NIST Activities in Smart Manufacturing

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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 agencies
- Government agencies
- Measurement laboratories
- Standards organizations
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.
Manufacturing is challenged by a changing world and more aggressive and adept competition.

Technology - to spur innovation and enhance productivity and quality - is a critical factor for the success of U.S. manufacturers.

EL helps manufacturers to innovate and compete more effectively by providing measurement science to help advance technology and reduce risks of technology adoption.
Manufacturing measurement science research and services:

- Development of performance metrics, measurement and testing methods, predictive modeling and simulation tools, knowledge modeling, protocols, technical data, and reference materials and artifacts
- Evaluation of technologies, systems, and practices, including uncertainty analysis
- Development of the technical basis for standards and practices—in many instances via testbeds, consortia, standards development organizations, and/or other partnerships with industry and academia
Driving Manufacturing Technology Innovation Through Measurements and Standards

Process has been proven in many NIST-led standards projects, e.g.,
ASTM E54.08
ASME B5/TC52
ASME B89.1.12
Traceable Needs for Smart and Sustainable Manufacturing

- Smart Manufacturing Leadership Coalition (SMLC), “Implementing 21st Century Smart Manufacturing” (2011)
- SMLC Public-Private Partnership Program Recommendations (2010)
- MIT Sloan Management Review Special Reports on Sustainability (2009; 2011)
EL Manufacturing Program Portfolio

Smart Manufacturing, Construction, and Cyber-Physical Systems Strategic Goal:
• Smart Manufacturing Processes and Equipment
• Next-Generation Robotics and Automation
• Smart Manufacturing and Construction Systems
• Systems Integration for Manufacturing and Construction Applications

Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure Strategic Goal:
• Sustainable Manufacturing
• Sustainable, High-Performance Infrastructure Materials
• Net-Zero Energy, High-Performance Buildings
• Embedded Intelligence in Buildings
Smart Manufacturing Processes and Equipment Program

Objective: To develop and deploy advances in measurement science that will enable rapid and cost-effective production of innovative, complex products through advanced manufacturing processes and equipment

- **Additive Manufacturing Measurement Standards** – helping users best apply metal-based additive manufacturing systems for agile manufacture of innovative complex, custom products through ASTM F42 standards

- **Machine Tool Performance Standards** – reducing risks for users of high-tech machine tools through development of ISO 230 and ISO 10791 standards for machine tool performance

- **Machining Process Modeling Tools** – enabling enhanced machining performance and longer tooling life through standard test methods and performance data for materials and processes for use in validation of manufacturing process modeling and simulation tools

- **Micro- and Nano-manufacturing Measurement Science** – enabling improved micro- and nano-scale product quality and yield through advanced measurement techniques for in-process control
Next Generation Robotics and Automation Program

Objective: To develop and deploy advances in measurement science to safely increase the versatility, autonomy, and rapid re-tasking of intelligent robots and automation technologies for smart manufacturing and cyber-physical systems applications in the following thrust areas:

- **Sensing and Perception** – enabling next-generation robots that can safely collaborate with humans in unstructured environments and without costly fixturing, through development of ISO and ASTM standards

- **Manipulation** – enabling dexterous manipulation that is essential for agile manufacturing operations and a greater breadth of applications, including at the micro and nano scales, through RIA or ASTM standards for measuring performance

- **Mobility** – allowing manufacturing vehicles to operate safely and more effectively in the same workspace as humans, through development of industrial vehicle safety standards

- **Autonomy** – making possible agile and reconfigurable robots that are easily tasked to perform new manufacturing operations through standards and measurement tools for intelligent planning and modeling
Objective: To develop and deploy advances in measurement science to enable real-time monitoring, control, and performance optimization of smart manufacturing systems at the factory or site

- **Factory Networks** – enabling cost savings and ease of integration for factory networks of equipment and sensors by developing performance and conformance tests for data exchange and cybersecurity standards through IEEE and ISA

- **Information Modeling and Testing** – enabling seamless information exchange throughout production activities by developing validation and conformance tests for information exchange standards through ISO and the Dimensional Measurement Standards Consortium (DMSC)

- **Performance Measurement and Optimization** – enabling optimization of manufacturing across the shop floor by developing standards for measuring key performance indicators through the Association for Manufacturing Technology (AMT)
Objective: To develop and deploy advances in measurement science for integration of engineering information systems used in complex manufacturing networks to improve product and process performance

- **Engineering Systems Integration** – Enabling systems engineering standards that will reduce cycle time from product development to manufacturing and more efficiently communicate design information and manufacturing process data

- **Production Network Integration** – Enabling network integration standards to improve efficiency and agility, reduce production and inventory costs, allow for increased product customization, and support new manufacturing services model

- **Production Network Data Quality** – Developing and testing standard methods for quantifying the quality of engineering design models and manufacturing data that are critical to improving manufacturing productivity
Sustainable Manufacturing Program

Objective: To develop and deploy advances in measurement science to achieve sustainability across manufacturing processes enabling resource efficiency and production network resiliency.

- **Sustainable Processes and Resources** – enabling standards for characterizing and assessing sustainability performance (energy, materials, resiliency) of unit manufacturing and assembly processes, integrated production processes, and supplier networks.

- **Integration Infrastructure for Sustainable Manufacturing** – enabling standards for analyzing, simulating, and optimizing sustainability performance (energy, materials, resiliency efficiency) of complete manufacturing systems, including production processes and supplier networks.
Cyber-Physical Systems (CPS)

- Growing demands on NIST for standards associated with smart systems applications
  - Smart Buildings, Smart Grid, Smart Manufacturing, Smart Transportation, Smart Health Care
- NIST has responded with programs in individual domain areas
- Significant crosscutting technology gaps exist
  - Core systems engineering, integration, and standards for cyber-security, safety, reliability, complexity, autonomy, adaptability, scalability, interoperability
- Fundamental research challenges include:
  - Synthesizing and evolving complex systems with predictable behavior; anticipating emergent behaviors arising from interactions
  - Incorporating uncertainty into reasoning and decision-making
  - Modeling and defining levels of autonomy and optimizing the role of the human
  - Multi-scale, multi-physics modeling across discrete and continuous domains
- Impact on manufacturing: Innovative new class of manufactured products with networked and optimized smart operating systems
NIST CPS Actions

- Planned CTO roundtable
- Planned needs assessment workshop: Foundations for Innovation in CPS
- Cooperative Agreement with UMD for CPS research
  - Book assessing state-of-the-art
  - Market analysis to guide R&D investments
  - Framework for an open standards platform
  - Joint research in modeling and testing tools
- Planned executive course to be delivered by world class industry and research leaders
- NIST CPS Working Group
Manufacturing Facilities and Testbeds

- Manufacturing Robotics Testbed and Robot Test Facility
- Intelligent Automation and Sensing Lab
- Manufacturing Control System Networking and Security Lab
- Smart and Wireless Sensors Lab
- Advanced Manufacturing Systems and Networking Testbed
- Manufacturing Systems Integration XML Testbed
- Pulse-Heated Kolsky Bar Facility
Partnering Strategies with Industry

- Standards Engagement
- Planning Workshops
- Performance Metrics and Test Methods
- Unique Facilities and Testbeds
- Modeling and Testing Tools
- CRADAs and Consortia
- Competitions at NIST Test Arenas and other venues
- "Plugfests" at Tradeshows
Partners Representing Manufacturing Industry
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