

Bringing Industrial AI to Smart Manufacturing – Measurement and Evaluation Needs

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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

Measurement Science

- Creating the experimental and theoretical tools – methods, metrics, instruments, and data – that enable innovation

Standards

- Disseminating physical standards and providing technical expertise to documentary standards that enable comparison, ensure interoperability, and support commerce

Technology

- Driving innovation through knowledge dissemination and public-private partnerships that bridge the gap between discovery and the marketplace

NIST AT A GLANCE

Industry's National Laboratory



3,400+
FEDERAL
EMPLOYEES



5
NOBEL PRIZES



2 CAMPUSES
GAITHERSBURG, MD [HQ]
BOULDER, CO



3,500+
ASSOCIATES



10
COLLABORATIVE
INSTITUTES



400+
BUSINESSES USING
NIST FACILITIES



14
NATL OFFICE FOR
MANUFACTURING
INSTITUTES



51
MANUFACTURING
EXTENSION
PARTNERSHIP CENTERS



U.S. BALDRIGE
PERFORMANCE
EXCELLENCE PROGRAM

Strategic Priorities, National Impacts



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Cybersecurity



© Robert Rathe

Advanced Manufacturing

Strategic Priorities, National Impacts



Artificial Intelligence



Internet of Things

Used in the context of creating **critical-solution enabling tools** – metrics, models, and knowledge – for U.S. manufacturers. This includes:

- Development of...
 - Performance metrics
 - Measurement and testing methods
 - Predictive modeling and simulation tools
 - Reference materials (e.g. data sets)
- Conduct inter-comparison studies and calibrations
- Evaluation of technologies, systems, and practices
- Development of the technical basis for standards, codes, guidelines, and/or practices

- Artifacts
- Protocols
- Technical data
- Knowledge modeling

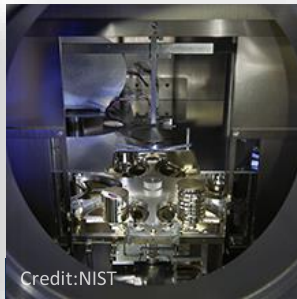


NIST Laboratory Programs

NIST



**Material
Measurement
Laboratory**



**Physical
Measurement
Laboratory**



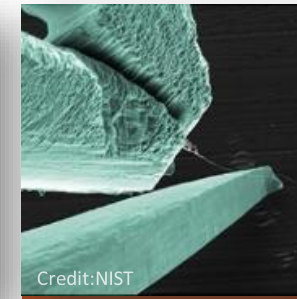
**Engineering
Laboratory**



**Information
Technology
Laboratory**



**Communication
Technology
Laboratory**



**Center for
Nanoscale
Science and
Technology**



**NIST Center
for Neutron
Research**

Engineering Laboratory Goal Areas

NIST



Resilience



**Smart
Manufacturing**



**Cyber
Physical
Systems**



Energy

Smart Manufacturing Enables...

- Make what you want, where you want it, and when you want it.
- Respond in real time to meet changing demands and conditions
- Easily and rapidly reconfigure factory production to optimize performance
- Deal with uncertainty and anomalies to enable continuous improvement
- Maintain seamless interoperability





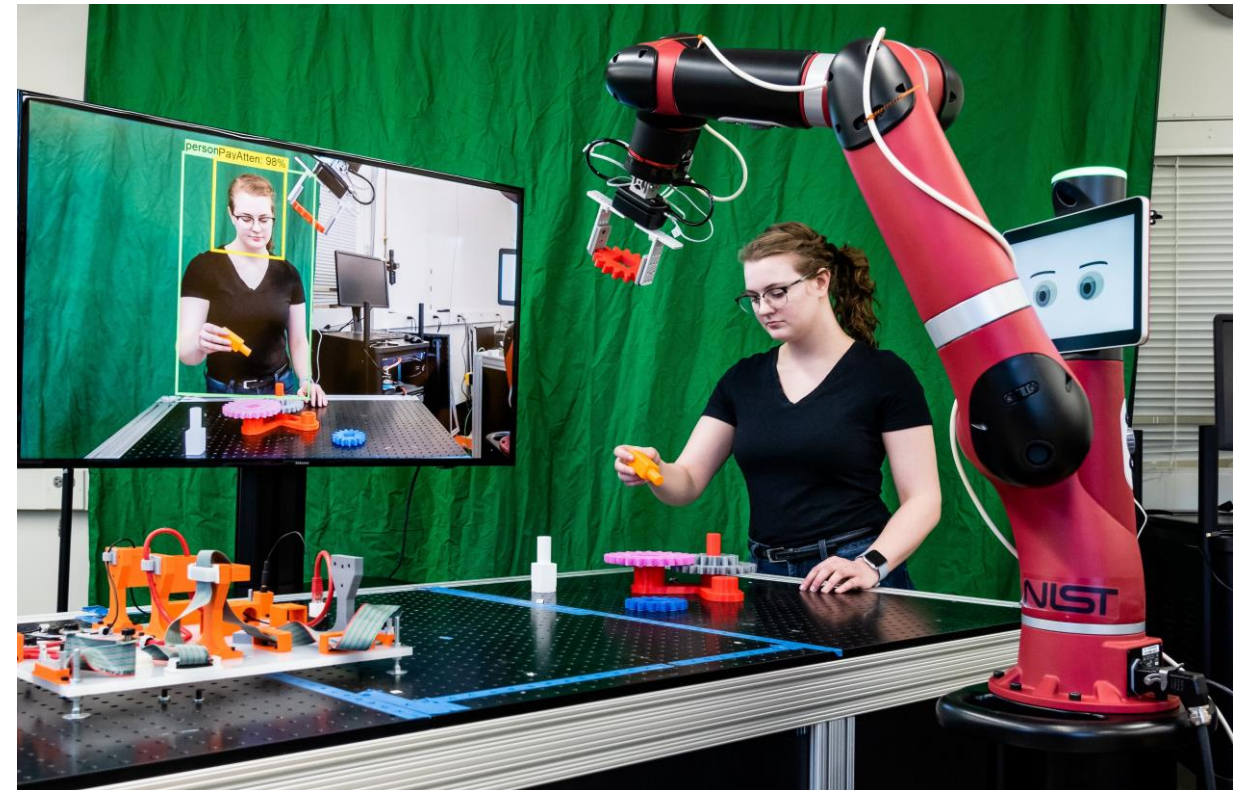
Objective: To enable the next generation of innovative and competitive manufacturing through dynamic production systems and rapid design-to-production transformation

- Measurement Science for Additive Manufacturing
- Measurement Science for Manufacturing Robotics
- Model-based Enterprise
- Trustworthy Systems, Components, and Data for Smart Manufacturing



Embodied AI and Data Generation for Manufacturing Robotics Research

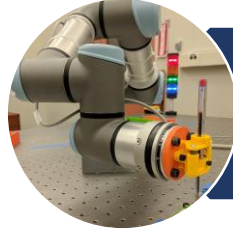
- Provides structured artificial intelligence (AI) and machine learning (ML) training datasets, and proven, trained, and applied AI/ML models, to improve the performance and autonomy of manufacturing robotic applications.
- Allows manufacturers to gain more value from their robots by allowing the robot to “learn” new tasks, and how to better perform existing tasks, without the need for human intervention.
- Initial area of focus are applying AI to:
 - Characterizing training data features
 - Human-robot interaction
 - Object pose recognition
 - Rapid robot task re-planning



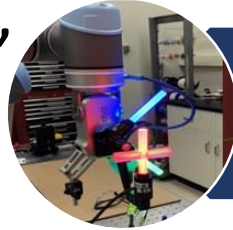
Prognostics and Health Management for Reliable Operations in Smart Manufacturing Research



To develop and deploy measurement science to promote the implementation, verification, and validation of advanced monitoring, diagnostic, and prognostic technologies to increase reliability and decrease downtime in smart manufacturing systems



Identification and Isolation of Robot Workcell Degradation



Assessment of Robot Accuracy Degradation



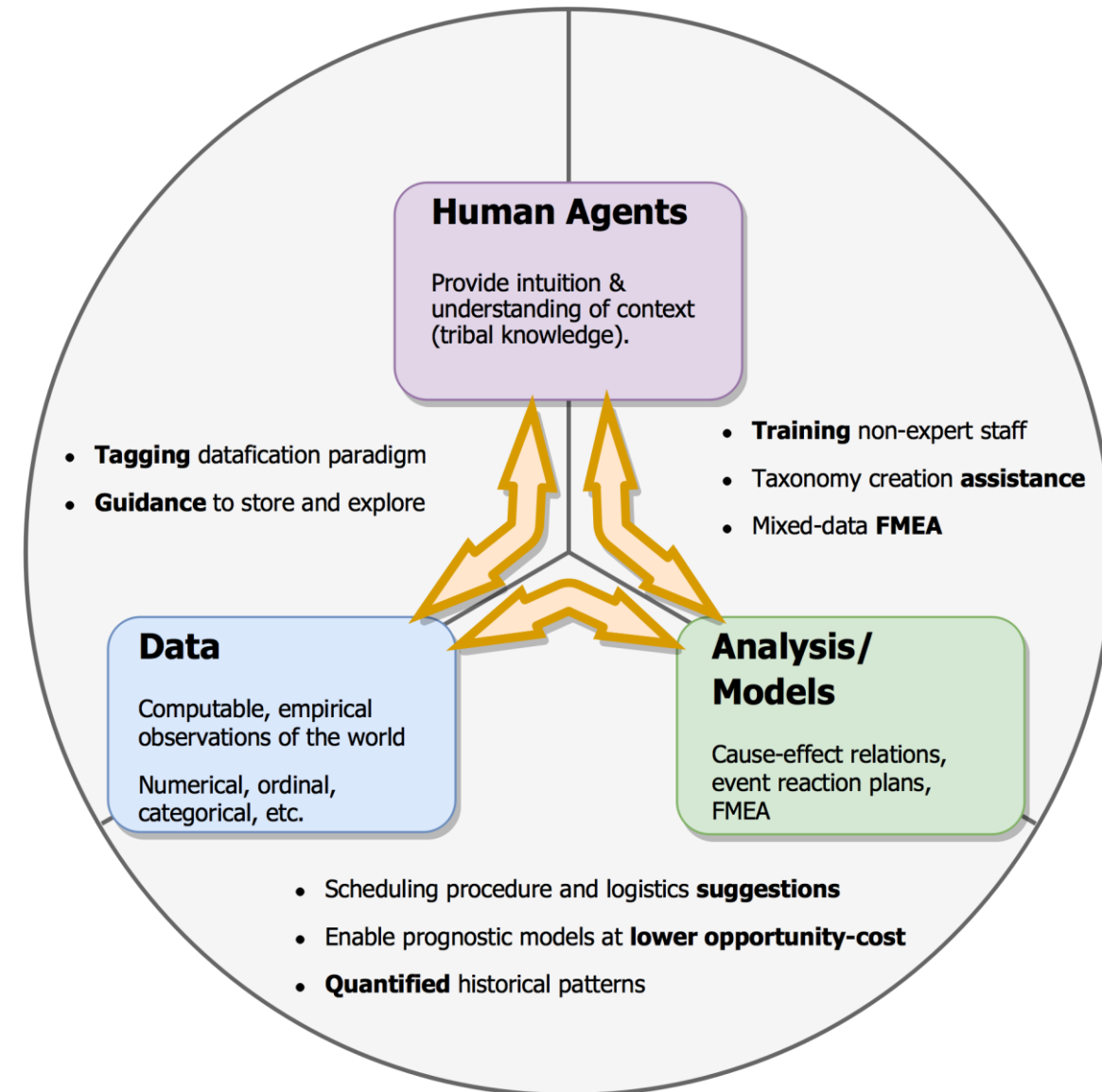
Smart Machine Tools – Linear Axes Diagnostics and Prognostics



Smart Machine Tools – Spindle Health Monitoring

Knowledge Extraction and Application for Manufacturing Operations

- Develop and deploy advances in standards, measurement science, and software tools using actionable, computable, domain knowledge stemming from **informal text-based data** to augment a manufacturers' ability to perform model-based and data-driven analyses.
- Explore hybridized Artificial Intelligence (AI) and expert-driven methodologies for **quantifying human knowledge**.
- Assist in labelling and analyzing text-based documents to **enable decision making and continuous improvement**.



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The screenshot shows a web page from the NIST Engineering Laboratory. The page title is "Enhancing Maintenance Strategies for Manufacturing Operations". The main content area contains several paragraphs of text discussing the challenges of modern manufacturing and the role of maintenance data. A sidebar on the left lists various content types: Data Sets, Events, In the News, Publications, Research Projects, Software & Tools, and Technologies. A search bar and a menu icon are visible in the top right corner. A large graphic on the right side of the page features a clock face with various maintenance-related terms overlaid: "Maintenance", "Condition monitoring", "System", "Manufacturing Components", "Prognostics", and "Diagnostics".

Enhancing Maintenance Strategies for Manufacturing Operations

The National Institute of Standards and Technology (NIST) is engaged in multiple research efforts to advance the design, deployment, and assessment of maintenance-supporting capabilities (e.g., monitoring, diagnostics, and prognostics) to increase reliability of and decrease downtime in manufacturing systems.

Manufacturing processes are becoming more complex, with increased integration of Industrial Internet of Things (IIoT) technologies, greater process reconfigurability to support product customization, and demands for higher precision. Technological evolution has also led to an increased awareness of manufacturing process performance and health through the generation and analysis of more targeted datasets. While greater complexity and reconfigurability have brought additional challenges to effectively maintaining processes and equipment, timely-actionable intelligence from emergent data sources can offer more insight into devising effective maintenance strategies.

Data to support maintenance activities in manufacturing environments can be generated from multiple sources including human-generated datasets and those automatically produced by a process, piece of equipment, or external sensor. Maintenance Work Orders (MWOs) are one example of human-generated data. Maintenance personnel create and augment MWOs throughout the life of a piece of equipment to track health status, capture faults/failures, and document repairs/solutions. Robot-level data (e.g., joint-level and tool-center-position data) is an example of an equipment-generated dataset. This data is typically generated by a robot's controller at a specific frequency where it can be analyzed to identify its performance, existing health state, and predicted future health state.

Collectively, two projects are developing publicly-available products and resources to enhance maintenance strategies within manufacturing operations. The [Prognostics and Health Management for Reliable Operations in Smart Manufacturing \(PHM4SM\)](#) project seeks to develop and deploy guidelines, test methods, and tools to promote the implementation, verification, and validation of maintenance-supporting technologies to increase reliability and decrease downtime in smart manufacturing systems. Complementing this effort, the [Knowledge Extraction and Application for Manufacturing Operations](#) project aims to develop and deploy advances in guidelines, software, and tools using domain knowledge stemming from informal text-based data to enhance manufacturers' ability to analyze data in support of maintenance activities.

Manufacturing USA Network

