Manufacturing USA and DMDII
Program Update and Activities in PHM

NIST Industry Forum on Machine Monitoring, Diagnostics and Prognostics

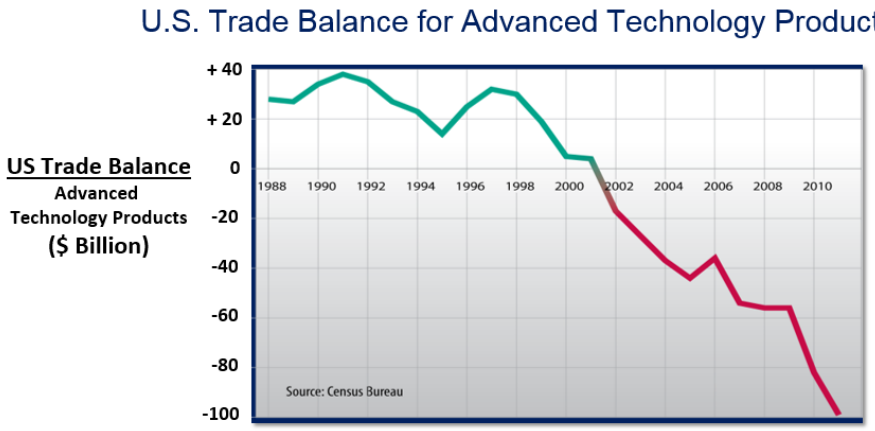
May 8, 2018

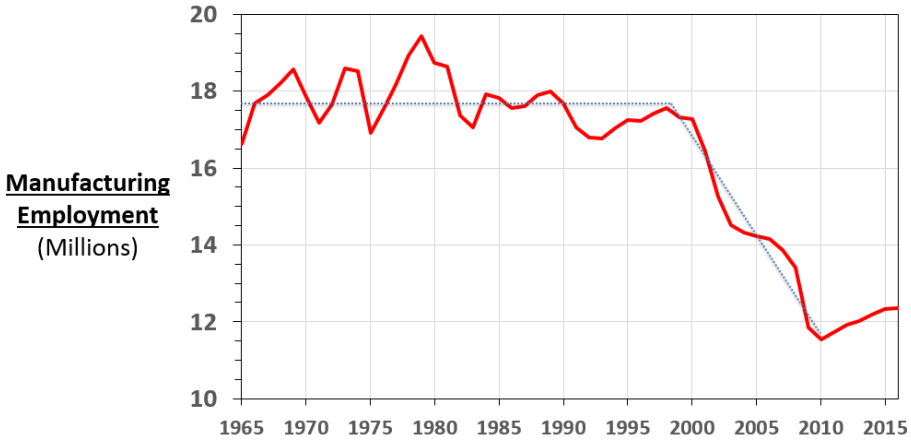
Mike Molnar
Advanced Manufacturing National Program Office
An interagency team building partnerships with U.S. Industry and Academia

Agenda

- Manufacturing USA® Overview
- How an Institute Works: DMDII
- Delivering Value: 2017 Results Highlights
- Example PHM Projects

Why Manufacturing USA





President's Council of Advisors on Science and Technology

- Advanced Manufacturing Partnership: 2011-2012
- Advanced Manufacturing Partnership 2.0: 2013-2014

Revitalize American Manufacturing and Innovation Act

- 118 bipartisan co-sponsors!
- signed into law December 16, 2014

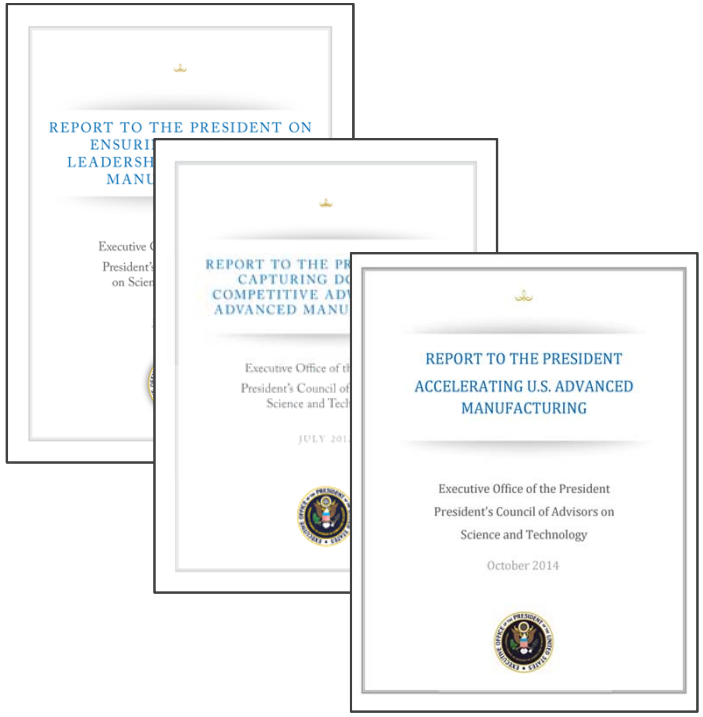
MFG USA®

Enhancing American Competitiveness by

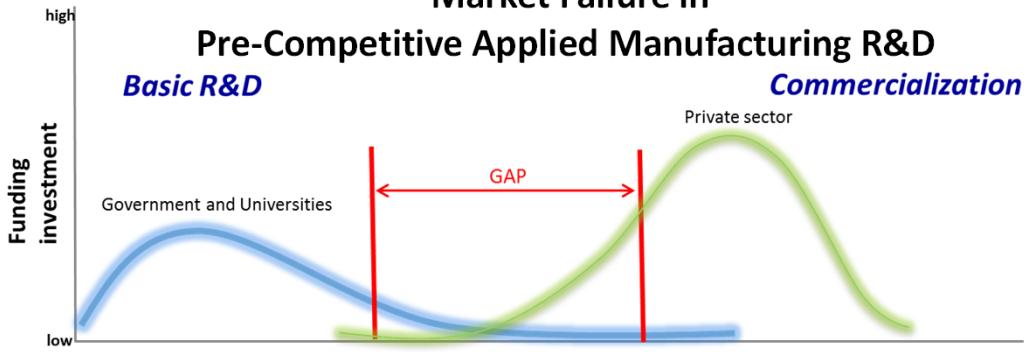
- Manufacturing technology
- Education & Workforce Development

Manufacturing USA: A Public-Private Partnership

President's Council of Advisors on Science and Technology



Market Failure in Pre-Competitive Applied Manufacturing R&D



Manufacturing Innovation Process

Basic manufacturing research → Proof of concept → Production in laboratory → Capacity to produce prototype → Capability in production environment → Demonstration of production rates

VISION

U.S. global leadership in advanced manufacturing

MISSION

Connecting people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth and strengthening our national security.

PROGRAM GOALS

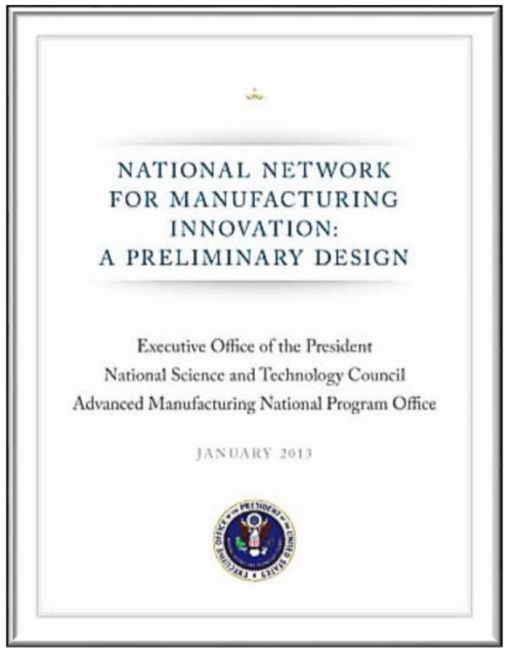
Competitiveness

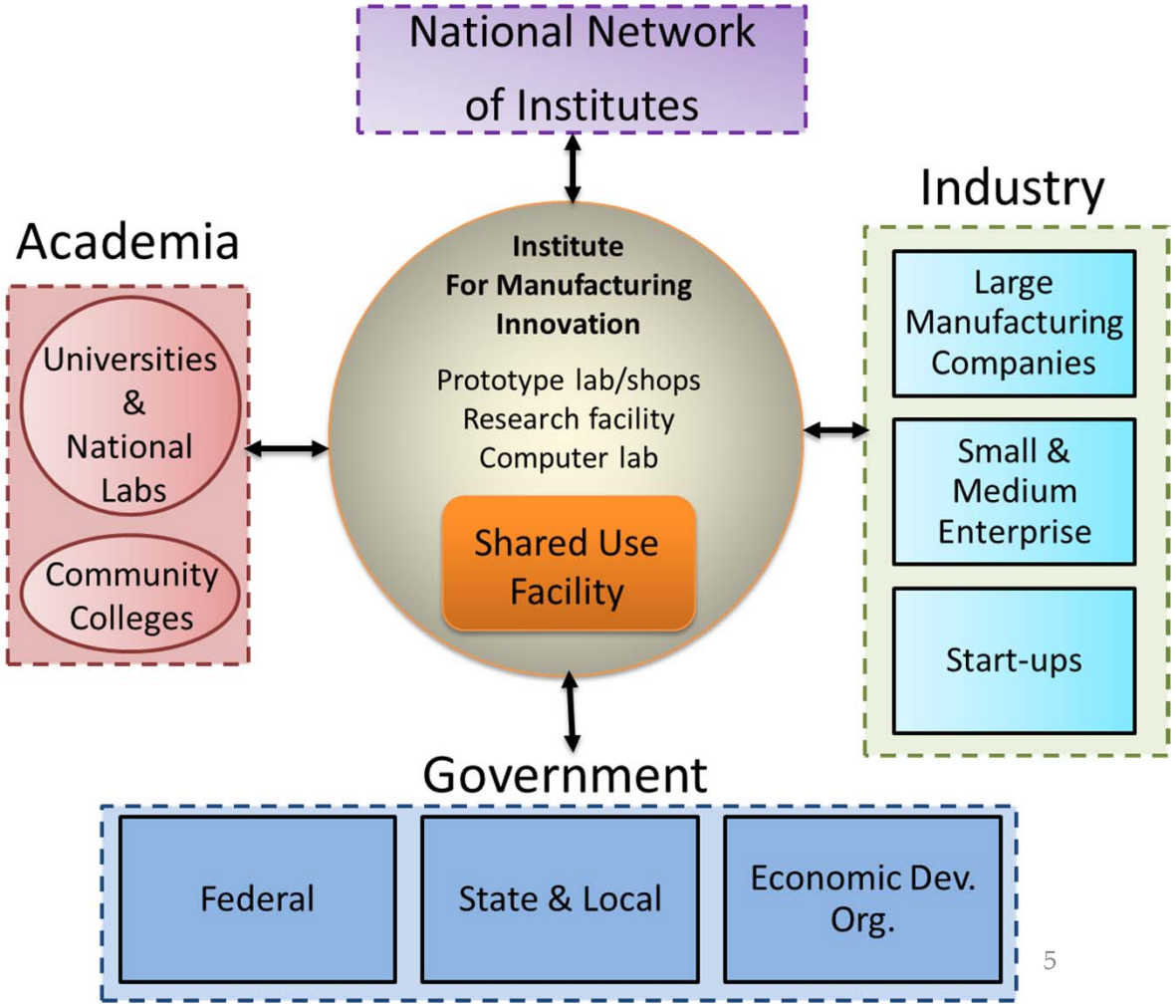
Technology Advancement	Workforce Development	Technology Sustainability

The Institute Design

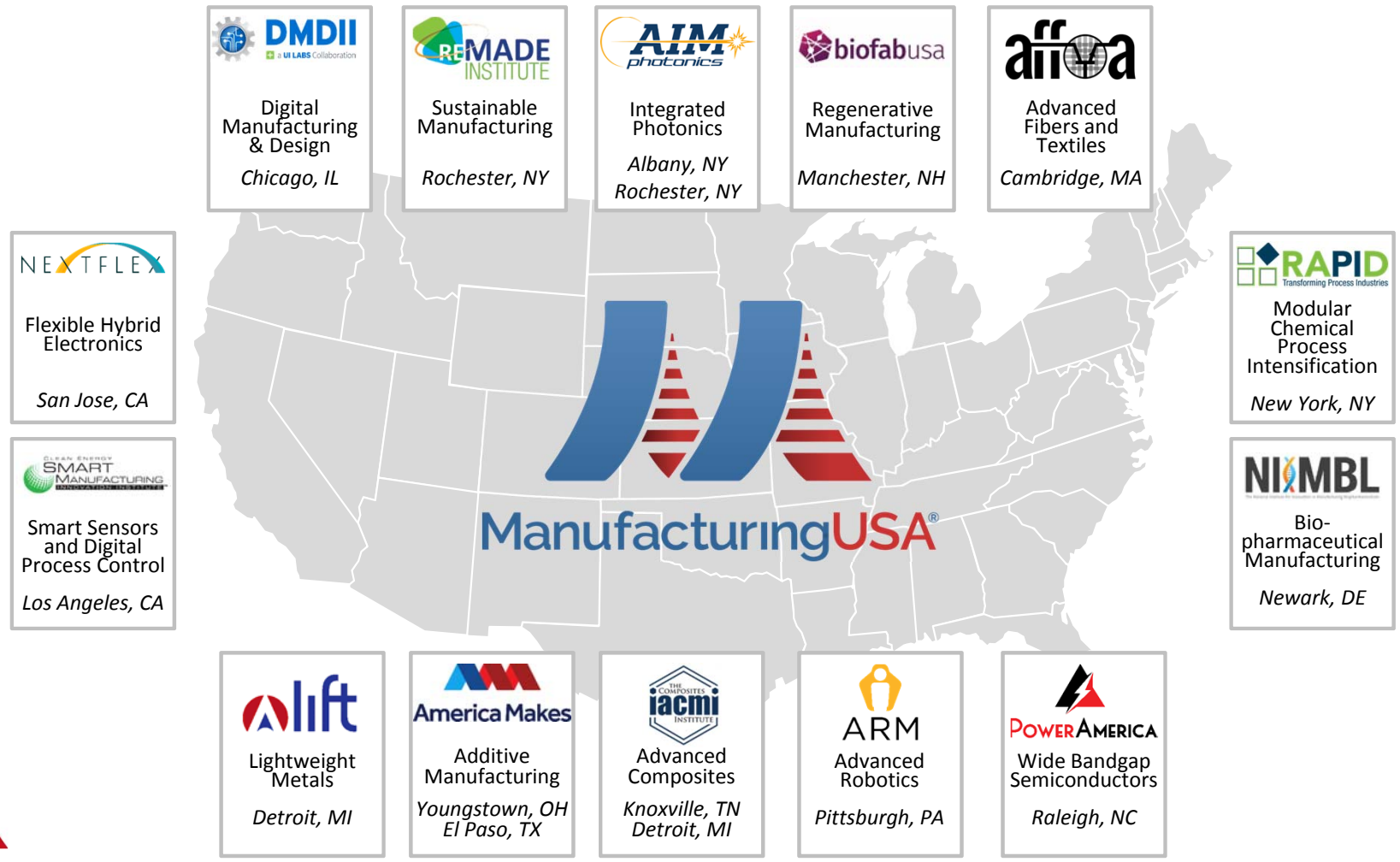
Creating the space for Industry & Academia to collaborate

Institute Framework Design published January 2013





Manufacturing USA Today



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Institute Example: Digital Manufacturing and Design Integration

UI LABS/DMDII Facility, Chicago IL
GRAND OPENING MAY 11, 2015

Agency sponsor: DOD
Startup funding: $70M public, $110M co-investment

94,000 square feet - digital manufacturing lab, instructional and collaboration space

1) Each Institute has a clear mission based on a critical Industry need

DMDII exists to transform American manufacturing competitiveness by accelerating the development and adoption of digital technology across the manufacturing enterprise

2) Each Institute creates value for industry participation and funding

A Workshops

Topic-focused sessions where partners engage in solution oriented discussions to drive projects and investments

B Factory Floor

Creating an experiential manufacturing environment to demo, test & prove a wide variety of DM&D technologies

C PROJECTS

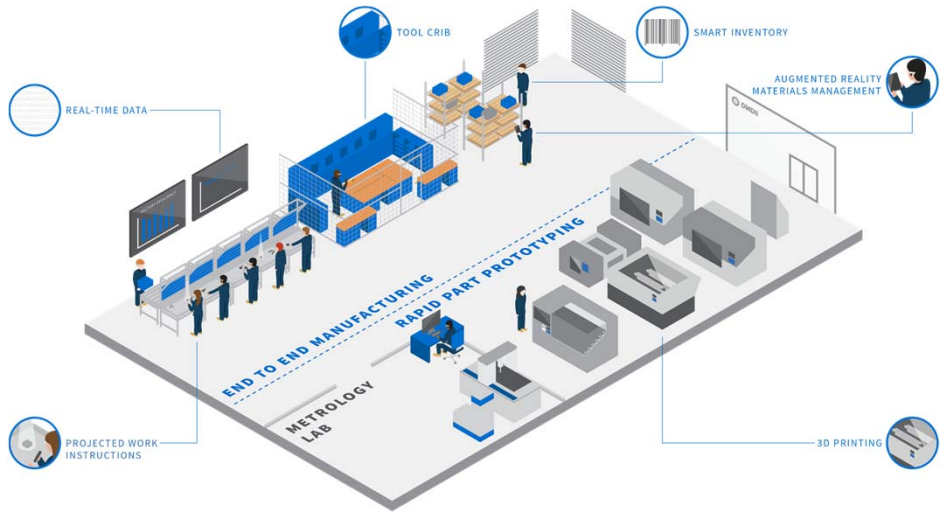
Applying the DMDII workshop and technical outcomes into real world applications

DMDII
a UI LABS Collaboration

3) Each Institute creates an effective collaboration space for pre-competitive applied R&D

Future Factory Platform

A neutral space for experimentation, testing, development and validation of next generation Digital Manufacturing solutions



Digital Capability Center

A dedicated training environment to teach core Digital Manufacturing concepts

DMDII
a UI LABS Collaboration

4) Each Institute is operated by an industry-led consortium

Aerospace & defense	Lockheed Martin, GE, Boeing, Rolls-Royce, Northrop Grumman
Industrial equipment	John Deere, Caterpillar, ITW
CPG	Stanley Black & Decker, Duracell
Chemicals & agriculture	Dow
Automotive	faurecia
Pharma & medical products	Johnson & Johnson
High tech & telecom	Siemens, Microsoft, Autodesk
Services	McKinsey & Company

Small to Mid-sized Manufacturers

Feralloy, Green Dynamics, Atlas Tool Works, Inc., WPC Wrightwood

High growth Startups + Technology Providers

ARIS, UpSkill, SCOPE AR, SupplyDynamics

Universities + Community Colleges

Northwestern University, Georgia Tech Research Institute, University of Illinois at Urbana-Champaign, University of Michigan

Department of Defense, Department of Energy, Department of Commerce, NSF, NASA, Department of Veterans Affairs, Department of Homeland Security, Office of Naval Research, United States Coast Guard, US Army Corps of Engineers, DARPA

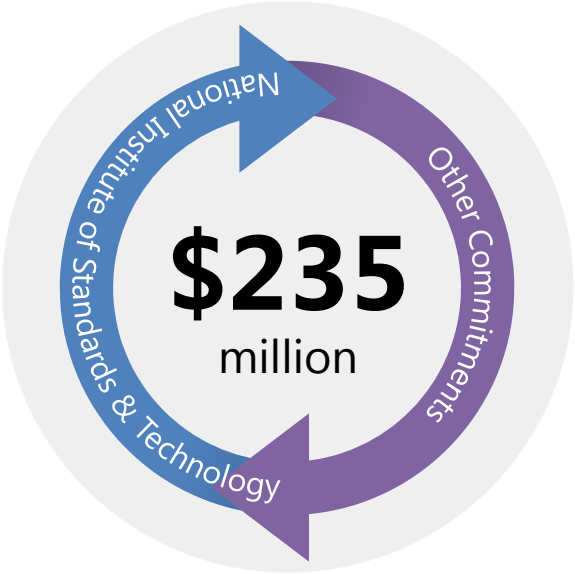
DMDII — a UI LABS Collaboration

5) Federal start-up funding for each Institute must catalyze at least 100% co-investment

Funding

$70,000,000
Digital Manufacturing Innovation Institute

DMDII
a UI LABS Collaboration



$165,000,000
Other Commitments

DMDII is funded by a five year $70,000,000 cooperative agreement from the federal government and leverages >$180,000,000 in other commitments.

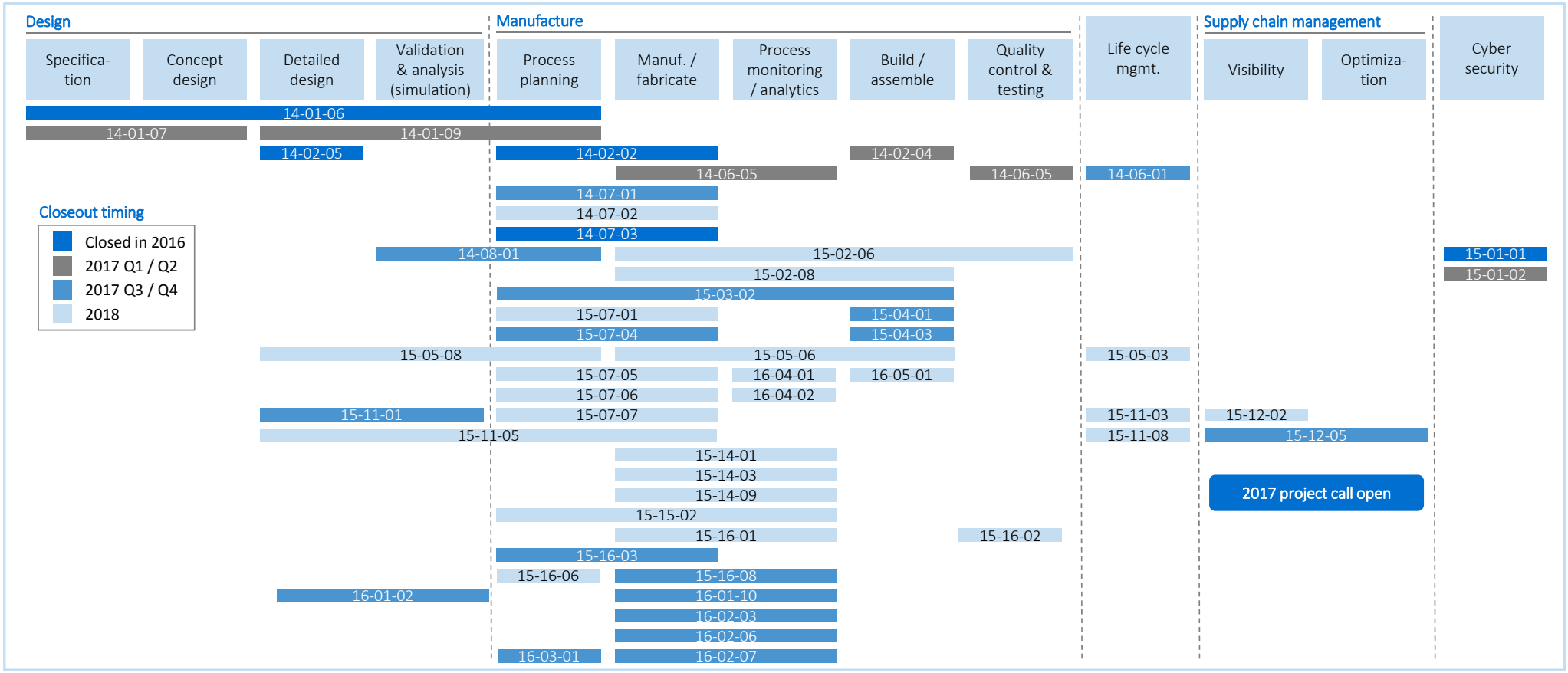
DMDII
a UI LABS Collaboration

6) Each Institute works on the industry priorities and big challenges only solvable by collaboration

	THEME	OBJECTIVES*
Design	**Move Manufacturing to the Left** Inform conceptualization and design phases with relevant, data-driven insights from across the entire product lifecycle. Ultimately part and product-related data of all kinds should move bidirectionally across the digital thread from concept to end-of-life.	• Pilot: "Day in the life of CAD" • Workshop/project: Real-time CAD feedback • Transitions: facilitate select project commercialization
Future Factory	**Integrate, Reduce-to-Practice to Drive ROI** Connect the dots of digital manufacturing, discover the remaining impediments to adoption and work through them. Integrate portfolio project outcomes plus emerging commercial technologies in DMDII's Future Factory sandbox as well as in a digital twin pilot involving a member manufacturer's operational environment.	• Pilot: Factory digital twin in member operations • Workshop: Sensor ROI & Marketplace • Integrations: 17+ projects & 3rd party solutions
Supply Chain	**Deliver Promise of Digital Thread & Digital Twin** Connect previous MBD/MBE/Digital Twin work with new project calls, workshops and pilots to build on the aggregate learnings. The proposed initiatives strive to reduce the technology to practice with pragmatic solutions that are inspired by real-world constraints represented through pilots and member feedback.	• Pilot: Supply chain design and digital twin • Workshop/playbook: Pragmatic model-based-definition • Workshop/pilot: Blockchain for supply chain use cases
Cyber Security	**Protect America's Growing Digital Manufacturing Advantage** Digital Manufacturing tech increases the sector's attack surface and simultaneously makes it an even more attractive target as the U.S. builds competitive economic advantage. A key focus is cyber-hardening small-to-medium-sized manufacturers (SMMs), which represent 90%+ of U.S. manufactured GDP.	• Cyber Security Hub: Work with DoD to establish** • SW Tool: SMM cyber assessment & mitigation • Training program: SMM cyber security basics**

DMDII a UI LABS Collaboration

7) Each Institute manages a balanced portfolio of real projects for industry

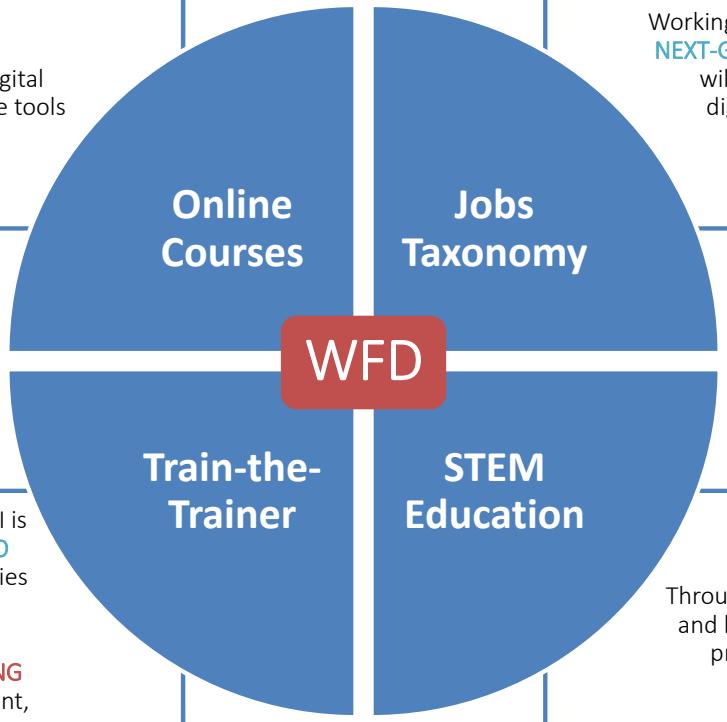


DMDII
a UI LABS Collaboration

8) Each Institute addresses the skills gap on education and workforce skills for their technology space

In collaboration with SUNY at Buffalo, DMDII has developed a MASSIVE OPEN ONLINE COURSE on digital manufacturing & design, demonstrating how these tools can be used throughout the product lifecycle.

Working with Manpower Group, DMDII has identified 165 NEXT-GEN JOB PROFILES/ROLES IN MANUFACTURING that will be created or transformed by the introduction of digital technology in the industry. This body of work defines the skills required to execute defined job classifications.



Through the MEP Institute Embed Program, DMDII is developing ASSESSMENT TOOLS AND USE CASES TO SUPPORT SMMs in the adoption of new technologies and processes.

DMDII is also building the DIGITAL MANUFACTURING COMMONS to extend the reach and scale of content, applications, and services to SMMs across the U.S.

Through our DIGITAL DAYS program, DMDII hosts middle and high schools for an afternoon of educational STEM programming and manufacturing career awareness.

The future of WFD at DMDII likely consists of a mix of experiential, in-person training and scalable online services

DMDII a UI LABS Collaboration

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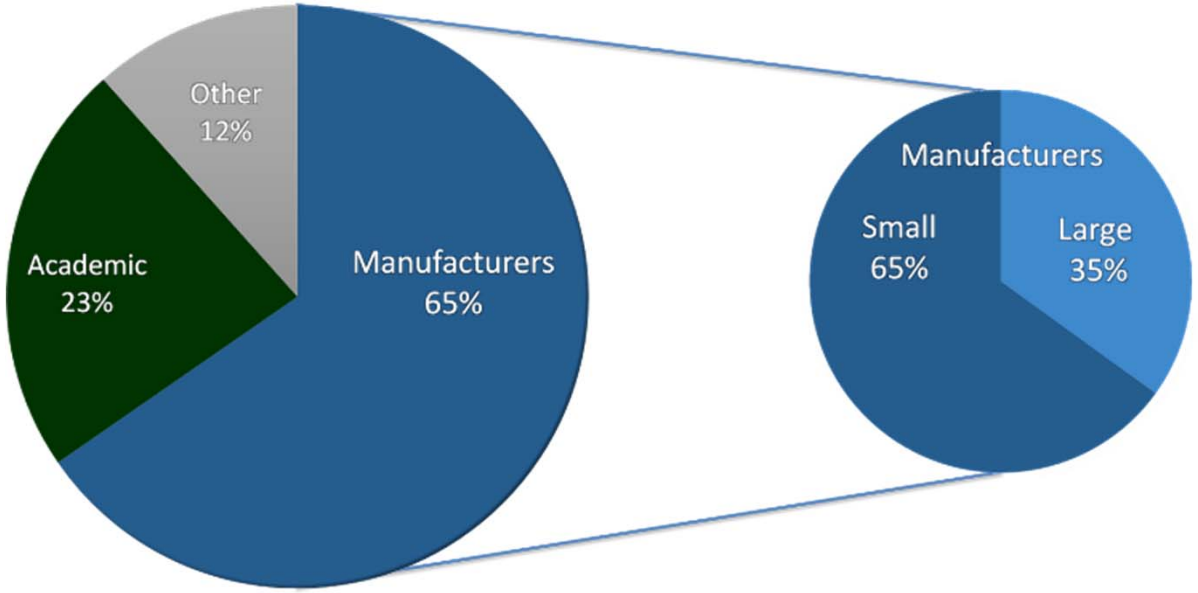
Impact to U.S. Innovation Ecosystem - Membership



1,291 members (FY 2017)

+50% increase in membership over 2016

65% from industry

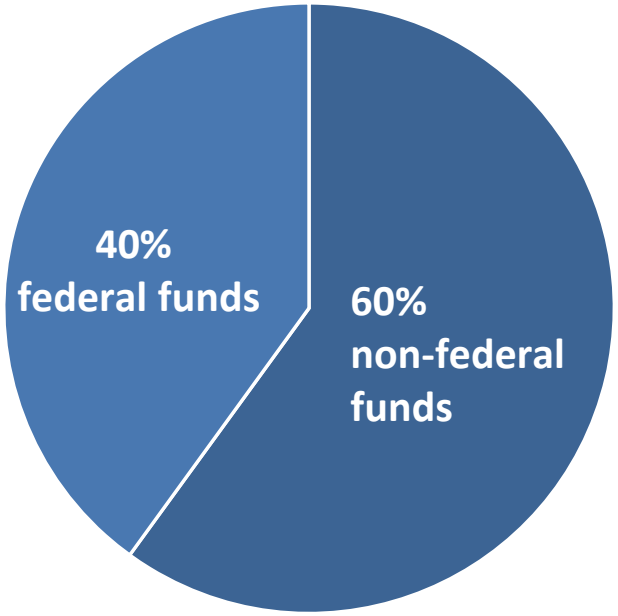
- 65% are small and medium-sized manufacturers

297 universities, community colleges, and other academic institutions

150 federal, state, and local government agencies, federal laboratories, and not-for-profits

Membership breakdown of 12 institutes in FY 2017

Leveraging Co-Investments



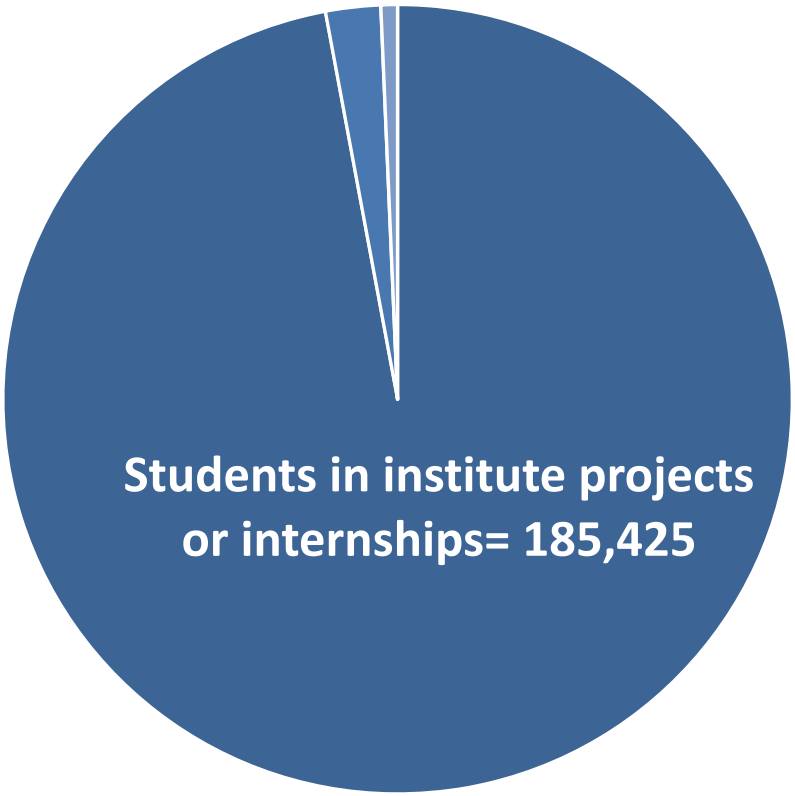
More than **1.5 to 1 investment** match (FY 2017)

$298,500,00 in total institute expenditures

- 60% of institute support came from non-federal matching funds
- 40% came from federal program funds

Expenditures funded all aspects of institute operation (e.g. technology advancement projects, education and workforce training efforts, and capital equipment)

Developing an Advanced Manufacturing Workforce



Nearly **200,000 people** participated in institute-led advanced manufacturing workforce development training programs

8X increase from 2016

- **185,425 students** in institute research and development projects, internships, or training
- **4,302 workers** completed institute-led certificate, apprenticeship, or training programs
- **1,299 teachers** and trainers in institute-led training for instructors

Technology Advancement

While many technology R&D projects can take several years to conclude, the high level of participation by industry and the progress in meeting technical objectives are early indicators of success.

273 Major Collaborative R&D Projects
FY 2017

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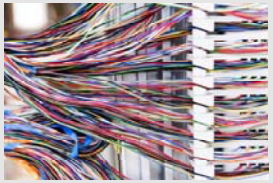
DMDII Project Portfolio includes PHM

Monitoring

Increasing accessibility to manufacturing data



16-02-03: Reconfigurable Retrofit Kit for Legacy Machines – Non-invasive sensors application to enable data capture on older machines

Diagnostics

Enabling advanced analytics on manufacturing data

15-14-01: Cloud-Enabled Machines with Data-Driven Intelligence – Framework for cloud-based online machine and process monitoring, diagnosis, and prognosis

Prognostics

Making decisions based on data to increase

16-04-01: Achieving Smart Factory through Predictive Dynamic Scheduling – Improve operations by combining MES metrics like OEE with predictive maintenance analytics

The DMDII research portfolio is developing tools to help manufacturers realize Prognostics and Health Management Tools (PHM) in their operations

16-02-03: Retrofit Kit for Legacy Machine Sensing in Secure Data Environments

Development of a reconfigurable retrofit kit for legacy equipment that provides significant flexibility and state-of-the-art network security

INDUSTRY CHALLENGE

Production optimization efforts for manufacturing organizations with primarily legacy equipment platforms are severely hindered by limited capabilities for low cost, user-configurable machine connectivity and in situ machine sensing. This project will address this technological gap by developing an open-platform, reconfigurable retrofit kit that provides for scalability of cost of ownership and enables user-driven selection of sensing capabilities.

PROJECT SOLUTION AND OUTCOMES

The project will assemble a network-secured, scalable retrofit kit that provides for integration of highly flexible machine sensing for a range of production environments encompassing both legacy and modern machine equipment. A unique aspect is that it will be built upon an industrially hardened Layer-3 compatible communications platform for isolating machine tools from network intrusion and will facilitate highly reconfigurable sensing using both wired and wireless communications protocols. This will enable manufacturers to seamlessly design and implement data sensing schemes to accommodate continuously evolving data measurement needs.

Georgia Tech, Mazak, ITAMCO, Caterpillar

POTENTIAL IMPACT

- The retrofit kit will provide the needed transitional technology for realizing ubiquitous and network secured sensing for legacy equipment.
- Data accessibility will further enable US manufacturers to leverage advanced analytics to strengthen competitiveness compared to more nascent, predominantly modern production capabilities worldwide
- Open-source, low-cost sensing for industrial platforms can be significant for user-driven process improvement efforts

15-14-01: Cloud-Enabled Machines with Data-Driven Intelligence

Framework for cloud-based online machine and process monitoring, diagnosis, and prognosis

INDUSTRY CHALLENGE

One of the primary problems faced by both small and medium sized manufacturers and large original equipment manufacturers is how to develop new machines with intelligence as well as retrofit legacy machines with intelligence so that in-process, remote monitoring, diagnosis, prognosis, and self-correction can be automatically performed.

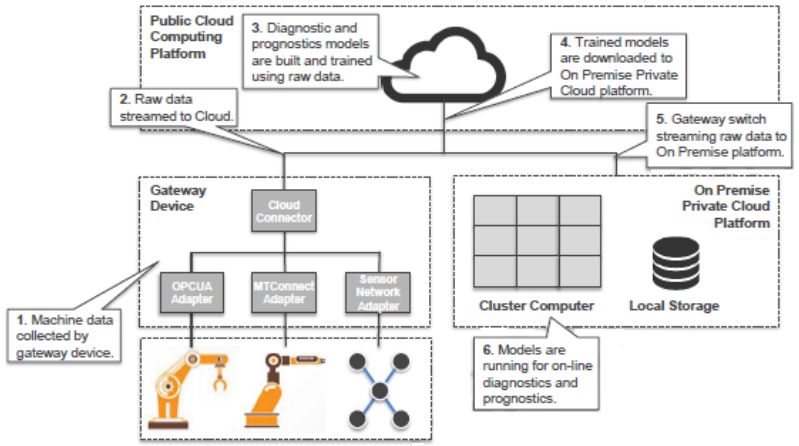
PROJECT SOLUTION AND OUTCOMES

- an interoperable data acquisition system that consists of a wireless sensing system, Predix™ Machine software, Predix™ powered gateway device, and a scalable on-premise private cloud platform
- a container-based high performance cloud computing platform that is integrated with the on-premise private cloud for processing real-time data streams, executing parallel machine learning algorithms, generating big data analytics, and visualizing data
- a set of experimentally tested algorithms that enables data-driven intelligence for online spindle diagnosis and prognosis in both legacy machines and general purpose CNC machines, executable on a hybrid cloud computing platform

Penn State University, GE Global Research, Microsoft, Case Western Reserve University

POTENTIAL IMPACT

- Ubiquitous and instant remote access to near real-time data without spatial constraints
- Secure and high volume data storage along with scalable, high performance computing.
- Big data analytics enabled by parallel and distributed computing, data mining and machine learning algorithms can be developed that enable manufacturers to process and manage massive data streams on a cloud-based computing platform.



16-04-01: Achieving Smart Factory through Predictive Dynamic Scheduling

Improve manufacturing operations by combining traditional MES technology metrics like OEE with in-depth predictive maintenance analytics

INDUSTRY CHALLENGE

- Current MES/OEE monitoring systems do not provide drill-down capabilities that enable end-users to investigate the condition/health of the machine so that appropriate measures can be performed to non-performing units
- Dynamic scheduling systems allow manual inputs or time-based inputs (preventive maintenance schedules) but they do not consider the actual condition/health of the machine.
- Actions based solely on machine health metrics are difficult to justify unless they are tied to factory performance metrics such as OEE and the predictive nature of these solutions are not harnessed to its full potential unless they affect actual maintenance schedules.

POTENTIAL IMPACT

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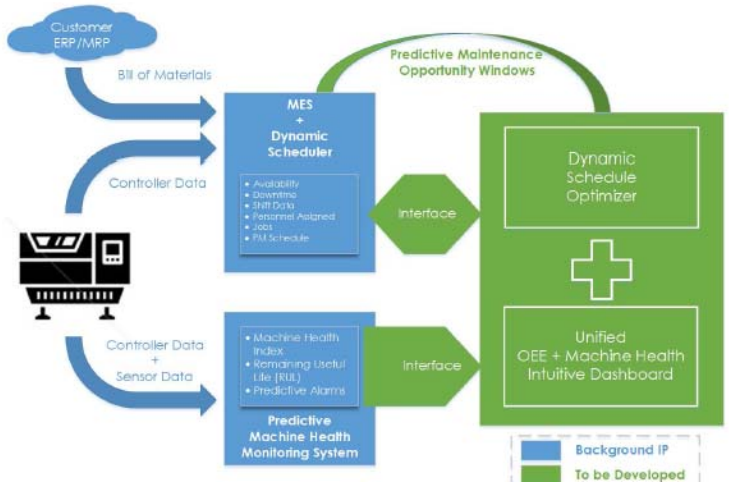
- Secure and high volume data storage along with scalable, high performance computing.
- Big data analytics enabled by parallel and distributed computing, data mining and machine learning algorithms can be developed that enable manufacturers to process and manage massive data streams on a cloud-based computing platform.

PROJECT SOLUTION AND OUTCOMES

- The customization of predictive health monitoring system and prognostics algorithms for accurate machine health estimation and prediction
- A systematic methodology for synthesizing system-level factory information and machine-level predictive health information into a Markov Decision Process model for predictive maintenance opportunity window estimation
- A new paradigm for maintenance scheduling that utilizes real-time health condition of machines, predictive analytics of future performance and remaining useful life, and system production information (e.g., buffer contents, short-term production requirement).



Forcam Inc., Predictronics Corp., Lockheed Martin, Northeastern University

Together We Are Securing America's Future

Making an Impact

- **14 institutes** developing new manufacturing techniques
- **~300 ongoing major collaborative R&D projects**
- **200,000 people trained** in advanced manufacturing
- $1B federal investment matched by over **$2B non-federal funds**

Thank you

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America Makes

affoa

AIM photonics

ARM ADVANCED ROBOTICS FOR MANUFACTURING

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CLEAN ENERGY SMART MANUFACTURING INNOVATION INSTITUTE

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The Institute for iacmi Advanced Composites Manufacturing Innovation

THE COMPOSITES INSTITUTE

lift

NEXTFLEX

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RAPID Transforming Process Industries

REMADE INSTITUTE

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