

The Power of Partnerships: Accelerating Innovation Through Public-Private R&D Collaborations

S. Shyam Sunder, Sc.D.
Director
Building and Fire Research Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce, USA

Presented at the
India R&D 2007 Conference, "Innovation—Advantage India"
Dec. 6, 2007, New Delhi



Good afternoon. This has been a fascinating discussion. And I'm delighted to be here to talk about how my organization—the National Institute of Standards and Technology—uses R&D partnerships to help accelerate U.S. innovation.

U.S. Innovation System

Strong R&D = Strong Economy

Key Principles

- Innovation is primarily driven by industry and the private sector
- Federal government provides funding for basic research, infrastructure support, “public benefit” research
- Strong protection of intellectual property, patents, licensing, etc.
- R&D tax incentives
- Venture capital funding system
- Harmonized standards and transparent regulatory system
- Investment in universities and science & technology workforce

2006 U.S. R&D Spending—

\$342.9 billion*

Industry, \$223 B

U.S. Government, \$96.8 B

Nonprofits/universities, 20.8 B

Other government, \$3.2 B



* Source: U.S. National Science Foundation, Division of Science Resources Statistics: <http://www.nsf.gov/statistics/nsf07331/tables/tab5.xls>

2

I’d like to start with a few comments about what I’ll call the “U.S. innovation system.”

The U.S. leads the world in R&D spending. According to the U.S. National Science Foundation, U.S. industry spends about \$223 billion annually, or about 2/3 of the total, while the U.S. government spends about \$97 billion a year. The rest comes from nonprofits, universities, and other sources such as state and local governments.

U.S. funding for R&D is a calculated investment in future economic growth. Economists have shown that about half of economic growth is tied directly to new technologies. These new technologies improve productivity, lower product costs, raise product quality and performance, and ultimately increase market share and economic growth.

Much of U.S. success in generating economic growth then, depends on sustaining high levels of innovation. And convincing industry to invest in innovation depends on creating a supportive and predictable environment.

I’ve listed a few of those elements here. The main message here is in the U.S. we’ve found that fostering innovation is a complex process that requires many different elements to be present in the right amounts at the same time.

NIST provides the “innovation infrastructure”

The equivalent of research “roads and bridges” the industrial and scientific communities need to develop and commercialize new technologies



- Groundbreaking research tools that foster new fields — quantum information, nanotechnology, bioscience
- Evaluated data for technology development
- Better measurement methods to ensure quality
- Performance measures for accurate technology comparisons
- Standards to assure fairness in trade

3

One of these key elements is a measurements and standards infrastructure. The analogy we often use is that NIST provides the infrastructure, the “roads and bridges,” that industry and science need to develop and commercialize new technologies. When a new area like nanotechnology, or biometrics, or biofuels comes on the scene, there is a lack of a common vocabulary or a set of agreed upon ways to describe both the performance of products made with the new technology and their quantities.

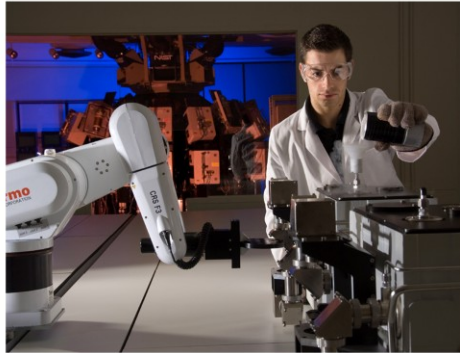
NIST helps fill this gap by learning all we can about the new field, typically many years before products using the technology arrive in the marketplace. At the same time we partner with our industry and university laboratories to gain first hand knowledge of any measurement needs that are impeding progress in the field.

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



4

As our formal mission statement says NIST works 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 At A Glance

Major Assets

- ~ 2,800 employees
- ~ 2600 associates and facilities users
- ~ 1,600 field staff in partner organizations
- ~ 400 NIST staff on about 1,000 national and international standards committees



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

Major Programs

- NIST Laboratories
- Baldrige National Quality Program
- Hollings Manufacturing Extension Partnership
- Technology Innovation Program

Joint NIST/University Institutes focused on:

- Basic Physics
- Quantum Science
- Biotechnology
- Coastal Environment

5

We do this with an array of different types of programs, about 2800 staff members, and numerous types of collaborations that take place on several different campuses. We have laboratory facilities and support groups specializing in different disciplines. We have specialized institutes that we operate jointly with research universities and other government agencies focused on specific research areas.

In addition, NIST manages and partially funds a network of locally operated field offices providing assistance to smaller manufacturers. We manage a National Quality Award that recognizes operational excellence by a wide range of different types of organizations.

And we have been authorized by our Congress to begin a new program to promote, and accelerate innovation in the United States through high-risk, high-reward research in areas of critical national need. The Technology Innovation Program will provide cost shared grants to individual, for-profit companies or joint ventures that may include for-profit companies, institutions of higher learning, national laboratories or non-profit research institutes, so long as the lead partner is either a small or medium-sized business or an institution of higher learning.

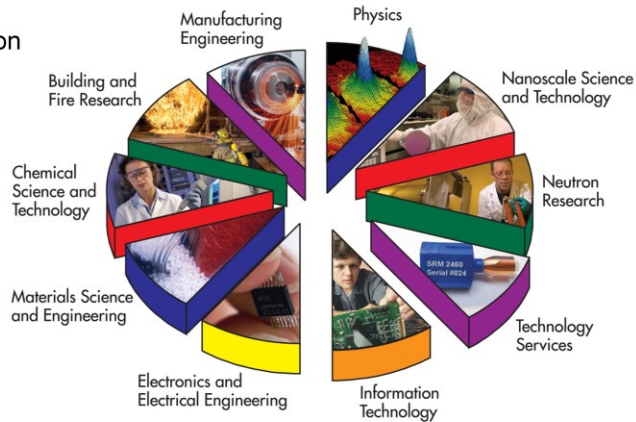
The NIST Laboratories

NIST's work enables:

- science
- technological innovation
- trade
- better quality of life

NIST works with:

- industry
- universities
- other government agencies
- other measurement laboratories
- standards development organizations



6

A defining feature of NIST is our diverse range of topic areas. Our research laboratories span 10 different major disciplines with extensive interdisciplinary activities.

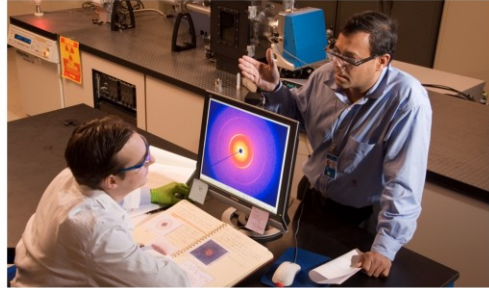
We frequently provide tours of our laboratories to both U.S. and foreign guests. We were delighted recently, for example, to host Ranjana Khanna, Assistant Secretary General of the Federation of Indian Chambers of Commerce and Industry. Often at the end of a tour a guest will be amazed at the depth and breadth of research areas NIST addresses and the extensive number of contacts maintained with other organizations on topics ranging from DNA analysis to building codes to standards for electronic voting machines.

Culture of Collaboration

- Wide range of methods—from brief informal efforts to multi-year joint research and consortia
- Mutual benefits for both NIST and research partner
- Guest research arrangements
- Facilities use
- Funding opportunities
- Patents, licensing agreements
- Manufacturing assistance
- Research fellowships for Postdoctoral and undergraduates students



© Geoffrey Wheeler



© Robert Rathe

7

By now you are probably seeing a theme here. Since our beginnings in 1901, NIST has had a strong culture of collaboration. As I mentioned at the beginning, U.S. innovation is primarily driven by the private sector. This means that to participate and fully support U.S. innovation, NIST needs to be in constant contact with companies large and small, both those engaged in research and those working to continually improve their products and services.

And as I mentioned earlier, we need to anticipate the needs of emerging new fields like nanotechnology, so that industry will have the measurement methods and standards needed to launch new products. That's why collaboration with universities is so important. Our universities are constantly generating the new knowledge that tomorrow's products will use. NIST programs and research collaborations help bridge the gap between this new knowledge and new products.

We also actively recruit the best postdoctoral researchers and even undergraduate students to work at NIST. When these students and graduates complete their fellowships working with NIST mentors, they become ambassadors back to industry and universities to continually strengthen these important collaborative relationships.

World-class staff, world class facilities

NIST Nobel Laureates

- Three Nobel Prizes in Physics in the last 10 years
- State-of-the-art, unique facilities
 - Advanced Measurement Lab
 - Center for Nanoscale Science & Technology
 - NIST Center for Neutron Research



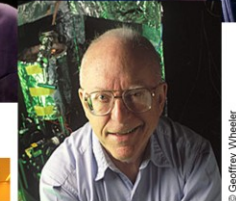
Courtesy HDR Architecture, Inc./Steve Hall ©Hedrich Blessing



Eric Cornell, 2001



William Phillips, 1997



John Hall, 2005



8

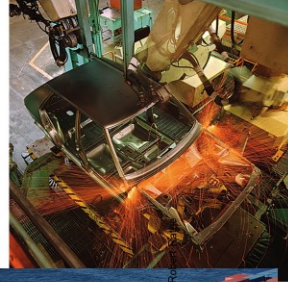
One of NIST's key advantages is the quality of our staff. NIST scientists have won the Nobel Prize in Physics three times since 1997. Other staff members have equally impressive national and international awards.

Our facilities are also among the best in the world. In particular, in 2004 we completed a new Advanced Measurement Laboratory that is the most advanced facility of its kind. The almost 50,000 gross square meter facility has five wings, two of which are entirely underground. No other facility of this size has so successfully achieved the combined features of strict temperature and humidity control, vibration isolation, air cleanliness, and quality of electrical power.

Our NIST Center for Neutron Research is another leading U.S. facility. It supplies beams of neutrons for imaging materials and structures non-destructively at atomic and molecular scales. The facility is used by more than 2,000 scientists and engineers annually from all over the world.

The result: a broad impact on everyday life

- Ultimate reference for \$5 trillion in annual U.S. sales based on measurement
- 19 economic studies show “benefit to cost” ratio for NIST work averages 44 to 1
- Advances manufacturing, ensures fair trade, improves public safety, better quality of life



All photos © Corbis

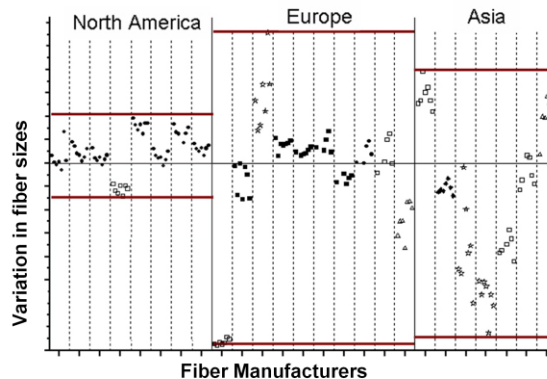
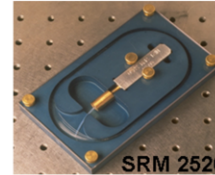
9

The bottom line: even though NIST is one of the smaller U.S. national laboratories in terms of our annual budget, we have tremendous impact on the everyday lives of our citizens. From industry to trade to public safety to health care, our programs help continually move the nation forward.

Example: Quality Problem, Measurement Solution

Fiber optics problem. Fibers could not interconnect without signal loss. NIST helped improve both measurements and standards.

By 1995 U.S. makers could measure fiber 3 times better than competitors and owned about 50 percent of the world market.



"The opportunity to work with NIST on this project gave Corning and other American fiber manufacturers a clear competitive advantage...."

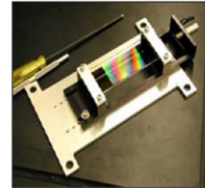
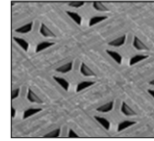
Jan H. Suwinski, Executive Vice President, Corning, Inc. (1993)

10

Perhaps the best way to prove this is with examples. In the mid 1990's for example, manufacturers of fiber optic cables were finding that differences in the diameters of these very thin manufactured fibers were causing signal loss. The fibers did not match up perfectly, causing some of the signal carrying light to leak out. NIST worked with U.S. fiber manufacturers to develop accurate measurement methods and issued a physical standard, a Standard Reference Material, that they could use to check their own measurements. As a result, U.S. manufacturers were able to quickly improve their processes and the quality of their fibers, simultaneously capture more of the international market.

Recent Success: Faster Materials Discovery

- Developing a new material can cost \$20 million and take up to a decade — costs U.S. industry \$20 billion/year
- NIST developed new measurement techniques used in products ranging from new detergents to improved adhesives for next-generation electronics
 - **1/5 the time and 1/5 the cost!**
- More than 20 organizations have already adopted these methods



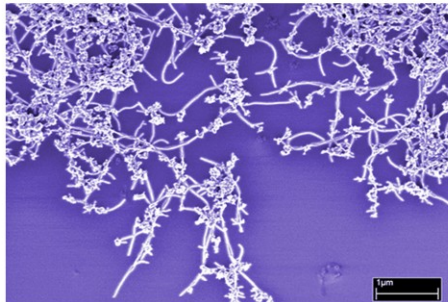
This need for speed in responding to market forces is another key advantage that strong partnerships provide. NIST recently developed advanced microfluidics materials techniques that allow researchers to measure the properties of tiny amounts of these new materials very quickly and accurately. Previously, manufacturers would have to spend \$20 million and 10 years to fully understand all of the properties of one new material such as a new adhesive or detergent. With the new NIST techniques the time and cost of such development work has been cut by 80 percent. And because this project has built in partners in industry and universities that were participants in a NIST sponsored research consortia, more than 20 organizations are already using the new method.

Recent Success: Understanding Nanotechnologies

**Potential Market:
\$1–2 Trillion/year**

Nanotechnologies — Devices and materials made with components and features smaller than 100 nanometers or billionths of a meter.

- Experts predict that in the **next 10 years half of all new materials will incorporate nanotechnologies.**
- NIST is developing reference materials and measurement methods to help this emerging industry ensure both quality and safety of nanotechnology products.



A new NIST measurement method rapidly determines the quality of a carbon nanotube sample.

A coating of a nanotube sample is sprayed on a quartz crystal. The crystal is gradually heated, vaporizing different forms of carbon at different temperatures.

12

Nanotechnology is a third rapidly developing area. The global nanotechnology industry is predicted to exceed \$1 trillion by 2015. Carbon nanotubes for example are super strong fibers that may find applications in everything from nanoelectronic circuits to medicines to aircraft. They are made from sheets of carbon atoms rolled into tubes. NIST is developing a carbon nanotube reference material that manufacturers can use to verify the quality, purity, and consistency of their nanotechnology products. This will help them incorporate carbon nanotubes into sophisticated products that have stringent requirements for quality and performance, as well as safety.

NIST Products and Services

Measurement Research

- ~ 2,200 publications per year

Standard Reference Data

- ~ 100 different types
- ~ 6,000 units sold per year
- ~ 130 million data downloads per year



© Robert Fraihe



Standard Reference Materials

- ~ 1,300 products available
- ~ 33,000 units sold per year

Calibration Tests

- ~ 16,000 tests per year

Laboratory Accreditation

- ~800 accreditations of testing and calibrations laboratories per year

13

NIST's contacts with industry and universities, in fact, stretch beyond our formal partnerships to 10's of thousands of customers yearly who buy our Standard Reference Materials, send their instruments to NIST for calibration, participate in our laboratory accreditation program*, or use NIST research results published in the open scientific literature.

Collaborative Efforts with India

- 66 guest researchers from India currently hosted by NIST
- Indo-U.S. S&T Forum established in 2000 — workshops leading to collaborations
- Standards in Trade Workshop — oil and gas sectors



© Shutterstock



© Robert Rofe

Cooperative Research Areas

- Nanoscale imprint lithography
- Integrated design engineering
- Tissue engineering
- Cyber security
- Biotechnology

14

And we are happy to be expanding our relationships and contacts with India. India's economy is blossoming. India's expertise for cost effective, cutting edge research in information technology, biotechnology, agriculture, energy, and many others areas is impressive. There are many things we can learn from each other.

We feel we are making a strong start through collaborations with 66 researchers from India who are currently working at NIST, as well as through a number of productive workshops set up through the Indo-U.S. S&T Forum.

Several NIST researchers have also recently traveled to India for major conferences and visits to research organizations and we hope to expand on these efforts in the future.

Opportunities for Expanding Interactions

- NIST welcomes suggestions for additional cooperative research areas
- Would be pleased to host tour of NIST laboratory facilities for FICCI and other Indian organizations with common interests
- NIST leadership is actively interested in finding new areas and new mechanisms for enhancing collaboration in mutually beneficial ways



© Shutterstock



15

Learning from the more than a century of experience and expertise gained by NIST in stimulating U.S. innovation and industrial competitiveness through measurement science, standards, and technology may be of great value to India as it seeks to expand private sector R&D investment and build a national S&T infrastructure that enables innovation and industrial competitiveness.

We at NIST would be delighted to work with FICCI and other Indian organizations to actively seek new areas and new mechanisms for enhancing collaboration in mutually beneficial ways.

Collaborations are in fact like all relationships worth cultivating. They must be constantly changing and adapting to new conditions to truly meet the needs of all involved.

Future Outlook: Overcoming Barriers to Innovation

Assessment of the U.S. Measurement System

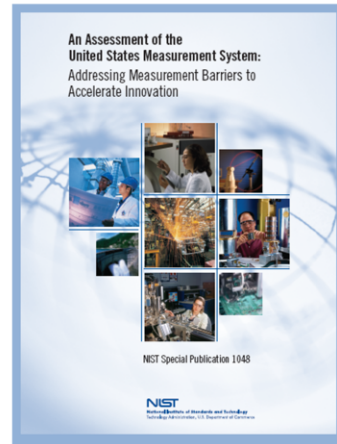
- Documents 723 measurement barriers to innovation
- Covers 11 industry sectors
- Over 1,000 contributors from industry, academia, and other government agencies

Examples:

- Biomarkers — detecting 1 molecule in a trillion!
- 3-D imaging at the nanoscale to understand material properties

Result:

- A roadmap to help NIST and other organizations plan research that accelerates innovation



16

And just nail down this point, I'd like to end by describing NIST's most ambitious collaboration yet. Earlier this year we completed a very broad assessment of the state of the U.S. Measurement System.

This multi-year, NIST-led project identified more than 700 scientific and technical measurement challenges hampering innovation across a sample of 11 industrial sectors and technology areas. These included such as industries as chemicals; electronics; energy, power, and environment; health care; materials; and nanotechnology. More than 1,000 people in industry, academia and government were involved in the study. We are now using the results to prioritize our work and develop research strategies.

Perhaps there are lessons learned through this exercise that will be helpful to you as well. I hope so. What's clear is that India is already a powerful economic force in the world market. And your work through this conference and many other efforts to create and improve R&D partnerships will sustain a uniquely Indian Innovation System that will ultimately reap large rewards for all its citizens.

Thank you very much for your attention.