NIST Contributions to Manufacturing and the Economy

Hratch G. Semerjian
Acting Director

National Institute of Standards and Technology
Technology Administration
Department of Commerce

June 28, 2004

Department of Commerce

Donald Evans
Secretary

Secretary
Deputy Secretary

- National Oceanic and Atmospheric Administration
- Patent and Trademark Office
- National Telecomm. & Info. Administration
- (Other bureaus)
- Technology Administration
  - National Technical Information Service
  - Office of Technology Policy
  - National Institute of Standards and Technology

Photo not available

Mr. Theodore Kassinger
Deputy Secretary Nominee

Phillip Bond
Under Secretary

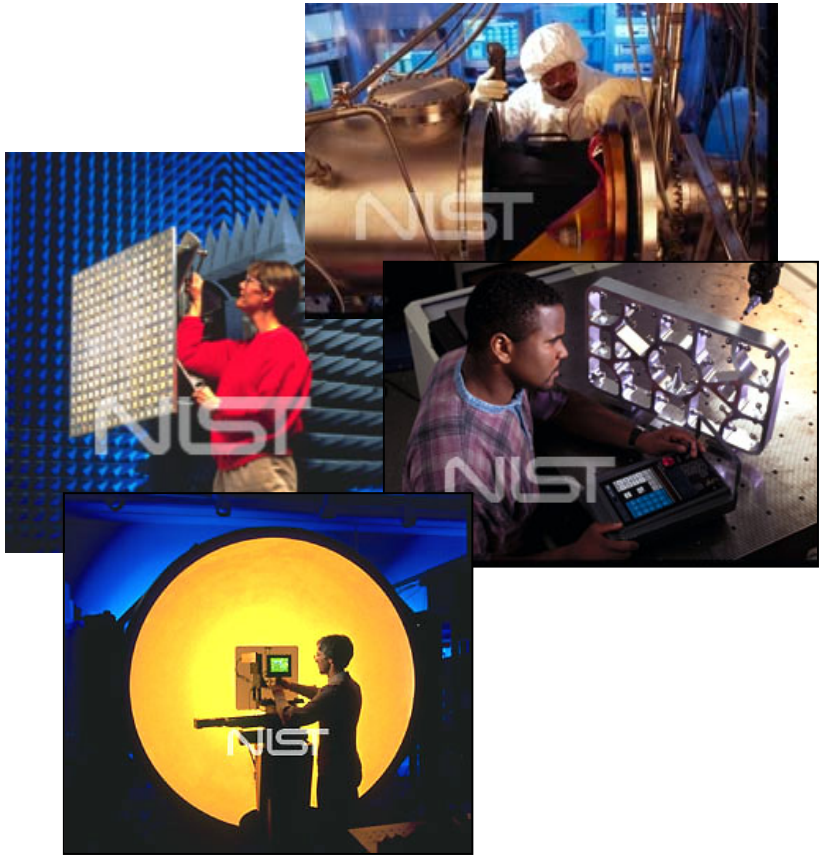
Dr. Arden Bement
Director

Dr. Hratch Semerjian
Acting Director

Dr. Richard Kayser
Acting Dep.
Director

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.

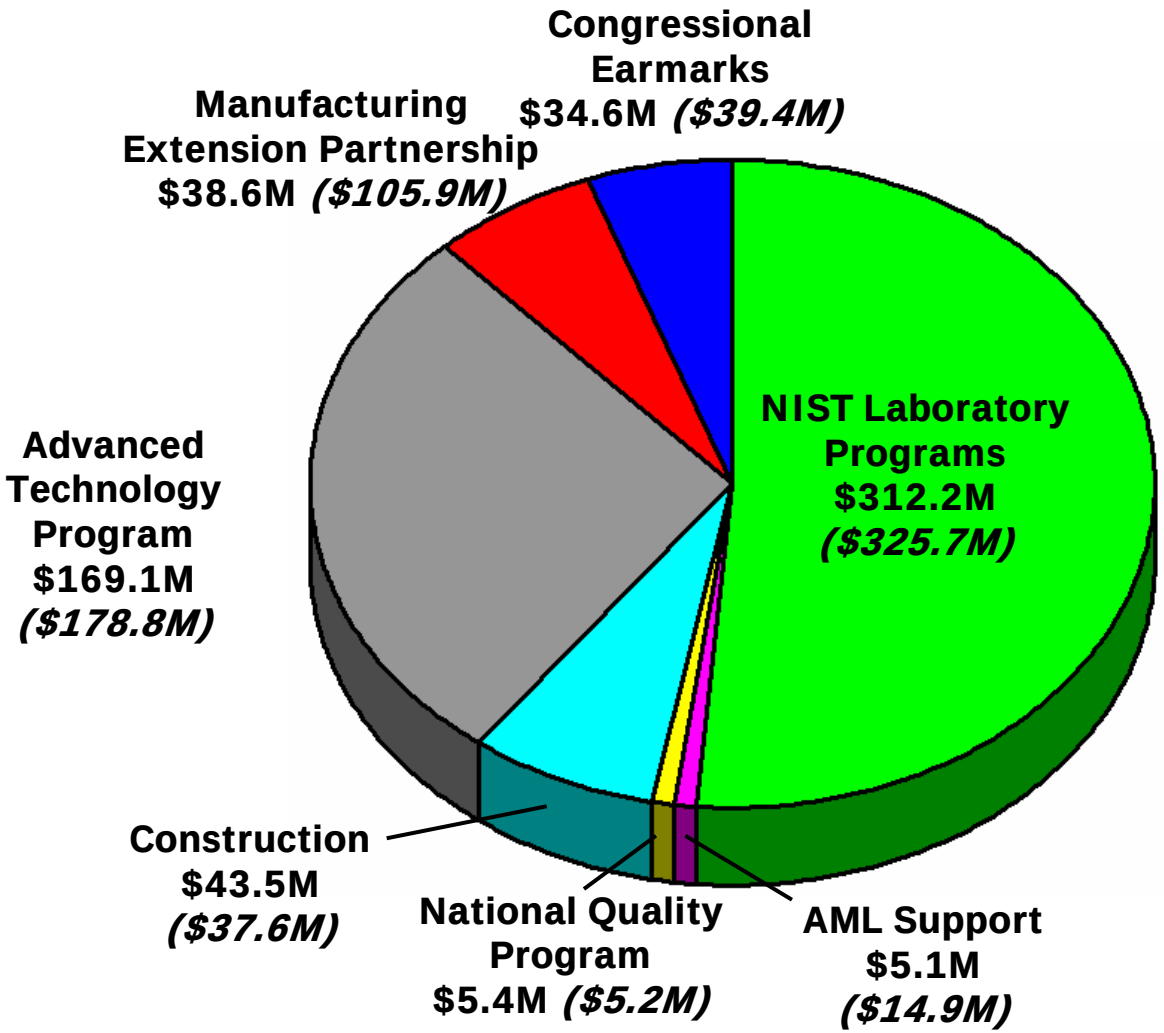


NIST Assets Include:

- 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

NIST Budget and Programs

FY04 & (FY03)



FY04
Total=$608.5M

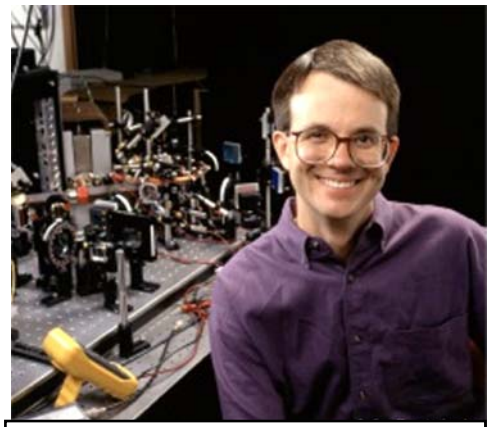
FY03
Total=$707.5M

World Renowned Scientists and Engineers

Bill Phillips
1997 Nobel Prize in Physics

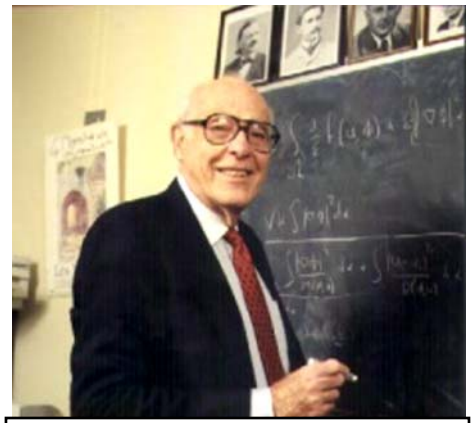
Gregory Linteris
Flew 2 Space Shuttle Missions

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

NIST laboratories occupy two campuses...

Gaithersburg, MD

Boulder, CO

..and two joint Institutes

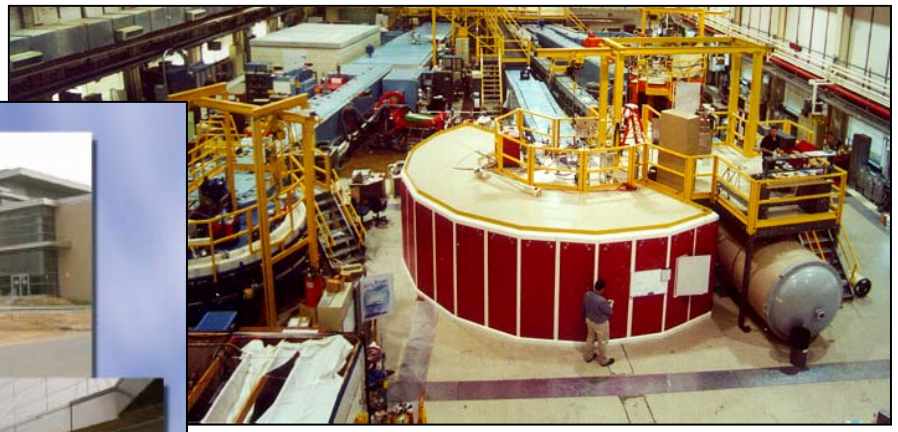
CARB
University of Maryland

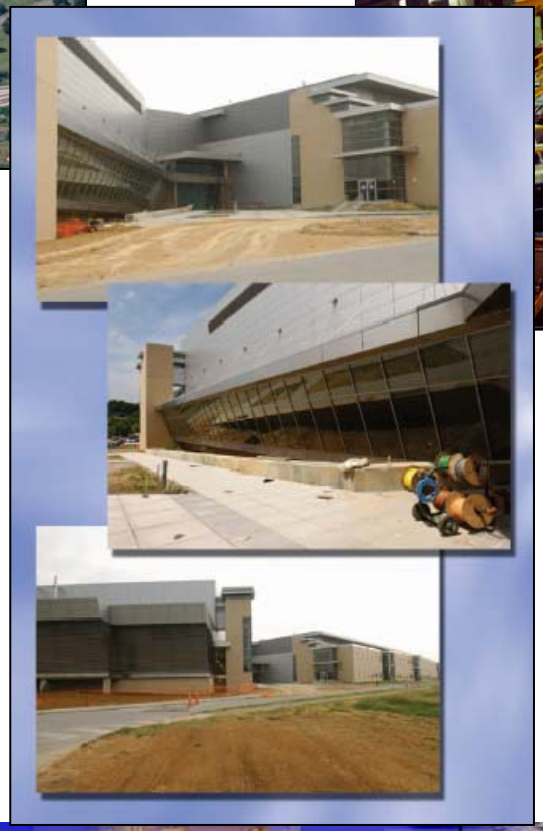
JILA
University of Colorado

NIST has Unparalleled Facilities

Gaithersburg, MD Site

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





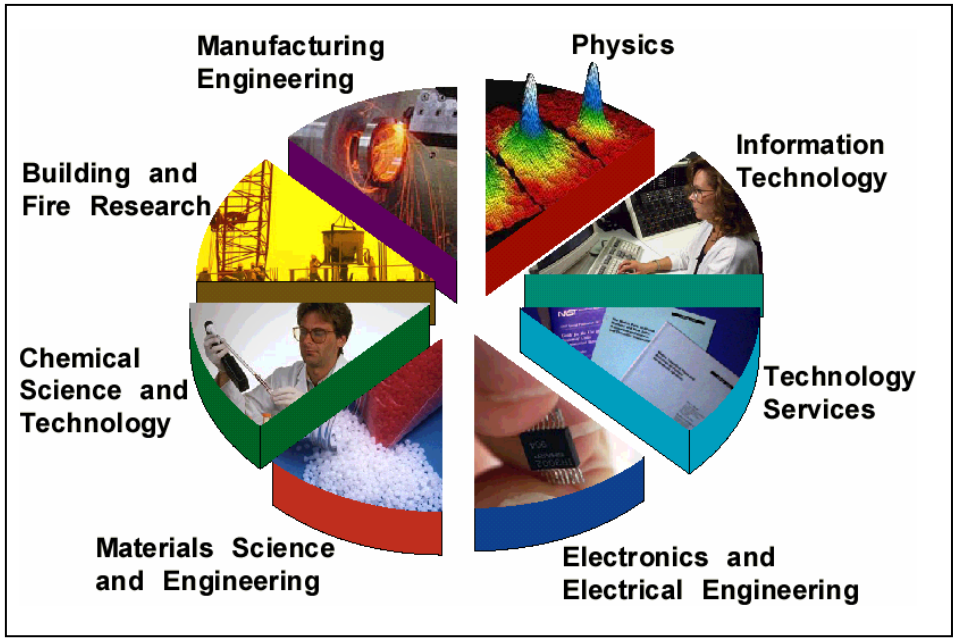
Advanced Measurement Laboratory (AML)

- 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



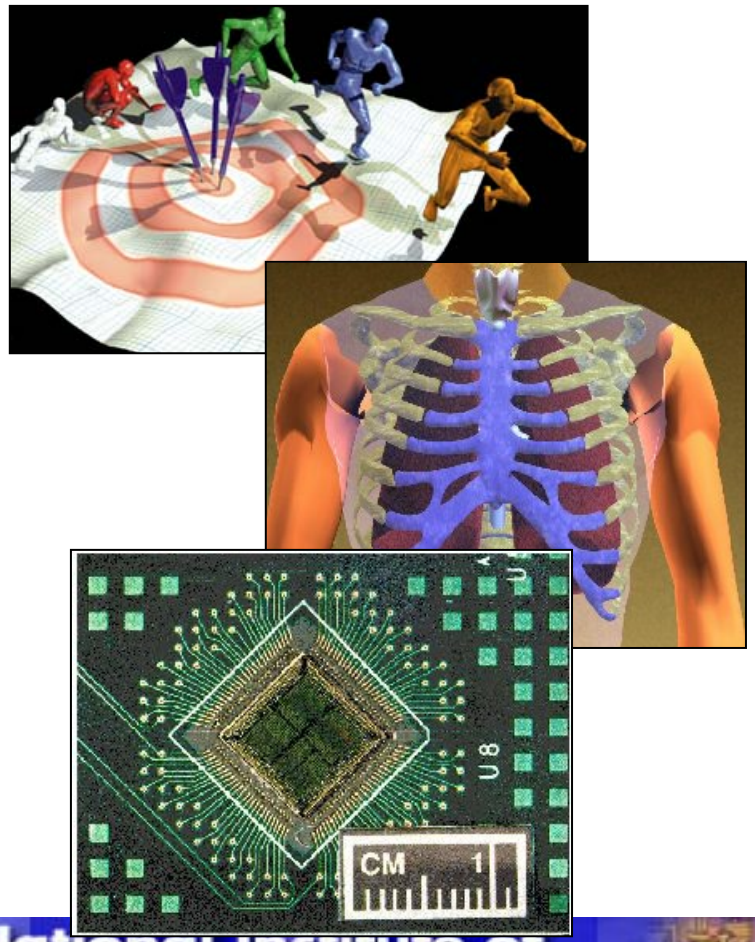
NIST's work

- Enables innovation
- Facilitates trade
- Ensures public safety and security
- Creates jobs

NIST works with

- Industry
- Academia
- Other agencies
- Government agencies
- Measurement laboratories
- Standards organizations

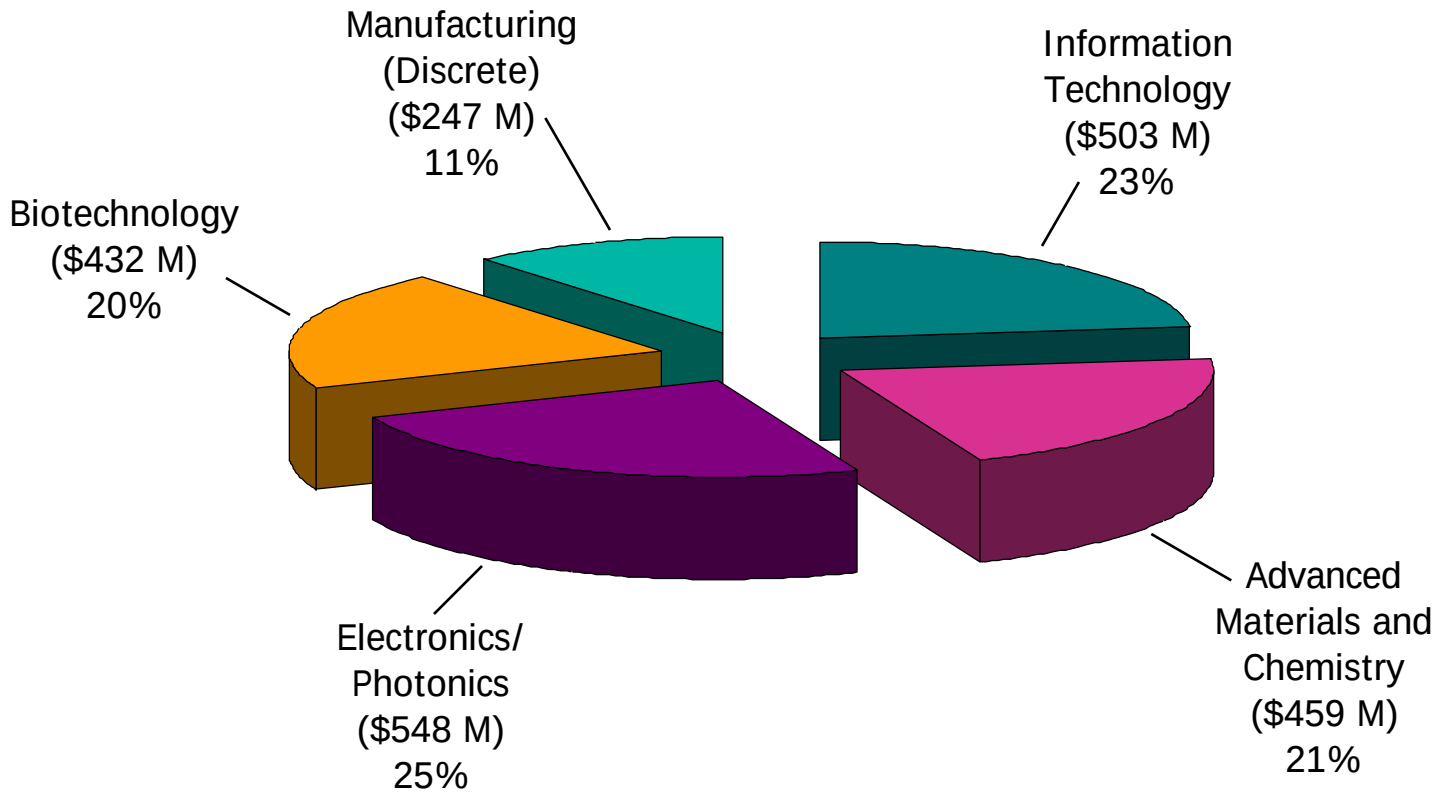
NIST Advanced Technology Program



- 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)

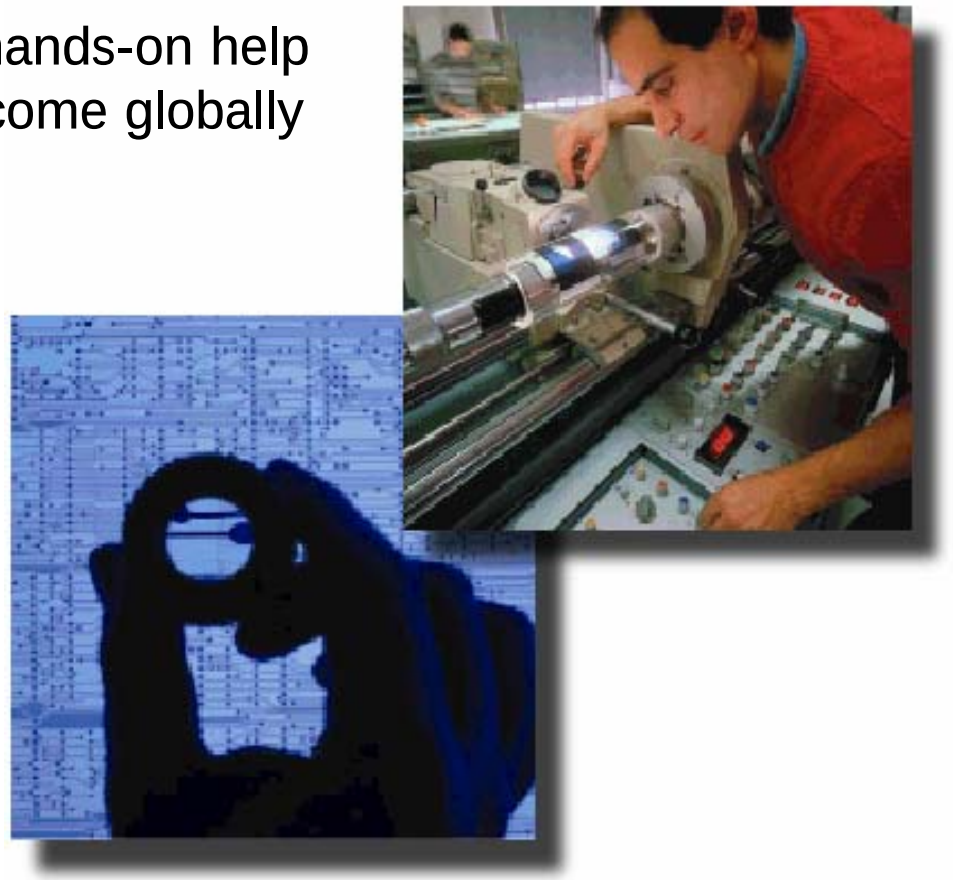
ATP Awards, by Technology Area (1990-2004)



$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

Baldrige National Quality Program

- Premier U.S. award for performance excellence and quality achievement.
- Awards in Manufacturing, Service, Small Business, Education, Health Care.
- 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:
http://www.nist.gov/public_affairs/factsheet/homeland.htm

NIST Research and Services Vital to Quality of Life

Practical, Indispensable Technical Contributions

- Diagnostic X Rays—S*tandards & 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*

NIST Research and Services
Integral to a Competitive, Productive Economy

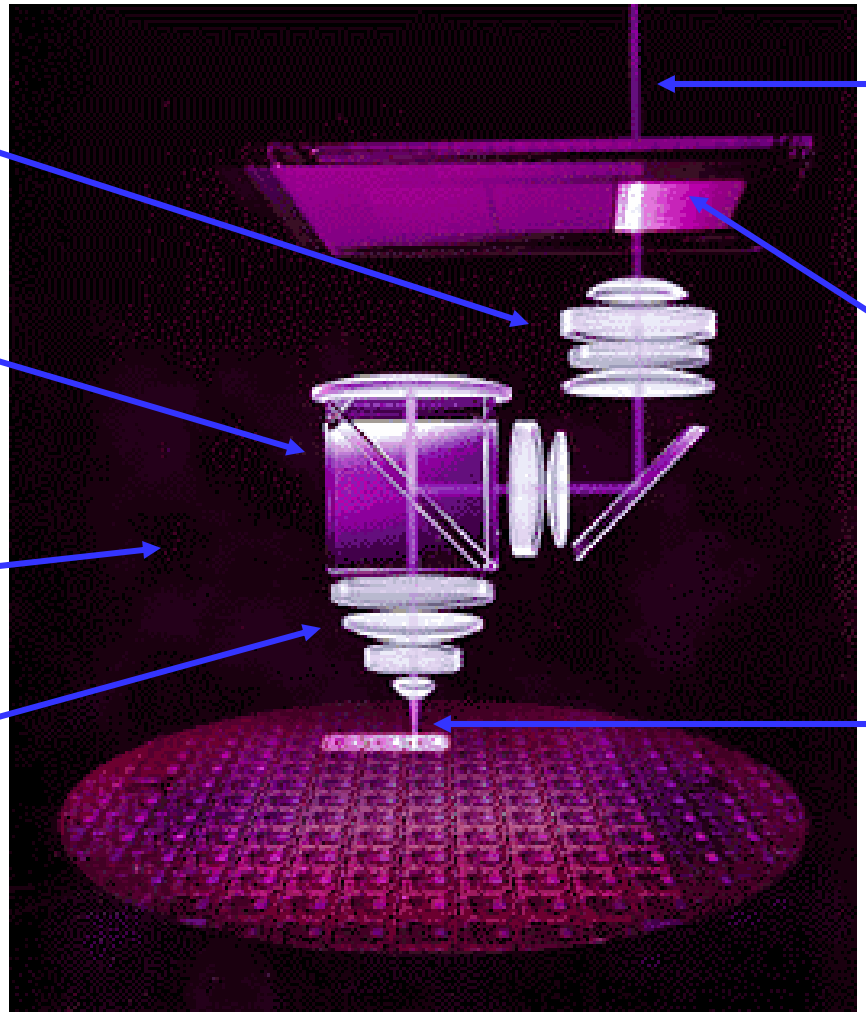
Embedded Tools Essential to Commerce, Industry

- **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


SEMICONDUCTOR/
ELECTRONICS/
PHOTONICS
DISCRETE
MANUFACTURING
ENERGY
PRODUCTION/
STORAGE/
TRANSMISSION
MANUFACTURING
BIO- & CHEM.
MANUFACTURING
AUTOMOTIVE
MANUFACTURING

NIST Measurements & Standards for Manufacturing

NIST 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

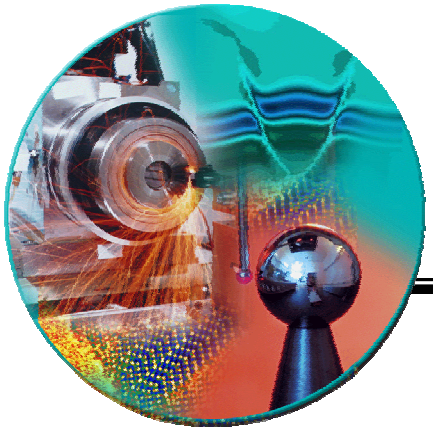
Measurements and Standards for Manufacturing

Manufacturing includes a broad spectrum of activities

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

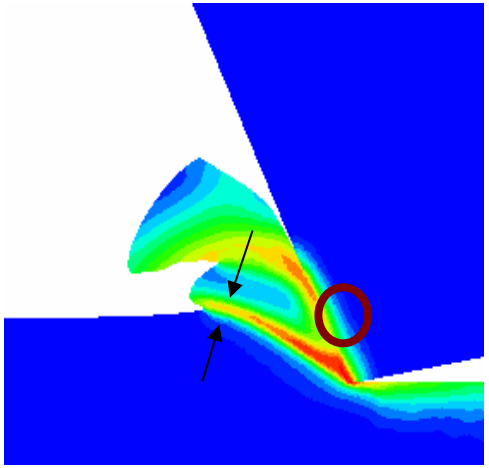
Measurements and Standards for Making Things...

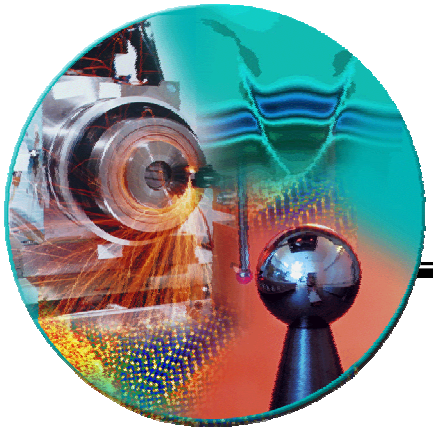
- Right
- Interoperable
- Traceable
- Small



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

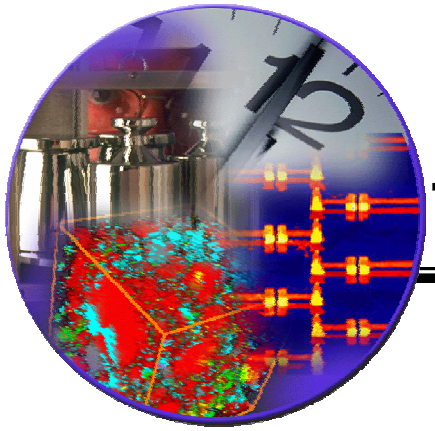




Making Things... Right (continued)

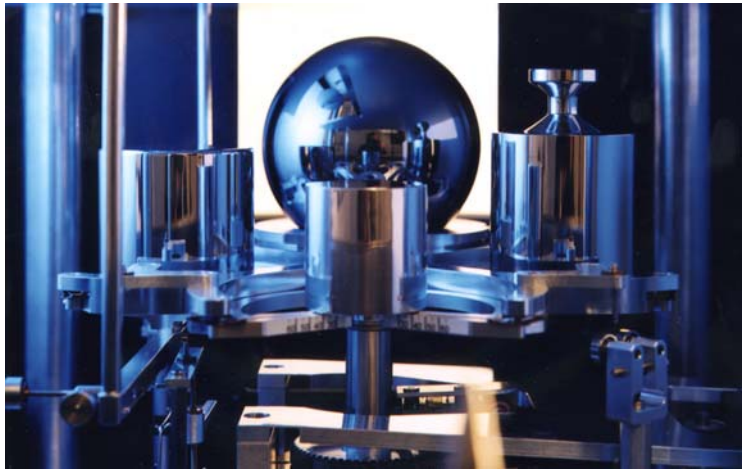
NIST Response:

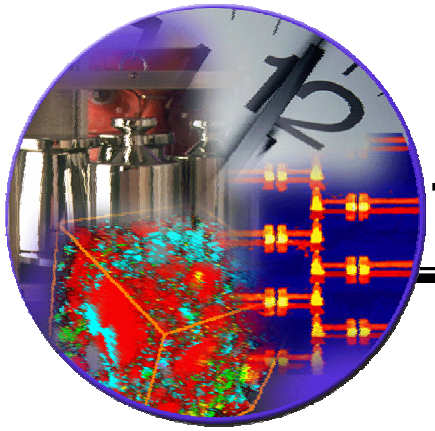
- Measurement methods, characterization, modeling, tests, data, standards and/or tools for:
  - Virtual prototyping and manufacturing process simulation
  - Advances in biomolecular and biomaterials manufacturing
  - Understanding and predicting the performance of high-performance concrete and other 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



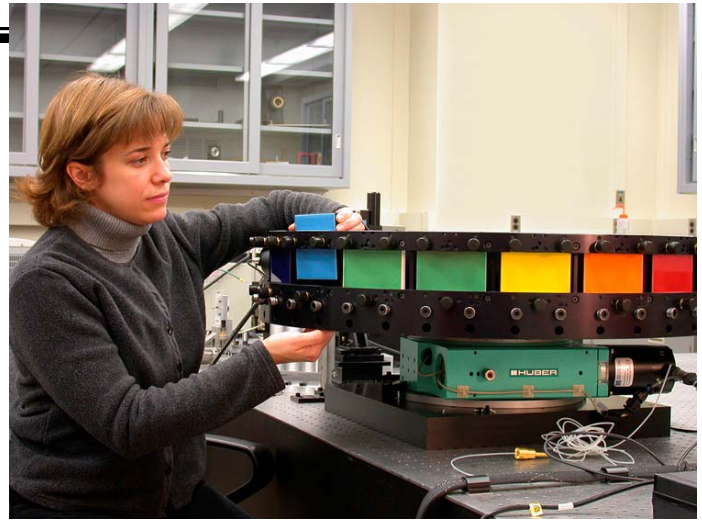
Making Things... Traceable

- 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





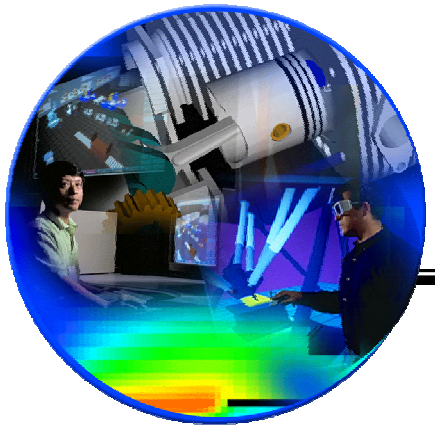
Making Things... Traceable (continued)



NIST Response:

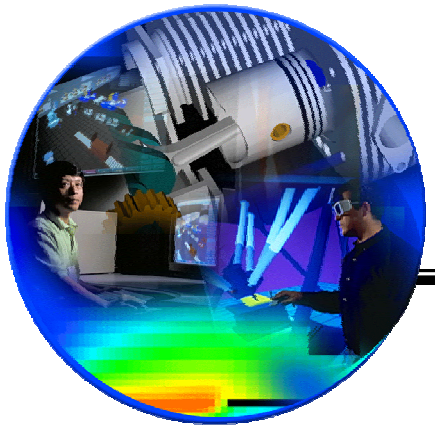
Realization and dissemination of measurements in:

- 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.

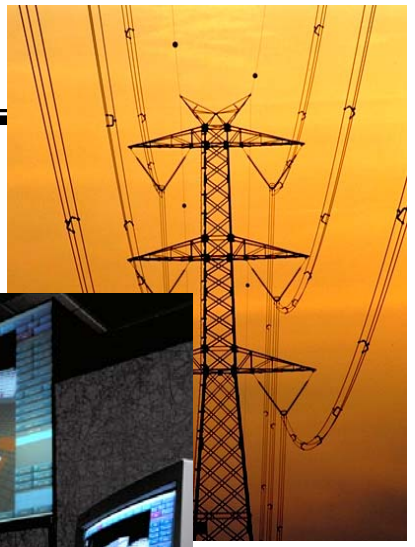


Making Things... Interoperable

- 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

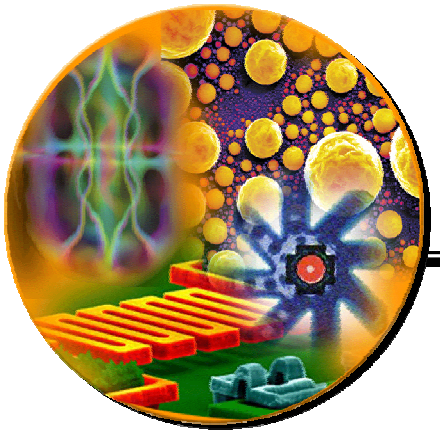


Making Things... Interoperable (continued)

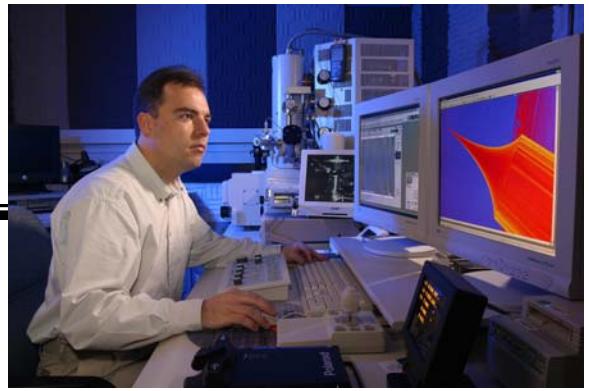


NIST Response:

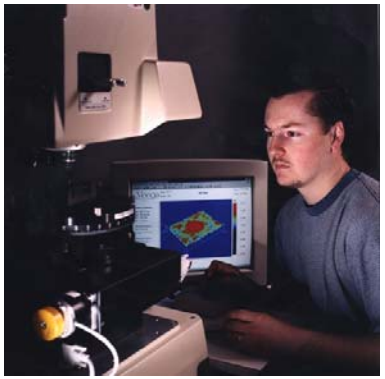
- Critical Infrastructure Protection (e.g., power grid and water distribution)
- Integrated Construction Environments
- Intelligent Control Systems
- Manufacturing Enterprise Integration
- Manufacturing Simulation and Visualization
- Electronic Commerce
- Healthcare Enterprise Integration



Making Things... Small



- 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

NIST Response

- International Standards Organizations
- Export Alert Service
- Standards in Trade Workshops
- NIST Standard Sales Worldwide
- Technical Trade Barrier Issues

Programs Guided by Stakeholder Roadmaps and Needs Assessment

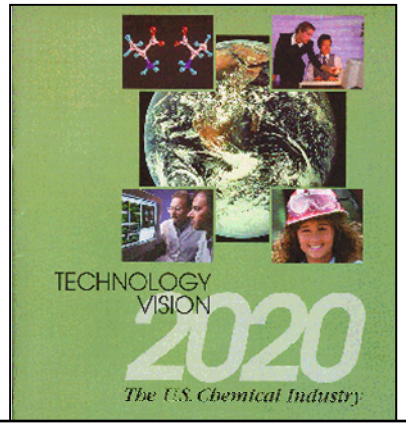
Semiconductor Industry Association

Optoelectronics Industry Development Association

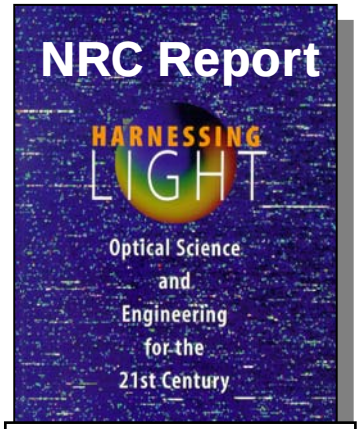
OIDA **Multiple Roadmaps**

President's Information Technology Advisory Committee

Roadmap



Chemical industry vision / roadmap



Optics needs

NIST Works with Industry Partners

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

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