NI ST Contributions to Manufacturing and the Economy

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National Institute of Standards & Technology

NIST’s mission is to develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.

NIST Assets Include:

- 3,000 employees
- 1,600 associates
- $771 million FY 2004 operating budget
- NIST Laboratories -- National measurement standards
- Advanced Technology Program
- Manufacturing Extension Partnership
- Baldrige National Quality Award
NI ST Budget and Programs

**FY04 & (FY03)**

**NI ST Laboratory Programs**
- FY04: $312.2M ($325.7M)
- FY03: Total=$707.5M

**Advanced Technology Program**
- FY04: $169.1M ($178.8M)

**Manufacturing Extension Partnership**
- FY04: $38.6M ($105.9M)

**Construction**
- FY04: $43.5M ($37.6M)

**National Quality Program**
- FY04: $5.4M ($5.2M)

**AML Support**
- FY04: $5.1M ($14.9M)

**Congressional Earmarks**
- FY04: $34.6M ($39.4M)

**FY04 Total=$608.5M**

**Congressional Earmarks**
- FY03: Total=$707.5M
World Renowned Scientists and Engineers

Bill Phillips
1997 Nobel Prize in Physics

Gregory Linteris
Flew 2 Space Shuttle Missions

Johanna Sengers
2003 Women in Science Award and NAS Member

Eric Cornell
2001 Nobel Prize in Physics

Deborah S. Jin
2003 MacArthur Fellowship ‘Genius Grant’

John Cahn
1998 National Medal of Science
NI ST laboratories occupy two campuses...

Gaithersburg, MD

Boulder, CO

...and two joint Institutes

CARB
University of Maryland

JILA
University of Colorado
NIST has Unparalleled Facilities

Gaithersburg, MD Site
- 578 acre site
- Laboratory space: ~700,000 assignable sq ft.
- Office space: ~500,000 assignable sq ft.

Advanced Measurement Laboratory (AML)
- Complex of 5 buildings, occupancy began in Jan ’04
- Stringent control of temperature, vibration, humidity, cleanliness
- Establishes state-of-the-art nano-fabrication capabilities, in the ~90,000 sq ft Cleanroom Building

The NIST Center for Neutron Research (NCNR) Guidehall
- the only U.S. capability for studies of biological dynamics, both temporal and spatial information are obtained.
- Neutron methods at the NCNR encompass an enormous range of time and length scales.
NIST Laboratories

NIST’s work
- Enables innovation
- Facilitates trade
- Ensures public safety and security
- Creates jobs

NIST works with
- Industry
- Academia
- Other agencies
- Government agencies
- Measurement laboratories
- Standards organizations
NI ST Advanced Technology Program

- Co-funding of private sector R&D to accelerate the development of high-risk, broadly enabling technologies.

- Auto Body Consortium - improved fitting of parts to save money for manufacturers and consumers.

- Tissue Engineering - new materials to repair damaged ligaments and tendons: several billion dollar impact.

- “DNA Chips” - new technology for cheap, rapid genetic analysis.
Advanced Technology Program (ATP)

ATP Awards, by Technology Area (1990-2004)

- Biotechnology ($432 M) 20%
- Information Technology ($503 M) 23%
- Manufacturing (Discrete) ($247 M) 11%
- Electronics/Photonics ($548 M) 25%
- Advanced Materials and Chemistry ($459 M) 21%

$2,189M awarded from 1990 – May 2004 (736 awards, forty three competitions)
Manufacturing Extension Partnership

- Nationwide network providing hands-on help to smaller manufacturers to become globally competitive

- **Business assistance**
  - Quality management
  - Human resource development
  - Financial planning
  - Other services

- **Technical assistance**
  - E-commerce
  - Process improvement
  - Plant layout
  - Product development
  - Energy audits
  - Other services

355,000 small U.S. manufacturers produce 55% of value added in manufactured goods, employ more than 12 million workers

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National Institute of Standards and Technology (NIST)
Baldrige National Quality Program

- Premier U.S. award for performance excellence and quality achievement.


- More than 2 million copies of Criteria for Performance Excellence distributed (not including downloads from Web).

- Quality programs modeled on Baldrige: 49 state and local (up from fewer than 10 in 1990); 60 international.
NIST Research and Services
Enabling Innovation

- Paving the Way for Economic Growth

- “Excellence in measurement science, driven by NIST, positions U.S. industry and universities to more quickly solve problems.”—IRI

- “Consequently, additional research in metrology at NIST is critical to future chip development.”—SIA

- “NIST stimulates and supports the development of the cutting-edge technology infrastructure needed to strengthen and safeguard America’s economic foundations and security capabilities.”—BIO
NIST Research and Services
Underpin Homeland Security, Public Safety

Technical Contributions Include

- Standards for Ballistic-Resistant Armor—2,700 Casualties Prevented
- Advanced Encryption Standard—Secure electronic transactions for millions of Americans
- Standards for Metal Detectors—Improved safety in airports, courthouses
- Standards for DNA analyses—Accuracy goes up, costs go down
- Interoperability Standards for Fingerprint Databases—FBI system can link to the rest of the world
NIST Contributions to Homeland Security

NIST measurements and standards support current activities and potential future advances in key homeland security areas including:

- Chemical, biological, radiological, nuclear, explosive (CBRNE) threat detection and remediation
- Safety of structures and occupants
- Safety and effectiveness of emergency responders
- Transportation system safety
- Information security and Critical Infrastructure Protection
- Biometric identification

Examples of NIST homeland security support programs:
NIST Research and Services
Vital to Quality of Life

Practical, Indispensable Technical Contributions

- Diagnostic X Rays—*Standards & tests underpin 30 million mammograms performed each year*

- Prostate- and Breast-Cancer Treatment—*Among 10 million medical procedures using radioactive materials traceable to NIST measurements*

- Smoke Detectors—*Performance standards for devices now in 94% of U.S. homes*

- Drinking-Water Quality—*Accreditation enables 55,000 community water systems to check, prove regulatory compliance*
Embedded Tools Essential to Commerce, Industry

- **Consumer Trust**—ultimate references for $5 trillion in annual sales based on measurement
- **Secure Automated Banking**—encryption technology embedded in nation’s 300,000+ ATMs
- **Integrity of Financial Transactions**—time-stamping of stock trades, etc., totaling hundreds of billions of dollars daily
- **Manufacturing Quality Control**—U.S. automakers and suppliers rely on 350 NIST reference materials
- **Reliable Data**—more than 53,000 volumes of NIST/ACERS “phase diagrams” distributed to materials researchers & manufacturers
NI ST Measurements & Standards for Manufacturing

NI ST support for the entire lithography process to manufacture microelectronic devices

- Light Scattering
- Optical Properties
- Index of Refraction of Gases
- Index of Refraction of Materials
- Laser Wavelength Standards
- Mask Properties
- Laser Power Measurements
Manufacturing includes a broad spectrum of activities

- Heavy equipment,
- Traditional metal cutting
- Semiconductor
- Manufacturer of healthcare devices
- Pharmaceutical
- Others...

Measurements and Standards for Making Things...

- Right
- Interoperable
- Traceable
- Small
Making Things... Right

➢ Product quality and manufacturing agility suffer from:
  ▪ Outdated, empirical processes and models
  ▪ Lack of tools and methods for sharing predictive knowledge
  ▪ A lack of smart tools with self knowledge, error compensation, and maintenance prediction
NIST Response:

- Measurement methods, characterization, modeling, tests, data, standards and/or tools for:
  - Virtual prototyping and manufacturing process simulation
  - Advances in biomolecular and biomaterials manufacturing
  - Understanding and predicting the performance of high-performance concrete and other advanced building materials
  - Accurate and consistent specifications for appearance and functionality of coatings and surfaces
  - Smart machine tools that can learn, self-correct, and communicate
  - A virtual cybernetic building for evaluating new products and systems such as fire detection and security systems
Measurement traceability assures the uniformity and quality of manufactured parts and industrial processes.

Accepted, traceable measurements are key to lower market transaction costs, extended supply chains, and global trade.
NIST Response:
Realization and dissemination of measurements in:

- Mechanical Metrology – force, mass, acoustics, & vibration
- Dimensional Metrology – over 13 orders of magnitude ranging from sub-nanometer to hundreds of meters
- Process Metrology – temperature, pressure, vacuum, fluid & gas flow, liquid density and volume
- Electromagnetic Metrology – volt, ohm, and amp
- Optical radiation metrology – non-contact thermometry, etc.
Making Things... Interoperable

- The modern extended manufacturing enterprise depends on sharing technical and business information.
- Three critical needs must be addressed:
  - **Structural** - reliable, seamless, and accurate information and knowledge transfer.
  - **Economic** - affordable solutions for all players.
  - **Security** - need to make the infrastructure more robust.
Making Things... Interoperable (continued)

NIST Response:

- Critical Infrastructure Protection (e.g., power grid and water distribution)
- Integrated Construction Environments
- Intelligent Control Systems
- Manufacturing Enterprise Integration
- Manufacturing Simulation and Visualization
- Electronic Commerce
- Healthcare Enterprise Integration
Nanotechnology will revolutionize many industries and yield new high-tech products.
Nanomanufacturing is the link between discoveries and products.
Both Nanotechnology and Nanomanufacturing will require:
  - Atomic level accuracy and repeatability
  - Ability to achieve desired performance attributes
  - Commercially viable costs
Enabling International Trade

Drivers

- Emerging Markets
- Heavy Investment Abroad
- Standards as Trade Barriers
Enabling International Trade

NI ST Response

- International Standards Organizations
- Export Alert Service
- Standards in Trade Workshops
- NI ST Standard Sales Worldwide
- Technical Trade Barrier Issues
Programs Guided by Stakeholder Roadmaps and Needs Assessment

- Semiconductor Industry Association
- Optoelectronics Industry Development Association (OIDA)
- Multiple Roadmaps

Chemical industry vision/roadmap

Optics needs

NRC Report

National Center for Manufacturing Sciences

National Institute of Standards and Technology
NIST Works with Industry Partners

Rhodia
Agilent
ROHM & HAAS
Boeing
Gillette
Caterpillar
The American Society of Mechanical Engineers

Agilent
BOEING
CATERPILLAR

GM
Ford
Procter & Gamble

Honeywell
Raytheon

AIAG
ICI

Raytheon

Schlumberger

National Institute of Standards and Technology

American Petroleum Institute

BASF

Dow

Bayer

3M
The Government Agencies Technology Exchange in Manufacturing (GATE-M)

- Represents Federal Interests
- NIST Leads
- Facilitates Information Exchange
- Identifies Leveraging Opportunities