Smart Manufacturing Workgroup

The Motivation, Vision and Call to Action for Capital Programs and Process, Batch and Discrete Manufacturing

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Can I call you back?
The “Big” Business Case

- Economic viability
- National security

Manufacturing …central and irreplaceable core of a strong, secure economy.
The Business Case from SPM Workshops

• Increased focus on EH & S compliance and risks of non-compliance
• Increased pressure to manage risk and uncertainty
• Heightened need for more than incremental energy and raw materials reductions
• Faster and more product transitions to realize economic value
• Enterprise management in response to globalization
• Changing workforce and need to use workforce more strategically
• Pressures to minimize environmental impacts
• Heightened social consciousness
• Resiliency - pressure to increase responsiveness to faults and changing conditions

*Dynamic demands accelerating on manufacturing*
OPERATIONALLY EXCELLENT COMPANIES OUTPERFORM

OPERATIONALLY EXCELLENT COMPANIES CONSISTENTLY OUTPERFORMED THE MARKET IN SHAREHOLDER VALUE CREATION

- Industry Week Global 1000 Financials
- Qualitative views on operations

Screened list (44 US companies) for financial analysis

Excellence filter

12 "Excellent" Companies

Average TRS

3X TRS performance relative to market

"Excellent" (Discovery List)

"Excellent" S&P 500 Industrials

S&P 500 Industrials

Wilshire Index

### The Business Case for a User-Provider Approach

<table>
<thead>
<tr>
<th>Industry</th>
<th>Provider</th>
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</thead>
<tbody>
<tr>
<td>• Global competitiveness of existing assets</td>
<td>• Must understand multi-company “industry vision” for future facilities</td>
</tr>
<tr>
<td>• Installed base of equipment nearing obsolescence</td>
<td>• Large percentage of installed base of automation equipment nearing obsolescence</td>
</tr>
<tr>
<td>• High capital and operations costs</td>
<td>• Must understand how safe, reliable, quality and profitable interrelate</td>
</tr>
<tr>
<td>• Energy and sustainability issues</td>
<td>• Teaming with users on early development and co-development leverages and lowers total cost</td>
</tr>
<tr>
<td>• Multi-faceted objectives</td>
<td>• Must understand own future resource needs</td>
</tr>
<tr>
<td>– Zero EH&amp;S and Process incidents</td>
<td></td>
</tr>
<tr>
<td>– Reliability and risk management</td>
<td></td>
</tr>
<tr>
<td>– Effective risk management</td>
<td></td>
</tr>
<tr>
<td>– Resilient/fault tolerant operations</td>
<td></td>
</tr>
<tr>
<td>– Quality of products</td>
<td></td>
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<tr>
<td>– Cost Effectiveness</td>
<td></td>
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<td>– Asset productivity</td>
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Managing Risk & Uncertainty

- Business decisions should be informed with both business and operational uncertainty and risks
- Plant operations should be able to “dial in” along the spectrum of risk
- Grade and product transitions should be optimized for situational economic, environmental and energy impacts
- Operational decisions should be informed by risk of instability
- Responses to abnormal situations should be informed by risk and uncertainty in operating limits and constraints

Resilient Operations Requires Increased Emphasis on Risk Management
Risk Domains

Used with permission, DuPont
Risk Management Transformation

Traditional Risk Management

• Risks as individual hazards
• Risk identification and assessment
• Focus on all risks
• Risk mitigation
• Risk limits
• Risks with no owners
• Haphazard risk quantification
• Risk is not my responsibility

Enterprise Risk Management

• Risk in context of business strategy
• Risk “portfolio” development
• Focus on critical risks
• Risk optimization
• Risk strategy
• Defined risk responsibilities
• Monitoring and measurement
• Risk is everyone’s responsibility
Key Business Transformations

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment in Facilities</td>
<td>Investment in Knowledge-Embedded Facilities</td>
<td>Investment and management of facilities and knowledge are equally important.</td>
</tr>
<tr>
<td>Reactive</td>
<td>Proactive</td>
<td>Economic optimization is achieved by anticipation and decision, understanding probability, risk and impact.</td>
</tr>
<tr>
<td>Response</td>
<td>Prevention</td>
<td>Sensing, modeling and analysis are used to predict events and operations are controlled to mitigate the impact.</td>
</tr>
<tr>
<td>Compliance</td>
<td>Performance</td>
<td>Zero-incident EH&amp;S is part of the performance culture.</td>
</tr>
<tr>
<td>Tactical</td>
<td>Strategic</td>
<td>Requirements become opportunities, optimizing total enterprise operation.</td>
</tr>
<tr>
<td>Local</td>
<td>Global</td>
<td>Every decision must be made in the context of a globally competitive environment.</td>
</tr>
</tbody>
</table>
## Key Technical Transformations

<table>
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<tr>
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<th>To</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-off Models in Operations</td>
<td>Models integrated into Operations</td>
<td>Pervasive, coordinated, consistent and managed application of models</td>
</tr>
<tr>
<td>Dispersed Intelligence</td>
<td>Distributed Intelligence</td>
<td>Data, information, knowledge, models and expertise available and used to make decisions at the right time and place</td>
</tr>
<tr>
<td>Unintelligent systems</td>
<td>Self-aware Systems</td>
<td>Autonomous systems that understand role and performance in enterprise; systems that take action to optimize role</td>
</tr>
<tr>
<td>Proprietary Systems</td>
<td>Interoperable Systems</td>
<td>Systems that communicate through standard protocols for information sharing, capability and best-in-class components</td>
</tr>
<tr>
<td>Unpredictable Industry</td>
<td>Predictable Industry</td>
<td>Operations within defined operating envelopes with predictable impacts</td>
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</table>
Excellent Work Underway
Resilient Proactive Plant Operations

Knowledge-enabled Workforce in Global Operation

Smart Process

Smart Manufacturing Process

People, Knowledge and Models to a Combined Key Performance Indicator

Key Plant Assets to Global Application

Key Plant Assets to Enterprise Application

Knowledge to Operating Models

Data To Knowledge
Develop standards and tools to enable communication in process manufacturing

Get the data. Enable better control, design next-generation actuator/sensor networks for improved model-based state estimation and bias detection knowledge

Apply standard approaches to model the process manufacturing enterprise and its activities
Implement approaches to develop, manage, and validate models.

Enable rapid modeling and evaluation of molecular-based properties.

Develop algorithms for real-time, large-scale operation.

Develop tools for fault detection/isolation and root cause analysis.

Knowledge to Operating Models
Develop knowledge and data models for data-driven equipment asset lifecycle management

Develop intelligent real-time tools to manage transitions and respond to process and performance threats

Models to Key Plant Assets to Enterprise Application

Develop and maintain models as key corporate assets

Develop intelligent real-time tools to manage transitions and respond to process and performance threats

Enable equipment assets in process operations to autonomously recognize and respond to situations

Develop plant-wide status data visualization
A Fundamental Transformation Results

- Distributed intelligent manufacturing
- Explicit management of risk and uncertainty
- Distributed business and operating intelligence to units through integrated models
- Resilient Plant Operation
Create universal metrics to evaluate and integrate global processes

Integrate enterprise- and plant-level planning for multi-objective optimization

Models as Key Plant Assets to Global Applications

Develop techniques and standards for integrating across the supply chain

Standardize cross-industry best practices and tools
Provide comprehensive knowledge capture and knowledge management solutions

Enhance new employee development

Develop Augmented Key Performance Indicators

Reassess curricula and pedagogy, and provide life-long learning

On-the-job training for process manufacturing
Smart Manufacturing Transformation

- Ultimate "meaningful use" is to create significant and measurable improvements in U.S. manufacturing competitiveness through highly-optimized, dynamic demand-driven and sustainable industrial plants and supply chains enabled by information and knowledge technologies.

- Key goals:
  - Move to proactive operations and life-cycle management to optimize manufacturing economics, quality, safety and efficiency
  - Drive energy, sustainability, EH&S and economic agility into meaningful integrated manufacturing performance criteria
  - Transform manufacturing from fixed, supplier-driven production to dynamic demand-driven production
  - Enable sustainable production of nationally strategic goods (e.g., Bio/Nano, Clean Energy, Green/Tech, and DOD needs.)
  - Increase U.S. manufacturing competitiveness and exports
  - Revitalize the 21st Century industrial community model
Longer-term Smart Manufacturing Metrics & Goals

- **Workplace and Process Safety**: Zero injuries or incidents by 20xx
- **Competitiveness**: Average cost of manufacturing in key U.S. industrial sectors equivalent to average costs in other nations (*level the playing field with Smart Manufacturing efficiencies*)
- 40% higher exports by 20xx
- **Flexibility**: 30% faster time-to-market by 20xx
- **Energy**: 20% reduction by 2020
- **Environmental**: Zero emissions by 20xx
- **Water**: XX% reduction by 20XX
- **Information Flow**: Carbon footprint listed on 60% of product packaging which enables customer demand for less carbon intensive production
- **Production Safety**: Track & trace in minutes vs. months by 20xx
- **Sustainability**: 25% of production recycled and/or reused by 20xx
- **Automatic Reporting**: Eliminate unnecessary reporting burden for data use by government agencies by 20xx
- **Verification** of metrics to be performed by appropriate federal government agencies as required by regulations and/or other requirements: FDA, EPA, DOC, DOE, etc.

A Good Start!!!
We are all in the Smart Plant business, now!!!