Smart Manufacturing, Manufacturing Intelligence and Demand-Dynamic Performance

*Smart Manufacturing Leadership Coalition (SMLC)*

http://smartmanufacturing.com
“The second transformation? Smart manufacturing. This is the first structural shift since Henry Ford launched the economic power of "mass production."

“We are just entering an era where the very fabrication of physical things is revolutionized by emerging materials science. Engineers will soon design and build from the molecular level, optimizing features and even creating new materials, radically improving quality and reducing waste.”

“The Internet is evolving into the "cloud"—a network of thousands of data centers any one of which makes a 1990 supercomputer look antediluvian.”

“From social media to medical revolutions anchored in metadata analyses, wherein astronomical feats of data crunching enable heretofore unimaginable services and businesses, we are on the cusp of unimaginable new markets.”
21st Century Smart Manufacturing

- Demand-dynamic economics keyed on the intelligence of the ‘customer’
- Coordinated enterprise responses throughout the entire manufacturing supply chain
- Predictive, preventive
- Integrated computational materials engineering
- Performance-oriented enterprise, minimizing energy and material usage and maximizing environmental sustainability, health and safety and economic competitiveness

Dramatically intensified application of manufacturing intelligence using advanced data analytics, modeling and simulation to produce a fundamental transformation to transition/new product-based economics, flexible factories and demand-driven supply chain service enterprises
If Smart Manufacturing is such a smart idea why aren’t companies already doing it?

Already Investing in Information Technology, Automation and Controls for 40 years
SMLC Implementing 21st Century Smart Manufacturing

- Air Liquide
- Alcoa
- Applied Materials
- CH2M Hill
- Cisco
- Dow
- DuPont
- Eli Lilly
- Emerson
- ExxonMobil
- Ford
- General Dynamics
- General Mills, Inc.
- General Motors
- Honeywell International
- Invensys
- Kraft
- Merck
- Microsoft
- Oakridge National Laboratory
- Owens-Corning
- Procter & Gamble
- Pfizer
- Praxair
- Rockwell Automation
- Sematech
- Carnegie Mellon University
- Purdue
- Georgia Tech
- RENCI/North Carolina Chapel Hill
- UCLA
- University of Texas Austin
- U. Wisconsin Milwaukee School of Management
- American Council for an Energy Efficient Economy
- American Institute of Chemical Engineers
- Council on Competitiveness
- Institute of Paper Science & Technology – Georgia Tech
- Manufacturing Institute
- National Center for Manufacturing Sciences
- National Council for Advanced Manufacturing
- Putman Media
- Walt Boyes – Spitzer and Boyes
- Jim Porter – President Sustainable Operations Solutions - Chief Engineer and Vice President Engineering and Operations DuPont Company (Retired)
- Denise Swink - Consultant
Smart Manufacturing is the Application of Networked-Based Manufacturing Intelligence & Integrated Performance Metrics

Actionable business & operations tradeoffs

Praxair Exxon Mobil

Untapped degrees of Freedom: performance, efficiency & productivity

General Mills

Anticipate, plan, manage risk across suppliers

Business Systems, ERP

Tracking & traceability

Customer

New forms benchmarking

General Dynamics

Computational Materials Engineering
High Fidelity Materials & Product Management

Praxair ExxonMobil

GM General Mills

GE

Supply Chain

Smart Grid

Smart Factory

Distribution Center

GM General Mills

GE

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Performance and Demand Dynamics

New real-time global Performance metrics –
• customization
• energy performance
• reuse

• Less vertically integrated
• More information driven
• Workforce ecosystem

• Customers “pushing” demands
• Flexible production - smaller volumes of custom products
Multi-Dimension Smart Manufacturing (MDSM)
“One-to-Many” - Manufacturing Across the Seams”

Design Data

Prototype
Materials & Process Tech
Product Manufacturing
Qualification

In Service

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

MDSM Program
“Host” Manufacturing Initiatives
Multi-Layered Smart Manufacturing Management (MLSMM)

Transformational Machines – People - Materials Dynamic Manufacturing Ecosystem

Meta Models

Prototype

Materials & Process Tech

Product Manufacturing

Qualification

AVM

1000s of control loops
Control Points - ?
Manpower – 10X
Time - minutes

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

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

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: Manufacturing & Qualification

Targets: Additive Manufacturing and Casting/Forging
Multi-Dimension Smart Manufacturing (MDSM) Challenges!

Challenge 1 – Workforce, Cyber, Physical Performance, Reduced Variability
Physical Test Bed/ At Scale Factory and Supply Chain Demonstrations of Applied Manufacturing Intelligence
• Scalable, secure, selective data and model interoperability cross-industry environment
• Configurable distributed workforce physical system framework for best practice distributed optimization, decision and automation across the micro, meso and macro range
• Configurable integrated performance metrics meeting company and industry requirements across the micro, meso and macro layers

Challenge 2 – Source to Customer Optimization Framework
Multidimensional integration of manufacturing enterprise data, control, automation, management and optimization infrastructures
• Architectures for integrated micro, meso and macro time scale data collection, data management, modeling, action and completion agreement
• Increased macro layer planning and qualification passes
• Data and modeling interoperability with vendor applications and provider platforms
• Secure interoperability with shared service hubs

Challenge 3 Multi-Dimensional Ecosystem - Real-time Syncing Virtual Models and Physical Operations
Integrated service framework for:
• Real-time validation and measurements
• Coordinated synchronization of micro, mesa and macro models at right time scales
• Task agreements between virtual models and physical operations & between micro, meso and macro layers
• Actionable windows in time and computational tractability

Challenge 4 Dynamic Supply Chain Intelligence
Precompetitive and competitive Factory and Supply Chain Community Source Modeling Innovation & Simulation Assimilation Platform
• Common infrastructure for real-time data-driven models that supports lite application layer
• Composable data, modeling and metrics ‘apps’ at application layer
• New modeling and simulation marketplace contribution and distribution architecture
Scaling a Multi-Dimensional Smart Manufacturing Infrastructure

**Challenge 1**
Physical Test Bed/At Scale Factory and Supply Chain Demonstrations of Applied Manufacturing Intelligence

**Meta 1**
Integrated Workforce, Cyber, Physical System (WCPS) Performance & Variability Reduction

**Multi-Dimensional Smart Manufacturing**
Virtual Manufacturing Demonstration Facility HUB

**Challenge 2**
Multidimensional integration of manufacturing enterprise data, control, automation, management and optimization infrastructures

**Meta 2**
Demand-Dynamic Customer to Source, Variability Adjustment, More Planning Passes

**Meta 3**
Real-time Qualification Integrated Computational Materials Engineering High Fidelity Production & Materials Operations

**Challenge 3**
Real-time Syncing Virtual Models and Physical Operations

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

**Challenge 4**
Precompetitive and competitive Factory and Supply Chain Community Source Modeling Innovation & Simulation Assimilation Platform

Enabling New & Dormant Technologies
Smart Manufacturing Platform
Infrastructure for Real-Time Data Driven
Modeling and Simulation

- Variability Management
  Real-time Plan Passes
- Community Source Resources
- Pre-competitive & Competitive Hub
- Apps Store Cloud Services
- Benchmarking Rapid Qualification ICME
- Standards and Reference Architecture IT Providers

SMLC Industry-Driven
Integrated Performance Metrics
Micro, Meso, Macro

SMEs
Small & Medium Enterprises
Manufacturing Consortia

Real-time Data & Modeling Workflow & Metric Toolkit/App Development

Key Development Resources
- Universities, SME’s Manufacturers, Labs

Community Source Market Place

Real Time Virtual Manufacturing Demonstration Facility (VMDF)
Applying the SM Platform

Performance Management Data & Modeling Workflow

Process sensor data

Data and Computation

Management Dashboard

Ref Arch Data Collection Manufacturer
Ref Arch Data Collection Supplier

Manufacturer Real-time
Manufacturer Data Warehouse

Local/Global Integrated Productivity Metric Dash Board

SM Platform Data and Computation Services

Encrypted links

Data Validation App
EPM App from Toolkit
Risk Scenarios App

Real-time Action & Risk Support App

Reduced Order Model Scenarios App

Linked Apps to Form Function
Smart Manufacturing

http://smartmanufacturingcoalition.com