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

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

• There are so many overlapping Model-Based X definitions
  • The 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.”
Real world feedback

Digital collaboration enables high-value information continuity across lifecycle processes

Cross domain system concept models

“Digital Twins”

High fidelity virtual prototypes for product functional V&V

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

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

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

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](http://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/](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 lose advantage

Source: PAS Technology
Current & Evolving MBx Standards

Selected standards (1 of 4)

  - Defines how models are annotated (geometric features, datums, dimensions, tolerances, inspection data, finish, notes, etc.)
  - Primary basis for MBx

(Courtesy of Anark)
• 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)
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