

Testimony of

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“Importance of Basic Research to United States’
Competitiveness”

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Chairman Ensign and Members of the Subcommittee, I want to thank you for inviting me to testify today about the importance of basic research and the vital role it plays in enabling competitiveness. I have the great honor of being the Director of the National Institute of Standards and Technology (NIST), one of our nation's oldest Federal laboratories. Our 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. Enabling innovation and competitiveness has been an important part of our mission since we were founded as the National Bureau of Standards 105 years ago. In the spring of 1900, when Congress was considering the Act that created the National Bureau of Standards, the accompanying Committee report stated:

“...that no more essential aid could be given to manufacturing, commerce, the makers of scientific apparatus, the scientific work of the Government, of schools, colleges, and universities than by the establishment of the institution...”

That statement is as true today as it was then. From our early electrical measurement research to today's quantum information science, NIST has long been a center for high-impact basic research.

In today's global economy, the ability of the United States to remain competitive relies increasingly on our ability to develop and commercialize innovative technologies. The amount of scientific components in products has increased dramatically. Just think about how much more complex an iPod is compared to a record player. The ability of America to be technologically innovative both drives and is driven by our ability to observe and to measure. If you cannot measure something -- you will not be able to control it. And if you can not control it -- you will not be able to reliably manufacture it. NIST's unique role, or niche, is to advance measurements and standards so that the next innovation can be realized and commercialized, thus allowing our industries to be competitive. Recognizing the importance of NIST's role in innovation and competitiveness, President Bush has included NIST as part of the American Competitiveness Initiative (ACI). The President's initiative includes key resources necessary for NIST to develop the measurement and standards tools to enable U.S. industry and science to maintain and enhance our global competitiveness.

When the Secretary of the Treasury proposed the creation of the measurements and standards laboratory that became this agency, he wrote:

“The extension of scientific research into the realm of the extremes of length, mass, time, temperature, pressure and other physical quantities necessitates standards of far greater range than can be obtained at present. The introduction of accurate scientific methods into manufacturing and commercial processes involves the use of a great variety of standards of greater accuracy than formally required.”

Extreme measurements are still needed today; the only difference is that today's measurement frontier is smaller, colder, more precise, and more accurate. One example of how these extreme measures impact innovation is the work of our most recent Nobel Laureate, Dr. Jan Hall. Dr. Hall significantly contributed to the development of the laser, first demonstrated in 1961, from a laboratory curiosity to one of the fundamental tools of modern science and a ubiquitous component of modern communications. His research concentrated on improving the precision and accuracy with which lasers can produce a specific, sharp frequency or color of light, and the stability with which they can hold that frequency. His work has been essential to the development of the laser as a precision measurement tool. This ability to precisely control the frequency and improve stability has enabled a broad range of laser innovations in science and technology, including precision spectroscopy for physical and chemical analysis, new tests and measurements of fundamental physical laws and constants, time and length metrology, and fiber-optic communications, among others.

As you can see by this example, NIST's measurement and standards infrastructure is part of the foundation upon which innovation is built. You can think of this "infrastructure" as the roads, bridges, and communications networks of the scientific world. Just like physical infrastructure, no one person or company can claim enough benefit from the work or has the capability to build this infrastructure. This "common good" infrastructure ultimately benefits whole industries.

Another area in which NIST's research impacts competitiveness is in the area of standards. Standards promote the freemarket by acting as the "grease" which increases transactional efficiency, resulting in reduced costs and opening of new markets thus enhancing competitiveness. Today, thanks in part to NIST, most consumers take it for granted that weights and measures are accurate and that products fit together. That was not always the case. In 1901, there were as many as eight different standard gallons; Brooklyn, NY recognized four different legal measures of the foot, and about 50 percent of tested food scales were wrong, usually favoring the grocer. Today, American consumers and businesses can be confident in the quantity of product being purchased – making transactions more reliable and cost effective.

However, the need for standards has increased as the economies of the world have become linked through global trade. To compete in this global marketplace, U.S. products must meet specified standards for quality and performance. NIST collaborates with other agencies and the private sector to represent U.S. interests in the development of international standards. Ideally, such standards should not put U.S. products at a competitive disadvantage.

The United States Standards Strategy calls for standards to be developed in an open and consensus-driven process and the resulting standard to be performance-based and relevant, in other words, to create a level playing field for all participants.

This philosophy is not consistently applied in all countries – requiring constant vigilance to prevent standards being adopted by other countries that *de facto* serve as barriers to trade.

NIST works proactively to encourage other countries to adopt standards that satisfy the criterion outlined above. For example, NIST staff has worked with U.S. based organizations, such as the International Code Council (ICC) and the National Fire Protection Association (NFPA) to promote the adoption and use of building and construction standards in different parts of the world – thus opening these markets to exports of U.S. products and services. As just one result, Saudi Arabia has adopted significant parts of the ICC Building and Construction Codes, requiring technologies that are widely used in the United States. The current value of Saudi Arabian new and planned construction is approximately \$35 billion. The Saudi Arabia Standards Organization (SASO) is currently translating the code into Arabic, paving the way for its use in other countries in the region.

So how is it that we know that measurements and standards play such an important role in terms of our economic competitiveness? Well, like everything else at NIST, we try to measure it. Over a seven year period, 1996-2002, NIST conducted 19 retrospective economic impact studies on a wide range of technologies and industries that can be collectively viewed as a legitimate indicator of NIST industry impact. The average benefit-cost ratio of the studies was 44 to 1. That means for every dollar invested in these projects, we documented \$44 of direct economic benefit to the nation.

One of the studies looked at the economic impacts of NIST's cholesterol standards program. In 1969, the variability of cholesterol in blood measurements was reported to be approximately 18 percent. Over the following 25 years, NIST -- working with the Centers for Disease Control -- established and maintained a reference infrastructure for cholesterol measurements that has contributed to a steady decrease in measurement variability to less than 5 percent, representing potential savings of over \$100 million per year in treatment costs for misdiagnosed patients. Additionally, due to the availability of highly accurate cholesterol reference materials, manufacturers of cholesterol measurement systems experience lower production costs than they would if standard reference materials were not available. They also faced significantly lower transaction costs than they would if the accuracy of their products was not "anchored" to these nationally-recognized standards.

Maintaining and extending our nation's competitiveness is critical to our nation's future economic security. To address this, the President has proposed the American Competitiveness Initiative (ACI). One component of the President's initiative is the strong commitment to double over 10 years investment in the key Federal agencies that support basic research programs in the physical sciences – the National Science Foundation, the Department of Energy's Office of Science, and NIST. ACI allocates \$535 million for the high impact research and facility upgrades at NIST. This is an increase of \$104.1 million over FY 2006 – after removing directed grants – a 24 percent

increase for our measurement and standards programs. The major focus of NIST's portion of the American Competitiveness Initiative includes the following:

Targeting the most strategic and rapidly developing technologies (\$45 million)

- **Enabling nanotechnology from Discovery to manufacture (\$20 million)**
This initiative will fund a national research facility for developing and disseminating nanoscale technologies, and an R&D effort, utilizing the resources of both the facility and NIST's multidisciplinary labs to develop measurement science, standards, and technology for nanomanufacturing.
- **Enabling the Hydrogen Economy (\$10 million)**
This initiative will expand research efforts at NIST to develop the technical infrastructure to enable safe production, storage, distribution, and delivery, as well as equitable sale, of hydrogen in the marketplace.
- **Quantum Information Science: Infrastructure for 21st Century Innovation (\$9 million)**
NIST proposes to accelerate advances in this critical field through three complementary efforts: (1) an expanded in-house program; (2) an enhanced effort to exploit the fundamental properties of quantum systems to develop new metrology tools and methods, and (3) funding for a Joint Quantum Institute.
- **Innovations in Measurement Science (\$4 million), and**
This initiative will expand the scope and nature of projects selected for the Innovations in Measurement Science Program to allow this program to keep better pace with the evolving needs of industry and science.
- **Cyber Security: Innovative Technologies for National Security (\$2 million)**
NIST proposes to work with industry and academia to develop measurement science and technologies to identify the level of vulnerability of IT systems, assess the effectiveness of cyber security controls, test system functionality, address vulnerabilities, identify vulnerabilities in real-time, and mitigate attacks.

Increasing the capacity and capability of critical national assets (\$27 million)

- **NIST Center for Neutron Research (NCNR) Expansion and Reliability Improvements: A National Need (\$22 million)**
This initiative begins a planned five-year program to expand significantly the capacity and capabilities of the NCNR to help meet this pressing national need.
- **Synchrotron Measurement Science and Technology: Enabling Next Generation Materials Innovation (\$5 million)**
NIST proposes to accelerate innovation in U.S. materials science by creating a diverse set of scientific instruments at the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory.

Meeting the Nation's most immediate needs (\$12 million)

- **Manufacturing Innovation through Supply Chain Integration (\$2 million)**
This initiative will enable an extensive and wide-ranging program with U.S. manufacturers, to develop standards for seamless data transactions throughout global supply chains.
- **Structural Safety in Hurricanes, Fires, and Earthquakes (\$2 million)**
This initiative will allow the development of technical tools required to enable innovations in multi-hazard risk assessment and mitigation technologies, and the scientific basis to improve the codes and standards used in the design, construction, and retrofit of buildings and physical infrastructure.
- **International Standards and Innovation: Opening Markets for American Workers and Exporters (\$2 million)**
Under this proposed initiative, NIST will promote U.S. competitiveness by ensuring that innovative U.S. businesses are better equipped to satisfy standards-related requirements in key export markets and that these firms have access to level playing fields.
- **Bioimaging: A 21st Century Toolbox for Medical Technology (\$4 million)**
NIST will partner its expertise in the physical and information sciences with the experience and know-how of the National Institutes of Health (NIH) and the bioimaging industry to develop the needed measurement capabilities to move from simple observation to quantitative diagnosis.
- **Biometrics: Identifying Friend of Foe (\$2 million)**
NIST will develop: (1) tests to determine the accuracy of multimodal systems; (2) image quality standards and standard measurement techniques to improve the accuracy and interoperability of facial recognition systems used for border security; (3) tests to determine the image quality of live-scan fingerprint equipment; and (4) tests and guidelines to assure that future biometric systems are interoperable and work in realistic environments.

Improving NIST Facilities (\$20.1 million)

- Physical improvement to research buildings in Boulder, CO (\$10.1 million)
- Increasing the base for Safety, Capacity, Maintenance and Major Repairs of NIST's Facilities (\$10 million)

In today's modern world, measurements and standards are critically important for such things as the integration of the manufacturing supply chain, development of novel nanomaterials, adoption of a hydrogen economy, and harnessing the power of quantum mechanics. I would now like to take the opportunity to talk about a few of our initiatives and how they will impact the United States' ability to innovate and remain competitive.

America's large manufacturers are globally distributed enterprises that rely on a system of small manufacturers, parts suppliers, shippers, and raw materials producers organized in extended supply chains. Using the auto industry as an example, the average car has over 15,000 parts coming from 5,000 manufacturers that must be there on time, every time, with the precise specifications of the large manufacturers. Production costs are no longer the only cost drivers in these global supply chains – an increasingly important factor is the cost of engineering and business activities, which depend critically upon clear and error-free exchange of information. Successfully managing production throughout the supply chain is critical to the competitiveness of these extended enterprises. An independent economic study commissioned by NIST found that the U.S. automotive supply chain loses \$1 billion annually from these inefficiencies. NIST research on interoperability standards is the key to successfully “lubricating” these supply chain transactions.

The nanotechnology-related market is predicted to exceed \$1 trillion globally by 2015. Within the next 10 years, experts expect at least half of the newly designed advanced materials and related manufacturing processes to be at the nanoscale. The United States is making significant investments in nanoscience and nanotechnology, and it is essential that we rapidly and efficiently transfer our basic scientific discoveries to practice within our manufacturing sector. Globally, no one country or region has a significant technological lead in this area—with the European Union, Japan, and other countries each investing about the same amount of government resources as the United States. Successfully translating nanoscale discoveries into manufactured products will be critically dependent on: (1) developing process technologies to efficiently and reliably produce commercially significant quantities of nanomaterials, (2) developing advanced measurement and process-control technologies—including standard reference materials—to monitor production processes and for quality control, and (3) close cooperation and interaction between the research sector, the manufacturing sector, and the national measurement standards system. In order to meet each of these requirements and thus allow the U.S. to be globally competitive, NIST will have to conduct the research to support the development of a measurement and standards infrastructure for nano-products.

Everyone understands that one of the factors affecting our global competitiveness is our dependence on foreign oil. President Bush issued a challenge to the nation's scientists and engineers in his 2003 State of the Union speech to overcome technical obstacles so that “the first car driven by a child born today could be powered by hydrogen, and pollution-free.” In order to make this vision of a hydrogen economy a reality, measurements and standards must lead the way.

For the past 50 years, NIST has been a leading provider of data on the chemical and physical properties of hydrogen. NIST's Center for Neutron Research (NCNR) is a premier facility for the study of hydrogen. The NCNR was cited by a 2002 working group of the White House Office of Science and Technology Policy as “the highest performing and most used neutron facility in the United States.” The NCNR already is being used in conjunction with major U.S. manufacturers to study the flow of hydrogen

through operating fuel cells to help improve the efficiency and durability of these devices. NIST is, in fact, the lead agency for weights and measures for vehicle fuels and will need to develop physical reference standards, calibration services, and new consensus standards to help ensure equitable trade of hydrogen in the marketplace. Moreover, NIST's expertise will be critical for advancing hydrogen process control technologies, the design of fuel cells, and the development of innovative tools needed to make the hydrogen economy a reality.

America's future prosperity and economic security may rely in part on the exotic properties of some of the smallest particles in nature to accomplish feats in physics, information science, and mathematics that are impossible with today's technology. Quantum information science seeks to use the fundamental properties of nature at very small scales to build technologies that can only be imagined today. While classical physics describes the way objects interact at the everyday scale, quantum physics describes the rules by which electrons, nuclei, and other subatomic particles interact. At these small scales the laws of our everyday experience breakdown and new phenomena arise. This revolutionary new technology offers potential solutions to issues looming on the horizon of technology development, including the limits of Moore's Law on the microelectronics industry. Around the year 2015, the microelectronics industry will reach its limit in reducing the size, and increasing the processing speed, of integrated circuits manufactured by traditional silicon technology. Additional process power and capacity will then only be achieved through revolutionary technologies such as quantum information. With several world-renowned scientists, including three Nobel laureates, NIST is perfectly positioned to play a more critical role in developing the tools for measuring, controlling, and ultimately understanding the quantum realm and harnessing its power to achieve benefits for the nation.

With my testimony today, I have demonstrated how and why NIST's basic research plays a unique role in our nation's research and development enterprise. NIST sits at the nexus of science and industry, conducting extreme measurement science and developing standards that allow industry to innovate and compete in the global economy. The President's 2007 budget recognizes this role and provides our researchers the ability to keep advancing the critical measurements that will enable U.S. industry to develop the most advanced and best products and services. Mr. Chairman, thank you for inviting me to testify today. I would be happy to answer any questions.