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

Smart Manufacturing and Sustainability

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SMLC Board

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

All information about the manufacturing process available when it is needed, where it is needed, and in the form that it is needed.
Our customers demand capital discipline and high reliability.

Our goal is to meet their demands and maintain high energy efficiency.
Smart Manufacturing Helps Meet Our Goals

• Low cost sensors and wireless enable real time decisions

• Hosted computing improves results at a lower cost

• Common infrastructure facilitates supply chain collaboration
Machine Operations & Line Management Trade-Offs

General Dynamics

Machine Function Benchmarking & Integrated Line and Energy Management

Managing Power from the Grid
General Mills

- Customers “pushing” demands
- Tracking & Traceability

Farming

Supply Chain

Manufacturing Plant

Distributor

Customer
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

Smart Factory

Customer

Distribution Center

FDA Tracking & traceability

Green Light
Analyze - to put into production
Make – right ingredients – confirmation on recipe
Release – meet requirements to release
Test Bed Generated SM Systems

Smart Machine Operations
- In production machine-product management
- Benchmarking machine-product interactions
- Integrated dynamic management of machine-electrical power interactions
- Adaptable machine configurations

In Production Use of High Fidelity Modeling and Simulation
- High fidelity modeling for better management
- Rapid qualification of components and products

In Production Decision Making with Global Integrated Metrics
- Dynamic Business and Operational Tradeoff Decision-Making
- Dynamic performance management of global integrated metrics
- Untapped cross factory degrees of freedom for optimizing efficiency and performance and compressing time

Supply Chain Management
- Supply chain variability reduction and management of risk
- Tracking and traceability

Design and Engineering
- Integrated product and manufacturability design
- New product and product transition planning
SMLC Commitment to a Comprehensive Approach

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

Suppliers

Enterprise Business System

Factory

OEM Machine Builders

Distribution Center

Customer

Suppliers
Whereas productivity measures are used to improve a “linear” process

Efficiency measures are used to improve a “closed loop” process

Advanced modeling and software simulation are critical to improve the efficiency of very complex closed loop processes

The transformation of IT-connected manufacturing to optimized plants & supply networks may be essential to efficiently manage this vision

Source: Yale University’s School of Forestry & Environmental Studies’ Center for Industrial Ecology
Multi-Layer Smart Manufacturing (MLSM)

**Workflow Foundation**

- **Prototype**
  - Design
  - Data

- **Materials & Process Tech**
  - Macro Layer
    - Product Volume
    - Scheduling
    - Supply Chain
  - Meso Layer
    - Management
    - Machine Flow
    - Optimization
  - Micro Layer
    - Sensors/Actuators
    - Control/Optimization
    - Automation

- **Product Manufacturing**
  - APP Store
    - Reference Flows
    - Process Models
      - Control
      - Metrics
  - People Involved
    - Integrated Metrics & Decision Making

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

- **In Service**
  - Macro Layer
  - Meso Layer
  - Micro Layer
  - People Involved

Conditional decisions
Model building & updates
Model insertion

MDSM Program
“Host” Manufacturing Initiatives
SMLC Concept

Workflow as a Service (WFaaS)

Factory Data Control & Automation Workflow

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

Application Instances

Meta Models

- Prototype
- Materials & Process Tech
- Product Manufacturing
- Qualification

Macro Layer
- 10s of control loops
  - Control Points: ?
  - Manpower: X
  - Time: days

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

Microlayer
- 1000s of control loops
  - Control Points: ?
  - Manpower: 1000X
  - Time: minutes

Proprietary Workflow
WfaaS Integrated with SaaS, PaaS, IaaS

Factory Data Control & Automation Workflow

Workflow (WfaaS)
- Provisioning
- Orchestration
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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

10x 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

Proprietary Workflow
SM Platform Apps Store, Shared Market Place & Distribution Hub

Multiple Service Environments

Figure 2: SM Platform Apps Store, Shared Market Place, and Distribution Hub for Manufacturers
“Apps” Store

- Process & Line Set Point Conditions
- Check Table Optimal Machine Usage
- Calculate Machine, Energy, Product Metric
- Dashboard Recommend Tradeoff Points

- CFD Preprocessing
- CFD Runs
- Update ROM using CFD Output
- Offline Simulation with ROM

- CFD Preprocessing
- CFD Runs

- Workflow Components
- Machine, Energy, Product Metric

- Data Definition Maps
- CFD
- ROM Template for SMR
- Machine energy usage calculation

- Integrated Metric
- Library of Workflows
- ROM Sync
- App Toolkits
- Apps as a Service
- Apps as code module
First Concept of the Smart Manufacturing Platform

Infrastructure for Real-Time Data Driven Modeling and Simulation

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

Key Development Resources Universities, SME’s Manufacturers, Labs

Variability Management Real-time Plan Passes

Community Source Resources Pre-competitive & Competitive Hub

Apps Store Cloud Services Benchmarking Rapid Qualification ICME

SMEs Small & Medium Enterprises Manufacturing Consortia

Test Bed Manufacturer & Supplier Crosslinking Engagements

Standards and Reference Architecture IT Providers

Community Source Market Place

Real Time Virtual Manufacturing Demonstration Facility (VMDF)
Smart Manufacturing Encompasses

- Cyber Systems
- Materials & Product Design & Engineering
- Control, Automation, In-production Management
- Engineering Resilient Systems
- Manufacturing Process Technologies
- Work Force Systems
- Physical Systems

Smart Manufacturing Enables

Smart Manufacturing = Cyber Physical

Smart Manufacturing Integrates
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