

Testimony of  
Dr. William Jeffrey

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

Before the  
House Committee on Appropriations  
Subcommittee on Commerce, Justice, Science and  
Related Agencies

March 8, 2007

Chairman Mollohan, Ranking Member Frelinghuysen and Members of the Subcommittee, I am pleased to appear before you today to present the President's FY 2008 Budget request for the National Institute of Standards and Technology (NIST). This is a strong budget for NIST and it will further enhance NIST's ability to support the measurement and standards needs of U.S. industry and universities. The FY 2008 request of \$640.7 million includes \$594.4 million for NIST's core (encompassing NIST's research and facilities) and \$46.3 million for the Hollings Manufacturing Extension Partnership. The budget for the NIST core represents an 11 percent increase over the President's FY 2007 request and a 21 percent increase over the FY 2007 continuing resolution (H.J. Res. 20) recently signed by the President (P.L. 110-5). This funding supports NIST's mission *to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards and technology in ways that enhance economic security and improve our quality of life.*

#### NIST's Impact on Innovation and the Economy

NIST has a long history of being at the forefront of new innovations through our high-impact measurements and standards. In 2003, the National Academy of Engineering identified 20 of the greatest engineering achievements of the 20<sup>th</sup> century – including automobiles, aircraft, lasers, computers, and the internet. NIST measurements and standards were integral to the successful development and adoption of virtually every one. Now NIST is paving the way for the greatest achievements of the 21st century which are still yet to be imagined.

NIST's measurement science and standards form part of the foundation upon which innovation is built. Just as the nation's physical infrastructure (e.g., roads or power grid) define the nation's capacity to build and transport goods – the nation has an innovation infrastructure which defines the nation's capacity to innovate. And investment in long-term basic research like that done at NIST is an integral component of the innovation infrastructure. As stated in the National Academy of Sciences' Rising Above the Gathering Storm, "*The power of research is demonstrated not only by single innovations but by the ability to create entire new industries.*"

NIST researchers are world leaders in their fields. They frequently arrive at the "cutting edge" of science before anyone else. And once there, they partner with industry and academia to identify and overcome barriers that can slow or even halt the progress of new innovations. With the proposed FY 2008 budget, NIST will continue developing the measurement and standards tools that enable U.S. industry to maintain and enhance our global economic competitiveness.

NIST continues to meet the nation's highest priorities by focusing on high impact research and investing in the capacity and capability of our user facilities and labs. This emphasis is validated by the high rate of return to the nation that the NIST labs already have demonstrated. Nineteen retrospective studies of economic impact show that, on average, NIST labs generated a benefit-to-cost ratio of 44:1 to the U.S. economy. The high rate of return results from the fact that new measurements or standards benefit entire industries or sectors of the economy -- as opposed to individual companies.

NIST supports U.S. innovation and economic competitiveness primarily through its measurements, standards, and national user facilities. Recent NIST successes highlight the importance of each of these critical components and illustrate how NIST's labs are able to return such a large benefit to the nation:

*Measurements* – NIST researchers recently developed new measurement techniques that allow for rapid and cost-effective assessments of advanced materials that are used in a range of products from new detergents to improved adhesives for next-generation electronics. Previously, it could cost industry \$20 million to develop and understand the characteristics of one new material. With this NIST measurement advance, the cost and time are estimated to have been cut by 80 percent. To facilitate the transfer of this technique to industry, NIST organized an open consortium now consisting of 23 members that are learning to use and adapt these new measurement techniques. As a scientist from Honeywell International put it, “...NIST offers an invaluable resource to show what can be done, and how to go about it. NIST Combinatorial Methods Center scientists are reawakening a major element of creativity that analytical science almost lost.”

*Standards* – Nanotechnology has the potential to revolutionize manufacturing. And one of the most promising nanomaterials is the carbon nanotube. Carbon nanotubes have unique electronic and mechanical properties that lend themselves to a variety of applications, ranging from the development of stronger and lighter materials to nanowires and transistors for miniature electronics. Regardless of the potential application, the quality of the materials is paramount. Unfortunately, current production techniques for carbon nanotubes result in products with high levels of uncertainty in their quality and uniformity. To address this concern, NIST is currently developing a carbon nanotube reference material. This reference material, when deployed, can be used by any nanotube manufacturer to validate their product's quality, purity, and consistency and accelerate the adoption of carbon nanotubes into more sophisticated devices.

*National User Facilities* -- NIST operates world-class user facilities that benefit the entire U.S. research community. Last year, approximately 2000 researchers from 60 different industries across the country leveraged the NIST Center for Neutron Research (NCNR). One recently developed application of the NCNR was to image the interior of operating fuel cells to help improve the efficiency and durability of these devices. Large and small companies involved in the manufacture or use of hydrogen fuel cells, including General Motors, Daimler-Chrysler, Dupont, and PlugPower, have benefited from this new capability. The NCNR is the premier facility in the world providing this capability. A National Academy of Sciences report describes the NIST efforts in regards to fuel cell technologies as “...a considerable achievement and one of the most significant analytical advances in the membrane fuel cell realized in decades. The NIST facility offers the entire fuel cell community unique research opportunities that previously eluded them.” Industry scientists have stated that the research

performed at the NCNR has allowed them to jump 5 years ahead in terms of fuel cell development.

The President recognized NIST's critical role for the nation as part of the American Competitiveness Initiative (ACI). The ACI describes NIST as: "... a high-leverage Federal research agency that performs high-impact basic research and supports the successful technical translation and everyday use of economically significant innovations..." Under the ACI, overall funding for NIST's core, the National Science Foundation, and the Department of Energy's Office of Science is together slated to double by 2016.

#### Preparing for the Future

The 21<sup>st</sup> century will be defined by technology innovations that fundamentally change the products and services available, the way they are manufactured and provided, and the impact on our quality of life. These advances will arise from basic research now beginning in, for example, nanotechnology, quantum science, and alternative energies – all areas in which NIST has a strong and increasing focus with its investments.

The goal of increasing physical sciences research at NIST (along with that supported by the National Science Foundation and the Department of Energy's Office of Science) provides a unique opportunity to strategically establish the programs, plans, and infrastructure that will more than double the impact that NIST has on the economy. To prepare for the future, NIST is working with industry to identify critical measurement barriers to innovation, evaluating the capacity and capability of NIST's physical infrastructure, forming new and strengthening existing partnerships, and updating the ways it stimulates the knowledge transfer from its labs to industry and academia.

For example, over the past year, NIST worked with over 1000 experts from industry and universities to identify measurement barriers to innovation in a number of critical industry sectors. Over 700 technical barriers were identified, analyzed, and documented in a report. NIST is now in the process of working with industry, universities, and other government agencies to address many of these identified barriers over the coming years.

In terms of facilities, NIST has conducted a rigorous evaluation of its laboratory capacity and capabilities on its Boulder, Colorado, campus. This review found facilities' shortfalls in our ability to meet both current and projected industry and university needs in a number of important areas. Examples include the high-speed and high-frequency measurements required for electronics, defense, and homeland security; measurements and tests at the single atom level; and improved methods for measuring time, an area expected to vastly improve navigation and positioning systems. Each technical area was evaluated in terms of necessary laboratory conditions (to include stability of temperature, vibration, and humidity, as well as air cleanliness). As a result of this assessment, new laboratory space to meet the nation's needs well into the 21<sup>st</sup> century is proposed in the FY 2008 budget (Boulder Building 1 Extension).

NIST also serves industry and academia by being a steward of world-class user facilities. As part of the ACI, NIST identified two important opportunities first called out in the FY 2007 budget and enhanced in the FY 2008 budget – increased capacity and capability of the NIST Center for Neutron Research and creation of the NIST Center for Nanoscale Science and Technology. Both of these facilities are designed to stimulate progress in support of our nation’s economic competitiveness.

The ACI provides NIST the opportunity to further promote U.S. innovation and industrial competitiveness. With focused, world-class research and facilities, NIST will have a greater impact on the 21<sup>st</sup> century economy than it did even over the past century.

FY 2008 President’s Budget

The increased funding provided through the FY 2008 request will directly support innovative advances in broad sectors of the economy as well as improve the safety and quality of life for our citizens. The following table summarizes the proposed FY 2008 budget. In this table we show both the FY 2007 President’s budget and the FY 2007 continuing resolution (P.L. 110-5) for comparisons as different baselines.

Budget Summary (\$ million) Showing Both FY 2007 President’s Request and P.L. 110-5 as Baselines

|                           | FY 2007 President’s Request | FY 2007 Continuing Resolution (P.L. 110-5) <sup>1</sup> | FY 2008 President’s Request |  | Change Between FY 2008 and FY 2007 Request | Change Between FY 2008 and P.L. 110-5 |
|---------------------------|-----------------------------|---|-----------------------------|--|--|---------------------------------------|
| STRS (Labs)               | 467.0                       | 432.8   | 500.5                       |  | 33.5                                       | 67.7                                  |
| CRF (Facilities)          | 68.0                        | 58.7  | 93.9                        |  | 25.9                                       | 35.2                                  |
| Core Subtotal:            | 535                         | 491.4   | 594.4                       |  | 59.4                                       | 102.9                                 |
| ITS (MEP + ATP) Subtotal: | 46.3                        | 183.6   | 46.3                        |  | 0  | (137.3)                               |
| TOTAL:                    | 581.3                       | 675.1   | 640.7                       |  | 59.4                                       | (34.4)                                |

The FY 2008 budget was formulated with the FY 2007 President’s request as the baseline. Since P.L. 110-5 provides a smaller budget for the NIST core (STRS and CRF) than the FY 2007 President’s request by \$43.6 million, some proposed initiatives in FY 2007 that will not receive full funding are implicitly contained within the President’s FY 2008 request. New initiatives and program increases are described in more detail below:

Scientific and Technical Research Services (STRS)

**Enabling Nanotechnology from Discovery to Manufacture (+\$6 million)**

The potential market for products containing nanomaterials is estimated at over \$1 trillion by 2015. Because of their small size -- a thousand times thinner than a human hair -- nanoscale products require entirely novel ways to characterize their physical properties and fully exploit their unique characteristics in the manufacture of new products.

<sup>1</sup> Totals for FY2007 do not include the 50% of the pay raise that was included in P.L. 110-5.

In FY 2007, NIST began a major initiative to address the measurement barriers hindering rapid development of nanotechnologies. A new NIST Center for Nanoscale Science and Technology (CNST) has been established that combines both research and a state-of-the-art nanofabrication and nanometrology user facility.

The research initiatives proposed in FY 2008 will build on recent NIST advances by:

- Developing ways to measure strength, stress, strain, optical, and electronic properties of nanostructures to improve processes and understanding of failure mechanisms;
- Creating three-dimensional, high-resolution imaging methods that reveal details of structure, chemical composition, and manufacturing defects and allow researchers to view nanostructures as they interact with their environment;
- Simulating nanoscale phenomena with computer models to allow economical development of production methods for complex nanodevices; and
- Producing the measurement techniques required to address the interagency efforts to characterize nanotechnology impacts to our health, safety, and environment.

### **Measurements and Standards for the Climate Change Science Program (+\$5 million)**

The climate is changing. Determining how fast it is changing, and understanding the complex relationships between all the environmental variables is a critical objective of the U.S. Climate Change Science Program. Many different climate monitoring systems in space, in the air, and on the ground are currently monitoring solar output as well as trapped and reflected heat by the Earth's atmosphere. These systems are operated by many countries and research groups. Establishment of absolute calibration and standard references will allow accurate intercomparisons of these systems, will help identify small environmental changes occurring over many years, and will reduce uncertainties in the data input to global climate change models.

With the proposed FY 2008 funding, NIST will, working in coordination with other agencies, develop:

- An international irradiance measurement scale to be used in rigorously calibrating satellite light intensity instruments prior to launch to ensure sufficient accuracy to allow valid comparisons among results from different instruments or from data sets taken over different periods of time;
- New instrument design strategies and quality assurance programs to optimize accuracy and stability of satellite-based irradiance measurement systems;
- Techniques for generating specific types of aerosols in the laboratory, measuring aerosol optical and physical properties, and for simulating aerosol properties that cannot yet be measured in the laboratory; and
- A database of critically evaluated data on aerosol properties collected at NIST and elsewhere.

### **Enabling Innovation Through Quantum Science (+\$4 million)**

Unlike the laws of physics that govern our "every day" world, the laws of physics that govern the quantum world of atoms, electrons, and light particles are fundamentally

different. These quantum particles are able to interact in ways that according to human experience would seem impossible. For example, a quantum particle can actually be in two different places simultaneously.

Conceptualizing these phenomena is difficult to say the least, but developing ways to exploit them for the development of technologically significant innovations is even more challenging. NIST, however, has world-class scientists who are leaders in the emerging field of quantum information science. Three NIST scientists have won Nobel Prizes in the last 10 years based on their work in this field. Many of the best minds in physics today believe that applications of quantum science will transform the 21<sup>st</sup> century just as integrated circuits and classical electronics revolutionized the 20<sup>th</sup> century.

The proposed FY 2008 initiative will build upon NIST's significant expertise in this area, and leverage the collaborations established in the recently created Joint Quantum Institute between the University of Maryland, NIST, and the National Security Agency. NIST proposes to accelerate the potential of the quantum world for enhancing our nation's competitiveness through research into:

- Quantum "wires" that use "teleportation" techniques to reliably transport information between the components of a simple quantum computer;
- Quantum memory analogous to the random access memory of today's computers to allow more complex logic operations;
- Quantum conversion processes that transfer information from one form of quantum information to another (for example, ways to transfer information about the quantum characteristics of an atom to a photon); and
- Quantum based measurement tools such as optical clocks and single electron counters.

#### **Disaster Resilient Structures and Communities (+\$4 million)**

The past few years have reminded us that both natural hazards – including extreme winds, storm surge, wildland fires, earthquakes, and tsunamis – as well as terrorist actions, are a continuing and significant threat to U.S. communities. The disaster resilience of our physical infrastructure and communities today is determined in large measure by the building codes, standards, and practices used when they were built. Many of these legacy codes, standards, and practices – which have evolved over several decades – are oversimplified and inconsistent with current risk assessments. As construction and rebuilding costs continue to rise, there is increasing recognition of the need to move from response and recovery to proactively identifying and mitigating hazards that pose the greatest threats.

The proposed FY 2008 initiative will, working in coordination with other agencies, develop:

- Standard methods to predict losses, evaluate disaster resilience, and estimate cost-to-benefit of risk management strategies at the community and regional scales that local officials can use to evaluate and mitigate risks via land-use planning and practices;

- Decision support tools to modernize codes, standards, and practices consistent with the risk;
- A validated “computational wind tunnel” for predicting extreme wind effects on structures; and
- Risk-based storm surge maps for the design of structures in coastal regions.

**National Earthquake Hazards Reduction (+\$3.25 million)**

Many earthquakes strike without warning. Within the U.S., more than 75 million people are located in urban areas considered to be of moderate to high risk of earthquakes. Just the economic value of the physical structures within these regions – not including the potential loss of life and economic disruption – is valued at close to \$8.6 trillion. To address this threat Congress has provided longstanding support for the National Earthquake Hazards Reduction Program which NIST coordinates across the Federal government.

This initiative will enhance the safety of:

- *New structures* by establishing and promoting performance-based standards for entire building designs and by accelerating the adoption of basic research into the model building codes, standards, and practices; and
- *Existing structures* through research on actual building performance in earthquakes; developing structural performance models and tools; and establishing cost-effective retrofit techniques for existing buildings.

Construction of Research Facilities (CRF)

**Building 1 Extension (B1E) – Enabling Sustained Scientific Advancement and Innovation (+\$28 million)**

When President Eisenhower dedicated the NIST facilities in Colorado in 1954, no one imagined that half a century later scientists would be manipulating matter atom-by-atom. Such technological advances require increasingly complex and difficult measurements – to be able to observe, characterize, and create structures at ever smaller spatial scales. As the structures shrink in size, small fluctuations in temperature, humidity, air quality, and vibration begin to distort the results. We are now at the point where laboratory conditions are inhibiting further advances in some of the most promising areas of research for the 21<sup>st</sup> century.

The \$28 million proposed in the FY 2008 budget will leverage previously proposed funds (\$10.1 million) in the FY 2007 budget to construct state-of-the-art laboratory space that will meet the stringent environmental conditions required for 21<sup>st</sup> century scientific advances. An additional \$38.1 million will be needed in FY 2009 to complete the project. With a total cost of \$76.2 million, the Building 1 Extension is the most cost-effective approach to enabling world-class measurement science in support of some of the country’s most important economic sectors.

### **NIST Center for Neutron Research (NCNR) Expansion and Reliability Improvements (+\$19 million)**

The NCNR is widely regarded as the most scientifically-productive and cost-effective neutron facility in the U.S., and serves more scientists and engineers than all other U.S. facilities combined. Neutron scattering techniques, in which beams of neutrons are used as probes to see the structure and movements of materials at the smallest scales are critical in a wide range of applications that will define the 21<sup>st</sup> century including nanotechnology, alternative energies, and understanding the structure of biological molecules. Because of the unique properties of neutrons for probing materials and their applications to some of the most advanced technologies, a significant shortage of neutron beam capacity and capability exists in the U.S. to satisfy the demands of industry and academia.

This initiative begun in FY 2007 is the second-year of a planned five-year program to expand significantly the capacity and capabilities of the NCNR. The program includes the development of a new neutron cold source together with a new hall to house the guide tube, modernization of the control system, and five new world-class neutron instruments. The specific FY 2008 funding will complete construction of the new guide hall.

### Industrial Technology Services

#### **Hollings Manufacturing Extension Partnership (MEP) (\$46.3 million – no change from FY 2007 President’s request; -\$58.3 million from P.L. 110-5)**

The MEP program is a partnership between the Federal government and local officials to provide assistance to small and medium sized manufacturers around the country. Surveys taken of companies one year after receiving MEP assistance indicate a significant financial benefit accrued to the individual company.

The Federal government is an important partner in the MEP program. Specifically, the Federal government:

- Develops new services and programs in response to the evolving manufacturing environment and propagates them throughout the network;
- Evaluates and ensures high-quality performance of every member of the network; and
- Ensures that small manufacturers remain the focus of the effort.

The above Federal role can be accomplished within the requested budget. The reduction of Federal funds to the local centers may have to be compensated through a combination of increased fees derived from the benefits accrued by individual companies and cost-savings in the operations of the centers.

#### **Advanced Technology Program (ATP) (\$0 – no change from FY 2007 President’s request)**

No funds for ATP are requested in the President’s FY 2008 budget. The FY 2006 enacted budget and the 109<sup>th</sup> Congress’ House mark and Senate Appropriations committee mark were consistent with the phase-out of the ATP program. The last new

awards were made in 2004 and sufficient funds were available in the carryover to complete all awards and provide government oversight.

The FY 2007 Continuing Resolution (P.L. 100-5) recently signed by the President included funding for the ATP program. NIST will work with Congress to ensure the funds are executed in the most effective manner to promote U.S. industry's competitiveness.

### Summary

Measurements and standards are the bedrock upon which any economy stands. Our founding fathers recognized this. The Constitution assigns the Federal government responsibility to both issue money and to "*fix the standards of weights and measures.*" The two are actually more similar than they might seem at first glance.

All economic transactions rest fundamentally on trust – trust between two parties that a given amount of something is worth a given amount of something else. Helping to create that trust for innovative new technologies is the common theme that runs through all of NIST's proposed FY 2008 research initiatives. Each helps build a missing or inadequate measurement base – a rigorous, accepted way of quantitatively describing something – that improves confidence in scientific results or improves the quality, reliability or safety of innovative products. Recent NIST measurements and standards research have enabled innovations now embedded in the iPod, body armor currently saving the lives of domestic law enforcement officers and our service men and women overseas, and in diagnostic screening devices for cancer patients making their treatment more targeted and accurate. The results of NIST research can be found in virtually every manufacturing and service industry.

For nearly 106 years, NIST research has been critical to our nation's current and future competitiveness. The increased funding in the President's FY 2008 budget for the NIST core will directly support technological advances in broad sectors of the economy that will quite literally *define* the 21<sup>st</sup> century -- as well as improve the safety and quality of life for all our citizens.

## **Biography**

Dr. William Jeffrey is the 13<sup>th</sup> Director of the National Institute of Standards and Technology (NIST), sworn into the office on July 26, 2005. He was nominated by President Bush on May 25, 2005, and confirmed by the U.S. Senate on July 22, 2005.

As Director of NIST, Dr. Jeffrey oversees an array of programs that promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life. Operating in fiscal year 2006 on a budget of about \$930 million, NIST is headquartered in Gaithersburg, Md., and has additional laboratories in Boulder, Colo. NIST also jointly operates research organizations in four locations, which support world-class physics, cutting-edge biotechnology, and environmental research. NIST employs about 2,800 scientists, engineers, technicians, and support personnel and has extensive cooperative research programs with industry, academia, and other government agencies. Its staff is augmented by about 2,500 associates and visiting researchers from industry and universities.

Dr. Jeffrey has been involved in federal science and technology programs and policy since 1988. Previous to his appointment to NIST he served as Senior Director for Homeland and National Security and the Assistant Director for Space and Aeronautics at the Office of Science and Technology Policy (OSTP) within the Executive Office of the President. Earlier, he was the Deputy Director for the Advanced Technology Office and Chief Scientist for the Tactical Technology Office with the Defense Advanced Research Projects Agency (DARPA). While at DARPA, Dr. Jeffrey advanced research programs in communications, computer network security, novel sensor development, and space operations.

Prior to joining DARPA, Dr. Jeffrey was the Assistant Deputy for Technology at the Defense Airborne Reconnaissance Office, where he supervised sensor development for the Predator and Global Hawk Unmanned Aerial Vehicles and the development of common standards that allow for cross-service and cross-agency transfer of imagery and intelligence products. He also spent several years working at the Institute for Defense Analyses performing technical analyses in support of the Department of Defense.

Dr. Jeffrey received his Ph.D. in astronomy from Harvard University and his B.Sc. in physics from the Massachusetts Institute of Technology.