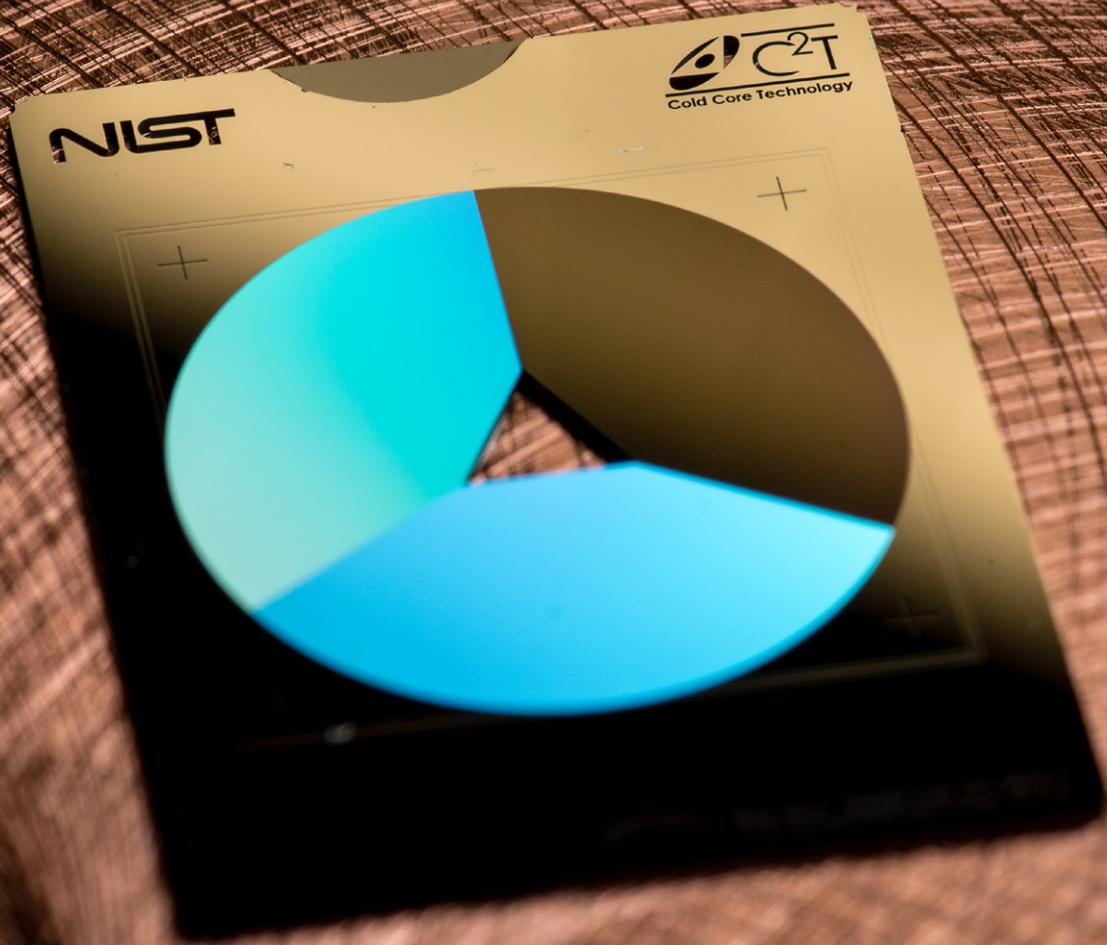


PRESIDENT'S FY 2020 BUDGET REQUEST TO CONGRESS

FOR THE NATIONAL INSTITUTE OF
STANDARDS AND TECHNOLOGY



Letter from the Director



I am honored to be the 16th Director of the National Institute of Standards and Technology (NIST). This Institute, tracing its roots to Article 1 of the U.S. Constitution, likely has the broadest portfolio of research and development in the world.

We are the nation's measurements experts. As America's national metrology institute, all measurements needed to confidently buy and sell products across the nation and in global trade, and to advance science and technology for the United States, trace back to NIST's state-of-the-art laboratories.

Think of any major technology on which you depend every day. NIST played an essential role in making it possible: computers, GPS, cell phones, aircraft, automobiles, buildings, pharmaceuticals.... For all technologies important to

commerce, NIST provides the measurements, standards, reference materials and data, in collaboration with industry, academia and governments, to establish a foundation of trust.

This past year has been truly historic for NIST. In November 2018, I was privileged to lead the U.S. delegation at a convocation of over 50 countries in Versailles, France. The nations voted unanimously to implement the most significant change to the International System of Units in 130 years. Beginning on May 20, 2019, all measurement units will be defined by natural phenomena rather than by physical artifacts. Made possible by decades of world-leading research by NIST, and collaborations with other national metrology institutes around the globe, this change will extend quantum-based measurement precision to a host of technologies and enable future innovations we can only imagine today.

NIST has been instrumental in unleashing American innovation through its extensive work this year to modernize technology transfer. A widely distributed green paper, created as part of the President's Management Agenda, details recommended steps to improve how America moves new discoveries arising from federally funded research from lab to market—a critical process for economic growth. The NIST findings, based upon extensive interactions with industry, academic and government experts, promise to dramatically enhance our nation's returns on investment from the \$175+ billion of federally funded research each year.

This budget request ensures NIST can continue its great work in advancing its core mission. It supports NIST's strength—paving the way to tomorrow's technology—with special emphasis on the important fields of quantum science and artificial intelligence. We're also committed to advancing knowledge and standards development in cybersecurity, privacy, communications, advanced manufacturing, next generation microelectronics, and many other fields.

NIST's work is central to U.S. innovation, critical to the success of products and services from U.S. businesses in the global marketplace, and to American jobs. We work every day to advance U.S. industrial competitiveness. NIST looks forward to pushing the boundaries of measurement science toward new standards and technology horizons in 2020 and beyond.

Sincerely,

A handwritten signature in black ink, which appears to read "Walter G. Copan". The signature is fluid and cursive.

Dr. Walter G. Copan
Under Secretary of Commerce for Standards and Technology &
Director, National Institute of Standards and Technology

Introduction

The National Institute of Standards and Technology (NIST) promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. For more than 115 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.

This budget request is consistent with the administration's priorities to redirect domestic discretionary resources to rebuild the military and make critical investments in the nation's security, and to keep the nation on a responsible fiscal path.

The **Scientific and Technical Research and Services (STRS)** account funds NIST's Laboratory Programs. Because technology discovery, refinement and commercialization rely on the ability to measure key attributes, NIST Laboratory Programs' measurement research and services are central to American innovation, productivity, trade, national security and public safety.

The **Industrial Technology Services (ITS)** account supports NIST's extramural programs. Manufacturing USA creates robust research infrastructure for U.S. industry and academia to solve industry-relevant problems. The budget request discontinues federal funding for the Hollings Manufacturing Extension Partnership program.

The **Construction of Research Facilities (CRF)** account funds the maintenance, repair, improvements, and major renovation of NIST facilities. While some progress has been made, the current state of NIST's facilities and failing infrastructure remain a serious concern to NIST's ability to deliver its mission.

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NIST computer scientist Megan Zimmerman and colleagues have trained a robot to recognize when a human coworker is paying attention while working on a task together. Here, Zimmerman streams a video feed to the robot to show if the human is paying attention. Boxes around the face show how sure the robot is that the human is attentive or inattentive. The robot will stop moving in the human's space if it determines the human is not paying attention to the task to ensure the human—and the robot's—safety.

Credit ©David Hills

Scientific and Technical Research and Services

The NIST research programs work at the frontiers of measurement science to ensure that the U.S. system of measurements is firmly grounded in sound scientific and technical principles. Today, the NIST laboratories address increasingly complex measurement challenges, ranging from the very small (nanoscale devices for advanced computing) to the very large (vehicles and buildings), and from the physical (resilient infrastructure) to the virtual (cybersecurity and data science). As new technologies develop and evolve, NIST's measurement research and services remain central to national defense, homeland security, trade and innovation.

NIST's Scientific and Technical Research and Services (STRS) activities provide industry, academia and other federal agencies with world-class research capabilities in measurement science that form the foundation of the global system of weights and measures and enable innovation. They supply basic and applied measurements, calibrations and standards that impact every aspect of our economy and lives, from the accuracy of airplane altimeters to the reliability of clinical measurements and the strength of the encryption technologies that protect our digital lives and businesses. They lend unbiased technical support to the development of open, industry-led and consensus-based documentary standards and specifications driving the deployment of advanced technologies and facilitating global commerce. NIST offers unique, cutting-edge user facilities that annually help more than 3,000 scientists from academia and industry advance the state of the art in nanotechnology, bioscience, advanced materials and other emerging technology areas.

"Building on a foundation of Federal R&D investments, America will be the nation that leads in today's emerging technologies."

*- FY 2020 Administration
R&D Budget Priorities*

Since its founding more than a century ago, NIST has sought to solve the most pressing measurement and technical challenges the nation has faced. From helping to standardize methods and materials for mass production techniques introduced during World War I to studying the collapse of the World Trade Center buildings on 9/11, NIST has sought to advance U.S. industry and security through measurement science and standards. NIST continues to provide measurement tools and standards that strengthen U.S. competitiveness and security in areas affecting Americans' daily lives.

The STRS account contains three line items: Laboratory Programs, Corporate Services, and Standards Coordination and Special Programs. To add more transparency beyond the STRS budget line item level, NIST is providing budget information by mission space as described below.

Strategic Focus Areas – Investing for the Long Term

Throughout its history, NIST has provided new industries with foundational measurement tools that enhance reproducibility, interoperability and reliability to accelerate innovation, adoption and impact. With input from academia and industry, NIST has identified four technical opportunities to support the industries of the future that are likely to significantly affect America's economy in the coming decades. NIST's ability to provide a strong and independent technical foundation for these areas may determine the future of U.S. leadership. This budget request maintains our focus on developing capabilities in each of these areas:

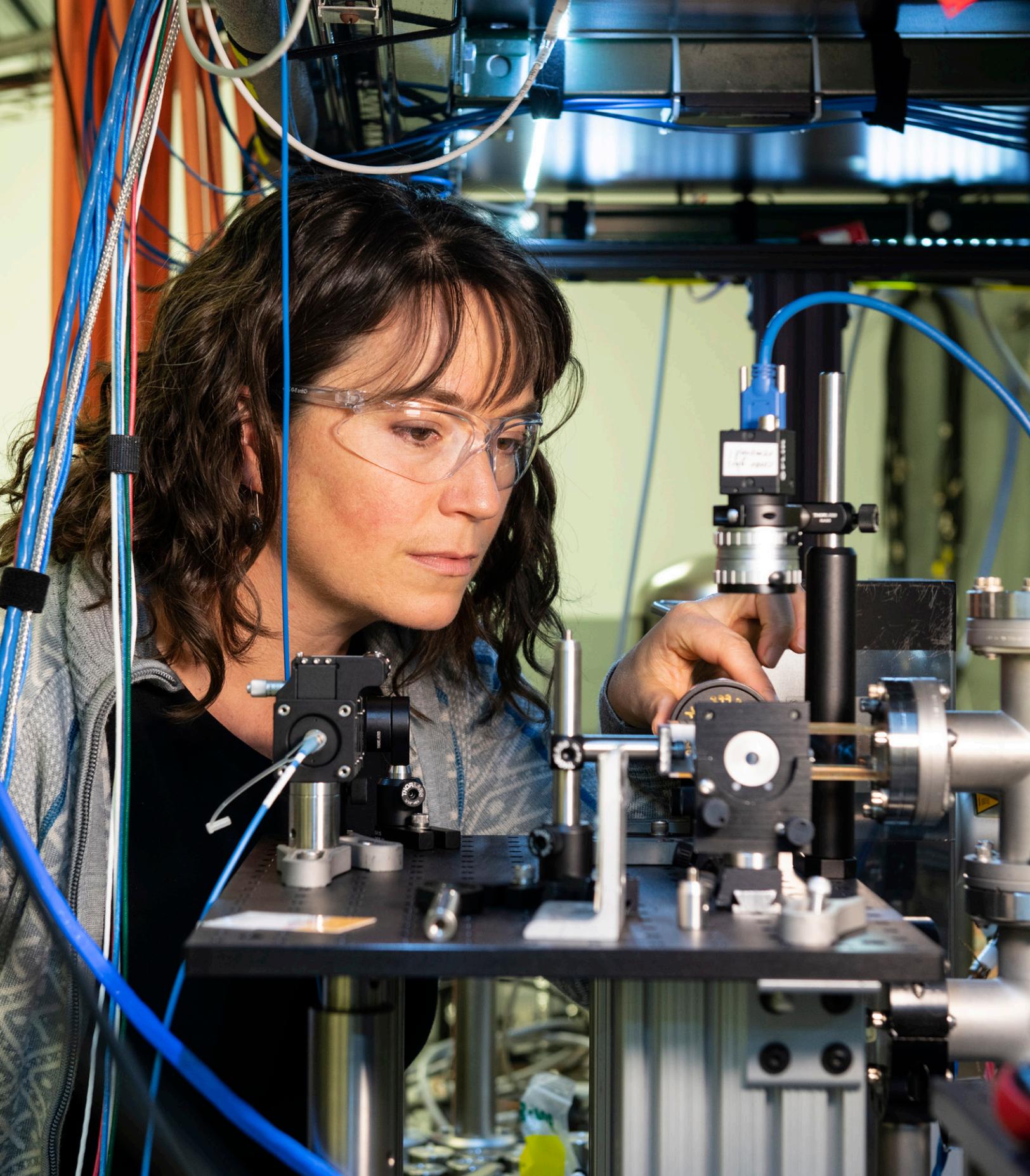
Quantum Science: NIST's world-leading expertise in quantum science, conducted with academic and industry partners, is furthering the development of new quantum measurement technologies upon which U.S. companies can build new businesses and services.

Artificial Intelligence and Data Science: NIST is developing measurements and data that address the performance and reliability of AI systems to accelerate their widespread adoption and enable the nation to realize the potential economic, societal and innovation benefits that AI systems offer.

Engineering Biology: NIST is enabling the design and manufacture of biological systems—for products such as high-value pharmaceuticals and commodity chemicals—by developing advanced measurement capabilities from the molecular to the cellular system scale.

Internet of Things: NIST is leveraging its expertise in advanced communications, manufacturing systems, cybersecurity and more to develop testing tools, best practices and standards that support the widespread deployment of safe and reliable internet of things technologies and applications.

NIST's research supports the development of technical standards that are crucial to drive innovation and applications. Over 400 NIST staff participate in international standards activities as technical experts and in leadership roles. Standards underpin every aspect of our daily lives, from enabling communication technologies such as Bluetooth and WiFi to ensuring the safety of devices such as pacemakers and step ladders. They promote confidence in the performance of products and enable international trade. The standards leadership and expertise provided by NIST is an essential element of a broader U.S. effort to lead in the emerging technologies that will define the 21st century economy.



NIST physicist Julia Scherschligt is part of the NIST-on-a-Chip program working to develop a suite of intrinsically accurate, quantum-based measurement technologies intended to be deployed nearly anywhere and anytime. These chips will allow instruments to perform work uninterrupted without the need for NIST's traditional measurement calibration services.

Credit: C. Suplee/NIST

Advanced Communications, Networks and Scientific Data Systems

NIST's Advanced Communications, Networks and Scientific Data Systems activities enable secure, reliable, high-speed wireless and wireline communications critical to U.S. economic competitiveness, safety and security. NIST measurement science research and support for the development of standards accelerates the deployment of next-generation communication technologies, including 5G, a term used to describe future wireless networks that will be faster and more reliable. These technologies will be necessary for self-driving cars, internet of things (IoT) applications, drones and future AI systems. NIST is committed to solving the measurement and deployment challenges of these fast-moving fields to help the U.S. achieve and maintain global leadership in these areas.

Budget Request

This request funds measurement science research and standards development that will strengthen the growth of IoT, smart systems and AI. NIST will consolidate efforts on its highest priority capabilities and research.

FY 2018 Enacted: \$68.6 million

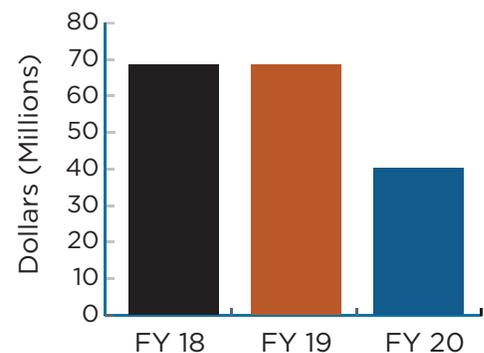
Lab Programs: \$63.9 M • Corp Serv: \$1.6 M • SC-SP: \$3.1 M

FY 2019 Enacted: \$68.6 million

Lab Programs: \$63.9 M • Corp Serv: \$1.6 M • SC-SP: \$3.1 M

FY 2020 Request: \$40.2 million (-41.4%)

Lab Programs: \$35.9 M • Corp Serv: \$1.1 M • SC-SP: \$3.2 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

- **+\$8.0 million** to expand ongoing research and measurement science efforts to promote adoption of AI technologies in the marketplace.
- **-\$37.3 million** eliminating programs addressing multiple IT and data challenges, including measurements and standards work addressing internet infrastructure protection, cloud computing, medical record interoperability, data visualization and cyber-physical systems interoperability.



The NIST Antenna Metrology Project performs measurements on advanced antenna systems operating in complex environments. For example, the Large Antenna Positioning System (pictured) is supporting the development of next-generation 5G wireless and spectrum sharing systems.

Credit: NIST

Program Highlights

The future global economy requires reliable and readily available communication capabilities that can meet skyrocketing demand for wireless data. NIST will continue to pioneer measurement science and standards for secure advanced communications, networks and data to ensure U.S. leadership in these technologies. For example:

- By **collaborating with stakeholders** across government, industry, academia and international bodies, NIST is developing standards, guidelines and measurements to address urgent communications challenges such as **implementing IoT in industrial settings** where there is significant wireless frequency interference.
- NIST organizes a **national network of federal, academic and commercial test facilities** that provides the unbiased testing, modeling and analyses to develop and deploy wireless spectrum-sharing technologies and to inform policies and regulations.
- NIST contributes to the research, standards and data required to realize the full promise of AI as an enabler of American innovation across industries and economic sectors. **NIST fosters trust in AI and machine learning** by developing standards, tests and metrics to make AI-based technologies more secure, usable, interoperable and reliable.
- As the complexity and the size of datasets increase, traditional approaches to communications simply fail to scale. NIST is working to ensure a **trusted digital world** through new approaches using machine learning to render the communication infrastructure more autonomous and able to perform more complicated tasks.

Advanced Manufacturing and Material Measurements

NIST has partnered with the U.S. manufacturing sector for more than a century and has a proven track record of delivering the tools and technical expertise that existing manufacturers and aspiring start-ups need. NIST's Advanced Manufacturing and Material Measurements activities provide industry with precision measurement technologies, tests, protocols, trusted systems and world-class scientific and engineering knowledge through targeted research across a broad portfolio—including advanced materials development, advanced sensing, biomanufacturing and smart manufacturing systems. NIST's efforts support the Administration's *Strategy for American Leadership in Advanced Manufacturing* by enabling the development of a strong U.S. manufacturing base that is essential to our economic and national security.

Budget Request

NIST requests funds to continue its efforts to ensure the U.S. remains a competitive force in advanced manufacturing, ensuring economic and national security.

FY 2018 Enacted: \$147.8 million

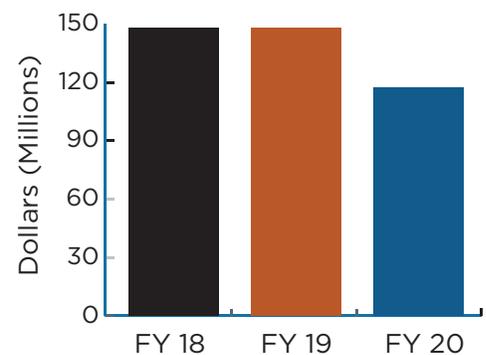
Lab Programs: \$131.9 M • Corp Serv: \$3.5 M • SC-SP: \$12.4 M

FY 2019 Enacted: \$147.9 million

Lab Programs: \$132.0 M • Corp Serv: \$3.5 M • SC-SP: \$12.4 M

FY 2020 Request: \$117.5 million (-20.1%)

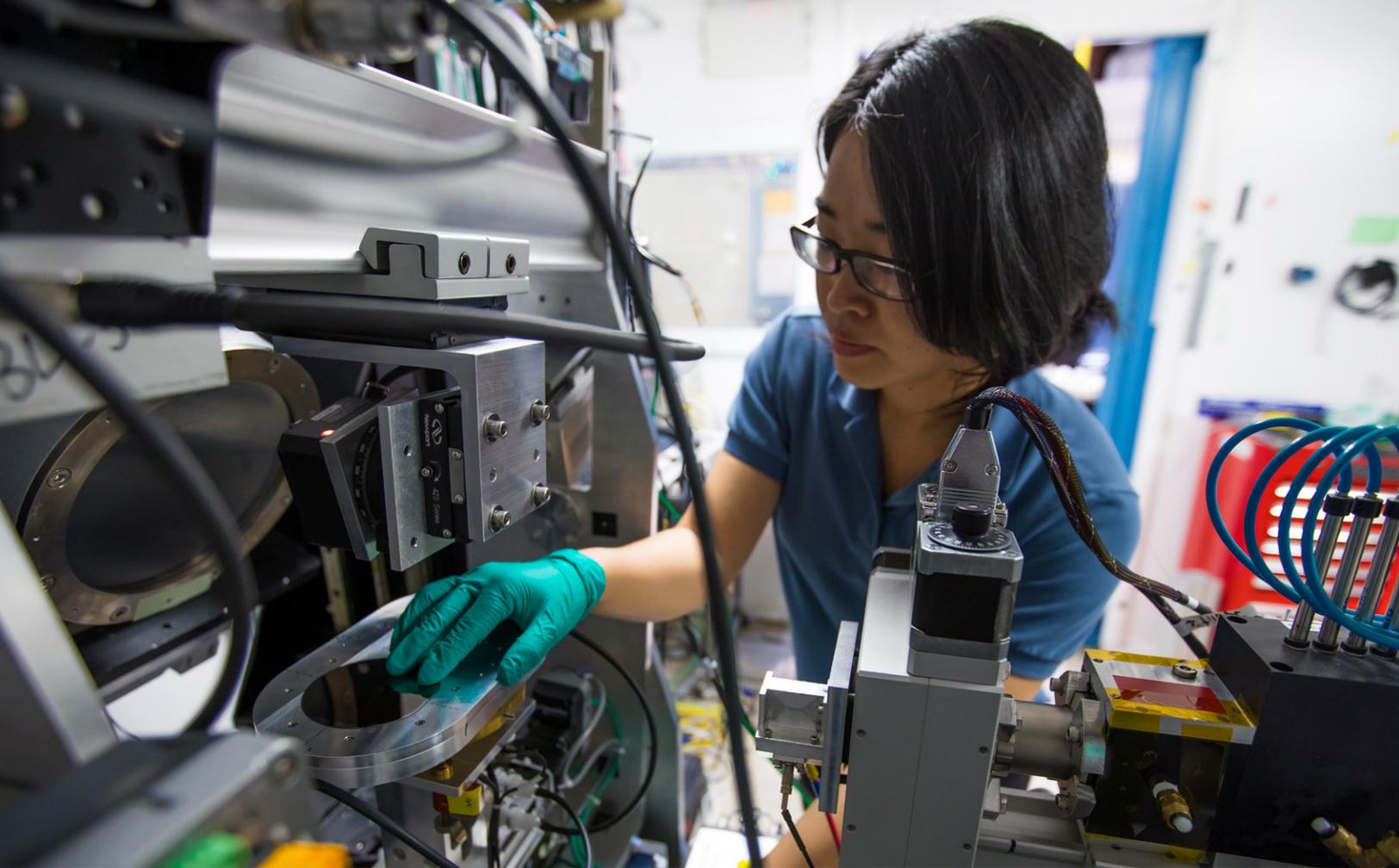
Lab Programs: \$107.4 M • Corp Serv: \$2.4 M • SC-SP: \$7.7 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

- **+\$10.0 million** to support advances and breakthroughs in measurement science, standards and material characterization by NIST that will accelerate the design, development and manufacturability of next generation microelectronics.
- **-\$42.5 million** terminating NIST's efforts addressing structural materials challenges, including reliability testing for bridges and pipelines, body armor testing, and trace materials detection. NIST will cease operation of its beamlines at Brookhaven National Laboratory, ending a decades-long investment in leading-edge materials characterization instruments, and will not support multiple standard reference materials and standard reference datasets for U.S. chemical and steel industries. NIST will eliminate funding for the Advanced Materials Center of Excellence led by Northwestern University and stop work on energy and environmental applications, including the termination of grants supporting the recycling and reuse of plastics.



Fang Ren, a postdoctoral scholar at the SLAC National Accelerator Laboratory, loads a sample into a beamline to measure the physical properties of hundreds of new metallic glasses. Northwestern University researchers in the NIST Advanced Materials Center of Excellence used an AI algorithm to determine the mixtures, which were then manufactured by NIST scientist Jae Hattrick-Sempers. The team demonstrated that combining high-throughput approaches with machine learning algorithms accelerated the discovery of new glasses for industrial applications 1,000-fold.

Credit: Dawn Harmer/SLAC National Accelerator Laboratory

Program Highlights

NIST's measurement research in manufacturing processes and advanced materials provides the foundation for the nation's manufacturers to innovate, invent and create new products and services more rapidly and more efficiently than their competitors around the world. For example:

- NIST develops standards and test methods to help industry take advantage of the **latest manufacturing robotics technologies**. This work includes technical standards for exoskeletons that can dramatically improve the performance of workers on manufacturing floors, warfighters and the individuals with mobility impairments.
- NIST partners with the pharmaceutical industry to develop widely available reference materials and measurement methods. For example, **NIST's monoclonal antibody reference material** provides a benchmark for companies to ensure quality measurements of their biological drugs and to spur biopharmaceutical innovations.
- NIST supports **large-scale manufacturing** needs by developing laser-based measurement techniques to ensure large objects such as aircraft wings are the right size for proper assembly and function.
- NIST is developing approaches to overcoming technical barriers to the **adoption of additive manufacturing** (also known as 3D printing) such as surface quality, part accuracy, material properties, real-time monitoring and process modeling.

Cybersecurity and Privacy

NIST's Cybersecurity and Privacy activities strengthen the security of our digital world through a portfolio bridging foundational and applied cybersecurity research, and through the development of publicly available standards and technical guidance. NIST's sustained outreach supports the effective application of standards and best practices enabling the adoption of practical cybersecurity and privacy approaches. Through internal research and collaboration with the private sector, academia, standards development organizations, other government agencies, and national and international stakeholders, NIST addresses the nation's current and future measurement science needs and is responsive to Congressional and Administration priorities.

Budget Request

NIST requests funds to strengthen the security of the digital systems upon which the nation's critical infrastructure is built.

FY 2018 Enacted: **\$82.8 million**

Lab Programs: \$77.7 M • Corp Serv: \$2.0 M • SC-SP: \$3.1 M

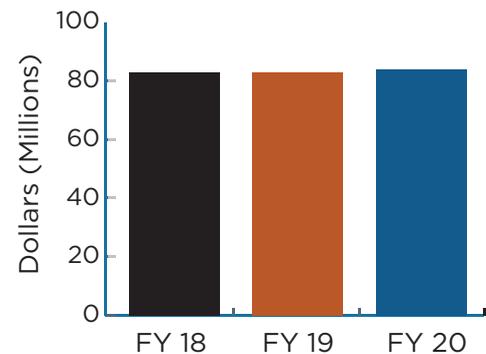
FY 2019 Enacted: **\$82.8 million**

Lab Programs: \$77.7 M • Corp Serv: \$2.0 M • SC-SP: \$3.1 M

FY 2020 Request: **\$84.0 million (+1.3%)**

Lab Programs: \$79.4 M • Corp Serv: \$1.4 M • SC-SP: \$3.2 M

Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.



No major program changes in FY 2020.

Program Highlights

The federal government, critical infrastructure sectors and all Americans increasingly depend on cyberspace. At the same time, the threats posed by criminals, certain governments and terrorists are growing in frequency and impact in an increasingly complex landscape. NIST helps our partners in the private sector, academia and government manage their risks and ensure our digital ecosystems can be sources of innovation and growth. For example:

- NIST is preparing for the future IT environment by developing methods to characterize, evaluate and ultimately improve the security of IT systems, including leading the cryptography community to develop the first **post-quantum standards**.
- The NIST **National Vulnerability Database (NVD)** is the U.S. government repository of standards-based vulnerability management data. With an average of 17 terabytes of data downloaded monthly, these data provide critical security metrics to U.S. agencies and businesses alike.



At the National Cybersecurity Center of Excellence (NCCoE), NIST brings together experts from industry, government and academia to develop cost-effective and easily deployed cybersecurity approaches based on commercially available technologies. NIST researcher Gema Howell is part of the NCCoE's Mobile Device Security Team, which develops resources like the Mobile Threat Catalogue to help organizations improve their mobile device security.

Credit: NIST

- NIST's Cybersecurity for the **Internet of Things (IoT)** program is developing technical resources and guidance to improve the cybersecurity of connected devices and the environments in which they are deployed.
- To address the nation's evolving privacy needs, particularly the sharing of personal information with software tools across the internet and through social media, NIST is developing a **Privacy Framework** for organizations to better identify, assess, manage and communicate about privacy risks.
- NIST leads the **National Initiative for Cybersecurity Education (NICE)** program in partnership with government, academia and industry to accelerate learning and skills development, nurture a diverse community, and guide career development and workforce planning.

Fundamental Measurement, Quantum Science and Measurement Dissemination

The NIST laboratory programs work at the frontiers of measurement science to ensure the U.S. system of measurements is firmly grounded on sound scientific and technical principles. NIST determines the definitive methods for nearly every kind of measurement employed in commerce and research, provides NIST-traceable calibrations, and disseminates standards and best practices throughout the nation. The NIST laboratories address increasingly complex measurement challenges as new technologies develop and evolve. NIST's measurement research and services remain central to innovation, productivity, trade, national security and public safety.

Budget Request

NIST requests funds to support core programs advancing the precision, accuracy and comparability of the measurements that underpin the U.S. economy and innovation ecosystem.

FY 2018 Enacted: \$218.4 million

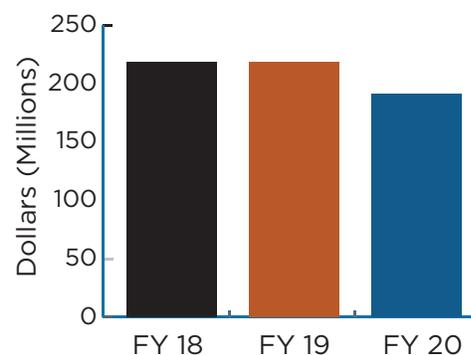
Lab Programs: \$165.6 M • Corp Serv: \$5.2 M • SC-SP: \$47.4 M

FY 2019 Enacted: \$218.3 million

Lab Programs: \$165.6 M • Corp Serv: \$5.2 M • SC-SP: \$47.4 M

FY 2020 Request: \$191.4 million (-12.3%)

Lab Programs: \$162.2 M • Corp Serv: \$3.6 M • SC-SP: \$25.6 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

- **+\$10.0 million** to prioritize NIST's efforts to establish and support an industry consortium to accelerate quantum-related research and applications, in fulfillment of the White House *National Strategic Overview for Quantum Information Science*.
- **-\$40.2 million** to stop or reduce measurements and calibrations that support customers in sectors from communications and defense to manufacturing and transportation. NIST will reduce support for the operation of the Organization of Scientific Area Committees for Forensic Science and eliminate funding for the NIST Forensic Science Center of Excellence led by Iowa State University. NIST will reduce its presence and contributions in international legal metrology, eliminate support for the Urban Dome program and reduce funding for the development of nanoscale imaging and fabrication tools not focused on advanced electronics manufacturing applications.



NIST's biorepository holds samples from a variety of marine life, including turtles, oysters, seabird eggs and many more. The samples can reveal changes in pollutants over time and place. The biorepository also contains Standard Reference Materials, which are products that are mostly used by other labs and members of industry to check their analytical measurements and perform other kinds of quality-control tests.

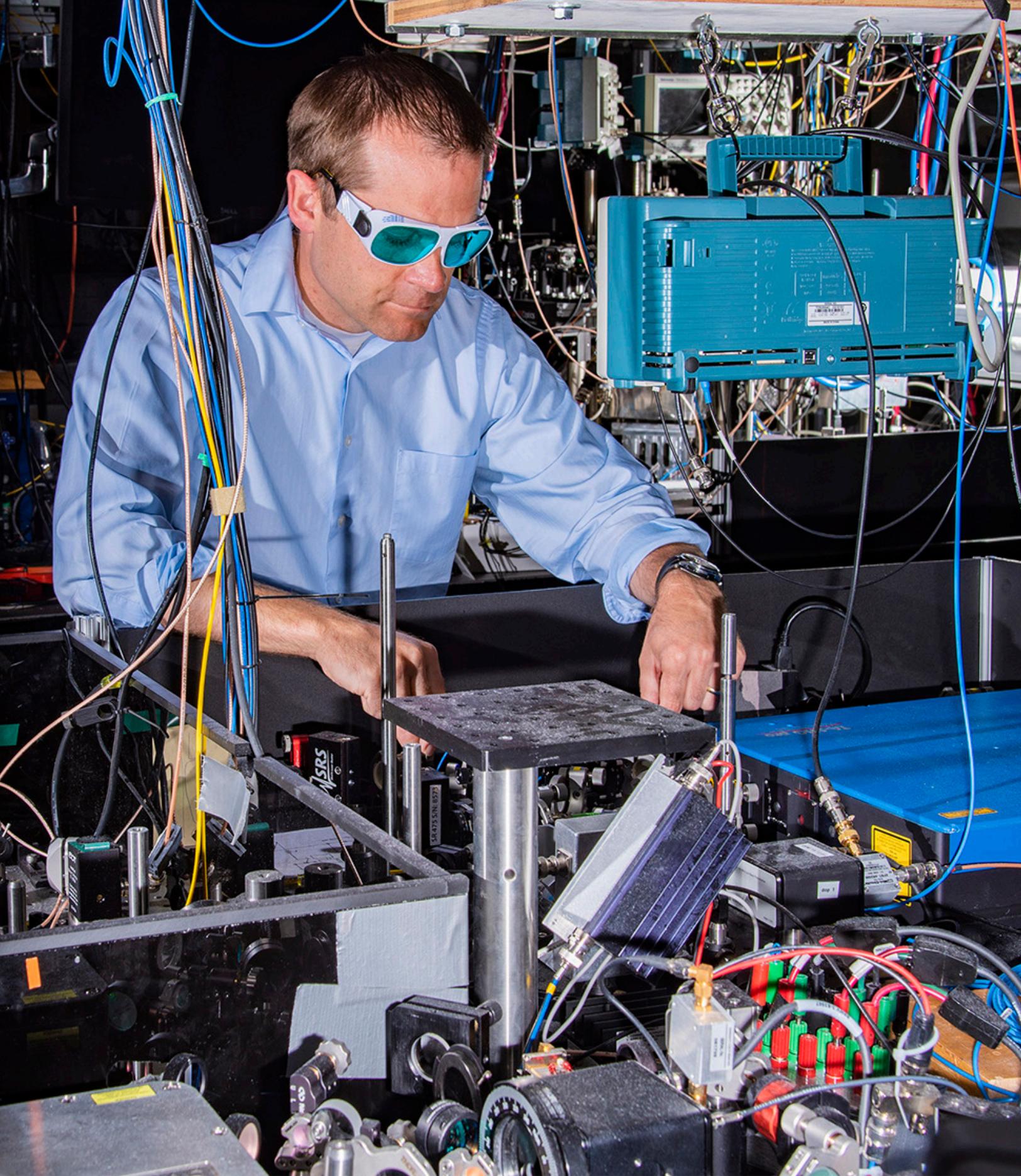
Credit: A. Holt/NIST

Fundamental Measurement, Quantum Science and Measurement Dissemination (cont.)

Program Highlights

NIST maintains and disseminates the authoritative values for the International System of Units (SI) base units in the United States, along with developing the methods and technology required to realize and/or measure each base unit to the highest possible accuracy. Typically, that endeavor results in major impacts in measurement science, as well as advanced metrology for industry, medicine, defense and homeland security, science and government. NIST Measurement Services consist of calibration services, reference materials, reference instruments and reference data that are continually improving and evolving to meet the nation's needs. For example:

- Using a NIST-designed and constructed weighing machine to measure mass using electrical currents and mechanical forces, scientists have measured the Planck constant to the highest accuracy to date. **The Planck constant (h) is used for the new definition of the kilogram**, part of the international SI redefinition that was finalized during a vote of the 26th General Conference of Weights and Measures in November 2018. The redefinition will be effective on May 20, 2019, World Metrology Day.
- NIST scientists have devised **atomic clocks** that are a **100-fold improvement in accuracy** over the current best clocks. More precise time standards will improve the navigation of spacecraft and help scientists look for variations in fundamental constants that could signal new physics. NIST's remote time and frequency measurement service delivers quality assurance to laboratories worldwide. These services reach and impact a wide variety of industrial sectors, including U.S. defense, aerospace, nuclear energy and finance.
- As the U.S. weighing and measuring systems have gone from completely mechanical devices to electronic devices, and now to electronic signals, **NIST is leading the way to ensure fairness in e-commerce**. For example, NIST recently published a draft set of standards that proposes measurements and procedures for states to ensure equal and fair regulations for both software-based ride-hailing services and traditional taxi services.
- NIST has embarked on a sweeping **NIST-on-a-Chip** program to bring measurement services out of the lab and directly to the user. NIST is developing a suite of intrinsically accurate, quantum-based measurement technologies to be transferred to the private sector, opening lab-to-market opportunities. These technologies will enable users to make precision measurements on factory floors, in hospital diagnostic centers, in commercial and military aircraft, in research labs, and ultimately, in homes and automobiles and on personal electronic devices.
- NIST recently launched the **Quantum Economic Development Consortium (QED-C)** in partnership with SRI International. QED-C aims to expand U.S. leadership in global quantum R&D and the emerging quantum industry in computing, communications and sensing. With funding from both the government and private-sector member organizations, the consortium fosters public-private sector coordination and will help determine workforce needs, provide access to technology platforms and processes, foster sharing of intellectual property, and lead other developments required to support the quantum economy.



NIST physicist Andrew Ludlow and colleagues achieved new atomic clock performance records in a comparison of two ytterbium optical lattice clocks. Laser systems used in both clocks are visible in the foreground, and the main apparatus for one of the clocks is located behind Ludlow.

Credit: J. Burrus/NIST

Health and Biological Systems Measurements

NIST is paving the way for a vibrant U.S. biotechnology market by developing measurements that enable the reproducibility of biomedical research results to ensure the efficacy and safety of treatments and ultimately increase confidence in clinical decisions. As a nonregulatory agency, NIST partners with industry and other government agencies to provide measurement science and standards that are essential for health and bioscience innovations. NIST's programs range from supporting underlying technologies and measurements for precision medicine and medical imaging to accelerating understanding in synthetic biology and genomics. New and improved measurement capabilities provide the basis for industries to harness this information for future medical technologies.

Budget Request

NIST requests funds to support innovation, safety and confidence in the nation's bioscience and health care.

FY 2018 Enacted: \$19.5 million

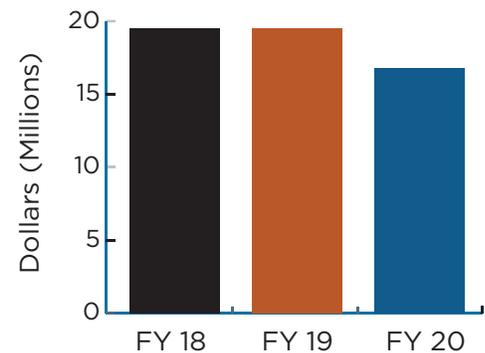
Lab Programs: \$18 M • Corp Serv: \$0.5 M • SC-SP: \$1.1 M

FY 2019 Enacted: \$19.5 million

Lab Programs: \$18 M • Corp Serv: \$0.5 M • SC-SP: \$1.1 M

FY 2020 Request: \$16.8 million (-14.0%)

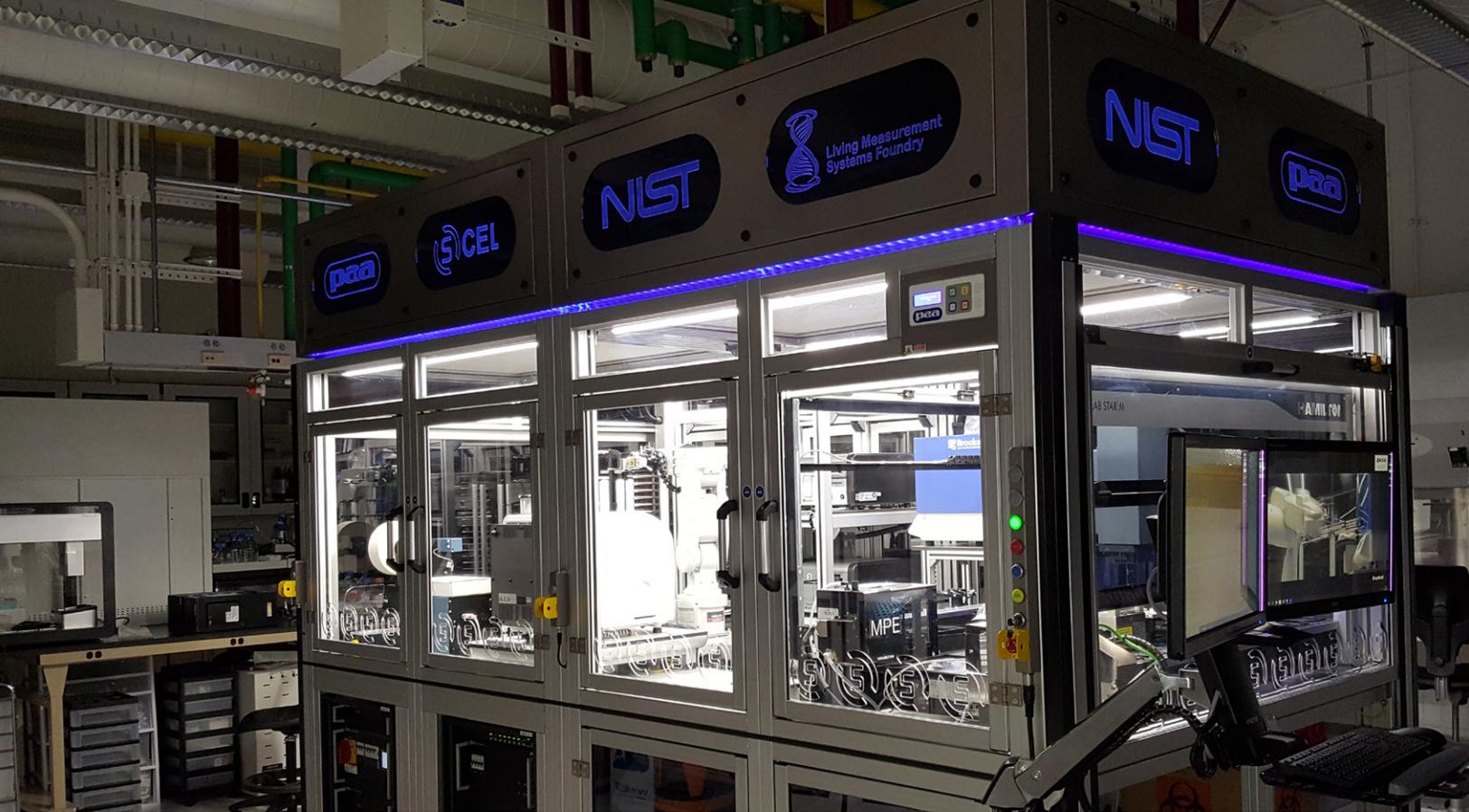
Lab Programs: \$15.4 M • Corp Serv: \$0.3 M • SC-SP: \$1.1 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

- **-\$3.0 million** to consolidate research efforts at the NIST campus in Gaithersburg, Maryland, ending support for the Joint Institute for Metrology in Biology (JIMB), a partnership with SLAC National Accelerator Laboratory and Stanford University to develop advanced measurement capabilities for the growing synthetic biology industry.



The NIST Foundry for Living Measurement Systems is a fully integrated, high-throughput system to automate common tasks in synthetic biology research from liquid handling and multi-well plate measurements to flow cytometry and nucleic acid sequencing.

Credit: NIST

Program Highlights

Breakthrough technologies such as gene sequencing, gene editing and advanced imaging have laid the foundation for significant growth opportunities in fields beyond medicine and health such as chemical manufacturing, energy and agriculture. NIST is focusing its bioscience efforts to build the measurement science capabilities that will support progress in these emerging areas. For example:

- To harness the full potential of engineering biology, NIST continues **to push the boundaries of measurement science, technology and standards** to support safe and reliable biomedical innovation. This will allow for faster development, translation and commercialization of emerging biotechnologies for diverse applications.
- NIST's role in **administering the U.S. Technical Advisory Group to ISO/TC 276 Biotechnology** has been crucial in promoting and facilitating the voluntary consensus standards necessary to ensure integrity in biotechnologies and enhance the global competitiveness of U.S. businesses.
- NIST is developing expertise in **high-throughput cell culture** and measurements of engineered microbes to establish capabilities that will enable routine, safe and reliable engineering of cells for the development of effective living therapeutics, environmental sensing and structured materials fabrication.
- NIST is advancing **quantitative medical imaging methods** through the development of standards and calibrations essential to hundreds of millions of annual medical screening procedures (X-ray, mammography, magnetic resonance, among others) in the United States. A NIST team created the first widely useful standard for magnetic resonance imaging used to monitor breast cancer.

Physical Infrastructure and Resilience

NIST's Physical Infrastructure and Resilience activities support the safety, interoperability and resilience of the nation's infrastructure at the component, structure and system levels. NIST's research supports the development of building codes that make the built environment healthier for occupants, more resilient against hazards, and safer for both residents and first responders. In collaboration with policy makers, building officials and planning groups, NIST produces guides to help communities integrate resilience into their economic development, zoning, mitigation and other local planning activities that impact buildings, public utilities and infrastructure systems.

Budget Request

NIST requests funds to develop measurement methods, reference materials and data that support innovation in the performance and resilience of the built environment.

FY 2018 Enacted: \$67.0 million

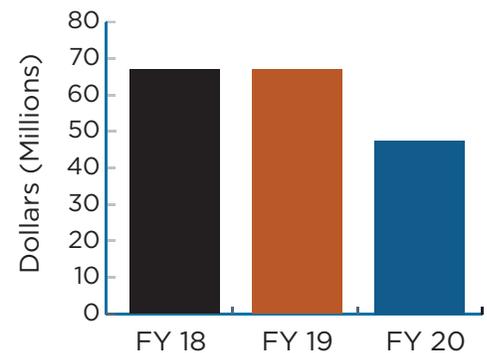
Lab Programs: \$60 M • Corp Serv: \$1.6 M • SC-SP: \$5.3 M

FY 2019 Enacted: \$67.0 million

Lab Programs: \$60 M • Corp Serv: \$1.6 M • SC-SP: \$5.3 M

FY 2020 Request: \$46.5 million (-30.6%)

Lab Programs: \$45.0 M • Corp Serv: \$1.1 M • SC-SP: \$0.4 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

- **-\$20.2 million** eliminating work on developing and deploying advances in science and technology to markedly improve building energy efficiency and occupant safety in the United States. NIST will eliminate funding for the Disaster Resilience Research Grants Program, the Fire Research Grants Program and the Community Resilience Center of Excellence led by Colorado State University.



In 2018, NIST dispatched teams across the country to evaluate infrastructure failures as a result of natural disasters, including hurricanes and wildfires. NIST recently launched a multi-year effort to study how critical buildings and emergency communications systems performed in Puerto Rico during Hurricane Maria.

Credit: Eliud Echevarria / FEMA

Program Highlights

NIST's fundamental research, standards support and measurement protocols help architects, engineers, urban planners, local governments and first responders create and maintain safer, healthier and more resilient built environments. For example:

- Using specialized equipment and advanced simulations, NIST's research into wildland urban interfaces helps firefighters and communities develop fire prevention and mitigation strategies. NIST's program includes the one-of-a-kind **National Fire Research Laboratory** with advanced measurement capabilities.
- NIST is strengthening the resilience of communities by developing resources such as the **Community Resilience Planning Guide for Buildings and Infrastructure Systems**, including interactive web-based tools to assist users of the guide.
- The **National Construction Safety Team (NCST) Act** authorizes NIST to establish and dispatch teams to investigate major infrastructure failures within 48 hours. Similarly, NIST has leadership roles in the congressionally mandated interagency **National Windstorm Impact Reduction Program** and the **National Earthquake Hazards Reduction Program**.
- NIST researchers carry out R&D to improve model building codes, voluntary standards and best practices for the design, construction and retrofit of buildings, structures and necessary services such as power, water and transportation.

Exploratory Measurement Science

NIST's mission requires deep expertise in a broad range of disciplines. To best position NIST to support U.S. technological interests well into the future, it is essential that NIST maintain a portfolio of exploratory measurement science research. This portfolio includes investing in higher-risk and potentially transformative projects selected in a competitive internal process, and the NIST National Research Council Postdoctoral Research Associateship Program that brings researchers of exceptional promise to NIST.

Budget Request

NIST requests funds to develop the next generation of cutting-edge measurement tools and technologies.

FY 2018 Enacted: **\$66.8 million**

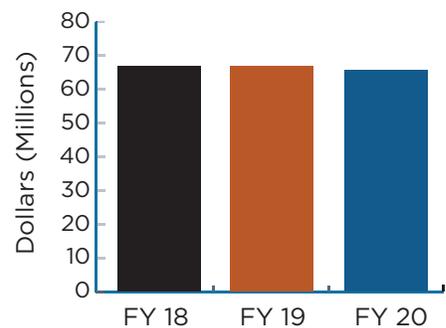
Lab Programs: \$60.8 M • Corp Serv: \$1.6 M • SC-SP: \$4.4 M

FY 2019 Enacted: **\$66.8 million**

Lab Programs: \$60.8 M • Corp Serv: \$1.6 M • SC-SP: \$4.4 M

FY 2020 Request: **\$65.7 million (-1.7%)**

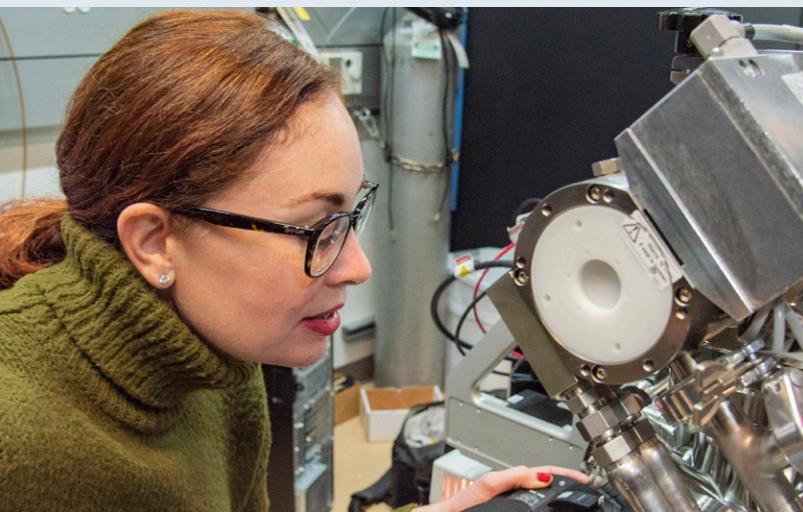
Lab Programs: \$62 M • Corp Serv: \$1.1 M • SC-SP: \$2.6 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

-\$2.0 million terminating supplementary Strategic and Emerging Research Initiatives funding to support the Joint Institute for Metrology in Biology (JIMB), a partnership with SLAC and Stanford University.



NIST engineer Ann Chiamonti Debay leads a team working on subnanometer-resolved 3D chemical mapping of atoms, which, if possible, could be worth hundreds of billions of dollars to U.S. industry.

Credit: Burrus/NIST

Program Highlights

NIST's exploratory research accelerates innovation in emerging areas. For example:

- NIST is pushing the boundaries of temperature measurement by developing a system using **magnetic nano-objects** to enable accurate measurement and control anywhere temperature plays a critical role.
- Building on its expertise in cryogenics and quantum circuits, NIST is building a small-scale **quantum network test bed** to develop standards and benchmarks for quantum technologies.

NIST User Facilities

NIST operates two unique and valuable user facilities that provide U.S. scientists with access to cutting-edge expertise and capabilities to perform innovative research beyond the reach of the user's own laboratory. The NIST Center for Neutron Research (NCNR) features world-class neutron instrumentation and expertise in the development and application of neutron measurement technologies. The Center for Nanoscale Science and Technology (CNST) provides users with rapid access to state-of-the-art tools needed to fabricate and characterize nanoscale structures, devices and materials.

Budget Request

NIST requests funds to provide unique measurement and research capabilities to U.S. scientists.

FY 2018 Enacted: **\$51.4 million**

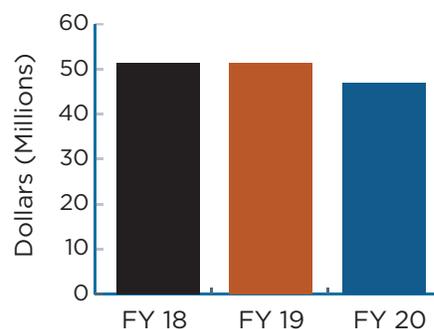
Lab Programs: \$50.1 M • Corp Serv: \$1.2 M • SC-SP: \$0 M

FY 2019 Request: **\$51.4 million**

Lab Programs: \$50.1 M • Corp Serv: \$1.2 M • SC-SP: \$0 M

FY 2020 Request: **\$47.0 million (-8.6%)**

Lab Programs: \$46.1 M • Corp Serv: \$0.9 M • SC-SP: \$0 M



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Proposed program changes in FY 2020:

- **-\$5.0 million** reducing services at the NCNR, including ceasing operation of two neutron scattering instruments and decreased funding for reactor maintenance, resulting in the loss of at least 200 research participants annually and a potential increase in unscheduled reactor shutdowns.



The CNST works closely with researchers from NIST, academia, industry and other government agencies to enable innovation in computing, quantum information science and sensing.

Credit: Kristen Dill

Program Highlights

- The NIST user facilities provide researchers from across the country with access to **state-of-the-art facilities** and instrumentation to meet user needs in neutron scattering and nanofabrication.
- Serving more than **70 U.S. companies** annually, the NIST user facilities continue to evolve to ensure that their capabilities meet the needs of the U.S. scientific community.

Technology Transfer

NIST broadly defines technology transfer as the overall process by which its knowledge, facilities or capabilities in measurement science, standards and technology promote U.S. innovation and industrial competitiveness to enhance economic security and improve quality of life.

NIST uses many different approaches to work collaboratively with industry and other organizations. Primary activities include participation on committees in Standards Developing Organizations, Cooperative Research and Development Agreements (CRADAs) and Material Transfer Agreements (MTAs), User Facilities, Postdoctoral Research Program, Guest Researchers, and conferences, seminars, and workshops. NIST offers direct work products that can be used by others, including licensing patented inventions, laboratory accreditation services, Standard Reference Data (SRD) and Standard Reference Materials (SRMs).

NIST has a unique role in promoting and reporting on the overall strength of federal efforts in technology transfer, including the Return on Investment Initiative (ROI). As part of the President’s Management Agenda, ROI seeks to enable even greater return on the federal government’s investment in research and development.

NIST TECHNOLOGY TRANSFER ACTIVITIES AND PRODUCTS (FY 2018)	
Invention Disclosure and Patenting	71 invention disclosures 54 patent applications filed 28 patents issued
License Agreements	11 new 60 active
Calibration Services	11,771
Active Traditional Cooperative Research and Development Agreements (CRADAs)	476
Material Transfer Agreements (MTAs)	290
National Voluntary Laboratory Accreditation Program (NVLAP)	674 NVLAP-accredited laboratories
User Facility Research Participants	3,415 Center for Nanoscale Science and Technology 2,742 NIST Center for Neutron Research
Participation in Standards Developing Organizations	423 staff members in 116 organizations
Scientific and Technical Publications	1,415
Standard Reference Data (SRD)	2,670 e-commerce orders 8,413 sold via distributor 3,190 product downloads
Standard Reference Materials (SRM)	31,503 units sold
NIST Postdoctoral Researchers	155
NIST Guest Researchers	3,221

Baldrige Performance Excellence Program

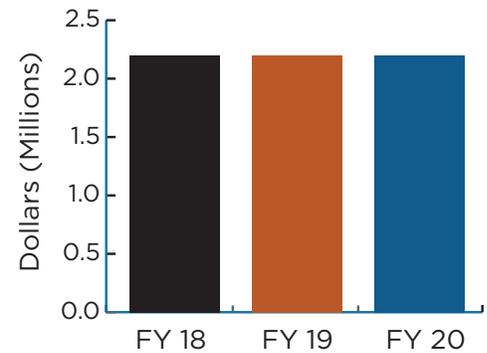
The Baldrige Performance Excellence Program oversees the nation's only Presidential award for performance excellence while offering criteria, assessments, tools, training and a community for those dedicated to helping organizations improve. In addition to traditional awards in manufacturing, health care, education and nonprofit sectors, the program has introduced the Baldrige Cybersecurity Excellence Builder and the Communities of Excellence framework to promote adoption of best practices in cybersecurity and across entire communities.

Budget Request

FY 2018 Enacted: **\$2.2 million**

FY 2019 Enacted: **\$2.2 million**

FY 2020 Request: **\$2.2 million (0%)**



No program changes in FY 2020.



Alamo Colleges District instructor Richard Jewell teaching a turbine engine class at St. Philip's College Southwest Campus. Alamo Colleges District was a 2018 Baldrige Award winner.

Credit: The Alamo Colleges District

Program Highlights

The program directly impacts thousands of organizations every year through their use of the Baldrige framework, participation in the award process, and attendance at conferences and training programs. For example:

- Health care organizations that adopt the Baldrige model demonstrate improved clinical outcomes, patient experience, patient safety and lower cost of care.
- Businesses demonstrate better revenue, margins, job growth, workforce development and engagement, customer satisfaction and engagement, and community support.



America Makes employee Ashley Totin works at one of the center's 3D printing machines. America Makes, located in Ohio, was the first Manufacturing USA institute.

Credit: NIST

Industrial Technology Services

NIST's extramural programs, which include Manufacturing USA and the Hollings Manufacturing Extension Partnership (MEP) help U.S. industry develop and implement new technology, develop robust supply chains, and refine their systems for efficiency and effectiveness, all while making them more competitive in the global economy.

Manufacturing USA is a network of 14 manufacturing innovation institutes where companies, universities, community colleges and entrepreneurs develop new manufacturing technologies with broad applications. The primary goal of the network is to ensure that American innovations and inventions currently going offshore for production in competitor nations are scaled up from lab experiments to products and processes that can be used by U.S. manufacturers.

“Advances in manufacturing enable the economy to continuously improve as new technologies and innovations increase productivity, enable new products and create entirely new industries.”

*- Strategy for American Leadership
in Advanced Manufacturing*

The MEP program is a federal-state-industry partnership that consists of centers located across the country working directly with their local manufacturing communities to strengthen the competitiveness of our nation's domestic manufacturing base. NIST MEP provides technical assistance in adopting advanced manufacturing technologies, addressing emerging manufacturing needs, and understanding foreign manufacturing and compliance issues. They provide guidance on cybersecurity of supply chains and transferring technology from NIST labs and other federal research organizations.

Manufacturing USA

Manufacturing USA is a national network of 14 manufacturing innovation institutes reaching more than 1,300 industry, government and academic institutions that work together to restore U.S. leadership in advanced manufacturing by accelerating the development of game-changing technologies through access to state-of-the-art facilities and workforce training. NIST coordinates the nationwide network of institutes and funds the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL).

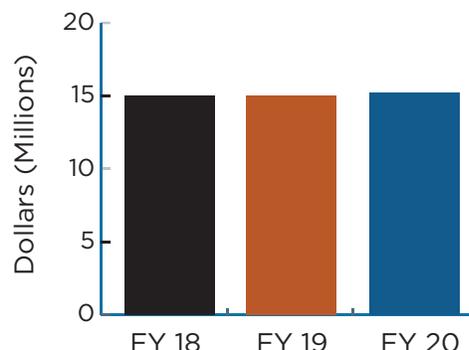
Budget Request

NIST requests funds to maintain support for NIIMBL and to coordinate the institute network.

FY 2018 Enacted: **\$15.0 million**

FY 2019 Enacted: **\$15.0 million**

FY 2020 Request: **\$15.2 million (+1.1%)**



Note: FY 2020 request includes \$1.6 million to fund inflationary adjustments. Total may not add due to rounding.

Program Highlights

- **Manufacturing USA institutes** collectively represent two-thirds of Fortune 50 U.S. manufacturers, over 500 small manufacturers and eight of the 10 top-ranked research and engineering universities.
- Its education and workforce **training programs** have reached nearly 200,000 individuals and include programs focused on training veterans in advanced manufacturing skills.
- **Nonfederal funding** matches federal funding at a 2-to-1 ratio, exceeding the original 1-to-1 goal and demonstrating the value of the network to industry, academia and the states.

No program changes in FY 2020.



Scientists training on best manufacturing practices for biopharmaceuticals, accelerating development of cost-effective manufacturing technology to ensure the availability of new medical therapies.

Photo courtesy of the Biotechnology Training and Education Center at North Carolina State University, a NIIMBL partner.

Hollings Manufacturing Extension Partnership

Established pursuant to the Omnibus Trade and Competitiveness Act of 1988, MEP comprises a network of grant-supported centers in all 50 states and Puerto Rico that provide technical and business assistance to small manufacturers. Since its creation, MEP has worked with 94,033 manufacturers, leading to \$111.3 billion in sales and \$18.8 billion in cost savings, and has helped create and retain 985,317 jobs. A 2018 report by the W.E. Upjohn Institute found the program generates a return of nearly 14.5:1 for the federal investment.

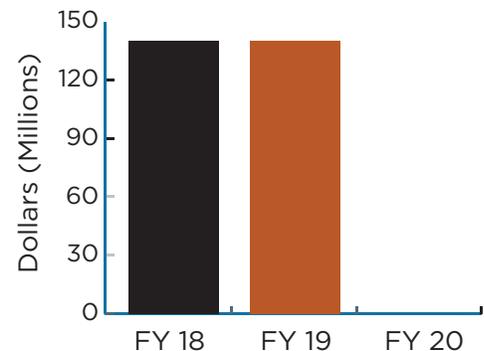
Budget Request

The FY 2020 budget eliminates federal funding for NIST MEP.

FY 2018 Enacted: **\$140.0 million**

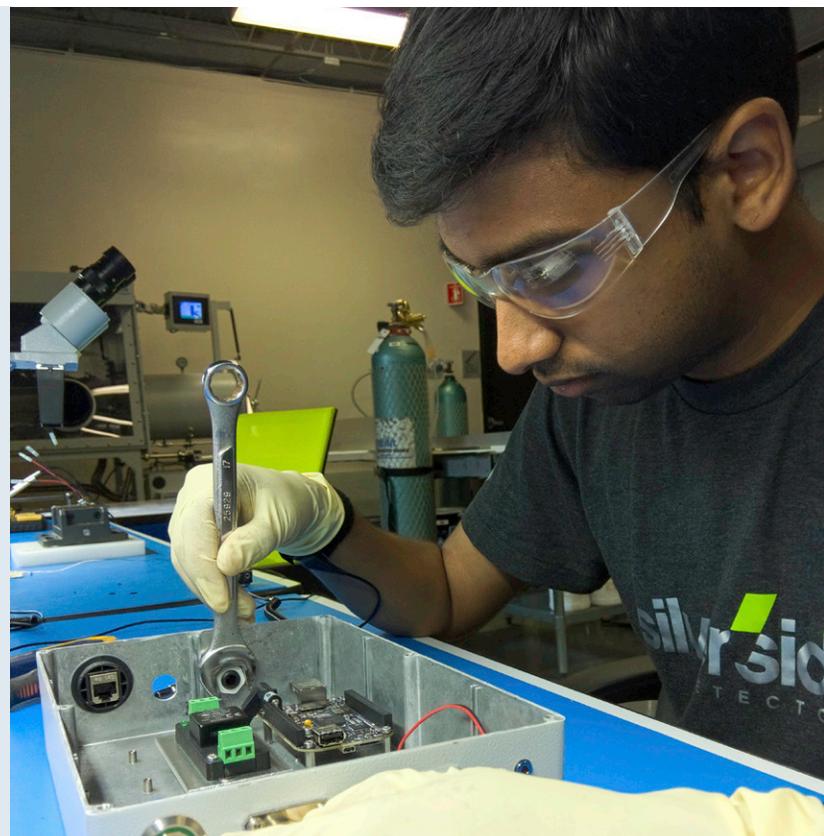
FY 2019 Enacted: **\$140.0 million**

FY 2020 Request: **\$0 (-100%)**



Proposed program changes in FY 2020:

- **-\$140.0 million** eliminating funding for the MEP program, including 81 federal employees. MEP centers would instead need to rely on non-federal sources of funding to maintain the over 1,300 non-federal technical experts in the 51 organizations that operate the program.



Silverside Detectors, a client of MassMEP, are a team of scientists, engineers and security experts that solve complex customer application problems. They apply physics and strategic policy analysis to create solutions that make jobs of first responders easier and help global security. Credit: NIST MEP



Renovations on NIST's Radiation Physics Building as of February 2019.

Credit: ©David Hills

Construction of Research Facilities

The NIST Construction of Research Facilities (CRF) appropriation funds NIST construction activities, including 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.

“State-of-the-art Federal science and technology infrastructure is critical to the continued success of our Nation.”

- FY 2020 Administration R&D Budget Priorities

Unfortunately, NIST’s ability to maintain and renovate its infrastructure has been falling further and further behind. With many NIST facilities dating from the 1950s and 1960s, basic environmental controls and infrastructure are failing at an increasing rate, undermining NIST’s ability to deliver the precision measurement science necessary to drive U.S. innovation and industrial competitiveness.

Scientific work at NIST laboratories supports national priorities such as manufacturing, health care, physical infrastructure, information technology and many other areas.

Scientists and engineers working to push beyond the limits of today’s advanced technology require stable environments. Variations in temperature cause sensitive optics to misalign; fluctuations in humidity interfere with

sensitive measurements of light; and vibrations make reliable, sensitive spatial measurements impossible. When making the world’s most precise measurements or creating quantum-based measurement tools that are only a handful of atoms wide, the tiniest variations in temperature, vibrations from increased local traffic, poor air quality, or unreliable electrical current can destroy months of work.

The 50- to 60-year-old facilities cause a major productivity loss and prevent NIST from performing the most demanding measurement research needed by industry and the scientific community. Current laboratory conditions create significant inefficiencies, and the aging facility systems present safety concerns. In terms of lost productivity, many measurements can only be conducted sporadically when environmental conditions are stable, and significant experimental data and construction of nanoscale can be rendered worthless by poor laboratory conditions. The types of high-precision research and measurement the future requires will not be possible without wholesale facility upgrades.

Construction of Research Facilities

The funds requested in FY 2020 support Safety, Capacity, Maintenance and Major Repairs (SCMMR) and Construction and Major Renovations. The request supports staff salaries and recurring preventive maintenance contracts and materials. Previously scheduled equipment replacements for FY 2020 will not be funded and the considerable deferred maintenance backlog will not be addressed. Any funds available beyond these costs will be directed primarily toward emergency needs only. NIST's utility infrastructure has been experiencing an increased frequency of major failures in the last few years, resulting in the need for emergency utility system repairs or replacement projects. These include major electrical system equipment, steam system, HVAC system repair and replacement of piping and valves for domestic, sanitary and storm sewer systems following ruptures or failures.

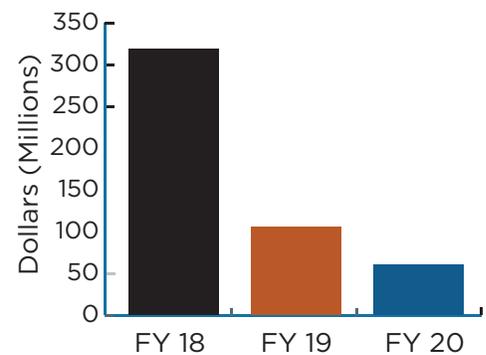
NIST's Building 1 project at the Boulder campus has been identified as a candidate project to be funded through the GSA Federal Capital Revolving Fund. The Fund would provide up-front funding, estimated to be \$288.0 million, to renovate Wing 5, Wing 4, Spine, Wing 1, Wing 2 and a portion of the Headhouse (auditorium, library, front lobby, conference rooms, police dispatch, and cafeteria). At the FY 2020 base funding level, NIST would repay this GSA revolving fund through annual discretionary appropriations in 15 annual payments of \$19.2 million.

Budget Request

FY 2018 Enacted: **\$319.0 million**

FY 2019 Enacted: **\$106.0 million**

FY 2020 Request: **\$59.9 million (-43.5%)**



Proposed program changes in FY 2020:

- **-\$34.8 million** resulting in deferment of SCMMR projects, including critical site and facility infrastructure projects necessary for routine facility operations.
- **-\$31.0 million** reflecting the one-time construction drop out for the Building 1 renovation project.
- **+\$19.2 million** to provide for the repayment of the GSA Federal Capital Revolving Fund.



A close-up shot of a water main break at 4 a.m. on October 31, 2018. The water main break resulted in having to stop most research activities in four lab buildings for five days.

Credit: NIST

Program Highlights

- NIST continues to make significant progress on the renovation of Building 245 on its Gaithersburg campus, which was fully funded in FY 2018.
- Building 3 in Boulder was completed on time and under budget. Opened in May 2018, the building houses a state-of-the-art facility for telecommunications research.

BUDGET TABLES

Table 1. Construction of Research Facilities (\$, thousands)

ACTIVITY	FY 2018 Enacted	FY 2019 Enacted	FY 2020 Request
Construction of Research Facilities	319,000	106,000	59,890

Table 2. Industrial Technology Services (\$, thousands)

ACTIVITY	FY 2018 Enacted	FY 2019 Enacted	FY 2020 Request
Hollings Manufacturing Extension Partnership	140,000	140,000	0
Manufacturing USA	15,000	15,000	15,172
ITS Total	155,000	155,000	15,172

Table 3. Scientific and Technical Research and Services (\$, thousands)

ACTIVITY	FY 2018 Enacted	FY 2019 Enacted	FY 2020 Request
Advanced Communications, Networks and Scientific Data Systems	68,643	68,643	40,323
Lab Programs	63,903	63,903	35,959
Corporate Services	1,645	1,645	1,138
SC-SP	3,095	3,095	3,226
Advanced Manufacturing and Material Measurements	147,817	147,874	117,555
Lab Programs	\$131,8977	131,955	107,441
Corporate Services	\$3,543	3,543	2,450
SC-SP	12,377	12,377	7,633
Cybersecurity and Privacy	82,779	82,779	83,997
Lab Programs	77,700	77,700	79,372
Corporate Services	1,984	1,984	1,372
SC-SP	3,095	3,095	3,242
Fundamental Measurement, Quantum Science and Measurement Dissemination	218,358	218,300	191,438
Lab Programs	165,581	165,639	\$162,250
Corporate Services	5,233	5,222	3,609
SC-SP	47,544	47,440	25,580
Health and Biological Systems Measurements	19,536	19,536	16,823
Lab Programs	17,972	17,972	15,367
Corporate Services	468	468	323
SC-SP	1,095	1,095	1,133
Physical Infrastructure and Resilience	66,969	66,969	46,543
Lab Programs	60,043	60,043	44,985
Corporate Services	1,605	1,605	1,110
SC-SP	5,321	5,321	448
Exploratory Measurement Science	66,821	66,821	65,804
Lab Programs	60,774	60,774	62,124
Corporate Services	1,602	1,602	1,108
SC-SP	4,445	4,445	2,572
NIST User Facilities	51,377	51,377	47,036
Lab Programs	50,146	50,146	46,184
Corporate Services	1,231	1,231	852
SC-SP	0	0	0
Baldrige Performance Excellence Program	2,200	2,200	2,200
STRS Total	724,500	724,500	611,719

Note: Totals may not add due to rounding.

COVER IMAGE: This NIST-on-a-Chip device is a grating chip which will enable practical, deployable and affordable atom-based devices. The chip simplifies the optics needed for laser cooling and trapping of atoms or molecules. A normal trapping system requires six lasers and a host of carefully aligned optical components. This chip makes it possible to use a single laser, and has an aperture to allow for pre-cooling and back-loading atoms or molecules from a hot source.

Credit: Jason Stoughton/NIST