Haresh Malkani
Chief Technology Officer

Miguel Corcio
Director of Technical Projects
CESMII
Project Portfolio & Future RFPs

CESMII Annual Meeting
2019 February 28

The Home of Smart Manufacturing
Well, we hope to change that today!

Ninety-nine percent of what's wrong with people is not enough excitement.

L. Ron Hubbard
We are Uniquely Positioned to Solve Complex Manufacturing Problems

Problem → Idea → Projects → Solution → Success
1. The Role of Projects in CESMII’s Mission
2. Current R&D Portfolio
3. Future Focus Areas and RFP
The Role of Projects in CESMII’s Mission
Roadmap and Application Projects Directly Support the Technology Pillars

- Facilitate SM adoption
- Develop value proposition
- Mitigate risks and barriers
- Provide strategies & tools
- Collaborative R&D
- Develop key technologies
- Robust & configurable
- Integration into SM system
- Build & sustain SM skills
- Customized training
- Resources & programs
- Technology & practices
- SM Platform & Marketplace
- Enable reuse of technologies
- Secure, flexible, scalable
- Cost effective deployment

CESMII $$$ + Member $$$

Member $$$

Create/Build

Validate/Demonstrate

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Projects Accelerate the Development and Use of CESMII Technologies

**Roadmap Projects**

“Develop”

Enabling Technologies
- Sensing
- Control
- Modeling
- Analytics

Platform Capabilities
Workforce Development*

**The SM Platform™**

- Marketplace
- Tools
- Capabilities
- Infrastructure

**Application Projects**

“Use”

Use Platform
To validate & demonstrate
SM technologies &
SM training*

**Identify Gaps**

* Restructuring of these projects being considered
Our Projects Help Build Fundamental Blocks of Smart Manufacturing
We Selected 10 Projects from 41 Strong Submissions from our First RFP

- Submitted: 41
  - Total: $54M
  - CESMII: $32M
  - Cost Share: $22M
  - 78 Members

- Initial Selection: 24
  - Evaluated by (32)
  - CESMII Team
  - Ranked L: 17
    - Ranked H, M: 7

- Revised Selection: 20
  - Potential Application Projects
  - Alternates
  - Shape & Confirm

- “Not Now”
  - Total: $19,634,960
    - CESMII: $11,674,607
    - Cost Share: $7,960,353

- Potential Application Projects
  - Total: $6,081,969
    - CESMII: $4,197,755
    - Cost Share: $1,884,214

- Alternates
  - Total: $10,912,180
    - CESMII: $7,248,547
    - Cost Share: $3,663,633

- Shape & Confirm
  - Total: $15,947,256
    - CESMII: $9,618,189
    - Cost Share: $6,329,067
    - 43 Members

Total: $54M
CESMII: $32M
Cost Share: $22M
78 Members
Our R&D Project Portfolio is Strongly Aligned with our Strategic Plan

43 Member Organizations Represented

Selected Projects

1. Data Modeling for Machine Learning and Data-Centric Analytics for Smart Aerospace Additive Manufacturing
2. Smart Manufacturing Workforce Development Model
3. Smart Connected Workers in Advanced Manufacturing
4. Inferential Modeling for Driving Out Energy Waste
5. Energy Management Systems for Subtractive and Additive Precision Manufacturing
6. Factory 4.0 Educational Toolkit
7. Production of zero-defect (ZD) slabs through the implementation of Smart Manufacturing technologies in steel continuous casting
8. Smart Manufacturing of Cement
10. Smart Manufacturing for Chemical Processing: Energy Efficient Operation of Air Separation Unit
Texas A&M
Smart Manufacturing for Chemical Processing: Energy Efficient Operation of Air Separation Unit

ArcelorMittal
Production of zero-defect (ZD) slabs through the implementation of smart manufacturing technologies in steel continuous casting
Project selections reflect much of our membership make-up

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<th></th>
<th>West Coast</th>
<th>North</th>
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<th>Flow-path, Plant or Enterprise</th>
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<td>Process Breadth</td>
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<td>4</td>
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<th>Manufacturing Type</th>
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<td>Both</td>
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<tr>
<td>Process</td>
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<td>Discrete</td>
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<td>Chemical</td>
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<tr>
<td>Cement</td>
<td>1</td>
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<tr>
<td>Steel</td>
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<tr>
<td>Workforce</td>
<td>2</td>
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</table>
ThinkIQ
Inferential Modeling for Driving Out Energy Waste

Virginia Tech
Energy-Efficient Material Processing through Automated Process Monitoring and Controls
The portfolio is aligned with our Strategic Investment Plan

1. Cross-cutting R&D and Reusability
2. Process and Controls
3. Sensors
4. Data Modeling for Machine Learning and Data-Centric Analytics
5. SM Platform Infrastructure
6. Business Development & Workforce Development

### TOP 10 TECHNICAL AREAS OF INTEREST PROPOSALS FUNDING REQUESTS VS CESMII BUDGET

<table>
<thead>
<tr>
<th>Area</th>
<th>Funding Request</th>
<th>CESMII Budget</th>
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<tbody>
<tr>
<td>1. Cross-cutting R&amp;D and Reusability</td>
<td>$968,996</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>2. Process and Controls</td>
<td>$3,411,888</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>3. Sensors</td>
<td>$1,000,000</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>4. Data Modeling for Machine Learning</td>
<td>$2,959,865</td>
<td>$3,500,000</td>
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<tr>
<td>&amp; Data-Centric Analytics</td>
<td></td>
<td></td>
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<tr>
<td>5. SM Platform Infrastructure</td>
<td>$907,053</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>6. Business Development</td>
<td>$813,925</td>
<td>$2,500,000</td>
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<tr>
<td>&amp; Workforce Development</td>
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**TOTAL CESMII BUDGET**

**TOTAL (PRELIMINARY SELECTION) TOP 10**
University of Louisville
Smart Manufacturing of Cement

University of California - Irvine
Smart Connected Workers in Advanced Manufacturing
## The 10 Project Teams

### Data Modeling for Machine Learning and Data-Centric Analytics
- **Honeywell**
  - Morf3D
  - UCLA
  - USC
  - Missouri University S&T
  - Identify3D
  - Sentient Science Corp
  - Stratonic

### Smart Manufacturing Workforce Development Model
- **El Camino Community College**
  - California State University Northridge
  - UC Berkeley
  - UCLA

### Smart Connected Workers in Advanced Manufacturing
- **UC Irvine**
  - Atollogy
  - Aerospace Corporation
  - General Mills
  - UCSD
  - California State University Northridge
  - Honeywell

### Inferential Modeling for Driving Out Energy Waste
- **ThinkIQ**
  - General Mills

### Energy Management Systems for Subtractive and Additive Precision Manufacturing
- **University of Connecticut**
  - United Technologies Research Center
  - J&J Supply Chain Strategy & Deployment
  - Connecticut Center for Advanced Technology
  - State of Connecticut

### Factory 4.0 Educational Toolkit
- **Penn State University**
  - Massachusetts Institute of Technology
  - Arconic

### Production of zero-defect (ZD) slabs through the implementation of smart manufacturing technologies in steel continuous casting
- **Arcelor-Mittal**
  - Purdue University
  - Missouri University of Science & Technology
  - RPI

### Smart Manufacturing of Cement
- **University of Louisville**
  - Argos

### Energy-Efficient Material Processing through Automated Process Monitoring and Controls
- **Virginia Poly Tech Institute & State University**
  - Univ. of Virginia
  - Penn State University
  - Arconic
  - Commonwealth Center for Advanced Manufacturing (CCAM)

### Smart Manufacturing for Chemical Processing: Energy Efficient Operation of Air Separation Unit
- **Texas A&M Engineering Experiment station (TEES)**
  - Praxair
  - Rensselaer Polytechnic Institute
  - AspenTech
  - University of Texas Austin
  - PSE Inc
  - Texas A&M University
1. How aligned is the current R&D portfolio to CESMII’s mission?

- Strongly aligned: 67%
- Moderately aligned: 33%
- Weakly aligned: 0%

Source: https://api.cvent.com/polling/1/api/poll/v.mp0f/5
Future Focus Areas and Project Calls
How we Intend to Identify Top Priority Focus Areas

1. CESMII Roadmap
2. Industry Needs
3. Platform Capabilities & Needs
4. Affinity Groups
5. Top Priority Focus Areas & Project Calls
6. Standing Committees
7. RMC & Member Capabilities
BP3 Roadmap Project Priorities (Technology)

- **Enabling Technologies**
  - Sensing, Control, Analytics, Modeling Optimization, Machine Learning

- **Platform**
  - Ingestion Contextualization Data Management Profile Builder Interoperability Workflow orchestration Marketplace Apps & Tools

- **Emerging Technologies**
  - 5G Artificial Intelligence Cybersecurity

**Project Distribution by Industry**

**Project Distribution by Size of Manufacturer**

**Project Focus Will Continue to Evolve**
Classification of Project Types based on Focus Areas

Enabling Technologies
- Specific Gaps in roadmap
- Emerging technologies
- Workforce development

Enabling R&D Projects

Platform Capability Projects
- Core capabilities
- Apps & Tools

SM Platform™
- Profile builder
- Device, machine, process profiles
- Integration with vendor apps

Innovation Projects

Demonstration/Validation
- Manufacturer use case
- SM platform capabilities

Application Projects

Projects will be solicited across all industry types and manufacturer sizes (small, medium, large)
### Proposed Types of Projects – BP3

<table>
<thead>
<tr>
<th></th>
<th>Roadmap Projects (Enabling R&amp;D)</th>
<th>Roadmap Projects (Platform Capability)</th>
<th>Roadmap Projects (Innovation)</th>
<th>Application Projects</th>
<th>Hackathon</th>
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<tbody>
<tr>
<td><strong># of projects</strong></td>
<td>~5</td>
<td>~10</td>
<td>~50</td>
<td>TBD by Members</td>
<td>~5-10</td>
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<tr>
<td><strong>Project funding</strong></td>
<td>~$500K-$750K</td>
<td>~$200K-$500K</td>
<td>~$200K</td>
<td>TBD by Members</td>
<td>TBD</td>
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<tr>
<td><strong>Member cost</strong></td>
<td>~50%</td>
<td>~50%</td>
<td>~50%</td>
<td>100%</td>
<td>100%</td>
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<tr>
<td><strong>Duration</strong></td>
<td>~12+ Months</td>
<td>~6-12 Months</td>
<td>~6 Months</td>
<td>TBD by Members</td>
<td>~2 Days</td>
</tr>
<tr>
<td><strong>Focus areas</strong></td>
<td>Specific Gaps in: Sensing, Control, Analytics, Modeling Optimization, ML Explore emerging trends: 5G, AI, Blockchain, Cybersecurity</td>
<td>Ingestion Contextualization Data Management Profile Builder Interoperability Workflow orchestration Marketplace Apps &amp; Tools</td>
<td>Device Profiles Machine Profiles Process Profiles Apps &amp; Tools</td>
<td>Use of existing platform tools to solve a specific mid to long term manufacturing problem</td>
<td>Use of existing platform tools to solve a specific short term manufacturing problem</td>
</tr>
<tr>
<td><strong>RFP timing</strong></td>
<td>~2Q 2019</td>
<td>~2Q 2019</td>
<td>~2Q 2019</td>
<td>~2H 2019</td>
<td>~2H-2019</td>
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<tr>
<td><strong>Cadence</strong></td>
<td>Annual</td>
<td>Rolling</td>
<td>Rolling</td>
<td>Rolling</td>
<td>Annual</td>
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Investing in Enabling Technologies

Enabling R&D Projects: ~5 Projects, ~$500-750K each, ~50% cost share, ~12 Months

- CESMII identifies **focus areas** in enabling and emerging technologies
- **Formal project call** is issued
- RMCs and members submit short **white papers** on their ideas
- CESMII (with input from standing committees) **short lists** the proposals
- CESMII invites **full proposals** from short listed teams
- CESMII conducts **formal evaluations** (internal and external)
- CESMII **selects and approves** list of projects
Building the Platform

CEDMII identifies specific **platform development needs**

CEDMII develops **requirements** document

CEDMII invites **proposals** from member based teams with specified domain expertise

CEDMII conducts **formal evaluations** (internal and external)

CEDMII **selects and approves** projects

**Platform Capability Projects:** ~10 Projects, ~$200-500K each, ~50% cost share, ~6-12 Months
Shrinking the SM R&D Innovation Lifecycle

**Innovation Projects:** ~50 Projects, ~$200K each, ~50% cost share, ~6 Months

- Use a structured **Agile** R&D Framework
- Identify best cross section of manufacturing **challenges**
- Manufacturer defines a **target asset/process** based on mfg problem
- Form an **Integrated** SM Innovation Project (IP) **team**
- The SM IP Team builds an **SM Profile** of the asset/process
- The SM IP Team builds, trains, refines **apps for solving problem**
- CESMII sanctions and **publishes** profile and apps on the **SM Marketplace™**
Demonstrating SM Solutions

Application Projects: Number and size determined by member, 100% cost share, ~6-12 Months

- CESMII industry member identifies specific manufacturing use case that can be solved using Existing CESMII SM Platform & Technologies for the project
- Team develops a proposal and submits to CESMII
- CESMII conducts evaluation of the proposal
- CESMII approves the projects
Hackathon

Hackathon: 3-5/year, 100% cost share, ~2 days

• A “mini” version of an application project, but much shorter duration (1-2 days)

• Identify 3-4 manufacturer sites across the US, with pre-defined set of problems
  • Based on affinity groups
  • Based on access to manufacturers’ facilities/equipment

• Invite CESMII member teams to selected sites

• Team is chartered to solve the problem using SM Platform and CESMII expertise
2.1 ______ with the focus areas and proposed approach for the NEXT set of RFPs.

- Agree: 59%
- Am neutral: 31%
- Disagree: 10%

Source: https://app.cvent.com/polling/v1/app/polls/apvr/inpy
Are you excited yet??
Democratizing SMART MANUFACTURING

EDUCATED, DATA-DRIVEN CULTURE
SMART ASSETS
SMART DECISIONS
OPERATIONS & SUPPLY CHAIN VISIBILITY

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www.cesmii.org
CESMII
Smart Manufacturing Platform™

CESMII Annual Meeting
2019 February 28

The Home of Smart Manufacturing
IF YOU BUILD IT, THEY WILL COME.
Storyline

1. The CESMII SM Platform™ And The CESMII Common Profile Model™

2. Our Approach to Building The CESMII SM Platform™ With Partners

3. Demonstration
Think About What Manufacturers Want to Do With Data

Bring Tools to Data, Data to Tools in a Workflow Based Platform

Example use case:

- Improve **performance** on metals processing equipment using **real-time data** and predictive **models** in a **workflow** based environment.
How Do We Help Them Accomplish That?

A Platform for Consumers

- Navigation
- Phone
- Games
- Reference
- eMail
- Ride Sharing (a platform too)

A Platform for Manufacturers

- Analytics
- Modeling
- Contextualization
- Connectivity
- Sensors
- Control
- OT Workflows
The CESMII SM Platform™
and
The CESMII Common Profile Model™
High Level View: Core Functionalities of the SM Platform™

Marketplace

Application Workflow

App 1

App 2

App 3

App 4

App 5

SM Information Bank

Contextualization Engine

Ingestion Engine

Source 1

Source 2

Source 3

Source 4

Source 5

Visualization Tools

Conversion Tools

Core Platform Components

Workflow Components

V.T.

C.T.

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Integration of OT & IT Technologies in the SM Platform™

What is required to do so

**IT Focus**
- Marketplace
- Secure, Scalable Cloud Infrastructure
- Connectivity & Data Management

**OT Focus**
- OT Apps
- Interoperability & OT Workflows
- Contextualization

Contextualization → Sensing → Control → Visualization/Analytics

Predictive Modeling
Contextualization is at the Heart of the Platform

**LEGACY**
- Application
- Data Store
- Driver

*Unique, monolithic technology stack for every product*

**TODAY**
- Connect OPC

*Unique technology stack for every product in each vendor’s portfolio*

**SM De Facto Standard**
- API
  - Platform
    - Common Profile Model™
    - Data Store: T/S + Relational
  - Connect OPC UA, MQTT
  - Others...

*Common infrastructure stack for every product, every vendor*
The Common Profile Model™ - Crowd-Sourcing Manufacturing Domain Expertise

CESMII Members
Industry thought leaders & SME’s

Common Profile Model™
Enable SME’s to Digitize their Domain Expertise

Profile Designer™ (Contextualizer)

Device Profile
A collection of devices (sensor, drive, robot…)

Machine Profile
A collection of devices (machine, compressor…)

Process Profile
A collection of Machines (line, supply chain…)

Data Lifecycle Management
Preserving Context at every level

Device Profile
- Performance
- Energy
- Quality
- Material & Production
- Predictive Maintenance
- Asset Management
- Business Process Integration
- Support SLA

Machine Profile
- Performance
- Energy
- Quality
- Material & Production
- Predictive Maintenance
- Asset Management
- Business Process Integration
- Support SLA

Process Profile
- Performance
- Energy
- Material Flow
- Buffers
- Inventory
- Routes
- Location
- Business Process Integration
- Support SLA
SM Profile (data model) definitions can include any combination of OT, Design, and Enterprise data:
- Data to be collected/ingested/stored
- Faults, alarms
- Events
- Math / KPI calculations, etc.
- Predictive models
- Images, video, audio
- Enterprise Integration touchpoints
- Workflow touchpoints (in, out)
- Content (visualization, reports, dashboards)
- Design / Digital Twin
- Material Flow, Buffers, Routes, etc.

Device Profile:
1. Device Health & Diagnostics
2. Asset Management
3. Business Process Integration
4. Support SLA

Machine Profile:
1. Performance
2. Energy
3. Quality
4. Material & Production
5. Predictive Maintenance
6. Asset Management
7. Business Process Integration
8. Support SLA

Process Profile:
1. Performance
2. Energy
3. Material Flow
4. Buffers
5. Inventory
6. Routes
7. Location
8. Business Process Integration
9. Support SLA

Data Lifecycle Management: Preserving Context at every level

The Common Profile Model™ - Crowd-Sourcing Manufacturing Domain Expertise
Objective: Create a Plug & Play experience for all Manufacturers, from Discrete to Continuous Process

1. A seamless experience based on Hyperscale infrastructure and vital technology contributions from CESMII
   - CPM Designer (Contextualizer)
   - Common Data Model definitions (extend OPC)
   - A data store construct that integrates time series, relational and unstructured data

2. CESMII will invest aggressively to encourage (fund) the manufacturing ecosystem to build Profiles & Apps
   - Device Vendors
   - Machine Builders
   - System Integrators
   - IT App Vendors
   - OT App Vendors
The SM Platform™ - What Done Looks Like

Vendor/Machine-Specific Protocols

Edge Profile Content

Edge Data Store
Store-N-Forward

High Availability & Disaster Recover

Deployment
Device Management

Security

IOT Edge

SM Edge™

On-Premise

Cloud (Public/Hybrid)

SM Platform™

Data Ingestion Hub with SM Platform Integration

Vendor Apps (COTS)

Home-grown Applications

Platform Workflow

Model-Based Ent Integr.

Vendor Analytics Engines

Relational

Time Series

Documents

Image Video

Data Lake

Audio

Cloud Data Store

SM API

SM Essentials™

SM Apps™

SM Profiles™ (Device, Machine, Process)

Profile Designer™

Microsoft Services

CESMII Technology

SM Marketplace™
The Smart Manufacturing Marketplace

Provision the SM Platform™
• Cloud – CESMII bits + Azure IoT Services
• Edge – CESMII bits + IoT Edge Services

SM Apps™
• All sanctioned Apps, Models, Workflows (Private & Public)
• Require integration via our SM Platform API

SM Profiles™
• Library of 1000’s of Device, Machine & Process Profiles

SM Essentials™ Market
• Members share their needs for specific Profiles, Analytics Models, Guidance, Implementation Support, etc.
• Members respond
The SM Platform™: 10 Minutes to Value

1. Access the SM Marketplace™
2. Provision your SM Platform™
   • Cloud Services
   • Edge Services
3. Deploy Edge Services on secure HW connected to control system
4. Search for and instantiate SM Profiles™ that match the devices & equipment you’re connected to
5. Initiate ‘Run’ Mode
   • Multiple SM Edge’s federated
   • SM Profiles™ assembled into data model
   • Data Collection initiated
6. Identify SM App(s)
   • COTS Applications
   • Predictive Models
   • Workflow Engines
   • Model-based integration with Enter Sys
   • O365, Power BI, Dynamics365, Flow...

Manufacturing Plug & Play Environment That Requires NO Domain Expertise to Begin Creating Value
Building
The CESMII SM Platform™
With Partners
We Will Build the Platform with a Highly Talented Collaborative Team

- Technical Standing Committee
- CESMII Technical Team
- Platform Advisory Committee

SM Platform Working Group

- Technology Vendors
- Manufacturers
- Subject Matter Experts
- Systems Integrators
Leveraging Our Strengths – CESMII and A Hyperscale Cloud Provider

**IT Focus**
- Marketplace
- Secure, Scalable Cloud Infrastructure
- Connectivity & Data Management

**OT Focus**
- OT Apps
- Interoperability & OT Workflows
- Common Profile Model

CESMII’s Members

Analysts Tools
- Predictive Models
- Problem solving Workflows
- SM Profile Builder
- Device, Machine & Process Profiles
- Data contextualization tools
- Data ingestion tools
Partnering to Accelerate the Delivery of the SM Platform™

Dawn James
Industry Advocate
Worldwide Manufacturing & Resources Industry

Microsoft
Empowering Manufacturers with Azure Cloud Computing

Dawn James
WW Manufacturing & Resources Industry, Industry Advocate
Microsoft’s manufacturing and resources priorities

Big bets

**Industrial IoT**
- Product-as-a-service
- Factory of the future
- Intelligent supply chain

**Smart energy**
- Digital upstream oil and gas
- Digital upstream mining
- Digital grid

**Precision agriculture**
- Smart agriculture
- Smart products and connected logistics
- Genomics and research and development

Solutions

- Modern workplace in manufacturing
- Connected factory
- Connected field service
- Big compute in manufacturing
- SAP on Azure in manufacturing
- Health and safety
- Azure digital twins
- Partner solutions
Achieving Business Objectives with Azure IoT & AI
Building a better future together
Thank You For Your Partnership!
Our Partnership with Microsoft: Platform as a Service Approach

Traditional On-Premise

- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

Managed by vendor

You manage

Infrastructure as a Service

- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

Managed by vendor

Managed by CESMII

Cloud (Public/Hybrid)

Platform as a Service

- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

Managed by Microsoft

Software as a Service

- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

Managed by vendor/Member
The SM Platform™ core stack will include the ability to integrate data ingestion and data contextualization tools in a cloud environment.

Technology partners ThinkIQ and OSIsoft will contribute to this by developing technology that combines OSIsoft’s strengths of broad connectivity, storage, secure data transfer protocols, high-performance storage and retrieval with ThinkIQ’s flexible tools for semantic modelling, data federation and data analytics.

The technology will be validated and verified through demonstration of solutions in the SM Platform™
Meeting Short Term Needs While Developing a Scalable and Sustainable Platform

**Core Capabilities**

- Deploy to RMCs
- Use for Projects

(Support Projects)

**Short Term**

- Refine Requirements
- Refine Architecture
- Develop Capabilities

**Long Term**

- Advisory Committees
- Technical Experts
- Members
- Technology Partners

Agnostic, Comprehensive, Scalable, Sustainable
ENGAGE WITH US!

Democratizing SMART MANUFACTURING

EDUCATED, DATA-DRIVEN CULTURE
SMART ASSETS
SMART DECISIONS
OPERATIONS & SUPPLY CHAIN VISIBILITY

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