CESMII
SMART MANUFACTURING INSTITUTE

A Perspective of US Manufacturing Innovation: Purdue Smart Manufacturing Innovation Center (SMIC)

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Purdue University

USA Manufacturing Innovation Institutes

Manufacturing USA was created in 2014 to secure U.S. global leadership in advanced manufacturing by connecting people, ideas, and technology. Manufacturing USA institutes convene business competitors, academic institutions, and other stakeholders to test applications of new technology, create new products, reduce cost and risk, and enable the manufacturing workforce with the skills of the future.

Manufacturing USA®

A Perspective of US Manufacturing Innovation

CESMII

DOE/CESMII

Smart Manufacturing Innovation Center (SMIC)

A national network of Centers-of-Excellence funded by US Dept of Energy (USDOE), located throughout the U.S. to democratize Smart Manufacturing technologies and capabilities across small, medium, and large industries.

CURRENTLY THERE ARE **7 SMIC'S** THROUGHOUT THE COUNTRY

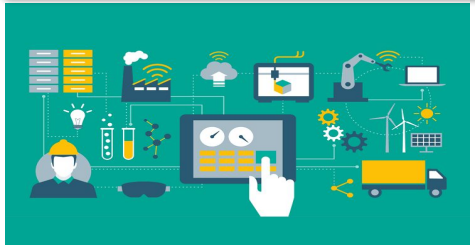
UCLA · Rensselaer · NC State University · feyen zylstra Industrial Tech Solutions · Case Western Reserve University · digital foundry at New Kensington · Purdue University

Purdue SMIC: Goals & Objectives

SMART MANUFACTURING INNOVATION CENTER

SMIC Goal : AI to Improve Manufacturing Productivity

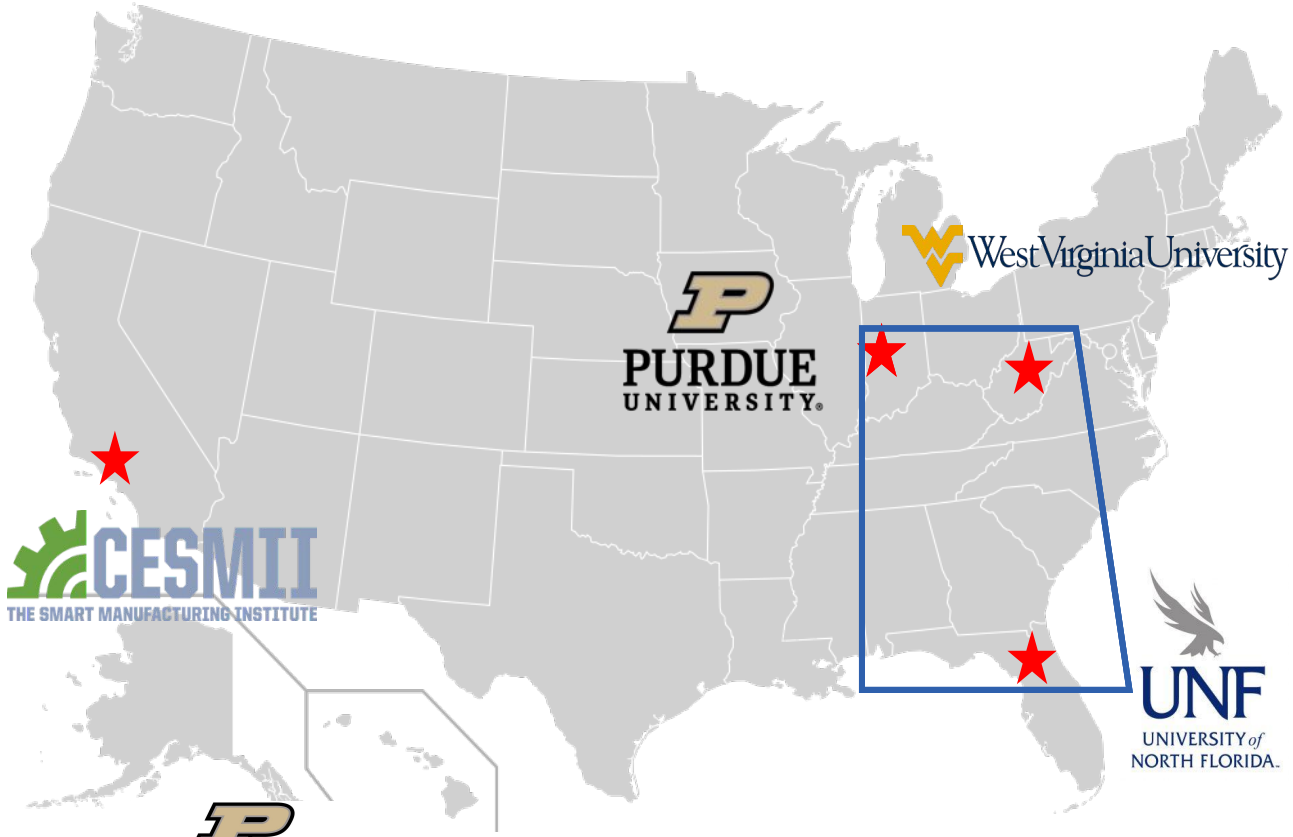
Objective: Accelerate & Democratize AI Adoption in Smart Mfg



I. **Showcase Smart Manufacturing Methods through the SM Innovation Platform**
- Use SMIP to lower barrier for adoption of AI solutions across industries
- Provide shop floor-friendly methodologies for non-experts to configure and deploy AI solutions across different manufacturing applications

II. **Feature SM Testbeds to Showcase Manufacturing Process Improvements**
- 3-Testbeds (Purdue, WVU, & UNF)
- Demonstrate benefits of AI powered solutions to achieve higher levels of efficiency, productivity, quality, performance, and resiliency in supply chain networks

III. **Host CESMII Outreach events**



Microsoft

CATERPILLAR®

PURDUE UNIVERSITY
Manufacturing Extension Partnership
MEP National Network

INDUSTRIAL EXTENSION
PART OF THE MEP National Network

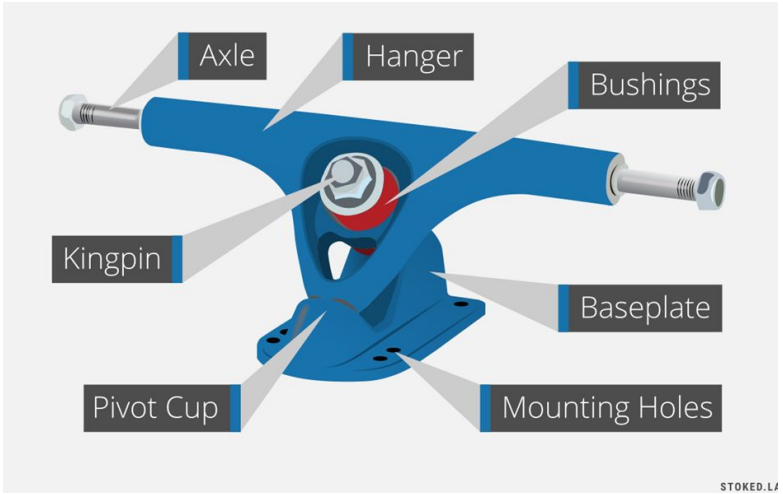
SMIC Testbed: Smart Foundry

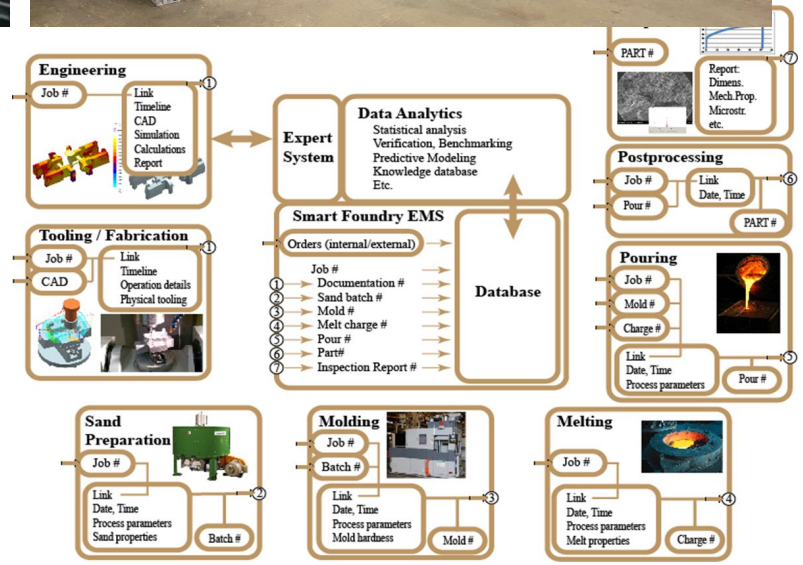
Smart Foundry Testbed

- Industry grade green sand gravity casting multi-alloy foundry using electric resistance, induction, and natural gas furnaces.
- Capabilities for real time monitoring, control, with full operational traceability of all processes from melt to finished casting.
- AI/ML powered Digital Twin (DT) models for capturing insights from data to facilitate intelligent control of the foundry operations to improve performance, quality, and consistency of the castings via predictive outcomes.
- Connectivity to CESMII's SM Innovation Platform (SMIP)

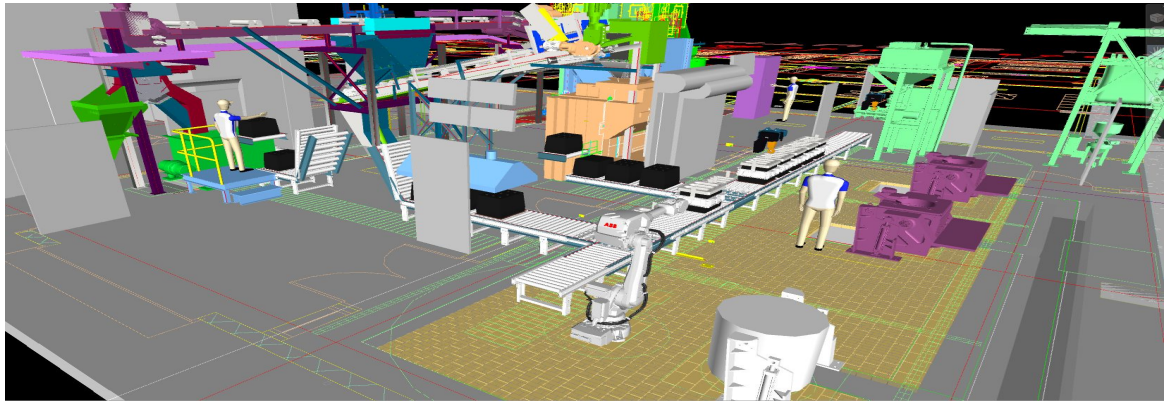
Testbed Configuration

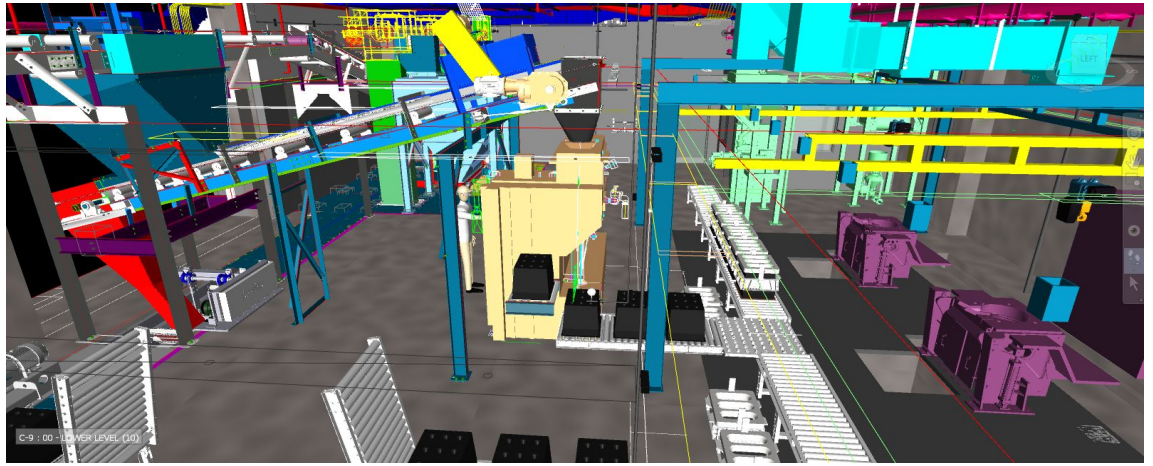
- FDNX-1 Sand Molding Machine
- Model 1F Mix-Muller w/ a Simpson-Hartley Compactability Controller
- VX500 Additive Sand 3D Printing System
- ABB IRB4600 2.05m/60kg Foundry Plus Robot Pouring System with IRC5 Controller
- EC-600 Dynarad® Electric Crucible Aluminum Melting/Holding Furnace.
- 125 kW VIP® Power-Trak® Solid State Induction Power Supply with 500 Lb. Dura-Line® Induction Furnace
- Baker 200-T 600K Btu/hr Natural Gas Fired Crucible Furnace

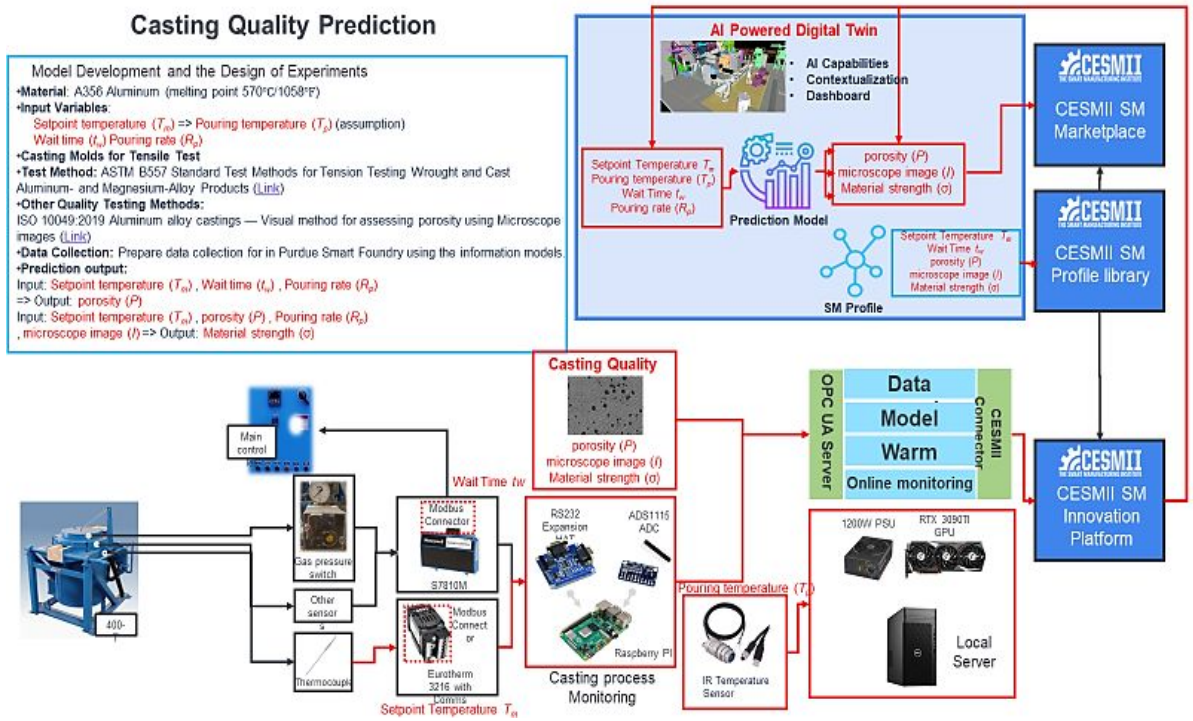




SMIC Testbed: Smart Foundry







Improving the Gating System to Increase Casting Yield by 4%

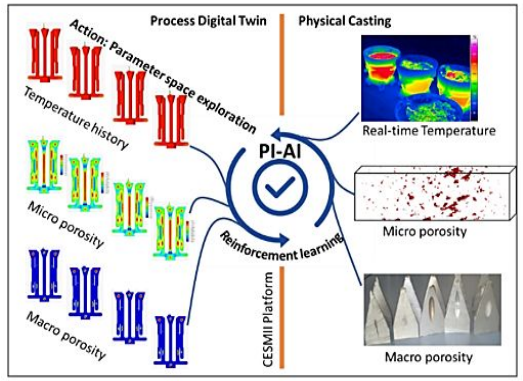


Figure 4: A physics-informed AI (PI-AI) system that integrates the measured data with the physics-based FEA simulations, which is a high-fidelity process digital twin.

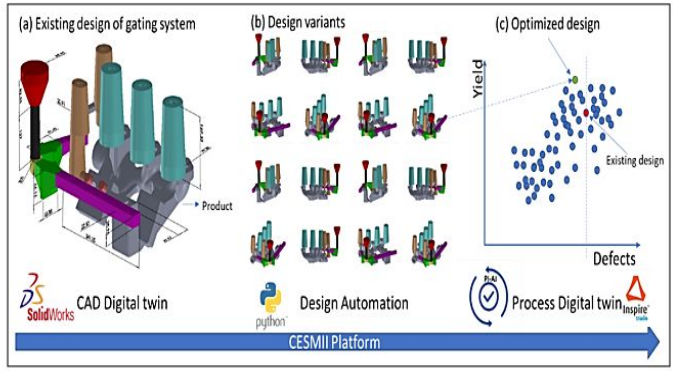


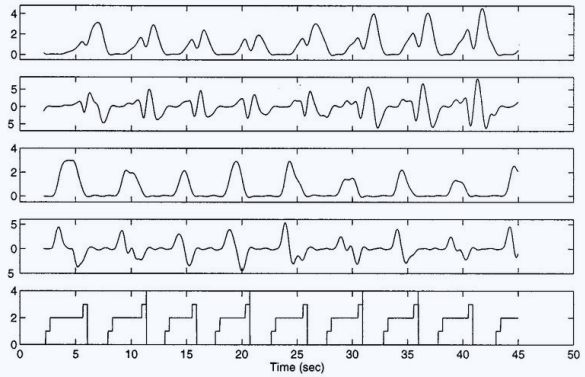
Figure 5. (a) Existing gating design from BCI, (gray-colored area is the product, remaining is gating system); (b) Design variants; (c) Evaluation and optimization using process digital twin

A 4% improvement in casting yield could reduce energy consumption in the melting process by 217 MWh, reduce 280 metric tons of casting waste, and reduce GHG emissions by 6,625 metric tons annually across the casting process lifecycle.

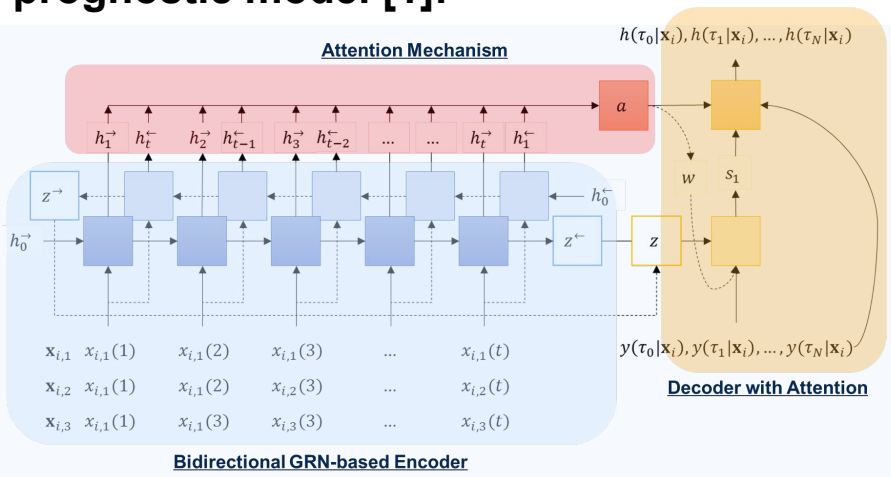
Purdue SMIC: Advanced AI/ML Predictive/Prognostic Tools

PURDUE UNIVERSITY

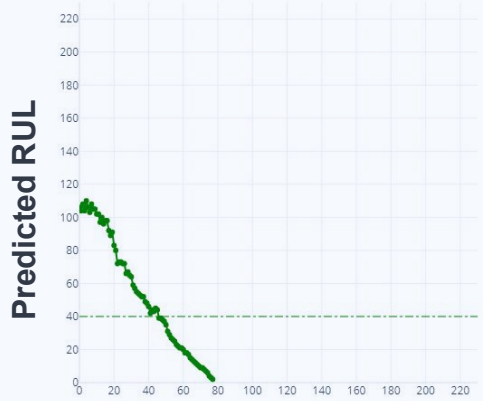
Seq2surv - A transformer-based deep prognostic model [1]:



Time series signals

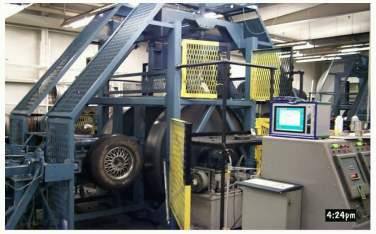


Seq2surv Model



Reliability estimates

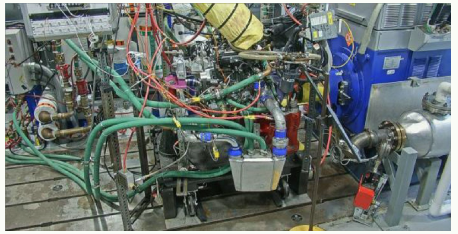
Industrial applications:



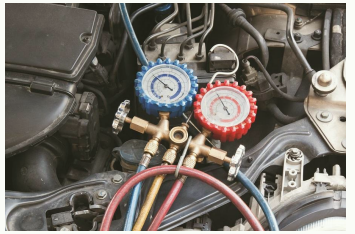
Tire Reliability

Machine Maintenance

Battery Degradation



Engine test



AC efficiency

Superior model performance [1] - more than 300% error reduction as compared to the best existing model
Industrial significance – a highly generalized prognostic tool for a wide range of industrial projects

[1] Li, X., Krivtsov, V. and Arora, K., 2022. Attention-based deep survival model for time series data. Reliability Engineering & System Safety, 217, p.108033.

Purdue SMIC: Testbed for Smart Additive/Hybrid Manufacturing

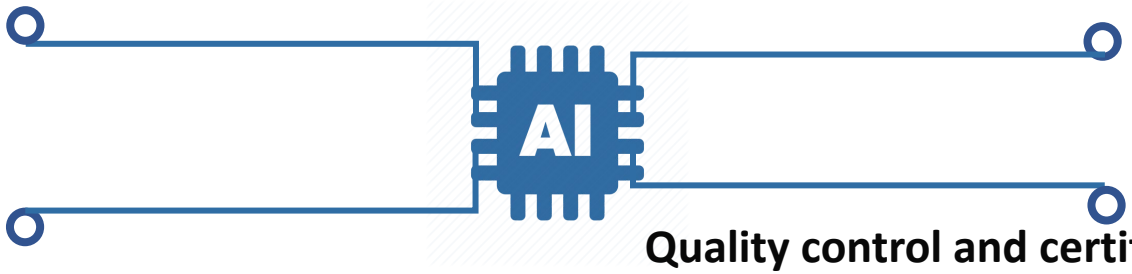
PURDUE UNIVERSITY

Combing Additive, Subtractive, and Welding

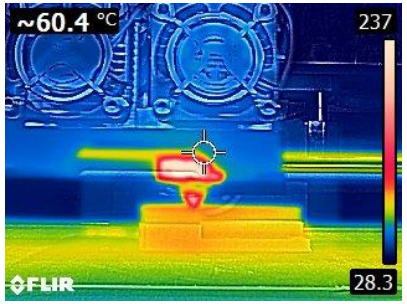
1) High throughput Additive/Hybrid

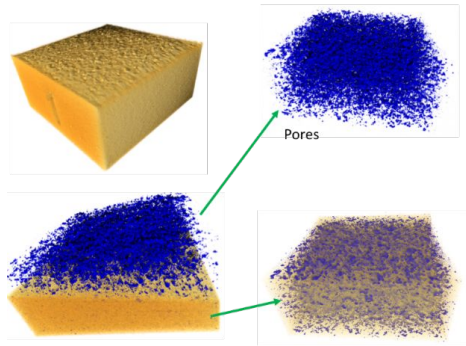
2) Upgrade existing parts

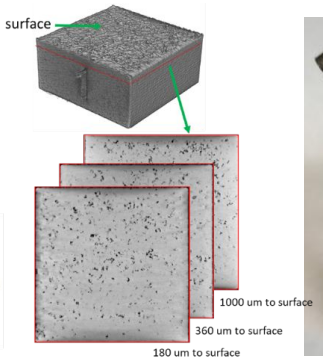
3) Repair parts



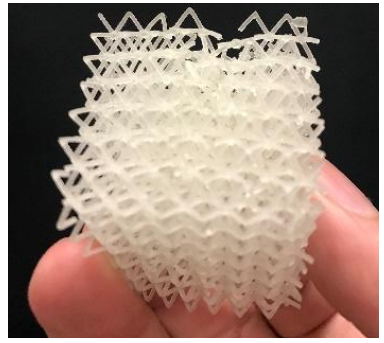
Smart process control with In-Situ Monitoring







Quality control and certification



UNF – Satellite SMIC Testbed Capabilities

UNF's Digital Machining Testbed

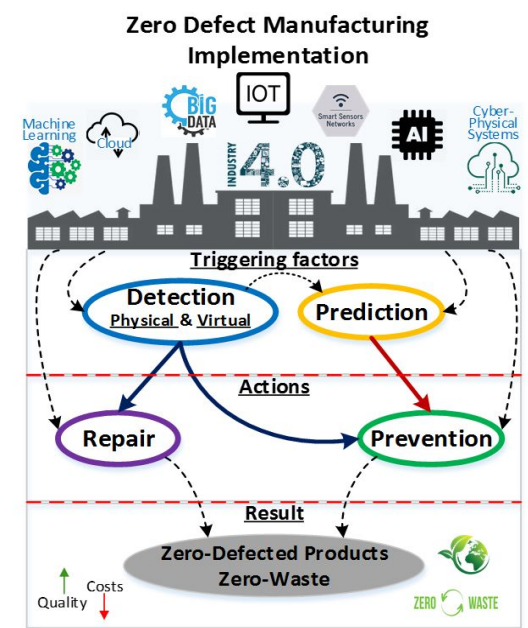
- Feature **Zero Defect Manufacturing** utilizing smart machining integrated with digital twin and AI capabilities
- **Predict Product Quality** by using data from the sensor signals
- Leverage CESMII's SM Innovation Platform (SMIP) by establishing **connectivity with the manufacturing asset(s)**

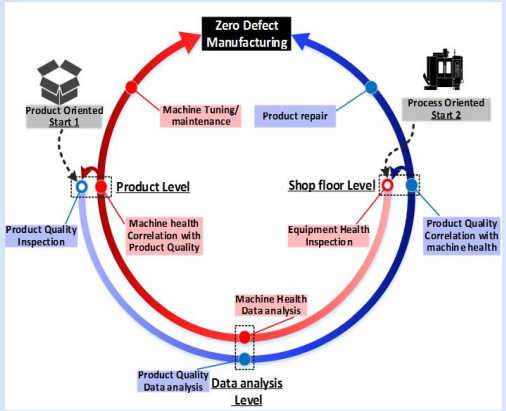
UNF's Digital Machining Facility Key Assets

- The **Haas ST20 Lathe** is a versatile CNC turning machine. The lathe is equipped with three live tool spindles to allow cross cutting and milling to create parts with sophisticated radial geometry
- The **Haas Mini Mill** is a versatile 3 axis CNC milling machine with automatic tool change. The machine is capable of machining large metal parts up to 16" x 12" x 10" and has a 7.5hp spindle motor with 6000rpm maximum

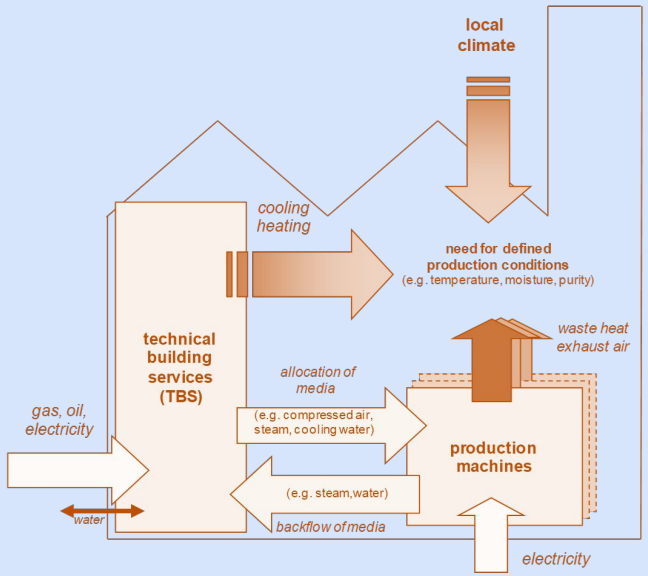
UNF – Satellite SMIC Capabilities

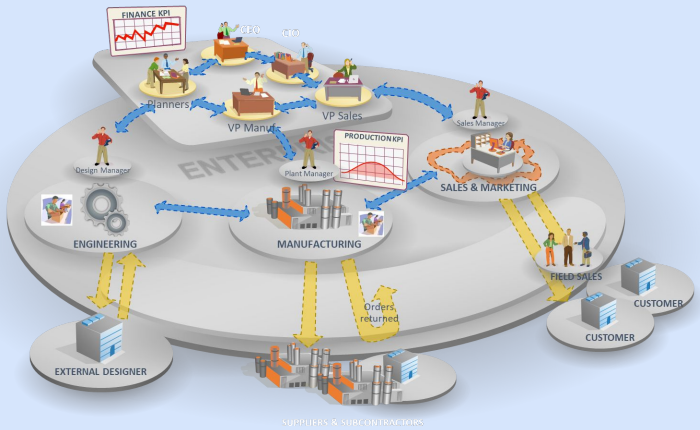
Zero Defect Manufacturing



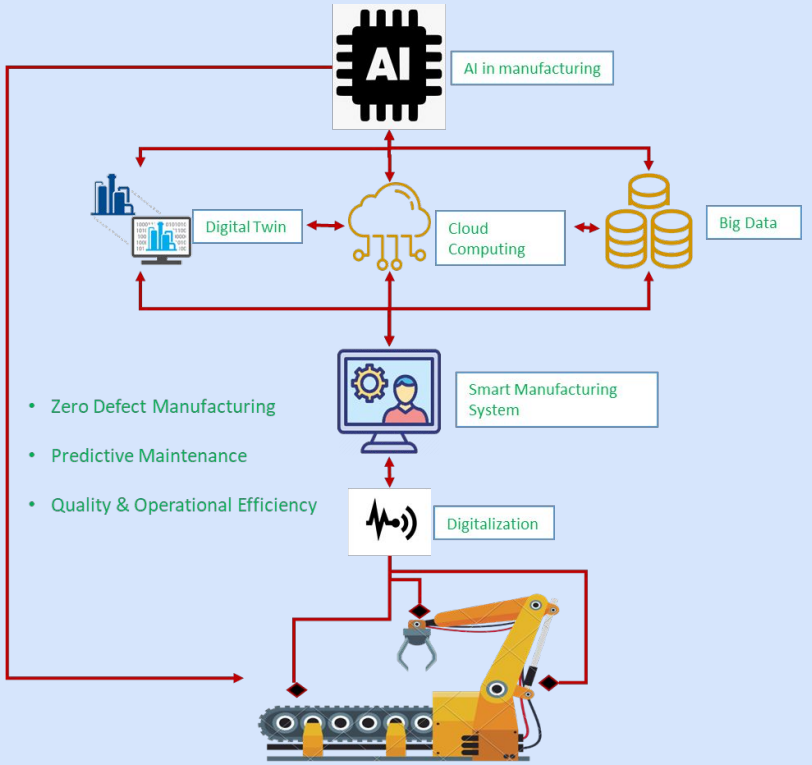


Energy Efficient Manufacturing





AI in Manufacturing



W. Virginia University – Satellite SMIC

Accelerate & Democratize AI Adoption in Smart Mfg

WVU Smart Manufacturing Testbed serves as CESMII/DOE demonstration center for **development/validation of AI/ML capabilities to improve resiliency of Digital Supply Networks**

Objectives:

- Showcase Smart Manufacturing Methods through the SM Innovation Platform
- Feature SM Testbeds to Showcase Manufacturing Process Improvements
- Host CESMII Outreach events

West Virginia University
SMART MANUFACTURING LAB

Funded by CESMII THE SMART MANUFACTURING INSTITUTE U.S. DEPARTMENT OF ENERGY

Dr. Thorsten Wuest
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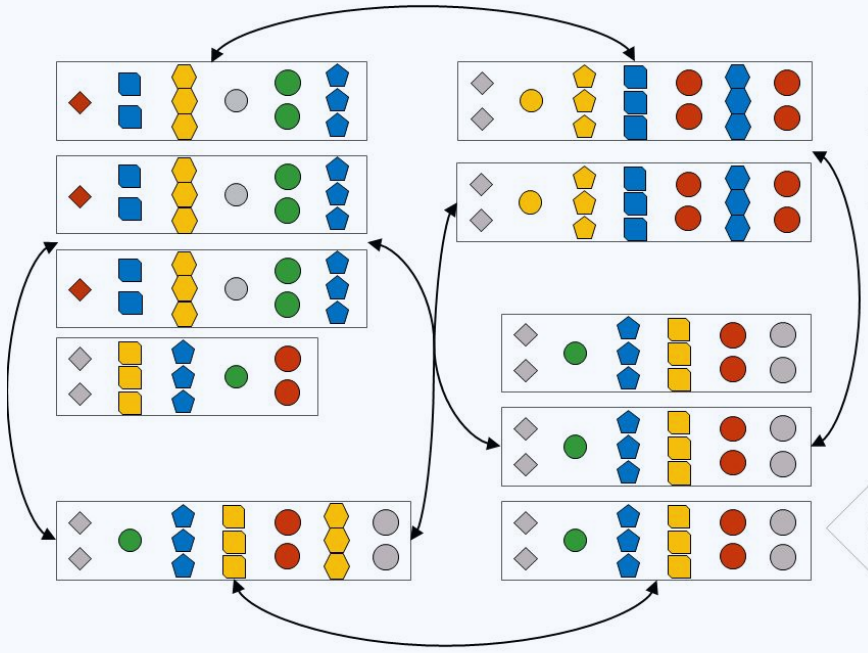
Digital Supply Networks and the Connected Enterprise

Develop agile production network to alleviate the production risks during emergencies

Coordinate material flows, capacity, and manufacturing resources to satisfy both regular demands, e.g., vehicles, and emergency demands?

Connected manufacturing systems



Network Interaction

Optimized flows of machines and components

Achievable Ramp-up Time

Achievable Capacity

Target Capacity

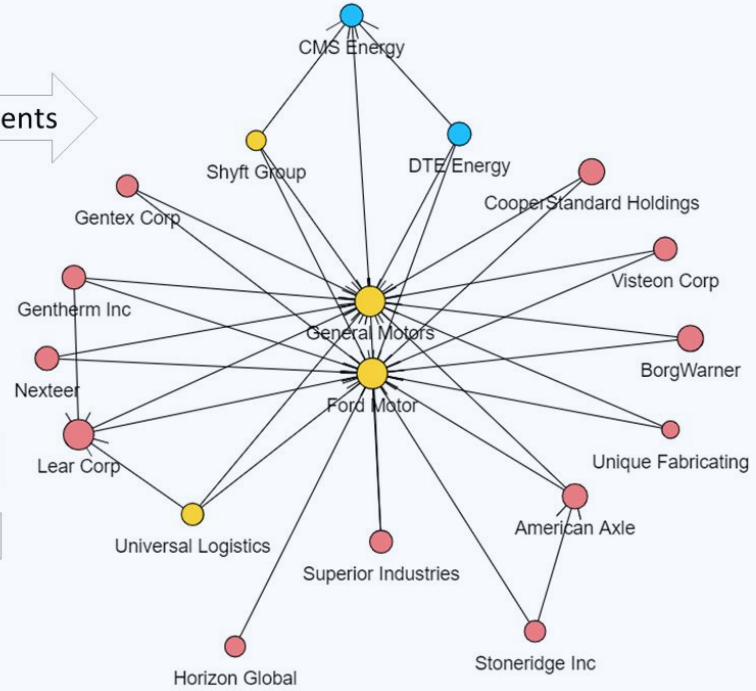
Target Ramp-up Time

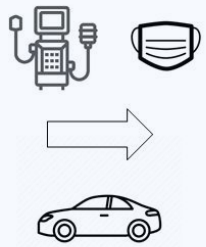
Optimized flows of products and demands

car part
car body
car electric

resource flow
material flow

Connected supply chain





An agile production network [5] with the <u>flexible capacity</u> to respond to changes in an emergency;
Use the network interactions to intelligently <u>coordinate asset management and material flow</u>

[5] Epureanu, B.I., Li, X., Nassehi, A. and Koren, Y., 2021. An agile production network enabled by reconfigurable manufacturing systems. CIRP Annals, 70(1), pp.403-406.

Cloud/Edge Manufacturing: Smart Solution Development

Robot Operating System

ROS

Microsoft

Azure Machine Learning

Azure Digital

Cosmos DB

Power BI

Visual/Analytics/A

Workflow

Unity

Future: Identify3D, ProcessIntel, SimInsights, ShelfAware, GED MFG, etc.

SM API

GraphQL

SM Innovation Platform - Interoperability, Open, Scalable, Secure

Azure

SM Edge - Connector

Purdue Smart Foundry

SM Edge - Connector

WVU Digital Manufacturing & Supply Networks

SM Edge - Connector

UNF Digital Machining

SM Edge - Connector

Industry Engagement

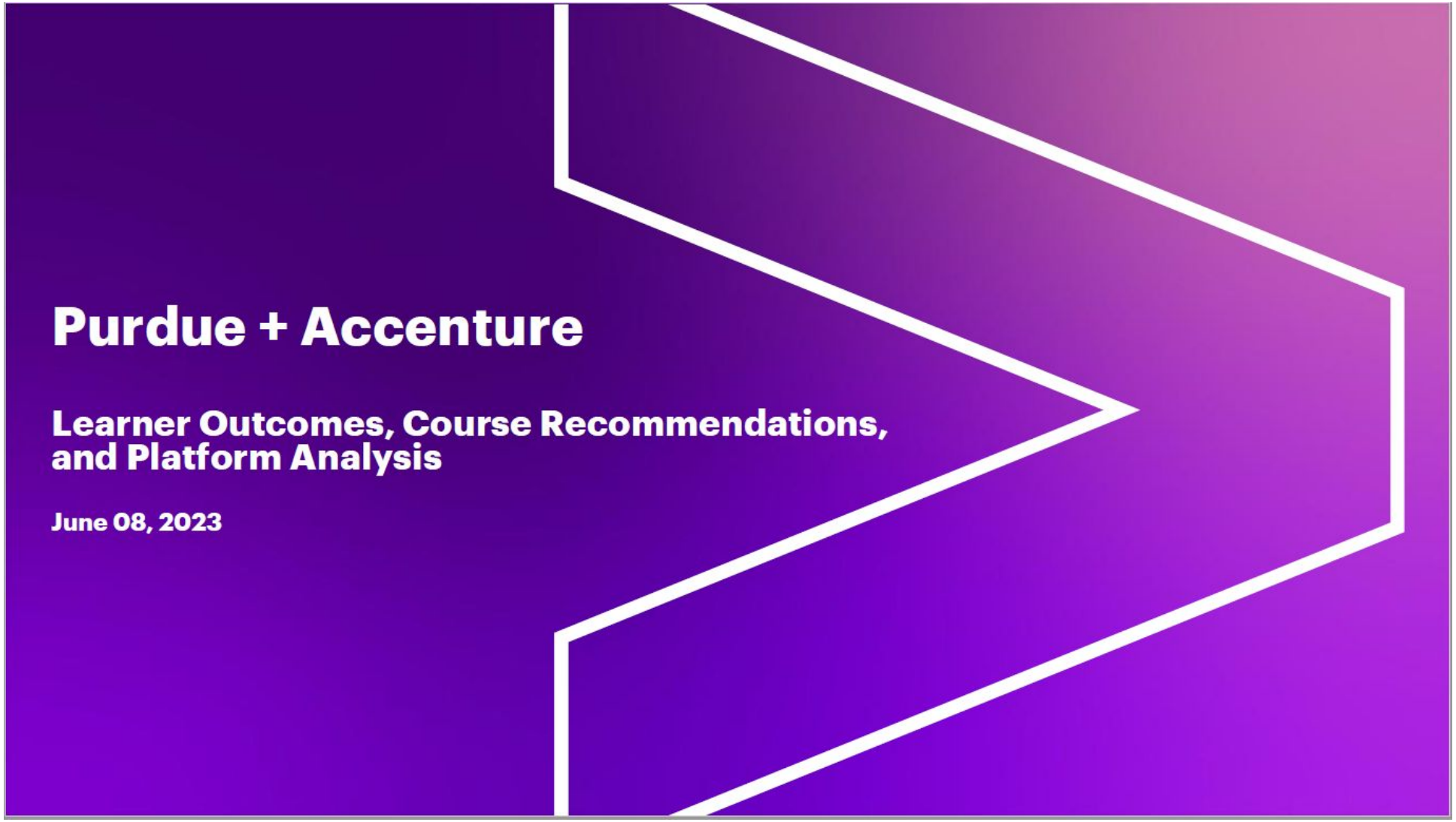
OUTREACH & ENGAGEMENT

2-hr SM Teasers - Lunch & Learn Seminar Series on the 9-Pillars of I4.0

- I4.0 & Driving Business Success in Manufacturing
- Introduction to Industrial Internet of Things
- Smart Warehousing Benefits & Digitally Transforming the Supply Chain Industry
- Smart Industry and Applications of AR/VR in Manufacturing
- Smart Foundry Technologies for Improving Quality & Productivity in Metal Casting Foundries
- Predictive & Prescriptive Maintenance in Manufacturing
- Additive & Hybrid Technologies for Small Batch Manufacturing
- COBOTS & Human Robot Collaboration in Manufacturing
- Industrial Cyberthreats and Manufacturing IT/OT Security
- Others

WORKFORCE DEVELOPMENT

How we will democratize and accelerate AI Adoption in Manufacturing



WORKFORCE DEVELOPMENT

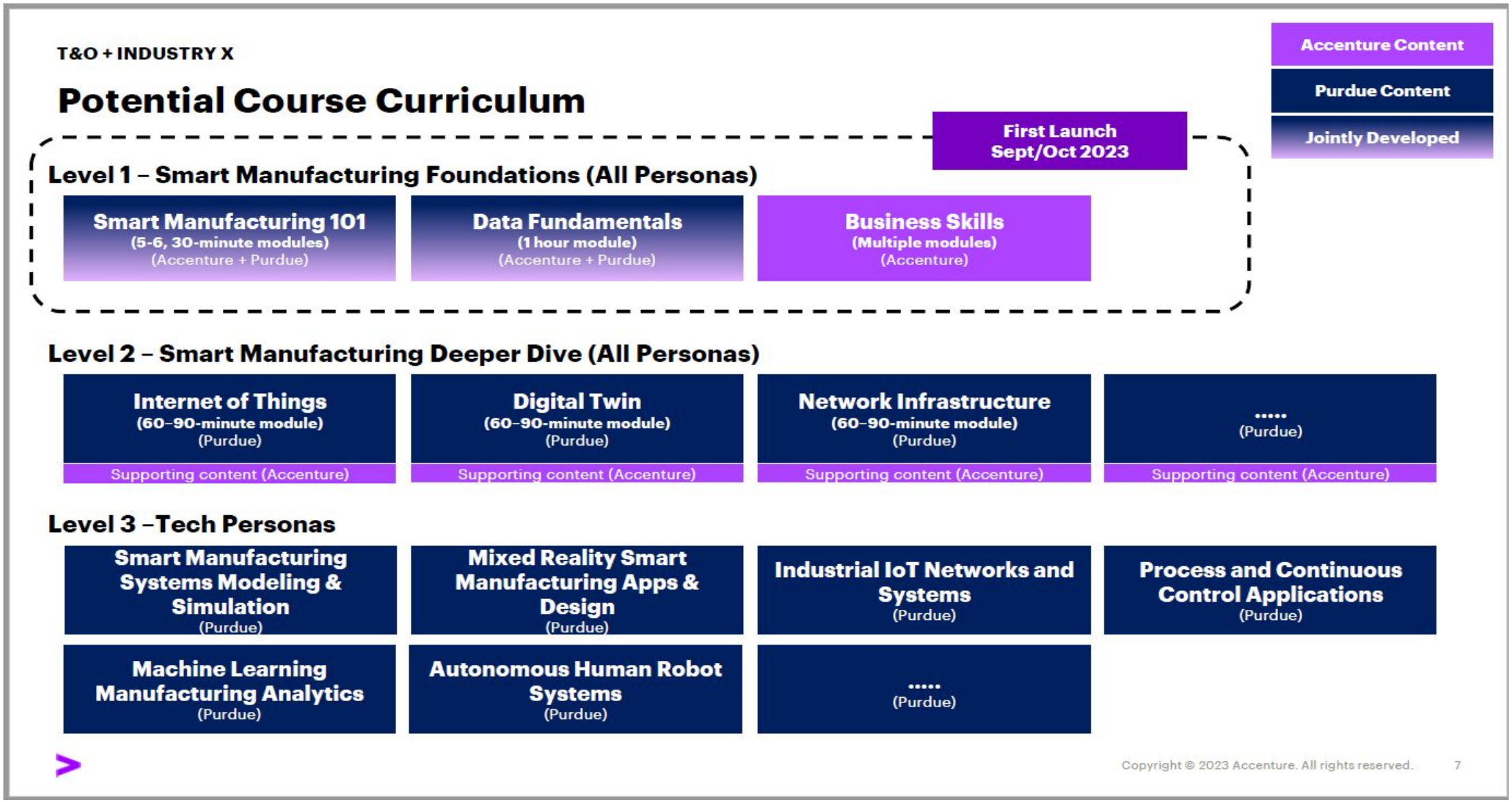
T&O + INDUSTRY X

Key Personas

- Foundational Accenture Academy Content Available
- Purdue Smart Manufacturing Content Available

	Operator	Manufacturing Supervisor	Non-Manufacturing Supervisor	Technology Expert
				
Persona Profile	Existing Manufacturing Frontline Looking to Upskill	Manufacturing Supervisor Looking to Upskill	Non-Manufacturing Mid-Level Supervisor Looking to Pivot into Manufacturing	Non-Manufacturing IT Team Member Looking to Pivot into Manufacturing
Example Current Roles	• Production Operator • Production Team Leader • Maintenance Technician • Quality Control Operator • Planning Team Member • Electronics/Equipment Technician • Field Service Technician	• Production Supervisor/Engineer • Quality Supervisor/Engineer • Manufacturing Engineer • Smart Factory Engineer • Design/Product Engineer • Electrical Engineer • Controls Engineer • Industrial Automation Engineer	• Engineering/Supply Chain Supervisor • Project/Program Manager • Supply Chain-Automation Lead/Expert • Quality Engineer • Continuous Improvement Manager/Supervisor	• Cloud Solution Architect • Full Stack App. Developer • Data Science Analyst • IOT and Data Analyst • Software Engineers • Systems Designer • Electromechanical Engineer
Potential Skills Gaps	• Using tablets/wearables/mobile • Digital tools (dashboards, HMI machines in their stations) • Connected Worker Technology • Working with dashboards • Data-based decision making • Communication • Troubleshooting	Operator Skills + the below: • Smart Manufacturing Tech • Time management • Reporting • Data entry/management • Problem solving • Communication/Escalation • Data Analysis • Prioritization • Workforce Management	• Smart Manufacturing 101 / Tech • Lean Six Sigma • Data Mining / Metric definition • Problem Solving • Team and Time Management • Leadership • Communication • Reporting • Dashboard Utilization • Accountability	• Manufacturing Specific Tech • AI for physical infrastructure • Augmented reality • Network Infrastructure • Manufacturing Data Flow • IT vs OT critical systems and network knowledge • OT software licensing and ownership process • DevOps/Agile

WORKFORCE DEVELOPMENT



OUTREACH & ENGAGEMENT

How we will democratize and accelerate AI Adoption in Manufacturing

1. Leverage Microsoft and their network of MTC Centers to engage with a national manufacturing audience.

1. Outreach efforts include:
   - ✔ Provide engineering support services
   - ✔ Education, skilling & workforce development
   - ✔ Help industries scale AI applications
   - ✔ SM programs at Purdue, WVU, and UNF engaging with industry on related projects
   - ✔ Others

MICROSOFT TECHNOLOGY CENTER

Thank you.