The infusion of intelligence that transforms the way industries conceptualize, design and operate the manufacturing enterprise

Strategic Standards Management as a Neglected Competitive Underpinning
Northwestern University – NIST March 2013

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https://smartmanufacturingcoalition.org
http://smartmanufacturing.com
Smart Manufacturing

“Information that drives the next century’s structural shift in manufacturing.”

Smart Manufacturing Leadership Coalition (SMLC) - 501c (6)

Making real-time info available:
• when it is needed,
• where it is needed
• and in the form it is needed throughout the Manufacturing ecosystem

SMLC Partnerships

Test Beds - General Dynamics, General Mills, General Motors, Praxair, Corning, Pfizer, NETL, Alcoa, Exxon Mobil, Shell, Air Liquide, RPI/Center for Advanced Technology Systems

Design/manufacturing Platform Providers – JPL/NASA, UCLA, Rockwell, Honeywell, Emerson, Nimbis Modeling & Simulation

Materials, Design, Manufacturing – Caltech/JPL, NETL, Argonne, UCLA, UT Austin, Tulane, NCSU, CMU, Penn, Purdue Smart Manufacturing/Smart Grid – EPRI Global Performance Metrics – AIChE, ACEEE, Sustainable Solutions Agency partners – NIST, NSF Regional partners - Center for Smart Manufacturing Innovation (CA), Wisconsin Manufacturing Institute
The SMLC’s Collaboration “IP”

**SMLC: The Coalition**
- Orchestrator and oversight of the SM Platform development and use
- Industry-driven “open architecture”
- Collaboration and partnerships
  - design, implementation, assimilated use of infrastructure

**Critical collaboration based elements**
- Reference architecture and interoperability approaches
- Federation based standardization
- Defining pre-competitive and competitive
- Operating and business parameters for Apps store
- Industry driven metrics
- Industry-driven workflow service definition and structure
- Business model and transaction approach
- Risk mitigation

*SMLC has invested about $1,000,000 to date*
Smart Manufacturing Test Beds

**Design**

- Praxair dynamic energy management & cross unit performance

**Operations**

- Line and Energy Management
- Managing Power from the Smart Grid

**Supply Chain**

- General Dynamics
- Machine Function Benchmarking & Integrated

- FORD in-production
- Virtual aluminum castings
General Mills
Networked-Based Manufacturing
Intelligence & Collaborative Manufacturing

EDI transaction & quality certifications

Recipe Management
Mapping formula into operating recipes

Mapping SAP information into operation

Supply Chain

Business Systems, ERP

Smart Grid

Customer

Distribution Center

FDA Tracking & traceability

Green Light
Analyze - to put into production
Make – right ingredients – confirmation on recipe
Release – meet requirements to release

Graphics courtesy of Rockwell Automation
The Technical Basis for Collaborative Manufacturing and the SM Platform

Challenge 1
Factory and supply chain demonstrations sites of applied manufacturing intelligence

Meta 1
Integrated Workforce, Cyber, Physical System Performance
Variability Reduction
Benchmarking

Meta 2
Demand-Dynamic Customer to Source Variability Planning

Meta 3
Higher Fidelity Production
Real-time Qualification
Integrated Computational Materials Engineering
Materials & Energy Mgmt.

Meta 4
Interoperable Supply Chain Network
Control, Automation, Optimization
Management & Decision

Challenge 2
Integration of manufacturing enterprise data, control, automation, management and optimization infrastructures

Challenge 3
Real-time syncing virtual models and physical operations

Challenge 4
Precompetitive and competitive community source modeling innovation & simulation assimilation platform

Enabling New & Dormant Technologies
Existing Gaps in Today’s Manufacturing Space:

- Orchestration of standardized decision work flows
- Cross-application interoperability to achieve horizontal enterprise views & actions
- Actionable visibility across supply chain
- Predictive & real-time qualification of materials, products & actions (not after)
- Actionable multi-dimensional situational awareness
- Cross-company operational data to improve performance
- Design models in production

What is “smart” but NOT done so “smart” today
GMI’s ECO System of “STUFF”

Value Creation

Core Functions

Business Applications

Core Systems

Data Input

Master Data
(BOM, Specs, Vendor, Ingredients, FP)

Demand Driven Supply Chain

- Green Light to Convert
- Green Light to Ship
- Optimized Inventory

- Allergen/Micro WorkFlow
- eCOA

- Supplier Managed Inv
- Line Supply
- Bin Mgmt

- Overusage
- Trace/Recall
- BOM Validation
- Yard Mgmt
- Directed Work

- Production History
- Plant Floor Inventory
- Direct Consumption
- WorkFlow
- Demand Plan
- Production Order
- Line Schedule
- Lot Tracking
- Optimization Engine
- Raw Mat’l Inventory
- Finished Product Inventory

Core Systems

- MQIS
- MES
- SAP ERP
- SAP MRP
- SAP APO
- SAP PLM
- Red Prairie

Data Input
Multi-Layer Smart Manufacturing (MLSM)  
**Workflow Foundation**

**Design Data**
- Prototype
- Materials & Process Tech
- Product Manufacturing
- Qualification

**Macro Layer**
- Product Volume
- Scheduling
- Supply Chain

**Meso Layer**
- Management
- Machine Flow
- Optimization

**Micro Layer**
- Sensors/Actuators
- Control/Optimization
- Automation

**APP Store**
- Reference Flows
- Process Models
  - Control
  - Metrics

**Virtual MDSM Host**
- Dash Board
- Collaboration

**People Involved**
Integrated Metrics & Decision Making

**MDSM Program**
“Host” Manufacturing Initiatives

Conditional decisions
Model building & updates
Model insertion
Multi-Layered Smart Manufacturing Management (MLSMM)
Time Managed as Workflow Not Control
Transformational Machines – People - Materials Dynamic Manufacturing Ecosystem

10s of control loops
Control Points - ?
Manpower - X
Time – days

100s of control loops
Control Points - ?
Manpower – 10X
Time - hours

1000s of control loops
Control points - ?
Manpower – 100X
Time - minutes

Current Practice – One Pass per Day per Event; Too Late, Stale Data, Slow Responsive Manufacturing

Goals: 100x Event Variability Adjustment Capability & Dynamic Certification Improvement

Focus: Integrated metrics, Qualification, Computational Materials Engineering, High Fidelity Dynamic Operations
Workflow, Data, & Time

Smart Manufacturing Platform

Workflow

Sensor Data

Control & Automation Modeling & Simulation

Production Models

Calibration & Maintenance

Shared Data

Data collection, modeling & synchronization at Workflow level

Level 1 data collection, modeling & synchronization

Multi-scale time requirements

Embedded together

Single scale time requirement embedded in workflow

Asynchronous updating
Threading Systems Deployment Objectives Together

Data-to-Apps Paradigm for Broad Access
- Inverts current Apps to Data approach
- Facilitates big data apps
- Distributes App support
- Separates proprietary and shared
- Layers security

Composable Sensor Based SM Systems
- Apps store
- Data, metrics, models, actions, displays
- Increased 3rd party contribution
- Real-time systems across large time scales

Open Architecture
Infrastructure & Apps Store

<table>
<thead>
<tr>
<th>Data to Apps</th>
<th>Workflow-based</th>
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<tbody>
<tr>
<td>Apps Store</td>
<td>Composability</td>
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Workflow Based Architecture
- Composability & customization
- Design to manufacturing models
- Workflow libraries
- Technology insertion
Smart Manufacturing Workflow Architecture

Applications
Context
Mapping
Data

Smart Manufacturing Enabling “month-to-msec” Multi-dimensional Situational Awareness and Orchestration Across the Supply Chain

Smart Manufacturing Platform
Dashboard
Open Work Flows
Apps

Marketplace
Work Flow Apps

Company
Work Flow Apps

Shared
Data

Collected Across Sites

Production Models
Sensor Data
Calibration & Maintenance

Event Data
Time Series
WfaaS Integrated with SaaS, PaaS, IaaS

Factory Data Control & Automation Workflow

Workflow (WfaaS)
- Provisioning
- Orchestration
- Tasking
- State
- Security
- Provenance

Nimbis Services / UCLA Services
Technical Computing Marketplace

Buyer/User (SaaS)
- Buyer Dashboard
- Buyer Catalog
- Portal Apps

Seller/Provider (PaaS)
- Seller Dashboard
- Dev Tools
- Software Images

Compute Platform (IaaS)
- Cycles
- Software / Licenses
- Storage

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SM Platform Apps Store, Shared Market Place & Distribution Hub

Apps store drives practices & standards through visibility
SM Cloud Platform for Real Time Data Modeling & Simulation

Data-driven, M & S workflow

Secure Computation & Data Storage

Test Bed Crosslinking Engagements

SM Platform

Integrated Performance Metrics
Manufacturing Enterprise

Key Development Resources
Universities, SMEs, Manufacturers, Labs

Standards & Reference Architecture
IT Providers

Small & Medium Enterprises
Manufacturing Consortia
SM Platform
Implementation
Working Groups

Business Development Group
• Research study to develop business case
• Funding
• Problem definition
• SME outreach
• Support service structure
• Elevator speech for various audiences
• Communications Package, Advocacy

Platform
• Validation
• Cyber security
• Definition of open architecture
• Standards requirements
• Define a near-term demo
• App store functions
• Webinar

Test Bed
• Metrics
• Domains w/diversity
• Applications identification
• Mock ups
• Smart Grid interface
• Problem categories
• Sharing and Exchange of protocols
• Skills identification

People & Training
• Education & training (k-12, higher education, existing workforce)
• Existing workforce
• Lead the paradigm shift
• Test beds
• Public-policy & advocacy for workforce development
What is Smart Manufacturing?

A comprehensive design-manufacturing life cycle

ENTERPRISE OPTIMIZATION & SUSTAINABLE PRODUCTION
- Higher value products
- Improved quality
- Zero downtime
- Increased equipment life / utilization

ENERGY, SUSTAINABILITY, EH&S
- Improved safety
- Reduced energy and emissions
- Highly sustainable

AGILE DEMAND-DRIVEN SUPPLY CHAINS
- Higher product availability
- No inventory
- Product lifecycle management

Smart Grid
Enterprise Business System
Plantwide
Factory
Distribution Center
Customer
OEM Machine Builders
Supply Chains
Sustainable
Optimization
The infusion of intelligence that transforms the way industries conceptualize, design and operate the manufacturing enterprise.

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