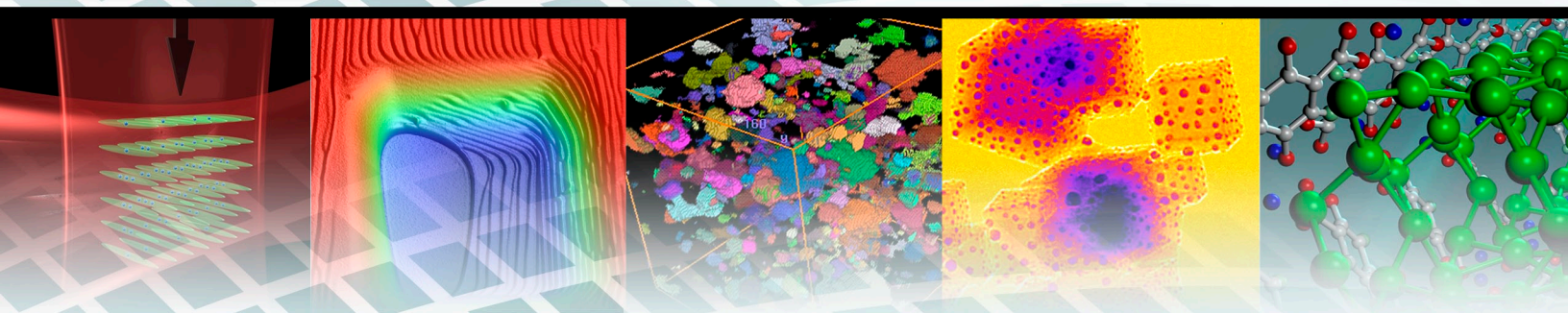
NIST 3-Year Programmatic Plan

FY 2013-2015



NIST
National Institute of Standards and Technology
U.S. Department of Commerce

NIST 3-Year Programmatic Plan

FY 2013-2015

June 2012

NIST National Institute of Standards and Technology • U.S. Department of Commerce

(Courtesy of HDR Architecture, Inc./Steve Hall © Hedrich Blessing)

Introduction

The National Institute of Standards and Technology (NIST) promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in a range of strategic areas critical to the nation's economy. The America COMPETES Act outlines major roles for NIST in promoting national competitiveness and innovation, and also calls for NIST to submit a three-year programmatic plan concurrent with the submission of the President's budget request to Congress. This document summarizes the focus of NIST programs for use in planning and prioritizing investments over this three-year period. NIST will continue to refine this plan as it works with the Administration to address national priorities.

This plan includes the following:

- Statement of NIST's mission;
- Overview and highlights of NIST laboratory programs;
- Overview and highlights of NIST Innovation and Industry Services programs; and
- Priorities for NIST FY 2013-2015.

(Credit: Christina Kiffney Photography)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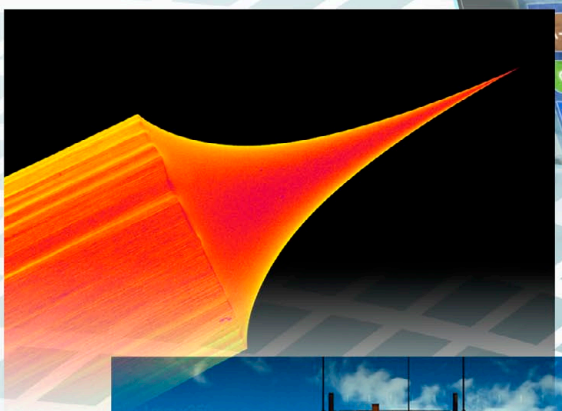

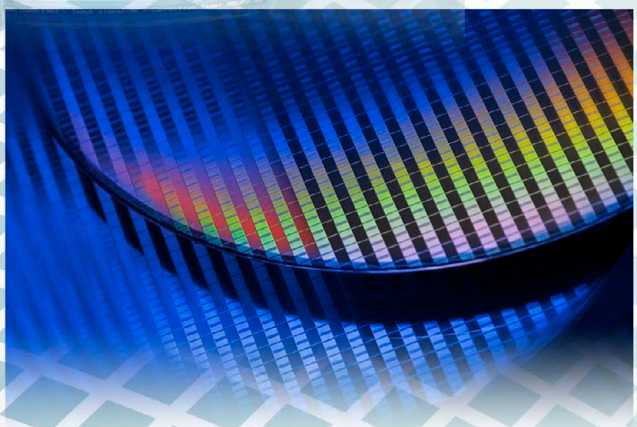


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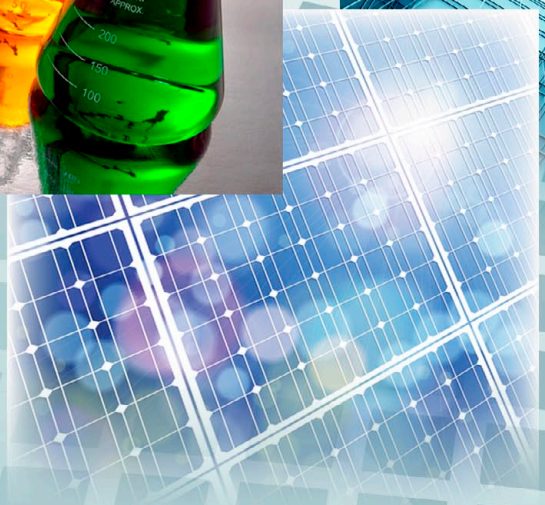
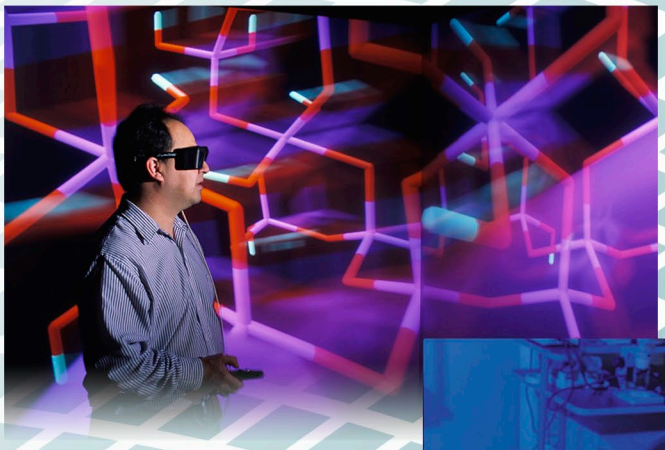


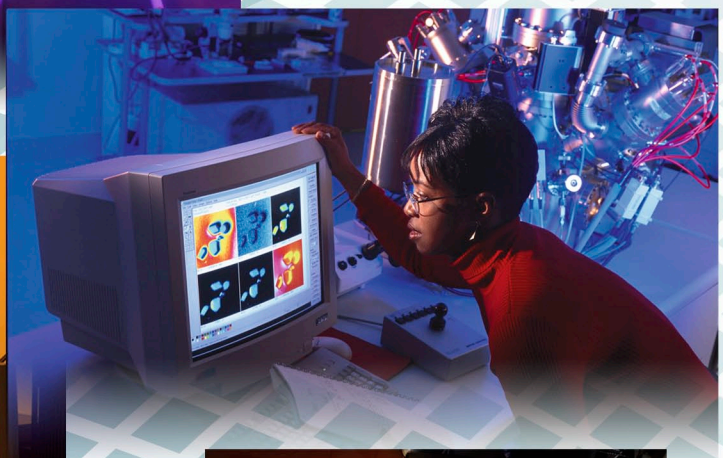
NIST Mission: Promoting U.S. Innovation and Industrial Competitiveness

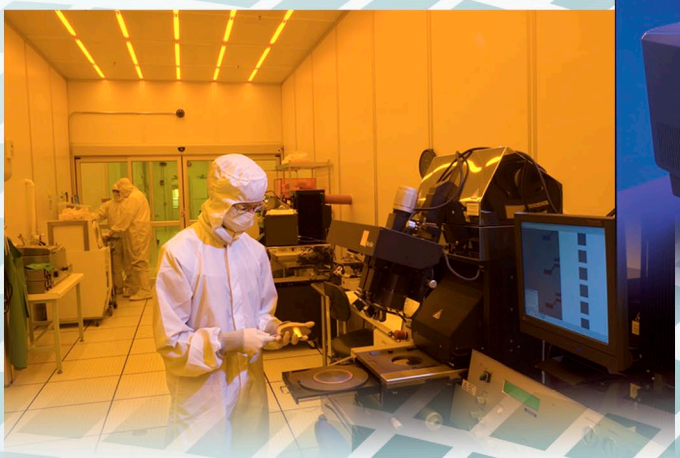
The NIST mission is to:

Promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life

Since 1901, NIST (and its predecessor, the National Bureau of Standards) has maintained the national standards of measurement, 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 successfully. As a non-regulatory agency in the U.S. Department of Commerce, 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.





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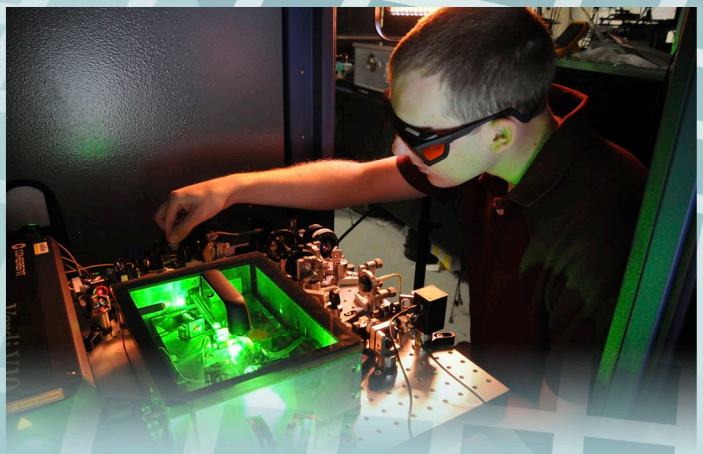
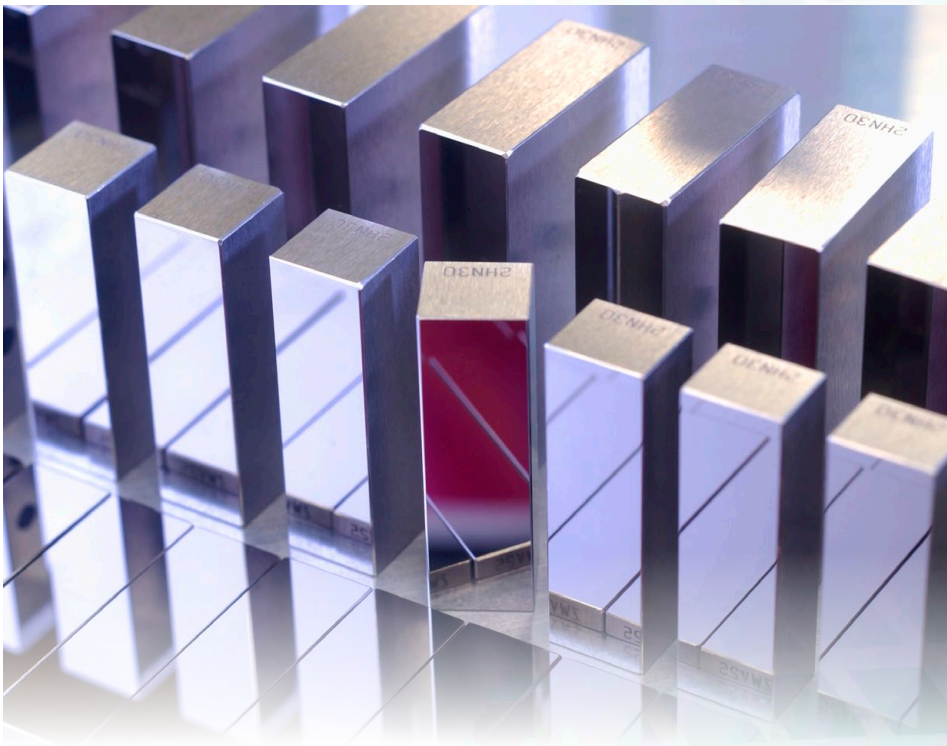


NIST Laboratory Programs

The NIST Laboratory Programs work at the frontiers of measurement science to ensure that the U.S. system of measurements is firmly grounded on sound scientific and technical principles. Today, the NIST Laboratories address increasingly complex measurement challenges, ranging from the very small (nanoscale devices) to the very large (vehicles and buildings), and from the physical (renewable energy sources) to the virtual (cybersecurity and cloud computing). As new technologies develop and evolve, NIST's measurement research and services remain central to innovation, productivity, trade, and public safety.

The NIST Laboratory Programs provide industry, academia, and other federal agencies with:

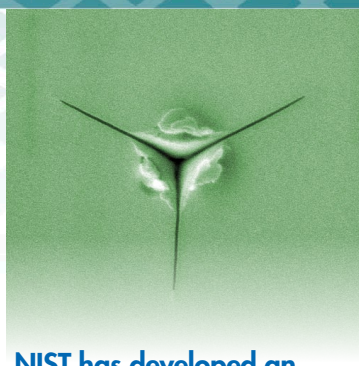
- Scientific underpinnings for basic and derived measurement units in the international standards community, measurement and calibration services, and certified reference materials;
- Impartial expertise and leadership in basic and applied research to enable development of test methods and verified data to support the efficient commercialization and exchange of goods and services in industry and commerce;
- Support for the development of open, 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, which provides world class neutron measurement capabilities to the U.S. research community, and the NIST Center for Nanoscale Science and Technology, which supports nanotechnology development from discovery to production.



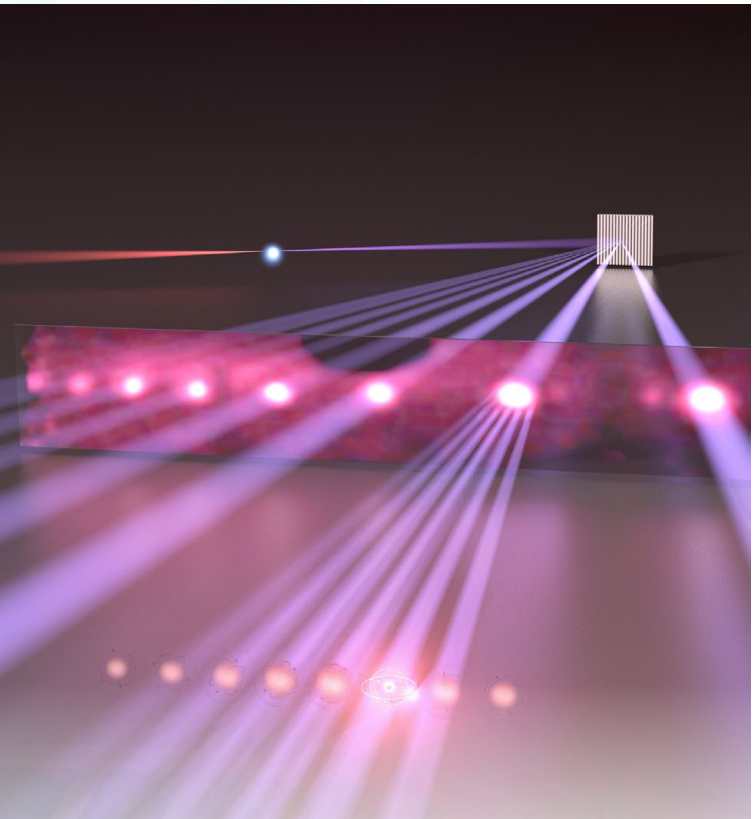
NIST receives thousands of gage blocks, highly accurate short length measuring tools, every year for calibration against NIST masters from manufacturers and government agencies around the world (Credit: Barry Gardner)

Driving Innovation through Measurement

NIST provides measurement and calibration services via its Standard Reference Materials®, calibration services, and Standard Reference Data. More than 32,000 units of 1,300 different types of certified reference materials were sold in FY 2011 to industry, academia, and government, to assure the accuracy of millions of measurements made daily in medical clinics, manufacturing plants, crime labs, and industrial labs throughout the United States. The calibration services NIST provides help customers achieve the highest measurement quality and productivity in areas such as dimensional, electromagnetic, ionizing radiation, mechanical, optical radiation, thermodynamic, and time and frequency measurements. In FY 2011, over 18,000 calibrations were carried out on more than 2,800 objects, which underpin hundreds of thousands of additional calibrations carried out in industry, academia and government agencies. NIST Standard Reference Data are well-documented numeric data used in technical problem-solving, research, and development; over 100 types are available for use in scientific and engineering applications, with over 19 million downloads recorded in FY 2011 (excluding web-based time services).



NIST has developed an nanoindentation test method that presses a diamond tip into an integrated circuit (IC) to measure the toughness of the insulating films contained within the IC. This technique is aimed at developing standards and testing methodology that will improve reliability and manufacturability of ICs (Credit: Dylan Morris/NIST)



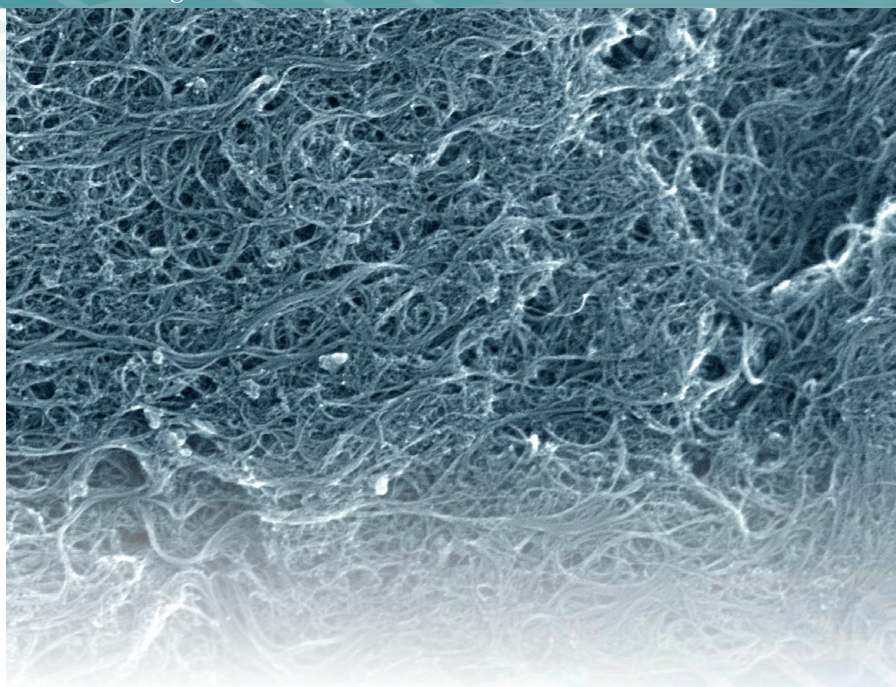
Artist's conception of the first "frequency comb" in the extreme ultraviolet band of the spectrum, which contains high-energy light less than 100 nanometers (nm) in wavelength, created by physicists at JILA. Laser-generated frequency combs are the most accurate method available for precisely measuring frequencies, or colors, of light (Credit: Baxley/JILA)

The International System of Units (SI) is essential to science, technology, and commerce. NIST coordinates U.S. government policy on the use of the SI by federal agencies as well as on the use of the SI by U.S. industry. NIST also provides official U.S. representation to the International Bureau of Weights and Measures (BIPM), created by the Convention of the Metre Treaty of 1875 and now including 55 member-states, as well as to the International Committee for Weights and Measures (CIPM), an 18-member committee whose principal task is to promote worldwide uniformity in units of measurement. In addition, NIST serves as the U.S. representative to the International Organization of Legal Metrology (OIML), a 119-member treaty organization that recommends manufacture and use requirements for legal metrology applications.

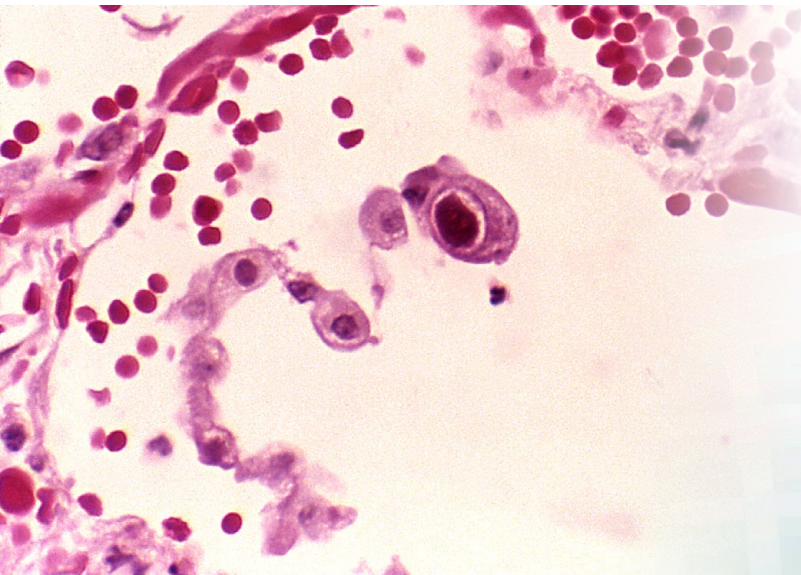
Highlights:

Promoting bioscience innovation in the regulatory environment:

NIST is ideally positioned to work with industry and federal regulatory agencies to develop innovative solutions to biological measurement challenges that will enable more efficient manufacturing and quality assurance processes. Biotechnology drugs, currently dominated by protein therapeutics, are the fastest-growing class of pharmaceuticals, as well as one of the fastest-growing categories of health care-related spending. NIST is developing measurement methods, protocols, and standards for improved, real-time measurement of biologic products during manufacturing. For example, NIST researchers are creating mass spectral methods and reference data to enable more accurate characterization of protein drugs. To do this, NIST is developing peptide libraries that will be made publicly available and will be valuable to biopharmaceutical researchers in their development of new protein therapies. Other bioscience efforts at NIST are targeted at measurement science to support new technologies, such as ultra-high throughput, next-generation DNA sequencing, the development of standards to support improved genetics-based disease diagnostics and therapy, and measurement of protein-based disease biomarkers. By partnering with other federal agencies including the National Institutes of Health and the Food and Drug Administration, the bioscience research program at NIST supports the new tools, standards, and approaches needed to support science-based regulatory decision-making and to create a flourishing environment for innovation in industry.

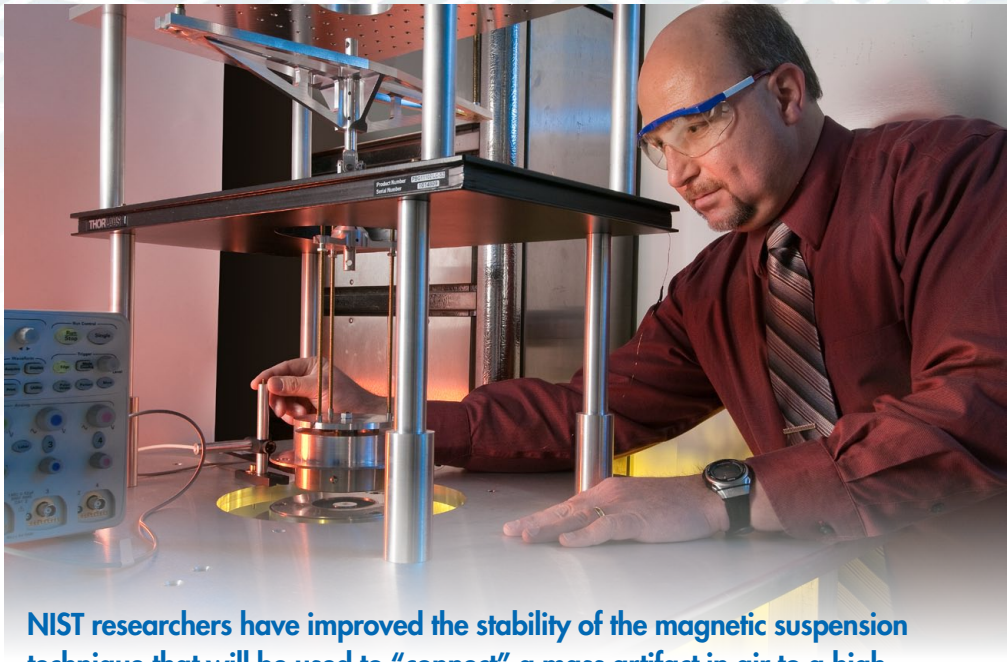


NIST has issued the world's first reference material for single-wall carbon nanotube soot, which offers companies and researchers a highly reliable source of uniform and well-characterized carbon nanotube soot for material comparisons, as well as chemical and toxicity analysis (Credit: Vladar/NIST)



Photomicrograph showing human lung cells infected with cytomegalovirus (CMV), a common pathogen that is particularly dangerous for infants and persons with weakened immune systems. NIST Standard Reference Material (SRM) 2366 will help health care professionals more accurately diagnose and treat CMV by providing a standardized CMV DNA. SRM 2366 joins more than 50 reference materials produced by NIST for quality control in clinical testing (Credit: E.P. Ewing/Centers for Disease Control and Prevention)

The new SI and the redefinition of the kilogram:



NIST researchers have improved the stability of the magnetic suspension technique that will be used to "connect" a mass artifact in air to a high precision mass balance in a vacuum to provide a direct comparison between masses in two different pressure environments. This will be important for transferring an "electronic kilogram" realized in vacuum to real-world mass artifacts used in air. Here, Patrick Abbott adjusts the position of the magnetic flux sensor used as the feedback element in the magnetic levitation system. (Credit: Earl Zubkoff)

NIST is playing a critical role in the revision of the SI, which includes research and development to support international efforts to prepare for a future redefinition of the unit of mass – the kilogram – which is the last remaining SI basic unit defined by an artifact. The 1889 definition of the kilogram was in terms of the mass of the international prototype, which is an artifact made of platinum-iridium kept at the BIPM in France under precisely controlled storage conditions. Since the establishment of the SI in 1960, progress has been made in moving away from artifact-based definitions to those utilizing invariant quantities such as fundamental physical constants and atomic properties. On Oct. 21, 2011, the CGPM (General Conference on Weights and Measures) passed a resolution declaring that the kilogram is to be redefined in terms of the fixed numerical value of the Planck constant (h).

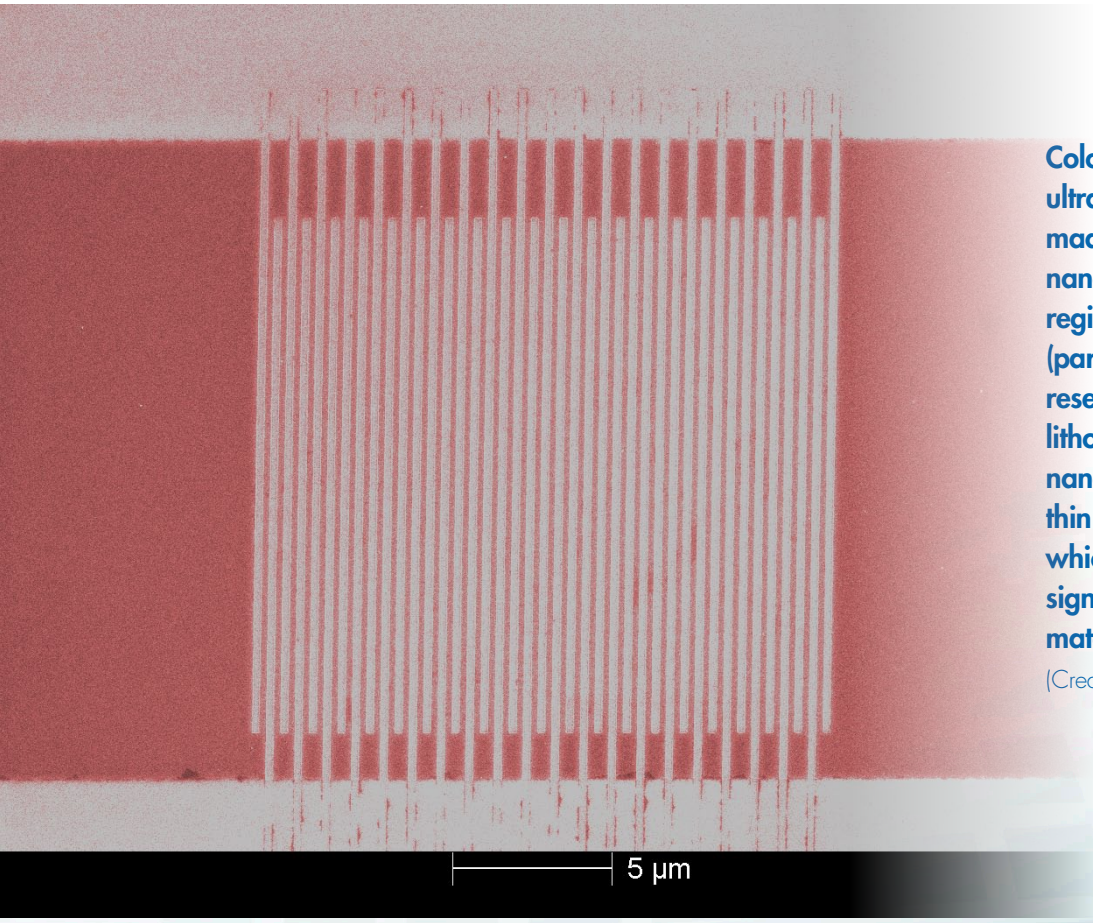
NIST is involved in two physically very different approaches to determine the value of h with high precision and accuracy. One employs a device called a watt balance, which measures the force required to balance a 1 kg mass artifact against the pull of the Earth's gravity by monitoring the voltage and current (hence the name "watt") involved in doing so. NIST researchers are actively involved in two watt-balance initiatives: a top-to-bottom investigation of the existing NIST vacuum-enclosed watt balance device in search of sources of error that can be eliminated to improve its measurement uncertainty; as well as construction of an entirely new watt-balance in a dedicated, climate-controlled facility.

The other approach to determining h, pursued by a single large international collaboration, involves "counting" the number of atoms (via unit cell volume of a crystal) in each of two highly pure 1 kg single-crystal enriched silicon spheres about 94 mm in diameter. The result provides a determination of the Avogadro Constant, which in turn can be used to obtain h using the well-known values of other constants. NIST researchers are part of an international team that is making precise measurements of the molar mass of silicon using isotope dilution mass spectrometry (IDMS) and multicollector-inductively coupled plasma mass spectrometry (MC-ICP-MS).

Cutting-edge quantum metrologies:

Researchers at NIST are continually pushing the boundaries of advanced, cutting-edge metrologies that can be applied to problems of national significance in such areas as communications, defense, electronics, energy, environment, health, lighting, manufacturing, microelectronics, radiation, remote sensing, space, and transportation. In one such area, quantum-based communication and measurement systems that use novel quantum states of light are being developed worldwide. However, the technologies used to generate, manipulate, and detect these states of light are inadequate for many emerging applications. NIST research in this field focuses on the development of single-photon technologies for quantum information science and technology.

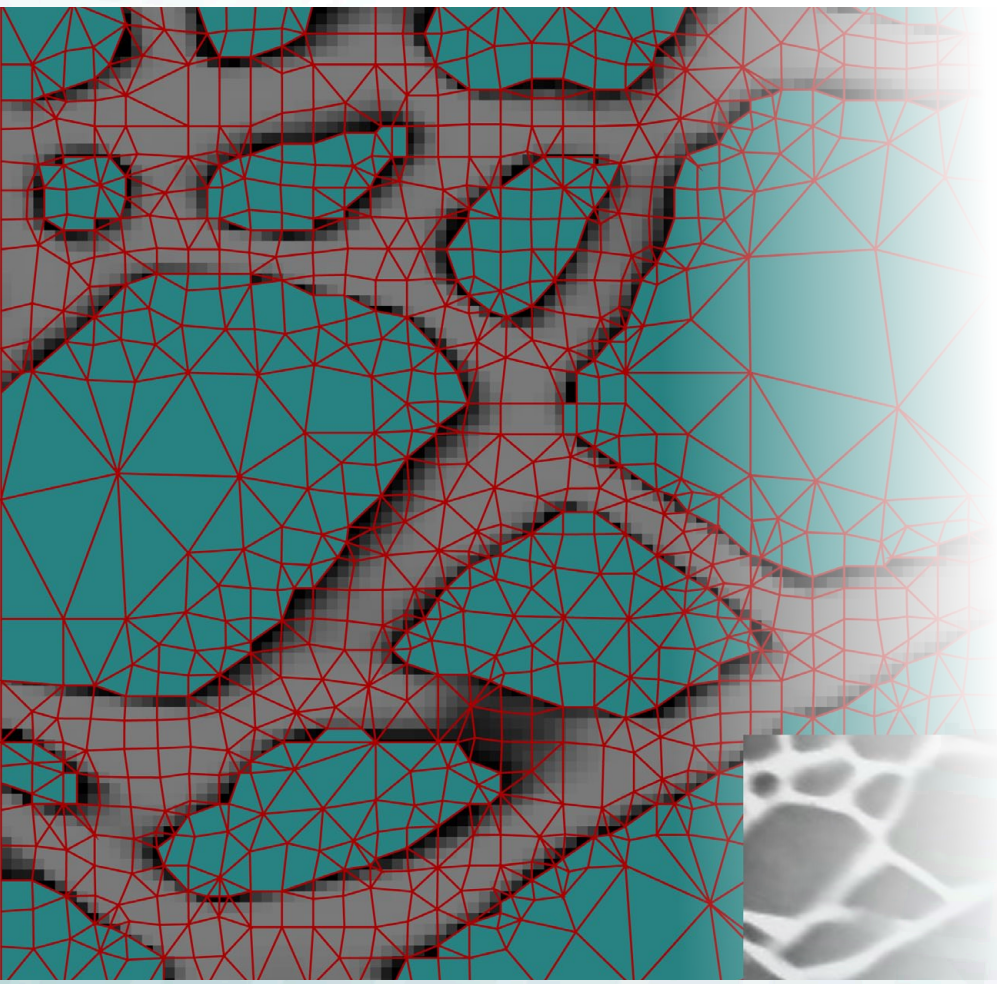
Key projects involve investigating the use of nonlinear fibers and nonlinear crystals as a source of correlated photon pairs or "squeezed light," and then manipulating the squeezed light in new ways to enhance precision measurements, as well as computing and communications based on quantum physics. In addition to creating these non-classical states of light, NIST builds detector systems that are the best in the world at operating at the single photon level.
Major recent accomplishments by NIST researchers in this program include demonstrations of the highest system detection efficiency for single photons (greater than 95 percent at 1550 nanometers (nm); world-record, long-distance quantum key distribution systems using superconducting nanowire single-photon detectors; and the first ever time-correlated single-photon counting with superconducting single-photon detectors.



Colorized micrograph of an ultrafast single-photon detector made of superconducting nanowires used at NIST to register individual photons (particles of light). NIST researchers use electron beam lithography to pattern the nanowires (vertical lines) on a thin film of tungsten-silicon alloy, which produces more reliable signals than the niobium nitride material used previously
(Credit: Baek/NIST)

Advanced materials measurements, modeling, and simulation:

Accelerating the pace of discovery and deployment of advanced material systems is an important element of the U.S. advanced manufacturing infrastructure that will enable industrial competitiveness in the 21st century. Advanced materials are critical in a wide range of industries, including aerospace and electronics, and support a number of national priorities, such as clean energy and national security. The Materials Genome Initiative is an interagency effort to revolutionize the advanced materials innovation infrastructure to enable rapid reductions in the development time for new materials and improve the properties of those materials. One of the goals of the initiative is to reduce the time required for materials design from the current 10-year average timeframe, to be more compatible with an 18-month product development cycle. NIST plays a leading role in developing the critical models, tools, standards, and data that will comprise the materials innovation infrastructure of the future. NIST researchers use a suite of experimental methods to measure phase transformation temperatures, boundaries and compositions, as well as other important material properties. These experimental capabilities are complemented by NIST expertise in a number of computational methods for predicting the composition and other key characteristics of new materials systems that will result in desirable materials performance. For example, the NIST-designed open access software OOF (Object-Oriented Finite element analysis) allows scientists to calculate properties of materials by reading an image and conducting virtual experiments that provide clues about how the overall material will behave. With collaborators from academia, industry, and other agencies, NIST will continue to build on its infrastructure of experimental and computational data and models for advanced materials design.



The software package, OOF (Object-Oriented Finite element analysis) is a specialized tool to help materials designers understand how stress and other factors act on a material with a complex internal structure. Once provided with a microscope's image of a composite material (inset), OOF software can help researchers identify the different substances (blue and gray areas) that make up the material and compute their response to stress or other effects
(Credit: Langer/NIST)

Accelerating the adoption and deployment of advanced technology solutions

The development and adoption of leading-edge IT capabilities integrated with manufacturing processes, transportation systems, utility networks, and healthcare applications will enable the transformation of these physical systems that are critical to our quality of life. In particular, improvements in these capabilities will allow real-time monitoring, control, and performance optimization of smart manufacturing systems in the factories of small, medium, and large companies, and will facilitate straightforward integration of engineering information systems used in complex manufacturing and construction. The development of IT-enabled systems and processes will require the development of advanced intelligent robots, sensors, and automation technologies.

Highlights

Smart Grid:

The Smart Grid is envisioned as a complex system of systems that incorporates many new technologies and operating paradigms in an end-to-end system that will function very differently than the legacy grid, and will deliver power more efficiently, reliably and cleanly. NIST will develop the necessary measurement science and standards, including interoperability and cybersecurity standards, to ensure the performance of the Smart Grid. This includes ensuring that the system, subsystem, and end-user levels can be measured, controlled, and optimized to meet performance requirements, especially for safety and security, reliability and resilience, agility and stability, and energy efficiency.

Credit: Markus Gann/Shutterstock

In order to accelerate the development of Smart Grid interoperability standards, Congress, through Section 1305 of the Energy Independence and Security Act of 2007 (Public Law 110-140) (EISA), assigned NIST the "*primary responsibility to coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems*" To meet this mandate, NIST has launched the Smart Grid Interoperability Panel (SGIP), a public/private partnership that provides an open forum for Smart Grid stakeholders to work towards developing consensus-based interoperability standards, published the Release 1.0 of *NIST Framework and Roadmap for Smart Grid Interoperability* as well as the three-volune *Guidelines for Smart Grid Cybersecurity* (NISTIR 7628), and established the Catalog of Standards to serve as a compendium of standards, practices, and guidelines considered relevant for the development and deployment of a robust and interoperable Smart Grid.

The focus of NIST's future activities in Smart Grid includes:

- Publishing Release 2.0 of the *NIST Framework and Roadmap for Smart Grid Interoperability,* which will identify existing standards ready for implementation, priorities for future standardization, as well as outline a Smart Grid architectural framework;
- Developing a revised Testing and Certification Framework to help ensure the interoperability of Smart Grid devices and systems;
- Promoting the international harmonization of Smart Grid standards in collaboration with the International Trade Administration (ITA) and the Office of the U.S. Trade Representative (USTR); and
- Developing measurement methods and tools to enable performance measurement and optimization of devices and systems to ensure that the Smart Grid provides adequate power quality and stable, reliable, and secure delivery of electricity.

(Credit Novelo/Shutterstock)

Cloud Computing:

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. As part of federal IT reform, the U.S. government has implemented a "Cloud First" policy, which mandates that agencies increase the use of available cloud and shared services. NIST plays an important role in implementation of this policy and of the Federal Cloud Computing Strategy, and seeks to catalyze the use of cloud computing within industry and government through the development of standards and guidelines. NIST aims to foster cloud computing systems and practices that support interoperability, portability, and security requirements that are appropriate and achievable for important usage scenarios. Early accomplishments include publication of *The NIST Definition of Cloud Computing* (Special Publication 800-145) and *U.S. Government Cloud Computing Technology Roadmap*, Volumes I (*High-Priority Requirements to Further USG Agency Cloud Computing Adoption*) and II (*Useful Information for Cloud Adopters*, Special Publication 500-293 in public draft).

Cybersecurity:

Cybersecurity is vital to the economic and national security interests of the United States. In addition to enabling more than $200 billion in annual e-commerce, interconnected networks of computers are essential for life-critical functions such as air traffic control and electric power distribution. Our nation's information technology resources face ever-increasing threats from malicious individuals, organizations, and nation states. The result is a large, direct economic impact; estimates show that billions of dollars are spent repairing systems damaged by cyber intrusions (http://www.fbi.gov/about-us/investigate/cyber/computer-intrusions).

NIST conducts the research, development and outreach necessary to provide standards and guidelines, tools, metrics and practices to protect the nation's information and communication infrastructure. NIST also plays a vital role in national and international cybersecurity standards-setting. The responsibilities assigned to

(Credit: Andrea Danti/Shutterstock)

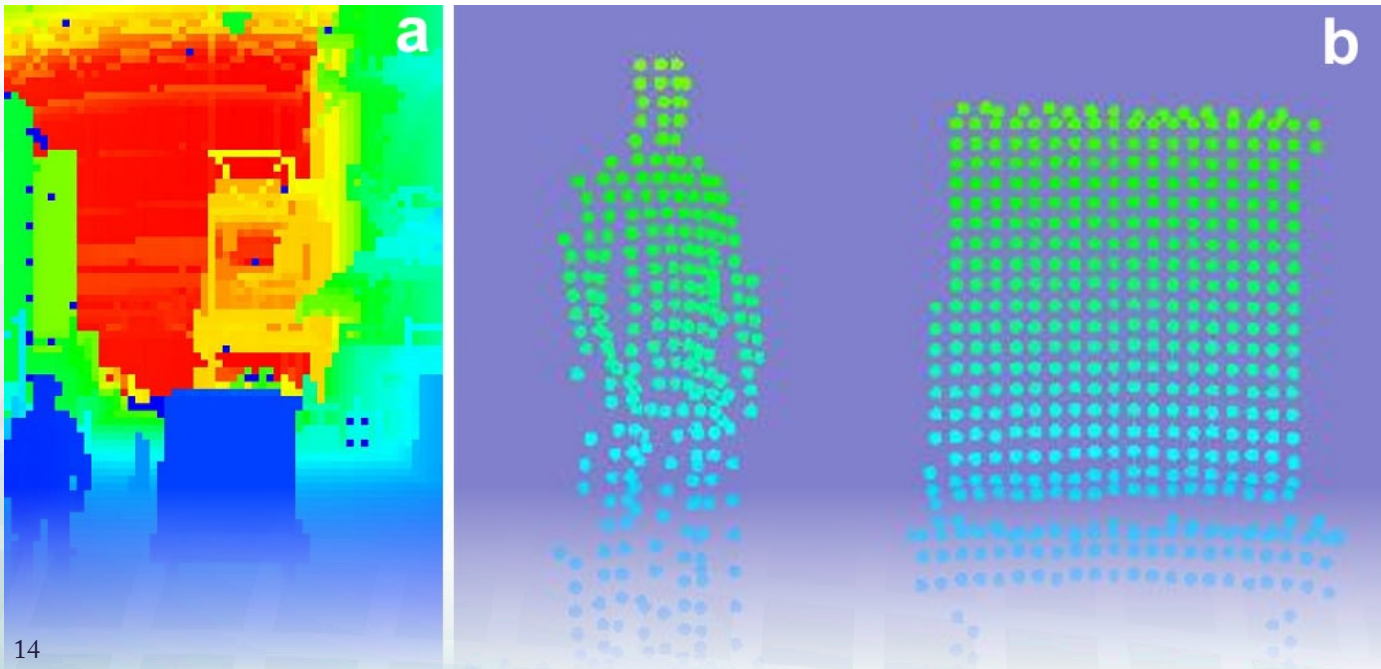
NIST under the Federal Information Security Management Act of 2002 (FISMA)(44 U.S.C. § 3541, et seq.) to assist federal agencies in securing their information systems are a major part of NIST's work in cybersecurity.

NIST will continue to update existing standards and guidance for use by federal agencies in securing their systems, as well as add to the NIST guidance in areas such as mobile security, anchors of trust, security automation, and basic input/output system (BIOS) security. Additionally, NIST is providing continuing leadership for the development of standards for cloud computing, identity management and cybersecurity education. NIST will also continually provide reference specifications in multiple areas, allowing others to leverage our work to increase the security of their systems and products.

Finally, NIST will encourage the adoption of strong security by the private sector through the Cybersecurity Center of Excellence, to be established in FY 2012. Established in cooperation with the State of Maryland, the Center will provide support and information on cybersecurity, and will also assist the private sector in securing their digital data.

Next-Generation Robotics and Automation:

Innovative measurement science and standards are necessary to enable the next generation of smart robots and automation systems and to foster their adoption in manufacturing in the United States at dimensions ranging from the very small to the very large. NIST has made significant contributions in addressing this significant advanced manufacturing need. Due to NIST's efforts, new International Standards Organization (ISO) 10218 robot safety standards were balloted in 2011 and have since been approved. The new standards resolve differences in robot safety requirements for the United States, Canada, and other countries, and provide for important new features for safe human-robot collaboration. NIST contributed key content to the Speed and Separation Monitoring (SSM) provision, which ensures safety by monitoring and maintaining a safe minimum separation distance and relative speed between the robot system and the human operator rather than relying solely on fixed guards. This provision is expected to result in increased productivity and reduced floor space and cost requirements for robot installations, and will enable new types of



human-robot collaborative tasks while still ensuring safe operation. In support of this effort, NIST also worked with German ISO representatives to produce draft speed- and position-monitoring guidelines for ISO TS 15066, the technical specification that provides guidelines for implementing ISO 10218 standards. The NIST standards contributions are supported by experimental research conducted on a prototype SSM safety system implementation in the NIST manufacturing robotics testbed.

NIST has also teamed with Willow Garage, a developer of robotics hardware and open-source software, to conduct the first-ever "Perception Challenge" to drive improvements in sensing and perception technology algorithms. This event was held at the IEEE Conference on Robotics and Automation (ICRA) in Shanghai, China, in May 2011. Robust perception is a core enabling technology for next-generation robotics used in manufacturing and other applications.

This "robot's eye view" shows how some common household objects appear through the vision system being used in the Perception Challenge. The objects are fuzzy because the cameras have limited resolution. However, the images do provide information on depth (distance of every point on an object). The checkered patterns help to define and verify objects in space. (Credit: Courtesy Willow Garage)

Many of these applications will require robots to be able to identify objects reliably and determine their position accurately, while operating in unstructured and cluttered environments. NIST measured the ability of each team to detect objects and compute their position in space for the challenge, and Willow Garage provided a common system on which to test the algorithms. The object of the challenge was for competing robot systems to identify and determine the position and orientation of each of a set of 35 objects. Techniques and metrics demonstrated in this and other competitions provide foundations for new standards and test methods for measuring perception system performance.

NIST is partnering with industry to enable the next generation of robots that can work safely next to humans, and to ensure that industrial robots and automated guided vehicles have the ability to see humans and avoid them. The images show examples of "robot eye views" of typical factory scenes that are used to develop performance standards to evaluate if the robot's sensor systems can identify humans and their relative positions in order to avoid collisions with them. (Credit: NIST)

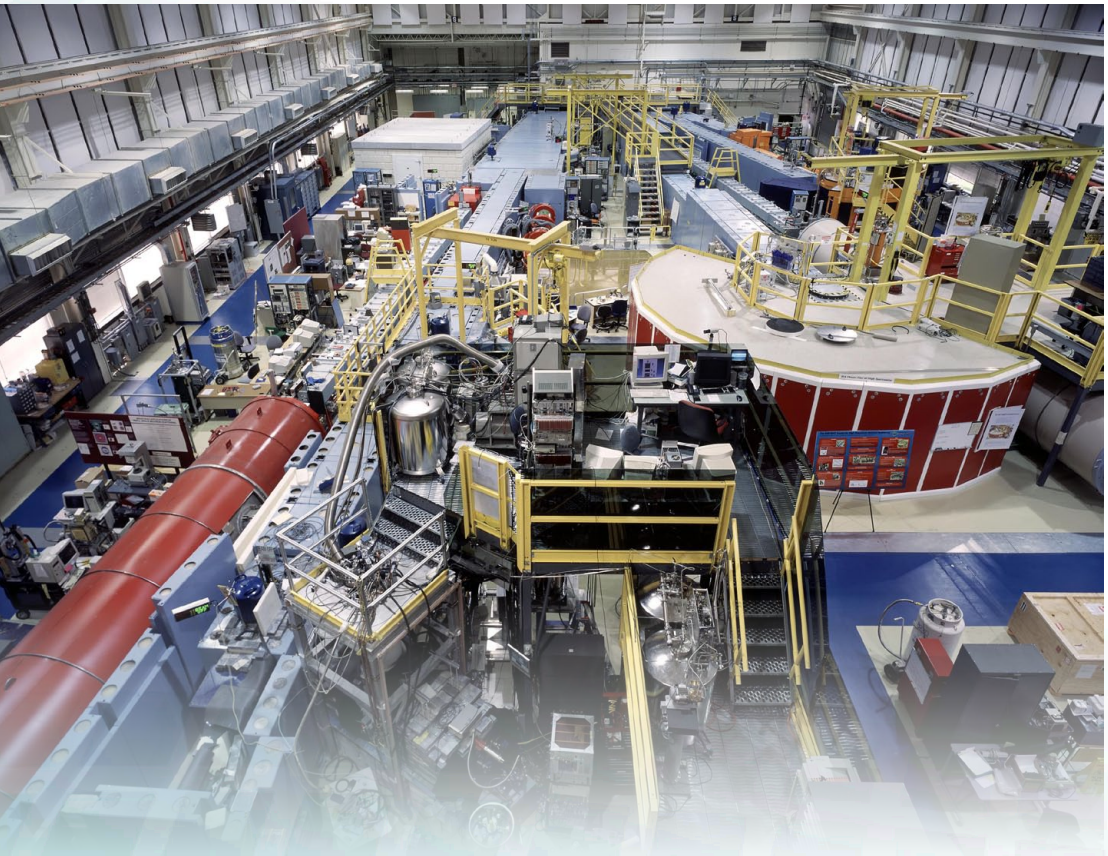
World class, unique, cutting-edge research facilities

Industry, academia, and other government agencies have access to unique NIST user facilities that support innovation in materials science, nanotechnology, and other emerging technology areas. The NIST Center for Neutron Research (NCNR) provides world-class neutron measurement capabilities to the U.S. research community, and the NIST Center for Nanoscale Science and Technology (CNST) Nanofab facility supports nanotechnology developments from discovery to production. The customer-focused mission of both NCNR and CNST includes the safe and reliable operation of the facilities, as well as the development and application of entirely new and cutting-edge measurement and fabrication techniques.

NIST Center for Neutron Research (NCNR):

The NCNR develops, delivers and maintains world-class neutron measurement capabilities and applies them to science and engineering problems of national interest. The NCNR is operated as a major national user facility with merit-based access made available to the entire U.S. scientific and technological community. In a typical year, more than 2,200 research participants, representing some 42 states, 32 government agencies, and 46 U.S. corporations, utilize the NCNR for neutron measurement studies. Between 1998 and 2007, these users contributed over 2,500 high-impact research papers to the open scientific literature.

Neutrons are powerful probes of the structure and dynamics of materials, and can be used to study a range of material behavior, ranging from molecules inserted into



Guide Hall of the NIST Center for Neutron Research. The NIST Center for Neutron Research (NCNR) serves more customers than all other U.S. neutron facilities combined. Beams of cold, slowed down neutrons pass through guide tubes (blue structures) to reach specialized instruments where they are used as probes to see material structures.
(Credit: Robert Rathe)

membranes simulating cell walls to protons migrating through fuel cells. The NCNR's neutron source provides the intense beams of neutrons required for these types of measurements. Neutron-based research covers a broad spectrum of disciplines, including engineering, biology, materials science, polymers, chemistry, and physics.

The NCNR currently contains 28 experiment stations, of which six provide high neutron flux sources for irradiation, and 22 are beam facilities, the majority of which are used for neutron scattering research. In April 2011, the NCNR undertook the planned shut-down of its neutron source in order to complete the *NCNR Expansion Project,* which began in 2007. This major initiative includes a new guide hall for neutron instruments, a technical support building, design, and construction of five new cold neutron instruments, and a new cold source dedicated to the NIST Multi-Axis Crystal Spectrometer (MACS), one of the world's most intense cold neutron spectrometers. The facility is scheduled to re-open in FY 2012 and installation of the new instruments will be completed by the end of CY 2012. Beyond CY 2012, additional new cold neutron instruments will be developed and installed to take full advantage of the new neutron beamlines, allowing an expected 500 additional research users annually.

The Polymers Division of NIST's Material Measurement Laboratory (MML) is partnering with the NCNR to develop a research consortium called *nSoft,* made up of industrial, government and academic members, whose mission is to lower barriers to NCNR access and collaboratively develop neutron-based measurement solutions for manufacturers of soft materials.

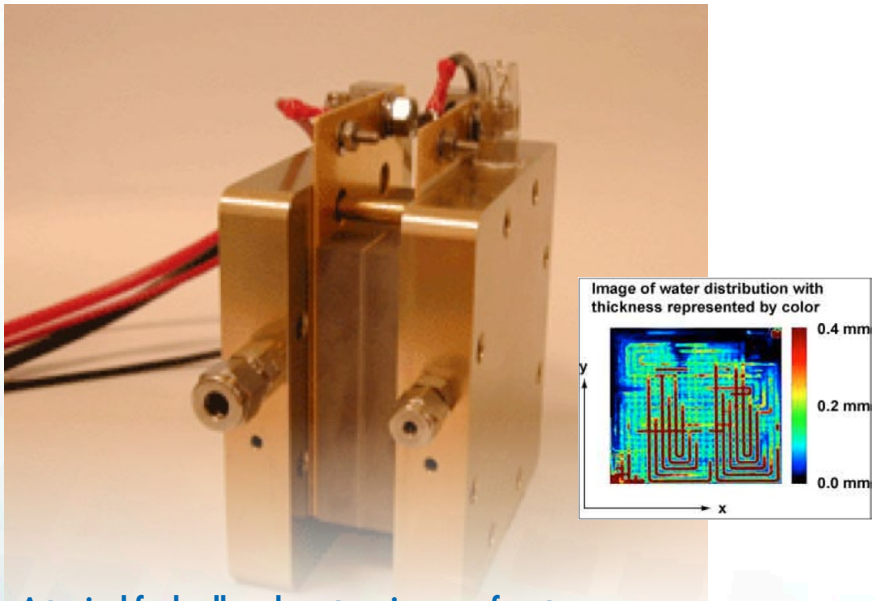
NCNR technical staff members Dan Adler and Mike Rinehart perform installation work on the new, advanced neutron guides as part of the NCNR Expansion Project. This particular guide will provide a very high flux of neutrons for experiments performed by the Physical Measurement Laboratory Neutron Physics group
(Credit: Yiming Qiu/NIST)

With a kick-off in FY 2012, *nSoft* will provide industry partners with (1) predictable and timely access to neutron facilities, (2) research and development programs focused on high impact issues in soft materials manufacturing, and (3) increased scientific capacity through training programs and collaborative activities.

Highlights:

- Neutron-based tools developed at NIST are being utilized to probe the structure and behavior of new materials at the nanoscale, making it possible to improve process technologies and develop new materials applications ranging from light-weight advanced materials for the auto industry to novel nanocomposites for polymer-based solar cells to innovative materials and approaches for the efficient energy storage.

- NIST neutron imaging has made it possible to look through the steel casings of operating hydrogen fuel cells and watch the flow and movement of water molecules as the cell functions, leading to better designs and performance. Neutron imaging capabilities can also probe internal stresses in materials such as pipelines, turbine blades, railroad rails, and shock absorbers in order to understand and improve the performance of products used in industry, transportation, and national defense.
- In studies of the structure and motions of very large biological molecules such as proteins, NIST is using neutrons to probe the bending and folding properties essential to protein function. The insights gained could lead to the development of new drug therapies, new anti-toxins, and improved vaccines.
- The unparalleled penetration and imaging power of neutron-based tools developed at NIST allows study of chemical interactions with porous or other complex structured materials, leading to the development of new, more efficient industrial catalysts and better ways to remove toxins from the environment, as well as a better understanding of complex biological systems at the cellular level.
- The advance of information technology requires a concomitant increase in the density of stored information, requiring the development of new nanostructured magnetic materials. NCNR capabilities enable NIST research teams to develop a detailed understanding of magnetism critical to the performance of these new data storage systems.



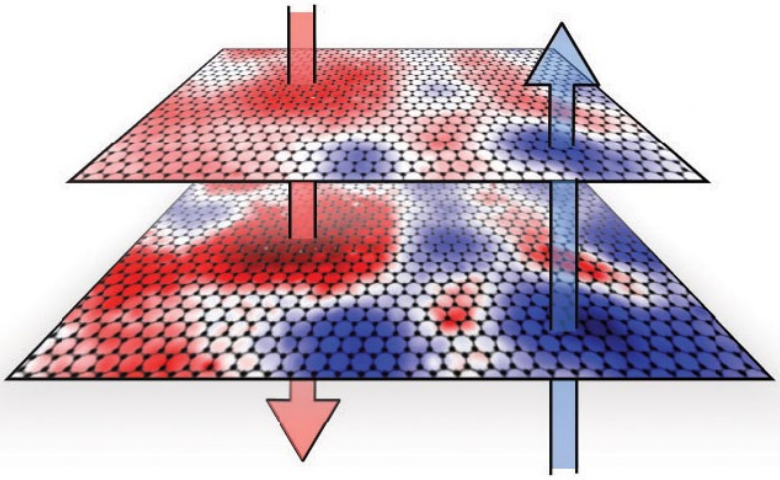
A typical fuel cell and neutron image of water formed inside during operation (Credit: NIST)

NIST Center for Nanoscale Science and Technology (CNST):

The CNST user facility was created to reduce barriers to innovation by providing industry, academia, and other government agencies with access to world-class nanoscale measurement and fabrication methods and technology. The unique CNST operating model is designed to support both the current and future needs of the national nanotechnology enterprise. The shared-use NanoFab facility provides convenient, rapid access to a comprehensive, state-of-the-art commercial tool set for nanoscale measurement and fabrication. Looking beyond the current state of the art, CNST research creates the next generation of nanoscale measurement instruments and methods, which are made available through to the scientific community through collaboration.

In the few years since its inception, the CNST has become a major national resource for nanoscale science and the development of nanotechnology. The number of research participants at the CNST is increasing rapidly, exceeding 1,400 in FY 2011 (the fourth full year of operation), and continues to grow. The research participants represent diverse communities, including 170 universities, 80 companies, and 28 government laboratories from across 43 states and the District of Columbia.

CNST's measurement and instrumentation research is currently focused on three nanotechnology areas broadly covering (1) nanoscale devices, architectures, and interconnects for future electronics; (2) nanomanufacturing and nanofabrication; and (3) energy conversion, storage, and transport at nanostructured interfaces. CNST is developing new instrumentation to fabricate and characterize a range of electrochemical energy conversion and storage devices in order to improve their efficiency and performance, including a novel electron paramagnetic resonance (EPR)-based spectroscopy system for probing the chemistry of nanoscale catalysts needed to produce photovoltaic cells, and an environmental transmission electron microscopy system with unique spectroscopic capabilities for observing the atomic-scale formation and growth of commercially important nanomaterials.



NIST measurements show that interactions of the graphene layers with the insulating substrate material causes electrons (red, down arrow) and electron holes (blue, up arrow) to collect in "puddles". The differing charge densities creates the random pattern of alternating dipoles and electon band gaps that vary across the layers. (Credit: NIST)

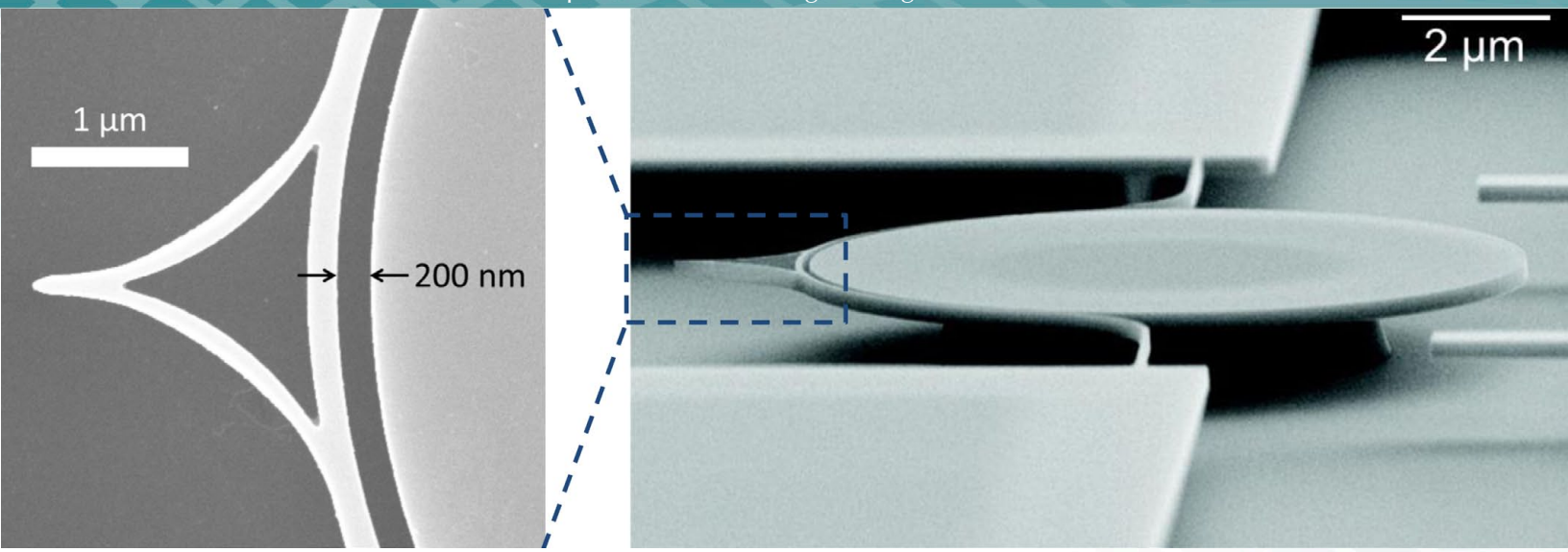
Within the CNST, the NanoFab facility is a world-class, 5,600 square meter (60,000 square foot) shared resource for nanofabrication and measurement – with more than 1,800 square meters (19,000 square feet) of cleanroom laboratory space and more than 85 major commercial measurement and processing tools. To meet specific needs of industry, the NIST NanoFab has created a quick and easy process for researchers to obtain equitable access to the equipment. Research at the NanoFab can be carried out by individual users or with the assistance of a technical expert from the NanoFab staff, imparting the flexibility needed to satisfy the widest range of needs, from expert academic

researchers to small companies with an innovative new technology but limited expertise in nanofabrication. Within the next three years, the NanoFab will add a variety of new commercial tools, including those for automated, reproducible lithography; wet chemical processing; and nanoscale patterning and chemical analysis of metals and other hard materials.

Highlights:

- NIST research is helping uncover the nanoscale structural changes that occur inside an individual nanowire battery during charging and discharging, providing valuable information for improving the efficiency and performance of future rechargeable power sources being developed based on nanowire technology. Scientists at CNST have fabricated complete, functional single-nanowire lithium ion batteries optimized for characterization in a transmission electron microscope.
- Working directly with a major U.S. manufacturer of nanotechnology instrumentation, researchers at NIST adapted a commercial focused ion beam column to use photoionized laser-cooled lithium atoms as an ion source, and demonstrated that NIST's patented Magneto-Optical Trap Ion Source (MOTIS – which builds on NIST researcher William D. Phillips' Nobel-Prize-winning work using lasers to trap and cool atoms - offers imaging performance competitive with the liquid metal ion sources used in current commercial systems. Their success establishes that NIST's MOTIS ion source and similar

NIST develops new measurement techniques and instruments and provides expertise and shared-use facilities to support the advancement of nanotechnology and semiconductor manufacturing. The NIST Center for Nanoscale Science and Technology's Nanofabrication Facility features about 1765 square meters (19,000 square feet) clean room space for photolithography and other nanoscale fabrication tasks
(Credit: NIST/CNST)



CNST researchers developed a nanomechanical cantilever probe with a high-sensitivity nanophotonic interferometer on a single silicon chip. Replacing the traditional bulky laser detection system with this integrated device allows cantilevers that are orders of magnitude smaller than those used in conventional atomic force microscopy to be built. This innovation creates opportunities for rapid, compact, and low-cost nanoscale metrology for a wide range of applications. (Credit: NIST)

systems may enable a wide range of new capabilities for such systems — from nanoscale imaging and defect metrology to ion implantation and material modification.

- Nanomanufacturing holds great promise across a number of application areas. For example, roll-to-roll manufacture of carbon-based nanostructured materials is a revolutionary process for producing high volumes of advanced materials for applications in aerospace and flexible electronics. However, cost-effective, rapid methods are needed that are capable of characterizing the nanoscale structure/properties of a material or device array as it is processed at high speed. NIST researchers are tackling these challenges. They are also working on understanding fundamental nanoparticle interactions by developing new particle- tracking methods as well as a suite of tools for accurate, precise, and reproducible measurements that could be used for determining potential environmental, health and safety effects of nanomaterials.
- Access to the NanoFab facility is accelerating important technology developments, including a new method to make precisely shaped holes in diamond, potentially leading to long-lasting micromachines. Research participants from industry are using the NanoFab to develop key chemical modifications needed to make nanoparticles that are 10 times more effective for use in a commercial medical diagnostic system, and to create a novel nanoscale measurement device to spur the development of fuel cell power sources.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NIST Innovation and Industry Services (IIS) Programs

In support of the Administration's emphasis on serving industry through outreach services, NIST provided three major externally-focused services through FY 2012: The Hollings Manufacturing Extension Partnership (MEP), the Baldrige Performance Excellence Program (BPEP), and the Technology Innovation Program (TIP).

The Baldrige Performance Excellence Program (BPEP) provides criteria for organizational performance self-assessment and serves as a resource to improve U.S. innovation, entrepreneurship, and competitiveness in businesses/industry, education, health care, and government and other public benefit organizations. The BPEP is responsible for managing the Malcolm Baldrige Quality Improvement Act of 1987 (Public Law 100-107), in cooperation with senior U.S. business, education, health care, and nonprofit leaders. The Baldrige Foundation, the private 501(c) 3 that has supported BPEP for over 20 years with the contributions of the private sector, has agreed to support operations of the Baldrige Program through 2012, while key program partners explore alternative business and funding models to sustain the mission of Baldrige in the future. The Technology Innovation Program (TIP), which supports, promotes, and accelerates innovation in the United States through high-risk, high-reward research in areas of critical national need, is beginning the process for an orderly shut-down and completion of on-going awards. Neither BPEP nor TIP are detailed further in the discussion below because beginning in FY 2012, they will no longer receive NIST-appropriated funds.

NIST's Hollings Manufacturing Extension Partnership (MEP) provides technical and business assistance to smaller manufacturers through a nationwide network in all 50 states and Puerto Rico through grant-supported partnerships between Federal and state governments and non-profit organizations. Field agents and programs in 60 centers nationwide help manufacturers understand, adopt, and apply new technologies and business practices, resulting in increased productivity, better performance, cost savings, waste reduction, and creation and retention of manufacturing jobs. MEP also acts as a strategic advisor to promote business growth and innovation and to connect manufacturers to public and private resources essential for expanding into new markets, developing efficient processes and training an advanced workforce. To enable future profitable manufacturing growth, the long-term focus of NIST's MEP Program will be on encouraging cultures of continuous improvement, accelerating the adoption of new technology to build business growth, responding to evolving supply chains, implementing environmentally sustainable processes, and establishing and enabling a strong workforce.

Highlights:

Accelerating Technology Transfer:

Transferring technology and commercialization of inventions from federal laboratories is part of MEP's mission responsibilities. Through its renewed focus on innovation. MEP will assist manufacturers in adopting technology in their manufacturing processes and products by scouting for technology solutions to meet current needs, presenting business opportunities to innovatively apply new technologies to attract new customers and enter new markets, and connecting manufacturers with partner resources to accelerate the development, intellectual property management and commercialization of these technologies.

MEP provides strategic business and technical assistance to numerous small and medium businesses such as Lee Spring (Brooklyn, NY), which produces custom wire forms manufactured to customer specifications (Credit: Kristen Dill)

National Innovation Marketplace (NIM):

In partnership with other organizations, MEP is developing the National Innovation Marketplace (NIM) which facilitates connections between original equipment manufacturers (OEMs) and potential suppliers, encourages technology translation and adoption, and provides analysis of business growth potential of new products. As an innovation clearinghouse, MEP, through and with its network of NIM partners, is facilitating the building of technology-based supplier networks. The NIM encourages the translation of emerging technologies: first, into business applications; second, into market opportunities; and third, into the adoption of new products. The NIM uses an "open innovation strategy," which involves partnering, licensing, and co-developing innovation with partners outside of a company instead of traditional internal research and development. Through the NIM, innovation sellers, buyers, investors and distributors across industries are connected through a three-pronged approach incorporating translation training, business opportunity forecasting, and access to manufacturers.

ExporTech:

In today's economy, U.S. companies are increasingly turning to international markets to offset declines in domestic sales. In fact, exporting is rapidly becoming the fastest growing segment of the market. ExporTech leads companies through a facilitated process that prepares them for profitable growth in global markets. ExporTech is deployed nationally as a collaboration between MEP, U.S. Export Assistance Centers, and other partners including District Export Councils, State Trade Offices, Export-Import Bank and the Small Business Administration. ExporTech

helps companies enter or expand in global markets by assisting participating companies to develop an international growth plan, providing experts who will vet their plans, and connecting the companies with organizations to help them move quickly beyond planning to actual export sales. Throughout the program, local experts knowledgeable in all aspects of exporting are brought in to provide information and guidance, enabling companies to accelerate their growth plan and speed to market.

Economy, Energy, and Environment (E3):

E3 is 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. Leveraging the resources of the Department of Commerce, the Department of Labor, the Department of Energy and the Environmental Protection Agency, the E3 Initiative provides customized assistance to manufacturers as they improve their competitiveness and business performance. E3 serves as a unique model by working directly with local manufacturers, utilities, and business communities to streamline the delivery of the most suitable technical and financial resources.

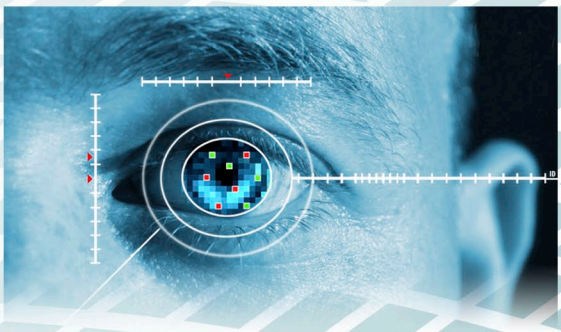
Make It In America:

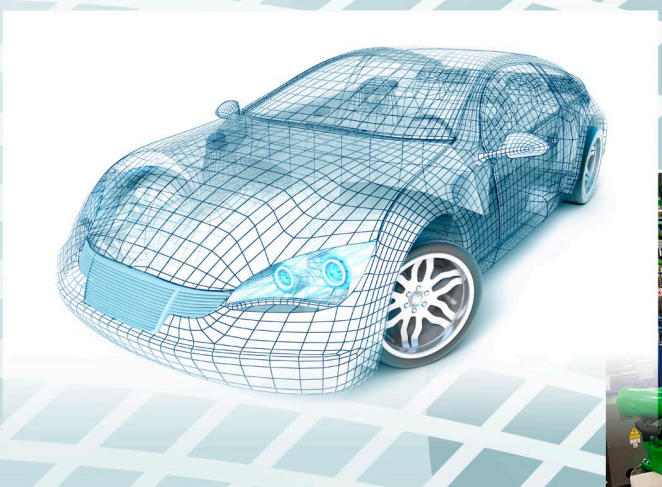
To make a measurable impact on rebuilding U.S. manufacturing and creating jobs, MEP is focused on a "Make It In America" agenda. MEP supports job creation now and in the future by encouraging manufacturers to collaborate in developing products in America. Through various public-private partnerships, MEP provides a valuable infrastructure that fosters resilient processes for manufacturers to "make it in America." The national MEP system scouts for U.S. manufacturing capabilities and capacities in an effort to solve difficult supply chain and procurement issues by connecting potential suppliers with federal procurement sources, assisting manufacturers with product expansion and/or alteration for additional uses, and securing the engineering necessary to produce technical data needed for product manufacturing.

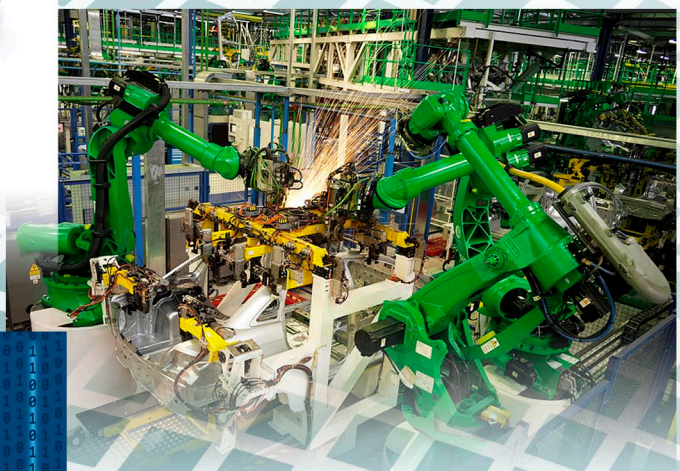
MAKE IT IN AMERICA
MANUFACTURING EXTENSION PARTNERSHIP

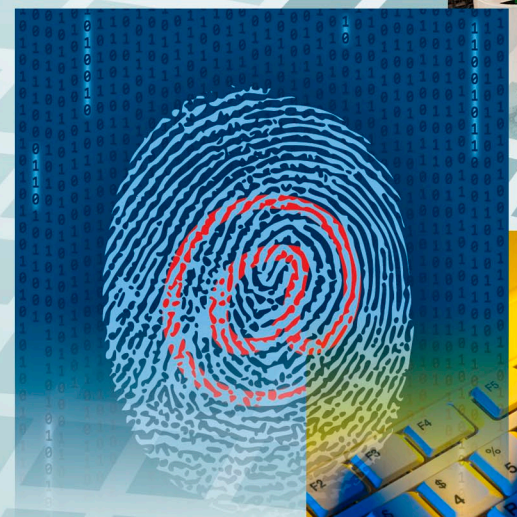
Innovation Engineering:

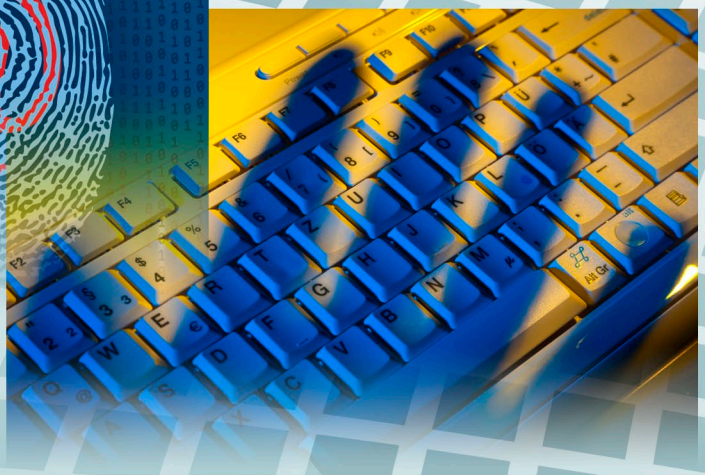
Innovation Engineering is a process to help companies increase innovation speed and decrease risk. The system provides results in process efficiency and risk reduction through the use of advanced education programs and digital tools that build confidence in executives' ability to lead the creation, communication and commercialization of new ideas. The key focus is on developing a quantified pipeline of innovations starting with the acceleration of existing ideas and moving to the definition and discovery of new ideas that address companies' problems and opportunities. Through the system and related training, companies are able to transform cultural attitudes, achieving acceptance of and proactive involvement with innovation.











Priorities for NIST, FY 2013-2015

For FY 2013 – 2015, NIST will align its programs with the following strategic priorities to ensure that targeted program investments meet its mission of advancing U.S. innovation and industrial competitiveness.

Strengthening U.S. advanced manufacturing capabilities:

NIST supports long-term U.S. economic competitiveness by strengthening development and deployment of advanced manufacturing capabilities. NIST will:

- Develop and deliver the measurement science tools that will support advanced manufacturing technologies (including materials modeling, nano and biomanufacturing, sensors, quality control processes, robotics, and other enabling technologies);
- Support technologies and practices that increase the competitiveness and resiliency of our nation's small and medium manufacturing base, through the Hollings Manufacturing Extension Partnership;
- Host the interagency Advanced Manufacturing National Program Office to coordinate private sector/government collaboration on the development and implementation of U.S. advanced manufacturing capabilities and policies; and
- Launch the Advanced Manufacturing Technology Consortia (AMTech) initiative that will bring together industry, universities, and the federal government to invest in highly promising R&D pre-competitive long-range industry focused R&D and accelerate the transfer of innovative technologies and products into the hands of American manufacturers.

(Credit: Rainer Plendl/Shutterstock)

Advancing the state of the art in cybersecurity solutions:

NIST is a recognized world leader in cybersecurity, with a track record of accelerating the development and deployment of cybersecurity solutions and standards that are reliable, usable, interoperable, and secure, as well as the measurements and standards infrastructure for emerging cybersecurity applications. NIST will:

Credit: Valerie Potapova/Shutterstock

- Encourage the rapid adoption of advanced security technology through the National Cybersecurity Center of Excellence (est. FY 2012) that will bridge the gap between the public and private sectors and provide U.S. companies with technical resources for developing, evaluating, and transferring the technology needed to secure their intellectual property and data; and
- Support the Administration's National Strategy for Trusted Identities in Cyberspace (NSTIC) initiative by facilitating the creation of an Identity Ecosystem that gives participants access to secure credentials and increases the opportunities for trusted on-line transactions. The National Program Office for NSTIC at NIST will support the development and activities of a private sector-led governance structure for the Identity Ecosystem as well as support pilots to increase access and usage of trusted credentials.

Accelerating technology transfer and commercialization:

Technology transfer is the process by which NIST knowledge, facilities and capabilities are deployed to fulfill public and private needs, and NIST plays a unique role in advancing the federal government's technology transfer goals. Technology transfer enables NIST to utilize its measurement science, standards, technology, and external partnership programs to fulfill its responsibility to promote U.S. innovation and industrial competitiveness. The October 2011 Presidential Memorandum, "Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses," challenges all federal agencies to increase the successful outcomes of technology transfer while simultaneously achieving excellence in basic and mission-focused research activities. NIST's responsibility for tracking and measuring the impact of technology transfer activities from federal laboratories represents a distinctive policy role.

Accordingly, NIST will:

- Establish and implement a five-year plan to increase technology transfer activities with external partners, including private firms, research organizations, and non-profit entities;
- Develop a comprehensive definition of the full range of NIST's technology transfer mechanisms and execute a coordinated effort to track the outcomes and impacts of such activities;
- Exercise continuing leadership through convening the Interagency Working Group on Technology Transfer to identify opportunities for improving technology transfer from Federal laboratories, and support OMB and OSTP in the review and monitoring of agency plans;
- Improve and expand the collection of metrics and develop rigorous economic impact models and tools for technology transfer; and
- Establish new competitive Centers of Excellence in measurement science areas defined by NIST, which will provide an interdisciplinary environment for NIST, academia and industry to collaboratively carry out basic and applied research with the end goal of enabling innovation and technology transfer.

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