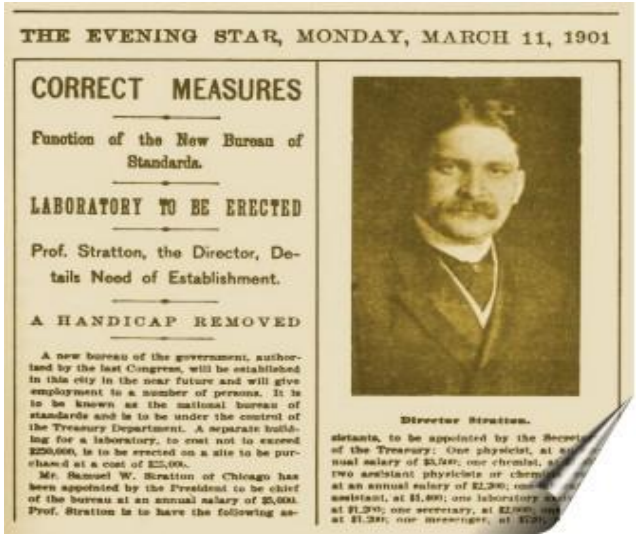
A Vision for the New NIST:
Integration of Research and Measurement Service Delivery

Willie E. May
Director, Chemical Science and Technology Laboratory
National Institute for Standards and Technology

National Institute of Standards and Technology (NIST)

- Non-regulatory agency within U.S. Department of Commerce

- Founded in 1901 as National Bureau of Standards



THE EVENING STAR, MONDAY, MARCH 11, 1901

CORRECT MEASURES

Function of the New Bureau of Standards.

LABORATORY TO BE ERECTED

Prof. Stratton, the Director, Details Need of Establishment.

A HANDICAP REMOVED

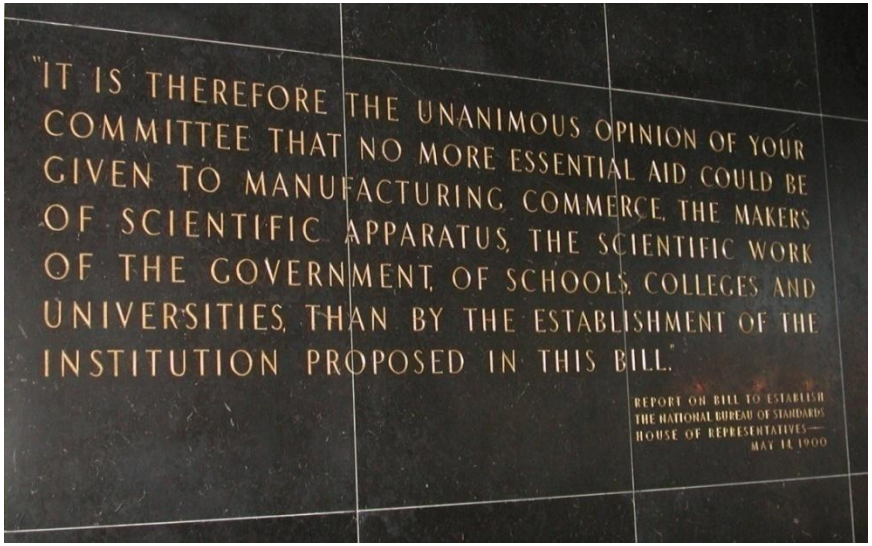
A new bureau of the government, authorized by the last Congress, will be established in this city in the near future and will give employment to a number of persons. It is to be known as the national bureau of standards and is to be under the control of the Treasury Department. A separate building for a laboratory, to cost not to exceed $250,000, is to be erected on a site to be purchased at a cost of $25,000.

Mr. Samuel W. Stratton of Chicago has been appointed by the President to be chief of the bureau at an annual salary of $5,000. Prof. Stratton is to have the following as-

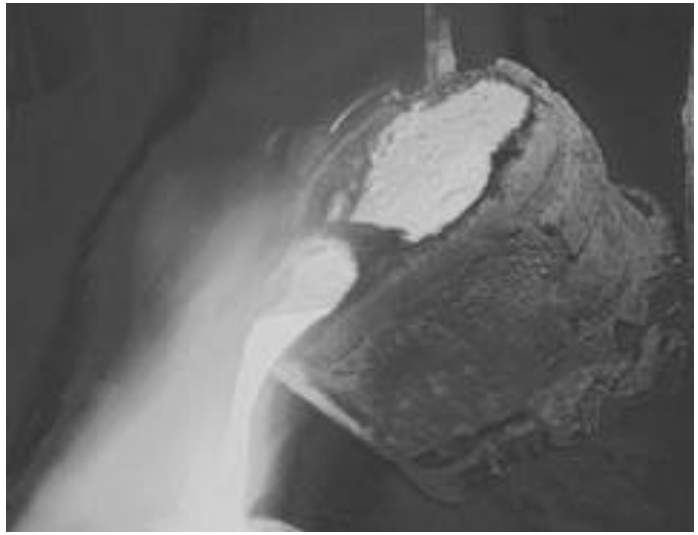
Director Stratton.

sistants, to be appointed by the Secre... of the Treasury: One physicist, at a ... nual salary of $3,500; one chemist, at ... two assistant physicists or chemi... at an annual salary of $2,250; one ... assistant, at $1,600; one laboratory ... at $1,200; one secretary, at $2,000, ... at $1,200; one messenger, at $720.

- To provide Measurement Services for:
  - **manufacturing**
  - **commerce**
  - **the makers of scientific apparatus**
  - **the scientific work of Government**
  - **schools, colleges, and universities**



Birth of the "Standard Samples" Program



1905

- **Standard samples program begins with "standardized irons" in collaboration with the American Foundrymans Association.**

1906

- **At the request of the Association of American Steel Manufacturers, the Bureau began work on certification of 17 types of steel.**

- **By 1951, there were 502 Standard Samples, 98 of these were steels**
- **Today, there are ~1300 different SRMs in NIST's catalog and ~ 30,000 units were sold in FY09**

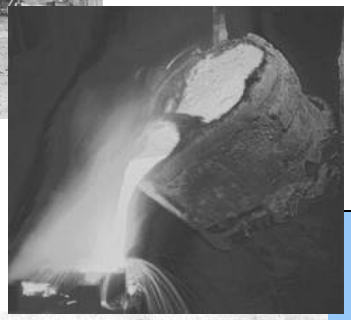
Organic Act of 1901; Updated in 2008

Functions and activities of the Institute include:

- **Custody and dissemination of national standards**
  - Calibrations, Certified Reference Materials, Reference Data, . . .
- **Determination of physical constants and the properties of materials,** when such measurements, standards and data are of great importance and are not to be obtained of sufficient accuracy elsewhere.
- **Comparison of US national standards** with those of other nations
- **Solution of standards problems for industry and other government agencies**
- **Assistance to industry**
  - In the development of measurements, measurement methods and basic measurement technology
  - In the development of technology and procedures needed to improve quality, modernize manufacturing processes, ensure product reliability and cost-effectiveness, promote more rapid commercialization …
  - Operation of National User Facilities

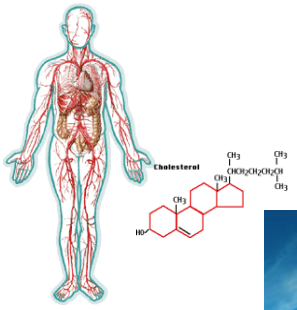
www.nist.gov/director/ocla/NIST%20Organic%20Act%20Updated%201-08.htm

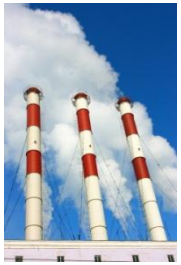
Since its inception NBS/NIST has focused its research and measurement services activities on contemporary societal needs.



1901

2010

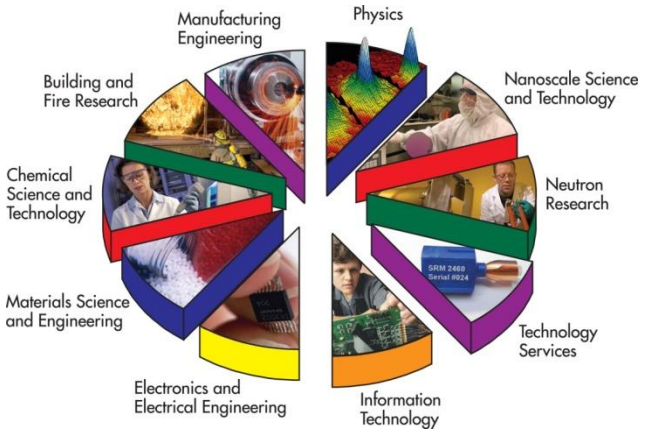




NIST: A Premier Scientific Institution

World-leading measurement science and standards program

- 3 Nobel Laureates since 1997
- MacArthur Fellowship winner in 2003
- National Medal of Science winners in 1998, 2008
- 60 National Academy Members (8 current)
- ~120 National Society Fellows and recipients of ~ 60 National/International Awards per year



A.V. Astin, Director of NBS (1951 – 1969)

The National Bureau of Standards, Physics Today, June, 1953

"The Bureau staff believes first of all in **the importance of scientific research** as a means of intellectual and spiritual advancement, as the foundation of our technological economy and high standard of living, and as the bulwark of our national security." "…a substantial portion of the program.. should be devoted to fundamental or nonprogrammatic research. … **on ideas of their own choosing**.."

"…the **development and maintenance of the standards** …provides the first and **primary reason for the Bureau's existence**. …This standards work must … keep abreast of the expansion of the frontiers of science…."

NIST maintains the world's most mature and comprehensive portfolio of Measurement Service Programs

But demand for NIST measurement services is escalating at a rapid pace:

⇑ internationally recognized and accepted reference materials, reference data, and calibration services for:

- demonstration of measurement traceability
- mandated use in some measurement/quality protocols
- Increasing request from other Agencies
- support for innovation in new technology areas (e.g., bio, nano, forensics, renewable energy, etc.)

Problem: Some critical measurement service needs are not being met

To meet the increasing need for critical Measurement Services, NIST must:

- better integrate its research and measurement service programs
- leverage its resources and capabilities through strategic partnerships

A Vision for NIST Measurement Services

NIST is seen by its staff and stakeholders as providing value to its customers with the right measurement services at the right time.

We succeed by:

- ***Identifying customers and their needs in an open and consistent process.***
- ***Maintaining a world-class research program in measurement science to enable our ability to respond to dynamic wide-ranging customer needs in a timely manner.***
- ***Leveraging our resources through strategic partnerships***
  - Utilizing strategic and more effective partnering with other NMIs
  - Leveraging private sector and other agency capabilities and resources
- ***Consistently assessing the direction, value and impact of our work.***
- ***Having staff be rewarded for their contributions to measurement service delivery as well as research.***

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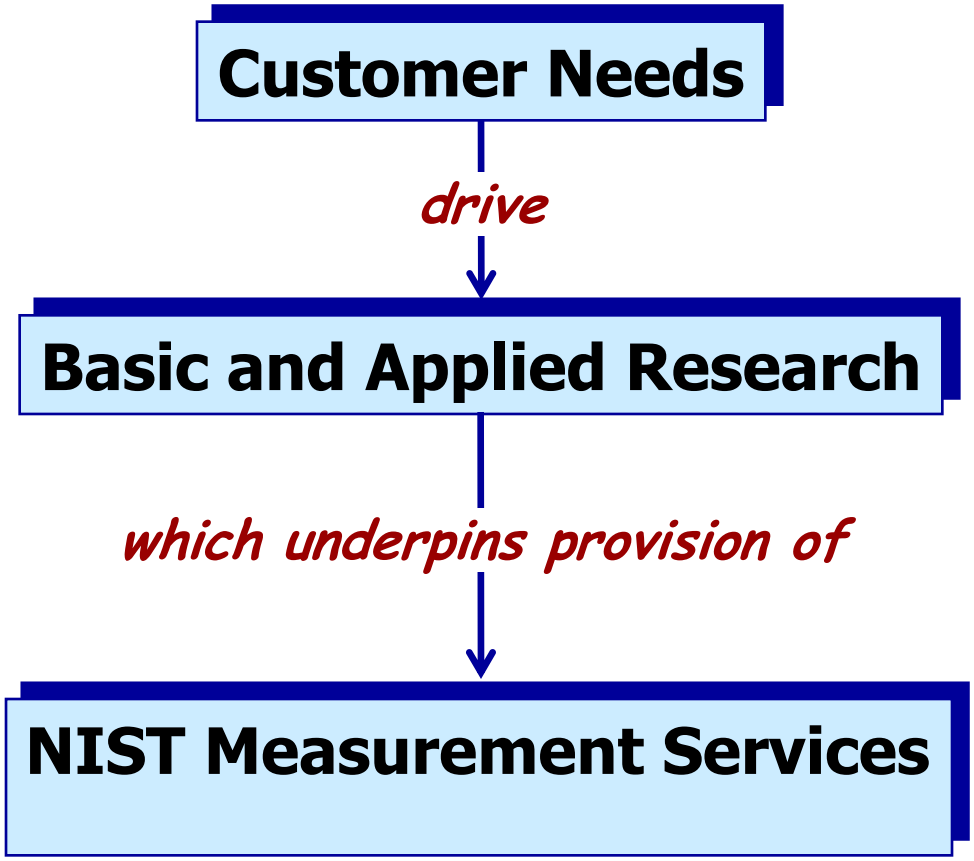


NIST Labs should support NIST's Mission through …

NIST Basic and Applied Research underpins Scientifically-Sound, Metrologically-Based Competencies and Measurement Capabilities

that are

Internationally Vetted and Recognized

to provide

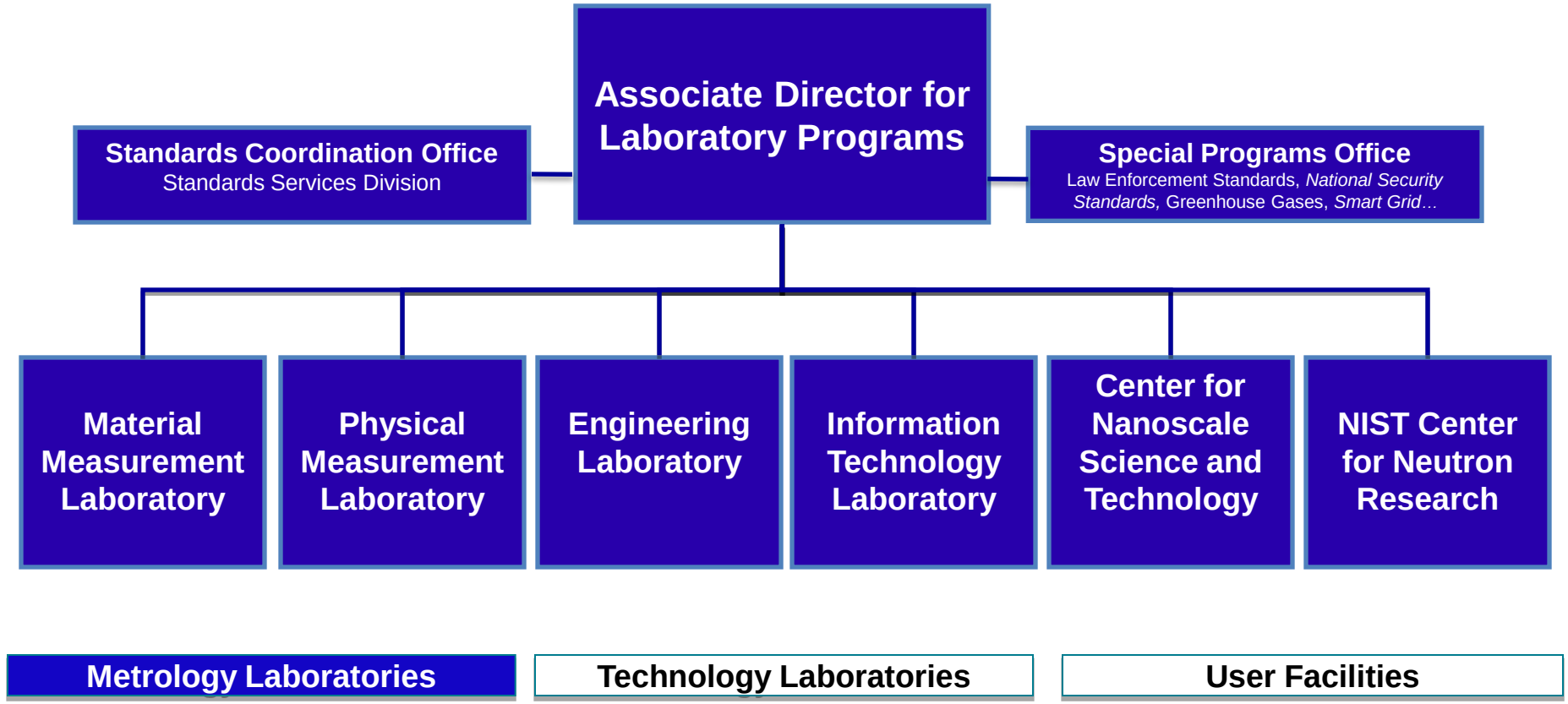
- **NIST Measurement Services**
  - Standard Reference Materials
  - Standard Reference Data
  - Calibrations
  - . . .
- Validated Reference/Test Methods and Measurement Guides
- Measurement Services for other government agencies
- Value-assignment of high priority customer-provided samples or materials

- *Peer Reviewed Publications for measurement technology transfer*
- *Documentary Standards*

base-funded

reimbursable

Realigned Laboratory Structure



Physical Measurement Laboratory

Proposed Functional Statement

The ***PHYSICAL MEASUREMENT LABORATORY*** *shall develop and disseminate the national standards for* ***length, mass, force and shock, acceleration, time and frequency, electricity, temperature, humidity, pressure and vacuum, liquid and gas flow, and electromagnetic, optical, microwave, acoustic, ultrasonic, and ionizing radiation*** *by activities ranging from fundamental measurement research through provision of measurement services, standards, and data.*

PML applies its measurement capabilities to problems of national significance through collaborations with industry, universities, and other agencies of government and supports the research community in such areas as:

- *communication*
- *defense*
- *electronics*
- *energy*
- *environment*
- *health and life sciences*
- *lighting*
- *manufacturing*
- *nanotechnology*
- *radiation*
- *remote sensing*
- *space*
- *transportation*

PML shall also be responsible for coordinating the NIST-wide **Weights and Measures, Laboratory Accreditation, and Calibration Service Programs.**

Material Measurement Laboratory

Proposed Functional Statement

The ***MATERIAL MEASUREMENT LABORATORY*** *shall serve as the national reference laboratory for measurements in the* ***chemical, biological, and material sciences*** *through activities ranging from fundamental and applied research on the composition, structure, and properties of industrial, biological, and environmental materials and processes, to the development and dissemination of certified reference materials, critically evaluated data, and other programs to enable assurance of measurement quality.*

MML shall serve a very broad range of industry sectors ranging from transportation to biotechnology and provide research, measurement services, and measurement quality assurance tools for addressing problems of national importance such as:

- *assessment of climate change*
- *renewable energy*
- *the nation's aging infrastructure*
- *environmental quality*
- *food safety and nutrition*
- *forensics and homeland security*
- *healthcare measurements*
- *manufacturing (ranging from advanced materials to photovoltaics to biologic drugs)*

MML shall also be responsible for coordinating the NIST-wide **Standard Reference Materials** and **Standard Reference Data** Programs

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Needs for NIST Measurement Services

Sources of Input

Administration's Science Priorities, e.g.,

- Smart Grid
- Healthcare Delivery
- Cyber-Security
- Manufacturing
- Innovation and Competiveness

Voice of Customers

- NIST External Needs Assessment Workshops
- Sector-Specific Consortia
- Professional Organizations/Societies
- Single Voices
- Other Government Agencies

Technical and Advisory Bodies

- VCAT
- NRC BOA

Project Prioritization Process

NIST cannot be all things to all people at the same time. Therefore, we obtain input on measurement needs from various sectors and then prioritize within and among sectors.

Heilmeier Questions

1. **What is the problem, why is it hard?**
2. **How is it solved today and by whom?**
3. **What is the new technical idea; why can we succeed now?**
4. **Why should NIST do this?**
5. **What is the impact if successful and who would care?**
6. **How will you measure progress?**

Prioritizing Via CSTL 5+1 Criteria

Industrial and/or National Need

The magnitude and immediacy of industrial and/or national need is assessed

Match to Mission

CSTL meets customer needs for measurements, standards, and data in the areas broadly encompassed by chemistry, biosciences, and chemical engineering

Contribution from CSTL Needed and will Make a Difference

CSTL's contribution is unique and critical for success

Nature and Size of Impact will be Noticeable

– The measure of anticipated impact relative to investment is evaluated (rate of return)

– Relevance of program judged by impact assessment not by income for NIST

Timely and Quality Output can be Provided

CSTL has the ability to respond in a timely fashion with high-quality output

Science/Technology Opportunity

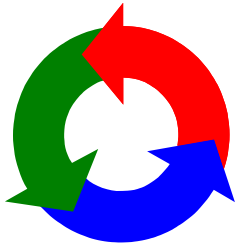
Recent scientific and technological advances present new opportunities that warrant investigation

Vision of Future

More **Impact Driven** *& Less* **Income Driven**

Need better processes for and increased focus on:

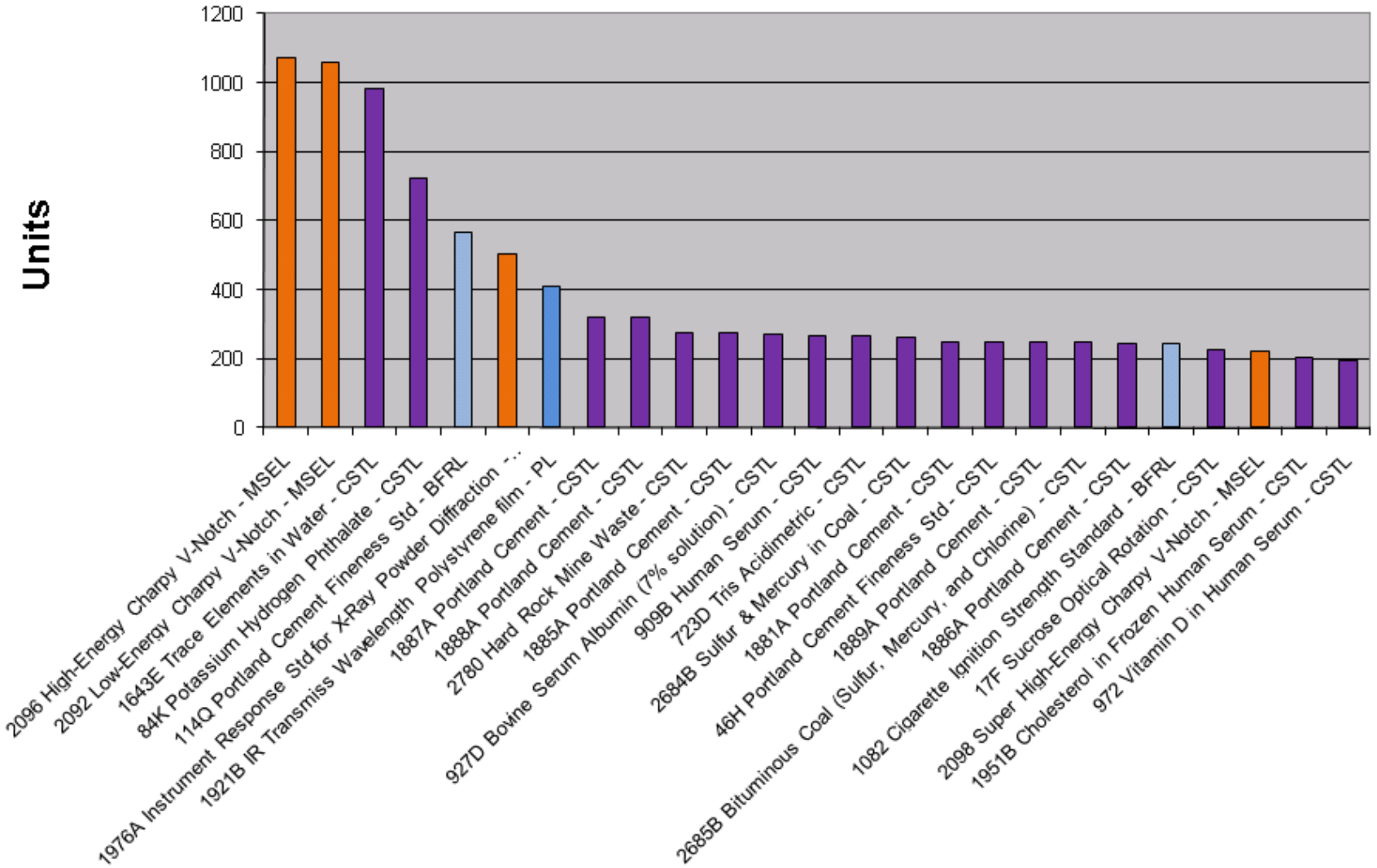
- Assessing and prioritizing needs within sectors
- Prioritizing among sectors
- Increasingly, standards needs driving measurement research
- Assessing impact of NIST Measurement Service Programs



- **For SRMs and SRD:**
  - Establishing more strategic collaborations with:
    - Private Sector and Other Agencies in the delivery of services
    - Other National Metrological Institutes (NMIs) in service delivery

- **For Calibration Services**
  - Developing acceptable mechanisms to meet customer traceability needs that do not require calibration services directly from NIST

Top 30 SRMs in FY2009



Are sales the best metric for impact?

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Research-Enabled Competencies Allow NIST to Respond to National Crises in a Timely manner

- Responding to World Trade Center attack
  - Structural integrity and materials investigations
    - 40 changes approved to date for International Building Code based on NIST recommendations
  - Development of new human identification tools
    - Only 50% of the bone and tissue samples yielded identification results by standard DNA testing methods due to high degradation of the specimens; NIST developed and validated the use of new genetic markers to enable reliable identifications; this technology has now been transferred to the commercial sector.
- Supporting Assessment of Gulf of Mexico Deepwater Horizon Incident
  - Oil flow estimations
  - Specimen Banking
  - Measurement Quality Assurance for Ecosystem Monitoring Studies
- Providing SRMs and other QA services to reduce interlaboratory variability in vitamin D measurement results
- Supporting Implementation of Smart Grid

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CIPM Mutual Recognition Arrangement

… was established in 1999 in response to a growing need for an open, transparent and comprehensive scheme to give users **reliable quantitative information on the comparability of national metrology services** and to provide the technical basis for wider agreements negotiated for **international trade, commerce and regulatory affairs.**

Requires:

1. **Declaring and documenting calibration and measurement capabilities (CMCs)**
2. **Evidence of *successful* participation in formal, *relevant* international comparisons**
3. **Demonstration of system for assuring quality of each NMI's measurement services**

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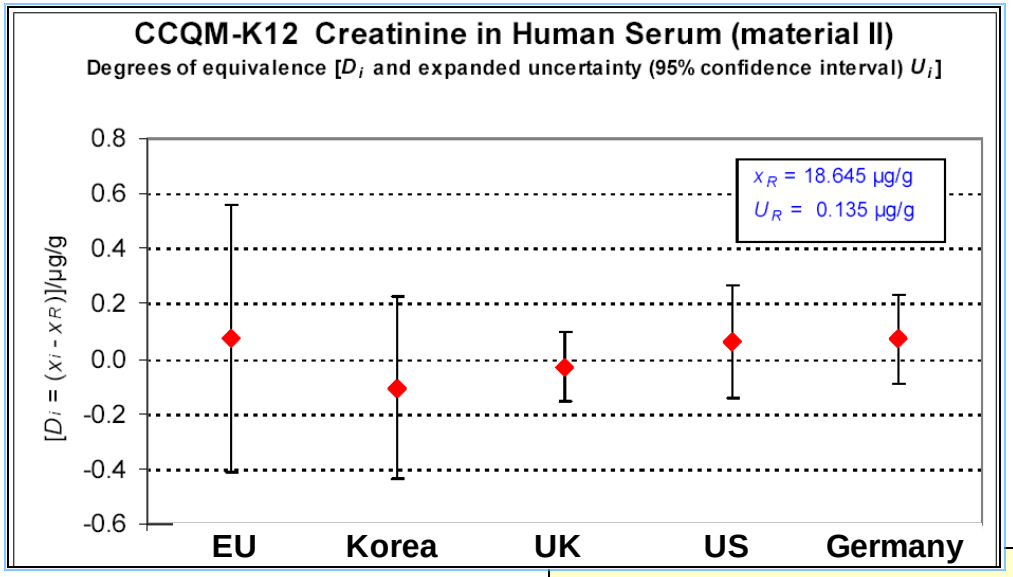
- Originally signed in by directors of NMIs of 38 member states of the Metre Convention
- It formalized existing *ad hoc* relationships, especially in the international chemical measurements community
- The MRA has now been signed by the representatives of 78 institutes (48 member states, 27 associates, 3 international organizations)

NIST Role in CIPM MRA

Began as an "unfunded mandate" with intense involvement in:

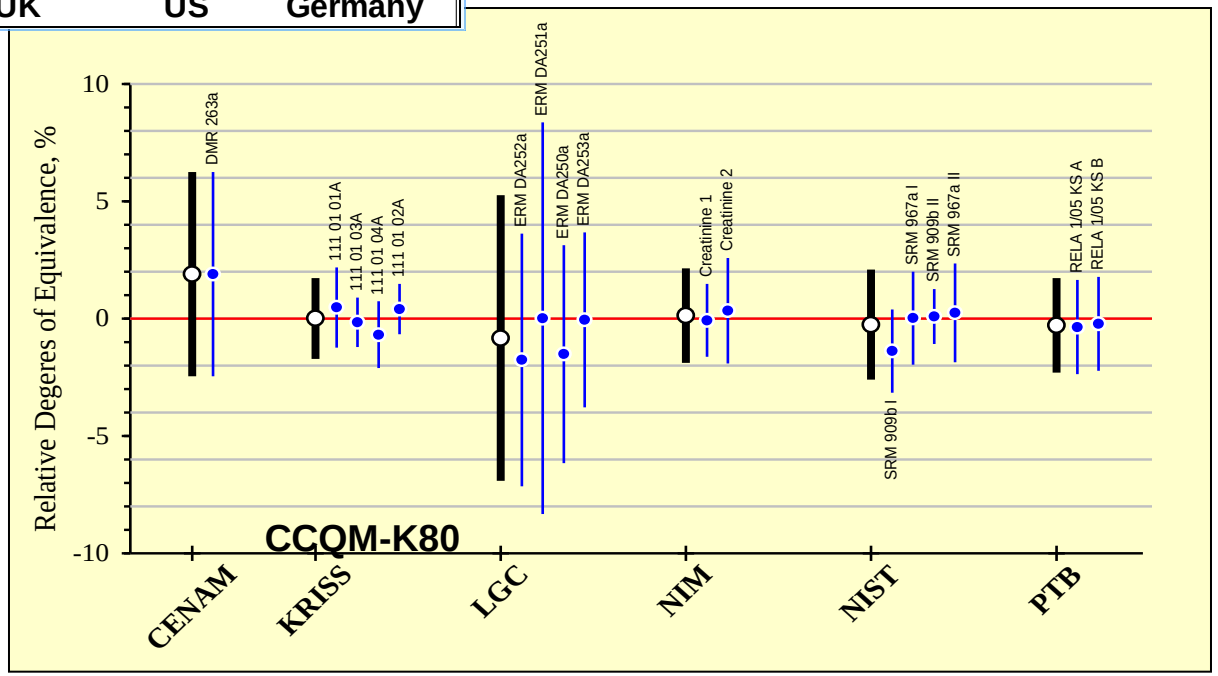
- Documentation of our capabilities for measurement service delivery
  - NIST has ~2,300 of the ~23,000 Calibration and Measurement Capabilities (CMCs) published in the CIPM MRA Appendix C .
- Key Comparisons
  - NIST has participated in ~330 Key Comparisons since the inception and has been the coordinating laboratory for over 60 of these
- Establishing Internationally-recognized Quality Systems for our Measurement Services

Leveraging NIST Participation in CIPM MRA Activities



Documented degree of equivalence of measurement capabilities
(that could be used to identify collaborators in delivery of NIST measurement services)

Comparison of value-assigned CRMs for Creatinine in Serum



NIST Traceable Reference Materials (NTRMs)

NTRM

• commercially produced reference material with a well-defined traceability linkage to existing NIST standards for chemical measurements.

Traceability Linkage

• established via criteria and protocols defined by NIST to meet the needs of the metrological community to be served.

Gas Mixture NTRM Program

Driver: **Increased demand for gas mixture standards**

- Response to Clean Air Act
- Gas program consumed 17% of NIST SRM production resources

NIST Action: **NIST worked directly with ~11 commercial specialty gas vendors to supply NIST-traceable mixtures**

Status: **Well-established, market-driven program with specialty gas companies; in place since 1992**

Economic Impact Study, 2002

Social Rate of Return	225%
Benefit to Cost Ratio	24:1
Net Present Value	$56M

Customers Impacted:

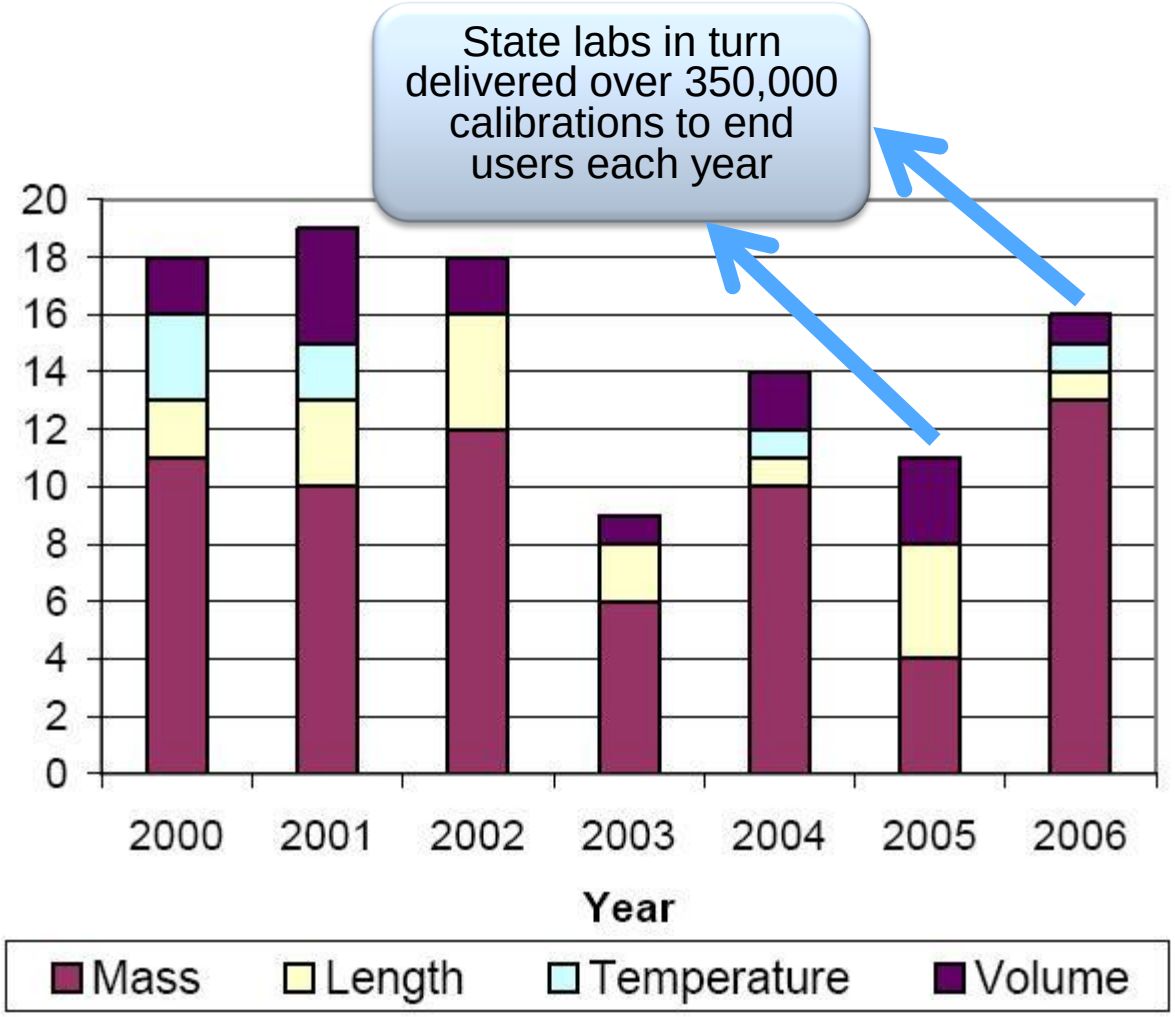
Specialty Gas Companies (*GCs)

End Users: Electric Utilities, Transportation Equipment Firms, Petrochemical Firms, Commercial Labs, Government Agencies

"… the NTRM program has served as an excellent vehicle for production of the high quality standards - of known pedigree - required by both industry and the regulatory community in the implementation of Title IV (SO_2 emissions trading) of the 1990 Clean Air Act."

Stephen Miller, Technical Director
Scott Specialty Gases

NIST Calibrations for State Labs



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NIST Formal Economic Impact Studies

Industry:	*Project*	*SRR*	*BCR*
Semiconductors:	**Resistivity** (test methods)	**181%**	**37**
	Thermal conductivity (matl properties test methods)	**63%**	**5**
	Wire Bonding (test methods)	**140%**	**12**
	Electromigration (test methods)	**117%**	**12**
	Software for design automation (software model)	**76%**	**23**
Communications:	**Electromagnetic interference** (test methods)	**266%**	
	ISDN (interoperability standards)	**156%**	
	Data encryption standards, security (test methods)	**267-272%**	**58-145**
	Role-based access control, security (ref model)	**44%**	**109**
Automation:	**Real-time control systems** (generic architecture)	**149%**	
	Machine tool software error compensation	**99%**	**118**
Manufacturing:	**Standards for product data exchange**	**32%**	**21**
Photonics:	**Optical fiber** (test methods)	**423%**	
	Spectral irradiance (test method (calibration))	**145%**	**13**
	Optical detection (stds and calibrations)	**72%**	**3**
	Laser & fiber optic power calibrations	**43-136%**	**3-11**

SRR = Social Rate of Return; BCR = Benefit-to-Cost Ratio

NIST Formal Economic Impact Studies *(Cont'd)*

Industry:	*Project*	*SRR*	*BCR*
Energy:	Electric meter calibrations	117%	12
Computers:	Software conformance	41%	
Electronics:	Josephson voltage standard (SRM)	87%	5
Materials:	Thermocouple calibrations	32%	3
	Phase equilibria for advanced ceramics (SRD)	33%	10
	Combinatorial methods consortium (methods)	161%	9
Pharmaceuticals:	Radiopharmaceuticals SRMs	138%	97
	Cholesterol in blood SRMs	154%	4.5
Chemicals:	Alternative refrigerants Reference Data	433%	4
	Sulfur in fossil fuel SRMs	1,056%	113
	Gas Mixture NTRMs	225%	24
Construction:	Building codes	57%	
	Roofing shingles	90%	
	Fire safety evaluation systems	35%	

lower transaction costs - lower compliance costs - energy conservation
increase R&D efficiency - increase product quality - enable new markets

http://www.nist.gov/director/planning/impact_assessment.cfm

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Better Recognition of Staff Contributions to Measurement Service Delivery

The general perception among the staff is that success in “curiosity-driven” research is rewarded more than contributions to measurement service delivery.

- some who make outstanding contributions but “just” in measurement service activities sometimes identify themselves as “second class citizens”

Rewards for contributions to measurement service development and delivery as well as mission-focused research and numbers of publications in high-impact journals is not uniformly practiced across NIST

- these rewards include career progression, internal and external awards, highlighting of importance of these activities by upper management during presentations, opportunities to participate in professional meetings, etc.

,

Staff should be rewarded for their contributions to **all institutionally-strategic** programs and activities.

Role of OU Director in the "New NIST"

Some new expectations for:

- **Leadership:**
  - Ensuring that measurement service needs within OU domain are identified, prioritized and addressed in a timely manner
  - Communicating OU goals, expectations and importance of measurement service delivery with staff at all levels; recognizing and rewarding staff for their contributions to **all institutionally-strategic programs and activities**
  - Establishing and maintaining strategic collaborations for the delivery of NIST Measurement Services, both internally and externally
  - Integrating and balancing research and services, projects and people, and new and existing strengths, skill sets, and expertise.
- **Alignment:** Ensuring that OU research and staffing activities are congruent with measurement service needs within the OU domain
- **Empowerment:** Optimizing priorities in carrying out assigned responsibilities with new OU authority for **entire** measurement service delivery enterprise
- **Accountability**
  - MML Director to be responsible for maintaining "health" of SRM and SRD service activities
  - PML Director to be responsible for maintaining "health" of NIST Calibration Services

Thanks for Your Attention….

Questions and Discussion are Welcome