

Industrial Scale Demonstration of Smart Manufacturing Achieving Transformational Energy Productivity Gains

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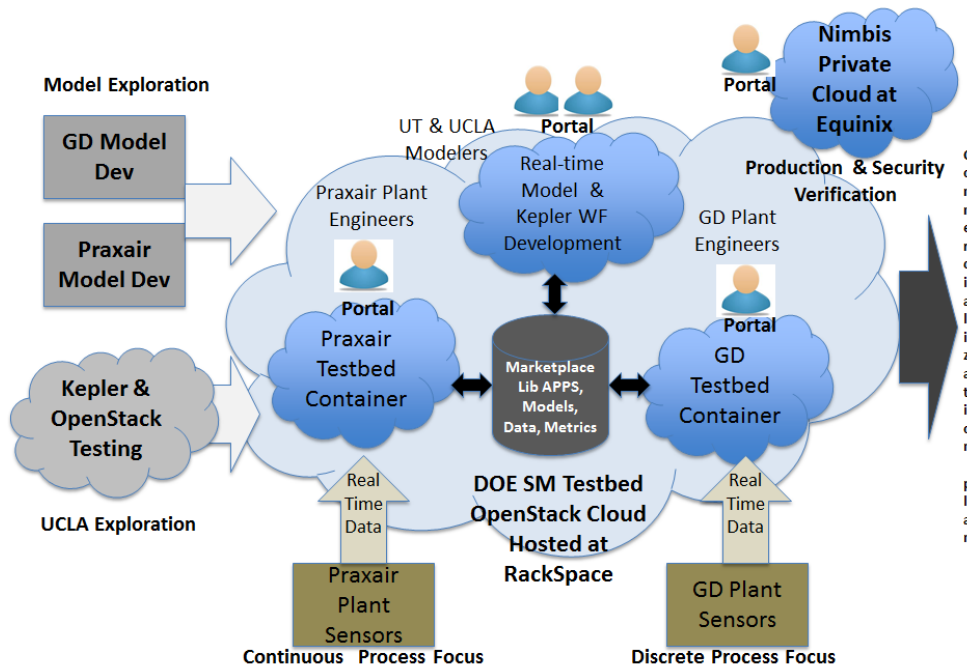
AIChE, General Dynamics, Emerson, NCMS, Nimbis Services, NIST, Praxair,
Schneider Electric, SMLC, UCLA & University of Texas
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Project Objectives



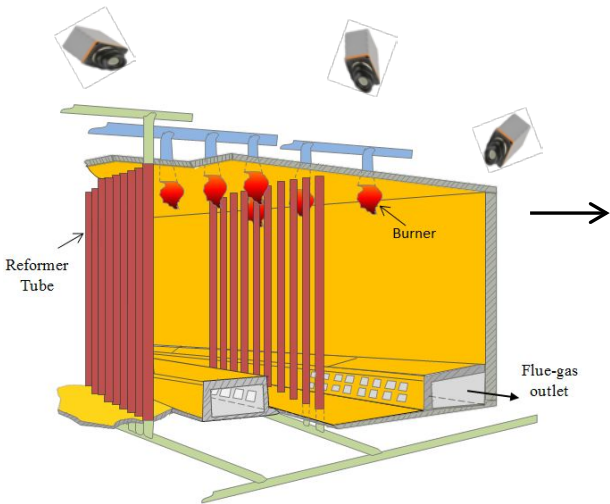
- Develop a prototype open architecture Smart Manufacturing (SM) Platform to facilitate extensive application of real-time sensor-driven data analytics, modeling and comprehensive performance metrics
- Accelerate the development, deployment and reuse of smart system applications while halving the cost

- 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) in an industry-defined Marketplace aligned with small, medium and large manufacturer requirements

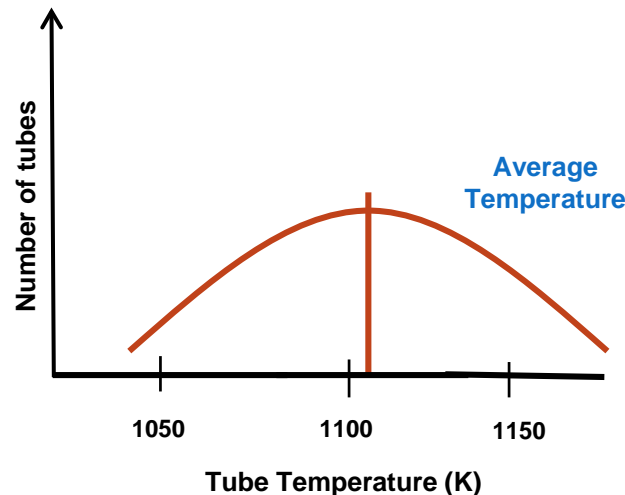
Technical Innovation-Two Test Beds

- 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 Innovation-Platform

Build a Rich Marketplace

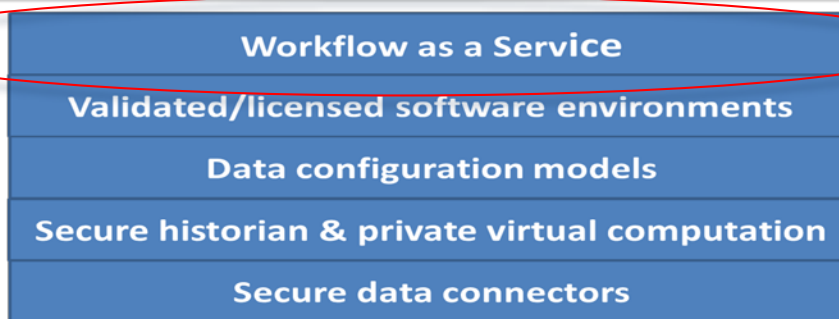
Reusable Configurations
Core Deployment Services
Trusted Data Services

WfaaS - OT/IT Construct

Marketplace
as a Service

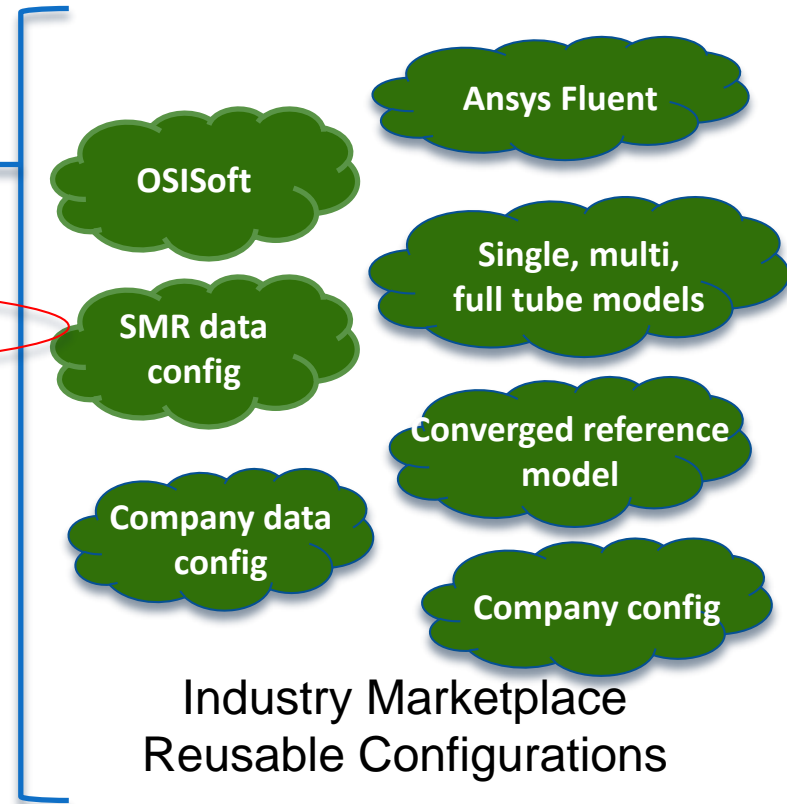


Development
Deployment
Performance
Reuse
as a Service



Cloud Integration Services

Security; Machine & Human Interfaces;
Virtual Compartments; Interoperability; Standards



Industry Marketplace
Reusable Configurations

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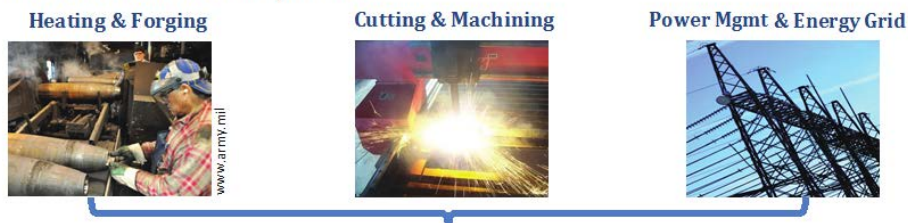
Transition (beyond DOE assistance)

- U.S. manufacturing enterprises should respond to dynamic markets and failures/incidents, obtain increased productivity, performance and agility with physical and cyber technology adoption; and reduce energy consumption. 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 (CESMII); test bed applications/metrics/sensors/ models can be reused for 18 other U.S. Praxair hydrogen plants and similar furnace applications in other companies and industry sectors.
- Industry community website 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 (CESMII).

Test Bed: Praxair



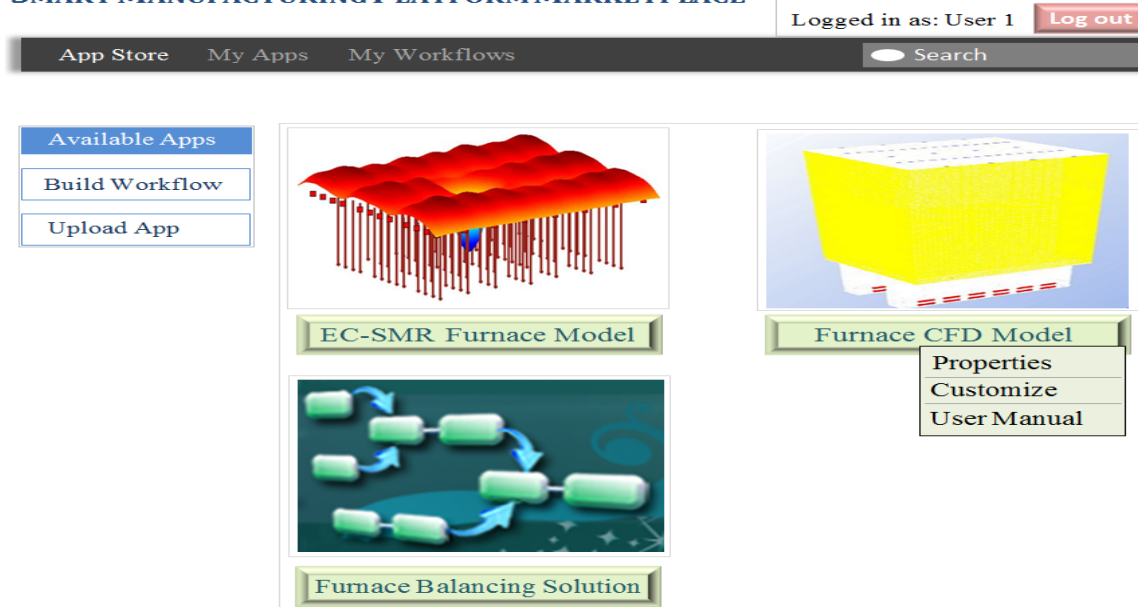
Test Bed: General Dynamics



Transition (beyond DOE assistance)

SM Platform Infrastructure

SMART MANUFACTURING PLATFORM MARKETPLACE

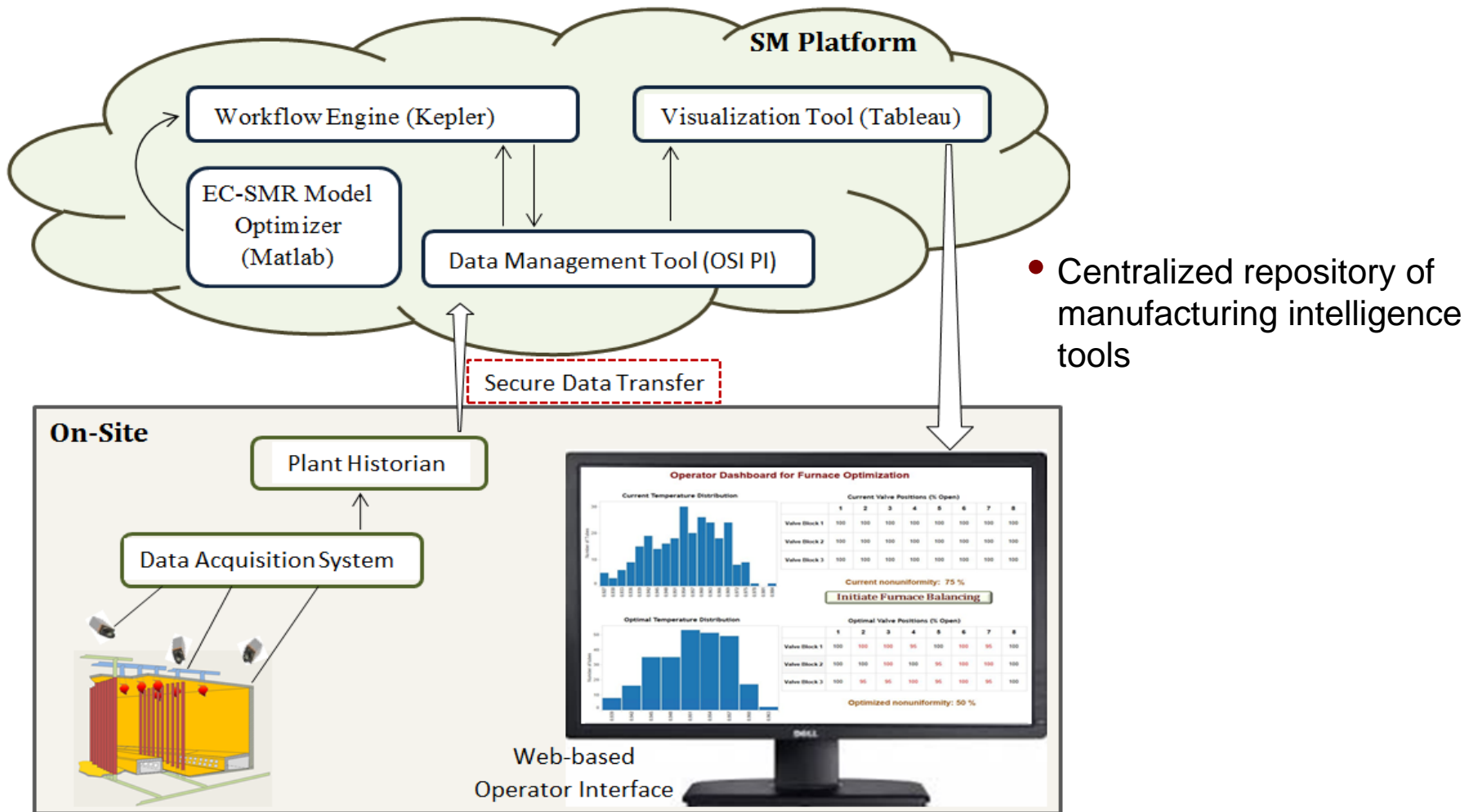


- Certified app 'configurations'
- Search engine
- Compose and reuse
- IoT for manufacturing
- DevOps for manufacturing
- Data to applications
- Trusted data, marketplace, end-to-end state services
- Continued with CESMII support

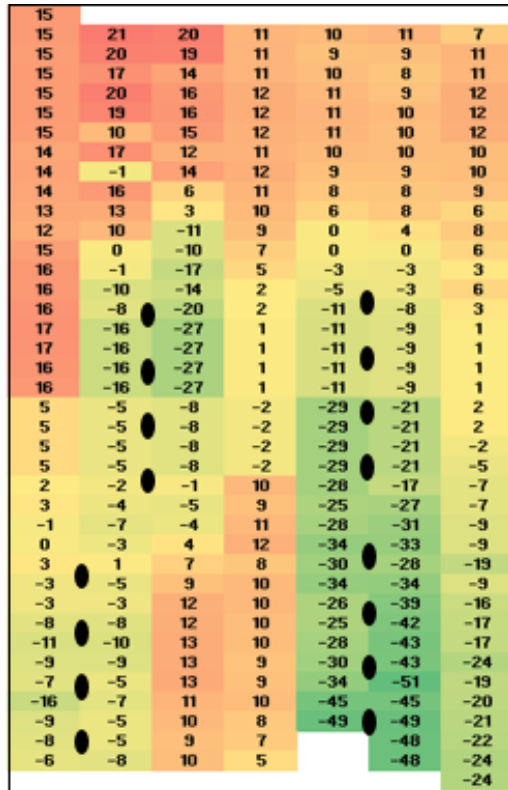


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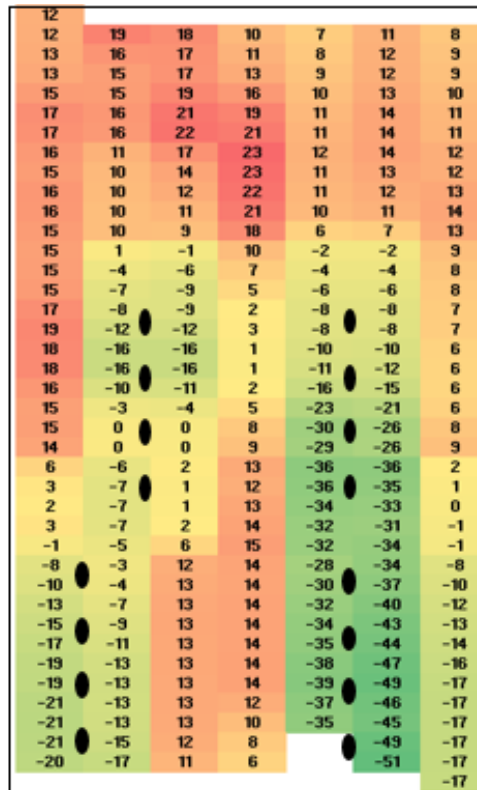
Smart Manufacturing: Cloud-based Infrastructure



Measures of Success



Observed Temperature Changes (K)



EC-SMR Model Prediction (K)

Temperature Decreases Temperature Increases

- Use the SM Open Platform to develop and deploy a first smart system:
 - Development that is 50% lower cost and faster than a one-off deployment (CESMII)
 - Accelerated implementation of integrated performance metrics (energy, quality, environment)
 - Compatible with SME, OEM and provider interests along the spectrum of what 'Open' Platform can provide and meets sufficient security criteria for diverse industries
- 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

Project Management & Budget

- Four year project (9/1/2013 – 11/30/2017)
- 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 used 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 and optimized productivity. Praxair purchased cameras after rental period.
- Current platform work transitioned into a production environment with user and developer interfaces as web services, and state and provenance as operational services.
- Benchmarking of energy usage and other metrics and model validation carried out, and heat treatment furnace and SMR operations optimized.
- Strategy for marketplace and commercialization implemented with CESMII.