Budget Authority of $300 million (from offsetting collections) will obligate over several fiscal years beginning in FY 2015.

MANDATORY ACCOUNT: Wireless Innovation (WIN) Fund

BUDGET PROGRAM: Wireless Innovation (WIN) Fund

As part of the National Wireless Initiative included in the Middle Class Tax Relief and Job Creation Act of 2012, NIST also has resources through the Wireless Innovation (WIN) Fund to help develop cutting-edge wireless technologies for public safety users. The WIN Fund contains $300.0 million in mandatory funds for NIST from the spectrum auction proceeds in FY 2015 to help industry and public safety organizations conduct research and develop new standards, technologies and applications to advance public safety communications in support of the initiative's efforts to build an interoperable nationwide broadband network for first responders. The spectrum auction provided $300.0 million for NIST to begin executing for this purpose in FY 2015, and will continue to execute in FY 2016 and in the outyears.

Object Class

Exhibit 16

Department of Commerce
National Institute of Standards and Technology
Wireless Innovation Fund
SUMMARY OF REQUIREMENTS BY OBJECT CLASS - MANDATORY APPROPRIATION

	Object Class	2014 Actual	2015 Estimate [1/]	2016 Estimate
11	Personnel compensation			
11.1	Full-time permanent	0	0	0
11.3	Other than full-time permanent	0	1,000	2,000
11.5	Other personnel compensation	0	0	0
11.9	Total personnel compensation	0	1,000	2,000
12.1	Civilian personnel benefits	0	0	1,000
13	Benefits for former personnel	0	0	0
21	Travel and transportation of persons	0	0	0
22	Transportation of things	0	0	0
23.1	Rental payments to GSA	0	0	0
23.2	Rental payments to others	0	0	0
23.3	Communications, utilities, and miscellaneous charges	0	0	0
24	Printing and reproduction	0	0	0
25.1	Advisory and assistance services	0	0	0
25.2	Other services	0	0	0
25.3	Purchases of goods and services from government accounts	0	0	0
25.5	Research and development contracts	0	9,000	27,000
25.7	Operation and maintenance of equipment	0	0	0
26	Supplies and materials	0	0	0
31	Equipment	0	0	0
32	Land and structures	0	0	0
41	Grants, subsidies, and contributions	0	0	0
42	Insurance claims and indemnities	0	0	0
99	Total Obligations	0	10,000	30,000

99	Object Class	2014 Actual	2015 Estimate [1/]	2016 Estimate
99	Total Obligations	0	10,000	30,000
	Unobligated balance from offsetting collections, end of year	0	0	0
	Budget Authority - Mandatory Account	0	10,000	30,000
	Less: Offsetting collections	0	0	0
	Net Budget Authority - Mandatory Account	0	10,000	30,000

Personnel Data

	2014 Actual	2015 Estimate	2016 Estimate
Full-time equivalent employment:			
Full-time permanent	0	0	0
Other than full-time permanent	0	3	10
Total	0	3	10
Authorized Positions:			
Full-time permanent	0	0	0
Other than full-time permanent	0	3	10
Total	0	3	10

[1/] WIN Mandatory Budget Authority of $300 million (from offsetting collections) will obligate over several fiscal years beginning in FY 2015.

Exhibit 33

Department of Commerce
National Institute of Standards and Technology
WIRELESS INNOVATION FUND
APPROPRIATION LANGUAGE AND CODE CITATIONS

1. For necessary expenses of the National Institute of Standards and Technology,

15 U.S.C. 272; 273; 278b-j; p

15 U.S.C. 272; 273; 278b-j; p provides basic authority for the performance of the functions and activities of the National Institute of Standards and Technology, authorizes appropriations for these purposes to be provided to the general public and specific institutions, governments, firms, and individuals, and requires the notification of Congress of a reprogramming of funds that exceeds a limit specified in public law.

2. MANDATORY ACCOUNT: Wireless Innovation (WIN) Fund: As part of the National Wireless Initiative included in the American Jobs Act, NIST also has resources through the Wireless Innovation (WIN) Fund to help develop cutting-edge wireless technologies for public safety users. The WIN Fund contains $300 million in mandatory funds for NIST from the spectrum auction proceeds in FY 2015 to help industry and public safety organizations conduct research and develop new standards, technologies and applications to advance public safety communications in support of the initiative's efforts to build an interoperable nationwide broadband network for first responders. The spectrum auction provided $300 million for NIST to begin executing for this purpose in FY 2015, ($278 million) and will continue to execute in FY 2016 ($22 million) to be followed by additional funding in the outyears.

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Summary of National Institute of Standards and Technology (NIST)

The operations of the NIST Working Capital Fund are reported in a program and financing schedule printed in the President's Budget, as well as reflected in the reimbursable amounts throughout this budget. The fund finances the initial costs of work performed by NIST and is reimbursed by applicable appropriations and advances or reimbursements from other agencies. A detailed cost accounting system is used to ensure that the actual cost of work performed for each job or task is recorded and identified with the appropriate source of financing. In addition to its function as a revolving fund, the Working Capital Fund is also used to handle annual and sick leave on an accrued basis, to acquire equipment as an investment to be recovered through amortization charges to programs, to distribute indirect costs to programs as overhead, to carry the recoverable costs associated with the production of Standard Reference Materials, and to carry supply inventories until issued for program use.

The table below summarizes the total NIST program, according to the source of financing. Following this table is a summary of the NIST reimbursable program by sponsor and source of support.

Summary of Total NIST Discretionary Program

(Obligations in thousands)

	FY 2014			FY 2015			FY 2016			
Source and Use of Funds Spent	Perm. Pos.[1]	FTE	Oblig.	Perm. Pos.[1]	FTE	Oblig.	Perm. Pos.[1]	FTE	Oblig.	Approp. Requested
Direct Funding										
Scientific and technical research and services	2,366	2,274	$651,565	2,412	2,391	$716,451	2,558	2,507	$758,660	$754,661
Industrial technology services	85	79	136,647	85	86	174,595	94	91	299,602	306,000
Construction of research facilities	76	65	63,410	76	76	62,316	76	76	59,000	59,000
Gifts and bequests	0	0	4,010	0	0	4,844 [3]	0	0	3,500 [3]	0
Total, direct funding	2,527	2,418	855,632	2,573	2,553	958,206	2,728	2,674	1,120,762	1,119,661
Reimbursable Funding and WCF Investments										
Construction of research facilities - building surcharge	0	0	1,371	0	0	892	0	0	0	
Research, development and supporting services:										
Federal government	443	423	91,069	443	455	100,810	443	455	93,003	
Calibrations and tests, technical and advisory services:										
Federal government	30	29	6,779	30	31	7,144	30	31	6,976	
Public and non-federal government	87	83	19,622	87	89	20,680	87	89	20,194	
Subtotal, Services	117	112	26,401	117	120	27,824	117	120	27,170	
National Voluntary Laboratory Accreditation Program	26	25	4,326	26	27	4,165	26	27	4,287	
Standard reference materials (SRMs):										
SRM Sales:										
Federal government	2	2	421	2	2	480	2	2	475	
Public and non-federal government	94	90	16,133	94	96	18,426	94	96	18,174	
Subtotal, SRM sales	96	92	16,554	96	98	18,906	96	98	18,649	
SRM investment adjustment	0	0	1,299	0	0	0	0	0	0	
Subtotal, SRM	96	92	17,853	96	98	18,906	96	98	18,649	
Total, Reimbursable program	682	652	141,020 [2]	682	700	152,597 [2]	682	700	143,109	
WCF Investments and Operating Adjustments										
WCF investments	0	0	15,769	0	0	27,018	0	0	16,889	
WCF transfers	0	0	7,700	0	0	0	0	0	1,500	
WCF operating adjustments	0	0	19,734	0	0	0	0	0	0	
Total, WCF Investments and operating adjustments	0	0	43,203	0	0	27,018	0	0	18,389	
Total, NIST program	3,209	3,070	1,039,855	3,255	3,253	1,137,821	3,410	3,374	1,282,260	
Offsetting adjustment for amortization of equipment	0	0	(21,629)	0	0	(17,806)	0	0	(16,889)	
Adjusted total, NIST program	3,209	3,070	1,018,226	3,255	3,253	1,120,015	3,410	3,374	1,265,371	

1/ Most NIST scientists and engineers are not engaged solely on one research project. Individuals may divide their time between two or more projects financed by different sources of support. Also, salary costs of many staff members are charged to an overhead account and subsequently prorated to all directly funded projects. For these reasons, it is not possible to report employment directly for any source of financing. The Permanent Positions above are statistically-derived numbers, based on the estimated work years distribution for NIST programs.

2/ Total reimbursable numbers are different from the next page due to inclusion of CRF reimbursable obligations.

3/ Estimate support from Foundation for the Malcolm Baldrige National Quality Award, Inc. to Baldrige Performance Excellence Program.

Department of Commerce
National Institute of Standards and Technology
REIMBURSABLE PROGRAM AND WORKING CAPITAL FUND INVESTMENTS
(Dollar amounts in thousands)

	FY 2014 Actual	FY 2015 Enacted	FY 2016 Estimate
Department of Defense			
Air Force	$9,228	$6,017	$5,813
Army	746	817	835
Navy	1,385	1,232	1,290
Other, Department of Defense	16,906	17,029	15,764
Subtotal, Department of Defense	28,265	25,095	23,702
Department of Agriculture	30	25	25
Department of Commerce	19,732	20,327	19,876
Department of Energy	4,781	5,674	4,445
Dept. of Health & Human Services	4,252	5,635	4,921
Dept. of Homeland Security	15,051	19,942	17,945
Department of the Interior	210	0	0
Department of Justice	5,068	8,009	7,969
Department of Transportation	430	297	298
Department of the Treasury	0	649	400
Department of Veterans Affairs	200	200	210
Environmental Protection Agency	75	85	85
General Services Administration	45	210	106
National Aeronautics & Space Admin.	2,317	2,771	2,717
National Science Foundation	2,949	2,833	2,500
Nuclear Regulatory Commission	2,347	2,500	2,500
Other	5,317	6,558	5,304
Subtotal, Other Agency	91,069	100,810	93,003
Calibrations & Testing	8,325	8,128	8,150
Technical & Advisory Services	22,402	23,861	23,307
Standard Reference Materials	17,853	18,906	18,649
Subtotal, Other Reimbursables	48,580	50,895	50,106
Total, Reimbursable Program	139,649	151,705	143,109
Equipment Transfers	7,700	0	1,500
Subtotal, WCF transfer	7,700	0	1,500
Equipment Investments	15,769	27,018	16,889
IE Amortization	(21,629)	(17,806)	(16,889)
WCF Operating Adjustments	19,734	0	0
Total, WCF Investments	13,874	9,212	0
Total, Reimbursable Program and WCF Investments	161,223	160,917	144,609

Department of Commerce
National Institute of Standards and Technology
PERIODICALS, PAMPHLETS, AND AUDIOVISUAL SERVICES
(Obligations in thousands)

	2013 Actual	2014 Actual	2015 Estimate	2016 Estimate
Periodicals	$0	$0	$0	$0
Pamphlets	11.1	15.3	25	20
Audiovisuals	33.5	24.3	35	35
Total	$44.6	$39.6	$60	$55

NIST produces one periodical a year, *The Journal of Research of the National Institute of Standards and Technology*. The final paper production was issued in January 2012 and the periodical is now issued electronically. The Journal of Research of NIST reports NIST research and development in metrology and related fields of: physical science, engineering, applied mathematics, statistics, biotechnology, and information technology.

Exhibit 36

Department of Commerce
National Institute of Standards and Technology
AVERAGE SALARY

	2014 Estimate	2015 Estimate	2016 Estimate
Average ES salary	$174,812	$176,560	$178,855
Average scientific and professional	174,954	176,704	179,001
Average Career Path Salary	109,526	110,621	112,059
Average salary of ungraded positions	57,436	58,010	58,764

FY 2015 average salaries reflects the 1.0% payraise and FY 2016 reflects the 1.3% payraise.

DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
NTIS Revolving Fund
Budget Estimates, Fiscal Year 2016
President's Submission

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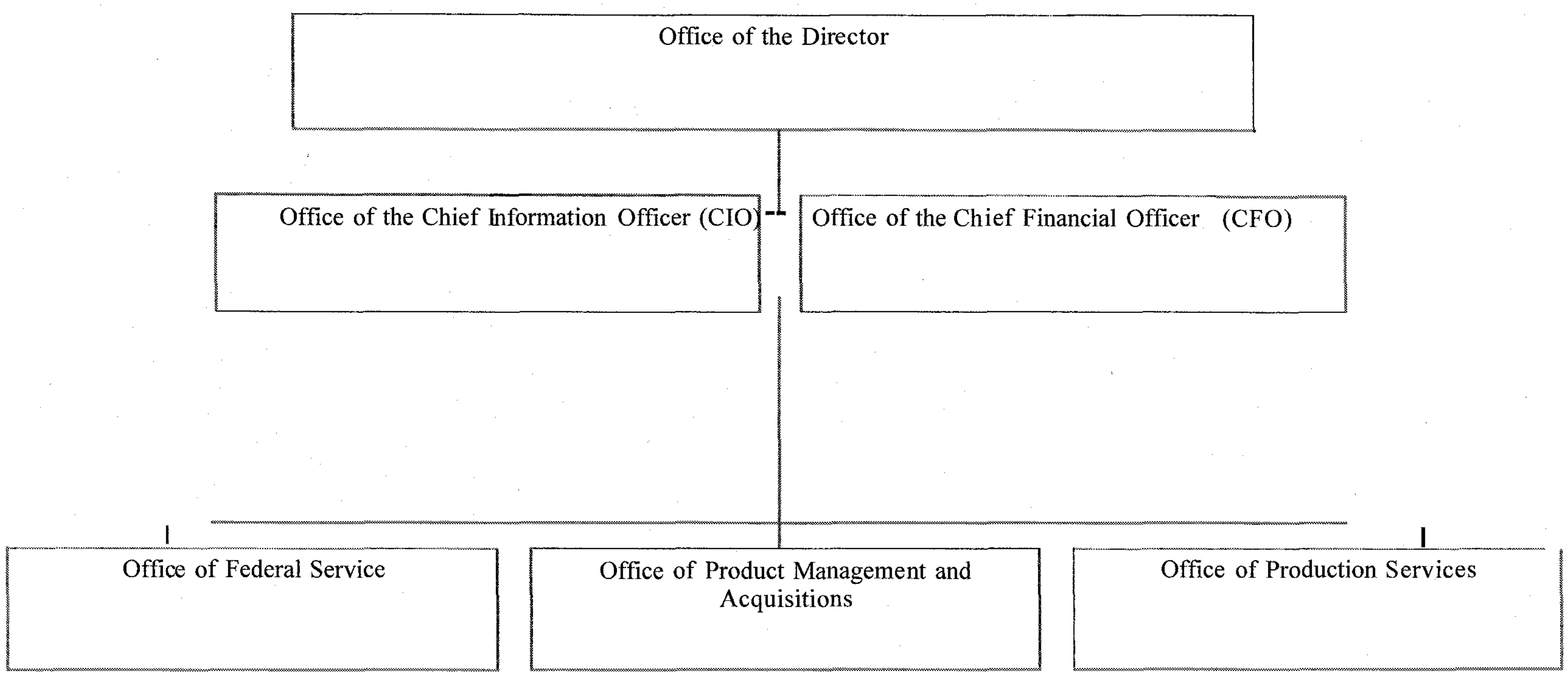
Exhibit 2

Department of Commerce
National Technical Information Service



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Department Of Commerce National
Technical Information Service NTIS
Revolving Fund
Budget Estimates, Fiscal Year 2016
President's Submission

General Statement

Goals of the Program

The National Technical Information Service (NTIS) seeks to promote innovation and economic growth by (a) collecting, classifying, coordinating, integrating, recording and cataloging scientific and technical information from whatever sources, domestic and foreign, that may be available, (b) disseminating this information to the public, and (c) providing information management services to other Federal agencies that help them interact with and better serve the information needs of their own constituents, and to do all without appropriated funds.

Statement of Objectives

NTIS' principal objective supports the Department's strategic plan to promote U.S. innovation and industrial competitiveness by providing business and industry, academia and the general public easy access to scientific and technical research and to ensure that such research is permanently available to future generations of researchers. To this end, NTIS acquires information products from agencies; abstracts, catalogs and indexes them so that they can easily be identified and merged into NTIS' permanent bibliographic database; and physically stores them or scans them into electronic image for reproduction on demand by customers.

NTIS' objectives are to (a) make it easier for the general public to locate federal technical information electronically; (b) build an array of collaborative working arrangements with private sector partners; (c) help other federal agencies meet their own information management and dissemination requirements; and (d) meet objectives in the most cost effective and efficient manner possible.

NTIS has demonstrated innovative achievements in its information dissemination activities as provided in the National Technical Information Act of 1988, codified in 15 U.S.C. 3704b. This Act directed NTIS to "implement new methods or media for the dissemination of scientific and technical, and engineering information." Supporting this directive, NTIS, as part of its base program and without appropriations, made its bibliographic database since 1990 available on the Internet, making the collection more widely available to the public and allowing customers to download products electronically. During FY 2016 those efforts will continue to be expanded and refined as analysis of the activities warrant. In this continuing effort, NTIS continues to follow all Administration policies restricting access to information that could be used improperly.

Summary of Performance and Resources

NTIS continues to make substantial progress in improving its service to the public. NTIS collects approximately 30,000 scientific and technical reports annually that are added to its permanent collection. NTIS also makes available to the public another 648,299 items in the form of articles, updates, advisories, etc., that are contained in various subscription products and/or databases it distributes. NTIS' activities and accomplishments continue to support its basic public purpose of serving as a comprehensive point of access and dissemination to federally-funded scientific, technical and related information.

The explosive growth of the Internet has provided NTIS with a unique opportunity to expand its information dissemination activities. Information products are disseminated in a variety of formats, including paper, microfiche, diskettes, audio-visual, CD-ROM, database leases, web site hits and electronic downloads. NTIS estimates it will provide approximately 53.9 million information items to the public in FY 2016.

NTIS plans to obligate $122,000 of earned revenue in FY 2016.

(Dollar amounts in thousands)

	FY 2014	FY 2015	FY 2016
National Technical Information Service:			
Reimbursement from offsetting collections:			
Information clearinghouse program	$109,659	$169,569	$122,000
Total, NTIS	$109,659	$169,569	$122,000

Note: Reimbursable Budget Authority, receipt and obligation data are estimates. Actuals will vary depending on products and services sold.

Department of Commerce
National Technical Information Service
NTIS Revolving Fund
SUMMARY OF REIMBURSABLE OBLIGATIONS
(Dollar amounts in thousands)

Activity: National Technical Information Service
Subactivity: Information Clearinghouse Program

	2014 Actual		2015 Enacted		2016 Base		2016 Estimate		Increase/ (Decrease) over 2016 Base	
Line Item	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount
National Technical Information Service: Information Clearinghouse Program	99	$109,659	150	$169,569	150	$122,000	150	$122,000	0	0
Total	99	$109,659	150	$169,569	150	$122,000	150	$122,000	0	0

Department of Commerce
National Technical Information Service
NTIS Revolving Fund
SUMMARY OF FINANCING
(Dollar amounts in thousands)

	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) Over 2016 Base
Total Obligations	$109,659	$169,569	$122,000	$122,000	0
Offsetting collections from:					
Federal funds	(97,238)	(155,769)	(108,200)	(108,200)	0
Trust funds	0	0	0	0	0
Non-Federal sources	(9,355)	(13,800)	(13,800)	(13,800)	0
Recoveries	0	0	0	0	0
Unobligated balance, start of year	(10,749)	(14,569)	(10,749)	(10,749)	0
Unobligated balance transferred	0	0	0	0	0
Unobligated balance, end of year	14,569	14,569	10,749	10,749	0
Budget Authority	0	0	0	0	0
Financing:					
Transfer from other accounts (-)	0	0	0	0	0
Transfer to other accounts (+)	0	0	0	0	0
Appropriation	0	0	0	0	0

Object Class

Department of Commerce
National Technical Information Service
NTIS Revolving Fund - Reimbursable Obligations
SUMMARY OF REQUIREMENTS BY OBJECT CLASS
(Dollar amounts in thousands)

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) over2016 Base
11.1	Full-time permanent (Compensation)	$ 9,118	$ 13.750	$ 13,888	$ 13,888	0
11.3	Other than full-time pem1ancnt	150	150	150	$ 150	0
11.5	Other personnel compensation	95	116	116	$ 116	0
11.8	Special personnel services payments	0	0	0	0	0
11.9	Total personnel compensation	9,363	14,016	14,154	14,154	0
12.1	Civilian personnel benefits	2,983	4,725	4,725	$ 4,725	0
13	Benefits for former personnel	0	0	0	0	0
21	Travel and transportation of persons	101	200	200	$ 200	0
22	Transportation of things	1,276	3,250	3,250	$ 3.250	0
23.1	Rental payments to GSA	1,895	1,950	1,950	$ 1,950	0
23.2	Rental payments to others	198	1,000	1,000	$ 1,000	0
23.3	Communications, utilities and miscellaneous charges	457	1,800	1,800	$ 1,800	0
24	Printing and reproduction	281	4,000	4,000	$ 4.000	0
25.1	Consulting services	48	100	100	$ 100	0
25.2	Other services	89,234	131,528	83,821	$ 83,821	0
25.3	Purchases of goods and services from Government accounts	1,345	1,500	1,500	$ 1,500	0
25.4	Operation of GOCOs	0	0	0	0	0
25.5	Research and development contracts	0	0	0	0	0
25.7	Operation and Maintenance of Equipment	1,017	500	500	$ 500	0
26	Supplies and materials	495	3.000	3,000	$ 3,000	0
31	Equipment	966	2,000	2,000	$ 2,000	0

Department of Commerce
National Technical Information Service
NTIS Revolving Fund - Reimbursable Obligations
SUMMARY OF REQUIREMENTS BY OBJECT CLASS
(Dollar amounts in thousands)

	Object Class	2014 Actual	2015 Enacted	2016 Base	2016 Estimate	Increase/ (Decrease) over 2016 Base
41	Grants, subsidies and contributions	0	0	0	0	0
42	Insurance claims and indemnities	0	0	0	0	0
43	Interest and dividends	0	0	0	0	0
44	Refunds	0	0	0	0	0
99	Total Obligations	109,659	169,569	122,000	122,000	0
	Earned Revenue/Reimbursable Obligations	109,659	169,569	122,000	122,000	0
	Total Obligations	109,659	169,569	122,000	122,000	0
	Personnel Data					
	Full-Time equivalent Employment:					
	Full-time permanent	98	145	145	145	0
	Other than full-time permanent	1	5	5	5	0
	Total	99	150	150	150	0
	Authorized Positions:					
	Full-time permanent	190	190	190	190	0
	Other than full-time permanent	10	10	10	10	0
	Total	200	200	200	200	0

Department of Commerce
National Technical Information Service
NTIS Revolving Fund
CONSULTING AND RELATED SERVICES
(Obligations in thousands)

	2014 Actual	2015 Estimate	2016 Estimate
Consulting Services	$48	$100	$100
Management and professional services	0	0	0
Special studies and analysis	0	0	0
Management and Support Services for research and development	0	0	0
Total	$48	$100	$100

Department of Commerce National
Technical Information Service NTIS
Revolving Fund
PERIODICALS, PAMPHLETS, AND AUDIOVISUAL PRODUCTS
(Obligations in thousands)

	2014 Actual	2015 Estimate	2016 Estimate
Periodicals	$2	$2	$2
Pamphlets	0	0	0
Audiovisuals	0	0	0
Total	$2	$2	$2

Department of Commerce National
Technical Information Service NTIS
Revolving Fund
AVERAGE GRADE AND SALARIES
(Obligations in thousands)

	2014 Actual	2015 Estimate	2016 Estimate
Average GS/GM Grade..	12.6	12.7	12.8
Average GS/GM Salary	$92,386	$92,426	$92,611

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FY 2016 Annual Performance Plan / FY 2014 Annual Performance Report

National Technical Information Service

Part 1: Agency and Mission Information

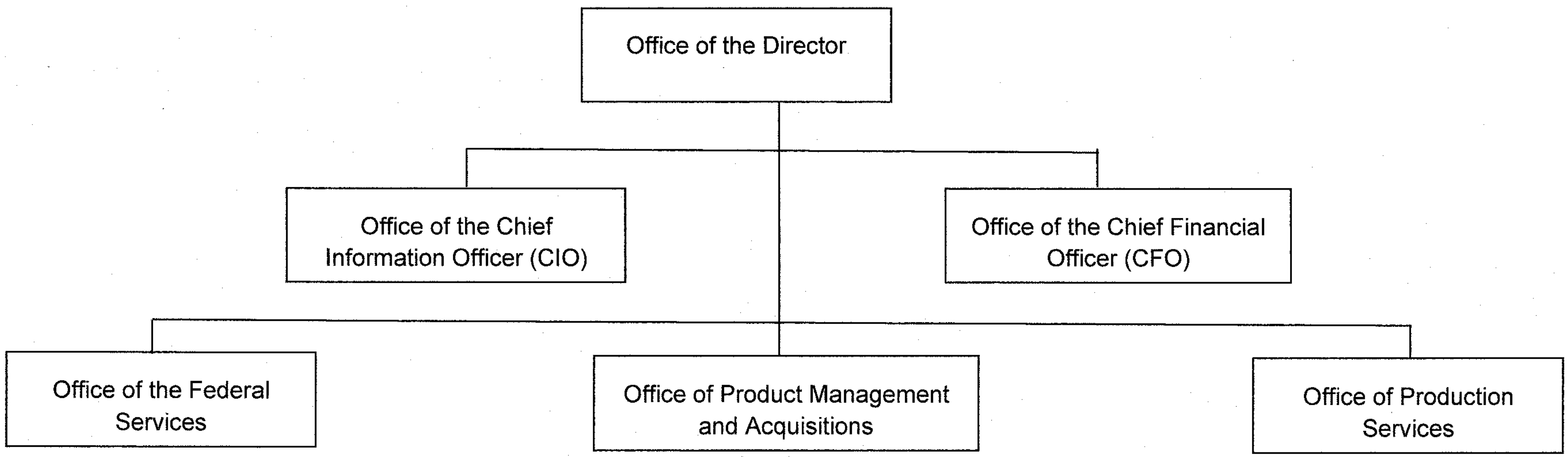
Section 1.1: Overview

NTIS provides the American public with permanent and ready access to scientific, technical, and business research through the acquisition, organization, and preservation of technical reports and information added to its permanent collection. NTIS collects, classifies, coordinates, integrates, records, and catalogs scientific and technical information from whatever sources, foreign and domestic, that may stimulate innovation and discovery and then disseminates that information to the public. In an effort to provide the American public with increased access to the vast collection of government information, NTIS utilizes advanced e-commerce channels, including providing downloads of any item in its collection that is in electronic format at no charge to the American public. NTIS also helps other Federal agencies interact with and better serve the information needs of their own constituents by providing information management services to the agency or to the public on behalf of the agency.

Section 1.2: Mission Statement

The National Technical Information Service (NTIS) seeks to support the nation's economic growth and technology use by bringing scientific and technical information to U.S. business and industry. NTIS promotes innovation and economic growth for U.S. business by (1) collecting and cataloging scientific and technical information from a variety of sources, foreign and domestic; (2) disseminating this information to the public; and (3) providing information management services to other federal agencies that help them interact with and better serve the information needs of their own constituents, and to accomplish this without direct appropriated funds.

Section 1.3: Organizational Structure



Part 2: Cross-Agency Priority Goals

Section 2.1: Overview

NTIS is not a leader of or a participant in any Cross-Agency Priority Goals.

Part 3: Strategic Goals and Objectives

Section 3.1: Corresponding DoC Strategic Goals, and Objectives

According to the structure of the new strategic plan, state the goals, objectives, objective numbers and the title and office of the person responsible for achievement of a given objective to which the bureau's programs apply in the form of a table as shown below. Program names are not stated here.

Goal	Objective Number	Objective Name	Leader
Strategic Goal 4 – Data: Improve government, business, and community decisions and knowledge by transforming Department data capabilities and supporting a data-enabled economy	4.1	Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.	Access to Federal STEI, Bruce Borzino, NTIS Director

Section 3.2: *Strategies for Objectives*

NTIS' principal objective supports the Department's strategic plan to promote U.S. innovation and industrial competitiveness by providing business and industry, academia and the general public easy access to scientific and technical research and to ensure that such research is permanently available to future generations of researchers. To this end, NTIS acquires information products from agencies; abstracts, catalogs and indexes them so that they can easily be identified and merged into NTIS' permanent bibliographic database; and physically stores them or scans them into electronic image for reproduction on demand by customers.

NTIS' objectives are to (a) make it easier for the general public to locate federal technical information electronically; (b) build an array of collaborative working arrangements with private sector partners; (c) help other federal agencies meet their own information management and dissemination requirements; and (d) meet objectives in the most cost effective and efficient manner possible.

Section 3.3: *Progress Update for Strategic Objectives*

NTIS has demonstrated innovative achievements in its information dissemination activities as provided in the National Technical Information Act of 1988, codified in 15 U.S.C. 3704b. This Act directed NTIS to "implement new methods or media for the dissemination of scientific and technical, and engineering information." Supporting this directive, NTIS, as part of its base program and without appropriations, made its bibliographic database since 1990 available on the Internet, making the collection more widely available to the public and allowing customers to download products electronically. Those efforts will continue to be expanded and refined as analysis of the activities warrant. In this continuing effort, NTIS continues to follow all Administration policies restricting access to information that could be used improperly.

Section 3.4: *Next Steps*

The explosive growth of the Internet has provided NTIS with a unique opportunity to expand its information dissemination activities. Information products are disseminated in a variety of formats, including paper, diskettes, audio-visual, CD-ROM, database leases, web site hits and electronic downloads.

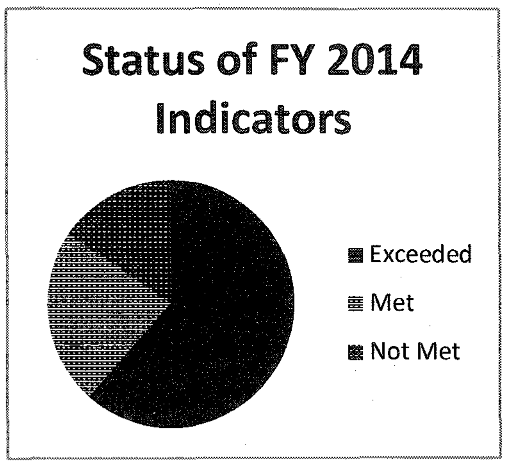
Part 4 Performance Goals / Indicators

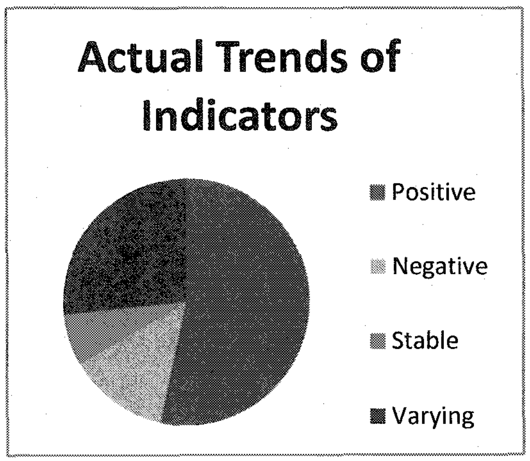
Section 4.1: Summary of Performance

Status is based on the following standard:

Exceeded	More than 100 percent of target
Met	90 - 100 percent of target
Not Met	Below 90% of target

An indicator with a positive trend is one in which performance is improving over time while a negative trend is an indicator that has declining performance. A stable trend is one in which the goal is to maintain a standard, and that that is occurring. A varying trend in one in which the data fluctuates too much to indicate a trend. At a minimum these indicators must have three years of data.





Section 4.2: Summary of Indicator Performance

Objective 4.1: Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.

Indicator	Target	Actual	Status	Trend
Number of Updated Items Available	910,350	648,299	Not Met	Positive
Number of Information Products Disseminated (Annual)	51,893,071	51,901,102	Exceeded	Positive

Section 4.3 Detailed Indicator Plans and Performance

Objective 4.1: Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.

Indicator	**Measure 1A. Number of Updated Items Available**							
Description	The number of items available for sale to the public from NTIS includes scientific, technical, and engineering information products added to the permanent collection, as well as items made available through online electronic subscriptions.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	745,000	765,000	825,000	875,000	892,500	910,350	430,000	440,750
Actual	893,138	969,473	836,579	978,871	987,866	648,299		
Status	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	Not Met		
Trend	Positive							
Explanation (if not met in FY 2014)	World New Connection (WNC) discontinued in FY2014							
Actions to be taken / Future Plans	Revise Target							
Adjustments to targets	Remove WNC from target							
Notes	WNC is approximately half of the target.							

Validation and Verification	
Data Source	NTIS operates and maintains internal systems for collection acquisition statistics.
Frequency	Data is available daily. Reports are produce monthly.
Data Storage	All data is stored within NTIS systems
Internal Control Procedures	NTIS' accounting and budget offices analyze and report performance data to management. Data verification is provided through regular internal and independent auditor reporting.
Data Limitations	Output Only
Actions to be Taken	None

Indicator	Measure 1B. Number of Information Products Disseminated (Annual)							
Description	This measure represents information disseminated and includes compact disks, diskettes, tapes, online subscriptions, electronic document downloads, web site pages, as well as traditional paper products.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	32,850,000	33,000,000	47,800,000	48,878,000	50,875,560	51,893,071	52,910,932	53.900,000
Actual	49,430,840	50,333,206	48,958,993	54,592,481	68,938,571	51,901,102		
Status	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded		
Trend	Positive. Both Actuals and Targets have risen each year.							

Validation and Verification	
Data Source	A modified commercial order processing system and standard Web analysis software package used by industry.
Frequency	Internal management activity reports are produced daily, summaries are produced monthly.
Data Storage	All data is stored within NTIS systems
Internal Control Procedures	NTIS' accounting and budget offices analyze and report performance data to management. Data verification is provided through regular internal and independent auditor reporting.
Data Limitations	Output Only
Actions to be Taken	None

Indicator	Measure 1C. Customer Satisfaction							
Description	This measure represents the percentage of NTIS customers that are satisfied with the quality of their order, the ease of order placement, and the timely fulfillment of that order. NTIS' continual efforts to maintain and possibly improve this very high rate of customer satisfaction are essential to the success of NTIS' performance and mission to collect and disseminate scientific and business-related information.							
	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Target	95-98%	95-98%	95-98%	95-98%	95-98%	95-98%	95-98%	95-98%
Actual	98%	98%	99.5%	98.4%	98.5%	98.3%		
Status	Met	Met	Met	Met	Met	Met		
Trend	Targets have remained stable. Actuals have slightly risen each year.							

Validation and Verification	
Data Source	A modified commercial order processing system.
Frequency	Internal management activity reports are produced daily, summaries are produced monthly.
Data Storage	All data is stored within NTIS systems
Internal Control Procedures	NTIS' accounting and budget offices analyze and report performance data to management. Data verification is provided through regular internal and independent auditor reporting.
Data Limitations	None
Actions to be Taken	None

Part 5: Other Indicators

None

Part 6: Agency Priority Goals

None

Part 7: Resource Requirements Table

Funding for the Resource Requirements table reflects total direct obligations. Reimbursable obligations are included insofar that amounts can be reasonably be predicted with little variance from year to year, and could reasonably affect the performance of indicators. Funding and FTE appear at the objective level. Do not include IT funding (which is no longer required).

	FY 2009 Actual	FY 2010 Actual	FY 2011 Actual	FY 2012 Actual	FY 2013 Actual	FY 2014 Actual	FY 2015 Estimate	FY 2016 Base	Increase / Decrease	FY 2016 Request
Objective 4.1: Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public.										
National Technical Information Service										
Total Funding										
Direct										
Reimbursable	$42,000	$42,500	$65,000	$65,500	$66,000	$109,659	$169,569	$122,000	$0	$122,000
Total										
Total FTE	150	150	150	150	150	99	150	150	0	150

Part 8: Other Information

Section 8.1: Major Management Priorities, Challenges, and Risks

NTIS provides the American public with permanent and ready access to scientific, technical, and business research through the acquisition, organization, and preservation of technical reports added to its permanent collection. NTIS collects, classifies, coordinates, integrates, records, and catalogs scientific and technical information from whatever sources, foreign and domestic, that may stimulate innovation and discovery and then disseminates that information to the public. In an effort to provide the American public with increased access to the vast collection of government information, NTIS utilizes advanced e-commerce channels, including providing downloads of any item in its collection that is in electronic format at no charge. NTIS also helps other Federal agencies interact with and better serve the information needs of their own constituents by providing information management services to the agency and to the American public on behalf of the agency. Under Section 203 of the Bipartisan Budget Act of 2013, Congress directed the Secretary of Commerce to establish a certification program for access to the Social Security Administration's Death Master File (DMF). The Secretary has delegated this responsibility to the Director, NTIS.

NTIS has demonstrated innovative achievements in its information dissemination activities as provided in the National Technical Information Act of 1988, codified in 15 U.S.C. 3704b. This Act directed NTIS to "implement new methods or media for the dissemination of scientific and technical, and engineering information." Supporting this directive, NTIS, as part of its base program and without appropriations, made its bibliographic database since 1990 available on the Internet, making the collection more widely available to the public and allowing customers to download products electronically. Additionally, on July 23, 2014, NTIS initiated an open access program to make electronic technical reports in its repository available to the American public free of charge. Those efforts will continue to be expanded and refined as analysis of the activities warrant. In this continuing effort, NTIS continues to follow all Administration policies restricting access to information that could be used improperly. On March 26, 2014, NTIS published an interim final rule, "Temporary Certification Program for Access to the Death Master File," that established the interim DMF certification program.

Section 8.2: Cross-Agency Collaborations

NTIS is not involved in any cross agency collaborations.

Section 8.3: Evidence Building

NTIS completed no evaluations in FY 2014.

Section 8.4: Hyperlinks

N/A.

Section 8.5: Data Validation and Verification

The FY 2014 Summary of Performance and Finance Information includes in the Secretary's Statement, an assessment of the reliability and completeness of the Department's performance data.

Section 8.6: Lower-Priority Program Activities

The President's Budget identifies the lower-priority program activities, where applicable, as required under the GPRA Modernization Act, 31 U.S.C. 1115(b)(10). The public can access the volume at: http://www.whitehouse.gov/omb/budget.