Model-Based X:
What is it and what is its status?
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Key Takeaways

Model-based X: What is it and what is its status?

- There are so many overlapping Model-Based X definitions
  - The of acronyms being used in industry today to define the digitalization of product related processes and information are confusing and becoming counterproductive
- Many of the well-intentioned naming conventions originated from industry groups, as well as from government/DoD, often based on the specific interests and objectives of those organizations
  - The differences and overlap of these different viewpoints can be narrow
- A set of challenges and standards-related opportunities are in front of us
- Without standards for MBx it is difficult to communicate design, build, maintenance, and other intent unambiguously across enterprises
- Standards for conveying product information vary by industrial segment

Complexity = Risk, Digitalization = Opportunity

Business success now requires a Model-Based X approach

- Significant electronics & software content
- New processes & materials—lighter, stronger, green
- Consumers demand “mass customized” products with all the latest technological features… Now!
- Shorter lifecycles = continuous product innovation
- “IoT” environment = constant market feedback

Complex market requirements demand more upfront cross-domain MBx approach

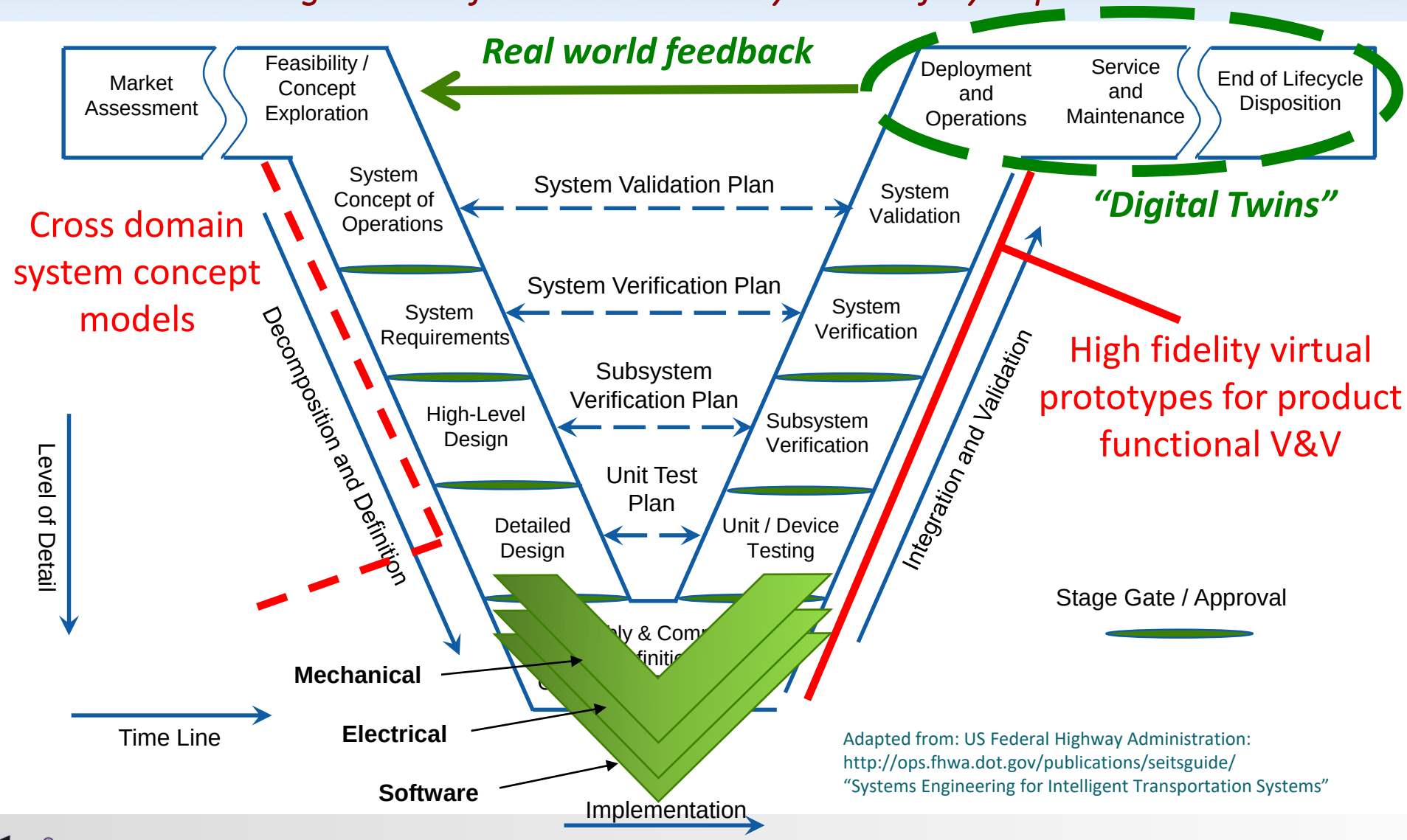
Which One? Common Model-Based Definitions

Overlapping & somewhat confusing terminology used by industry today—the acronym war isn't helping anyone

- Model-Based **Enterprise (MBE)** – "a vision to transform an enterprise's engineering, manufacturing, and aftermarket services through product data reuse and derived context, rather than interpreting inputs and recreating the models and drawings."
- Model-Based **Systems Engineering (MBSE)** – "the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."
- Model-Based **Engineering (MBE)** – Integrated use of models to define the system technical baseline across the full life cycle, across all disciplines, across all program members [models are the authoritative definition of the system]
- Model-Based **Definition (MBD)** – The practice of using 3D models (i.e., solid models, 3D PMI and associated metadata) within 3D CAD software to define (provide specifications for) individual components and product assemblies.
- Model-Based **Design (MBD)** – "A mathematical and visual method of addressing problems associated with designing complex control, signal processing and communication systems as applied in the design of embedded software."

Model-Based X Enables Systems Engineering

Digital collaboration enables high-value information continuity across lifecycle processes



Adapted from: US Federal Highway Administration:
http://ops.fhwa.dot.gov/publications/seitsguide/
"Systems Engineering for Intelligent Transportation Systems"

Digital Thread & Digital Twin (DoD/USAF)

The thread that binds…the product and systems world

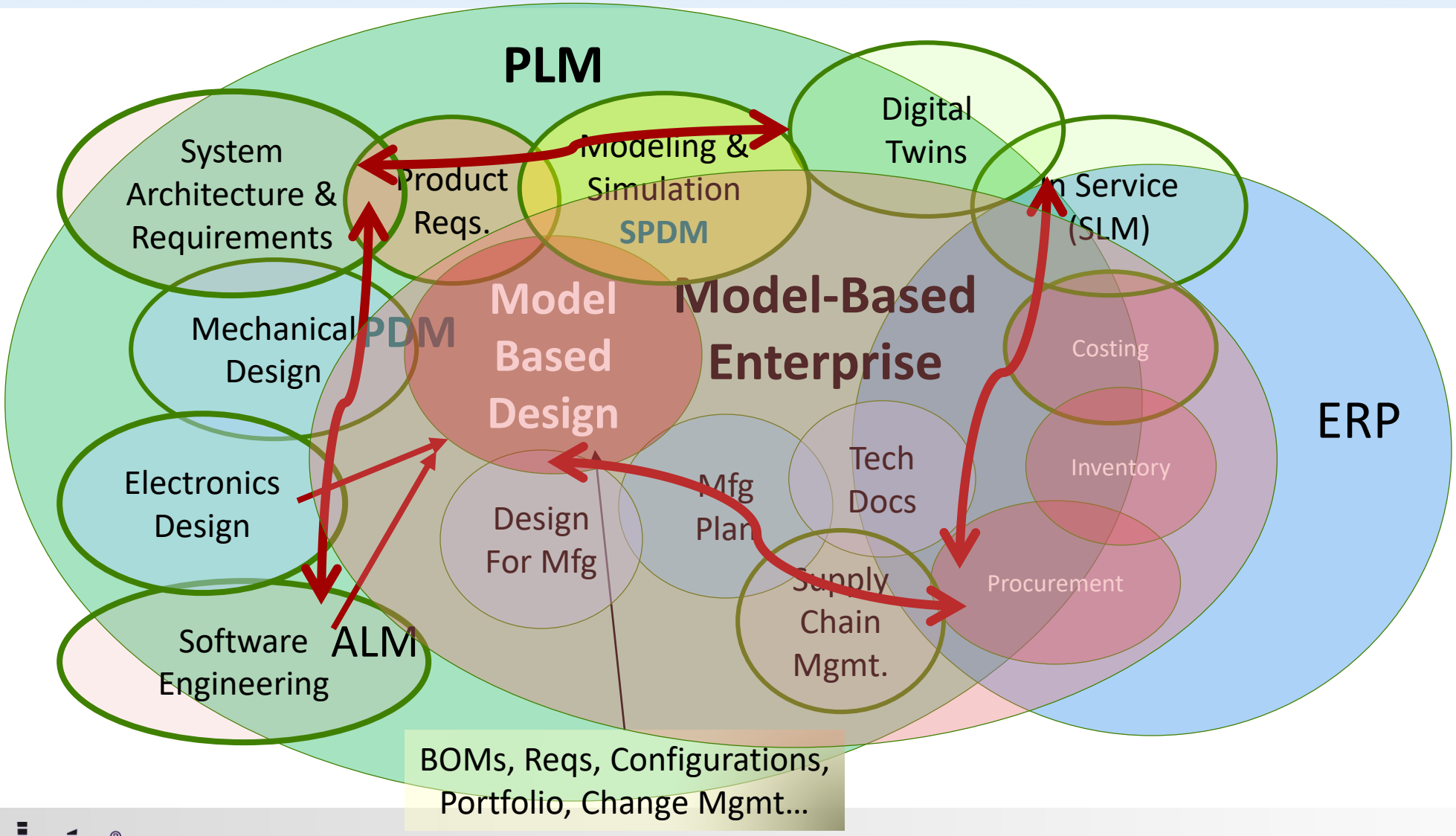
- ***Digital Thread*** is the creation and use of ***cross-domain*** **common digital surrogates** of a system to allow dynamic, real-time assessment of the system's current and future capabilities to *inform decisions throughout the entire life cycle*
- Digital surrogate (i.e., the ***Digital Twin***) is a ***physics-based*** description of the system resulting from the generation, management, and application of data, models, and information from authoritative sources across the system's lifecycle

Digital thread is enabled and supported by a robust systems model and 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

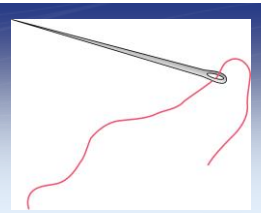
Sewing the Digital Thread: Vision

The use of model-based design information throughout the entire lifecycle



Sewing the Digital Thread: Standards

Significant collaboration efforts underway to integrate data and processes—an example



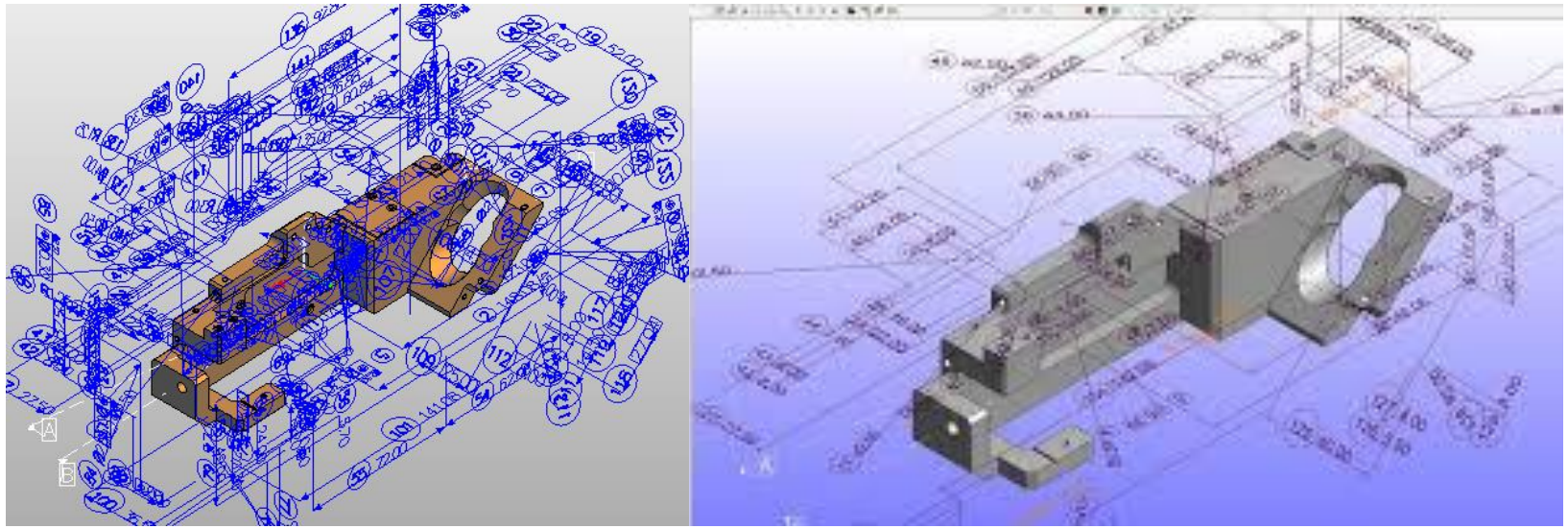
Evolving standards for cross-domain data linking & interoperability

- SysML v2.0 – Next generation MBSE systems modeling language
- UPDM – Unified systems modeling standard for DoD and MoD
- STEP AP 233/239/242 & 209 – New unified data architecture
- OSLC – Open Services for Lifecycle Collaboration (www.oasis.org)
- PDES Requirements Traceability Project – Connect requirements information across the domains of MBSE, PLM/MCAD & ECAD via open source Eclipse resources (ReqIF Studio, Lyo/OSLC, Papyrus)
- Modelica & FMI/FMU – Functional Mockup Interface/Mockup Unit
- MoSSEC – Modeling & Simulation information in a collaborative Systems Engineering Context (see http://www.mossec.org/)

Why You Need MBx Standards

Standards are necessary to overcome many of the issues with conveying data in an MBx

- Need a consistent way to communicate PMI and other information in the model throughout the lifecycle—without standards this will become (is) a free-for-all
- Drafting standards (ASME Y14.5M-1994) are not good enough—they don't cover all PMI and how to attach information to the 3D model
- Understand what is required to assure comprehension
- Without standards everyone goes own way and we loose advantage

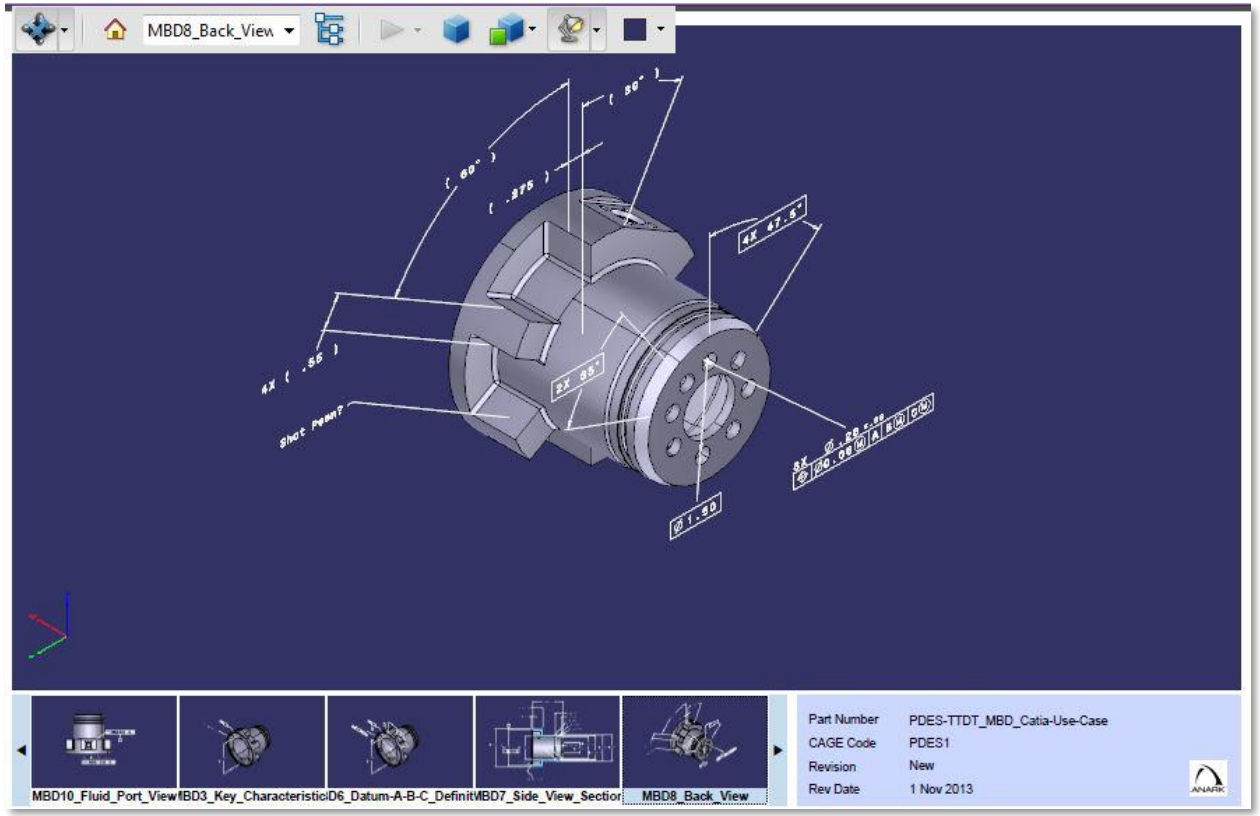


Source: PAS Technology

Current & Evolving MBx Standards

Selected standards (1 of 4)

- ASME Y14.41 “Digital Product Definition Data Practices”
  - Defines how models are annotated (geometric features, datums, dimensions, tolerances, inspection data, finish, notes, etc.)
  - Primary basis for MBx

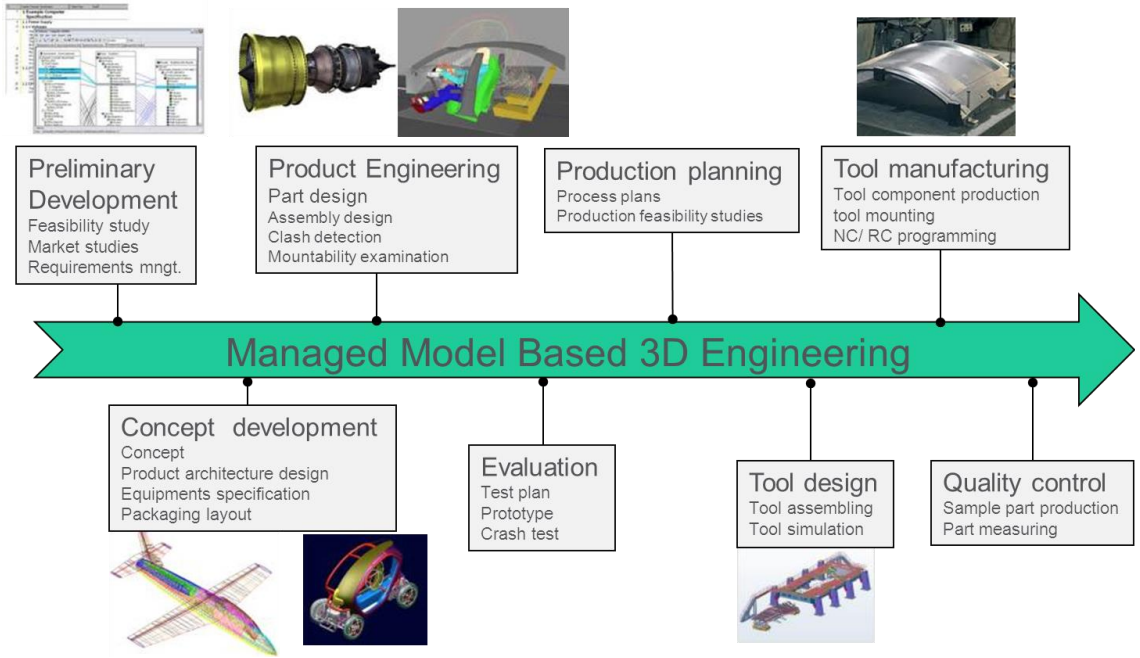


(Courtesy of Anark)

Current & Evolving MBx Standards

Selected standards (2 of 4)

- ISO 10303 Part 242 ed1 & ed2 “Managed Model-based 3D Engineering”
  - Merges 2 most widely used STEP standards for 3D model geometry,:
    - AP 203 (Configuration Controlled 3D Design)
    - AP 214 (Core Data for Automotive Mechanical Design Processes)
  - Defines STEP specification for 3D Model-Based PMI (Product and Manufacturing Information)
  - Not a lightweight CAD data format definition (see JT and 3D PDF on following slide)
  - Key support of Model-Based Definition (MBD)



(Image from AP242 Working Group)

Current & Evolving MBx Standards

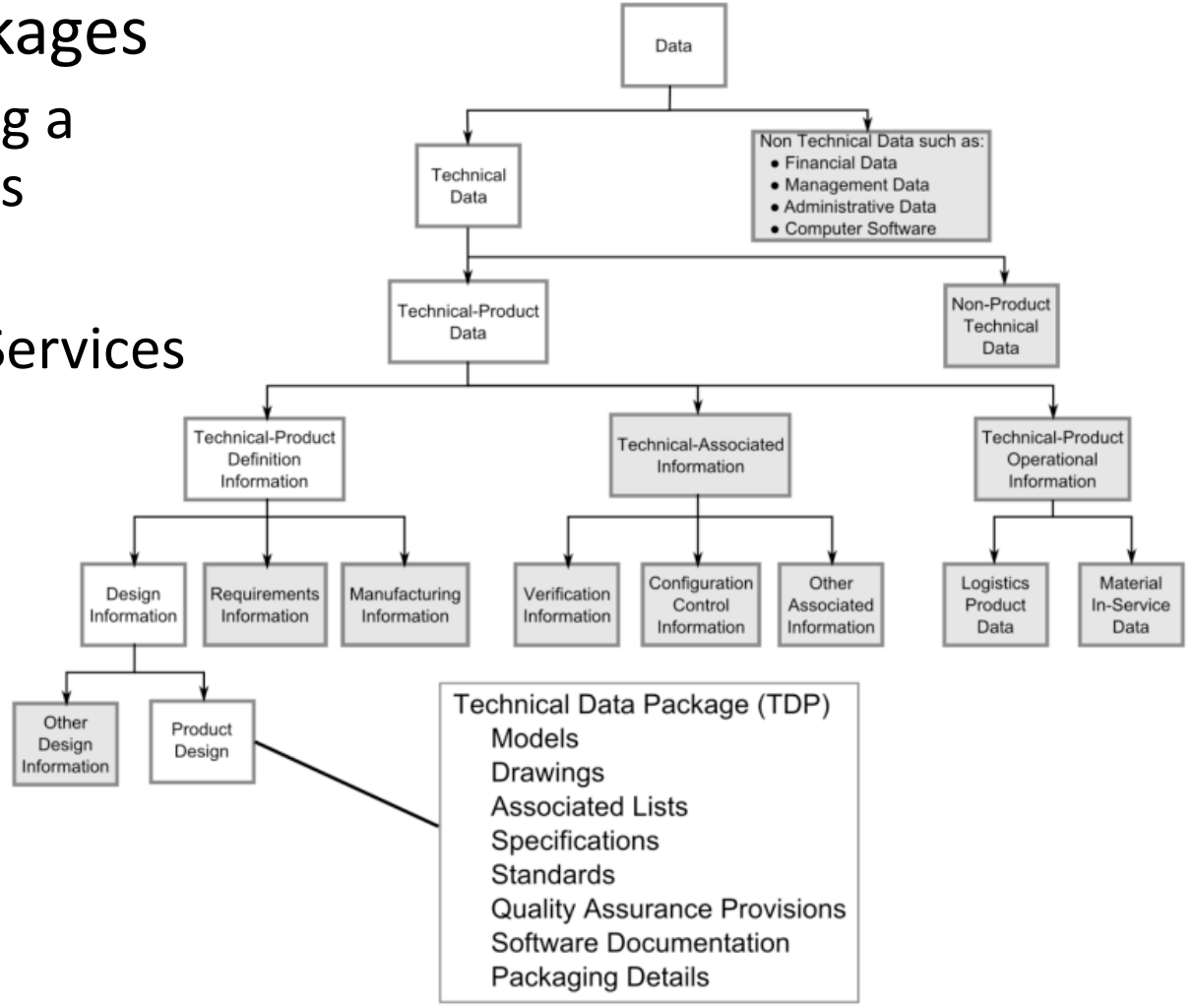
Selected standards (3 of 4)

- ISO 14306 “Structure and Content of a Binary File with Extension .jt”
  - JT standard is used to capture and repurpose 3D product definition data
  - Can contain multiple levels of geometric fidelity from precise to very lightweight
    - Supports CAD data exchange
  - Originally developed and sold by Siemens PLM Software as a lightweight 3D geometry format for visualization
  - Many CAD systems can read, write, and modify JT
- ISO 14739-1 “3D use of Product Representation Compact (PRC) format”
  - Aka “3D PDF”
  - Allows lightweight 3D geometry to be embedded & manipulated in PDF documents
  - Originally developed by Adobe, now managed by PDF3D

Current & Evolving MBx Standards

Selected standards (4 of 4)

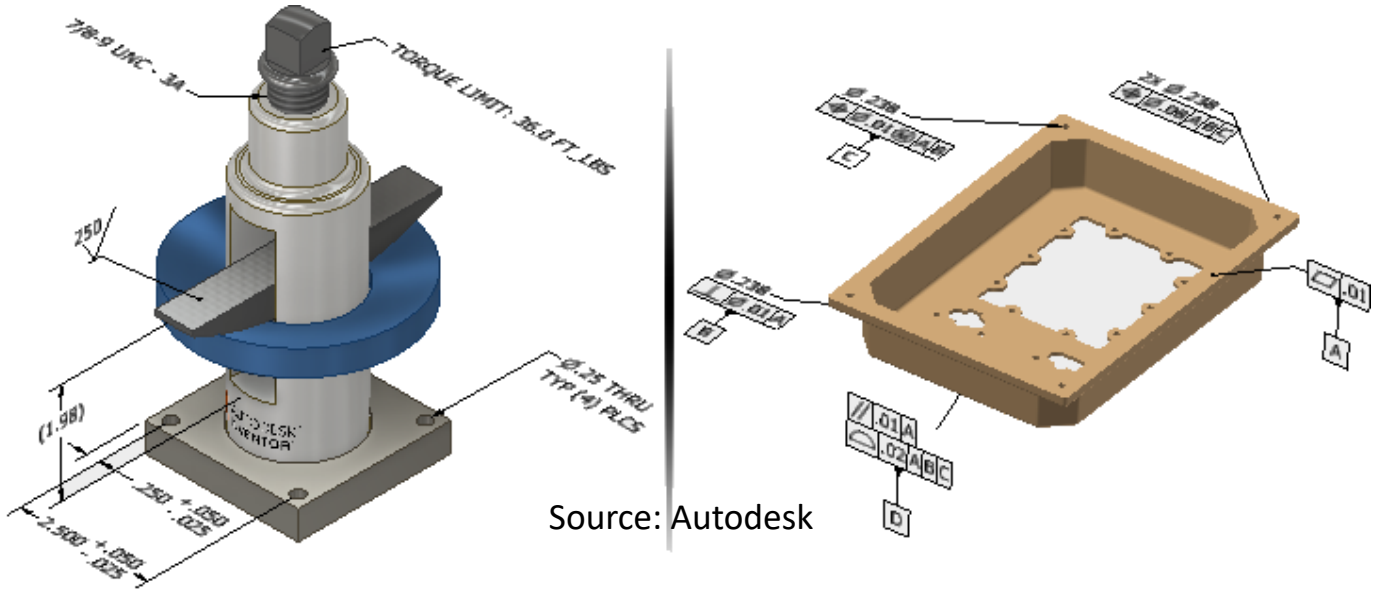
- MIL-STD-31000A—Technical Data Packages
  - Prescribes the requirements for preparing a technical data package, including 3D TDPs
  - Critical for DoD
  - Problem for DoD suppliers since Armed Services don't universally accept 3D TDPs
    - Loose the benefit, have to make drawings for delivery



Closely Related to MBx

To have a workable MBx you need to be cross functional

- Configuration management (many standards exist)
- Full systems definition
  - Mechanical, electrical, software, processes, other physics
- Manufacturing support
- Inspection support



Source: Autodesk

Closely Related to MBx

Standards for PDM, DMU & Configuration Management—many standards, many sources (1 of 2)

- ISO 17599: General requirements of Digital mock-up for mechanical products
- ISO 10007: Quality management systems—Guidelines for configuration management
- EN 9223-100 to -105: Programme Management—Configuration Management
  - Part 100: A guide for the application of the principles of configuration management
  - Part 101: Configuration identification
  - Part 102: Configuration status accounting
  - Part 103: Configuration Verifications, Reviews & Audits
  - Part 104: Configuration Control
  - Part 105: Glossary
- MIL-HDBK-61A: Configuration Management Guidance
- ANSI/EIA 649B: Configuration Management
- GEIA-HB 649: Configuration Management Handbook
- EIA 836B: Configuration Management Data Exchange and Interoperability

Closely Related to MBx

A few additional related standards (2 of 2)

- ISO 10303 Part 238 “Application Interpreted for CN Controllers”
  - Specifies an application interpreted model (AIM) for machining
  - Augmented w/ISO 10303 product geometry, GD&T, and PDM information
  - Addresses new technologies for additive manufacturing and composites
  - Not yet adopted by industry nor supported by many solution suppliers
  - Similar capabilities to AP 238 are provided in solution suppliers’ COTS offerings
- ISO 10303 Part 210 “Electronic Printed Circuit Assembly, Design, and Manufacturing” supports 3D models with electrical intelligence for:
  - Assemblies with electrical content at multiple levels of product hierarchy,
  - Assemblies being designed jointly by electrical and mechanical departments, and
  - Interconnections designed using layered abstraction, typically PCBs
  - Mature but not adopted by any major ECAD or PLM providers

Benefits of Using MBx Standards

Support the product lifecycle with high value information

- Better support all processes downstream from design (bidding, 3D TDP, manufacturing, MRO, owner/operator handover documentation, emergency response, …) through end of life
- Foster data reuse from early design throughout the product lifecycle
  - Data becomes more valuable
  - Less time recreating what already exists—such as documenting via drawings…
- Problem is that even with all the standards that follow, we still do not have complete coverage for specialty areas
  - Evolving areas such as additive manufacturing may not be completely supported
  - You may need to develop “standard” ways to annotate things you need to share

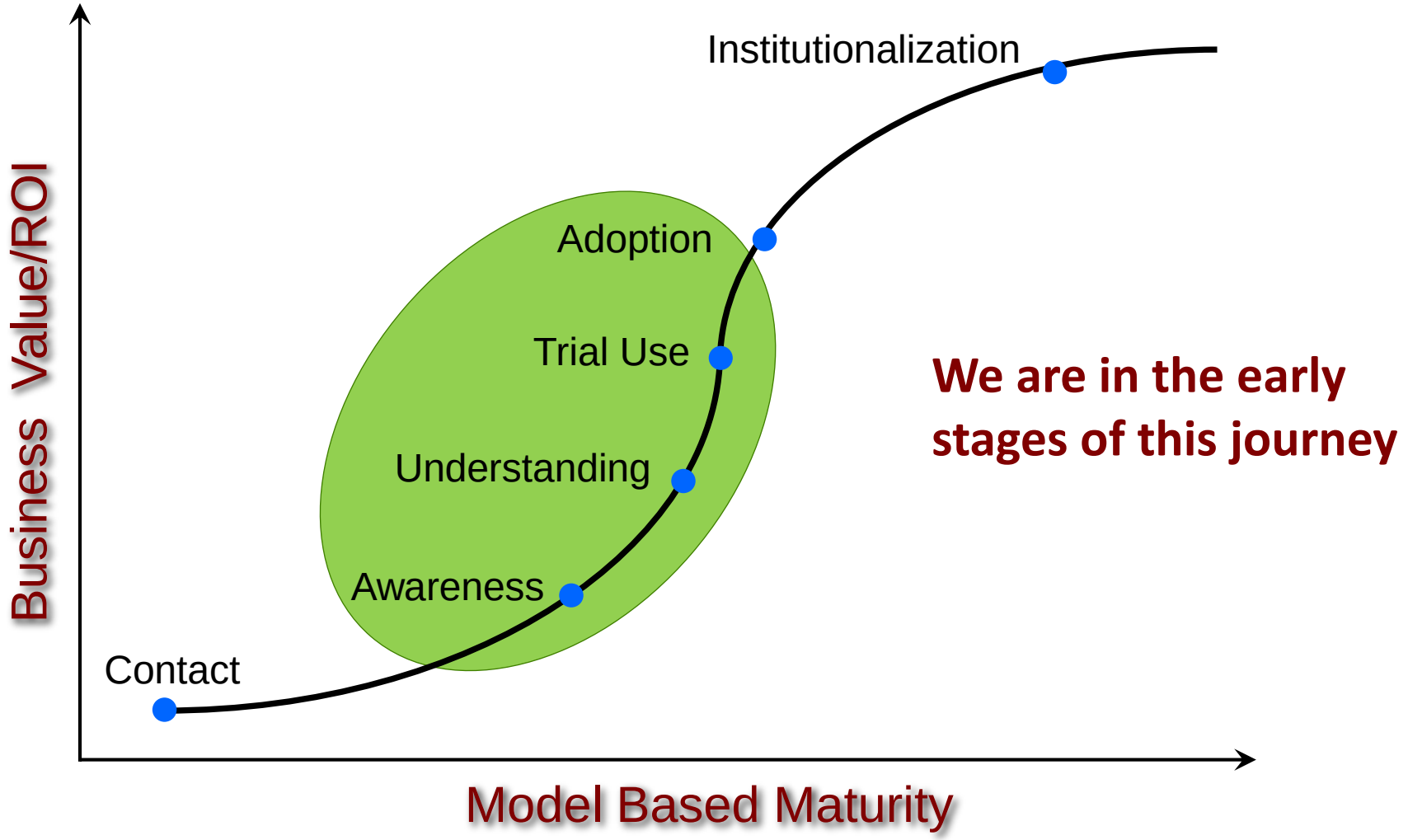
MBx Standards Players

Who is pushing for standards to be adopted

- Solution providers
  - Notably Siemens PLM Software (JT) and Adobe (3D PDF)
  - But many others as well
- Government agencies
  - EU, DoD, NASA, NIST, ASME
- Industrial companies and consortia tend to be domain specific
  - Automotive—AIAG and others
  - Aerospace—Aerospace & Defense PLM Action Group (see www.ad-pag.com)
  - Power & offshore—POSC & others

Business Value Comes with Adoption Maturity

It takes time, management commitment, education, standards adoption, cultural change, etc.



We are in the early stages of this journey

Concluding Remarks

Model-based X: What is it and what is its status?

- We need to solve the MBx acronym war, it's not helping anyone
- There are many standard definitions
  - What's most important is to use what works for you
- We need standards to support data for the full product lifecycle
  - A lifecycle and systems of systems view of data is critical
- Many standards, not one comprehensive standard
  - More work is required
- MBx requires standards, but which ones—be part of the conversation
- Participate in developing standards for your needs
  - Industry must look to support its customers and supply chain

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