



2019
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MBSE, PLM and the Digital Thread: Market Update

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Digitalization: Transforming Enterprises

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



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

Collaboration

Digital Thread

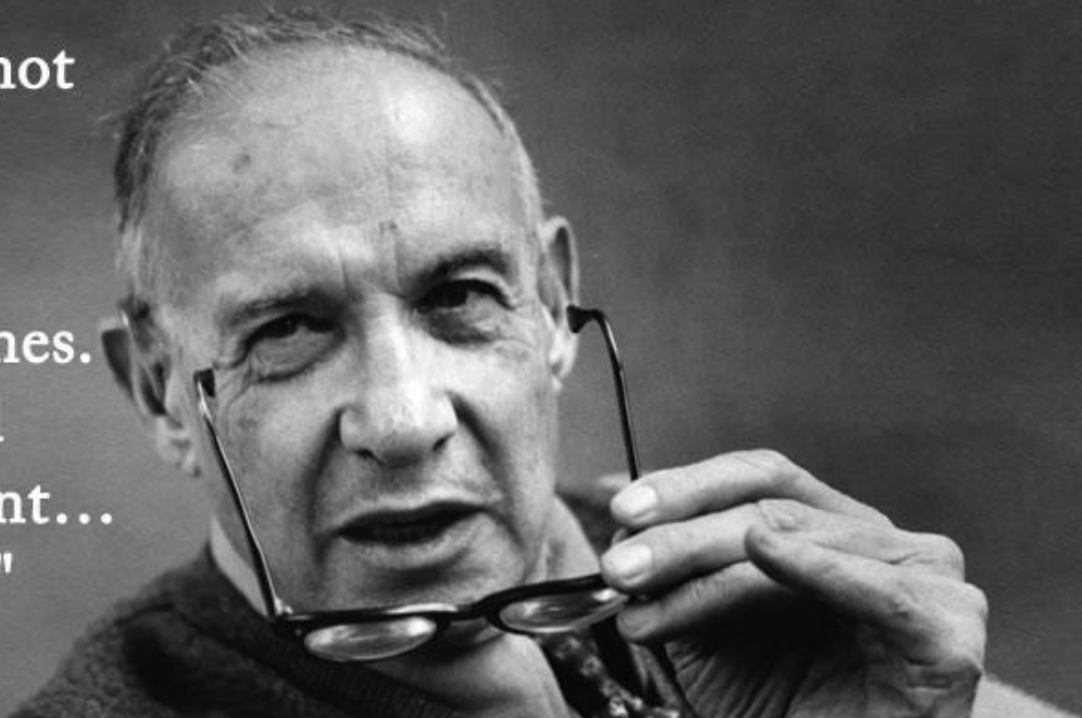
“Digitalization” accelerates change & innovation

"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

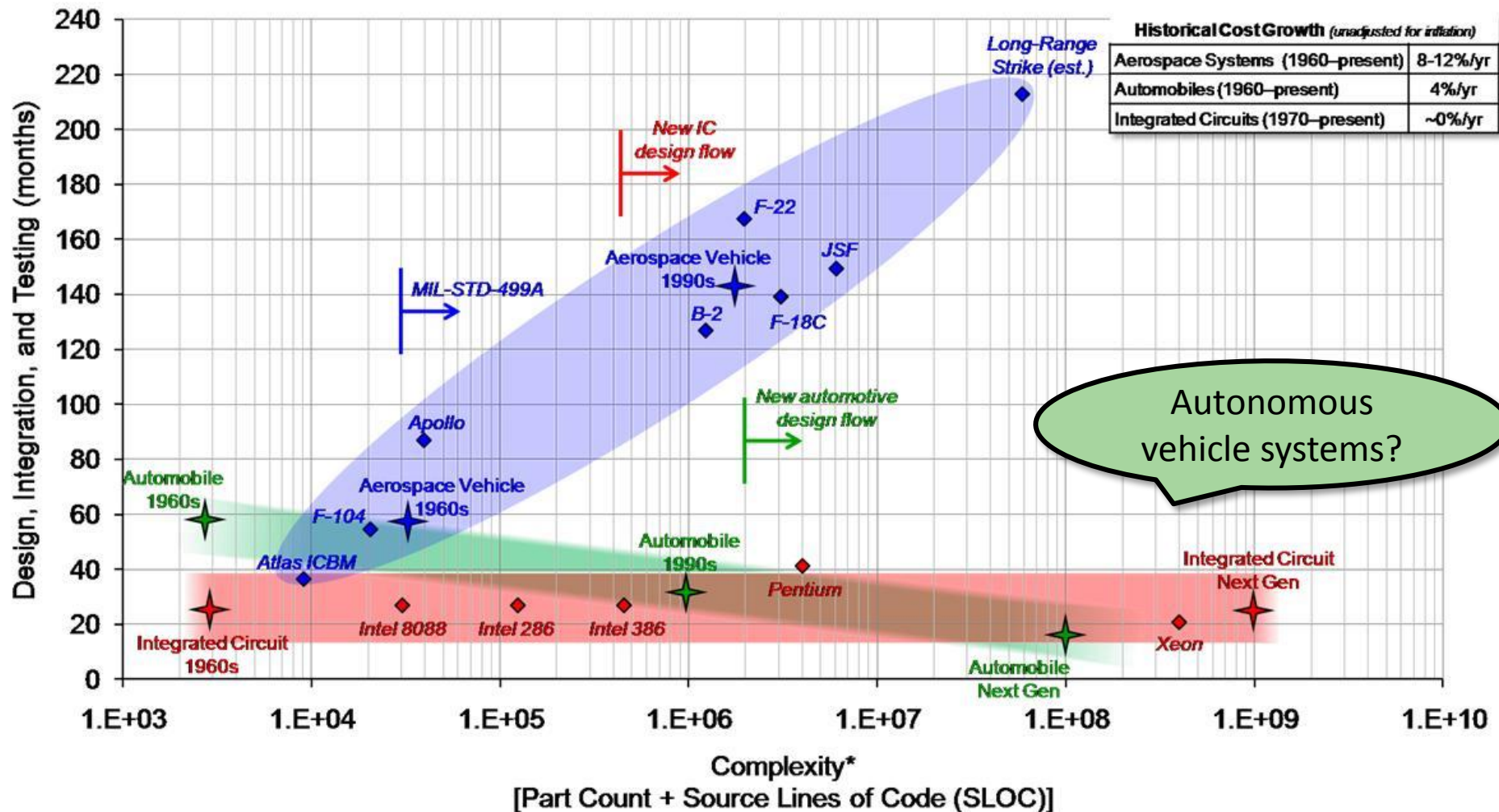


“Digitalization is the main reason just over half of the companies in the Fortune 500 have disappeared from the list since 2000.”

Pierre Nanterme, CEO Accenture, World Economic Forum



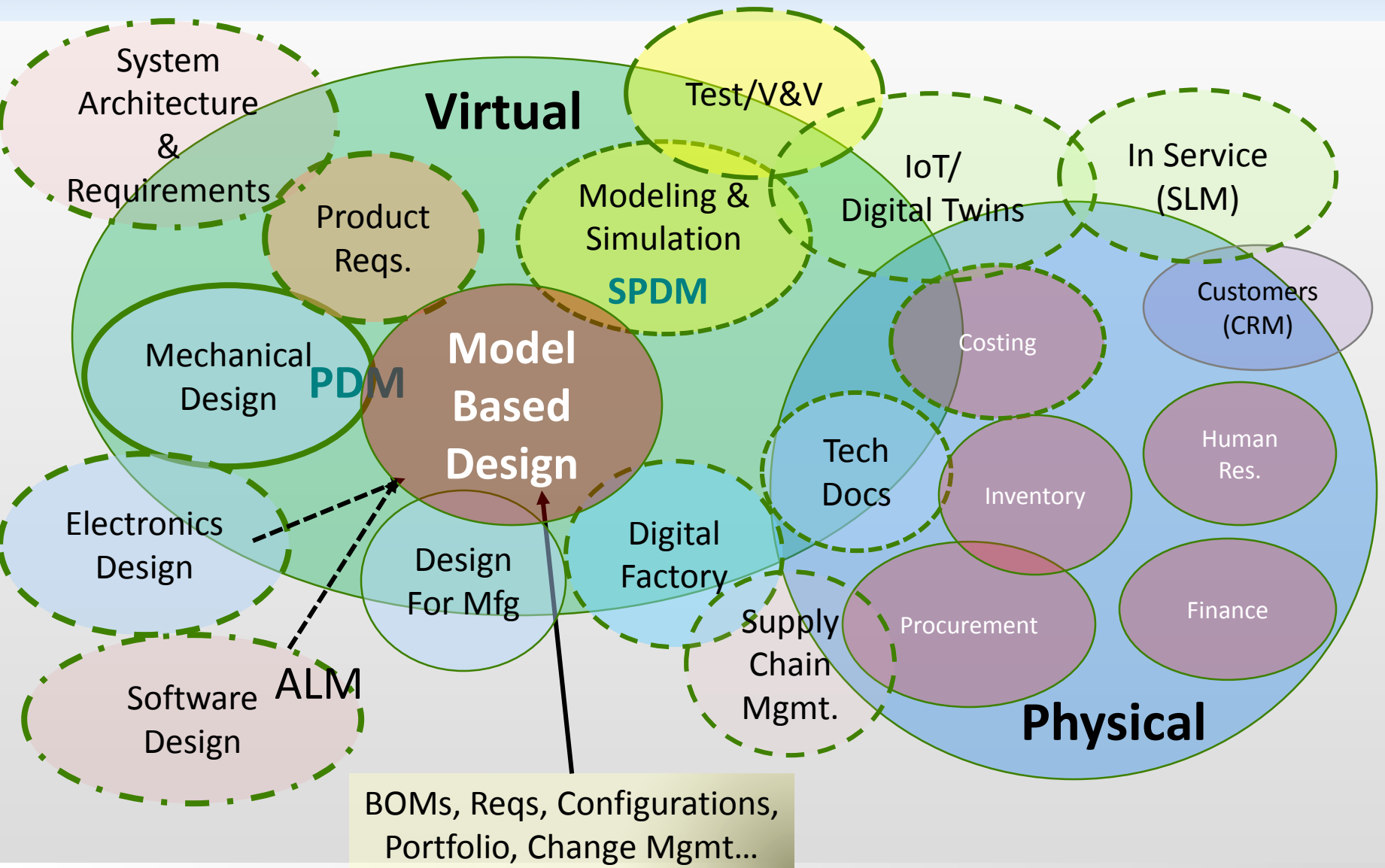
The Complexity Issue cuts across Industries



Source: DARPA AVM presentation.

Relationship of Digital Initiatives (“As Is”)

Key domains in model-based are typically managed partially or totally in silos today



Digitalization is Driving Major Product Development Trends

Bringing together digital initiatives across the entire lifecycle of systems

- 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 Modeling & Simulation



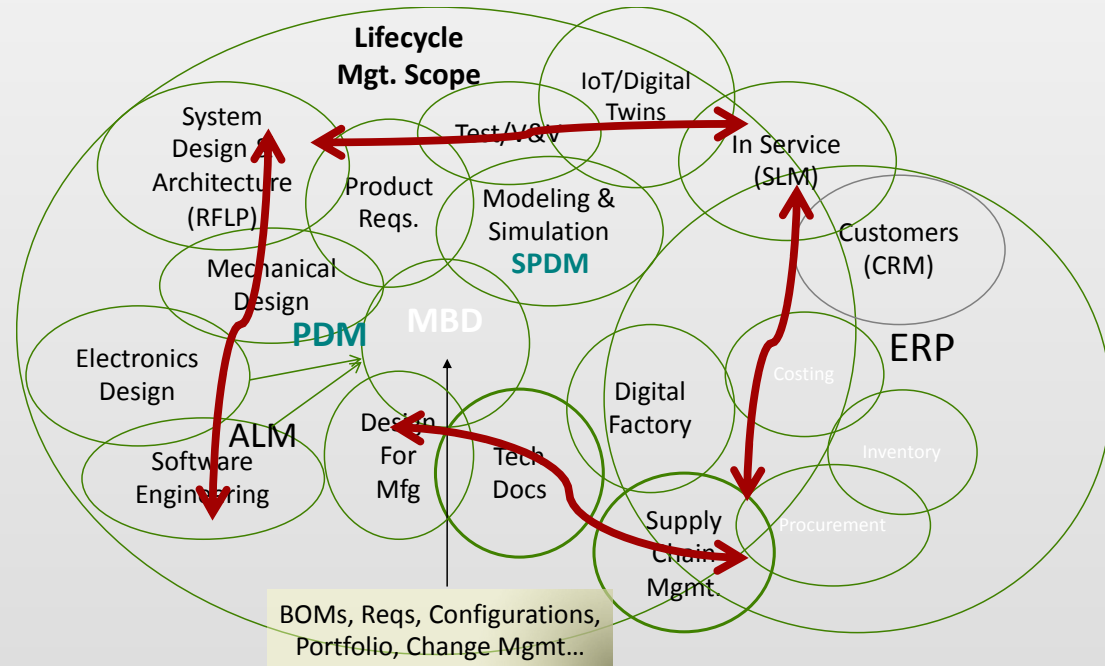
Technological advances enabling simulation use by more engineers earlier and throughout the product lifecycle

Digital Thread

CIMdata's preferred definition

- **Digital Thread** refers to the communication framework that allows a **connected data flow** and an **integrated view** of a physical asset's digital data (i.e., its Digital Twin) throughout its lifecycle cutting across traditionally siloed functions

Digital thread is enabled and supported by a robust end-to-end and connected systems model and related MBx processes



Extracted from: https://www.dodmantech.com/ManTechPrograms/Files/AirForce/Cleared_DT_for_Website.pdf

Also see: <http://www.manufacturing-operations-management.com/manufacturing/2016/04/what-is-the-digital-thread-and-digital-twin-definition.html>

PLM: The Required End-to-End Connectivity

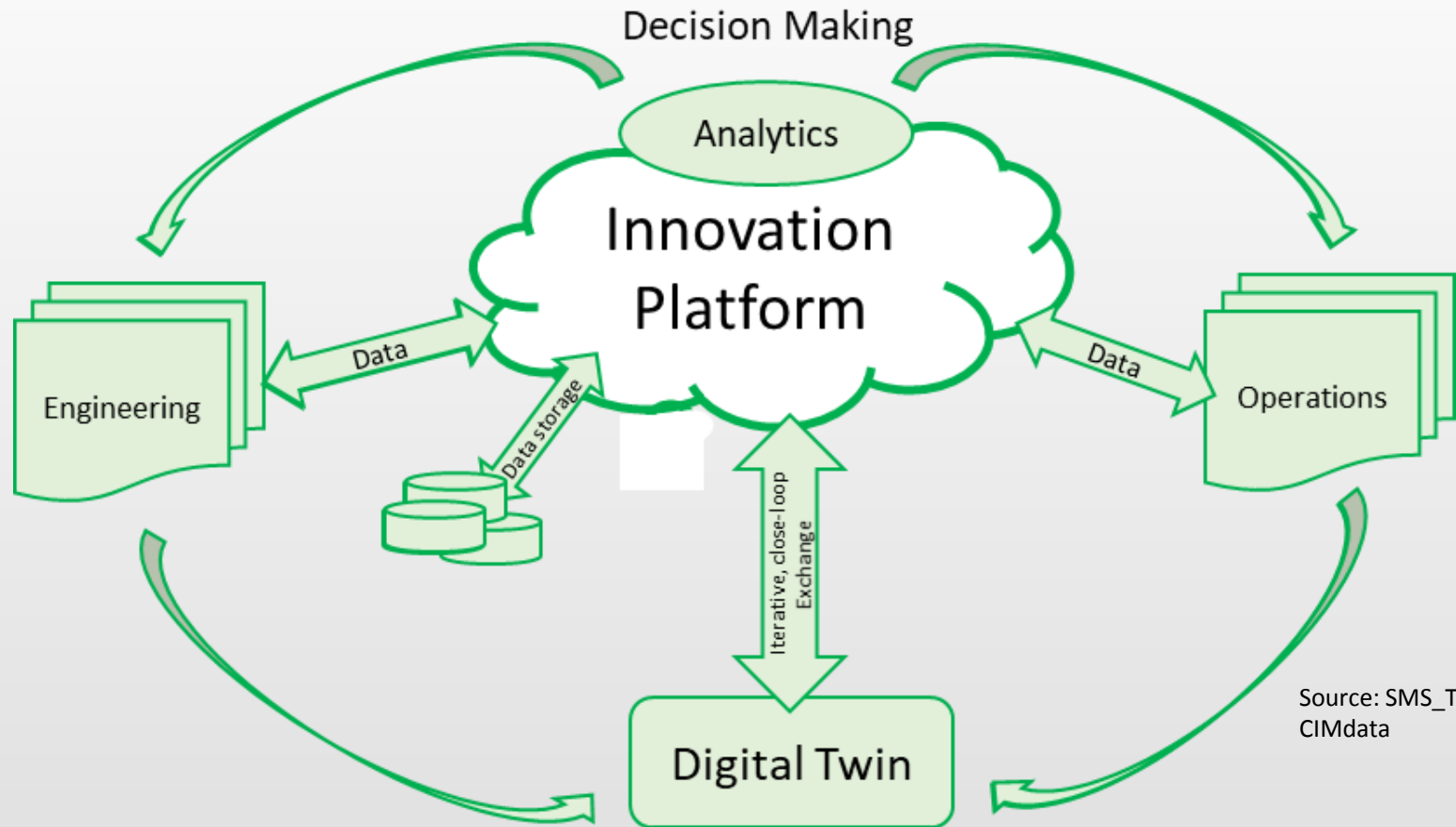
PLM touches all phases of a product's life—digitalization demands it



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

The Emergence of the Digital Platform

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



Source: SMS_ThinkTank™, CIMdata

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.

Platforms are now consolidating across domains

Leading vendors acquiring MBSE, ALM, EDA & IoT technologies



CIMdata PLM Market Forecasts

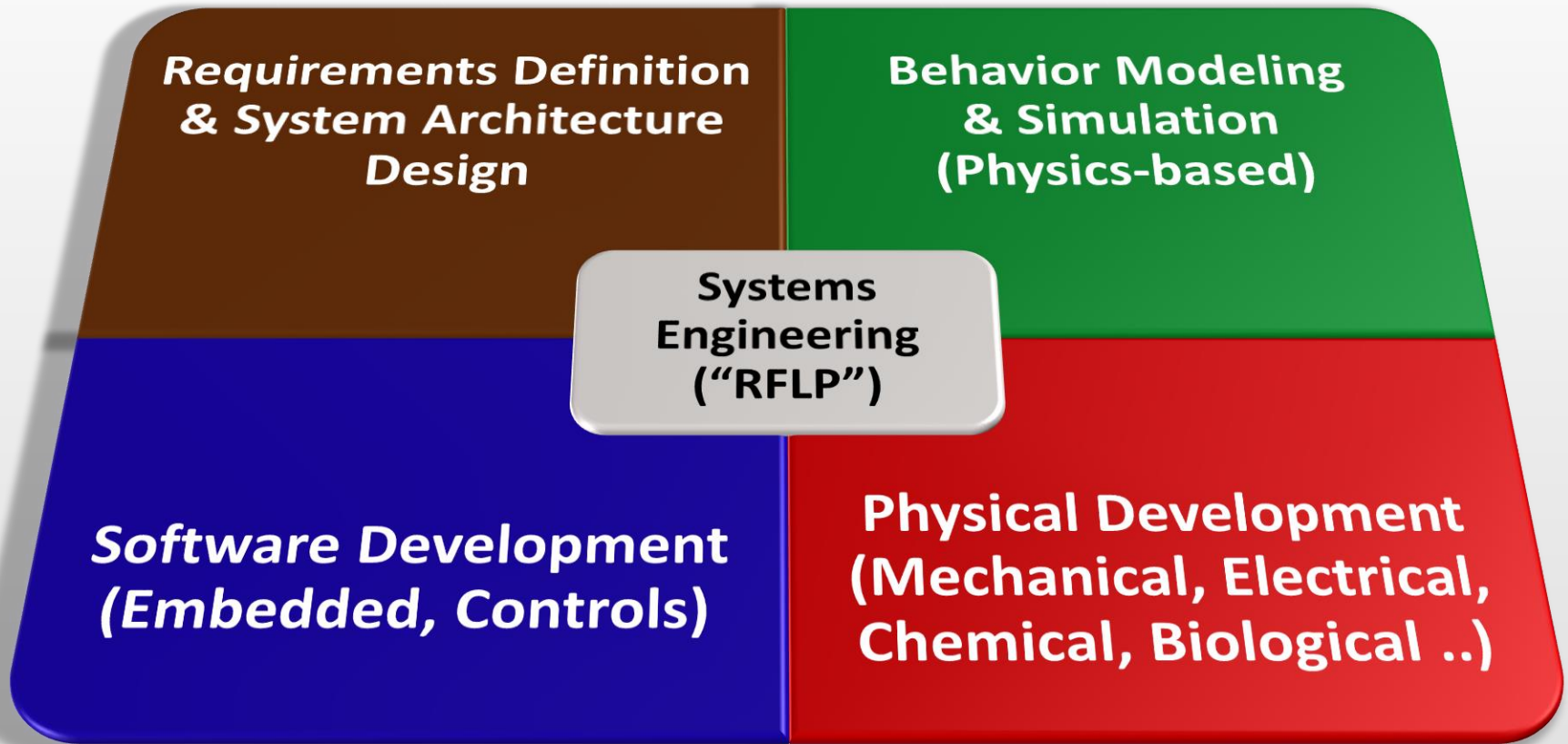
For 2018 (US\$ Millions) and 5-year compound annual growth rate (CAGR)

Segment	2018 Estimate	YoY Growth	5 Year CAGR
cPDM Comprehensive Technology Providers	\$6,164.07	6.4%	6.6%
cPDM-Focused Applications	\$2,387.49	7.2%	7.4%
Digital Manufacturing/Additive	\$828.40	8.7%	9.0%
SI/Reseller/VAR	\$7,478.24	6.6%	6.7%
Tools			
MCAD-Multi Discipline	\$3,985.35	5.2%	5.5%
MCAD-Design Focused	\$2,993.44	5.1%	5.2%
Non-Bundled CAM	\$1,452.49	6.2%	6.1%
Simulation & Analysis	\$6,173.07	8.1%	8.3%
Other Tools (e.g., SE, ALM)	\$1,494.86	7.6%	7.7%
EDA	\$9,764.57	7.1%	7.1%
AEC	\$3,925.25	9.5%	7.0%
Total	\$46,647.23	7%	6.9%

Estimates are US\$ (Millions)

Platforms are now consolidating across domains

PLM vendors acquiring MBSE, M&S, ALM, EDA & IoT technologies

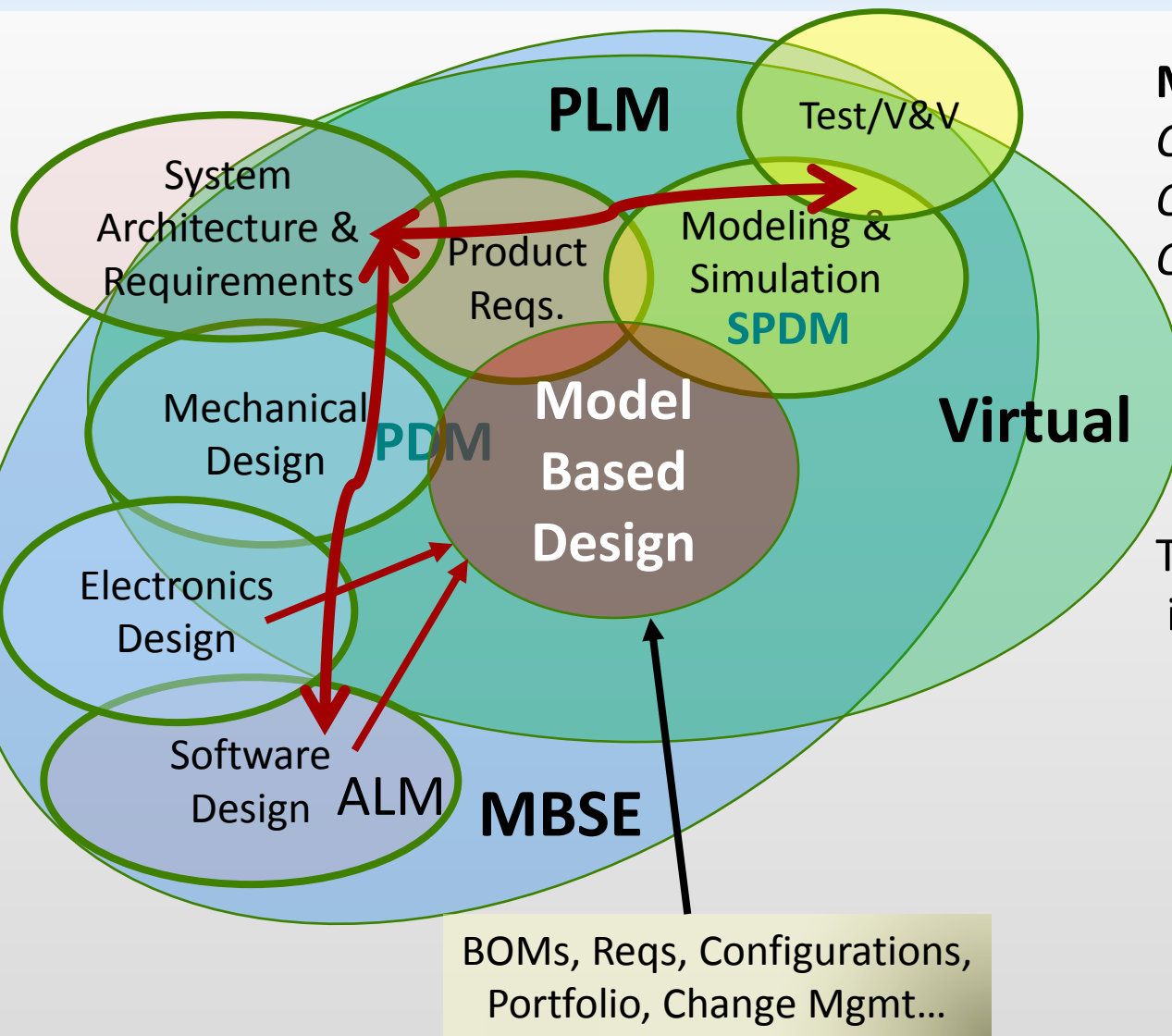


But still too way many tools in use for any single solution vendor to cover all the required disciplines



Sewing the MBSE Digital Thread ("To Be")

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



MBSE Use Case:

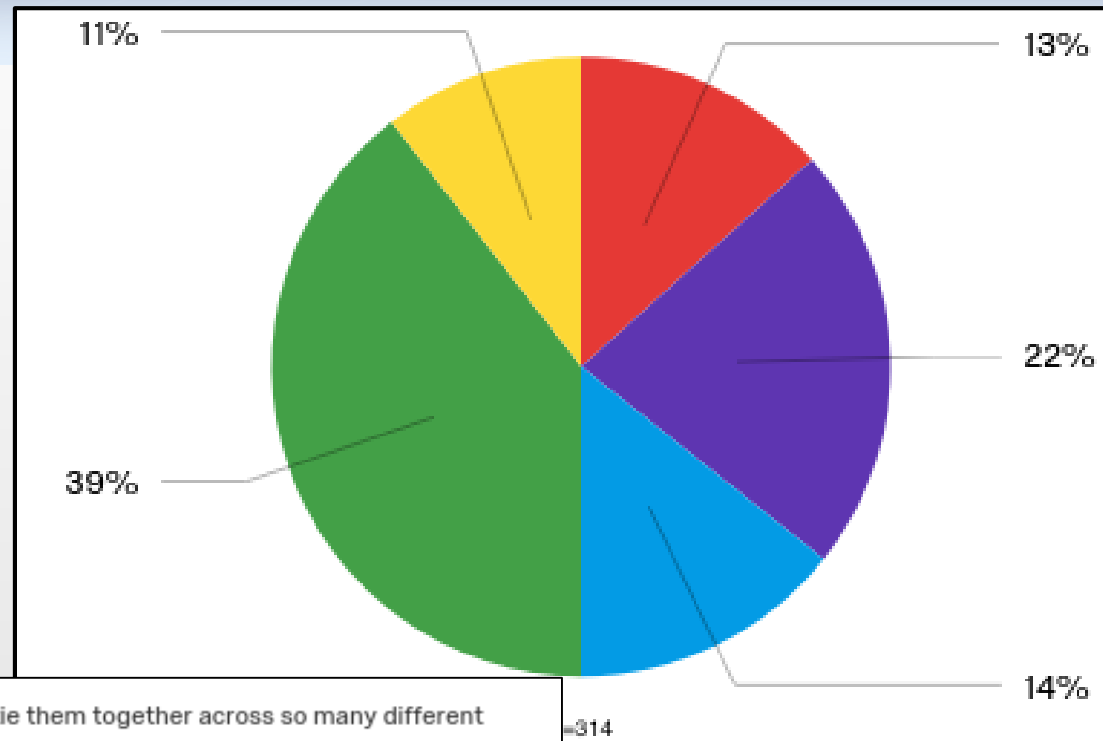
*Conceptual Design,
Optimization and Validation
Of Cyber-Physical Systems*

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

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*



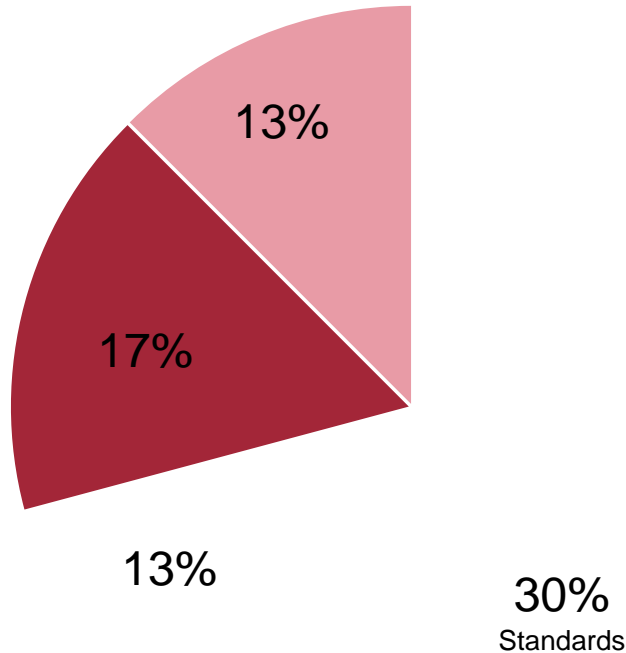
- We have so many existing models, it would be impossible to tie them together across so many different modeling environments, so we need to do it clean sheet
- The functionality available in clean sheet software would be really productive
- Our use case for MBSE is very specific, I don't think it would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

MIT MBSE On-line Course Survey of 300+ Engineers

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

MBSE Users: Standards Identified as Major Gap

The MBSE GAPS

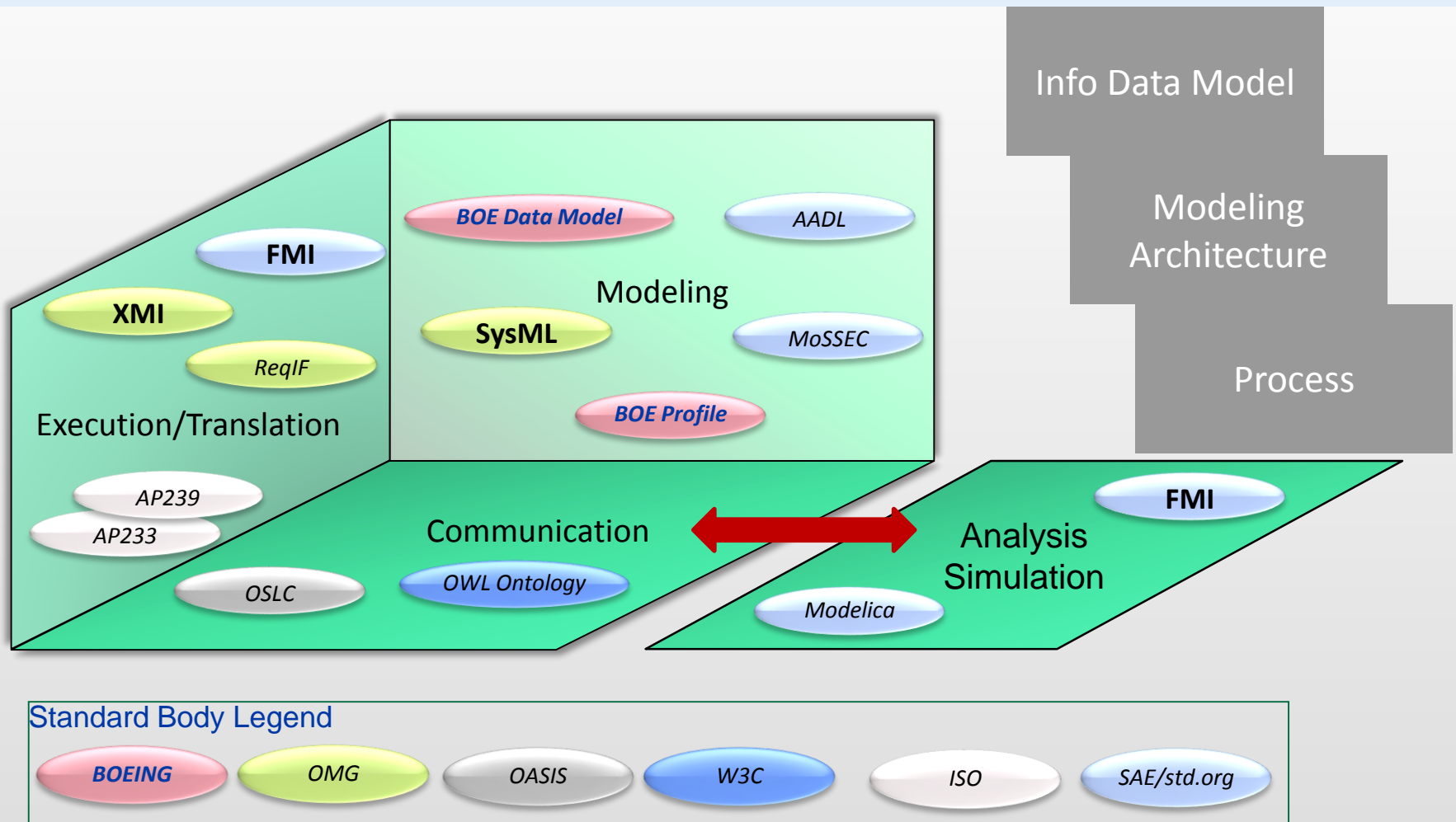


- Define/Justify MBSE
- Training-Implementation
- Integrate with PLM
- Standards - Interoperability
- Vocabulary
- Tool Integration (Vendors)
- Roadmap
- Modeling

“...just because you have a model doesn't mean you are model based...”

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

High Impact Standards- Critical MBSE Enablers



CREDIT: Bill Chown, Mentor Graphics; MBSE Roundtable, 2015 GPDIS

Enabling the Digital Thread Vision for MBSE

Key technical enablers to achieve the MBSE Digital Thread

Many MBSE IW Sessions
that address these key
technical enablers

Monday, 1/28 9AM-12PM

Systems Modeling &
Simulation WG (SMSWG)

1PM-4PM Salon F

MBSE Digital Exchange
Mark Williams, Boeing

A word cloud of technical enablers for MBSE, including SysML, FMI/FMU, ProcessAI, ReqIF, Standards, Platforms, OWL, AP2xx, XML, Semantics, Ontology, and MoSSEEC.

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 Benchmarks

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

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

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GROUP**



Final Thoughts

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



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IoT/Industry 4.0
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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

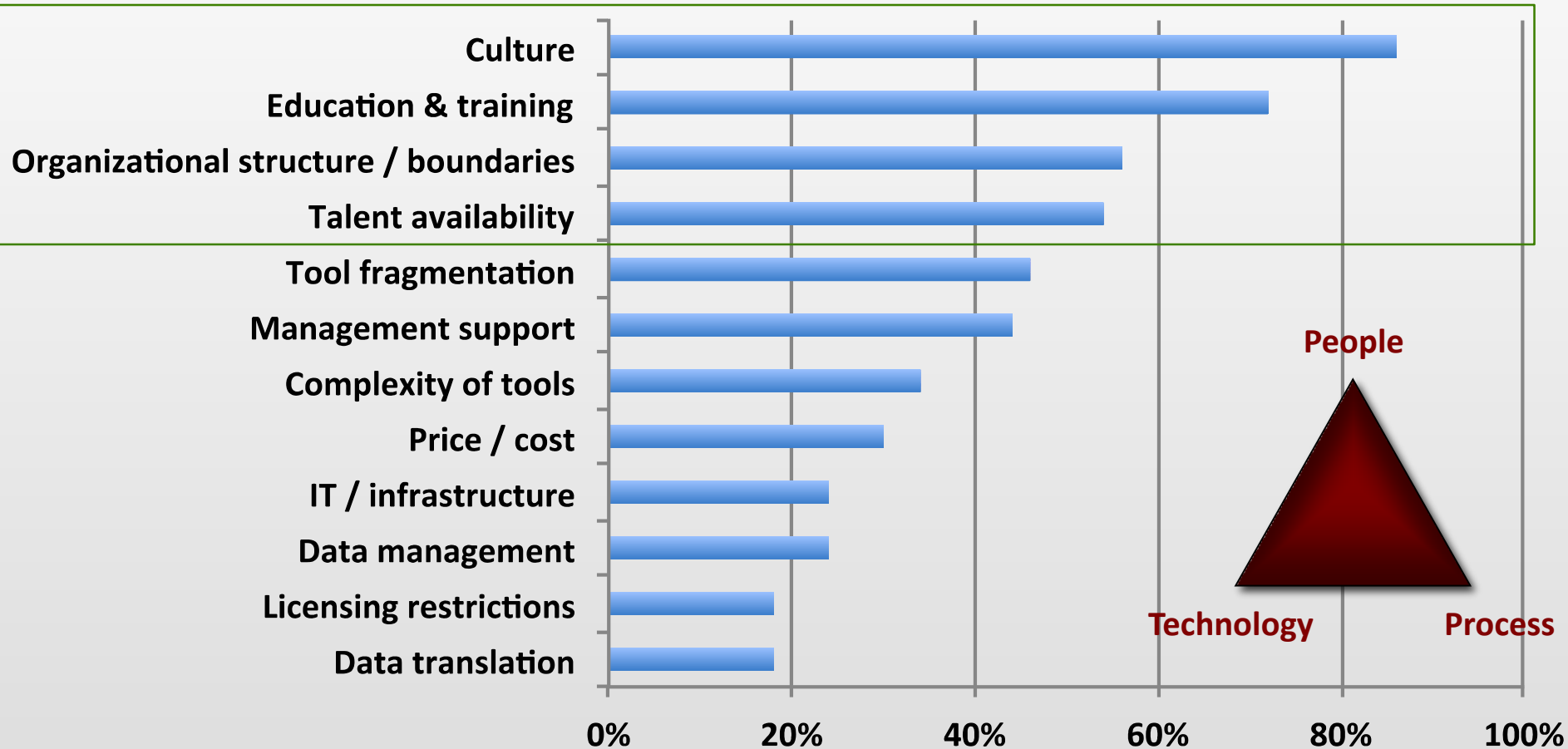
GET INVOLVED!



Barriers to Industry Implementation

What users cited as problems to overcome in adopting & using MBE/MBSE

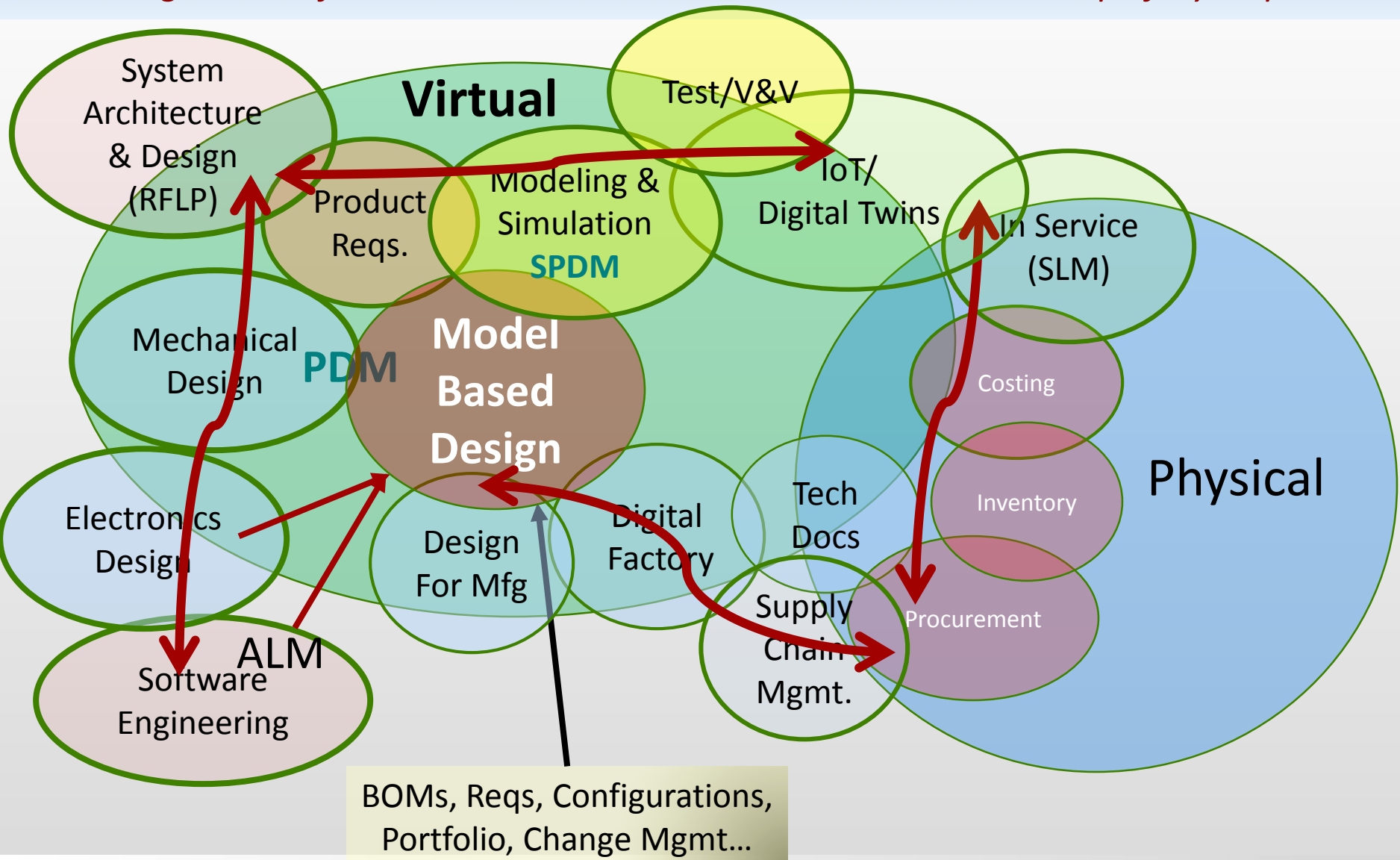
- It is about people & process as well—not just technology



Source: CIMdata MBSE web survey conducted with ANSYS & INCOSE (2015)

Connecting the Lifecycle Digital Thread

Building out all of these threads will enable the desired closed loop lifecycle process



MBSE, PLM & Digital Thread: Market Update



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