Enabling Digital Transformation: A Market Overview

Strategic Briefing for Datadvance/pSeven User Conference

12 October 2022

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Donald Tolle

Practice Director, Simulation-Driven Systems Development

- 40+ years of experience in the definition, development and implementation of simulation-driven engineering solutions
- Range of senior positions with PLM/CAE software & services providers (SDRC, UGS PLM/Siemens PLM, Comet Solutions)
  - Product Development Consulting Services
  - Software Product Management and Product Development
  - I-deas CAE & Test Business General Manager
  - Corporate Marketing, Business Development and Strategy/Mergers/Acquisitions
- Joined CIMdata in 2013 to help lead up the Simulation & Analysis Practice, Focus expanded to SDSD in 2015 to include S&A integration with SE (MBSE)
- Active participant in INCOSE, NAFEMS/INCOSE SMS WG, NAFEMS SDM WG, Aerospace & Defense Action Group, GPDIS, ASSESS Initiative Working Groups
- B.S in Mechanical Engineering and Masters in Business from Univ of Cincinnati

Our Mission…

Strategic management consulting for competitive advantage in global markets

CIMdata is the leading independent global strategic management consulting and research authority focused exclusively on PLM and the digital transformation it enables.

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

CIMdata Services…

Creating, disseminating, and applying our intellectual capital in support of your digital transformation

Research

- *Market research & analysis*
- *Technology research & analysis*
- *Reports & publications across multiple domains*
- *Market news*
- *Member services…*

Education

- Certificate Programs
- Executive seminars
- Technology seminars
- Educational webinars
- Int'l conferences & workshops
- Best practices training…

Consulting

- Strategy & vision
- Needs assessment
- Solution evaluation
- Best practices
- Quality assurance
- Program management
- Market planning…

Delivering strategic advice and counsel through a comprehensive, integrated set of research, education, and consulting services

PLM is a strategic business process - not software!

Digital Thread- Integration across many applications and data silos, each often focused on a part of the lifecycle

Portfolio Management

Planning

Conceptual Design

Product Engineering

Manufacturing Engineering

Requirements

PPM

PLE

SE

ALM

EDA

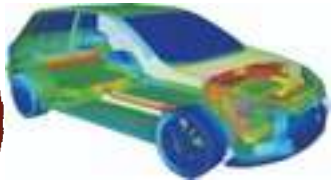
MDA

PDM

SDM

TDM

Simulation, Test & Validation



Digital IP

Re-use
Re-purpose
Re-mfg.
Re-cover
Re-cycle
Re-tire

Model- Based Systems Engineering

Modeling, Simulation, Analytics

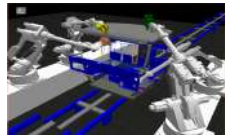
Digital Manufacturing

EAM / MRO / SLM

ERP / MES / MOM

Disposal & Recycling

Build & Produce



Maintenance & Repair

In-service Operations

Sales & Distribution

Quality Assurance

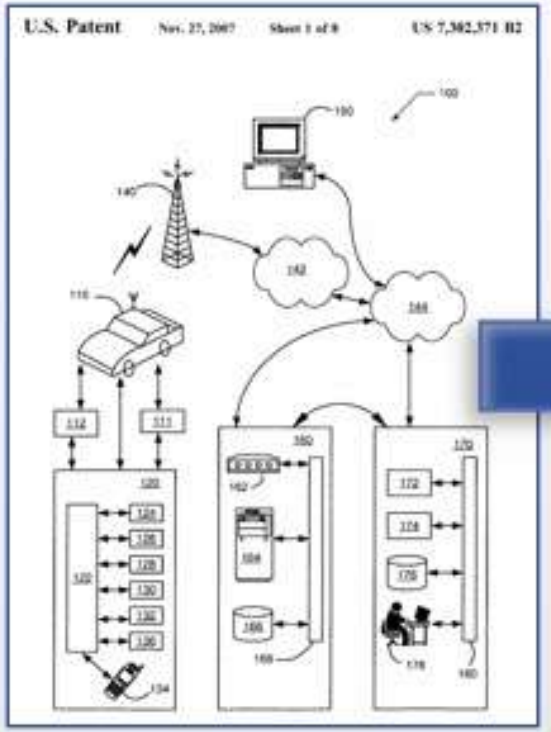
PLM Solutions—Information Management across Media, Process, Time, Geography, & Enterprise

Today's Major Trends & Potential Disruptors

A convergence of ideas, technologies, strategies, and associated complexities

Commercial Products Becoming Complex

Automakers use many models to make critical decisions, products are connecting, safety must increase



2005 - Diagnostics To Email

Image courtesy of Siemens

Figure 2—AVs Become Aware of Pedestrians While Operating in Connected Transportation Systems *Courtesy of Siemens*

2020+ Emerging Transportation Systems

Vehicles are becoming a subsystems in interconnected transportation systems

Complexity = Risk, Digitalization = Opportunity

Business Success now requires a systems-oriented Model-Based Engineering approach

- Cyber-physical systems- Electronics & software exploding
- New mfg processes & materials—lighter, stronger, green
- Consumers demand “mass customized” products… Now!
- Increased regulatory requirements across all industries
- 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

Digitalization is Driving Major Engineering Trends

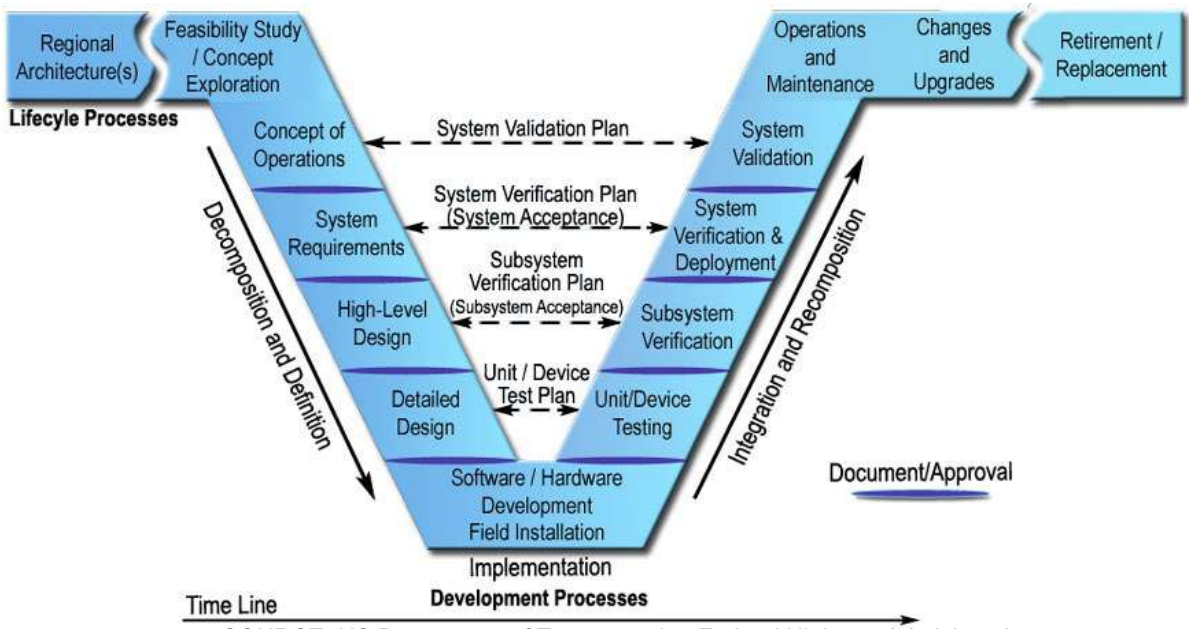
Investment in Simulation, Data Analytics and AI/ML to drive future Systems Development

• Product Innovation Platforms	*Multi-physics S&A and cross-domain systems level simulation increasingly relevant throughout the product lifecycle to enable innovation, quality and profitability (Generative Design/Engineering)*
• Democratization of Simulation	*Capturing the best practices of advanced simulation experts in easy to use low code applications deployed and managed via the web/Cloud*
• Model-Based Systems Engineering	*Connecting VOC/requirements with systems level design, modeling and simulation across all engineering domains and thru the lifecycle*
• Digital Thread & Digital Twins	*IoT & data analytics technology creating new insights and use cases for simulation models in manufacturing and operations as well as design*
• Smart Connected Products (IIoT, Analytics, AI/ML)	*Technological advances enabling simulation and analytics use by more engineers throughout the product lifecycle into mfg and operations*

Moving Toward a Model-Based Future

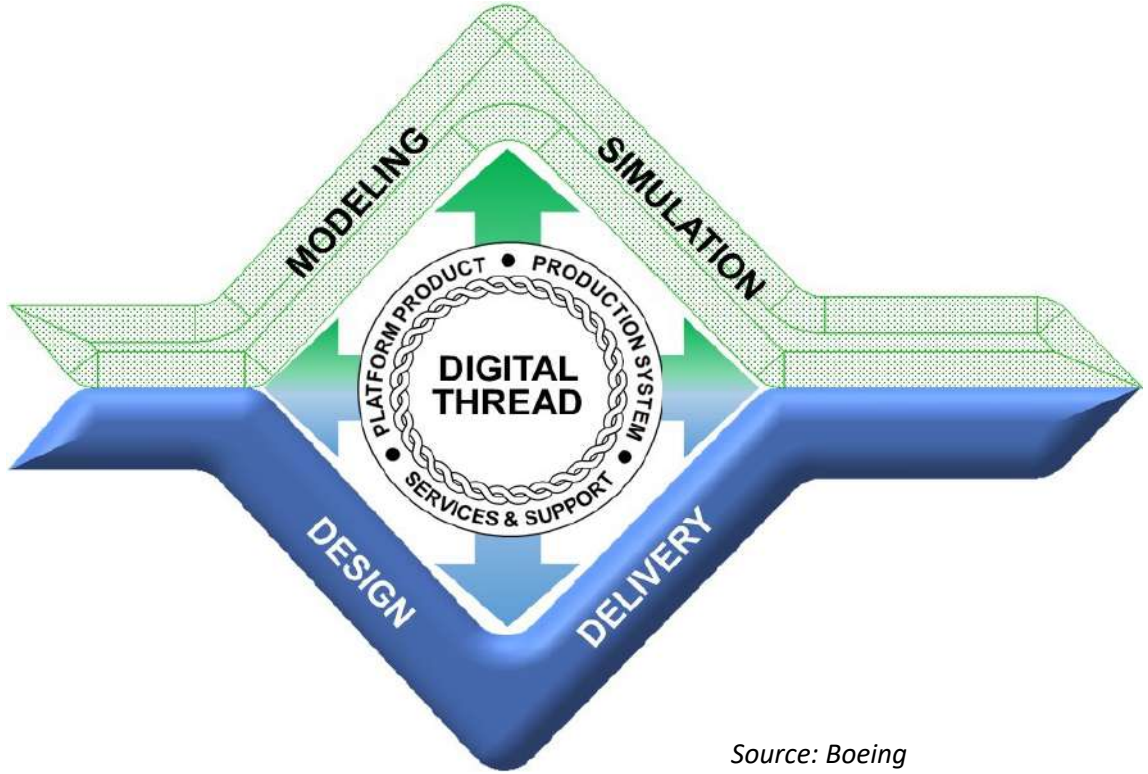
Transitioning to a digital thread of systems of systems

SE Vee



SOURCE: US Department of Transportation Federal Highway Administration
https://ops.fhwa.dot.gov/publications/seitsguide/section3.htm

MBE Diamond



Source: Boeing

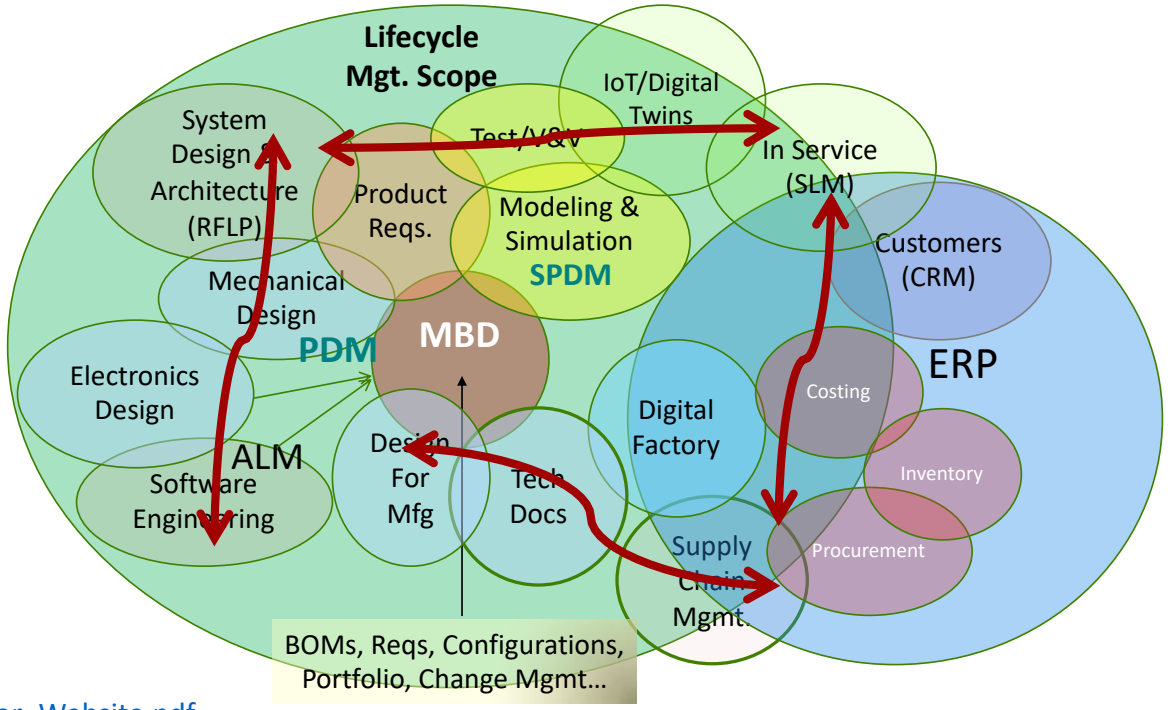
Transitioning from a document-focused mindset to a data-based model mindset that leverages information flow across the lifecycle

Digital Thread

CIMdata's preferred definition

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

Digital Thread is enabled and supported by a robust end-to-end and connected systems model and MBE processes



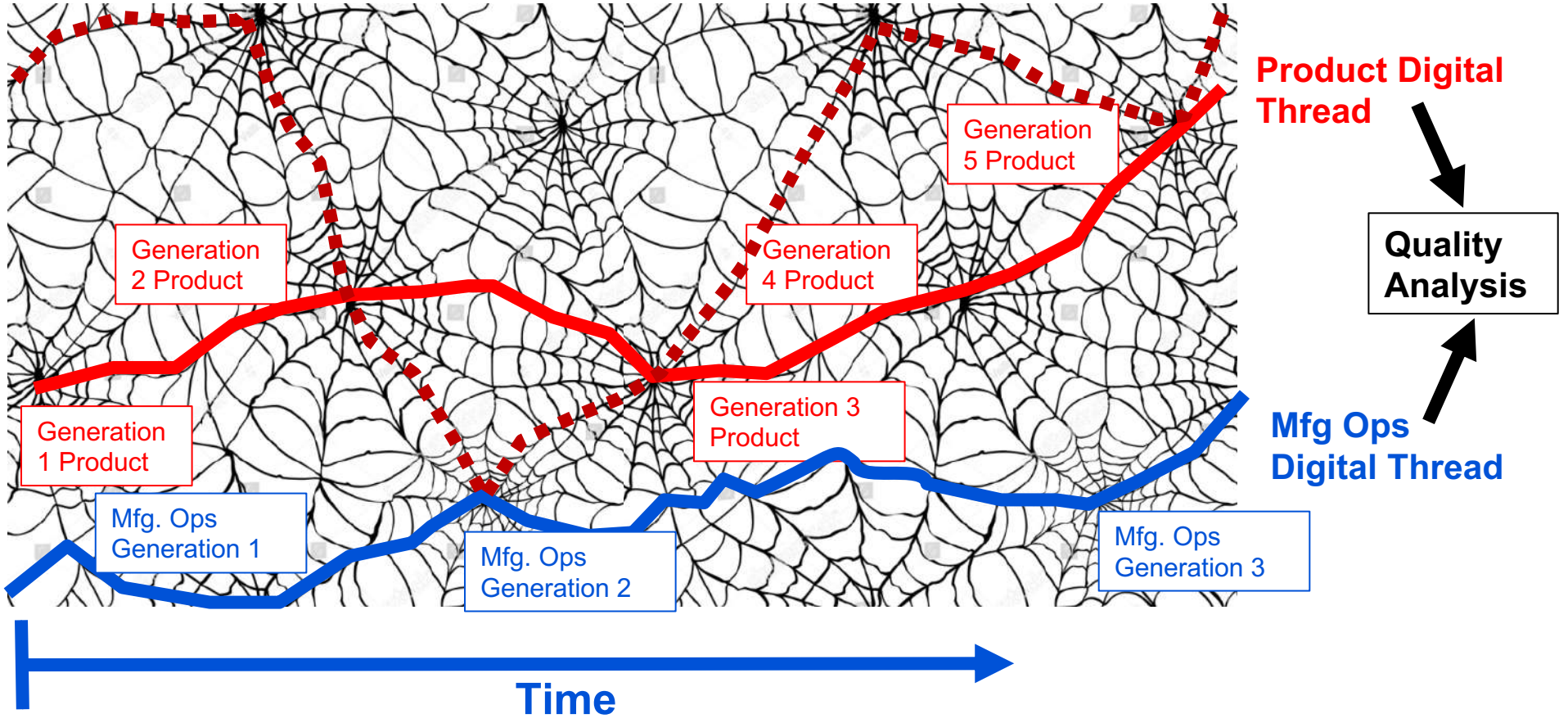
Extracted from: https://www.dodmantech.com/ManTechPrograms/Files/AirForce/Cleared_DT_for_Website.pdf

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

Many Digital Threads; Threads Are Not Linear

Gartner perspective: Digital Threads? We Need Digital Nets

Other digital threads?? Compliance? Cost? Others?



Source: *Digital Thread: Be Careful What you Wish For, It Just Might Come True*, presentation at PLM Road Map & PDT 2020, by Dr. Marc Halpern, Gartner, Inc.

MBE Trends: Addressing the Challenges

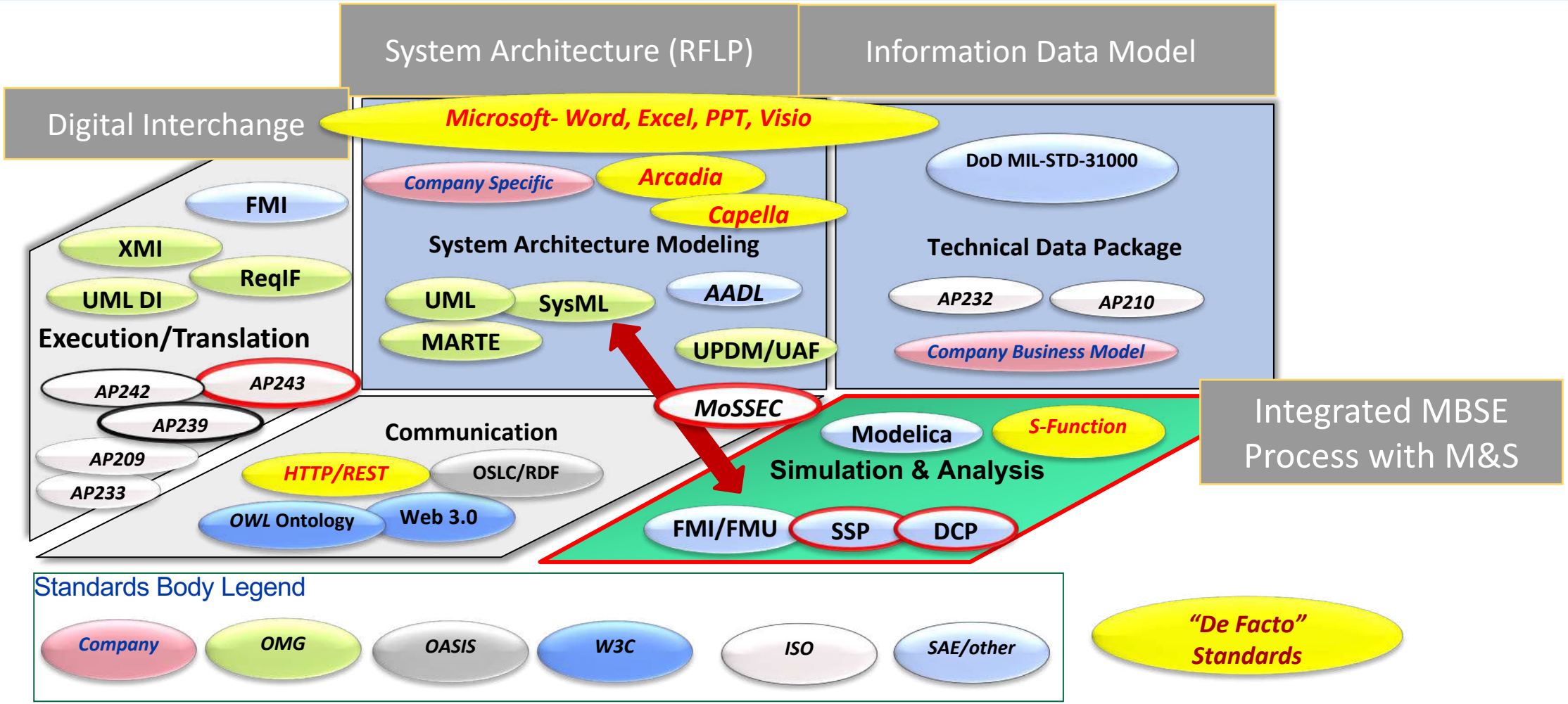
How is the MBx solutions market responding?

- MBE data exchange & interoperability standards to enable the lifecycle digital thread/digital twins capabilities
- Integration of underleveraged MDAO and SPDM tools with SE tools
- Leveraging emerging AI/ML technologies for “augmented intelligence”
- “Democratization” of a simulation-driven MBE approach

https://www.cimdata.com/en/resources/complimentary-reports-research/white-papers

High Impact "Standards"– MBE Process Enablers

Combination of formal international standards and industry "de facto" standards will enable MBSE



Adapted from Original Graphic: CREDIT to Bill Chown, Mentor Graphics; MBSE Roundtable, 2015 GPDIS

Digital Twin

An accurate digital representation of your products and/or services at any point throughout the lifecycle

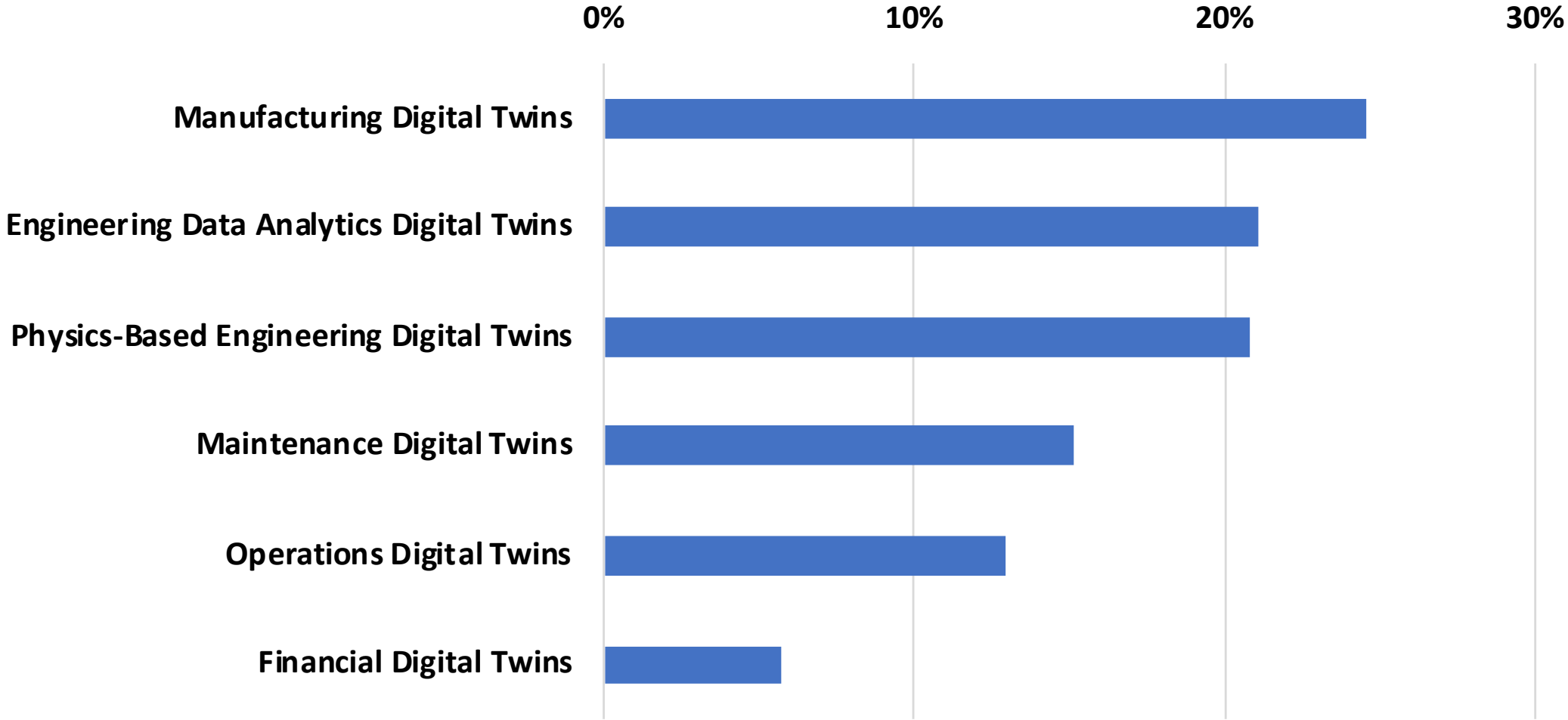
- A ***virtual representation*** (i.e., digital surrogate) of a physical asset or collection of physical assets (i.e., physical twin) that exploits data flow to/from the associated physical asset(s).

Digital twin is enabled and supported by a robust end-to-end and connected systems model and MBE processes

*Adapted from input from ASSESS (see www.assessinitiative.com)

Adoption of Digital Twins

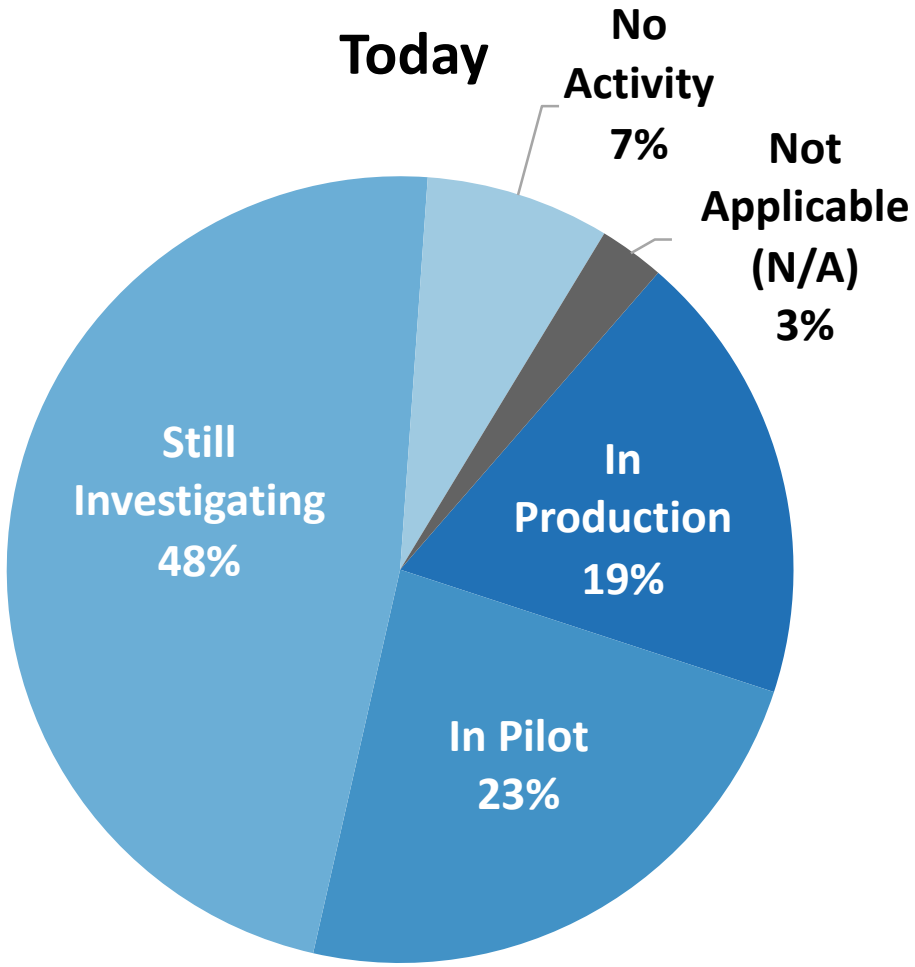
Expected areas for application for digital twin technologies - Next 5 years (All participants)

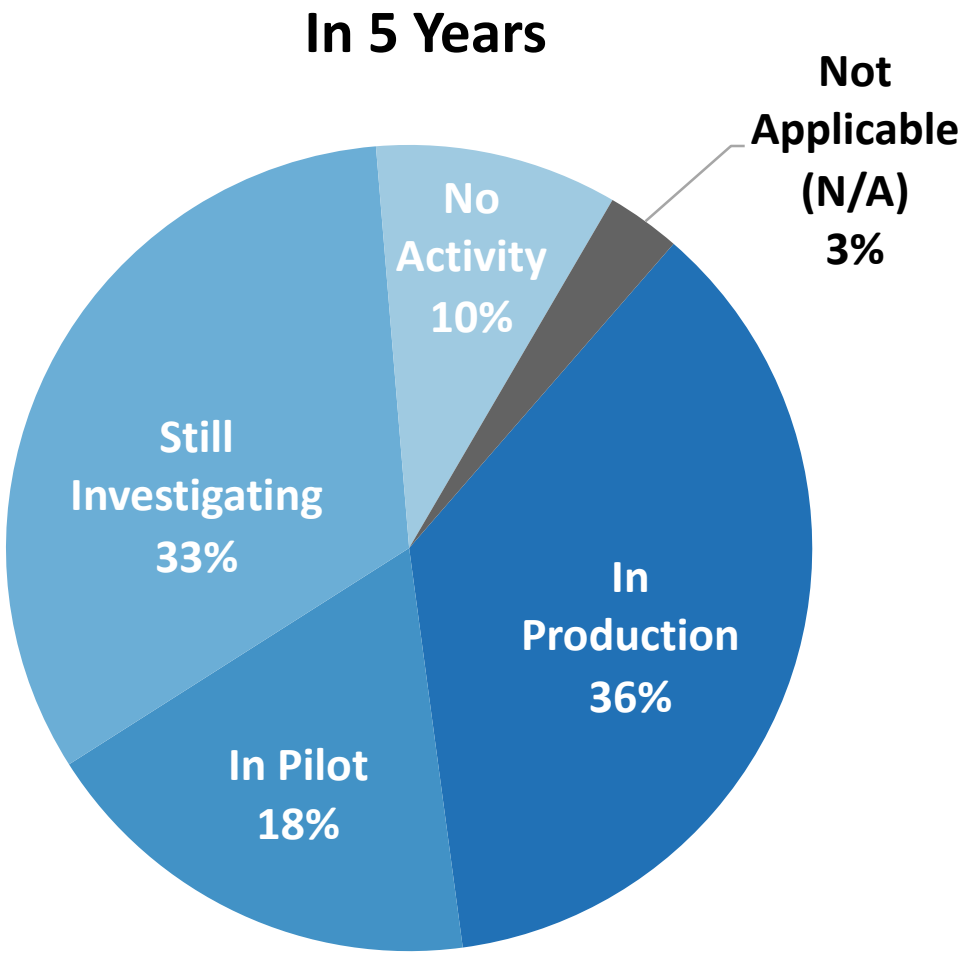


2020 CIMdata-Altair ATC Survey

Adoption of Digital Twins

Where is your company in the implementation of digital twin technology?





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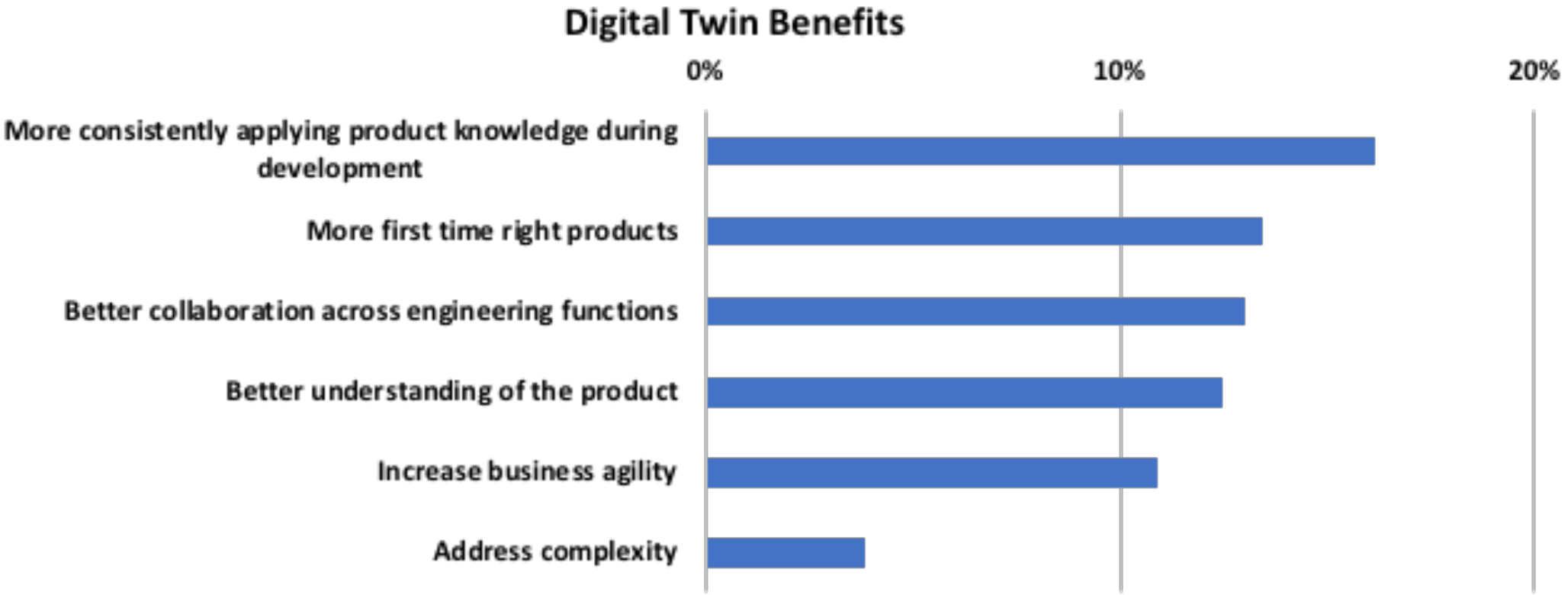
Adoption of Digital Twins

Expected benefits from digital twins - Next 5 years (All participants)

Benefits from utilizing Digital Twins

Applying product knowledge and product team collaboration helps yield more "first time right" products



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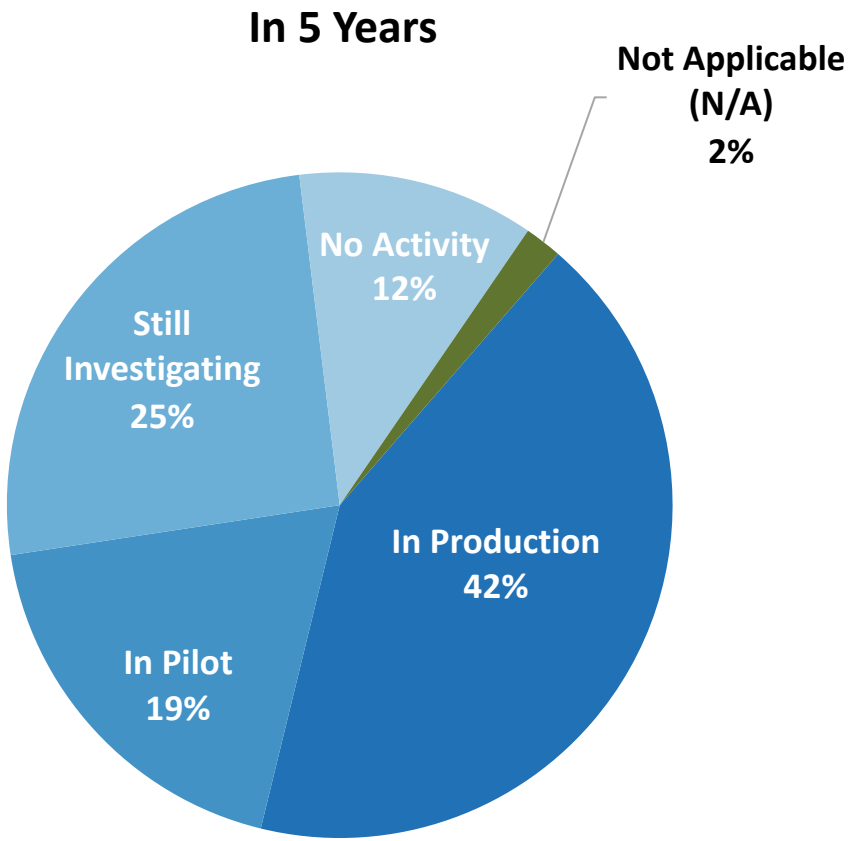
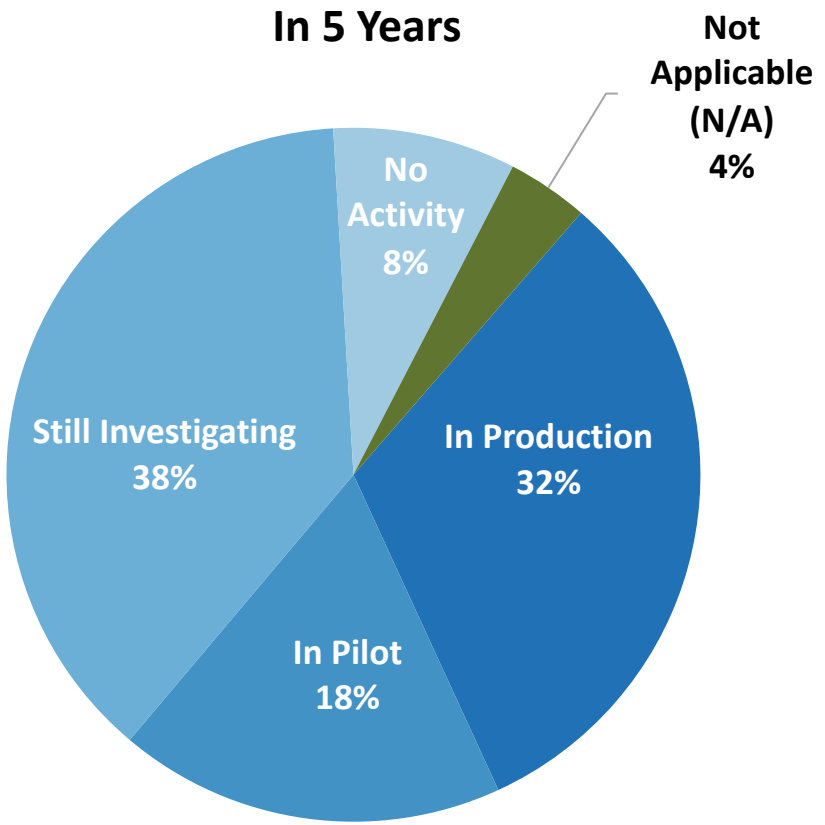
Adoption of Digital Twins

Management more optimistic than users

Management Forecast



Technical Specialist/ User Forecast



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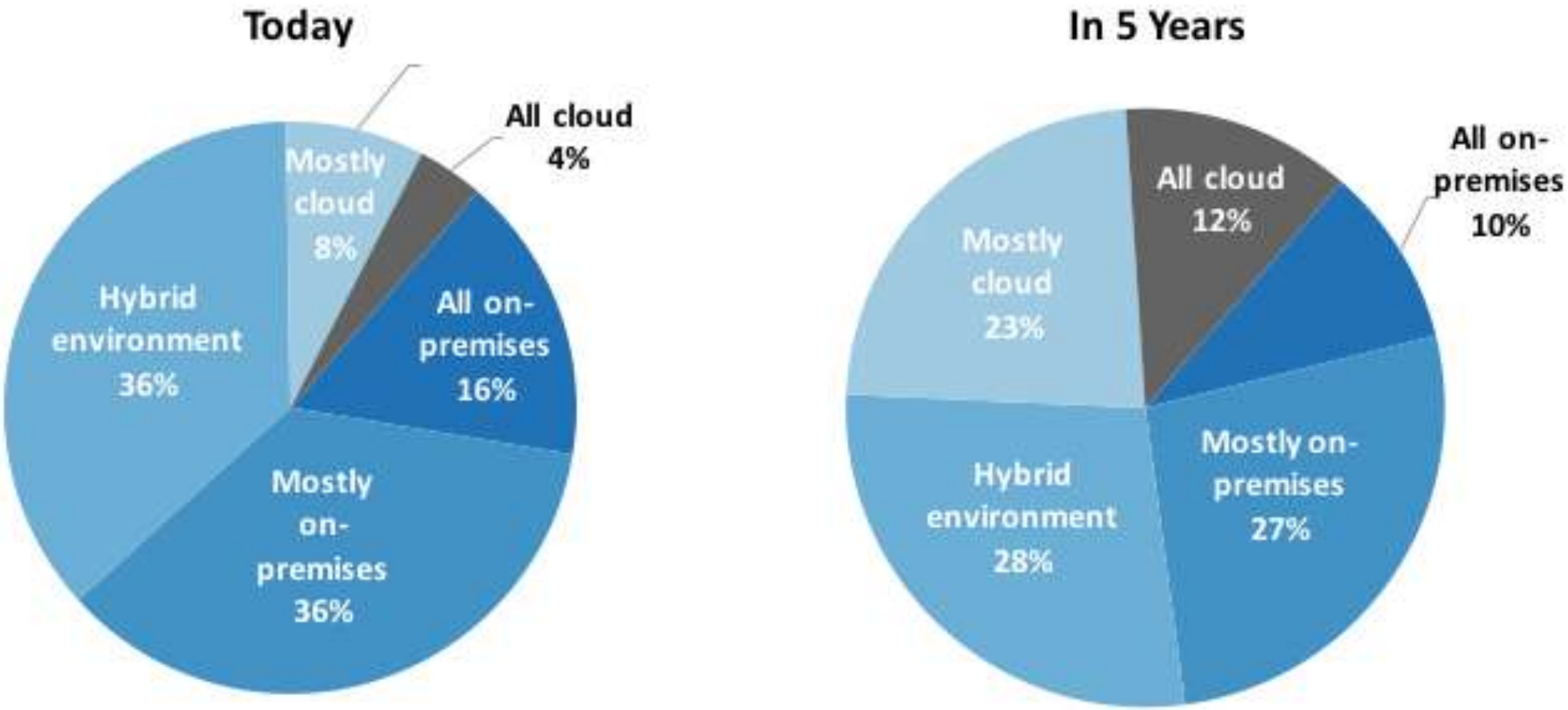
Cloud Utilization

Where is your company in the use of Cloud applications for engineering?



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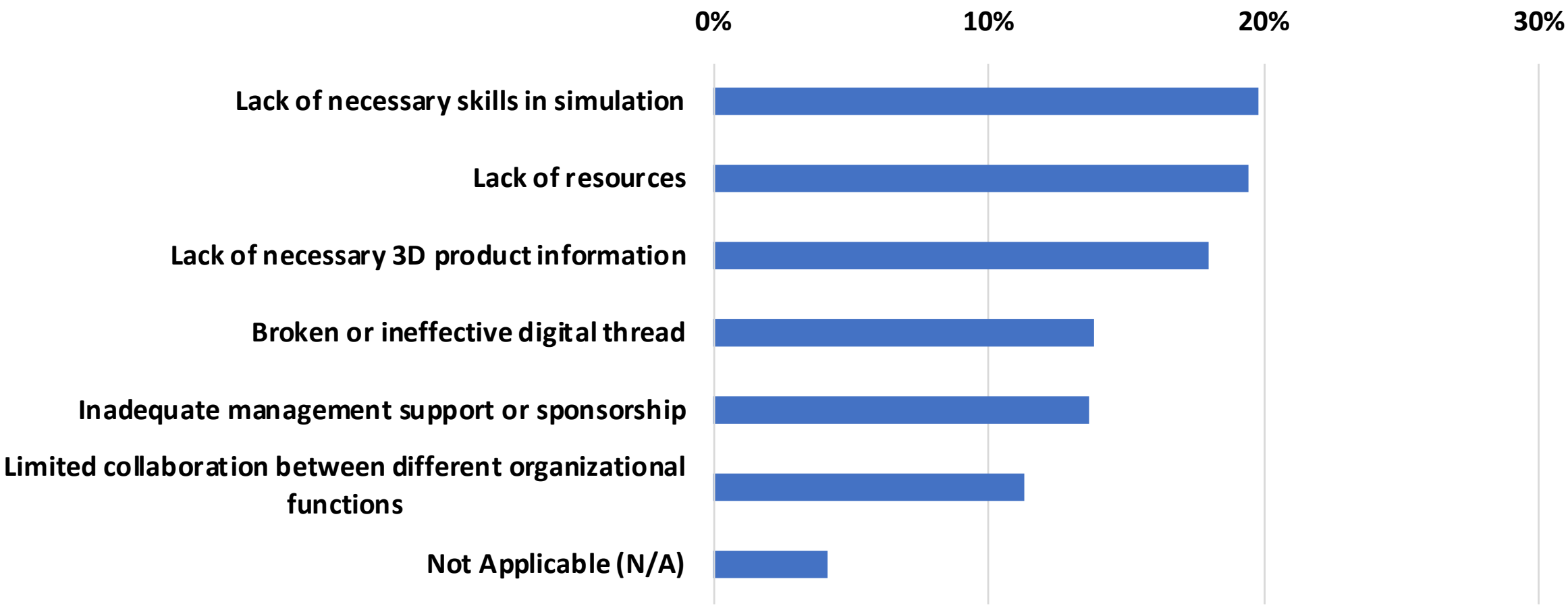
Adoption of Digital Twins

Expected roadblocks to digital twin adoption - Next 5 years (All participants)



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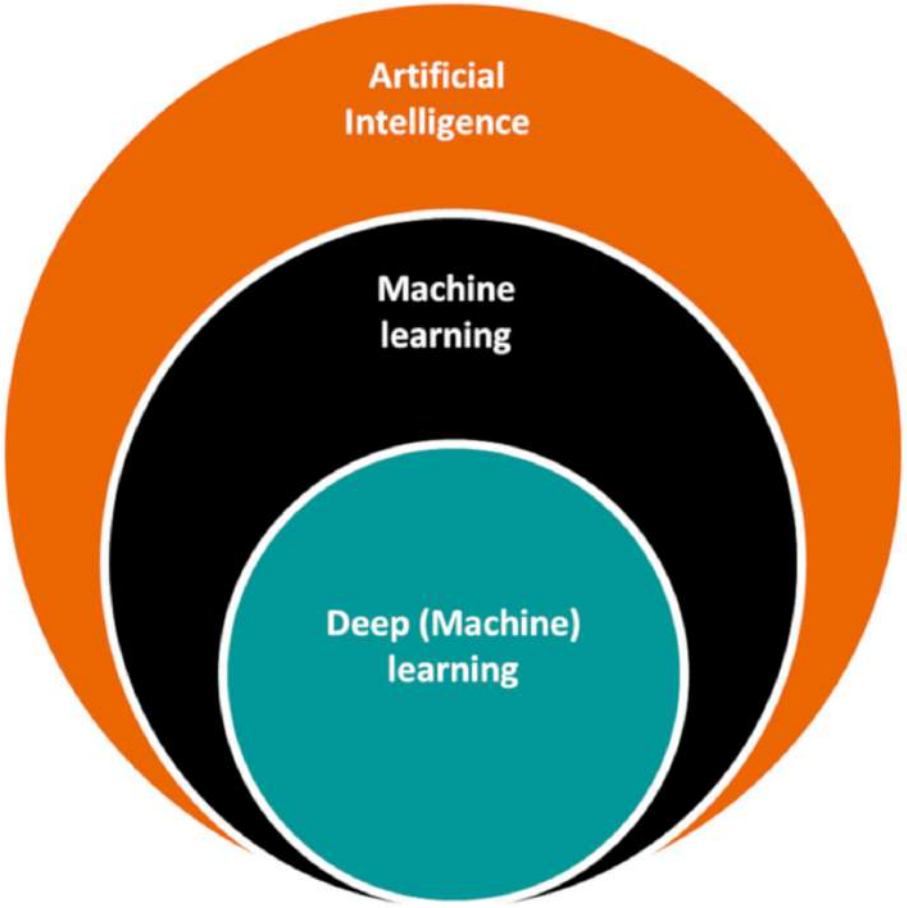
Opportunities: Addressing the MBE Challenges

Efforts underway to leverage AI/Machine Learning/Deep Learning with MBx processes and tools



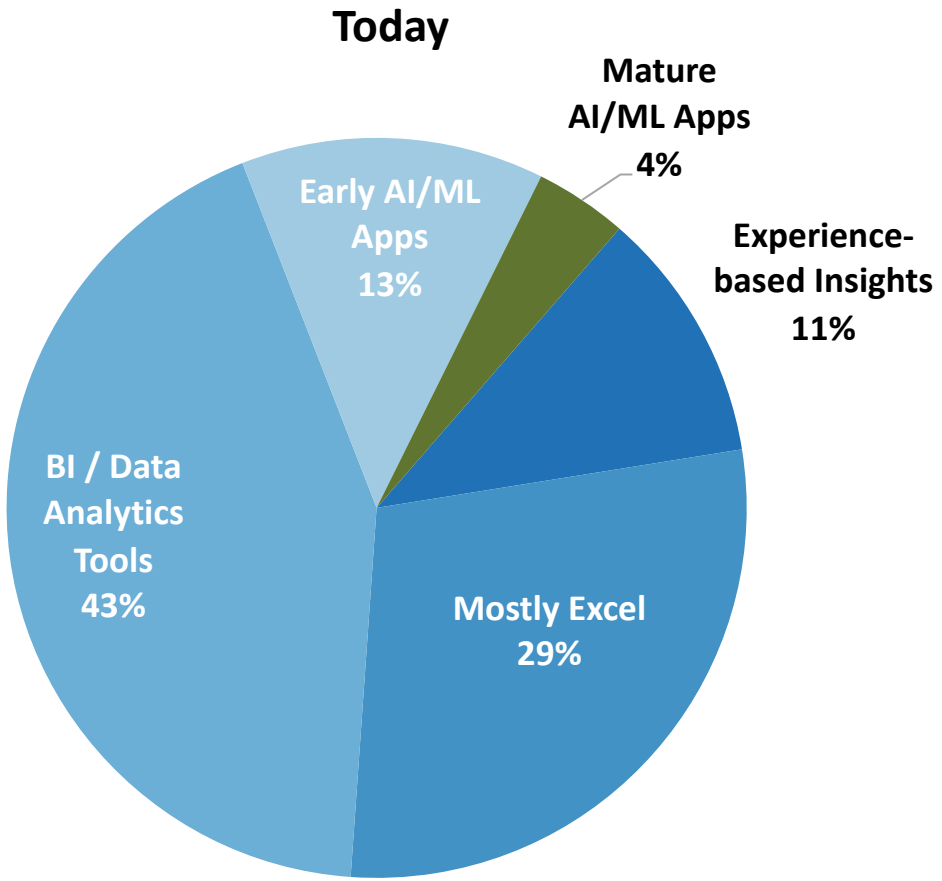
Source: Siemens Healthineers

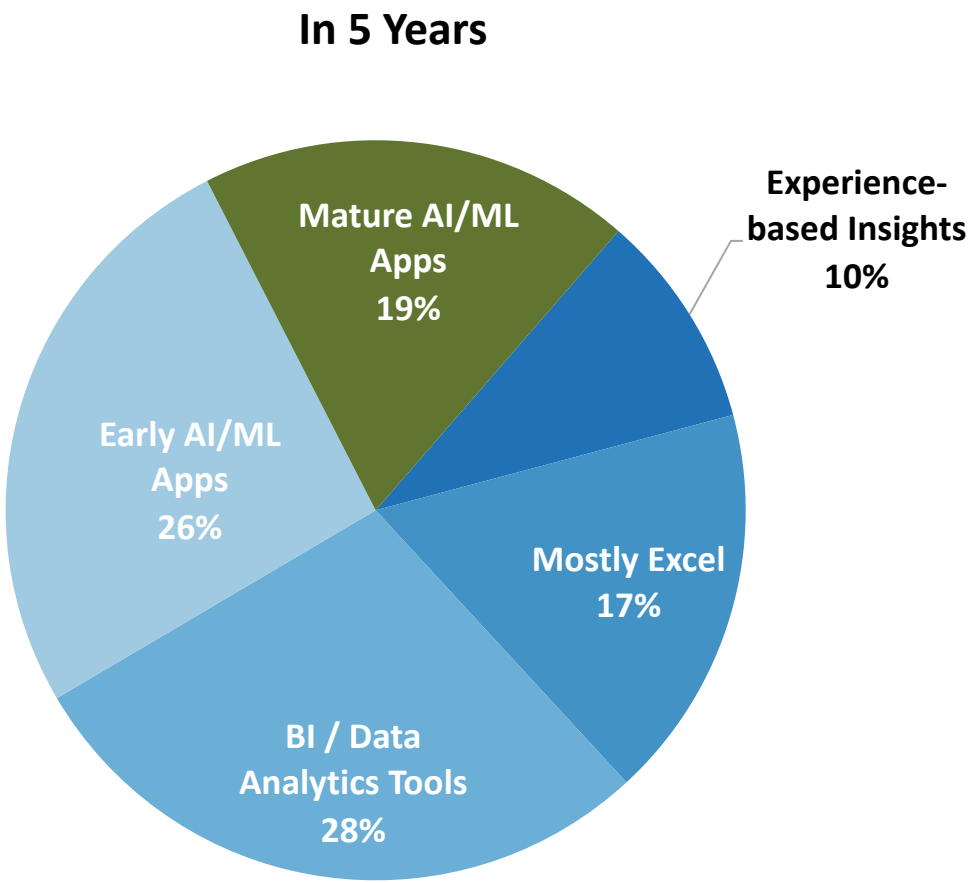
MBx application areas to augment human decision making and "democratize" usage:

- Interactive task specific User Interaction (UI)
- Understand requirements interdependencies across domains (software, hardware) and between logical, functional and physical aspects
- Automated and guided exploration of the feasible systems design space using Multi-Disciplinary Analysis and Optimization (MDAO)
- Automated and guided Uncertainty Quantification (UQ) for system level risk analysis
- VR/AR to "visually experience" the system design

What will be key drivers to impact decision making?

BI/Data Analytics, AI /Machine Learning, Experience, Spreadsheets





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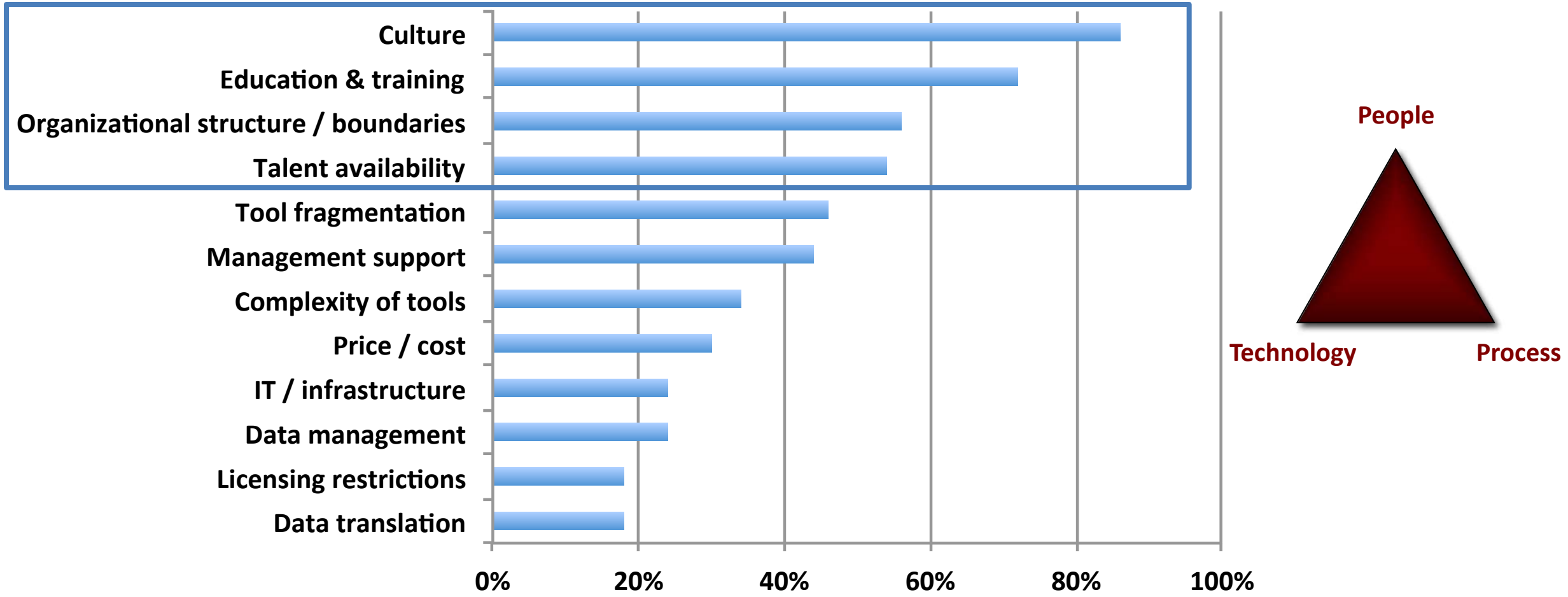
Barriers to Industry Implementation

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)

Market Forecasts

For 2022 (US$ Millions) and 5-year compound annual growth rate (CAGR)

Segment	2022 Estimate	YoY Growth	5 Year CAGR
cPDm Comprehensive Technology Providers	$8,581.24	10.9%	11.2%
cPDm-Focused Applications	$3,046.67	6.7%	7.5%
Digital Manufacturing	$933.92	6.7%	7.2%
SI/Reseller/VAR	$9,106.54	5.8%	6.7%
Tools			
MCAD-Multi Discipline	$4,131.32	3.1%	3.2%
MCAD-Design Focused	$4,257.32	9.7%	9.9%
Non-Bundled CAM	$1,637.83	5.4%	6.2%
Simulation & Analysis	$9,107.55	9.4%	10.2%
Other Tools (e.g., SE, ALM)	$2,106.63	7.9%	7.9%
EDA	$14,880.78	12.0%	11.6%
AEC	$8,594.36	14.4%	15.0%
Total	$66,384.17		10.1%

Concluding Remarks

Digital Transformation will continue to expand the use of Modeling, Simulation & Analytics

The development & management of smart, connected products is driving the need for digital engineering; Innovation, quality and speed is the WHY; Model-Based Engineering is the HOW

Simulation and Analytics are key business enablers for Digital/Model Based Engineering

Most companies are still spending on traditional areas of PDM and CAE; But we need to get past the foundational elements into underutilized areas like MDAO, UQ and SPDM

The growing application area of multi-disciplinary systems level digital twins, enabled by, data analytics, AI/ML, AR/VR and data interoperability standards hold great promise when deployed effectively across the engineering lifecycle domains

Enterprise MBx processes, culture and people skills are critical to business success

CIMdata

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