Workshop Agenda

• What is the MBSE Workshop?

• CIMdata - The State of the Industry
  Don Tolle

• Industry Report-out

• Rest Break

• Improving our Models with MoSSEC
  Judith Crockford

• Roadmap exercise
Workshop History at GPDIS

Global Product Data Interoperability Summit | 2018

• The first Systems Engineering Track in 2014
  • Solidified the impact on PLM
  • Contributions from Multiple Industries

• 2015 - The first Workshop
  • Prioritized Industry Data Standards: SysML, OSLC, FMI, ReqIF
  • Focus on OEM to Supplier Interoperability

• 2016 Workshop produced the Roadmap outline
  • Implementation issues - where/how to start
  • Future capabilities from the PLM Vendors

• 2017 Gaps in the Roadmap
  • Interoperability Issues
  • The need for Leadership
Don Tolle, PLM and MBSE SME

CIMdata is a worldwide firm, with over 30 years of experience, providing strategic management consulting to maximize an enterprise’s ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions.
• Why is MBSE important to our industry?

• What is MBSE?

Credit: SMC Systems Engineering Handbook – Systems Engineering Process – Figure 13
Define MBSE: **Model-based Systems Engineering**
The application of modeling to support system requirements, design, analysis, verification and validation throughout the development lifecycle.

Define MBD: **Model-based Design**
The mathematical representation of design functions, behavior, and software interactions.

Define 3D-MBD: **3D Model-based definition**
The use of 3D ECAD (digital geometry, 3D PMI and associated metadata) to define individual components, assemblies, and/or the complete product.
Graphically Define MBSE – The System Model

The System Model is the connective tissue between the domains…. John Sperling, ARAS Corp
The MBSE purpose is achieved if the models are consistent and can be used downstream **without recreation**.

**SysMBD**

Functional Behavior, Performance, Parametric analysis, Code Generation

**Architecture**

Architecture, Connectivity, Links Requirements Allocations, Data I/O,

**Software Partition**

**LRU A**

**LRU B**

**X = 5*a - \(1^{a-1}\)**

**Y = If-Sum-Else Z**

**Fortran Functions**
System Development view from AIA

Critical MBE Themes that Enable a Collaborative Government-Industry Digital Engineering Process throughout the DOD Acquisitions Lifecycle,
Dr. Peter Pan, Northrop Grumman

NIST MBE Summit presentation
GPDIS MBSE - The Landscape

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MBSE Standards and Consortiums

MBSE Data Standards
• SysML, AADL, Marte
• UAF (UPDM), Arcadia (Capella), AP233
• FMI, SSP, Modelica, HLA
• AP242, ReqIF, XMI
• MoSSEC, OWL, OSLC

MBSE Consortiums and Standard Bodies
• MBSE for PDES
• LOTAR for MBSE
• Object Management Group, and OASIS
• prostep ivip
• Modelica Association
Estimated Onboard SLOC Growth

Slope: 0.1778  Intercept: -338.5
(commercial airliners only)
Curve Implies SLOC doubles about every 4 years

This line fit is pegged at 27.5 M SLOC because the SLOC sizes for 2010 - 2020 are not affordable. The COCOMO II estimated costs to develop that much software is in excess of $10B

F-35 (2012): 24M
F-35 (2006): 6.8M
A330/A340: 2M
A320: 800K
B737: 470K
B747: 370K
B767: 190K
B757: 190K
A300FF: 40K
A300B: 4.6K
INS: 0.8K
F-16A: 135K
F-16D: 236K
F-22: 1.7M
A310: 400K

Boeing aircraft
Airbus aircraft
USAF fighter aircraft
Not affordable extrapolation

Airbus data source: J. P. Potocki De Montalk, “Computer Software in Civil Aircraft,” Sixth Annual Conference on Software Assurance (Compass ’91), Gaithersburg, MD, June 24-27, 1991
Boeing data source: J. J. Chilenski, 2009

2014 GPDIS Presentation: Dr. David Redman, Director, Aerospace Vehicle Systems Institute (AVSI)
2016 Workshop: Industry Roadmap

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<th>2015</th>
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<td><strong>Ontology, Semantics</strong></td>
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- **Integration Issue**
- **Weak**
- **Ready Today**

- Not OEM to Suppliers
- No Information Data Models
- Requirement Models
- Limited Integration
- Limited Vendor Support
- FMI in Auto Industry
- First OSLC Implementations
- Home Grown
- Few Trained Modelers
- Dedicated MBSE Organizations
- 20 SysML Brands
2016 Workshop: Participant Survey

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98 participants, 12 teams, 33 written submissions and 104 comments

- Define/Justify MBSE
- Training-Implementation
- Integrate with PLM
- Standards - Interoperability
- Vocabulary
- Tool Integration (Vendors)
- Roadmap
- Modeling

- No Experience
- No Implementation Roadmap
- Disjointed Tools
- Unknown or No Standards

No
Implementation
Roadmap

No
Experience

Disjointed
Tools

Unknown or
No Standards
2017 MBSE Workshop Results – Order of Most Mentioned

2017 MBSE Workshop participants identified these issues (prioritized)

- MBSE interoperability
- Leadership commitment to MBSE
- Lack of MBSE skills and training
- MBSE collaboration support
- MBSE needs to address requirements
- Lack of ontology/semantics understanding
2017 MBSE Workshop Results – Interoperability

- “MBSE interoperability issues are the biggest concern”
  - Is this a surprise?
  - Wouldn’t we expect that people attending a conference on interoperability would see interoperability as a top priority? (Self-selecting group)
  - What’s more interesting are the next items....
• “Leadership commitment”
  • We’ve seen this before….
The implementation of digital capabilities in the product realization process, such as early consideration of manufacturability during the development of the science & technology and the design & acquisition phases, is essential to dealing with this complexity and succeeding in this 4th industrial revolution.

Despite the recognition of importance for digital design and manufacturing, most participants believe their organizations lack capability.

Majority of senior leaders agree that digital is a priority, but few have a clear bold vision and strategy.

Translating strategy to clear action is a clear gap in a majority of organizations.

SOURCE: McKinsey survey, >200 responses from subject matter experts, industry leaders
2017 MBSE Workshop Results – Skills and Training

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• “MBSE skills and training”
  • Learning the language (most immediately think of SysML)
  • Tool learning curve
2017 MBSE Workshop Results – Food for Thought

- Does this feel about right?
- What do we do about it?

(Audience participates here)
1. MBSE interoperability issues
2. Leadership commitment to MBSE
3. The lack of MBSE skills and training
4. Standard MBSE collaboration techniques
5. How can MBSE address requirements issues?
6. Ontology/semantics are not always understood in the MBSE domain
We need to make it work!

Overwhelmed by implementation issues we lose sight of the technology’s collaboration opportunities.

Integrate Data that is authored in multiple sources, places, formats, tools

Alternative avenues for managing IP and copyrights

Use standards to expand the views of diverse data

Diversity in modeling methods, architecture frameworks, and agile development

Educating the workforce, Management, Suppliers, Prod System

Define the Details: meta-data, data models, nomenclature, usability, product structure and configuration management

Every interoperability exercise is unique.
Aerospace & Defense PLM Action Group

Founded in 2014, the Aerospace & Defense PLM Action Group is an association of aerospace & defense companies within CIMdata’s globally recognized PLM Community Program, which functions as a PLM advocacy group.

Our stated mission is to:

- Set the direction for the aerospace & defense industry on PLM-related topics that matter to members
- Promote common industry PLM processes and practices
Aerospace & Defense PLM Action Group

The MBSE Project is one of several focus areas

Can we exchange MBSE data between the OEMs and Tier 1 Suppliers?

All Aerospace OEMs essentially use the same suppliers, so verify amongst ourselves.

Develop Position Paper, evaluate near term opportunities, propose changes if needed.
## Summary for Phase 1

### Global Product Data Interoperability Summit | 2018

| MBSE Data Exchange Trials | All participants prepared OEM SCD & Technical Data Package; All models and Trial results data uploaded into AirCollab project folders | Red= Failure  
Grey= Partial Success  
Green= Success | Red= Failure  
Grey= Partial Success  
Green= Success |
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<td><strong>Data Export Standards Used</strong></td>
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Top Three Alternatives for SysML Interoperability

1. Use of a software adapter and service to facilitate data exchange

2. Require the use of a single brand of SysML-based authoring tools

3. Invest in the manual conversion of paper-based documents or hybrid
Recommendations

• Interim – Use ISO 42010-compliant architecture description languages (ADL) and define a common exchange tool and supporting translation service that can be used across the aerospace industry.

• Long term:
  • Endorse the SysML 2.0 RFP content, the non-mandatory features describing model interchange and formal semantics, and recommend the incorporation of UMLDI or equivalent into future SysML specifications.
  • Encourage our tool Vendors to prioritize an industry wide exchange strategy and to implement new industry standards (e.g. SysML 2.0) when they become available.

Future Opportunities

• Define the requirements for a 3rd Party software adapter and translation service
• Understand our own requirements about what we want to exchange
• Define a set of priorities to be addressed by the standard bodies and industry consortiums
• Monitor the market for solutions in the space of data interoperability and 3rd party adapter software
Test-Driven, Model-Based Systems Engineering
Industry Makes Rapid Advances

Technical University of Denmark
SE Transformation

INCOSE Accelerates the transformation of systems engineering to a model-based discipline.
Model-Based Systems Engineering in Real Life,

Companies demonstrate improved productivity and quality
Scenario Overview: For weight and cost reasons, the bicycle company’s management wants to use the same pedal crank set assembly on all of their models (off-road and long distance street bike versions). Based on a set of requirements for each model, the bicycle company’s Engineering department has asked the chain ring Supplier to provide analysis models and associated documentation that defines the best version to use.

OEM provides the Specifications:
Supplier provides Design Solutions/Alternatives:

Workshop Exercise: To support traceability and future reuse, what additional pieces of information (Who, What, When, Where, Why, How) should be recorded and associated with the supplier’s models? Write down the ten most important features to capture as part of this data exchange.
1) How do you identify yourself?  Cad or PLM systems, Engineer other, IT, Management, SE, Analytical, Solution Provider (describe your role)

2) Why is MBSE important to you?  (narrative)

3) Do you Have access to MBSE tools?  (Yes/No)

4) An ADL tool installed?  (SysML or other or multiple)

5) Does your company recognize MBSE as important contributor?  (initiative, practicing, deployed, trade)

6) Does your company have an MBSE department?  (part of SE org, initiative, mixed, dedicated)
7. What is your company’s greatest challenge for utilizing the MBSE technologies?

8. What information/industry assistance do you need to move the MBSE needle?

9. What can the MBSE Track at GPDIS do to help?