Manufacturing a Digital Renaissance
October 18, 2017

Mike Molnar
Advanced Manufacturing National Program Office

An interagency team building partnerships with U.S. Industry and Academia
Agenda

- U.S. Manufacturing Today
- The Manufacturing USA Program
- A Digital Manufacturing Future
U.S. Manufacturing Today

Jobs, Productivity
and State Data
Manufacturing Growth
Purchasing Managers Index (PMI) - *above 50 is expansion*

Source: [http://www.tradingeconomics.com/united-states/business-confidence](http://www.tradingeconomics.com/united-states/business-confidence)
Why should we care about US Manufacturing?

Manufacturing Economic Impact
Manufacturing drives jobs throughout economy - including services

- 10% of employment, average wages 24% higher
- 12% of gross domestic product

Source: U.S. Department of Commerce, Bureau of Economic Analysis
Why should we care about US Manufacturing?

U.S. manufacturers

• Employ over half of all R&D personnel in domestic industry

Manufacturing Innovation Impact

- 47% of exports
- 64% of scientists & engineers
- 66% of private R&D spend
- 70% of US patents to US entities

1/3rd of U.S Economic Growth is due to Innovation
% of Gross State Product versus % Employment

The Great Lakes region, along with North Carolina, California, and Texas, dominate the total value of gross state product (GSP) generated in the United States.

### States with Most Manufacturing GSP

1. California $277,634,000,000
2. Texas $237,082,000,000
3. Ohio $109,476,000,000
4. Indiana $100,908,000,000
5. Illinois $99,514,000,000

When total share of employment is considered, the heartland and the south stand out. The next chart shows the correlation between share of employment and share of GSP.

**States with Highest % of Employees in Manufacturing**

1. Indiana 14.03%
2. Wisconsin 13.33%
3. Michigan 11.09%
4. Iowa 10.81%
5. Ohio 10.39%

## US and Indiana Manufacturing Snapshot

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>Indiana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Manufacturing Output</td>
<td>$2,091 billion</td>
<td>$100 billion</td>
</tr>
<tr>
<td>Total Manufacturing Firms</td>
<td>251,857</td>
<td>7,163</td>
</tr>
<tr>
<td>Total Manufactured Goods Exported</td>
<td>$1,316.79 billion</td>
<td>$33.8 billion</td>
</tr>
<tr>
<td>Export Growth 2010-2015</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Small Business (&lt;500 employees) Share of Exports</td>
<td>97%</td>
<td>85%</td>
</tr>
</tbody>
</table>

Total 5 Export Markets:
- Canada
- China
- Mexico
- Japan
- U.K.

**Indiana:** 516,000 manufacturing employees, average compensation $73,765

**HOW INDIANA CONTRIBUTES | *2014-2016 Data | Source: National Association of Manufacturers**
The Manufacturing USA Program

Addressing the Innovation Challenge
US Manufacturing – Productivity plateau

Products Invented Here, Now Made Elsewhere
- Not Driven By Labor Cost
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

Enhancing American Competitiveness by
• Manufacturing technology
• Education & Workforce Development

National Network for Manufacturing Innovation

U.S. Trade Balance for Advanced Technology Products

Source: Census Bureau
Focus: address market failure of insufficient industry R&D in the “missing middle” or “industrial commons” to de-risk promising new technologies

Approach: bring private sector investment back to the gap
Manufacturing USA Strategic Goals

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

<table>
<thead>
<tr>
<th>Competitiveness</th>
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<tbody>
<tr>
<td>Technology Advancement</td>
</tr>
<tr>
<td>Workforce Development</td>
</tr>
<tr>
<td>Sustainability</td>
</tr>
</tbody>
</table>
Manufacturing USA – 2017
Regional Hubs with National Impact

- **Digital Manufacturing & Design**
  - *Chicago, IL*
- **Sustainable Manufacturing**
  - *Rochester, NY*
- **Integrated Photonics**
  - *Albany, NY*
- **Regenerative Manufacturing**
  - *Manchester, NH*
- **Advanced Fibers and Textiles**
  - *Cambridge MA*
- **Flexible Hybrid Electronics**
  - *San Jose, CA*
- **Smart Sensors and Digital Process Control**
  - *Los Angeles, CA*
- **Advanced Robotics**
  - *Pittsburgh, PA*
- **Advanced Composites**
  - *Knoxville, TN*
- **Additive Manufacturing**
  - *Youngstown, OH*
- **Lightweight Metals**
  - *Detroit, MI*
- **Digital Manufacturing & Design (New in FY 2017)**
  - *Chicago, IL*
- **Sustainable Manufacturing (New in FY 2017)**
  - *Rochester, NY*
- **Integrated Photonics (New in FY 2017)**
  - *Albany, NY*
- **Regenerative Manufacturing (New in FY 2017)**
  - *Manchester, NH*
- **Advanced Fibers and Textiles (New in FY 2017)**
  - *Cambridge MA*
- **Flexible Hybrid Electronics (New in FY 2017)**
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The Institute Design
Creating the space for Industry & Academia to collaborate
Example Institute: Digital Manufacturing

UI LABS/DMDII Facility, Chicago IL
OPENED MAY 11, 2015

Agency sponsor: DOD
Startup funding: $70M federal plus $110M co-investment

94,000 square feet - digital manufacturing lab, instructional and collaboration space
The Digital Manufacturing and Design Innovation Institute (DMDII) was launched in February 2014 in collaboration with the U.S. Department of Defense and is focused on digitizing American manufacturing by helping U.S. manufacturers harness data to make their products better, faster, and more cost-competitively.

DMDII has the following technology focus areas:

<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design, Product Development, Systems Engineering</strong></td>
<td>Creating improved design tools and processes, integrating data across the manufacturing lifecycle, and developing automated manufacturing planning</td>
</tr>
<tr>
<td><strong>Future Factory</strong></td>
<td>Enabling digital integration and control in the manufacturing environment, and implementing tools to increase flexibility throughout the production cycle</td>
</tr>
<tr>
<td><strong>Agile, Resilient Supply Chain</strong></td>
<td>Facilitating access to digital information, supply chain visibility, and design collaborations</td>
</tr>
<tr>
<td><strong>Cybersecurity in Manufacturing</strong></td>
<td>Designing and deploying assessment tools, and establishing a collaborative network for sharing best practices</td>
</tr>
</tbody>
</table>
2) Clear Industry Value Proposition

DMDII believes the key to revitalizing U.S. manufacturing is demonstrating end-to-end impact

DMDII facilitates digitalization and integration across the product lifecycle

Analysis DMDII conducted with McKinsey in 2016 shows massive value creation opportunities through digital manufacturing

“Advanced digital technologies are creating new opportunities for innovation and growth, and producing novel ways to improve and customize the customer experience. This digitally driven evolution is enabled by the rise of Industry 4.0.

That digital information is then analyzed and used to drive further intelligent action in the physical world, completing a physical-to-digital-to-physical loop of action and informed reaction.”

Source: Deloitte article, Industry 4.0 engaged customers

Source: McKinsey & Company
3) Strong Private – Public Partnership

To achieve that impact DMDII is assembling a diverse ecosystem of thought leaders

- Aerospace & defense
  - Lockheed Martin
  - Boeing
  - Northrop Grumman

- Industrial equipment
  - 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
  - WPC

- High growth Startups + Technology Providers
  - ARIS
  - UpSkill
  - Supply Dynamics

- Universities + Community Colleges
  - DARPA
  - National Institute of Standards and Technology
  - United States Army Corps of Engineers
  - US Navy
  - US Air Force
  - US Space Force

- Professional Societies
  - American Society of Mechanical Engineers
  - American Society of Civil Engineers
  - American Society for Quality
  - Society of Manufacturing Engineers

- Other Organizations
  - Manufacturing USA
  - Advanced Manufacturing
  - Digital Manufacturing
  - Additive Manufacturing

- Non-Profit Organizations
  - Industry Partnerships
  - Education Partnerships
  - Research Partnerships

- States and Universities
  - Illinois Institute of Technology
  - Georgia Tech Research Institute
  - Northwestern University

- Federal Government
  - US Department of Energy
  - US Department of Defense
  - US Department of Health and Human Services

- Industry Partners
  - Boeing
  - Caterpillar
  - Dow
  - Faurecia
  - Johnson & Johnson
  - Siemens
  - Microsoft
  - Autodesk

- Thought Leaders
  - Thought Leaders in Manufacturing
  - Thought Leaders in Industry
  - Thought Leaders in Innovation

- Communities
  - Manufacturing Communities
  - Innovation Communities
  - Technology Communities

- Networks
  - Manufacturing Innovation Network
  - Technology Innovation Network
  - Community Innovation Network
4) Addressing Critical National Challenges

DMDII has a number of established programs and assets to support the diverse needs of our partners

There is a need for industry, government, and academia to work collaboratively to help solve US manufacturing limitations through engaging in a number of DMDII frameworks that develop greater understanding of the current landscape, opportunities, and challenges within DMDII thrust areas and generate high value outcomes.

**DMDII Programs**

1. **Workshops**
   - DMDII creates high value experiences for our partners to collaborate to develop solutions to common challenges. We have established a methodologies that enables opportunities to be developed and create actionable next steps.

2. **R&D Project Portfolio**
   - DMDII leverages government funding to accelerate the adoption of digital manufacturing technologies through a variety of R&D projects focused on design, supply chain, cybersecurity, and future factory topic areas.

3. **Partner Innovation Projects**
   - DMDII uses its ecosystem and membership model to drive collaborations outside of the government matched projects.

4. **Future Factory and Digital Capability Center**
   - Real world manufacturing environments that serve as end-to-end system integration sandboxes – illustrating digital concepts within authentic use cases.

**Other Assets to be leveraged**

- Access to DMDII’s dark fibre, provides ARL the speed, flexibility, security, and access to research centers across the US.
- Exposure to early stage companies and technology provides ARL access to cutting-edge technical experts.
- Accelerate education, technical skills and workforce development efforts through DMDII’s existing partnerships and programs.
- Leverage DMDII’s flexible legal framework to enable ARL the ability to quickly award multiple party R&D efforts.
Leveraging DMDII’s R&D portfolio can accelerate organization's business investment through access to over $90M of research based on key industry pain points.

### Project by thrust and technology type

<table>
<thead>
<tr>
<th>Project by thrust and technology type</th>
<th>Project value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design, Product Dev., Systems Eng.</td>
<td>$48.3M</td>
</tr>
<tr>
<td>Future factory</td>
<td>$32.8M</td>
</tr>
<tr>
<td>Agile, resilient supply chain</td>
<td>$5.3M</td>
</tr>
<tr>
<td>Cybersecurity in manufacturing</td>
<td>$1M</td>
</tr>
<tr>
<td>Workforce Development</td>
<td>$3.3M</td>
</tr>
</tbody>
</table>

- **$32.8M**
- **$32.8M**
- **$5.3M**
- **$1M**
- **$3.3M**
Networking is a key to Manufacturing USA success.

First 8 Institutes: Nearly 1,200 organizations convened in an inter-industry network comprised of over 9,000 organization relationships.
Manufacturing USA is strengthening regional economic clusters

Inset: Advanced Mfg Ecosystem in Detroit, MI – Anchored by LIFT and IACMI

63 organizations from across seven Institutes have generated 125 connections.
Collaboration Multiplier Effect

- Institutes decrease the cost of experimentation for their members by providing access to cost prohibitive equipment and pooling R&D dollars.
  - Institutes are demonstrating the potential to deliver 5x leveraged value for members
  - Institutes give members access to not only government funding and partner funding on projects but also broader IP portfolios and R&D
Nearly 28,000 participated in institute-led workforce programs, including:

- **23,560 students** in institute research and development projects, internships, or training
- **3,386 workers** completed institute-led certificate, apprenticeship, or training programs
- **1,023 teachers** and trainers in institute-led training for instructors

Dear Colleague Letter: Supporting Fundamental Research to Enable Innovation in Advanced Manufacturing at Manufacturing USA Institutes

The National Science Foundation (NSF) is interested in receiving research proposals addressing critical fundamental research needs in advanced manufacturing, and particularly in projects that may enable innovations in the technical focus areas of one or more of the Manufacturing USA Institutes. Such proposals should leverage the facilities, infrastructure, expertise and member companies of one or more Institutes.
A Digital Manufacturing Future
The Fourth Manufacturing Revolution

https://www.youtube.com/watch?v=SCGV1tNBoeU
Digital Manufacturing Technology Trends

- **Digital Technologies**
  - Internet of Things/Ubiquitous Sensing
  - Digital Twin and Digital Thread
  - Big data & advanced analytics
  - Cloud computing
  - Mobile computing/apps
  - Security technologies

- **Advanced Manufacturing Capabilities**
  - Advances in additive processes/3D printing
  - Advances in robotics
  - Model-based everything
  - Complex systems engineering
  - Advances in materials
The Digital Twin – Simply Taking on Moore’s Law

https://www.linkedin.com/pulse/moores-law-heterogeneity-deep-learning-chien-ping-lu

Chen and Kurfess, 2017
Industry 4.0 and Digital Manufacturing is digitizing and integrating data across the value chain to drive insights and improved operational performance.

"Advanced digital technologies are creating new opportunities for innovation and growth, and producing novel ways to improve and customize the customer experience. This digitally driven evolution—which lays the foundation for what Deloitte calls the digital manufacturing enterprise (DME)—is enabled by the rise of Industry 4.0.

That digital information is then analyzed and used to drive further intelligent action in the physical world, completing a physical-to-digital-to-physical loop of action and informed reaction.”

- Deloitte

Annual new data stored by sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Petabytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>1,812</td>
</tr>
<tr>
<td>Government</td>
<td>911</td>
</tr>
<tr>
<td>Banking</td>
<td>771</td>
</tr>
<tr>
<td>Communications and Media</td>
<td>776</td>
</tr>
<tr>
<td>Retail</td>
<td>424</td>
</tr>
<tr>
<td>Professional Services</td>
<td>397</td>
</tr>
<tr>
<td>Securities and Investment Services</td>
<td>336</td>
</tr>
<tr>
<td>Healthcare</td>
<td>375</td>
</tr>
<tr>
<td>Education</td>
<td>276</td>
</tr>
<tr>
<td>Insurance</td>
<td>273</td>
</tr>
<tr>
<td>Transportation</td>
<td>256</td>
</tr>
<tr>
<td>Wholesale</td>
<td>245</td>
</tr>
<tr>
<td>Utilities</td>
<td>207</td>
</tr>
<tr>
<td>Resource Industries</td>
<td>166</td>
</tr>
<tr>
<td>Consumer and Recreational Services</td>
<td>116</td>
</tr>
<tr>
<td>Construction</td>
<td>87</td>
</tr>
</tbody>
</table>

SOURCE: IDC; McKinsey Global Institute analysis 2013
Industry leaders see the value of digital manufacturing

- Most stakeholders see digital manufacturing as key to long term competitiveness
- Many companies do not have an effective strategy in place to capture that value

**Overall, how important is digital manufacturing to the future competitiveness of your company in the next 5 years?**

<table>
<thead>
<tr>
<th>Importance of digital manufacturing to future success</th>
<th>Not Important</th>
<th>Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance</td>
<td>-4</td>
<td>-19</td>
<td>77</td>
</tr>
</tbody>
</table>

**How does your organization prioritize digital manufacturing initiatives?**

<table>
<thead>
<tr>
<th>Level of prioritization</th>
<th>Don’t know</th>
<th>Not Important</th>
<th>Priority for senior leadership</th>
<th>Driven by middle management</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>24</td>
<td>50</td>
<td>13</td>
<td>4</td>
</tr>
</tbody>
</table>

**Does your company have a well laid out strategy for digital innovations to enable competitiveness?**

<table>
<thead>
<tr>
<th>Plans in place and communicated across organization</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Important but not well laid out</td>
<td>50</td>
</tr>
<tr>
<td>Part of strategy but doesn’t enable competitiveness</td>
<td>13</td>
</tr>
<tr>
<td>Important but not part of overall strategy</td>
<td>7</td>
</tr>
<tr>
<td>Not important</td>
<td>4</td>
</tr>
<tr>
<td>Don’t know</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Survey, July 2015, 200+ participants from industry, academia and the federal government
Huge STEM Education Potential of Digital Manufacturing
Opportunities from Digital Manufacturing

Democratization of tools needed to **Design** and **Make**

Shared access to non-profit and commercial makerspaces.
Future Digital Manufacturers

Inspiration to Innovation to Making
Thank you!