Digital Twin, It Requires a Digital Thread PLM Road Map 2020 and PDT 2020 17 November 2020

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PLM Road Map & PDT 2020



November 17-19 Virtual Event



Global Leaders in PLM Consulting

www.CIMdata.com

Peter A. Bilello, President & CEO

Professional background

- More than 30 years of experience in the development of IT solutions for research, engineering, and manufacturing organizations worldwide
- Run numerous projects in PLM analysis, selection, implementation & management, synchronous and lean manufacturing consulting & software engineering, as well as general data management strategy development and support
- Authored many papers & research reports on PLM and related topics, as well as numerous articles, commentaries, and perspectives that have appeared in publications throughout the NA, EMEA & Asia
- Holds a B.S. in Computer Science (minor in Physics) & M.S.E. in Manufacturing Systems Engineering



CIMdata's 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's 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

- The concepts of digital twin & digital thread have been around for decades
 - Industry insiders generally agree that keeping them joined maximizes their value and justifies the effort of keeping them current
 - Yet the gaps between them seem not to be closing
- The specifics of digital twins & digital threads differ widely
 - Despite that many of their underlying considerations are similar
- Fundamentally, a digital twin without a digital thread is an orphan
 - Disconnected from the decisions and processes that impact it
- Whether the product is a drill bit or an aircraft, its virtual representation will undoubtedly struggle to be complete & up to date without a digital thread
 - When information flows between them are synchronized & unimpeded, multiple parts of the business benefit

Agenda

- The Digital Thread & Digital Twin: A Closer Look
- Why Close the Virtual & Physical Gap: The Potential Value
- Key Enablers That Are Evolving
- Concluding Remarks



The Product Lifecycle: End-to-End Information Flow

Product data touches all phases of a product's life—end-to-end connectivity & optimization are critical



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

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Lifecycle Information is Represented by Structures

Managing relationships between structures throughout the lifecycle—they must be managed throughout



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Digitalization Requires End-to-End Connectivity

This is the Digital Thread, which in turn supports multiple Digital Twins



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"Sewing the Digital Thread"

What are we attempting to connect?



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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 ۲
- MDA/MCAD/PDM •
- M&S/CAE/SPDM
- Test/V&V/TDM

Sewing the MBSE Digital Thread ("As Is")

Significant collaboration efforts underway to integrate data and processes



Evolving standards for cross-domain data linking & interoperability

- SysMLv2.0 & UPDM- Next generation systems modeling languages
- STEP AP 233/239/242 & 209 New unified data architecture
- OSLC Open Services for Lifecycle Collaboration (<u>www.oasis.org</u>)
- PDES Requirements Traceability Project Connect requirements information across the domains of MBSE, PLM/MCAD & ECAD
- AVSI SAVI Program- A&D Systems Architecture Virtual Integration
- FDX- German initiative for Functional Data Exchange file format
- Modelica & FMI/FMU (Functional Mockup Interface/Mockup Unit)
- MoSSEC Modeling & Simulation information in a collaborative Systems Engineering Context. See <u>http://www.mossec.org/</u>

Connecting the Lifecycle Digital Thread

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



Defining the Digital Thread

Enabled and supported by a robust end-to-end, connected systems model and MBSE processes

Product Conceptual Engineering Design Portfolio Manufacturing Planning Man **Digital Thread** refers to the **communication** Requirements framework that connects data flows, which can be used to produce an integrated and Re-use **Re-purpose** holistic view of an asset's data from physical Re-mfg. Re-cover and virtual systems (i.e., its digital twin) **Re-cycle** throughout its lifecycle across traditionally Re-tire 🔪 siloed functional perspectives



Maintenance & Repair

In-service Operation

Sales & Distribution Quality

Simulation & Validation

Build & Produce



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

Disposal &

Recycling

Defining the 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 MBSE processes

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



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A Non-Traditional PLM Industry Point of View

From Avnet, Inc., one of the world's largest distributors of electronic components and embedded solutions

- IoT provides analytical insights to improve business processes
- Empowers businesses to make better decisions
- Once an IoT product is installed, the sensors monitor it and record every issue that arises in the product
- Organizations can detect abnormal patterns in their asset's performance and take necessary actions to prevent damage
- Manufacturers can make changes to their manufacturing processes & avoid reoccurrence of any previously detected defects in future products



https://www.avnetworkshop.com/IoT-product-lifecycle-management.html

Imagine...What You Could Do?

... if you had a digital thread that provided the end-to-end connectivity, we are talking about



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Imagine...What You Could Do?

...if you had a Digital Thread that tied the virtual world to the physical world—MBE "Diamond" Symbol

DIGITAL TWINS



(Courtesy of The Boeing Company)

Imagine...What You Could Do?

... if your product information was always accurate & complete throughout the entire product lifecycle

- The integrity of information and effectiveness of the organization are linked
 - Integrity = accuracy and completeness of the information you use to make decisions
 - Effectiveness = the ability to respond accurately and quickly



Adapted from ICM's CM2 materials.

You Could Enable Digital Twins

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 MBSE processes

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

Key Characteristics of Digital Twins

Noteworthy characteristics of digital twins

- There is never a single Digital Twin
 - There are multiple Digital Twins for different purposes, each of which have specific characteristics
 - For example, Data Analytics Digital Twins, MRO Digital Twins, Financial Digital Twins, Engineering Digital Twins, and Engineering Simulation Digital Twins
- Each Digital Twin must have a physical twin (i.e., a physical asset)
 - A virtual representation can and should exist prior to the physical twin
 - The physical asset can be a plant, a ship, infrastructure, a car, any type of product
- Each Digital Twin must have some form of data communication with their Physical Twin
 - Does not have to be real time or electronic

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

You Could Enable A Robust MBSE Environment

True end-to-end lifecycle management with multiple feedback loops



You Could Also Do All of This...

Product & process innovation, efficiency & quality—the opportunities provided are numerous



Elements of the Product Lifecycle

Finally, the "Product" May Change

New business paradigms arise with the end-to-end enablement of the digital thread & appropriate digital twins

- When the virtual & physical are closely associated, the data becomes key
- What is the product or system?
 - The individual connected device?
 - The system of connected devices from one supplier?
 - The total system of connected devices?
 - Inclusive of data?
- Security, robustness, and flexibility are key characteristics for the connected device and for the system (of systems)
- An organization's lifecycle management environment needs to enable design and management of systems, and systems of systems
 - Standards, standards, and more standards need to defined, refined, and enforced

"Products as a Service" Example

KAESER KOMPRESSOREN "Smart Air Strategy" – Compressed Air 4.0



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Closing the Lifecycle Loops

An example from SAP: True PLM is the Evolution of the Product



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Support Exists from Multiple Providers

Digital Thread examples from some of CIMdata's mindshare leaders



The Digital Thread for Product Operators

Successful digital thread strategies require a strong data and lifecycle management foundation

- A truly successful digital thread strategy requires far more than collecting and analyzing data, and acting on it
- Products can benefit from it all-through their lifecycle
 - The "why" is clear and solid, but the what and how still aren't fully apparent
 - Success requires the ability to work cross-functionally across IT, analytics, and business groups – to drive process transformation not just at the front end, such as in the field, but all the way across the middle and back office that support the front in scalable ways
- PLM solutions act as the cross-functional process and data backbone, a necessary requirement for success digital thread-enabled strategies

Product lifecycle management enabling technologies support the digital thread

Closing the Loop with IoT

The digital thread spans the lifecycle from idea through life, must plan early for success late

- The digital thread ideally starts with requirements
 - Can start before with idea generation / management / crowdsourcing
 - Many solutions out there, DOORS most known, adopted
 - Overall low adoption rate, even informally
- You are going to gather data what use cases?
 - Need "V&V thinking" to help understand what sensors to add, data to capture
 - FMEA, other analysis 21 CFR Part 11 and 820 provide some useful approaches
 - Need to involve functions outside of product development, e.g., marketing & manufacturing
 - Permission to gather data, secure management part of the customer experience
- Really need IoT and PLM on the same page...

IoT: A Key Digital Thread Enabler

Top 10 Emerging IoT Technologies You Need to Know About (1 of 2)

- **Security**—required to protect IoT devices and platforms from both information attacks and physical tampering
- Analytics—required to exploit the information collected by "things"
- **Device Management**—management of the "things," requiring monitoring, firmware and software updates, diagnostics, crash analysis and reporting, physical management, and security management
- Short-Range IoT Networks—low-power, short-range networks that provide wireless IoT connectivity
- Wide-Area Networks—low-power, wide-area networks that provide wireless loT connectivity

Adapted from https://www.mhlnews.com/technology-automation/article/22051554/top-10-emerging-iot-technologies-you-need-to-know

Key Emerging IoT Technologies You Need to Know About (2 of 2)

- **Processors**—processors and architectures used by IoT devices
- Operating Systems new operating systems that are tuned for these new devices
- Event Stream Processing—typically distributed stream computing platforms
- **Platforms**—bundles of the infrastructure components into a single product
- Standards & Ecosystems—IoT appropriate standards and APIs

Adapted from https://www.mhlnews.com/technology-automation/article/22051554/top-10-emerging-iot-technologies-you-need-to-know



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Concluding Remarks

Digital Twin, It Requires a Digital Thread

- The concepts of digital twin & digital thread have been around for decades
 - Keeping them joined maximizes their value and justifies the effort to do so
- Fundamentally, a digital twin without a digital thread is an orphan
 - Disconnected from the decisions and processes that impact it
- The specifics of digital twins & digital threads differ widely
 - At the end of the day, they complement each other
- No matter what the product is...its virtual representation will undoubtedly struggle to be complete & up to date without a digital thread
 - When data the flows between them are synchronized & unimpeded, multiple parts of the business benefit

Ultimately, your focus should be on closing the virtual & physical gap

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