DEVELOPING MANUFACTURING CAPABILITY: RE-SHAPING THE ENTERPRISE

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What drives manufacturing competitiveness?

Tim Hanley, Deloitte

- TALENT
- COST
- WORKFORCE
- SUPPLIER NETWORK
- LEGAL AND REGULATORY
- EDUCATION INFRASTRUCTURE
- PHYSICAL INFRASTRUCTURE
- ECONOMIC, TRADE, FINANCIAL AND TAX SYSTEM
- INNOVATION POLICY AND INFRASTRUCTURE
- ENERGY POLICY
- LOCAL MARKET ATTRACTIVENESS
- HEALTHCARE SYSTEM

Source: Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2016 Global Manufacturing Competitiveness Index
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What is a digital enterprise?

A digital enterprise changes the way people work and how they use information.

Digital Product Definition

- Big Data Analysis and Analytics
  - Digital integrated value chains
  - Digital supply chains
- Digital sustainment and services
- Standard interfaces and data formats
- Mobile technologies
- Cloud computing
- Cybersecurity layers
- Human/machine interface
- Location detection technologies
- Sensors and data gathering
- Customer data capture
- Additive and traditional manufacturing

https://www.youtube.com/watch?v=SCGV1tNBoeU
Technology moving forward...

Tim Hanley, Deloitte

Shifts driving Industry 4.0

Digital-Physical Link

- Additive Manufacturing (3D Printing) becomes cheaper, more available and relevant for new materials
- Next-generation of robots that are intelligent, adaptive, connected and collaborative with humans

Human-Machine Interfaces

- Mass adoption of advanced user interfaces (touchscreens, wearables...)
- Introduction of new technologies and application in Virtual and Augmented Reality

Analytics and Artificial Intelligence

- Breakthroughs in Artificial Intelligence and Machine Learning
- Sophisticated and rapidly-developing algorithms leverage increased accessibility to quality data

Data Creation, Storage and Connectivity

- Sharp fall in the prices of data storage, computing power and bandwidth
- Massive advancements in cloud-based computing platforms
- Sensor prices continuously dropping

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Digital Manufacturing Technology Trends

Mike Molnar, NIST

- **Digital Technologies**
  - Internet of Things/Ubiquitous Sensing
  - Digital Twin and Digital Thread
  - Big data & advanced analytics
  - Cloud computing
  - Mobile computing/apps
  - Security technologies

- **Advanced Manufacturing Capabilities**
  - Advances in additive processes/3D printing
  - Advances in robotics
  - Model-based everything
  - Complex systems engineering
  - Advances in materials
PLM – a key element to digital enterprise

The digital product definition forms the core of how product information is moved through this sociotechnical system.

- However, still sequential
- Dynamic model re-purposing still lacking
- MBD must move beyond shape
- Lifecycle loop still not connected
The communications spectrum...

A complete MBD supports lifecycle communication

**SHAPE**

**BEHAVIOR**

**CONTEXT**

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**HUMAN TO HUMAN**

**HUMAN TO MACHINE**

**MACHINE TO HUMAN**

**MACHINE TO MACHINE**

Purdue Polytechnic

**PRODUCT LIFECYCLE MANAGEMENT CENTER OF EXCELLENCE**
MBD and Systems Engineering

The evolution of representations

Next step for PLM

Evolution of PLM to date

Geometry

MBx based

CAD based

Drawing based

Behavior

Context

Virtual environment based

Lifecycle based

Next step for SE

Evolution of SE to date

Specifications

Interface requirements

System design

Analysis & Trade-off

Test plans

Document based

Diagram based

Behavior

Structure

Requirements

Specifications
MBD and Materials & Process Characterization

Physics-based modeling

- Through surrogate meta-models create tools that can be used to inform decisions, in real time, for shop floor use.
The digital enterprise supply chain

Leveraging supplier and process data to ensure capacity

Collection and Integration of Data

Customer
• Feedback
• Close the loop

Validation and Testing/QC
• Digital validation & verification
• Accuracy and fidelity

Fleet Management and Utilization
• Delivery verification
• Monitoring and adjustment

Production Floor Integration
• Intelligent, integrated equipment
• Predictive capacity

Raw Materials
• Traceability
• Usage

Digital Product Data

Adapted from Kinnet, J. Creating a Digital Supply Chain: Monsanto’s Journey, October 2015.
By comparing digital product data to the physical performance of the object, variation can be tracked and used to inform design of next-generation products, develop predictive modeling and validation schemes for products, and to diagnose and solve problems that occur.
Clearing up some vocabulary...

- **A model-based enterprise (MBE)** is an environment. It is an organization that has transformed itself to leverage model-based information in its various activities and decision-making processes. In this environment, the model serves as a dynamic artifact that used by various authors and consumers of information for their respective tasks. The MBE embraces feedback from the various lifecycle stages to improve the model representation for the creation of subsequent products and product iterations. People working within the enterprise have an enlightened view of digital product information that can be leveraged in their daily work.

- **Model-based ______________ (MBx)** Model-based engineering (MBe), model-based manufacturing (MBm), model-based sustainment (MBs), and any other model-based [fill in the blank] (MBx) are categories of activity within the model-based enterprise. Any of these activities (and the people in them) use digital product data to represent shape, behavioral, and contextual information carried by the model-based definition to execute their functional role. Model-based activities are conducted by relying on the predictive and archival capabilities of the model, by relying on its high levels of fidelity to physical object or system.

- **A model-based definition (MBD)** is a thing. It is a digital representation (artifact) of an object or system. It is representative of the physical object or system and all of its attributes, and is used to communicate information within various MBx activities in a model-based enterprise. The MBD is rich in information – shape, behavior, and context – and it travels the information architecture within an enterprise (including its extended supply chain and customers), providing input to the various authors and consumers who need it. The model-based definition is analogous to the digital twin, although most people today do not think of it in such broad view. And the digital thread is the combination of the MBD and the IT architecture that connects the various functional areas of the model-based enterprise.
A changing workforce...

Tim Hanley, Deloitte

Advanced technologies will increase the skillsets required
...and potentially drive companies to explore different talent models

As Skill Requirements Increase, More Manufacturing Jobs Go Unfilled

New Manufacturing Jobs Require New Manufacturing Skills—It’s That Simple

(WSJ, May 2017)

Automation Will Lead To Collaboration Between Man And Machine

(Forbes, Jul 2017)

A Robot Can Be a Warehouse Worker’s Best Friend

Companies are racing to develop ‘collaborative’ robots, which are relatively cheap and can boost employees’ productivity

(WSJ, Aug 2017)

Trends
- Aging population
- Shortage of manufacturing talent
- Exponential technologies
- Gig economy / open talent
- Rapid product cycles

This next industrial revolution is about the combination of man & machine, not the replacement of one for the other.
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