**Next Generation Manufacturing**

Findings from an Industry-Driven Program with Matching Funds from the National Science Foundation

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**Next Generation Manufacturing Project**

**Mission**

Create a model for a Next Generation Manufacturing Enterprise that individual companies can use to develop their plans to achieve world class manufacturing well into the 21st Century.

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**Project Process**

- Roadmaps
- Industry Executives
- Research, Academia, Futurists
- Industry Practitioners

Validation, Review, Presentation to Critics

Final Presentation
The NGM Hierarchy or Framework

Global DRIVERS

NGM Enterprise ATTRIBUTES

Barriers to Attributes

IMPERATIVE Actions

Starting Point: The Extended Enterprise

• Company
  – Profit-making entity with “management sovereignty” and well-established bounds of ownership and liability . . .
• An Extended Enterprise
  – Group of institutions that shares knowledge and resources, and collaborates to create a product and/or service.

Paradoxes for the Enterprise

“Paradox”:

A statement which on the face of it seems
• self-contradictory
• absurd
• at variance with common sense

though, on investigation or when explained, it may prove to be well-founded.

O.E.D. “Modern” Definition

Paradoxes for the Enterprise

• Employee Security without Lifetime Employment
• Simultaneously Satisfy all the Stakeholder Needs
• Practice Collaborative Knowledge Sharing within Knowledge-Based Competition
• Profit from Long-Term Customer Relationships when Customers are becoming Less Loyal.
Paradoxes for the Enterprise

- Control Core Competencies without Owning Core Competencies
- Manage Knowledge, the New Discriminator, when that Knowledge belongs to the Knowledge Workers
- Recover Rising Plant and Equipment Costs with Shorter Product/Process Life

Global Drivers

- What factors external to the enterprise will require change?
- Why do we need a Next Generation?
- What’s wrong with the Present Generation?

Global Drivers

- Ubiquitous Availability and Distribution of Information
- Accelerating Pace of Technological Change
- Expanding Customer Expectations
- Technology Accessible to All
- Globalization of Markets
- Global Wage and Skill Shifts
- Environmental Responsibility and Resource Limitations

Attributes of a Next Generation Manufacturing Enterprise

1. Customer Responsiveness
2. Physical Plant and Equipment Responsiveness
3. Human Resource Responsiveness
4. Global Market Responsiveness
5. Teaming as a Core Competency
6. Responsive Practices and Culture
NGM ATTRIBUTES

• 1. Customer Responsiveness
  - The NGM Company will work with the customers to supply an integrated set of products and services that fit evolving requirements of function, cost and timeliness.

Customer Responsiveness

<table>
<thead>
<tr>
<th>Now</th>
<th>Next Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Solutions</td>
<td>Total Integrated Solutions</td>
</tr>
<tr>
<td>Deliver What is Ordered</td>
<td>Deliver What is Needed</td>
</tr>
<tr>
<td>Meet Current Requirements</td>
<td>Anticipate Evolving Requirements</td>
</tr>
<tr>
<td>Single Transaction Revenue</td>
<td>Life-of-Customer Revenue</td>
</tr>
<tr>
<td>Satisfy Customers</td>
<td>Satisfy Customers and all other Stakeholders</td>
</tr>
</tbody>
</table>

NGM ATTRIBUTES

• 2. Physical Plant and Equipment Responsiveness
  - The NGM Company will use an ever-growing knowledge base of the science of manufacturing to implement reconfigurable, scalable, cost-effective manufacturing processes, equipment, and plants that can be rapidly adapted to specific production needs.

Physical Plant and Equipment Responsiveness

<table>
<thead>
<tr>
<th>Now</th>
<th>Next Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience-Based Process Knowledge</td>
<td>Science-Based Process Knowledge</td>
</tr>
<tr>
<td>Dependence on Hard Tooling</td>
<td>Soft Tooling and Tool-less Processes</td>
</tr>
<tr>
<td>Automatic Equipment</td>
<td>Autonomous Equipment</td>
</tr>
<tr>
<td>Fixed Capacity</td>
<td>Variable Capacity</td>
</tr>
<tr>
<td>Fixed Mission Plant and Equipment</td>
<td>Recyclable Plant and, Equipment</td>
</tr>
</tbody>
</table>
NGM ATTRIBUTES

• 3. Human Resource Responsiveness
  – The NGM Company will depend on highly capable and motivated individuals and teams empowered to perform in a flexible work environment.

NGM ATTRIBUTES

• 4. Global Market Responsiveness
  – The NGM Company will develop a global manufacturing strategy to anticipate and respond to a continuously changing global market with its operations and infrastructure tailored to local requirements.

Human Resource Responsiveness

<table>
<thead>
<tr>
<th>Now</th>
<th>Next Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifetime Employment</td>
<td>Lifetime Employability</td>
</tr>
<tr>
<td>Company Plans Career Jointly</td>
<td>Individual and Company Responsible for Career</td>
</tr>
<tr>
<td>Individual Provides Labor and Knowledge</td>
<td>Universally Recognized Skills Certification</td>
</tr>
<tr>
<td>Hire and Retrain</td>
<td>Knowledge Acquisition Managed by Supply Chain Principles</td>
</tr>
<tr>
<td>Ad hoc Knowledge Acquisition</td>
<td></td>
</tr>
</tbody>
</table>

Global Market Responsiveness

<table>
<thead>
<tr>
<th>Now</th>
<th>Next Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Globally</td>
<td>Operate Globally</td>
</tr>
<tr>
<td>R&amp;D in Home Country</td>
<td>R&amp;D Dispersed</td>
</tr>
<tr>
<td>Foreign Company with Local Investment</td>
<td>Perceived as a Domestic Company in each Market</td>
</tr>
<tr>
<td>U.S. Market Share</td>
<td>Global Market Share</td>
</tr>
</tbody>
</table>
NGM ATTRIBUTES

5. Teaming as a Core Competency

- The NGM Company will practice teaming and partnering, within and outside the company, to bring needed knowledge and capabilities rapidly to bear on development, delivery, and support of their products and services.

Teaming as a Core Competency

<table>
<thead>
<tr>
<th>Now</th>
<th>Next Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Intellectual Property</td>
<td>Control and Share Intellectual Property</td>
</tr>
<tr>
<td>Hierarchical Power Structures</td>
<td>Shared Decision Making</td>
</tr>
<tr>
<td>Reward Individual Contribution</td>
<td>Reward Individual and Team Success</td>
</tr>
<tr>
<td>Physically Practice Core Competencies</td>
<td>Control Knowledge of Outsourced Core Competencies</td>
</tr>
<tr>
<td>Loyal to your Unit</td>
<td>Multiple Loyalties</td>
</tr>
</tbody>
</table>

NGM ATTRIBUTES

6. Responsive Practices and Cultures

- The NGM Company has the continuously evolving core competencies, organizational structure, culture, and business practices that enable it to anticipate and respond rapidly to changing customer demands.

Responsive Practices and Culture

<table>
<thead>
<tr>
<th>Now</th>
<th>Next Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasize Productivity</td>
<td>Emphasize Innovation and Creativity</td>
</tr>
<tr>
<td>Teach the Need to Change</td>
<td>Adopt a Process of Continuous Change</td>
</tr>
<tr>
<td>Customer Satisfaction Satisfaction</td>
<td>Society/Stakeholder</td>
</tr>
<tr>
<td>My Standards and Metrics</td>
<td>Shared Standards and Metrics</td>
</tr>
</tbody>
</table>
**Imperatives: Realizing the NGM Attributes**

Vision of an NGM Enterprise

- **Attribute 1**
- **Attribute 2**
- **Attribute n**
- **Barrier 1**
- **Barrier 2**
- **Barrier n**
- **Imperative 1**
- **Imperative 2**
- **Imperative n**

**PEOPLE-RELATED IMPERATIVES:**

- **Workforce Flexibility**
  - A new social contract based on the individual instead of the group to facilitate a more flexible and employable workforce.

- **The Knowledge Supply Chain**
  - Treating knowledge as a transferable unit and managing the generation, distribution and implementation of knowledge as a supply chain between academia and industry.

**BUSINESS PROCESS-RELATED IMPERATIVES:**

- **Rapid Product and Process Realization**
  - A well-defined technology, people and business process to move quickly from identification of customer needs to production and life cycle disposable of useful products.

- **Managing Innovation**
  - Developing and using systematic methods for encouraging innovation in all aspects of the extended enterprise.

- **Managing Change**
  - Acknowledging change as continuous and developing business processes to manage sustained change.
**TECHNOLOGY-RELATED IMPERATIVES**

- **Next Generation Manufacturing Processes and Equipment**
  - Understanding processes and equipment from a fundamental basis so they can be more rapidly developed, deployed in an optimized system and improved once in use.

- **Pervasive Modeling and Simulation,**
  - The use of modeling and simulation of technical and non-technical processes as an integral part of doing business.

**The NGM Company**

- Part of a Global Extended Enterprise
- Possessing the NGM ATTRIBUTES
  - Customer Responsiveness
  - Physical Plant & Equipment Responsiveness
  - Human Resource Responsiveness
  - Global Market Responsiveness
  - Teaming As a Core Competency
  - Responsive Practices and Culture
- Practicing People, Business Processes and Technology IMPERATIVES as an Integrated System

**TECHNOLOGY-RELATED IMPERATIVES**

- **Adaptive/Responsive Information Systems**
  - A new basis for information systems that facilitates rapid response between enterprise partners and their suppliers, resources and customers.

**The NGM Framework**

- Global DRIVERS
- NGM Enterprise ATTRIBUTES
- Barriers to Attributes
- IMPERATIVE Enablers and Action Recommendations