CESMII
THE SMART MANUFACTURING INSTITUTE

Modeling and Simulation in Smart Manufacturing

HPC for Manufacturing Workshop
LLNL, 2023 October 18-19

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Topics

- CESMII's view on advanced sensing, control, platforms, and modeling (ASCPM) in Smart Manufacturing
- Smart Manufacturing requires the right data at the right time, in the right place, in the right format for human and machine actions.
- CESMII Projects have demonstrated benefits and shared methods (playbooks) in key industry verticals

Mission Strategy Role

Smart Manufacturing **to drive next generation** of U.S. Manufacturing Productivity and Environmental Sustainability

U.S. DEPARTMENT OF ENERGY

UCLA
Program Home
2017

$140M +
$61M Renewal

Public Private Partnership

How

Monetize *Productivity, Precision, & Performance* at scale with **Advanced Sensing, Control, Platform, and Modeling for Manufacturing (ACSPM)**

180+ Partners

CESMII represents the ***voice of manufacturing;*** *engaging the smart manufacturing ecosystem through a membership model*

- **Manufacturers**
  Small, Medium & Large
- **System Integrators & Consultants**
- **Machine Builders**
- **Technology Providers**
- **Academia & Labs**

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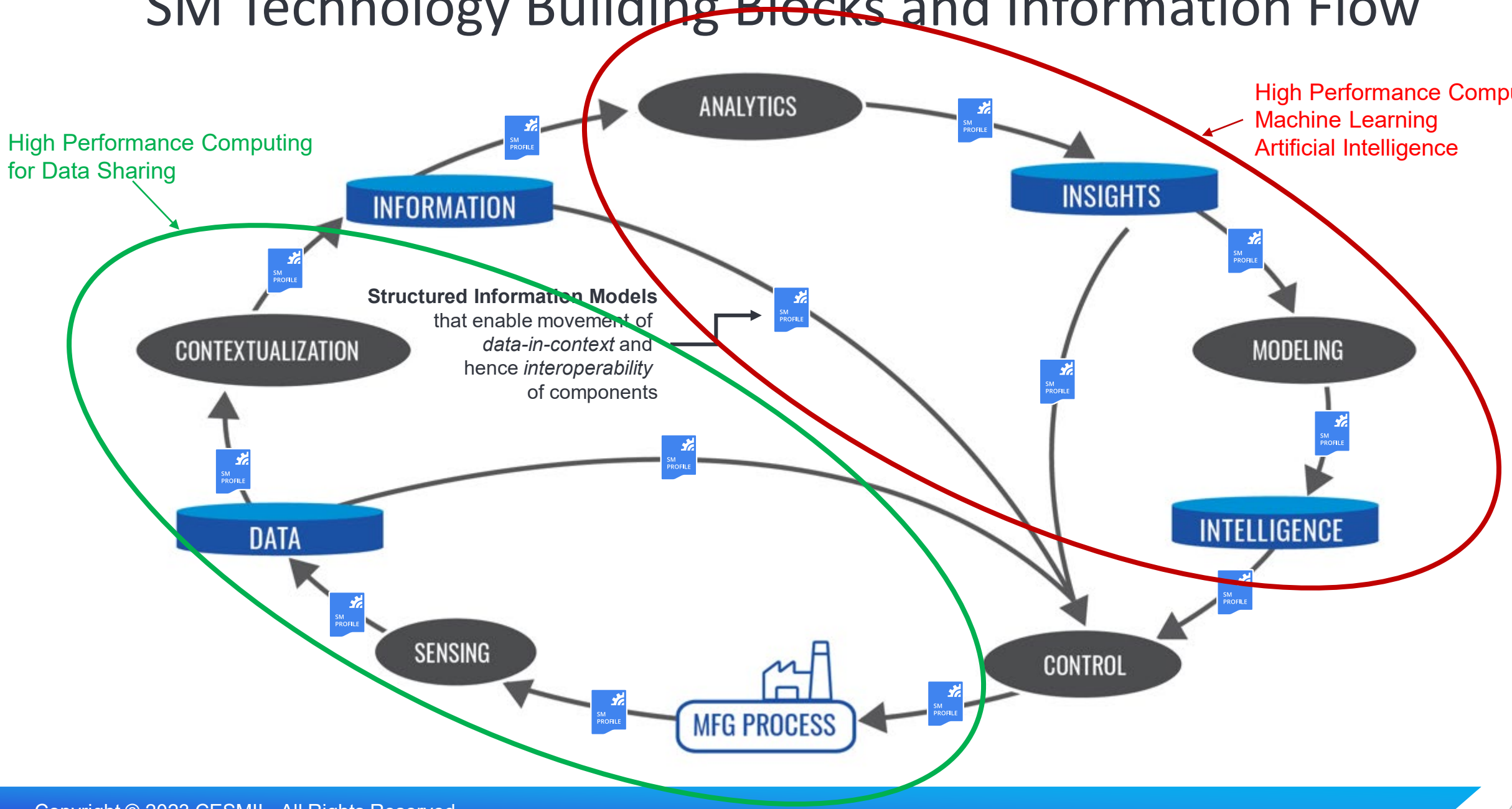
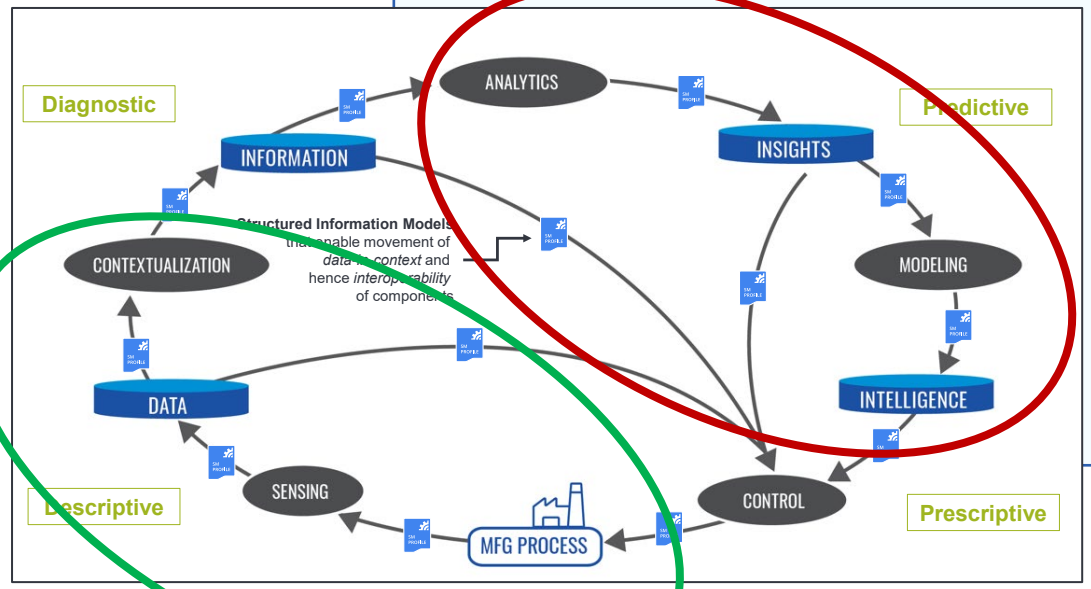
SM Technology Building Blocks and Information Flow



Leveraging HPC in CESMII



Data Driven Models

High Fidelity Models

High Performance Computing

Best Resources

Reduced Order Models

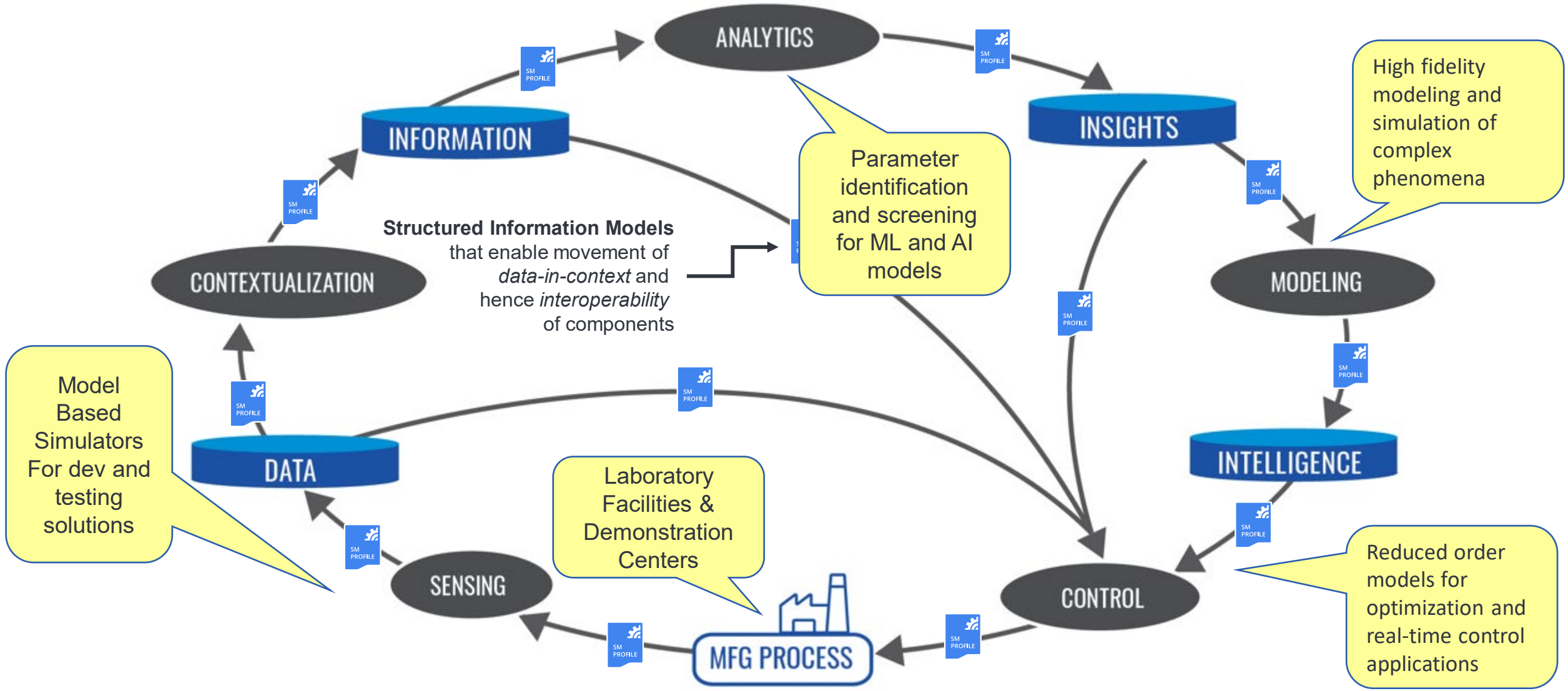
CESMII R&D

Manufacturer Needs (Predictive capabilities)

Data
Contextualization
Aggregation
Categorization
Pre -Processing

HPC = entire range of compute

Where HPC and National Labs can Collaborate



Project Examples where Modeling and ML has been used

Impacting Energy and Operational Performance Through Smart Manufacturing (SM) Technology, Innovation and Knowledge

CESMII THE SMART MANUFACTURING INSTITUTE

UCLA

SMMs

Food

Steel

Paper

Drying

Steel

Chemicals

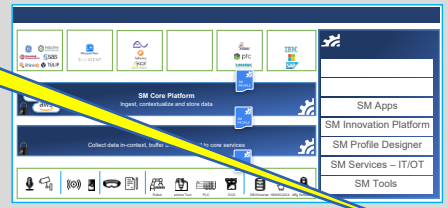
Thermal

Grinding

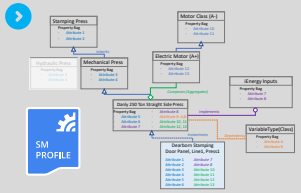
Cement

Aerospace

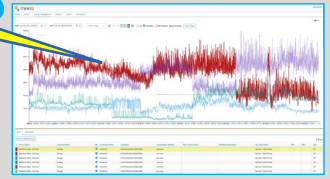
Standards based *plug and play infrastructure* for interoperability *and cost effective SM solution* implementation



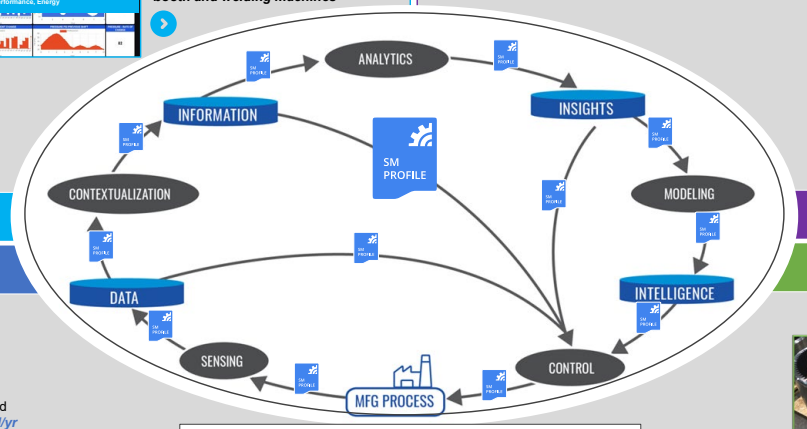
Structured Information Models (SM Profiles) that enable movement of *data-in-context* and hence *interoperability* of components



Energy Monitoring and Machine Learning Model for Energy Consumption in ***Food Industry*** leads to *5% reduction in energy waste, 25% relative improvement in yield*



Low cost hardware and reusable SM Apps to help SMMs target *10% improvement in energy intensity* and equipment efficiency on ***CNC, paint booth and welding machines***



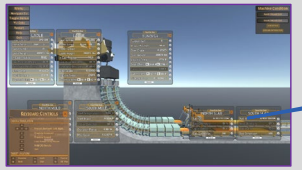
Smart Manufacturing Building Blocks

DIAGNOSTIC

DESCRIPTIVE

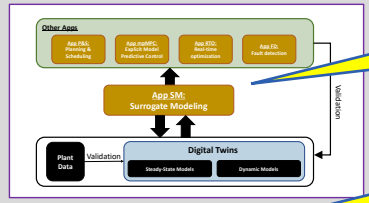
PREDICTIVE

PRESCRIPTIVE

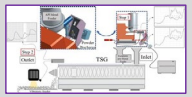


Digital Twin of a ***Steel Continuous Caster*** enables predictive maintenance *worth $2M/strand*

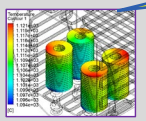
Process Prediction & Optimization Models for Air Separation Units ***(Chemical, Oil*** *10% reduction in* *consumption*



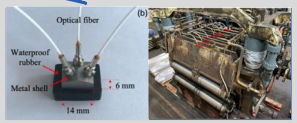
Data analytics and anomaly detection targets *5% improvement in yield* and ***5% decrease in energy consumption*** in **powder based Additive Manufacturing**



Model based process optimization results in *>30% energy reduction* in ***wet granulation in Pharma***



Monitoring, modeling and control solutions optimizes ***thermal processes for aerospace*** composite parts, *reducing energy use by 36%*



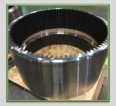
3D Displacement and Optical Strain Sensor for ***Steel Continuous Caster*** enables performance improvement and quality potentially worth *$90M/yr*

Off the shelf sensors, low cost gateway,, visualization and analysis tools to optimize cooling tunnel performance for a small food manufacturer eliminates downtime and improves quality for ***nutrition bars***

Low cost Edge hardware and computing solution using visual and process information provides ***affordable SM implementation for SMMs***

ML Based Soft Sensor for Entrained Air Content in Browstock Washing ***(Pulp and Paper)*** reduced defoamer usage by *35% and water usage by 10%*

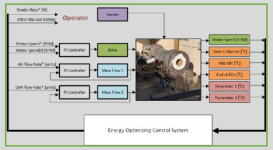
Sensing and modeling solution to reduce ***hop drying*** times by *14%, and a 10% reduction in energy usage.*



Large, Complex Industrial Gear

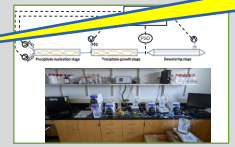
Hybrid predictive models *reduce energy consumption per part by 37%* for large ***industrial gear grinding operations***

Multi-physics predictive models and Advanced Controls lead to optimized operating conditions resulting in *10-15% reduction in energy usage* in ***Cement Kilns***



Audio & Vibration sensing, Systems level hybrid modeling, and super[illegible] control of machining [illegible]ations and tool wear prediction *results in 25% reduction in energy usage, 35% downtime*

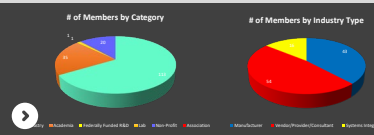
Sensing, modeling and control solution results in *elimination of impurities and water usage* in precipitation and dewatering stages for monoclonal antibodies ***bio pharma process***



SM Learning Kit with Cost effective hardware and software, complemented by training modules to upskill the SMM workforce and talent pipeline

Purdue and industrial partners created an **ABET accredited 4-yr BS Degree program** focused on SM technologies integrated with state-of-the-art facilities with industry grade equipment

National Presence – Smart Manufacturing Innovation Centers: Engage Manufacturing & Supply Chains where they are - local presence, test beds, training…



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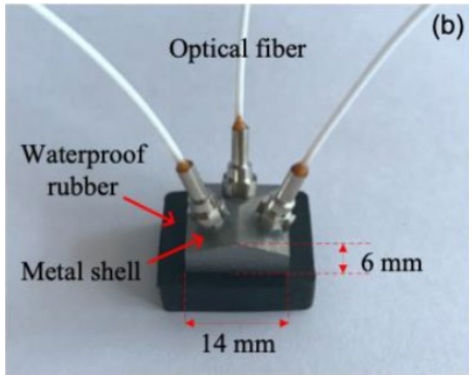
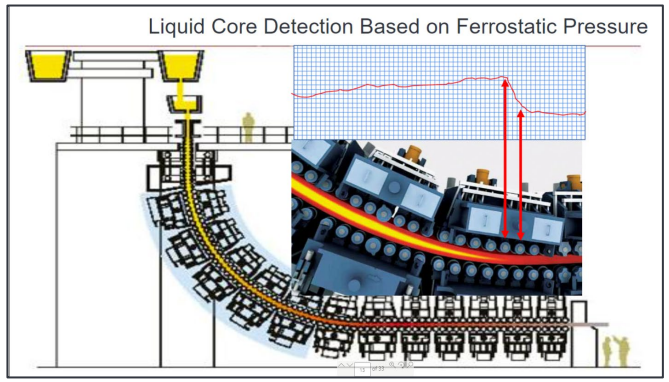
Smart Manufacturing in Steel Continuous Casting

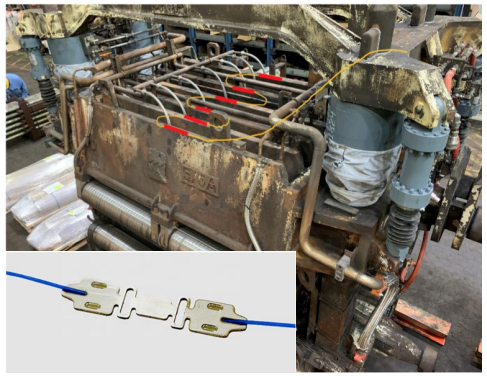
ArcelorMittal, RPI, Purdue, Missouri Science & Technology University

3D Sliding and Debonding Sensor

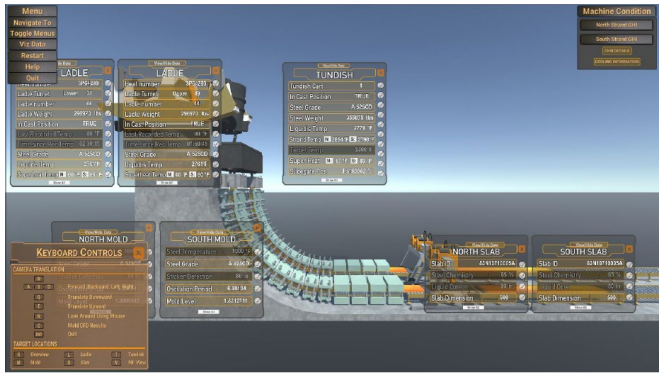


Liquid Core and Plugging Detection





Optical Strain Sensing



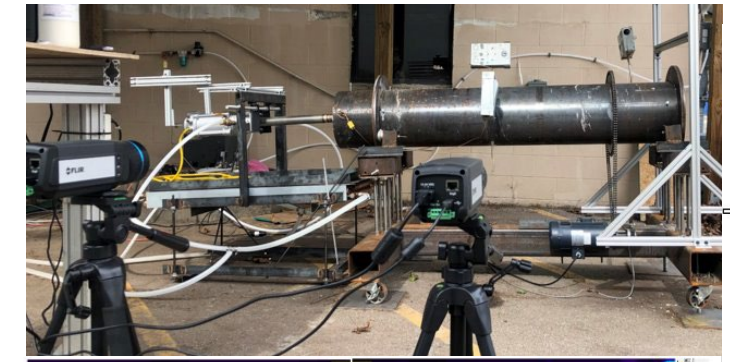
Continuous Caster Digital Twin

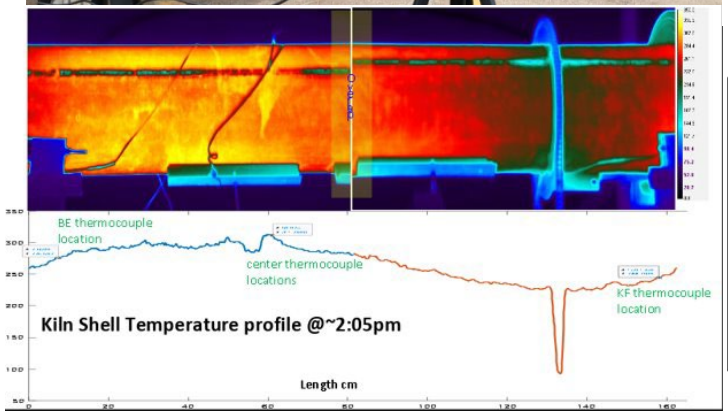
- Data acquisition infrastructure implemented and configured for caster health monitoring
- Advanced strain measurement and 3D displacement sensors to detect liquid core in continuous steel caster developed and tested
- Digital twin for simulating caster operation developed and demonstrated for maintenance applications
- Machine learning based model developed to predict caster plugging.

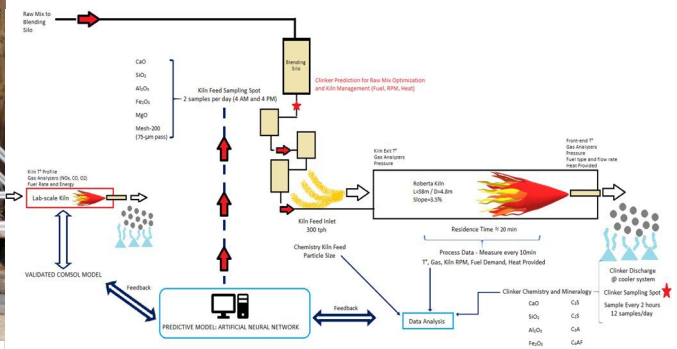
Significance and Impact: Realtime sensing and predictive modeling will improve caster performance and downstream product quality. Potential impact of $90M in energy savings for steel industry from improved quality, and $2M/strand from predictive maintenance.

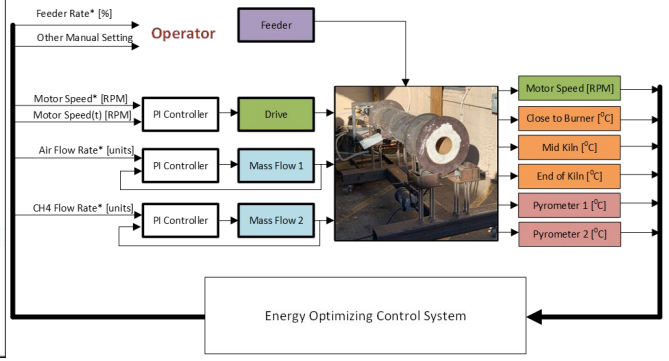
Smart Manufacturing for Cement

University of Louisville, Argos USA







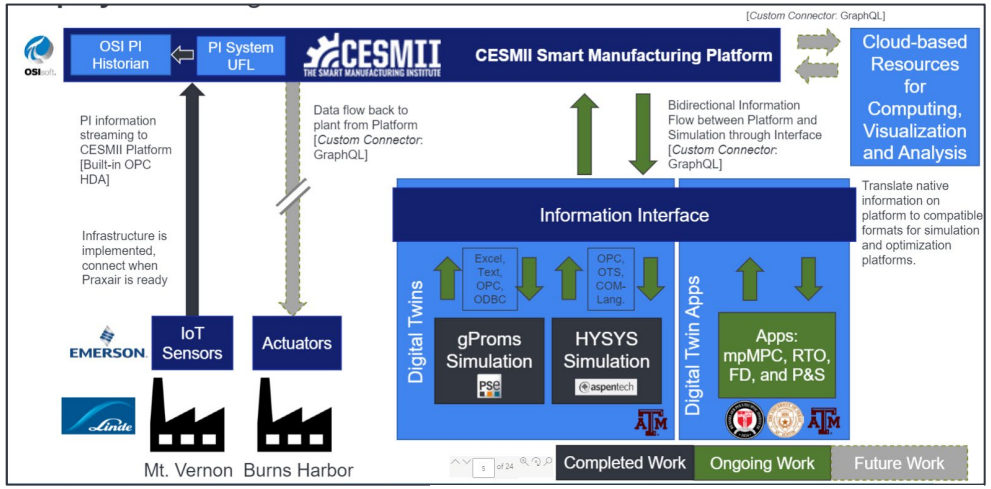


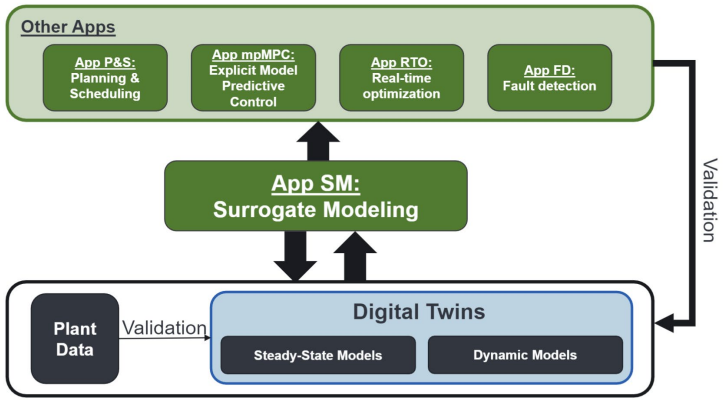
- Lab scale kiln constructed and instrumented with burner and sensors for conducting experiments
- Multi-physics thermal and flow models developed and validated with instrumented kiln
- Machine learning model developed to predict clinker quality based on operational parameters
- Real-Time Process Assessment and Control System developed for energy optimization

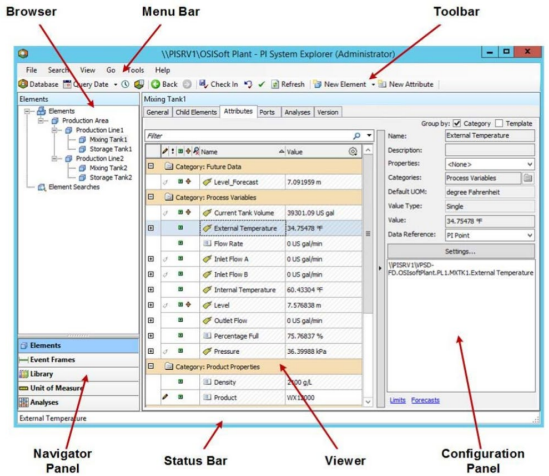
Significance and Impact: Validated multi-physics predictive models will lead to optimized operating conditions contributing to up to 15% reduction in energy usage in production kilns

Smart Manufacturing in Chemical Industry

Texas A&M, Emerson, AspenTech, PSE, RPI, OSISoft, UT Austin





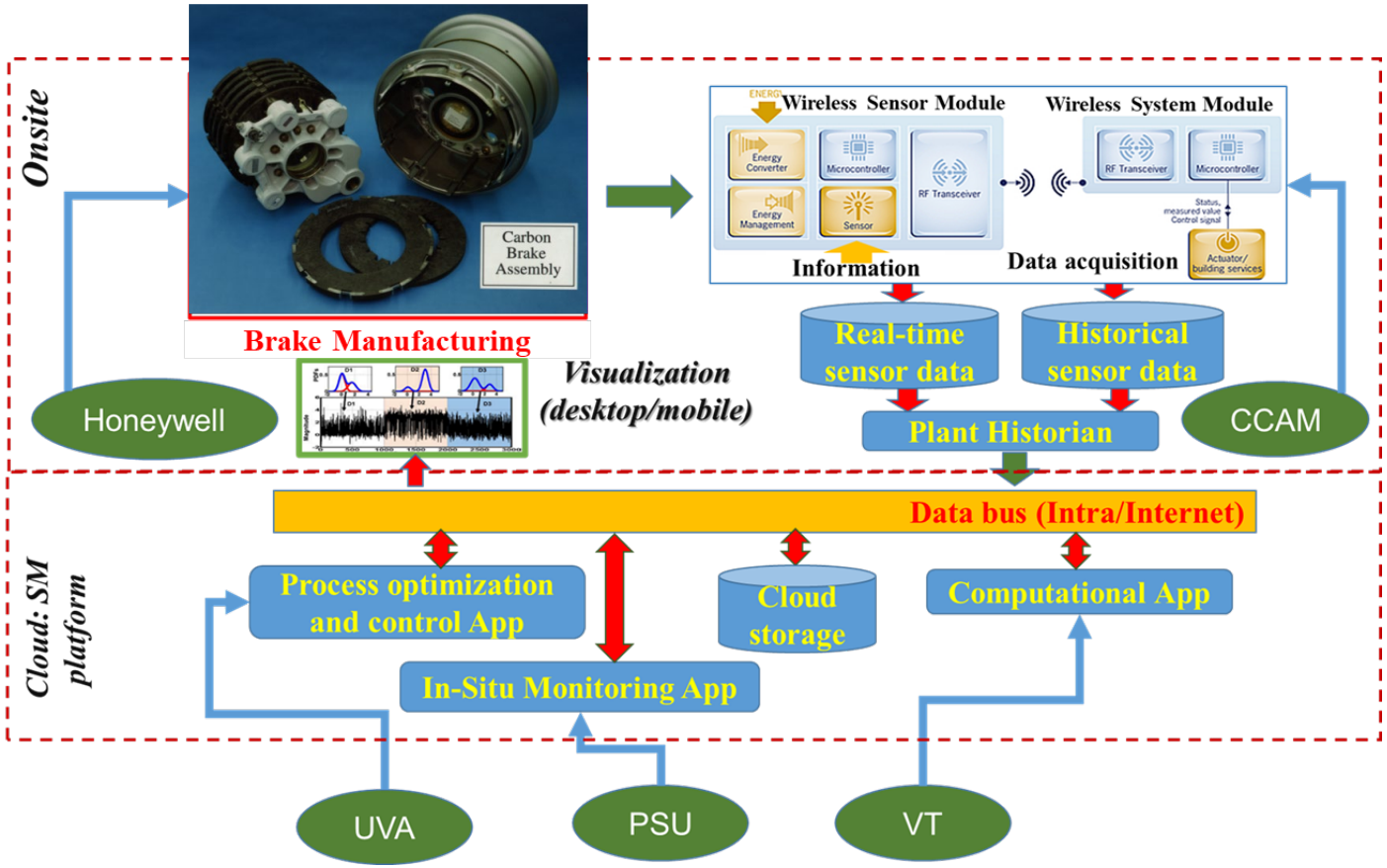


- Steady state and dynamic models (Digital twins) developed and validated for predicting operational behavior of Air Separation Unit (ASU)
- Surrogate models developed for ASU control application including fault detection, real-time optimization, scheduling and predictive control
- Real-time asset monitoring solution for the ASU and auxiliary equipment has been implemented
- Asset templates for ASU equipment developed

Significance and Impact: Predictive modeling and real-time monitoring for air separation units will lead to increase in operating efficiencies and energy savings worth $10M/yr for one large manufacturer, with potentially similar impact to other manufacturers with similar ASUs.

Smart Manufacturing in Composite Brake Mfg

Virginia Tech, Honeywell, University of Virginia, Penn State University, Commonwealth Center for Adv. Mfg.



- Data acquisition and platform infrastructure developed
- Computational Models for Energy Consumption and Product Quality Prediction developed & validated
- Process anomaly detection algorithm developed and validated
- Physics based and data driven prediction models developed and validated for process optimization

Significance and Impact: Automated process monitoring and control will lead to a reduction of 15% in energy consumption for Honeywell's CVI process

Engage with us!

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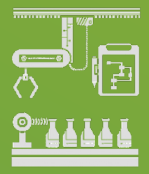
Democratizing SMART MANUFACTURING

EDUCATED, DATA-DRIVEN CULTURE



SMART ASSETS

SMART DECISIONS

OPERATIONS & SUPPLY CHAIN VISIBILITY

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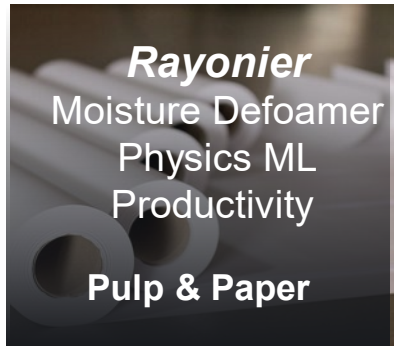
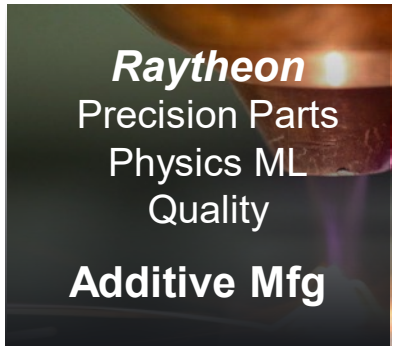
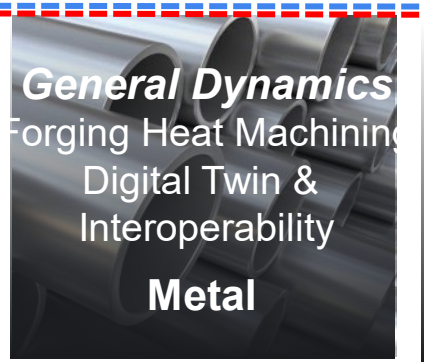
Backup

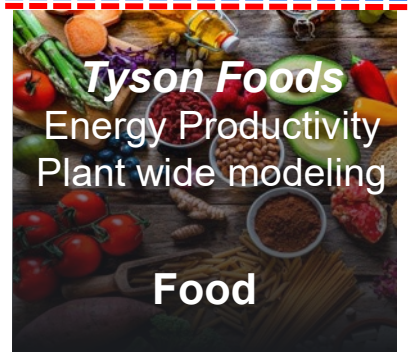
Data Centered Smart Manufacturing

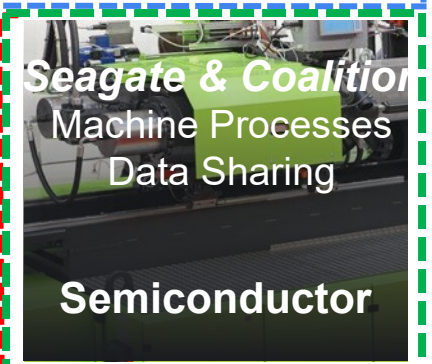
Asset Improvement | Distributed Operations | Line Operation/ Factory Improvement | Data Supply Chain

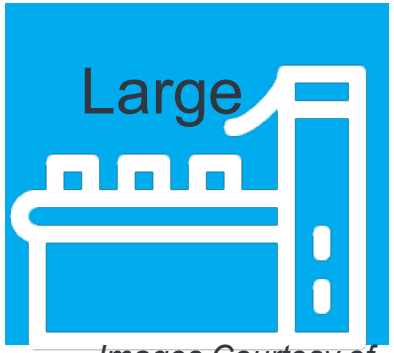












Supply Chain Interoperability | Supply Chain Resilience

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