Model-Based Engineering: Opportunities, Risks, and Best Practices

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Model-Based Engineering

Using idealized representations of technical content as significant support of engineering reasoning, evaluating, decision making, and creating.

The representations and the infrastructure that supports them are convenient for sharing, collaborating, adapting, innovating, and re-using.
Key Issues

• What economic, business, and technology factors currently make model-based engineering a significant opportunity?

• What are today’s major challenges at enabling model-based engineering?

• What top priorities for planning model-based engineering and best practices for implementing it?
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Organizations Need Agility to Address Changing Global Business Conditions

Changing Demographics

Gartner

Organizations Need Agility to Address Changing Global Business Conditions

Uncertain Materials Pricing

Source: The Association of Chartered Certified Accountants (ACCA), Global economic conditions survey report: Q2, 2012


Source: http://www.emergingtextiles.com
Embedded Software Increases Complexity of Product Design and Quality Risks

Cars

Software
  Applications

Hardware
  Middleware
  Embedded

 Suppliers and Partners

Smart Devices

Even Computerized Clothing

http://electronics.howstuffworks.com/high-tech-gadgets/computer-clothing.htm
HPU/GPU Will Further Accelerate Ongoing Hardware Price / Performance Advances

Source: Jon Peddie Research, 2012
Enabling Software Markets are Growing and Maturing

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Maturing Market of Commercial Vendors with Ongoing Innovation

- Engineering-Centric
- Corporate and Back Office

- Small Enterprise
- Large Enterprise

- Scale

- Specialty Engineering Vendors: Altair, Ansys, MSC, ESI, Mathworks
Maturing Market of Commercial Vendors with Ongoing Innovation

- Dassault Systemes
- PTC
- Siemens

Scope

Corporate and Back Office

Engineering-Centric

Small Enterprise

Large Enterprise

Scale

Specialty Engineering Vendors

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Specialty Engineering Vendors
Maturing Market of Commercial Vendors with Ongoing Innovation

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Aras, Selerant, Sopheon, other specialty PLM vendors, Microsoft

Autodesk

Dassault Systemes, PTC Siemens

Oracle, SAP

Altair, Ansys, MSC, ESI, Mathworks

Specialty Engineering Vendors

Microsoft
Positioning MbE and MbM in the Business Application Landscape

Virtual and intellectually driven

Physical and transaction driven
Positioning MbE and MbM in the Business Application Landscape

- CRM (Customers)
  - Response to market opportunity
  - Market requirements and analytics

- PLM (Products)
  - Product/Process design
  - Product Quality Analytics
  - Product Requirements
  - Life cycle Support

- MES
  - Production
  - Physical and transactionally driven
  - Orders and Cash

- ERP (Financials & Material Flows)
  - Order
  - Order fulfillment
  - Product to Ship

- SCM (Suppliers)
  - Parts and materials
  - Virtual and intellectually driven
Positioning MbE and MbM in the Business Application Landscape

- **MbE (Product Development)**: Virtual and intellectually driven
  - Design content, history, eBOMs
  - Product performance analytics
  - MbE

- **MbM (Business Operations)**: Physical and transactionally driven
  - Orders and Cash
  - Fulfillment, service BOMs
  - MRO needs
  - MbM

- **PLM (Product Lifecycle Management)**
  - MbE
  - MbM

- **CRM (Customer Relationship Management)**
  - Customers
  - CRM

- **ERP (Enterprise Resource Planning)**
  - Orders and Cash
  - Fulfillment
  - Customer BOMs
  - MRO status/needs
  - ERP

- **MES (Manufacturing Execution System)**
  - Production
  - MES

- **SCM (Supply Chain Management)**
  - Suppliers
  - SCM

- **Orders and Cash**
  - Orders and Cash

- **Financials & Material Flows**
  - Financials & Material Flows

- **Orders and materials**
  - Orders and materials

- **Lifecycle Support**
  - Lifecycle Support

- **Products**
  - Products
Positioning MbE and MbM in the Business Application Landscape

**Product Requirements**
- Design content, history, eBOMs
- Product performance analytics
- Product Requirements

**Lifecycle Support**
- Lifecycle Support

**Orders and Cash**
- Orders and Cash
- MRO status/needs
- MRO needs

**Fulfillment**
- Fulfillment
- Parts & materials
- Orders

**MRO**
- MRO
- MRO

**MbM**
- MbM Service
- MbM

**MbE**
- MbE

**PLM**
- PLM

**CRM**
- CRM
- Design content, history, eBOMs
- Fulfillment, service BOMs

**ERP**
- ERP
- Financials & Material Flows
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- MRO needs

**SCM**
- SCM
- Suppliers
- Orders and Cash

**Virtual and intellectually driven**

**Physical and transactionally driven**

**Gartner**
Key Issues

- What economic, business, and technology factors currently make model-based engineering a significant opportunity?
- What are today’s major challenges at enabling model-based engineering?
- What top priorities for planning model-based engineering and best practices for implementing it?
Key Model-Based Engineering Challenges That Organizations Face

- Change management
- Knowledge transfer
- Defining data architecture
- Redundant application architectures
- Data/drawing/document synchronization
- Synchronizing role-based views of content
- Sharing data
- Enabling models with sufficient fidelity for needs
- Defining user environments (e.g. 2D/3D harmonization)
Question: How would you characterize the potential/actual impact of these managerial challenges on your PLM implementation?

- Ingrained business processes
- Underestimating the effort/resources
- Cultural resistance
- Budgetary constraints
- Scope creep
- Project management challenges
- Lack of executive sponsorship

Importance

- Not Important
- Project-Threatening

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Technical Challenges Deploying PLM are Relevant to ERS

Question: How would you characterize the potential/actual impact of these technological challenges on your PLM implementation?

<table>
<thead>
<tr>
<th>Nature of Challenge</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of consensus and standards for NPD processes</td>
<td>Extremely</td>
</tr>
<tr>
<td>Data integration problems</td>
<td>Extremely</td>
</tr>
<tr>
<td>Lack of consensus and standards for NPD data</td>
<td>Extremely</td>
</tr>
<tr>
<td>Problems integrating with existing IT applications</td>
<td>Extremely</td>
</tr>
<tr>
<td>Inadequate IT infrastructure</td>
<td>Very Important</td>
</tr>
</tbody>
</table>

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Discordant Formats Will Make Software Support of ERS Challenging

- Mergers and acquisitions
- Partners and suppliers
- Customers
- Legacy data
- MRO providers
- Multiple design applications
Upgrading Software Can Be Like Re-Wiring Your House with the Electricity On

- Adapting to changing business needs
- Linking legacy data and applications
- Scope Creep
- Training
- Maintaining business operations
- Serving expanding user communities
- Containing costs
Key Issues

• What economic, business, and technology factors currently make model-based engineering a significant opportunity?

• What are today’s major challenges at enabling model-based engineering?

• What top priorities for planning model-based engineering and best practices for implementing it?
Systems Engineering and Requirements Mgmt. Take “Center Stage” for ERS

- Simulation and Test Data Management Software
- Math Modeling/Systems Engineering Software
- MCAD/ECAD/xCAE Software
- Requirements Mgmt. Software/Systems
- Req. Mgmt. Hardware/Systems
- Root Cause Analysis (e.g. FMEA/FRACAS/Six Sigma)
- Database (Predicted Potential Risks/Recorded Defects)
Systems Engineering and Requirements Mgmt. Take “Center Stage” for ERS

- Math Modeling/Systems Engineering Software
  - (e.g. Mathworks Matlab, Simulink)
- Simulation and Test Data Management Software
  - (e.g. Altair, Ansys EKM, DS SDM, MSC)
- Application Lifecycle Mgmt. (ALM) Software
  - (e.g. PTC MKS, IBM Rational)
- Requirements Mgmt. Software/Systems
  - (Note: Cognition apps enhance these functions)
- MCAD/ECAD/xCAE Software
  - (e.g. Altair, Ansys Cadence, DS, PTC Creo, Mentor)
- PLM/(PPM) Software
  - (e.g. PTC ProjectLink, Planview, Sopheon)
- PLM/(PDM) Software
  - (e.g. DS Enovia, PTC PDMLink, Siemens Teamcenter)
- Root Cause Analysis
  - (e.g. FMEA/FRACAS/Six Sigma)
- Database
  - (Predicted Potential Risks/Recorded Defects)
Key Technology Adoption Risks

- Technology maturity
- Extent of learning curve
- Corporate readiness
Lessons Learned From Best PLM Software Deployments Apply to CAE
Lessons Learned From Best PLM Software Deployments Apply to CAE

Leveraging Configurational Thinking and Lean Principles

Prime Directive – "Lean Thinking"
Fulfill Customer-Perceived Value
Best Practice: Lean Thinking for CAE

All Investments and Activities That Do Not Deliver Value Are Waste

Lean Business Practices

CAE Software Requirements

Lean IT Practices

External Customer Priorities
• Product reliability
• Product quality
• Timeliness to market
• Product cost

Internal Customer Priorities
• Software performance
• Access to CAE applications
• HW/SW infrastructure Costs
• Access to data/models/other content

Lean Principles
Elevate Customer Perceived Value
# Best Practices Uncovered from PLM Deployments Apply to ERS

<table>
<thead>
<tr>
<th>No.</th>
<th>Best Practice</th>
<th>Manufacturer</th>
<th>Benefits Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Focus on building business capability at the mindset layer</td>
<td>U.S.-based healthcare manufacturer</td>
<td>More systematic team-centric NPD processes with less dependence on skilled individuals</td>
</tr>
<tr>
<td>2</td>
<td>Mind-set layer of &quot;macro&quot; level elements</td>
<td>International beverage company</td>
<td>Instituted phase-gate process, yielding major quality advances</td>
</tr>
<tr>
<td>3</td>
<td>Evangelize the &quot;configuration&quot; mindset broadly</td>
<td>Parts and equipment supplier</td>
<td>Removed redundancy from product portfolio accelerated growth</td>
</tr>
<tr>
<td>4</td>
<td>Don't outsource configurational thinking</td>
<td>Parts and equipment supplier</td>
<td>Clear corporate thought leadership cultivated greater global cooperation</td>
</tr>
<tr>
<td>5</td>
<td>Triangular governance for IT implementation activities</td>
<td>Apparel and footwear company</td>
<td>Streamlined NPD processes yields shorter time to market</td>
</tr>
<tr>
<td>6</td>
<td>Engage suppliers in the PLM business transformation</td>
<td>European machinery manufacturer</td>
<td>Reduced incompatible and redundant product data improved NPD collaboration</td>
</tr>
<tr>
<td>7</td>
<td>Continue configurational thinking during change management</td>
<td>U.S.-based healthcare manufacturer</td>
<td>Helped institutionalize processes for capturing and reusing produce content</td>
</tr>
</tbody>
</table>

This research was conducted in collaboration with Satish Nambisan, Lally School of Management, Rensselaer Polytechnic Institute and Robert G. Fichman Carroll School of Management, Boston College.
Top 13 CAE and Simulation Opportunities

- Broadly Recognized
  - Maturity: Evolving
  - Challenge to Adopt: Nascent-Emerging

- Incremental Impact on Design Success
  - Lowest Challenge to Adopt
  - Moderate Challenge to Adopt
  - Highest Challenge to Adopt

- Significant Impact on Design Success

- Transformational Impact on Design Success
Top 13 CAE and Simulation Opportunities

- CAD integration
- Adapt gaming technology
- Multi-sensory feedback

Impact on Design Success:
- Incremental
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- Transformational

Maturity:
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Top 13 CAE and Simulation Opportunities

- Broadly Recognized
  - CAD integration
  - Simulation/test data management
  - Advanced materials modeling
  - MEMS/nano simulation
- Evolving
  - Optimization
  - Analytics
  - Error estimation and control
  - Adapt gaming technology
- Nascent-Emerging
  - Multi-sensory feedback
  - MEMS/nano simulation
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- Impact on Design Success
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Gartner
Top 13 CAE and Simulation Opportunities

- CAD integration
- Optimization
- Simulation/test data management
- Multiphysics simulation
- Stochastic simulation
- Systems simulation
- Complexity analysis
- Transformational
- Incremental
- Significant
- Nascent-Emerging
- Evolving
- Broadly Recognized
- Challenge to Adopt
- Maturity

- Error estimation and control
- Advanced materials modeling
- MEMS/nano simulation
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- Analytics
- Simulation/test data management
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- CAD integration

- Lowest
- Moderate
- Highest
Summary

• What factors currently make model-based engineering a significant opportunity?
  - leverage evolving technology to accelerate engineering and transfer knowledge

• What are today’s major challenges at enabling model-based engineering?
  - Change management; consensus on data architecture; evolution to a new data architecture and infrastructure

• What top priorities for planning model-based engineering and best practices for implementing it?
  - Aligning technical opportunities to business priorities tempered by risk factors
Thank You!!

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