

# NAFEMS Webinar

## CIMdata: Emerging Standards for MBSE



Webinar: Emerging Standards for Model-Based Systems Engineering  
February 21, 2019

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*Strategic management consulting for competitive advantage in global markets*

**CIMdata is the leading independent global strategic management consulting and research authority focused exclusively on the PLM market.**

**We are dedicated to maximizing our clients' ability to design and deliver innovative products and services through the application of PLM.**

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## CIMdata: Emerging Standards for MBSE

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**PLM Process Requires End-to-End Connectivity**  
*PLM touches all phases of a product's life—digitalization demands it*



Information

Requirements

Re-use  
Re-purpose  
Re-mfg.  
Re-cover  
Re-cycle  
Re-tire  
Disposal & Recycling

Portfolio Management    Planning    Conceptual Design    Product Engineering    Manufacturing Engineering

Simulation & Validation

Build and Produce

Maintenance & Repair    In-service Operation    Sales & Distribution    Test & Quality

PLM Solutions—Information Management across Media, Process, Time, Geography, & Enterprise

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## CIMdata: Emerging Standards for MBSE

### PLM – CIMdata's Definition

*Digital transformation of the lifecycle—enabled by a product innovation platform*

- Strategic business approach
  - **NOT** just technologies
  - Consistent set of business solutions
- Collaborative creation, use, management & dissemination of product related *intellectual assets*
  - All product/plant definition information – the virtual product
    - AEC, MCAD, EDA, ALM, SE, requirements, simulations, analytics, portfolio, formulas...
  - All product/plant process definitions – the virtual processes
    - Processes that plan, design, produce, operate, support, decommission, recycle...
- An innovation platform that supports the extended enterprise
- Spans the full lifecycle, from idea/concept through life



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### Digitalization: Transforming Enterprises

*Digitalization requires rethinking the business, product, and data*

- Radical advances in digitalization are underway all around us in both our personal social and professional lives
- Digitalization itself as been defined in many ways, but the most succinct is the business strategy best geared to extract real-world value from digital data (e.g., Airbnb, Amazon, etc.)
- The Internet of Things (IoT) with its billions of connected devices is and will play a major role
  - A source of “big data” and enabling closed loop lifecycle management
  - Making the digital thread and digital twin more achievable



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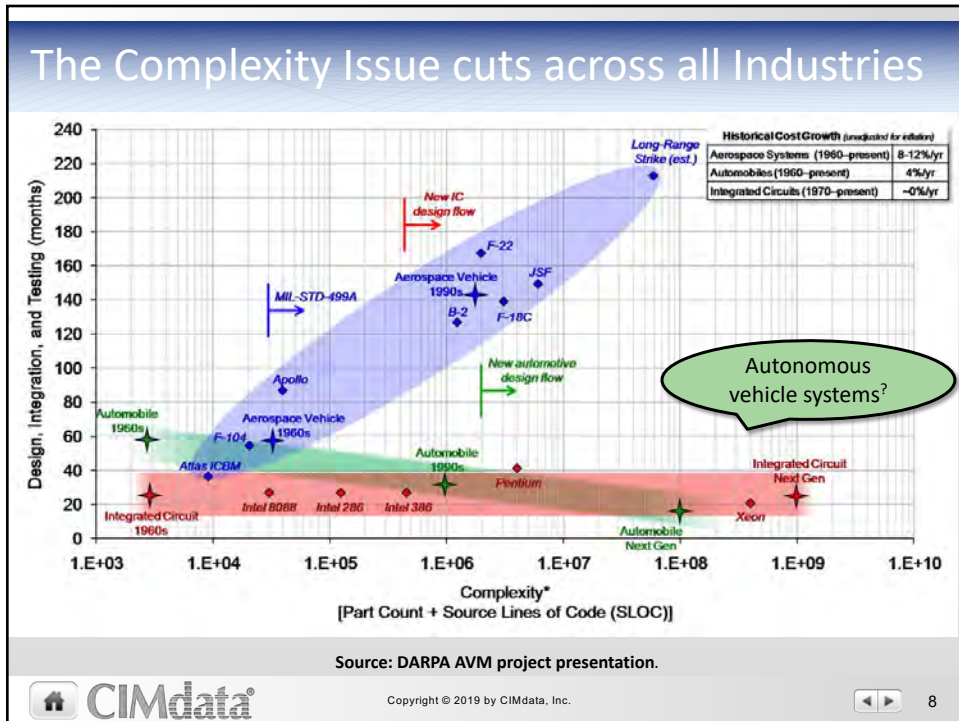
## CIMdata: Emerging Standards for MBSE

“Digitalization” accelerates change & innovation

“The enterprise that does not **innovate** inevitably ages and declines. And in a period of rapid change such as the present... the decline will be fast.”  
-Peter F. Drucker

“Digitalization is the main reason just over half of the companies in the Fortune 500 have disappeared from the list since 2000.”  
Pierre Nanterme, CEO Accenture, World Economic Forum



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
**Complexity = Risk, Digitalization = Opportunity**  
*Business Success now requires a Model-Based Systems Engineering approach*



- Cyber-physical systems- Electronics & software growing 
- New mfg processes & materials—lighter, stronger, green
- Increased regulatory requirements across all industries
- Consumers demand “mass customized” products... Now!
- Shorter lifecycles = continuous product innovation
- Yet extremely long systems lifecycles in select industries
- “Industrial IoT” environment = constant market feedback 

**Complex market requirements demand more upfront cross-domain engineering**

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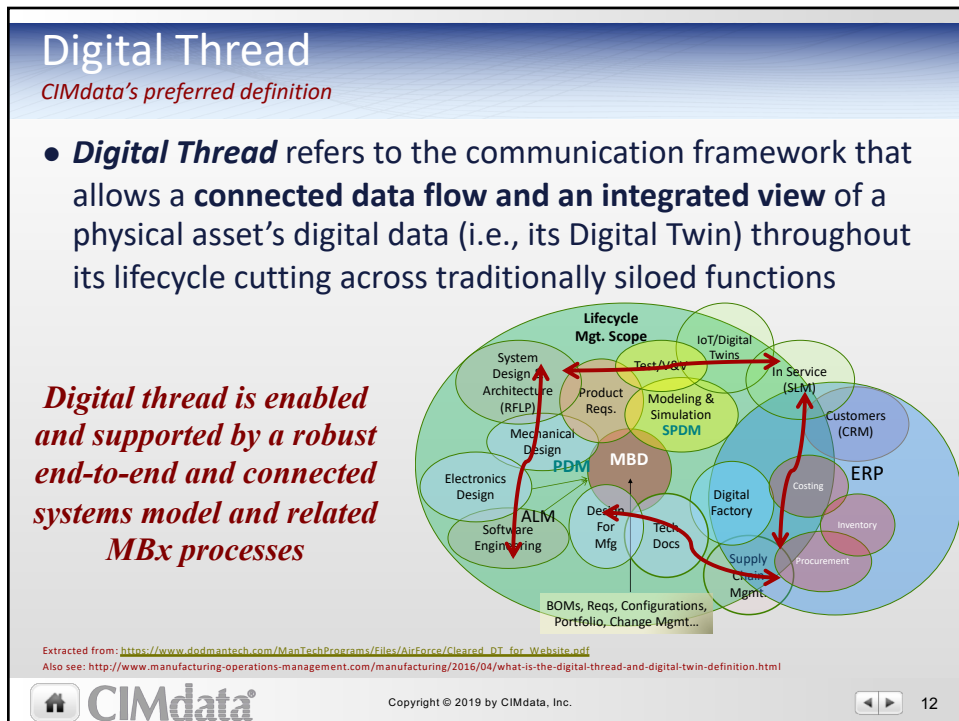
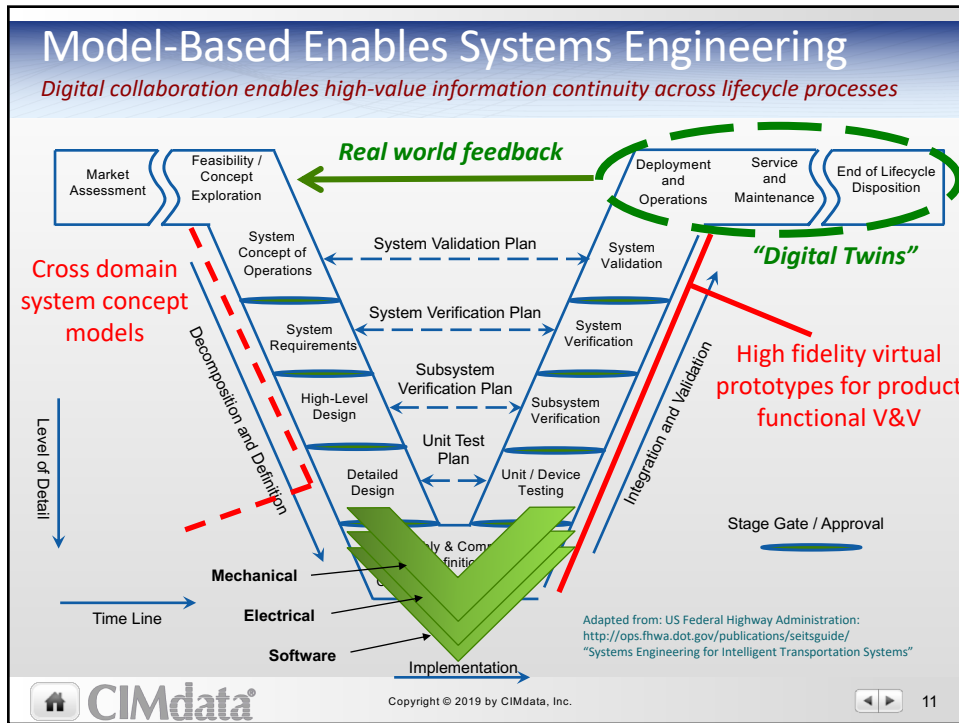
**Digitalization is Driving Major PLM Market Trends**  
*Focus on Simulation-Driven Systems Development*

• Product Innovation Platforms	 Simulation increasingly relevant throughout the product lifecycle to enable innovation, quality and profitability
• Modeling & Simulation Platforms	 Open Platform with ‘best of breed’ solutions is critical for delivering simulation value across the product lifecycle
• Model-Based Systems Engineering	 Connecting VOC/requirements with systems level design, modeling and simulation across all engineering domains
• Digital Thread & Digital Twins	 IoT & data analytics technology creating new insights and use cases for simulation models in operations
• Democratization of Simulation	 Technological advances enabling simulation use by more engineers earlier and throughout the product lifecycle

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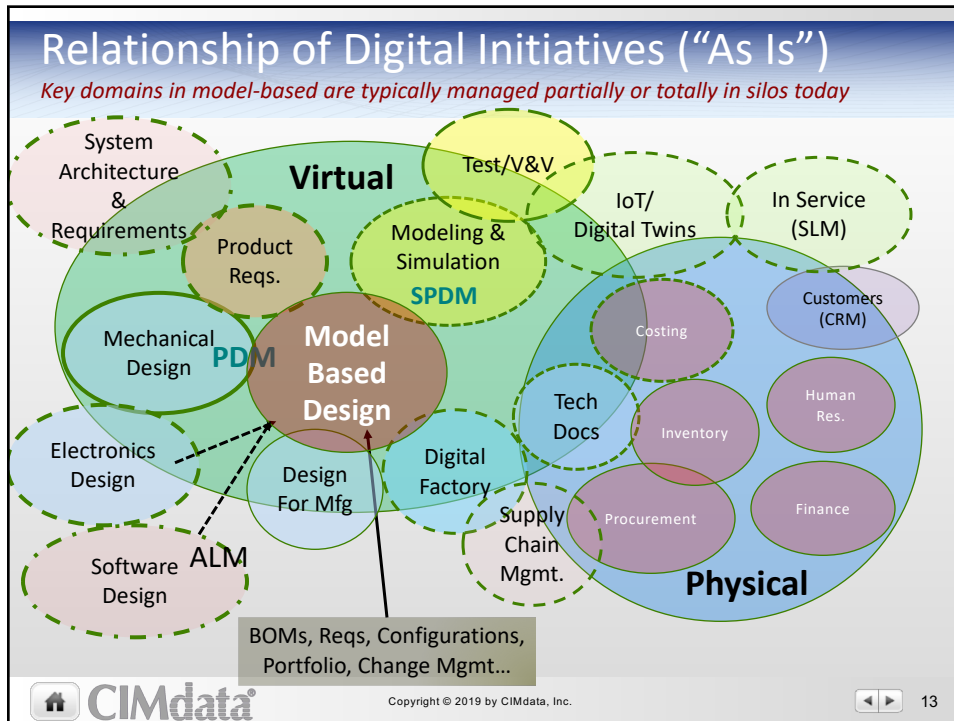
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**Can there really be a digital master model?**  
*Often competing requirements and digital data distributed across domains*

YOUR USER REQUIREMENTS INCLUDE FOUR HUNDRED FEATURES.

DO YOU REALIZE THAT NO HUMAN WOULD BE ABLE TO USE A PRODUCT WITH THAT LEVEL OF COMPLEXITY?

GOOD POINT. I'D BETTER ADD "EASY TO USE" TO THE LIST.

*Which models are most critical to connect in meeting the overall design requirements and with lifecycle traceability? ...some...all...?*

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### The Emergence of the Digital Platform

*Platformization: The next evolution of PLM, required to support digitalization*

Source: CIMdata & SMS\_ThinkTank™

Typically, there are several platforms involved to realize all the benefits of having a Digital Twin available. The underlying Product Innovation Platform needs to be able to bring the threads of all those platforms together to ensure that data and information is consistent and not duplicated.

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### Platforms are consolidating across domains

*Major players acquiring MBSE, M&S, ALM, EDA & IoT technologies*

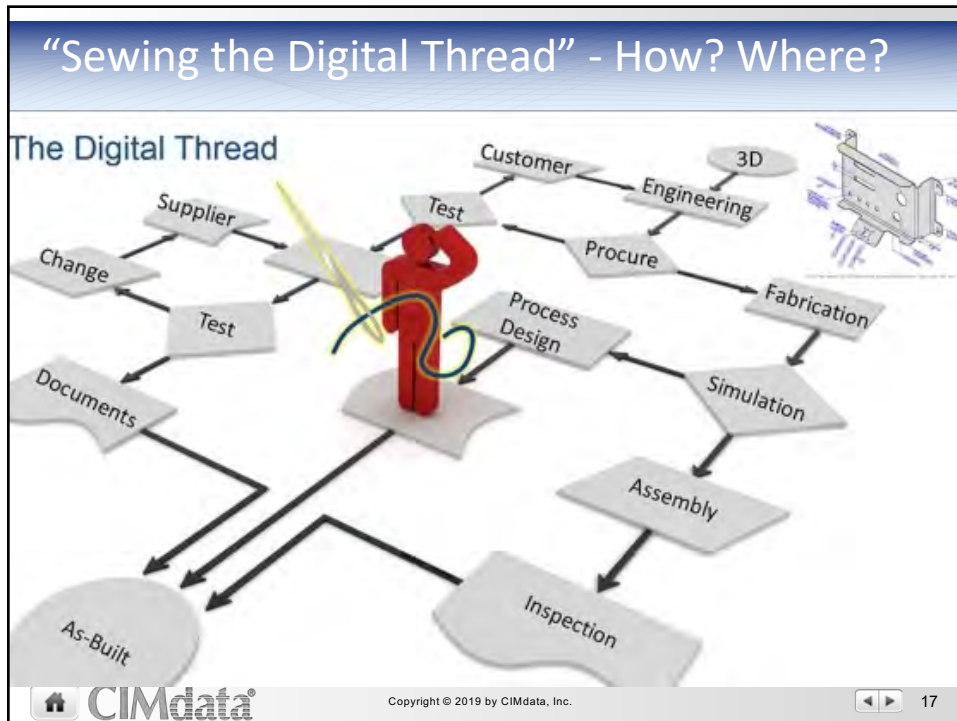
*But still too way many tools in use for any single solution vendor to cover all the required disciplines*

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### Why we need MBx Interoperability Standards

- Deal with Complexity of Systems Design Information
  - Across heterogeneous software tools and data architectures
- A Methodology for Data Exchange & Collaboration to Support Design Reuse of Product Data and Models
  - Connect information silos in engineering and manufacturing domains
  - Digital thread across the entire product lifecycle
  - Digital thread for the extended virtual enterprise including suppliers
  - Maintain information over time- Long Term Archiving & Retrieval (LOTAR)
- *Deliver Business Impact & ROI = \$\$*
  - Reduce Product Total Lifecycle Costs
  - Control/Improve Product and Process Quality
  - Enable Product and Process Innovation for Competitive Advantage

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## CIMdata: Emerging Standards for MBSE

Many Groups Involved with Many Standards

Consortiums, Bodies, and Specifications



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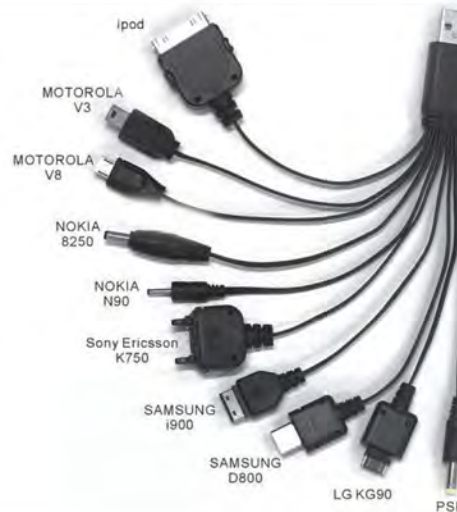
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Remember early cell phone “standard” connectors?



- Lack of standards is bad but..
- Too many “standards” are equally a problem for practical implementation and widespread adoption by industry & solution providers



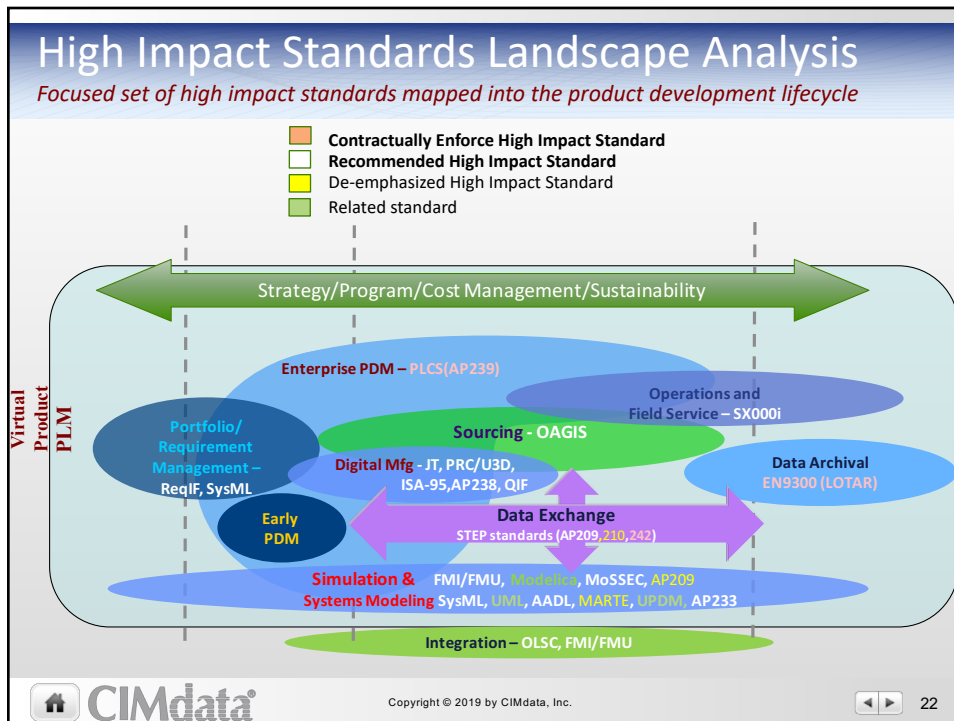
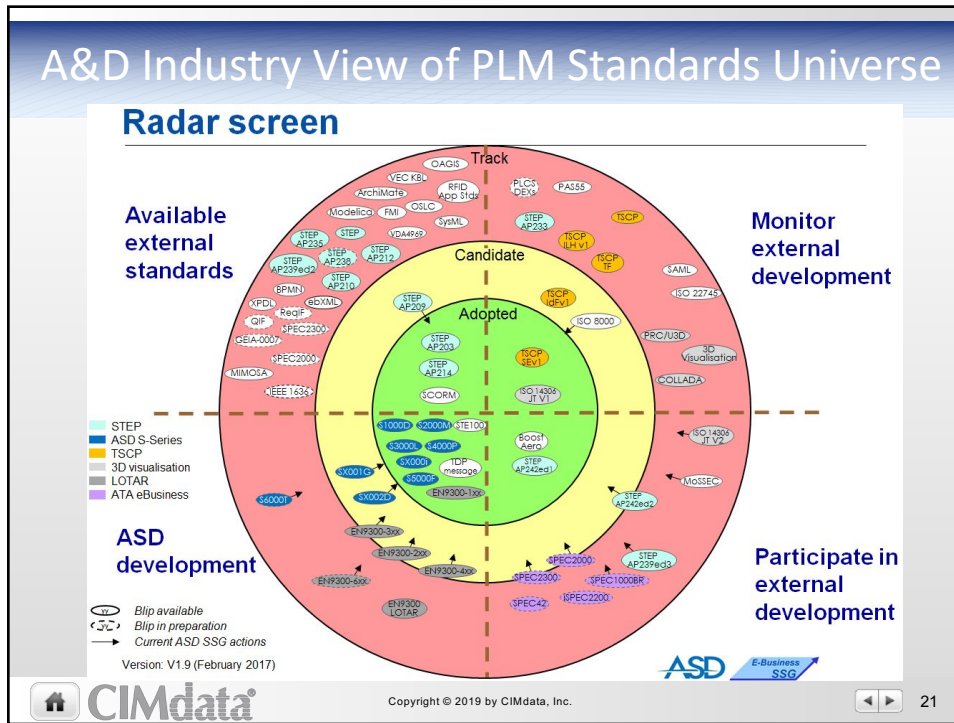
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### Sewing the MBSE Digital Thread ("To Be")

*Conceptual Systems Engineering across domains; connections to PLM/M&S for V&V*

**MBSE Use Case:**  
*Conceptual Design, Optimization and Validation Of Cyber-Physical Systems*

The thread needs to connect information across domains:

- \* Systems Architecture & Requirements
- \* Software/ALM
- \* EDA/ECAD/EBOM
- \* MDA/MCAD/PDM
- \* M&S/CAE/SPDM
- \* Test/V&V/TDM

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### Challenge: Tool Integration, Data Interoperability

- If you pursued MBSE, would you start with a clean sheet in specific MBSE software, or would you write custom software to tie your existing models together? Why?
- *Majority indicated need to tie together existing models in some manner*

Response	Percentage
We have so many existing models, it would be impossible to tie them together across so many different modeling environments, so we need to do it clean sheet	11%
The functionality available in clean sheet software would be really productive	13%
Our use case for MBSE is very specific, I don't think it would be captured off the shelf tools, so we'll be better off plugging our existing models together	22%
We have so many existing models, the effort required to rebuild them in a clean sheet approach would be untenable	39%
Other	14%

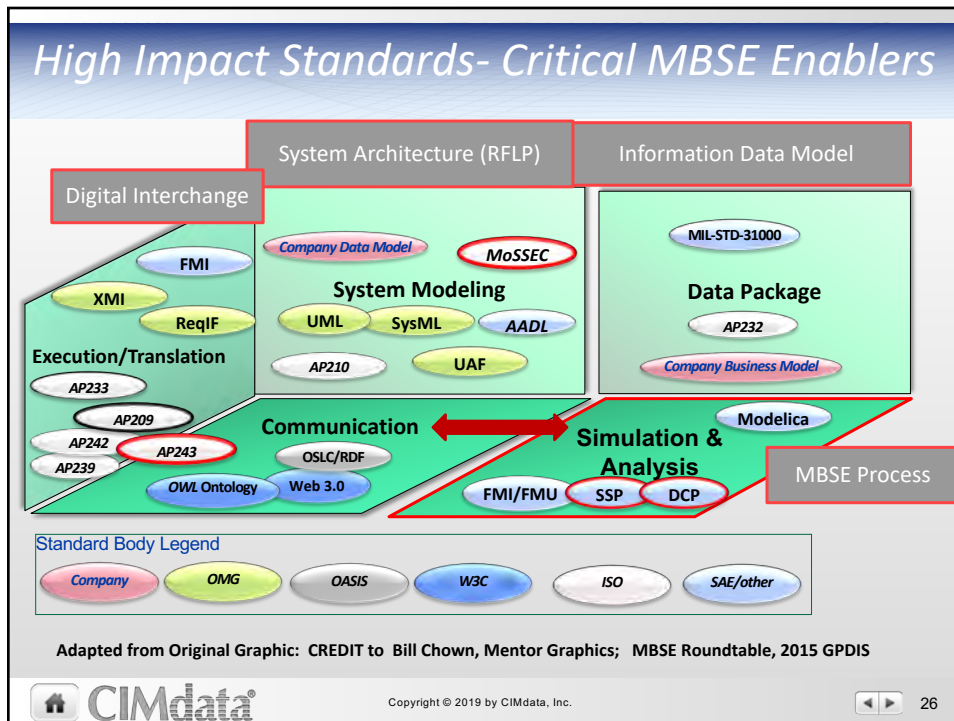
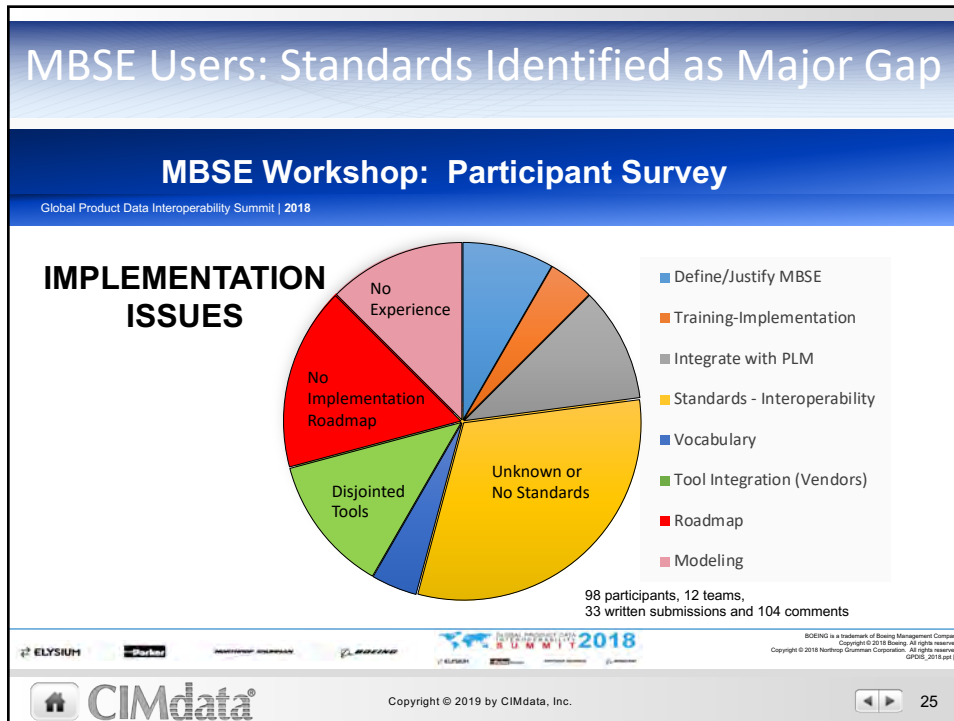
*MIT MBSE On-line Course Survey of 300+ Engineers*

*Bruce Cameron, TSP  
 MBSE LinkedIn blog post  
 May 17, 2017*

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### Cross-Domain Model Interoperability & Digital Data Linking

*Evolving Industry Standards will be critical for “sewing the Digital Thread”*

- MBSE systems modeling languages (UML/SysML, Papyrus, Capella, etc.) and architecture frameworks (UPDM/UAF, Systematica, Arcadia, etc.)
- ISO/STEP AP 233/239/242 & 209– Consolidated data model backbone
- Web collaboration standards such as XML/XMI, URLs, RDF and OSLC for data linking across authoring tools and data management platforms
  - Open Services for Lifecycle Collaboration (<https://open-services.net/>)
- ReqIF- Requirements Interface Format based on XML
- Modelica® & FMI/FMU – Functional Mockup Interface/Mockup Unit
  - New standard in process- System Structure and Parametrization (SSP)
  - New standard in process- Distributed Co-simulation Protocol (DCP)
- MoSSEC – Modeling & Simulation information in a collaborative Systems Engineering Context (AP243) See <http://www.mossec.org/>



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### Formal Standards and “de facto” Standards (“As Is”)

*Are we moving fast enough to provide real business impact to the industry?*

- Some of the most widely used data formats today for digital data interoperability have become “de facto” standards for engineering data exchange and collaboration just because so many engineers use them
  - Microsoft “engineering tool suite” (.xls., .doc., .pptx, .vsd, mpp)
  - Systems simulation- Matlab/Simulink S-Functions, Modelica .mo
  - Structural analysis- Nastran .bdf, ADAMS .mnf, ABAQUS .odb, ANSYS .agdb, etc.
- Others evolved into formal collaboration standards- 3DPDF, JT, OSLC
- On the the other hand, a number of formal standards are not widely used by industry today despite relative maturity of the standards
  - Unfortunately, some are in the MBSE domain- ISO STEP AP233 (SE focus)
- Some standards have been in process for well over a decade and are still evolving towards maturity/widespread adoption (e.g., AP209, SysML)
- Some standards moved quickly to adoption- Modelica and FMI/FMU



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### Modelica Assn: Functional Mockup Interface (FMI)

**Problems / Needs**

- Component development by supplier
- Integration by OEM
- **Many different simulation tools**



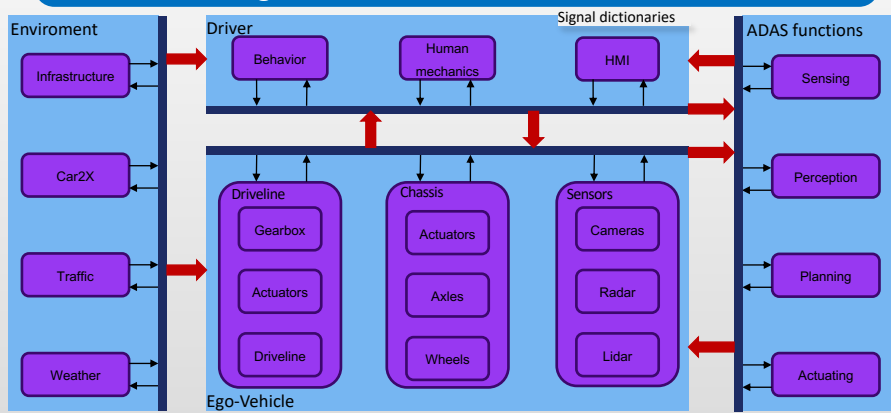
- Tool independent standard to support both model exchange and co-simulation of dynamic models <https://fmi-standard.org/>
- Original development part of EU-funded MODELISAR project led by Daimler
- First version FMI 1.0 published in 2010; FMI 2.0 released July 2014 with additional functionality
- Active development, testing and support from Modelica® Association project
- Standard currently widely adopted and supported by over 100 tools
- FMI's business model helps drive industry adoption

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### System Structure and Parameterization: SSP

*One level "above" an FMU- Public release expected during Q1, 2019*

**Purpose of SSP: Standardize interconnected system of components and controls, including parameterization and variants handling**



Usage of SSP in defining Simulation Architecture for ADAS

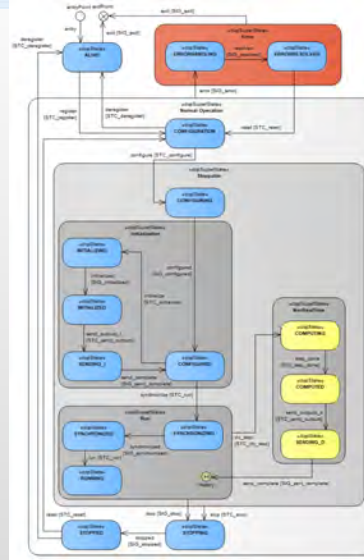
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### Distributed Co-simulation Protocol: DCP

- What is it?
  - Standardization of data exchange protocol for distributed co-simulation, real-time and non real-time, also connecting real hardware testbeds with virtual parts
- Who is involved?
  - Developed by automotive OEM, and suppliers, test hardware vendors and simulation software vendors
- Continuation of EU research project ACOSAR
- Public review of draft standard started in Q4 2018



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### Modelica Assn: Coordinated Set of Standards

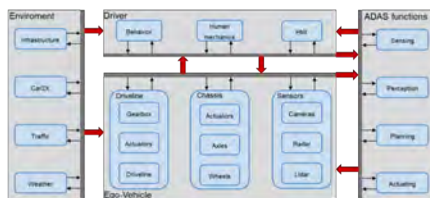
Modelica:  
Build the model



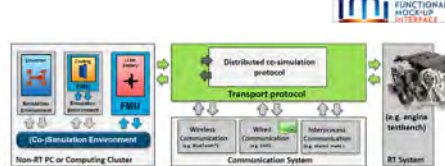
FMI: Interface  
and deploy models



SSP: model-based collaboration  
across the extended enterprise



Distributed Co-simulation Protocol: Let models  
talk to one another and hardware



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### Formal Standards and “de facto” Standards (“As Is”)

*Are we moving fast enough to provide real business impact to the industry?*

Observations based on ~40 years working in the PLM technology industry

- *Standards need to address a real business issue for a sufficiently large yet targeted segment of industrial end users (detailed use cases!)*
- *Software solution providers will invest in supporting standards when industry really adopts and uses them.... and especially if industry requires contractual compliance in order for solution providers to continue to sell their commercial software*
- *Industrial users will lose interest in standards that take too long to be developed and officially released by the standards organizations*
- *Standards that don't get quickly adopted & widely used will die a slow painful death and become useless, even if/when they ultimately mature*



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### MoSSEC: Emerging Standard to Enable MBSE

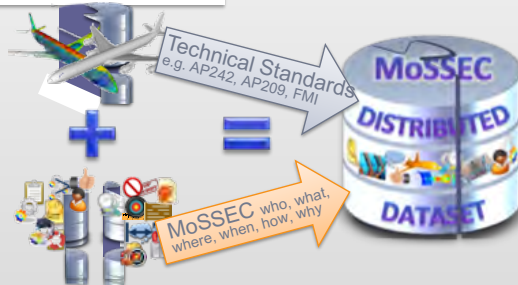
Combining Modelling and Simulation Data with Collaboration Data:

Who, What, Where, When, How & Why

#### Modelling and Simulation data

- Managed by PLM/SPDM tools
- Exchanged with technical standards

PDT Europe  
October, 2017



Together this supports a lifecycle model-based enterprise



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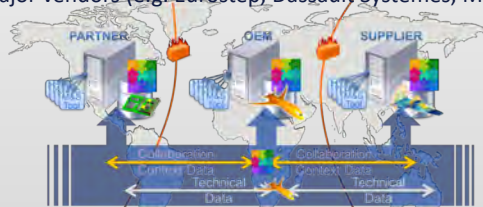
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### MoSSEC: Work-in-Progress ISO/STEP Standard

- ❑ ISO Committee Draft approved June 2018 (ISO/AWI 22071, **AP243**)
  - International Standard release planned by late 2019/early 2020
- ❑ **The Who, What ,Where, When, How, Why:** Shares systems engineering context of modelling and simulation data between internal teams/domains and extended enterprise
  - Builds on AP239/AP242 standards and leverages new STEP extended architecture
  - Leverages modern W3C/REST/OSLC type web services for global collaboration
- ❑ Supported by industrial partners (e.g. Airbus, Rockwell Collins, Boeing, BAE Systems)
- ❑ Supported by major vendors (e.g. Eurostep, Dassault Systèmes, MSC Software, Siemens)



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### Sewing the MBSE Digital Thread (“To Be”)

*Significant collaboration efforts underway to integrate data and processes*

In addition to the standards organizations, there are a number of industry initiatives underway to help enable MBSE data interoperability and design collaboration within enterprises as well as across the OEM/supply chain

- Global Product Data Interoperability Summit (GPDIS)- SE/MBSE track since 2014
- NIST Model Based Enterprise Summit- Annual event since 2016
- MBSE for PDES & LOTAR for MBSE- PDES and INCOSE collaboration
- INCOSE Tool Integration and Lifecycle Management (TIMLM) Working Group
- Digital Engineering Information Exchange (DEIX) Working Group
- protstep ivip- Smart SE project focused on M&S integration with SE for V&V
- ASSESS- Analysis, Simulation, and Systems Engineering Software Strategies
- Joint NAFEMS/INCOSE Systems Modeling & Simulation Working Group (SMSWG)
- CIMdata Aerospace & Defense PLM Action Group



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### Sewing the MBSE Digital Thread (“To Be”)

*Significant collaboration efforts underway to integrate data and processes*

Reference sites for some of the major MBSE-related industry initiatives:



- <https://gpdisonline.com/2018-presentations/>
- [www.nist.gov/news-events/events/2018/04/model-based-enterprise-summit](http://www.nist.gov/news-events/events/2018/04/model-based-enterprise-summit)
- <http://wiki.omg.org/MBSE/doku.php?id=mbse:smswg>
- [http://www.omgwiki.org/MBSE/doku.php?id=mbse:incose\\_mbse\\_iw\\_2019](http://www.omgwiki.org/MBSE/doku.php?id=mbse:incose_mbse_iw_2019)
- <https://www.incose.org/incose-member-resources/working-groups/transformational/digital-engineering-information-exchange>
- <https://www.prostep.org/en/projects/smart-systems-engineering/>
- [https://www.acq.osd.mil/se/initiatives/init\\_de.html](https://www.acq.osd.mil/se/initiatives/init_de.html)
- [https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:modelmgt:iw2017:pdes\\_lotar\\_slides\\_iw2017.pdf](https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:modelmgt:iw2017:pdes_lotar_slides_iw2017.pdf)
- <https://www.cimdata.com/en/aerospace-and-defense#>



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### SMSWG Standards Ecosystem Focus Area

An SMSWG sub-team has been established to provide a focal point for identifying and promoting formal standards (and “de facto” standards) that enable systems modeling and simulation via improved **model/data interoperability and cross-domain engineering collaboration** within the context of achieving MBSE/MBE (i.e., the lifecycle Digital Thread)

- Don Tolle of CIMdata is acting as project leader/coordinator of this MBSE Standards Ecosystem sub-team (d.tolle@cimdata.com)
- The role of this sub-team is to provide a more formal linkage to the various standards bodies (e.g., OMG, Modelica, OASIS, PDES/STEP, etc.) and industry/government working groups and associations involved with standards (e.g., INCOSE, NAFEMS, NDIA, NIST, ESA, ASD, CIMdata, prostep ivip, ASSESS, etc.)

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### SMSWG Standards Ecosystem Focus Area

The 4 major focus areas identified to date are outlined below and each focus area will be led by one or more industry subject matter experts (SME)

- 1) Modelica Association standards (Modelica, FMI/FMU, SSP, DCP, etc.)  
SME- Hubertus Tummescheit (Modelon)
- 2) PDES/STEP AP standards related to systems modeling and simulation including linkage with LOTAR and MoSSEC (pending AP standard)  
SMEs- Mark Williams (Boeing), Adrain Murton (Airbus)
- 3) Web standards (OASIS/OSLC, RDF, XML/XMI, UML DI, others TBD)  
SME- Axel Reichwein (Koneksys)
- 4) OMG standards- Requirements and Systems Architecture (RFLP) (ReqIF, SysML v2, UAF, others TBD)  
SME- Roger Burkhart (John Deere)



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### How to learn more about the SMSWG Community

Complete [the request form](#) on the [NAFEMS SMSWG website](#).

Indicate if your organization is a member of NAFEMS and/or you are a member of INCOSE.

Once signed up, you will receive announcements for upcoming meetings and also have access to the [SMSWG Collaborative Community](#).

The INCOSE MBSE Initiative also maintains an [SMSWG wiki page](#), with publicly available meeting materials.

An INCOSE Working Group page for SMSWG is in progress.



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Aerospace & Defense PLM Action Group



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Aerospace & Defense PLM Action Group

Project Focus: Assess and develop improved digital approach for MBSE Data Interoperability for OEM/Supply Chain Collaboration

Phase 1 (2017): Assess current state of model exchange standards  
Phase 2 (2018): Assess and score digital collaboration alternatives  
Phase 3 (2019): Detailed Use Cases, Requirements & Tool Assessments


*MBSE position paper now available at CIMdata AD PAG web site:*



<https://www.cimdata.com/en/aerospace-and-defense#>

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### Sewing the MBSE Digital Thread (“To Be”)

*Commercial software solutions emerging to integrate data and processes*

Similar to the emergence of third-party software solutions for “vendor neutral” 3D MCAD interoperability in the 1990s, there are a number of companies outside of the major PLM/MBSE solution providers that are emerging to address the need for interoperability of MBSE models and data capturing systems requirements and systems architecture design:

- InterCAX- Syndeia suite <http://intercax.com/products/syndeia/>
- Sodius- SE Collab <https://www.sodius.com/en/products/secollab>
- Ingrano Solutions- ModelBus <http://ingrano-solutions.com/tool-integration>
- MID AG- smartfacts platform <https://www.smartfacts.com/>
- Koneksys- Focus on OSLC/web collaboration standards [www.koneksys.com](http://www.koneksys.com)
- Others: Know Gravity, HCL, dSpace

Note: Not intended to be a comprehensive list of providers nor a CIMdata endorsement or ranking



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### Sewing the MBSE Digital Thread (“To Be”)

*Significant collaboration efforts underway to integrate data and processes*

In addition to M&S integration efforts underway at the major PLM/CAE companies such as ANSYS, Altair, DS/SIMULIA, MathWorks, and Siemens PLM, “vendor neutral” commercial software solutions are also emerging to address the need for integration of MBSE requirements and systems architecture models with physics-based modeling & simulation capabilities for concept trade studies, design optimization and V&V

- Maplesoft- MapleMBSE <https://www.maplesoft.com/products/maplembse/>
- Phoenix Integration- ModelCenter MBSEpak <https://www.phoenix-int.com/product/mbsepak/>
- Modelon - <https://www.modelon.com/#>
- InterCAX- <http://intercax.com/products/syndeia/>
- Open CAE & OpenMBEE- Open source frameworks developed by NASA/JPL <http://www.openmbee.org/>

Note: Not intended to be a comprehensive list of providers nor a CIMdata endorsement or ranking



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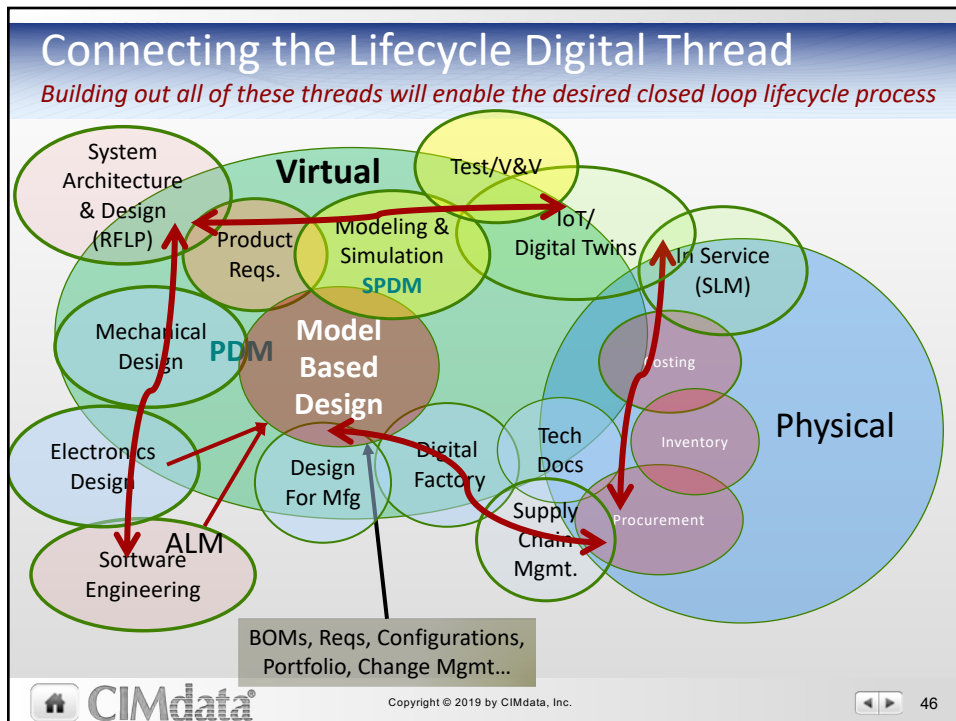
## CIMdata: Emerging Standards for MBSE

**Final Thoughts**  
*Digitalization, MBSE, PLM and Digital Thread: Where to next?*



**Innovation**  
**Digital Twin**  
**IoT/Industry 4.0**  
**Interoperability**  
**Model-Based**  
**PLM**  
**Digital Thread**  
**Systems Engineering**  
**Transformation**  
**ROI**

**Collaboration**



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## CIMdata: Emerging Standards for MBSE

### Enabling the Digital Thread Vision for MBSE

*What is needed to address the industry's business needs?*

**MBSE implementation will ultimately require a blend of:**

- 1) **Process change** leveraging MBSE best practices of early adoption leaders across all industry segments<sup>1</sup>
- 2) **Common ontology, semantics & languages** for systems architecture design
- 3) **Innovation platforms & software tools** for PLM/MBSE/IoT integration
- 4) **Model & Data management** across the enterprise domain silos
- 5) **Robust standards** for PLM/MBSE data interoperability

<sup>1</sup>Frank Popielas, Edward A. Ladzinski – SMS\_ThinkTank: “Systems Engineering – Challenges for Management”; CAASE18, June 5-7, 2018; Cleveland, OH



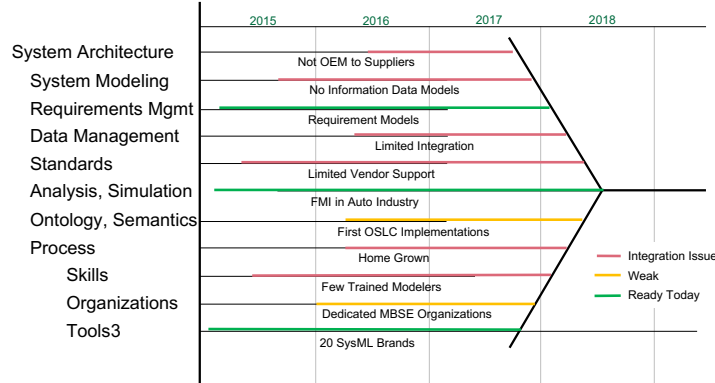
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### Progress Being Made in Several MBSE Areas

#### MBSE Workshop: Industry Roadmap

Global Product Data Interoperability Summit | 2018



ELYSIUM | PTC | AUTOCAD | ANSYS | SAP | IBM | ORACLE | MICROSOFT | SAP | IBM | ORACLE | MICROSOFT | SAP | IBM | ORACLE | MICROSOFT



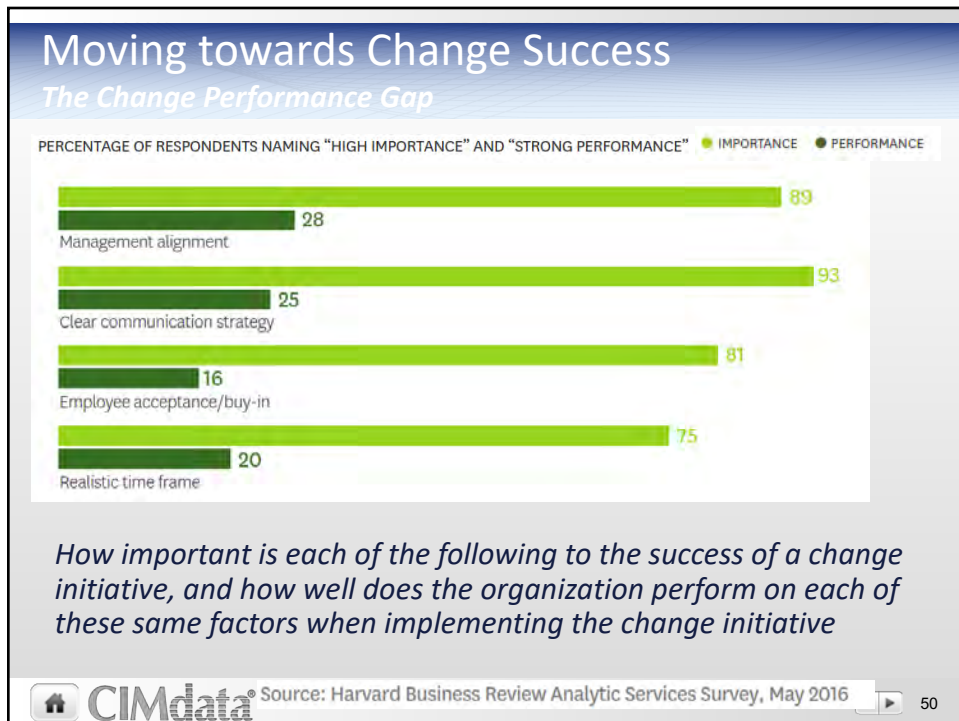
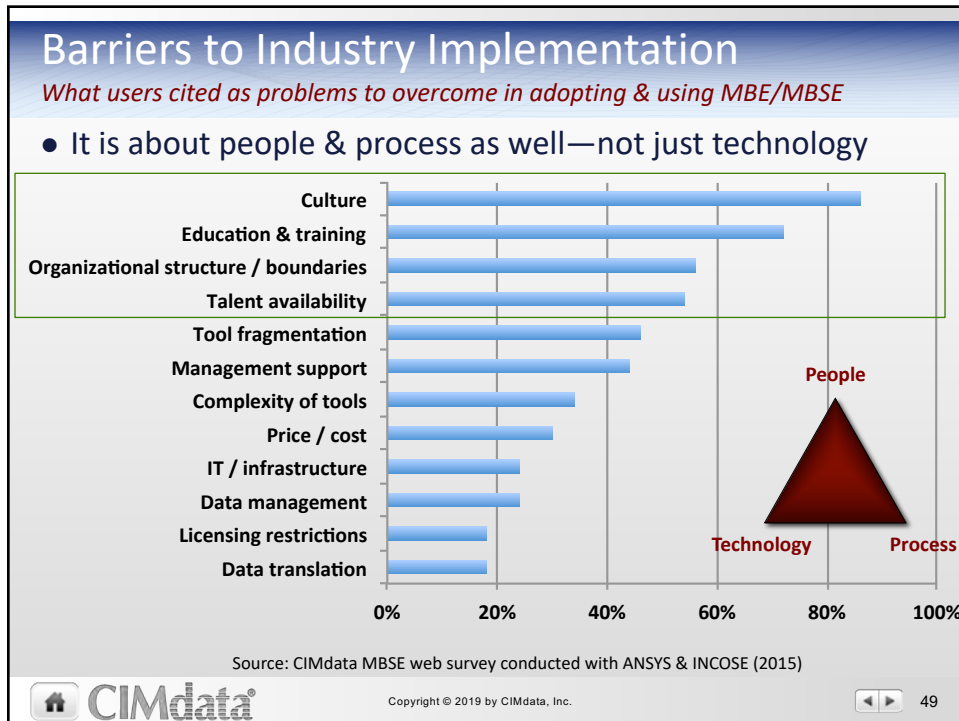
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2018 GPDIS MBSE Workshop— Dr. Harris Keynote

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.

Gregory A. Harris, PH.D. – Auburn University

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

Participants indicating digital is a top 10 driver of future competitiveness	81%
Organizations with "high" digital capability today	16%

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

Digital is a senior Leadership priority	52%
We have a strategy for how digital will enable competition	23%
Our digital efforts are innovative and bold	34%

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

Digital strategy translated to specific initiatives	20%
There is clear communication from leadership on digital strategy	24%
We have well defined metrics / KPIs	16%

SOURCE: McKinsey survey, >200 responses from subject matter experts, industry leaders. UI LABS Collaboration

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### Summary - Key Factors for Business Success

*Driving a Model-Based Enterprise Digitalization Strategy to Realization*

- Needs to be developed and supported in the context of an enterprise application architecture platform and data model
- *Implemented and promoted based on specific MBE business use case success and measurable ROI* **Crawl...Walk...Run!**
  - Define and pilot well-defined MBx processes in specific business focus areas— Must account for cultural change and the people buy-in/training required
- Maturity models and governance are essential to success
- Need to have “integrated, yet open” solutions of software and services based on industry standards and best practices
- Industry & DoD need to support new contractual concepts **AND** accept electronic project deliverables/signoffs/TDPs

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## CIMdata: Emerging Standards for MBSE

Enabling the Digital Thread Vision for MBSE  
*Industry initiatives underway to address known gaps and challenges*

MBSE standards bodies as well as industry research and best practices collaborations are actively underway. They need active industry support!

**GET INVOLVED!**



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Emerging Standards for MBSE  
*MBSE standards will be effective only if we all help define and actively use them!*



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