Industrial Scale Demonstration of Smart Manufacturing Achieving Transformational Energy Productivity Gains

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AIChE, General Dynamics, Emerson, NCMS, Nimbis Services, NIST, Praxair, Schneider Electric, SMLC, UCLA & University of Texas

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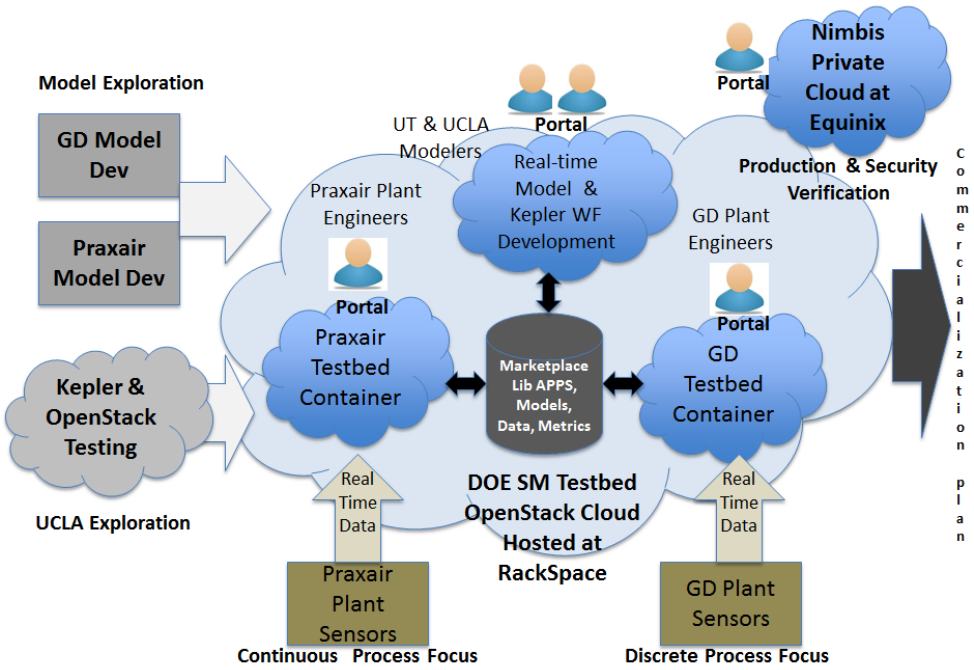
Project Objectives



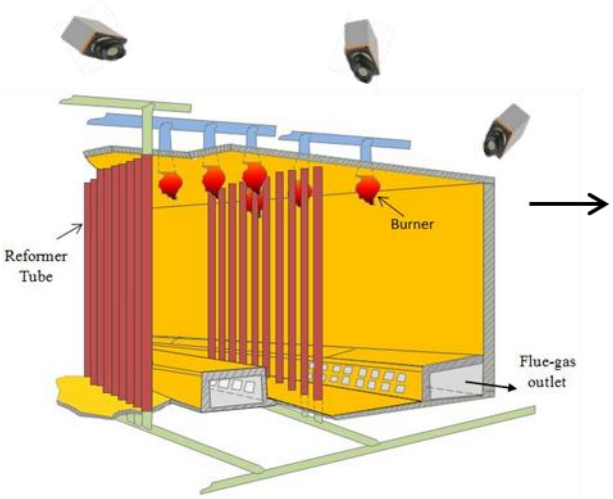
- Develop a prototype open architecture Smart Manufacturing (SM) Platform to facilitate extensive application of real-time sensor-driven data analytics, modeling and comprehensive performance metrics
- Accelerate the development, deployment and reuse of smart system applications while halving the cost

- Demonstrate SM Platform applicability, interoperability and operational security on two diverse commercial test beds at Praxair and General Dynamics. Employ new sensors, models and operating strategies to reduce waste heat.
- Develop plans to commercialize, sustain, and grow SM technology through the SM Open Platform deployment services and application libraries (apps), alignment with provider involvement, and trusted brokering of data and applications in an industry-defined Marketplace aligned with small, medium and large manufacturer requirements

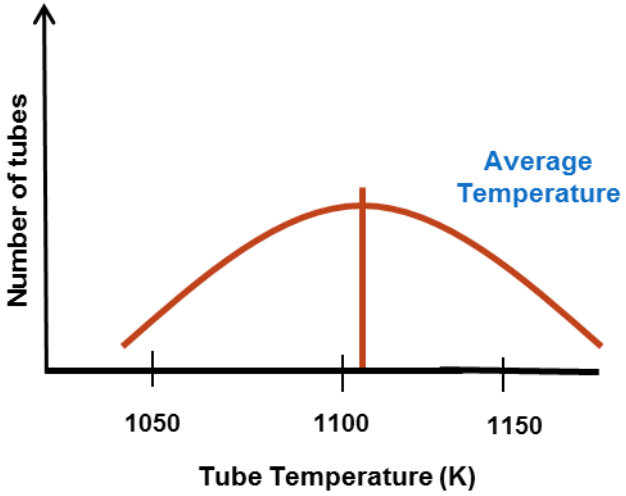
Technical Approach-Two Test Beds

- Install image-based temperature measurements on Steam-methane reforming (SMR) unit so that real-time model-based decisions can reduce energy use and increase productivity in an SMR unit. SM Platform provides configurable, multi-vendor modeling and big data management, high performance computation and storage resources, and enables high fidelity modeling and interoperability with SMR controls.

Steam-Methane Reformer Furnace



SMR Temperature Distribution

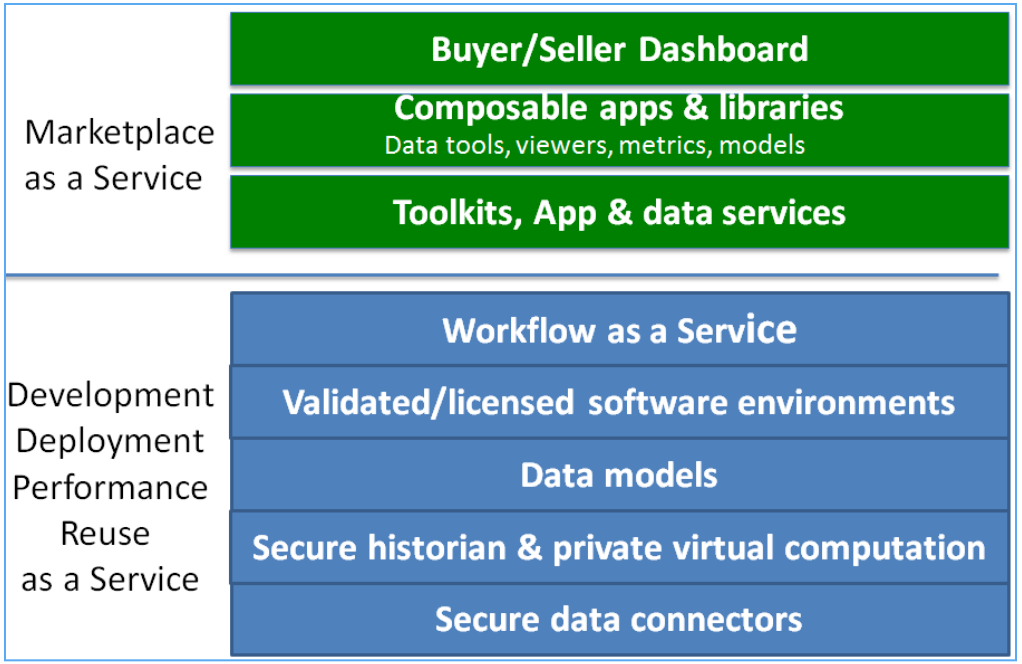


GD Production Line

- Install measurements and software to reduce energy use and increase productivity in heat treatment and machining of artillery shell casings and commercial metal parts. Deploy real-time data analytics and modeling to optimize heating and forging together with CNC machine operation. Integrate energy and product performance metrics for an entire line operation, where materials property targets are influenced by furnace/machine conditions. Interface with ISO 50001 program.

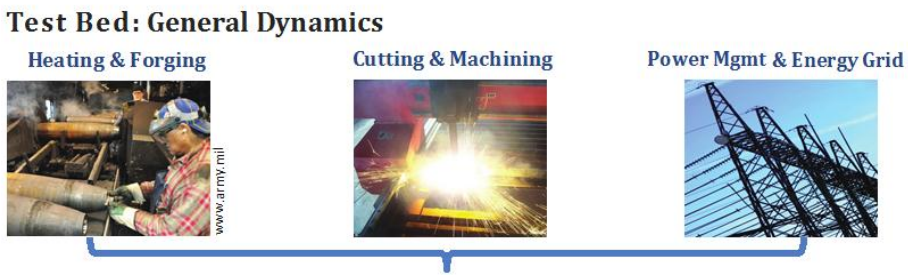
Technical Approach-Platform

- SM Platform is an innovative web-based infrastructure that marries cloud technologies with real-time manufacturing data for building dynamic enterprise systems, scaling IT infrastructure and managing software applications for local use
- Supports data analytics and manufacturing asset optimization through configurable modeling and data analysis. Models modified to exploit platform capabilities (Apps).
- Increases access to new software for real-time operational decision-making, making a broader base of software solution innovators possible
- Lowers risk, cost and barriers to entrance; accelerates development and reuse/retrofit of existing serviceable factory systems
- Manages provider neutral, trusted Marketplace access to data, apps and deployment services



Transition and Deployment

- U.S. manufacturing enterprises, value chains and ecosystems are turning to data and information to respond to dynamic markets and failures/incidents, obtain increased productivity, performance and agility; accelerated versatility with physical and cyber technology adoption; and better environment and energy productivity. Project SM offers transformational infrastructure with potentially lower cost and widespread adoption (SME's).
- Capabilities of the SM platform demonstrated with the two test beds will be translated and scaled to other SM test bed opportunities; test bed applications/metrics/sensors/ models will be reused for 18 other U.S. Praxair hydrogen plants and similar furnace applications in other companies and industry sectors.
- Industry community website will be established to include outreach, interaction, input, and co-development with communities of interest and manufacturing leaders.
- Sensor, modeling, control, and optimization results developed by UT and UCLA will be translated to other continuous, batch, and discrete industries.

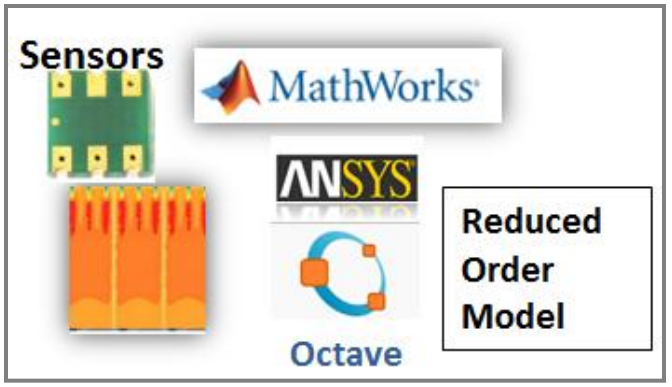


Transition and Deployment

- Commercialization of the SM Platform technology is public-private data, software, service and resource strategy promoted through Smart Manufacturing Leadership Coalition (SMLC), building on the NNMI Institutes and AMP 2.0.
- Company, commercial, open source and community software systems co-exist and change with market drivers and new technology; multiple application IP models are managed and integrated adhering to industry-accepted security standards
- Cloud based software applications are contributed and deployed from the marketplace (cloud-based) using open API standards
- Orchestration tools, infrastructure and marketplace infrastructure support integration with automation and software vendors, promoting new business solutions
- The platform service infrastructure is IP that is managed by the SMLC, licensed (e.g., SMLC members) and made available through secure public, private and hybrid cloud deployments

Measures of Success

- Use the SM Open Platform to develop and deploy a first smart system (called SM Platform modeling):
  - Development that is 50% lower cost and faster than a one-off deployment
  - Accelerated implementation of integrated performance metrics
  - Progressive expansion of system scope
  - Usable orchestration and flexibility provided for diverse company, sector, manufacturing structures, heterogeneous systems and problem areas
  - Compatible with SME, OEM and provider interests along the spectrum of what 'Open' Platform can provide and meets sufficient security criteria
- Realize improved productivity and energy reduction (30% of waste heat) at two commercial plants through use of models, advanced sensors, and controls orchestrated and optimized with smart systems

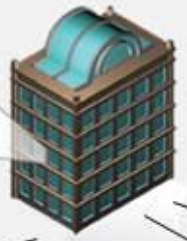


SMLC

Affordable, Accessible, Innovative and Secure Intelligent, Seamless & Collaborative Networked-Based, Smart Manufacturing

Connected Supply Chain

- Agile
- Demand Driven
- Raw Material to Finished Product



Business Systems, ERP

Safe Production

- Improved safety
- Fewer incidents
- More user friendly

Sustainable Production

- Higher value products
- Data for decision making
- Product Lifecycle Management

Supply Chain

Smart Factory

Distribution Center

Customer

Smart Grid

Energy Efficient

- Lower emissions
- Less energy used
- Green manufacturing

Optimization

- Asset Utility/Zero Downtime
- Quality/Zero Defects
- Reliable results

Project Management & Budget

- Three year project (9/1/2013 – 11/30/2016)
- 8 project tasks and 9 milestones
  - SM Platform Designs-infrastructure, security, software protocols
  - Test Bed Measurements/Sensors, Data Collection, Math Models
  - Productivity Metrics, Dashboard
  - Commercial Outreach, Marketplace, Website, Workshops, Webinars
  - Market Environmental and Energy Benefit

Total Project Budget	
DOE Investment	$7,798,383
Cost Share	$3,408,643
Project Total	$11,207,026

Results and Accomplishments

- Working prototype SM platform demonstrates orchestration of multisource data, multivendor software applications through new Workflow as a Service (WfaaS) capability and vendor agnostic infrastructure, provisioned through Open Stack cloud deployment.
- Flexible architecture provides company secure applications, data collection, and computational infrastructure with managed IP in a secure web environment; includes application connectors to diverse factory proprietary automation systems.
- Additional sensors installed and mathematical models for test bed furnaces are functional using cloud-based computing (parallelization→10 to 100 speedup); infrared camera data analyzed in framework of data-driven statistical predictions and computational fluid dynamics modeling, leading to improved sensor/control placement. Praxair purchased cameras after rental period.
- Current Platform work is building the production environment, the user and developer interfaces as web services, and state and provenance as operational services.
- Benchmarking of energy usage and other metrics, model validation, and furnace optimization.
- Strategy for marketplace and commercialization outlined.