

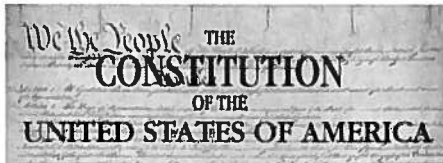
Overview of NIST and Engineering Laboratory

June 13, 2012
Roadmap Workshop

Measurement Science R&D Roadmap for Windstorm and Coastal Inundation Impact Reduction

Dr. S. Shyam Sunder
Director, Engineering Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce

Authority for and Importance of Standards



Article I, Section 8: The Congress shall have the power to... *fix the standard of weights and measures*

National Bureau of Standards established by Congress in 1901

- Eight different "authoritative" values for the gallon
- No standards for nascent electrical industry
- American instruments sent abroad for calibration
- Consumer products and construction materials uneven in quality and unreliable



Estimated that 80% of global merchandise trade is influenced by testing and other measurement-related requirements of regulations and standards

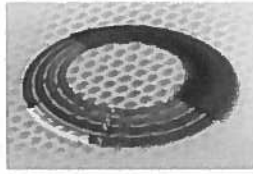
NIST's Unique Mission

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.

- Mission focus: Targeting Investments to Advance U.S. Innovation and Boost Economic Recovery
- Deep research expertise underpins technological innovation – e.g. lasers, memory, GPS, wireless
- Non-regulatory status enables important role as a convener that facilitates collaboration between industry and government



Cybersecurity: Improved response to cyber threats



Nanomanufacturing: New measurement tools for advanced materials manufacturing



Energy: Measurements and standards for energy security

3

NIST At A Glance

Gaithersburg, MD



- NIST Research Laboratories
- Manufacturing Extension Partnership
- Baldrige Performance Excellence Program
- Technology Innovation Program

Boulder, CO



- ~ 2,900 NIST employees
- ~ 2,600 associates and facility users
- ~ 1,600 field staff in partner organizations
- ~ 400 NIST staff serving on 1,000 national and international standards committees

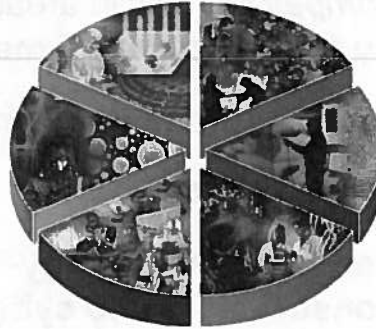
The NIST Laboratories

NIST's work enables

- Advancing manufacturing and services
- Helping ensure fair trade
- Improving public safety and security
- Improving quality of life

NIST works with

- Industry
- Academia
- Other federal agencies
- State and local government agencies
- Measurement laboratories
- Standards organizations



Providing measurement solutions for industry and the Nation

NIST has... ...world-class staff



Jan Hall
2005 Nobel Prize
in Physics



Eric Cornell
2001 Nobel Prize
in Physics



Bill Phillips
1997 Nobel Prize
in Physics



John Cahn
1998 National Medal of
Science



Anneke Sengers
2003 L'Oréal-UNESCO
Women in Science Award



Debbie Jin
2003 MacArthur
Fellowship

Engineering Laboratory Mission

To promote U.S. *innovation and industrial competitiveness* in areas of critical national priority **by anticipating and meeting the:**

- **measurement science and**
- **standards**

needs for technology-intensive manufacturing, construction, and cyber-physical systems in ways that enhance *economic prosperity* and improve the *quality of life*.

Engineering Laboratory Vision

To be *the* source for:

- creating **critical *solution-enabling* measurement science**, and
- critical technical contributions underpinning emerging **standards, codes, and regulations**

that are *used* by the U.S. manufacturing, construction, and infrastructure industries to strengthen leadership in domestic and international markets.

EL is the primary federal laboratory serving the manufacturing and construction industries.

EL Core Mission Functions¹

- Fire prevention and control
- National earthquake hazards reduction
- **National windstorm impact reduction**
- **National construction safety teams**
- Building materials and structures
- Engineering and manufacturing materials, products, processes, equipment, technical data, and standards
- Green manufacturing and construction
- Manufacturing enterprise integration
- Smart grid devices and systems
- Collaborative manufacturing research pilot grants
- Manufacturing fellowships

¹Authorized by NIST Organic Act or by other statutes

Measurement Science Products

Measurement science research and services include:

- development of performance metrics, measurement and testing methods, predictive modeling and simulation tools, knowledge modeling, protocols, technical data, and reference materials and artifacts
- conduct of inter-comparison studies and calibrations
- evaluation of technologies, systems, and practices, including uncertainty analysis
- development of the technical basis for standards, codes, and practices—in many instances via testbeds, consortia, standards and codes development organizations, and/or other partnerships with industry and academia

EL Strategic Goals

- **Smart Manufacturing, Construction, and Cyber-Physical Systems:** To enable the next generation of innovative and competitive manufacturing, construction, and cyber-physical systems through advances in measurement science
- **Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure:** To enable sustainable and energy efficient manufacturing, materials, and infrastructure through advances in measurement science
- **Disaster-Resilient Buildings, Infrastructure, and Communities:** To reduce the risk and enhance the resilience of buildings, infrastructure, and communities to natural and manmade hazards through advances in measurement science



EL Programs Aligned with EL Strategic Goals

- **Smart Manufacturing, Construction, and Cyber-Physical Systems**
 - Smart Manufacturing Processes and Equipment
 - Next-Generation Robotics and Automation
 - Smart Manufacturing and Construction Control Systems
 - Systems Integration for Manufacturing and Construction Applications
 - Smart Grid Devices and Systems
- **Disaster-Resilient Buildings, Infrastructure, and Communities**
 - Fire Risk Reduction In Communities
 - Fire Risk Reduction In Buildings
 - Earthquake Risk Reduction In Buildings and Infrastructure
 - Structural Performance Under Multi-Hazards
- **Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure**
 - Sustainable Manufacturing
 - Sustainable, High-Performance Infrastructure Materials
 - Net-Zero Energy, High-Performance Buildings
 - Embedded Intelligence In Buildings

Building, Industrial, and Vehicle Integration with Smart Grid

Our programs are identified, developed, carried out, the results implemented, and consequences measured in partnership with key customer organizations

EL Goals and Programs

EL Goal/Program	FY 2012 Funding
Goal: Smart Manufacturing, Construction, and Cyber-Physical Systems	
Smart Manufacturing Processes and Equipment	\$4.0M
Next-Generation Robotics and Automation	\$5.8M
Smart Manufacturing and Construction Control Systems	\$4.3M
Systems Integration for Manufacturing and Construction Applications	\$6.9M
Smart Grid Devices and Systems Program	\$8.0M
Goal: Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure	
Sustainable Manufacturing	\$5.3M
Sustainable, High-Performance Infrastructure Materials	\$3.2M
Net-Zero Energy, High-Performance Buildings	\$8.9M
Embedded Intelligence in Buildings	\$3.2M
Goal: Disaster-Resilient Buildings, Infrastructure, and Communities	
Fire Risk Reduction in Communities	\$4.7M
Fire Risk Reduction in Buildings	\$7.6M
Earthquake Risk Reduction in Buildings and Infrastructure	\$4.1M
Structural Performance Under Multi-Hazards	\$3.5M
Total	\$ 69.5M

Partners Representing Construction and Building Industry

Construction Industry Institute

- Board of Advisors
- Breakthrough Strategy Committee
- Benchmarking and Metrics Committee
- Cost of Inadequate Interoperability Study
- Workshops and Conferences
- Research Teams



FIATECH Consortium

- Capital Projects Technology Roadmap
- Cost of Inadequate Interoperability Study
- Automating Equipment Information Exchange
- Intelligent and Automated Construction Job Site
- Building Information Modeling
- Workshops and Conferences



(Conceived by CII and NIST in 1999)



Building and Fire Codes and Standards

- Technical Guidelines
- Measurement Techniques
- Performance Prediction Tools
- Committees, Councils, and Boards
- Workshops and Conferences
- Collaborative Research
- Publications
- Working Groups



Partnering Strategies with Industry

- **Planning and Roadmapping Workshops**
- **Testbeds, Facilities, and Tools**
 - Unique Facilities and Testbeds
 - Modeling and Testing Tools
 - Performance Metrics and Test Methods
- **Standards Engagement**
 - Technical basis for emerging standards
 - National and International standards committee
 - Conformity assessment
- **Cooperation Mechanisms**
 - CRADAs and Consortia
 - Cooperative Agreements and Contracts, incl SBIR
- **Other Tech Transfer Mechanisms**
 - Patents and licensing
 - Industry Associates at NIST
- **NIST Sponsored Events**
 - Competitions at NIST Test Arenas and other venues
 - "Plugfests" at trade shows



Fire Risk Reduction in Buildings and Communities

Objective: To develop and deploy advances in measurement science to improve the resilience of communities, the safety of building occupants, and the performance of structures and their contents to unwanted fires by enabling innovative, cost-effective fire protection and response technologies and tactics

- Enable the development and implementation of advanced technologies and tactics to improve fire service safety and effectiveness
- Enable improved standards, codes, and technologies to increase the fire resistance of Wildland-Urban Interface (WUI) communities
- Enable the manufacture of cost-effective fire-safe materials and products
- Enable effective fire protection technologies
- Derive lessons from analysis of disaster and failure events



Earthquake Risk Reduction in Buildings and Infrastructure

Objective: To develop and deploy advances in measurement science to resist earthquake effects, improve safety, and enhance resilience of buildings, infrastructure, and communities

- Technical support for seismic practice and code development
- Problem-focused, user-directed research to support development of performance-based seismic design concepts and guidelines
- Problem-focused research and technical resources (e.g., guidelines and manuals) development to improve seismic engineering practice
- Evaluated technology made available to practicing professionals in the design and construction communities



Structural Performance Under Multi-Hazards

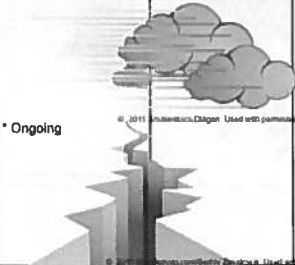
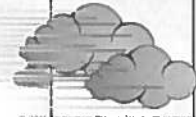

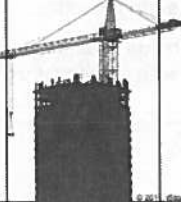

Objective: To develop and deploy advances in measurement science to enhance the resilience of buildings and infrastructure to natural and manmade hazards

- **Prevention of Progressive Structural Collapse**
 - Develop performance-based pre-standards for mitigation of disproportionate collapse incorporating structural robustness metrics, cost-effective strategies to prevent progressive collapse, validated computational tools
- **Fire Safety Design and Retrofit of Structures**
 - Develop a performance-based approach to evaluate fire behavior of structures, incorporating fire loads, material response, and overall structural response to elevated temperatures
 - Deliver verified tools, guidance, and pre-standards for the fire resistance design and rehabilitation of steel and concrete structures
- **Wind Engineering and Multi-hazard Failure Analysis**
 - Develop the measurement science methods and tools that will enable performance-based standards for designing structures to resist wind and storm surge in a multi-hazard context



NIST Disaster and Failure Studies

Earthquakes	Hurricanes	Construction/ Building	Tornadoes	Fires
San Fernando, CA (1971) Mexico City, Mexico (1985) Loma Prieta, CA (1989) Northridge, CA (1994) Kobe, Japan (1995) Kocaeli, Turkey (1999) Maule, Chile (2010)* Christchurch, NZ (2011)*	Camille, MS/LA (1969) Alicia, Galveston, TX (1983) Hugo, SC (1989) Andrew, FL (1992) Hurricanes Mitch and Georges, LAC (1998) Hurricanes Katrina and Rita (2005)	Skyline Plaza Apartments, Bailey's Crossroads, VA (1973) Willow Island Cooling Tower, WV (1978) Kansas City Hyatt Regency, Kansas City, MO (1981) Riley Road Interchange, East Chicago, IN (1982) Harbor Cay Condominium, Cocoa Beach, FL (1981) L'Ambiance Plaza, Hartford, CT (1987) Ashland Oil Tank Collapse, Florence, PA (1988) U.S. Embassy, Moscow, USSR (1987) Murrah Federal Building, Oklahoma City, OK (1995) World Trade Center Disaster, New York, NY (2001) Dallas Cowboys Indoor Practice Facility, May 2009	Jarrell, TX (1997) Spencer, SD (1998) Oklahoma City, OK (1999) Joplin, MO (2011)*	DuPont Plaza Hotel, San Juan, PR (1986) First Interstate Bank Building, Los Angeles, CA (1988) Loma Prieta Earthquake, CA (1989) Hillhaven Nursing Home (1989) Pulaski Building, Washington, DC (1990) Happyland Social Club, Bronx, NY (1990) Oakland Hills, CA (1991) Hokkaido, Japan (1993) Watts St, New York City (1994) Northridge Earthquake, CA (1994) Kobe, Japan (1995) Vandalia St, New York City (1998) Cherry Road, Washington, DC (1999) Keokuk, IA (1999) Houston, TX (2000) Phoenix, AZ (2001) Cook County Administration Building Fire (2003) The Station Nightclub, RI (2003) Charleston, SC, Sofa Super Store Fire (2007) Witch Creek & Guejito, CA, WUI Fire (2007) Amarillo, TX, WUI Fire (2011)

NIST Disaster and Failure Studies

Results

- Probable technical cause
- Lessons learned: successes and failures
- Improvements to standards, codes, practices, technologies
- Future research priorities

NIST Authorities & Roles:

- **NCST Act (2002):** building failures, evacuation and emergency response procedures
- **NIST Act (1950, as amended):** structural investigations; fire-resistive building materials; materials, mechanisms, structures, components, and systems
- **Fire Prevention and Control Act (1974):** fire investigations
- **NEHRP Reauthorization Act (2004):** earthquakes
- **National Windstorm Impact Reduction Act (2004):** windstorms and floods
- **National Response Framework:** structural and fire safety; disaster operations and situation assessment; urban and industrial hazard analysis; recovery

A program focus: Develop and maintain archival disaster and failure database of hazards, performance of buildings and infrastructure, evacuation and emergency response, and related factors (e.g., mitigation, response)

NIST and Wind Engineering

- **Aerodynamic testing of Empire State Building (1930s)**
- **Disaster Studies (Camille to Katrina; Jarrell to Joplin)**
- **Full-scale measurements of pressures**
- **Development of modeling:**
 - micrometeorological (wind profiles, turbulence)
 - extreme value statistics (wind maps)
 - bluff body aerodynamics (intern. round robin; databases)
 - structural dynamics (WTC)
 - aeroelasticity (tall buildings)
 - structural reliability (safety margins, wind load factors)
 - tornado and hurricane speeds; wind-borne missiles
- **Major contributions to ASCE 7, ANS 2.3, NRC NUREG**



Miami hurricane
1926 (ENR)

National Windstorm Impact Reduction Program (NWIRP)

- Created by the National Windstorm Impact Reduction Act of 2004 (PL 108-360)
- Objective - "achievement of major measurable reductions in losses of life and property from windstorms"
- Interagency Working Group: NIST, NOAA, FEMA, and NSF
- Lead Agency: White House Office of Science and Technology Policy (OSTP)
- NIST responsibilities (PL 108-360, Section 204(c)(1)):
 - Support R&D to improve building codes and standards and practices for design and construction of buildings, structures, and lifelines

NWIRP Reauthorization Status

- Legislation *pending* in both the House (H.R. 3479) and Senate (S.646) would:
 - Reauthorize NWIRP (and NEHRP)
 - Make NIST lead agency for NWIRP
 - Create combined Interagency Coordinating Committee for NWIRP and NEHRP (NIST, NSF, FEMA, USGS, NOAA)

On-Going Windstorm Impact Reduction R&D

- **Objective:** To develop the measurement science methods and tools that will enable performance-based standards for designing structures to resist wind and storm surge in a multi-hazard context
- **Thrusts:**
 - Develop wind climate database and analysis procedures to better reflect the extreme wind climatology in non-hurricane prone regions
 - Develop science-based methodologies for aerodynamic simulation/measurements to improve both computational and wind tunnel studies
 - Develop methodology for computation of risks posed by the combined hurricane hazards of wind, storm surge, and waves.
 - Conduct technical study of the Joplin Tornado

R&D Topics in Planning Stages

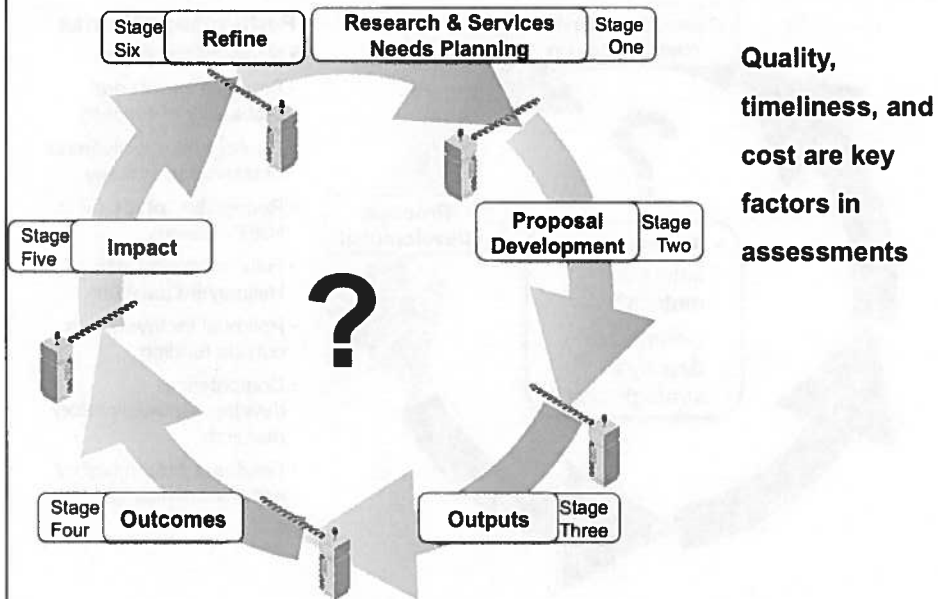
- **Design to Resist Windstorm and Storm Surge Hazards**

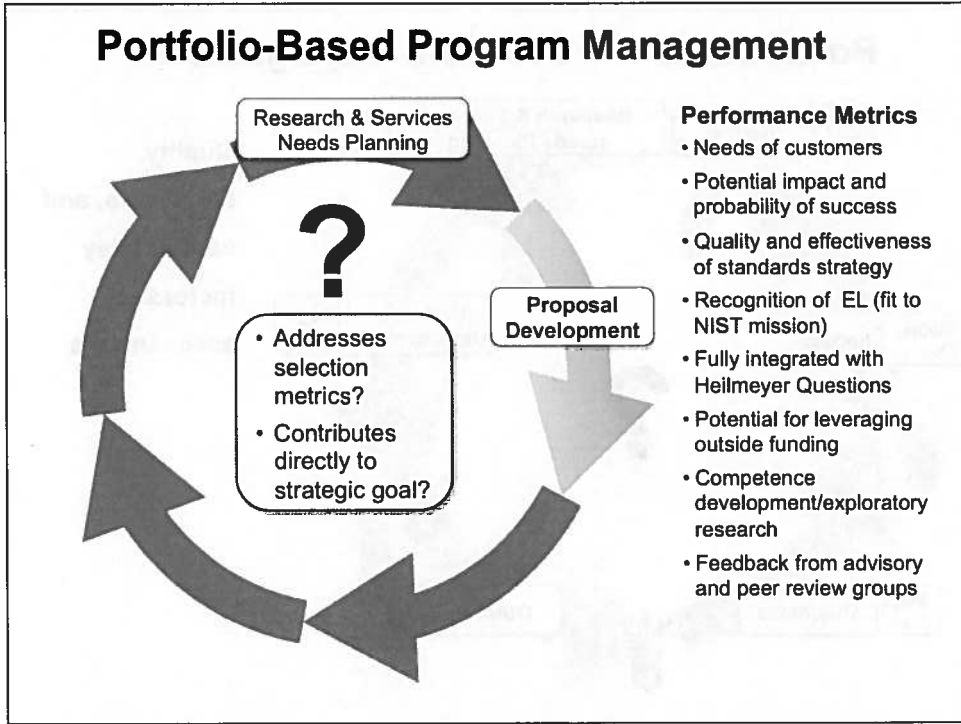
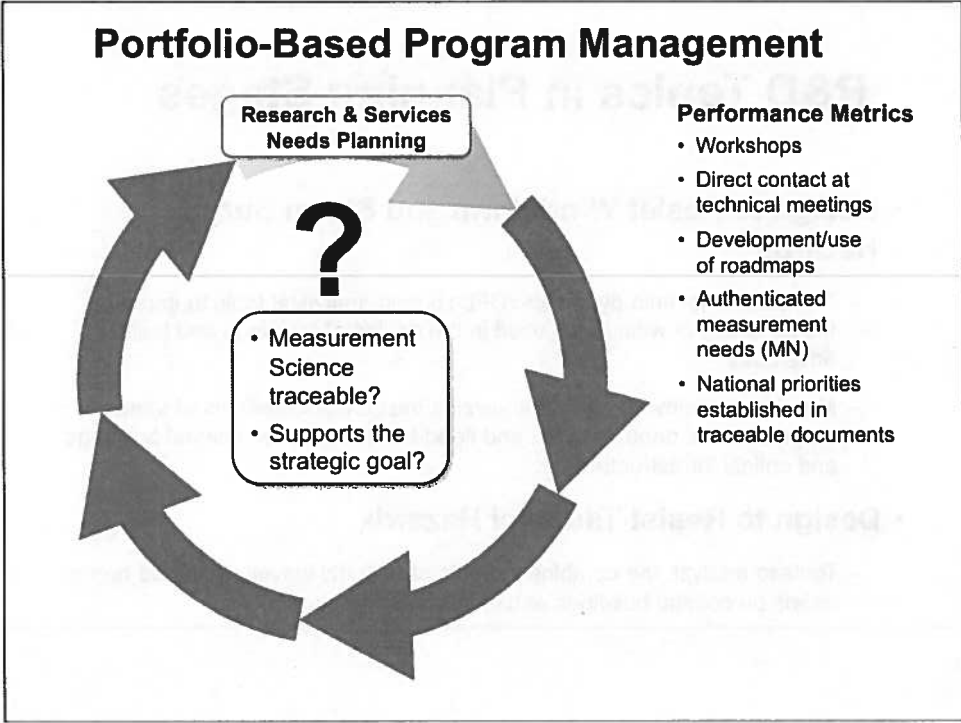
- Computational fluid dynamics (CFD) based analytical tools to improve the accuracy of wind loads used in the design of buildings and building envelopes
- Map-based software tool for analyzing the combined effects of storm surge velocity, depth, waves, and flood-borne debris on coastal buildings and critical infrastructure

- **Design to Resist Tsunami Hazards**

- Tools to analyze the combined effects of tsunami waves and flood-borne debris on coastal buildings and critical infrastructure

Portfolio-Based Program Management

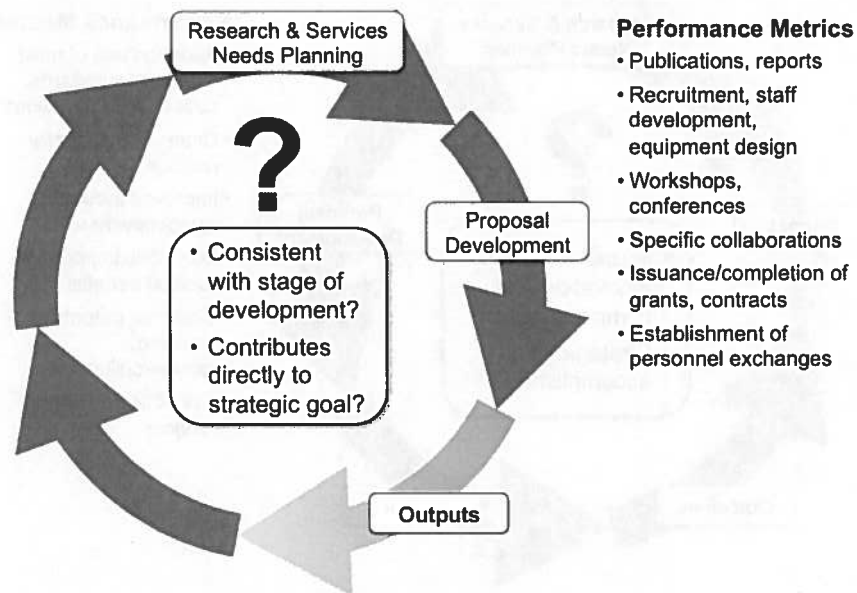


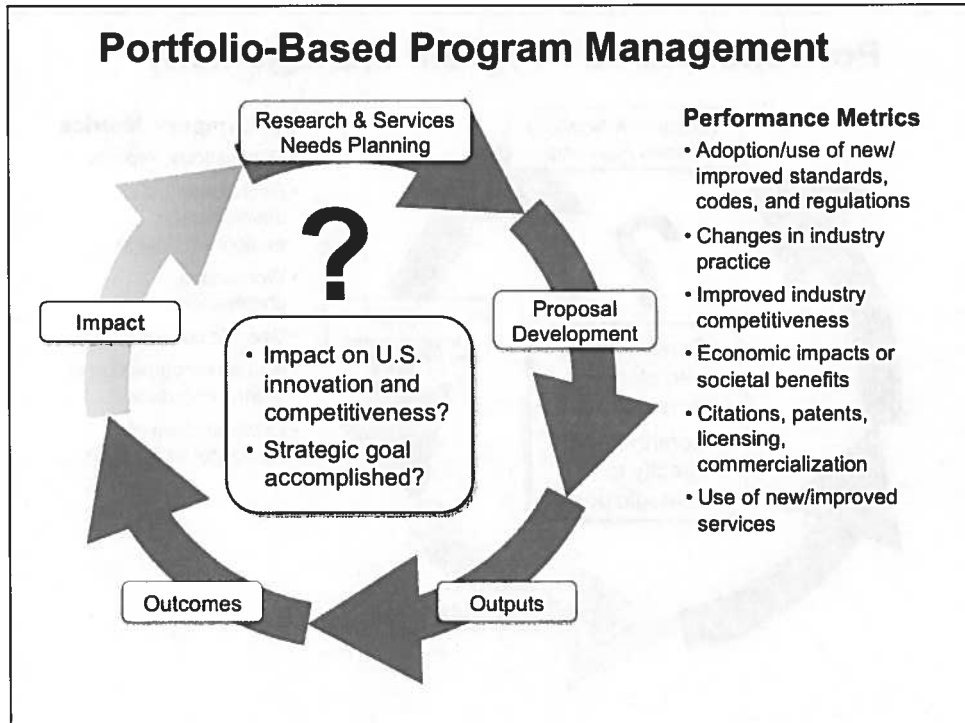
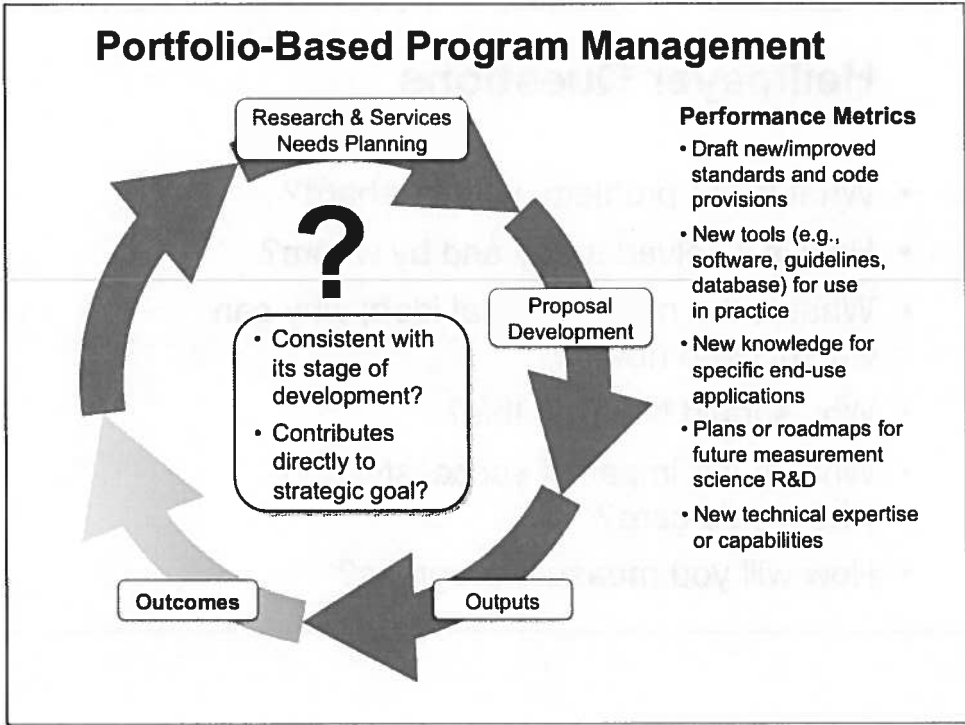


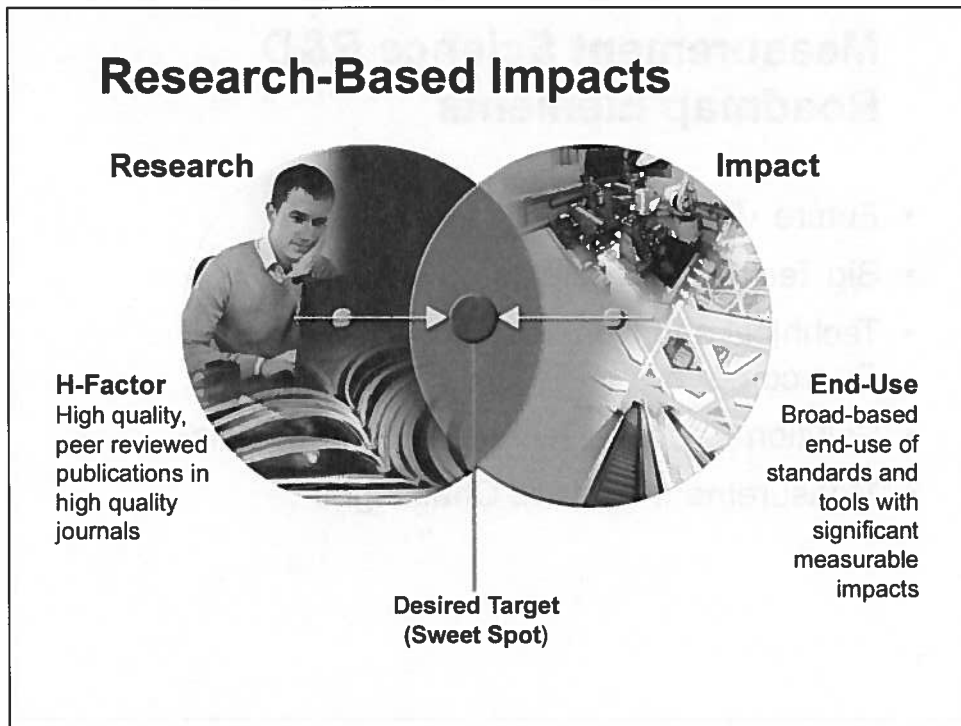
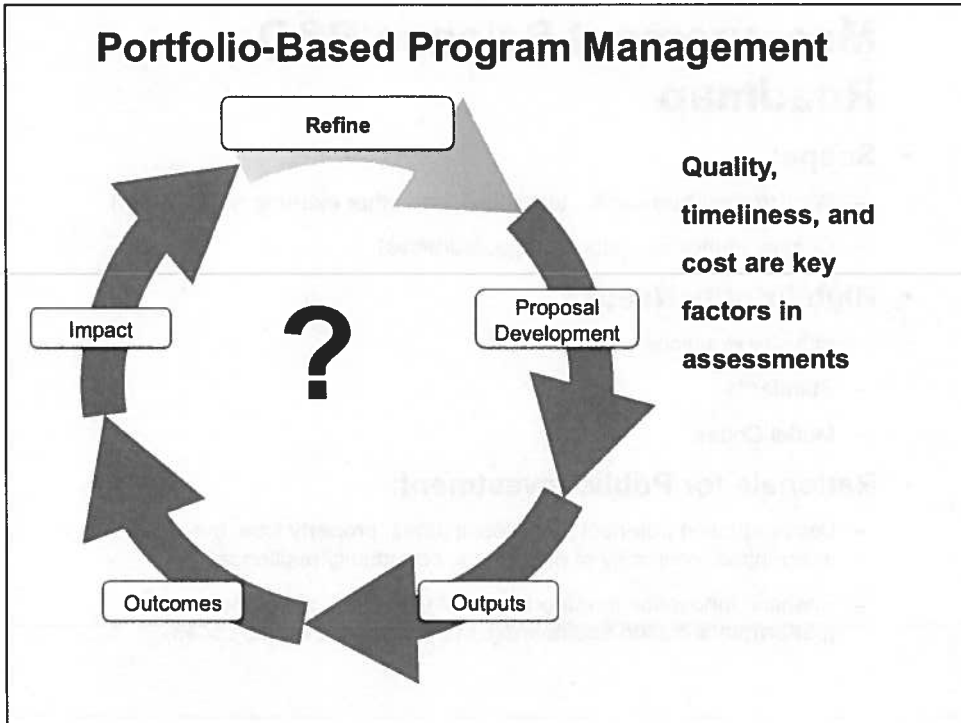
Heilmeyer Questions

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

Portfolio-Based Program Management







Measurement Science R&D Roadmap

- **Scope:**
 - Windstorms (hurricanes, tornadoes, and other extreme wind events)
 - Coastal inundation (storm surge, tsunamis)
- **High Priority Needs:**
 - Industry Practices
 - Standards
 - Model Codes
- **Rationale for Public Investment:**
 - Loss reduction potential (fatalities, injuries, property loss, business interruption, continuity of operations, community resilience)
 - Enabling innovation in materials, design, construction, and retrofit (performance-based engineering, standards, and model codes)

Measurement Science R&D Roadmap Elements

- Future Vision/State
- Big Technical Problems
- Technical and Non-Technical Barriers to Overcome
- Solution-Enabling Technologies and Tools
- Measurement Science Challenges

Charge to Workshop Participants

- Formulate a broad strategic approach and objectives for NIST windstorm and coastal inundation impact reduction research for buildings, structures, and lifelines, including both new and existing construction
 - Adapt ATC 57 approach used in seismic road-mapping
 - Assist in prioritizing research and development needs
 - Include 'standards strategy' consideration – how to get the R&D products into standards, codes and practices
 - Enhance linkages from NIST/NWIRP to the broader engineering community

R&D Roadmap Framework

- **Focus Area 1:** Systematic support of the windstorm and coastal inundation standards and code development process
 - **Program Element 1:** Provide technical support for windstorm and coastal inundation **engineering practice and code development** process
 - **Program Element 2:** Develop the technical basis for **performance-based windstorm and coastal inundation engineering** by supporting problem-focused, user-directed research and development

R&D Roadmap Framework

- **Focus Area 2:** Improve windstorm and coastal inundation design and community resiliency
 - **Program Element 3:** Support the development of **technical resources (e.g., guidelines and manuals)** to improve windstorm and coastal inundation engineering practice
 - **Program Element 4:** Make **evaluated technology** available to practicing professionals in the windstorm and coastal inundation design and construction communities
 - **Program Element 5:** Develop the technical basis for windstorm and coastal inundation engineering to support **community resilience within an all-hazards framework**

Contact Info

Shyam Sunder
Director

301 975 5900
sunder@nist.gov

Engineering Laboratory
National Institute of Standards and Technology
100 Bureau Drive
Gaithersburg, MD 20899-8600

www.nist.gov/el

