Clean Energy Smart Manufacturing Innovation Institute

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• Manufacturing USA Overview

• Current Barriers and Opportunities

• US Department of Energy Goals for CESMII

• Global Efforts in Smart Manufacturing

• Q&A
But before we begin-

So what is smart manufacturing?

It simply means creating new and additional jobs in US

Smart way to improve efficiency, productivity, and competitiveness (more profit)

But I could not resist an alphabetical soup

SM = IoT+CPS+AI (ML)
Focus is to address market failure of insufficient industry R&D in the “missing middle” or “industrial commons” to de-risk promising new technologies.

Basic R&D

TRL 3

TRL 7

Commercialization

Credits: Dr. Frank Gayle, AMNPO, N...
**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.

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**Goal 1:** Increase Competitiveness

**Goal 2:** Facilitate Technology Transition

**Goal 3:** Accelerate the Manufacturing Workforce

**Goal 4:** Ensure Stable and Sustainable Infrastructure

*The four interrelated program goals. From 2016-2019 Strategic Plan*

Credits: Dr. Frank Gayle, AMNPO, NIST
Each institute has:

1) Clear, unique institute focus
2) Clear industry value proposition
3) Strong Partnerships
4) Ability to address critical challenges
5) A balanced portfolio of projects

Consortia are open—new members able to join
Progress to Date

- $600 million federal investment matched by over $1.3 billion non-federal
- Nine active institutes: 1,300 members, over 240 technology development projects.
  - Members include two-thirds of Fortune 50 U.S. manufacturers
  - 8 out of the 10 top-ranked research and engineering universities.
- Competitions underway for additional institutes

Manufacturing USA, A Third-Party Evaluation of Program Design and Progress, Deloitte Study, Jan 2017

Institutes are achieving high degrees of network connectivity and strong member recruitment, reaching respective “tipping points” that drive towards success. The number of members and degree of member connectivity are key indicators of the sustainability of an Institute’s network. There are early signs that Institutes are reaching “tipping points” where organizations see membership as necessary to their own success and seek out membership without being prompted.
OUTLINE

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- Q&A
Barriers according to McKinsey Analysis

Manufacturers need to overcome major implementation barriers, of which some are more relevant for advanced players.

Top 5 barriers mentioned by manufacturers with no/limited progress in Industry 4.0:

1. Difficulty in coordinating actions across different organizational units
2. Lack of courage to push through radical transformation
3. Lack of necessary talent, e.g., data scientists
4. Concerns about cybersecurity when working with third-party providers
5. Lack of a clear business case that justifies investments in the underlying IT architecture

Additional top barriers mentioned by more advanced manufacturers:

1. Concerns about data ownership when working with third-party providers
2. Uncertainty about in- vs. outsourcing and lack of knowledge about providers
3. Challenges with integrating data from disparate sources in order to enable Industry 4.0 applications

Level of progress in Industry 4.0


Industry 4.0 after the initial hype Where manufacturers are finding value and how they can best capture it, McKinsey Global Institute
## The Age of Analytics: Competing in a Data-Driven World

There has been uneven progress in capturing value from data and analytics.

**Potential impact: 2011 research**

<table>
<thead>
<tr>
<th>Location-based data</th>
<th>Value captured</th>
<th>Major barriers</th>
</tr>
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<tbody>
<tr>
<td>▪ $100 billion+ revenues for service providers</td>
<td>50–60%</td>
<td>Penetration of GPS-enabled smartphones globally</td>
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<tr>
<td>▪ Up to $700 billion value to end users</td>
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</table>

**US retail**

| ▪ 60%+ increase in net margin | 30–40% | Lack of analytical talent |
| ▪ 0.5–1.0% annual productivity growth | | Siloed data within companies |

**Manufacturing**

| ▪ Up to 50% lower product development cost | 20–30% | Siloed data in legacy IT systems |
| ▪ Up to 25% lower operating cost | | Leadership skeptical of impact |
| ▪ Up to 30% gross margin increase | |

**EU public sector**

| ▪ ~€250 billion value per year | 10–20% | Lack of analytical talent |
| ▪ ~0.5% annual productivity growth | | Siloed data within different agencies |

**US health care**

| ▪ $300 billion value per year | 10–20% | Need to demonstrate clinical utility to gain acceptance |
| ▪ ~0.7% annual productivity growth | | Interoperability and data sharing |

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1. Similar observations hold true for the EU retail sector.
2. Manufacturing levers divided by functional application.
3. Similar observations hold true for other high-income country governments.

**Credits:** Mckinsey Global Institute

**Source:** Expert interviews; McKinsey Global Institute analysis
CESMII Opportunities to US Competitiveness

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Considerations for Developing and Deploying Smart Manufacturing Technologies

- What is the problem and why is it hard?
- How is it solved today and what are the barriers?
- What is new and innovative in our approach?
- Why is it critical for the institute goals? Who will benefit?
  - Who are the cross-industry partners?
- What is our measure of success and what impacts it will have?
- How much it will cost and how long it will take?
- What are the risks and payoffs?
- What is our short-term, mid-term and long-term strategy for success?
Let us look at RD&D, IT/OT Focus

**Research (Development and Demonstration)**
- Testbed development and deployment
- Testbed requirements w.r.t ASCPMM
- Testbed Characteristics
- Infrastructure Requirements
- Process modeling & measurements
- Prediction, Control and Optimization

**Technology (Operations & Information)**
- Process Technology
- Open Standards
- Sensor technologies
- Testbed Architecture
- Data Analytics and HPC
- Open Standards
- Sensor technologies
- Testbed Architecture
- Data Analytics and HPC

**U.S. Department of Energy**
Energy Efficiency & Renewable Energy
Let us look at Workforce Development Focus
• Manufacturing USA Overview
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We will need a Reference Model for Smart Manufacturing

Prof. Jim Davis will elaborate on this more
Reference Architecture Model Industry 4.0

RAMI 4.0 (DIN SPEC 91345:2016-04 Standard)
The Industrial Internet Reference Architecture (IIRA) is a standards-based open architecture defined by the Industrial Internet Consortium (IIC).

Standardization efforts

- Industrial Internet Consortium - The Industrial Internet Reference Architecture (IIRA) - [http://www.iiconsortium.org/](http://www.iiconsortium.org/)

- Platform Industrie 4.0, Reference Architectural Model Industrie 4.0 (RAMI 4.0), [https://www.plattform-i40.de/i40/Redaktion/EN/Downloads/Publikation/rami40-an-introduction.pdf](https://www.plattform-i40.de/i40/Redaktion/EN/Downloads/Publikation/rami40-an-introduction.pdf)

- Predictive Model Markup Language (PMML) standard as well as Portable Format for Analytics (PFA) standard developed under Data Mining Group (DMG) - [http://dmg.org/](http://dmg.org/)


Inspired by considerations of value and use

Repeatable and Cost reducing Solution across Industry sectors

CESMII – The value proposition through RD&D

CESMII Role: Better Business models and Value Chain, Education and Training, OEM and Supply Chain Engagement for Testbeds and Open Standards Platform Implementation

CESMII Role: Reduce cost of Testbeds, Scaling up First-of-Kind Application Toolkits, Workforce Training, Open Standards Platform

Project Types:
- purely exploratory
- employ existing knowledge to solve SM problems
- create new SM technologies for their intrinsic interest
- create new technologies in close collaboration with members

Adapted from: Donald Stokes (Pasteur’s Quadrant: Basic Science and Technological Innovation, Brookings Institution, 1997)
Q&A ???

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Advanced Manufacturing Office (AMO) Multi-Year Program Plan For Fiscal Years 2017 Through 2021

Backup slides
### We need a Testbed Framework

<table>
<thead>
<tr>
<th>Levels*</th>
<th>Data What</th>
<th>Motivation Why</th>
<th>Function How</th>
<th>Network Where</th>
<th>Time When</th>
<th>People Who</th>
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<tbody>
<tr>
<td>Machine Level</td>
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<td>Process Level</td>
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<td>Shop floor level</td>
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<td>Plant Level</td>
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<td>Extended</td>
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<td>Enterprise Level</td>
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<td>(Including supply network)</td>
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<td>Deployed</td>
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<tr>
<td>Testbed</td>
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*Testbed Architecture cell level description with respect to testbed characteristics and requirements could be based on Zachman Framework*
Based on the Testbed Framework let us look at OT&IT Integration

<table>
<thead>
<tr>
<th>OT</th>
<th>IT</th>
<th>IIoT</th>
<th>PCO</th>
<th>MS&amp;A</th>
<th>Data analytics</th>
<th>HPC</th>
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<tbody>
<tr>
<td>Sensors</td>
<td>M2M</td>
<td>ICS</td>
<td>CPS</td>
<td>Security</td>
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<td>Petroleum refining</td>
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<td>Chemicals</td>
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<td>Metals manufacturing</td>
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<td>Food and beverage</td>
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<td>Glass</td>
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<td>Pulp and paper</td>
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<td>Discrete manufacturing &amp; Other opportunities</td>
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Platform Industry 4.0 – Based on RAMI 4.0

- connects embedded system smart production technologies and processes
- focuses on the end-to-end digitization
- digitizes the horizontal and vertical value chains

Working Groups
1. Reference architectures, standards and norms
2. Research and innovation
3. Security of networked systems
4. Legal framework
5. Work, education and training

http://www.plattform-i40.de/I40/Navigation/EN/ThePlatform/ActivitiesAndParticipation/activities-and-participation.html;jsessionid=8CB23AD28F96956A7090F270088C7E26
Smart Manufacturing Institute Mission & Vision:
- Sustainable engine for U.S. Manufacturing.
- The operating system accelerates technology adoption from sensors to Cloud Computing.
- Hard dollar impacts are being achieved by US Manufacturers with this system today
- Improvements in productivity, job growth, energy efficiency, supply chain, and safety
- We serve energy intensive and dependent companies of all sizes
- Smart Manufacturing is manufacturing in 2030

Lead: Smart Manufacturing Leadership Coalition (SMLC)
Coverage: Local Representation across the US: HQ: LA, CA
Hub: CMTC, Gulf Hub: Texas A&M, Mid West: Building Team, NW
Hub: PNNL, NE Hub: RPI, SE Hub: NC State

Key Objectives and Metrics for Smart Manufacturing (SM):
- First of kind live commercial test beds globally in the US
- 15% energy efficiency improvement proven in test beds 3-5 years
- 50% reduction in SM systems deployment costs in 5 years
- U.S. energy productivity doubled every 10 years
- SM implementation costs recovered in less than 10 years
- US SM workforce capacity increased two-fold by 2020, five-fold by 2030
- 40% increase in SM supply chain participation by 2030

~200 partners from industry, academia, NGOs and state/local: $70M Federal Funding, $170M Cost Share
Key elements of a successful CESMII roadmap – My Mind map

**Goals:**
1) Doubling U.S. energy productivity every 10 years
2) Recovering SM systems implementation costs via energy savings and productivity in 10 years
3) Increasing U.S. SM workforce capacity five-fold by 2030
4) Increasing supply chain participation by 40% by 2030

**Milestones:**
1) Improve energy efficiency by 15% in first of a kind industrial Test Beds in 5 years
2) Reduce SM systems deployment costs by 50% in 5 years
3) Increasing U.S. SM workforce capacity two-fold by 2020 and reach five-fold by 2030
4) Self-sustain after 5 years

**Gaps and barriers:** (we will learn more from BP1 Roadmap)
1) Comprehensive analysis of business case and C-suite buy in
2) Skills, knowledge gap for workforce development
3) Data availability, generation and ownership
4) Data interoperability and IT-OT integration across different functional units
5) Open platforms, interoperability standards and industry reference architecture (IT and OT)

**Action items:** (we will learn more from BP1 Roadmap)
1) Develop innovation ecosystem and Standardize Open Software and Communication Platforms
2) Develop Advanced Sensors and Smart Sensor Networks
3) Develop Improved Real-Time Data Analytics and Control Systems using Cloud Computing
4) Develop Advanced High Fidelity Modeling (V&V and UQ)
5) Develop First-of-Kind Application Toolkits for SM Deployment
6) Enable Availability of Appropriate Testbeds

**Priorities and timelines:** (BP1) – (BP2 and beyond will be based on BP1 Roadmap)
1) Finalize Technology Roadmap for Smart Manufacturing (M6)
2) Complete the Strategic Investment Plan (SIP), in a multiyear format, to define, select, prioritize, and allocate funding to activities across the Institute (M6)
3) Application Projects per region to showcase requirements for the SM Platform architecture (M5)
4) Execute Membership Agreements with committed and prospective members (M2 - M6)
5) Final version of the Institute Sustainability Plan document (M6)
What are the Goals and Focus of the Institute?

- increased productivity
- improved energy efficiency
- Cost reduction for installation

**Problem**

Optimize the energy efficiency and in general resource efficiency of energy *intense/dependent* manufacturing process

**Solutions**

- How much energy efficiency can be achieved?
- What is the current state of the art?
- What is the new innovation?

- open and interoperable platform
- plug and play connectivity
- integration and customization

What is the strategy for deployment through Testbed for Smart Manufacturing?

Concept of testbed for Smart Manufacturing Systems Integration

- Market and business drivers
- Specific System Application
  - Networked Enterprise A
  - Networked Enterprise B
  - Networked Enterprise C
- Replicable Testbeds
  - Testbed 1
  - Testbed 2
  - Testbed 3
  - Testbed 4
- Lab/Pilot study

Enabling technology requirements

New technology capabilities

Knowledge Gaps about Technology

- Technology A
- Technology B
- Technology C

New insights

- Analytics Algorithms
- Sensing
- Modeling and Simulation