2018 MBSE Workshop

Greg Pollari, Rockwell Collins

and

Mark Williams, Boeing Company

GLOBAL PRODUCT DATA INTEROPERABILITY

SUMMIT 2018

ELYSIUM Parker Aerospace NORTHROP GRUMMAN BOEING

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

- **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**

CIMdata – The State of PLM Industry

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.

GPDIS MBSE – Industry Report

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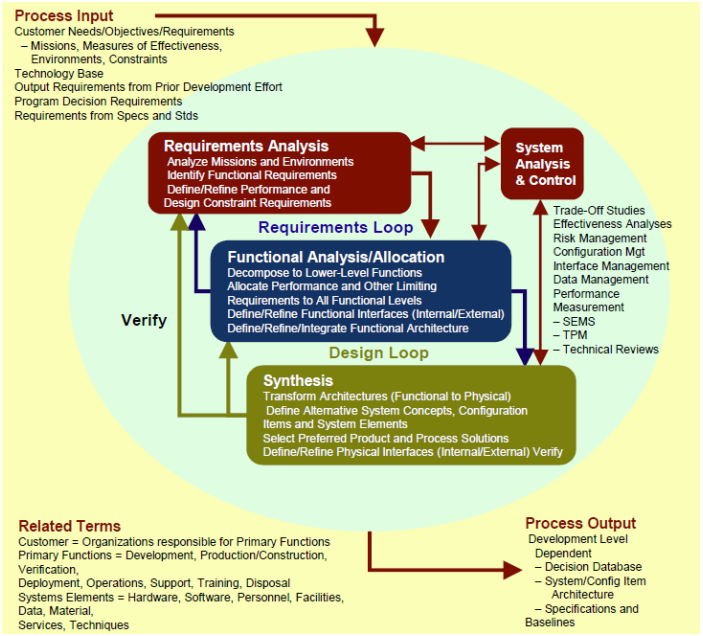
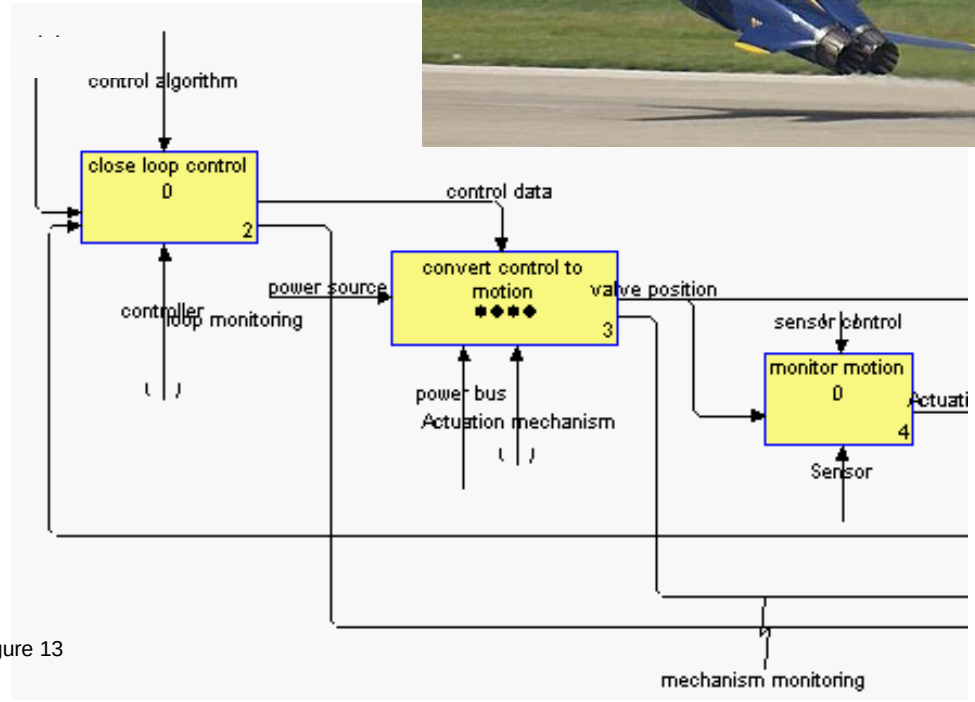
- **Why is MBSE important to our industry?**
- **What is MBSE?**





Credit: SMC Systems Engineering Handbook – Systems Engineering Process – Figure 13

Contrast MBSE – Baseline Definitions

Define MBSE: **Model-based Systems Engineering**

The application of modeling to support system requirements, design, analysis, verification and validation throughout the development lifecycle.

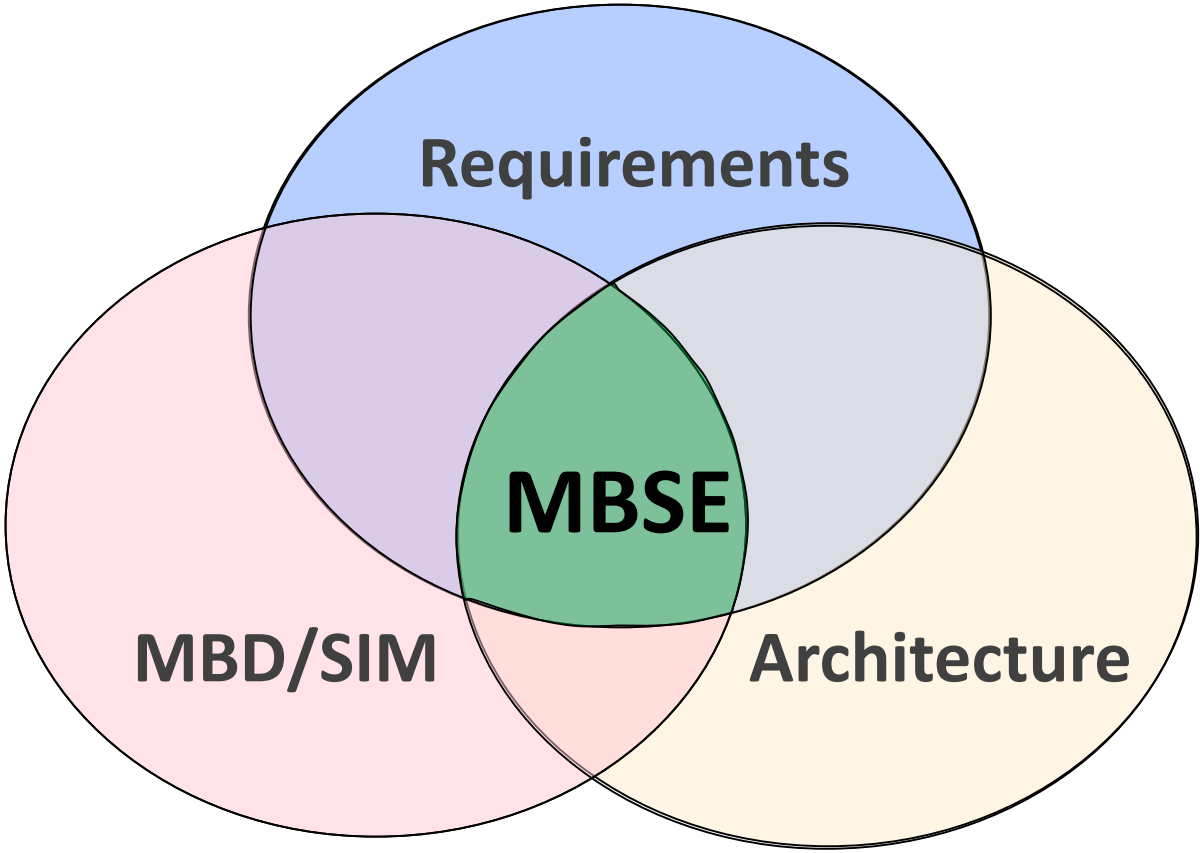
Define MBD: **Model-based Design**

The mathematical representation of design functions, behavior, and software interactions.

Define 3DMBD: **3D Model-based definition**

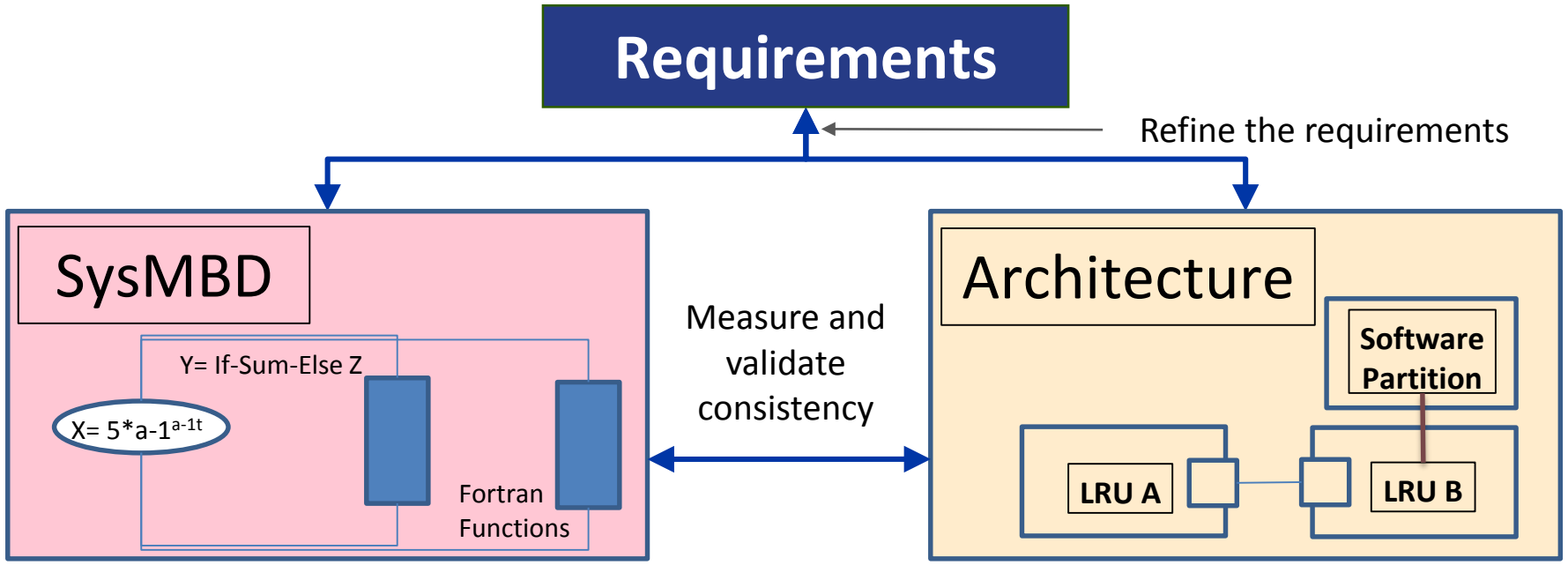
The use of 3D ECAD (digital geometry, 3D PMI and associated metadata) to define individual components, assemblies, and/or the complete product.

Graphically Define MBSE – The System Model



The System Model is the connective tissue between the domains….. John Sperling, ARAS Corp

MBSE Digital Artifacts

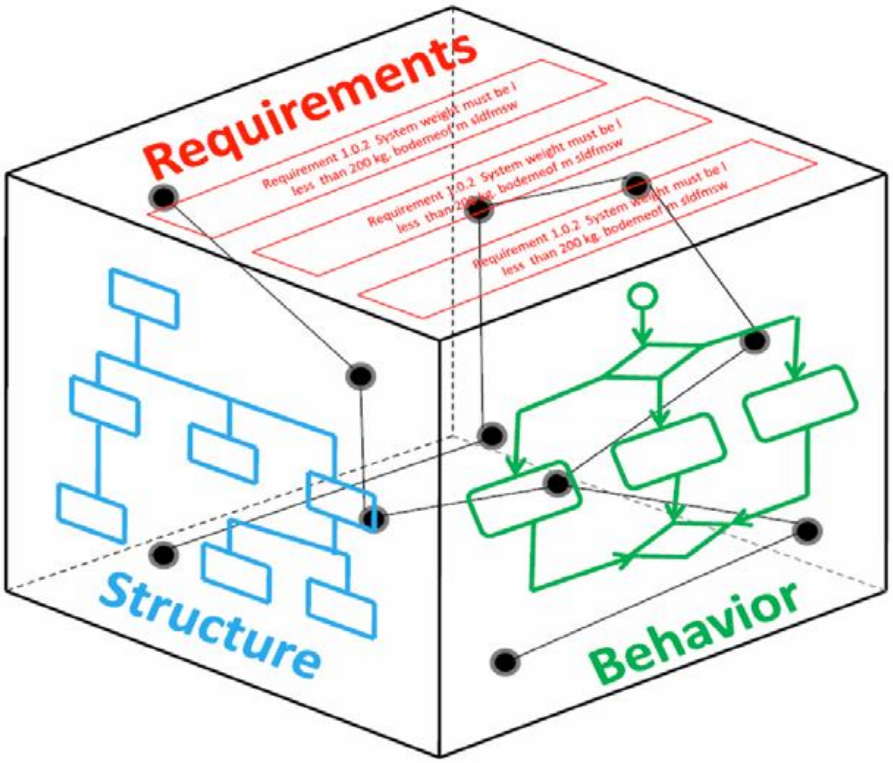


Functional Behavior, Performance, Parametric analysis, Code Generation

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

The MBSE purpose is achieved if the models are consistent and can be used downstream **without recreation**

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

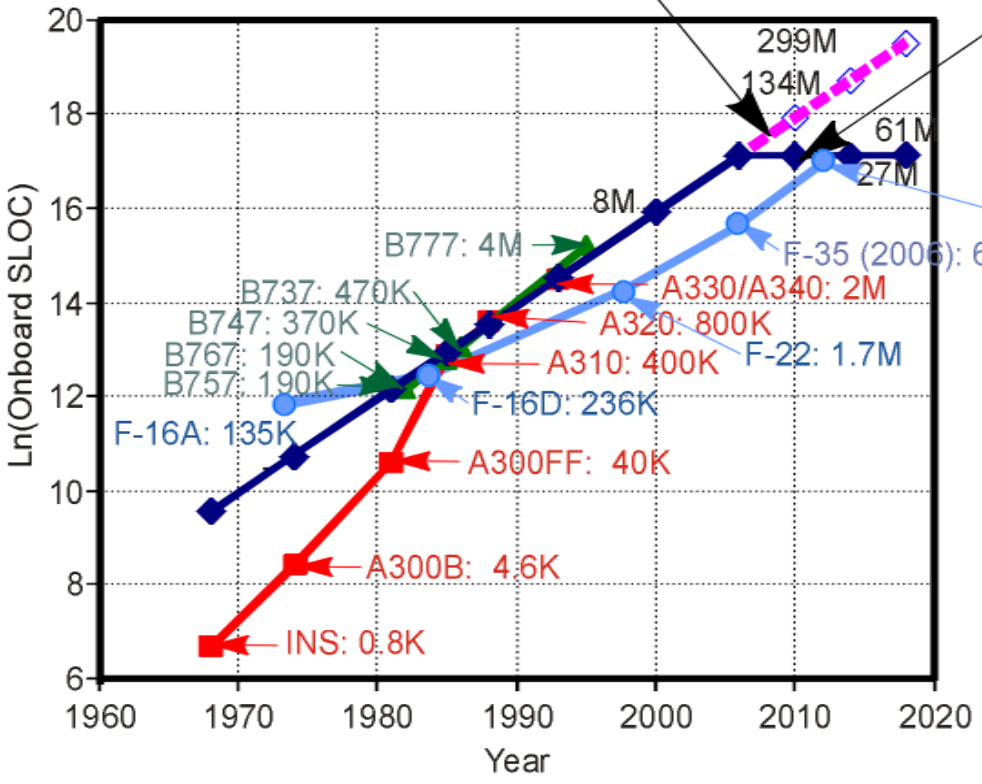
MBSE Consortiums and Standard Bodies

- MBSE for PDES
- LOTAR for MBSE
- Object Management Group, and OASIS
- prostep ivip
- Modelica Association

Product COST Variables

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

- Straight line curve fit
- 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
USAF fighter data source: Hagen and Sorenson, "Delivering Military Software Affordably,: Defense AT&L, March-April 2013

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

2016 Workshop: Industry Roadmap

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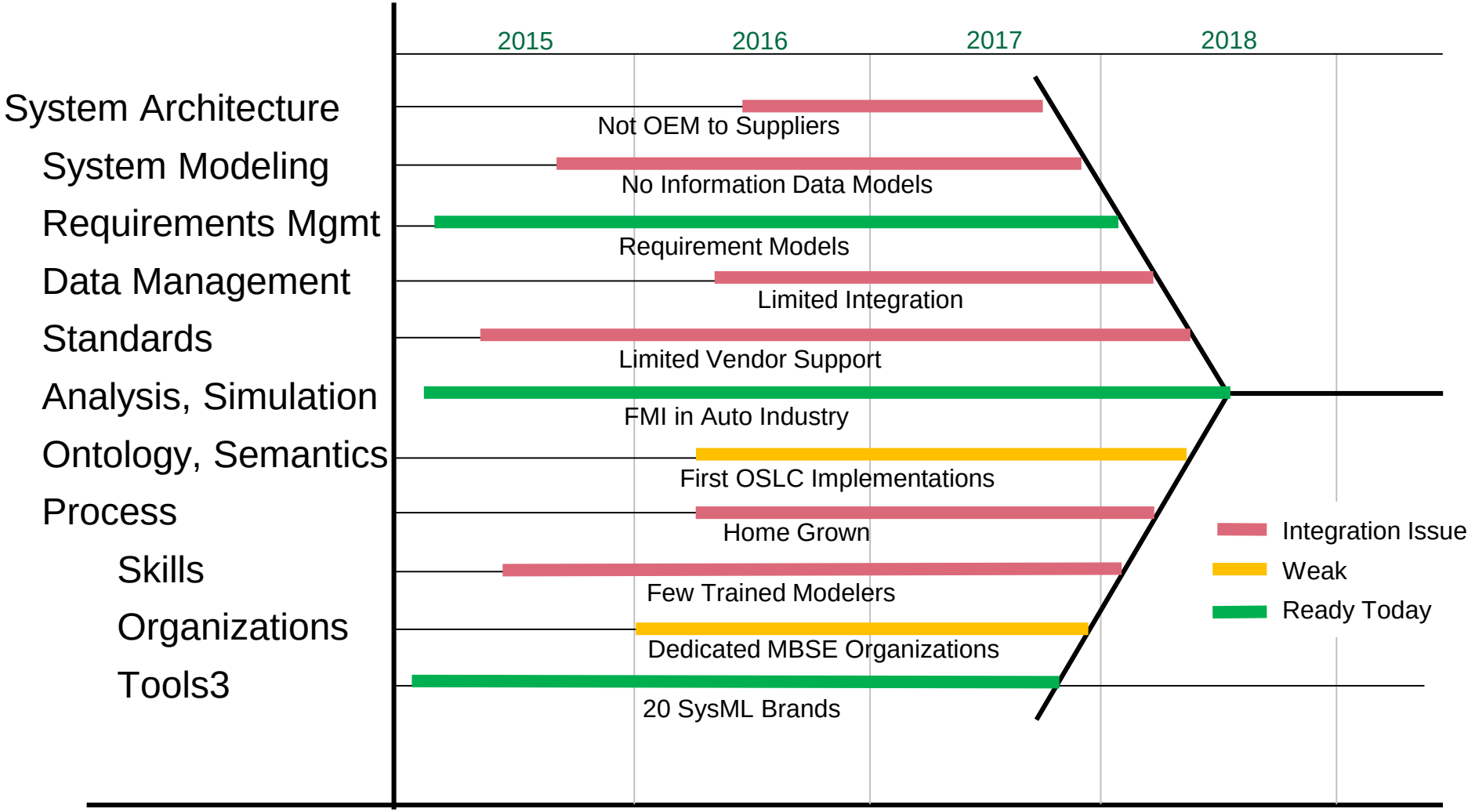
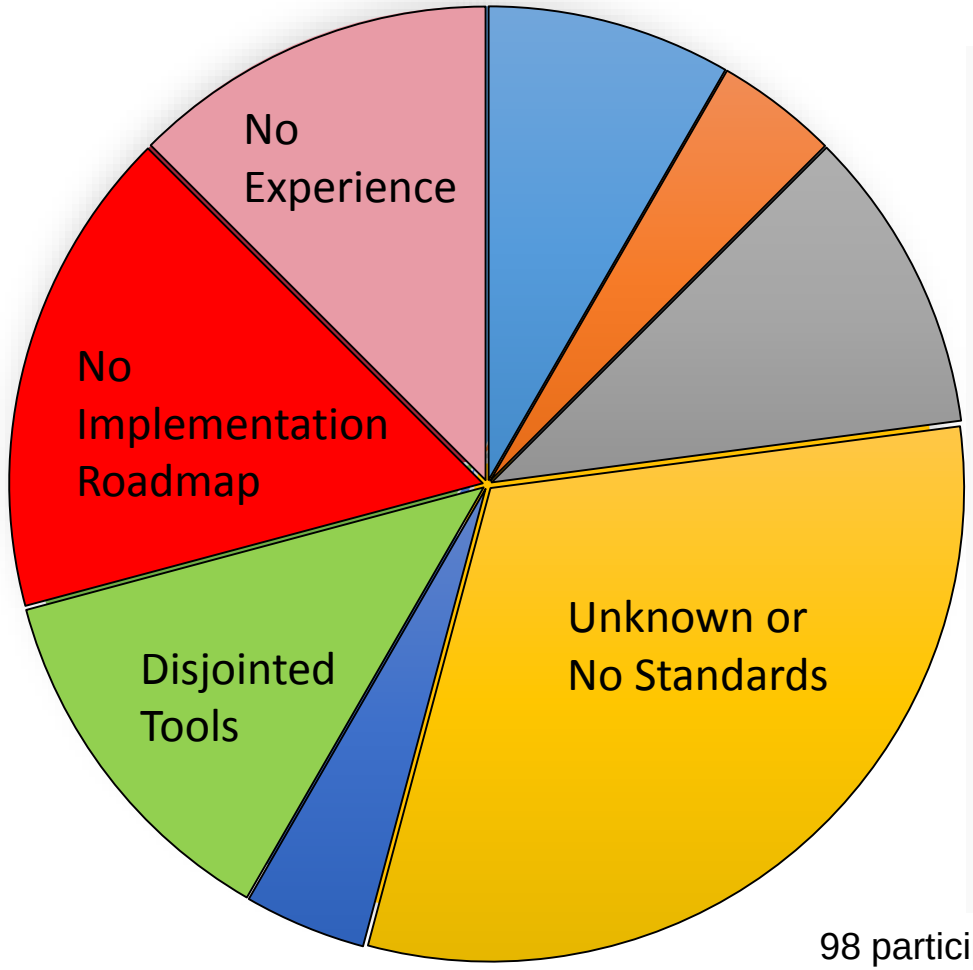


2016 Workshop: Participant Survey



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

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….**

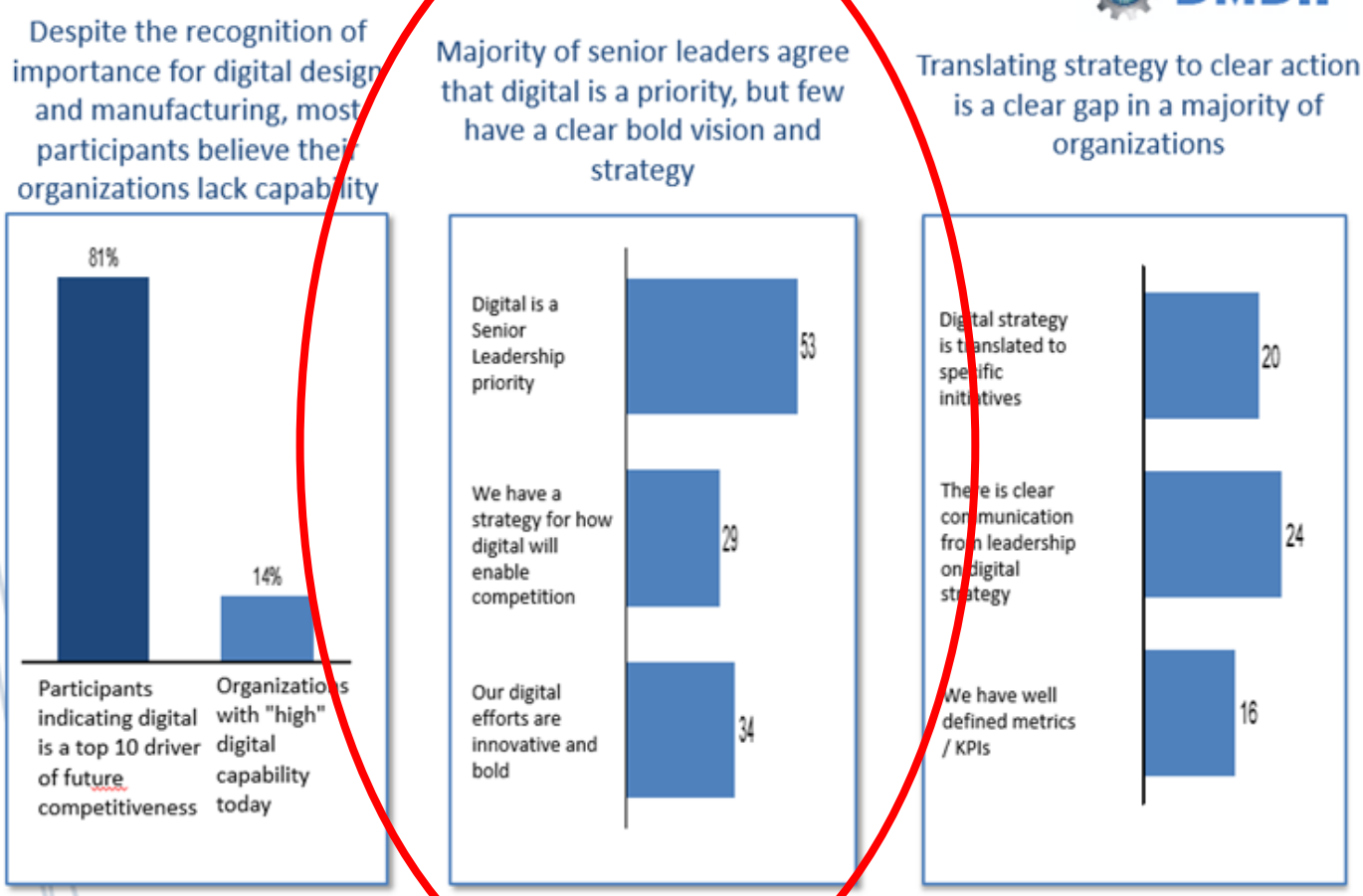
2017 MBSE Workshop Results – Leadership Commitment

- **“Leadership commitment”**
  - **We’ve seen this before….**

2017 MBSE Workshop Results – Greg Harris Keynote

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.

DMDII



2017 MBSE Workshop Results – Skills and Training

- **“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)

2017 Workshop: Participant Survey

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.

Advocating for MBSE

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CIMdata The Leader in PLM Education, Research, and Strategic Management Consulting

PLM RESOURCES EDUCATION PLM CONSULTING RESEARCH MEMBERSHIPS EVENTS CALENDAR

- Home: Aerospace & Defense PLM Action Group
- Members
- Mission
- Publications
  - Direction Statements
  - Research Reports
  - Position Papers

HOME > HOME: AEROSPACE & DEFENSE PLM ACTION GROUP

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

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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

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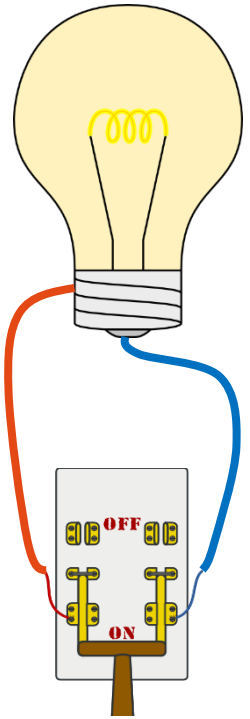
AEROSPACE & DEFENSE PLM ACTION GROUP

MBSE Data Exchange Trials		All participants prepared OEM SCDR & Tecnhical Data Package; All models and Trial results data uploaded into AirCollab project folders				Red= Faliure Grey= Partial Success Green= Success	Red= Faliure Grey= Partial Success Green= Success
Round 1	**OEM Role**	**OEM Modeling Tools Used**	**Data Export Standards Used**	**Supplier Role**	**Supplier Tools Used**	**Trial Outcome (System Model)**	**Trial Outcome (Requirements)**
	Boeing	MagicDraw v18.1	UML 2.5 XMI	GE	IBM Rhapsody v8.2.1	Failure	Failure
	Boeing			Rolls-Royce	PTC Integrity v8.3.18 & Enterprise Architect, DOORS v9.5	Failure	Partial Success
	Boeing	DOORS v9.6	ReqIF v1.1	Airbus	IBM Rhapsody v8.1.4	Failure	Failure
Round 2	**OEM Role**	**OEM Modeling Tools Used**	**Data Export Standards Used**	**Supplier Role**	**Supplier Tools Used**	**Trial Outcome (System Model)**	**Trial Outcome (Requirements)**
	Airbus	IBM Rhapsody v8.1.4 (Reqs included in SysML model)	XMI	Rolls-Royce	PTC Integrity v8.3.18 DOORS v9.5	Failure	Failure
	Airbus			GE	IBM Rhapsody v8.2.1	Failure	Failure
	Airbus			Boeing	Rhapsody 8.1.5	Failure	Partial Success
	Rolls-Royce	PTC Integrity Modeler v8.3.18	XMI	Boeing	Rhapsody 8.1.5	Failure	Failure
	Rolls-Royce			GE	IBM Rhapsody v8.2.1 DOORS NG	Failure	Partial Success
	Rolls-Royce	DOORS v9.5	ReqIF v1.0	Rolls-Royce	PTC Integrity Modeler v8.3.18	Failure	Partial Success
	GE	IBM Rhapsody v8.2.1	UML 2.3 XMI	Boeing	Rhapsody 8.1.5	Failure	Failure
	GE	DOORS NG	ReqIF v1.2	Rolls-Royce	PTC Integrity v8.3.18 DOORS v9.5	Failure	Failure



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**

MBSE - A&D PLM Action Group

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

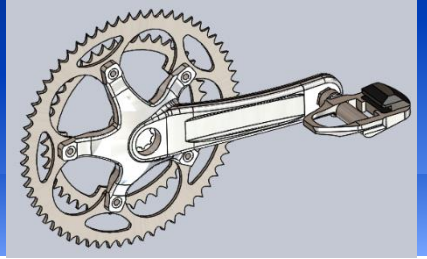
INCOSE Accelerates the transformation of systems engineering to a model-based discipline.

IEEE SPECTRUM

Model-Based Systems Engineering in Real Life,

Companies demonstrate improved productivity and quality

Improving our Models with MoSSEC



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.

Roadmap Survey – Baseline 1

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)

Roadmap Exercise – Baseline2

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?**