PLM Road Map™ & PDT North America 2023
The Digital Thread in a Heterogeneous, Extended Enterprise Reality
A call for PLM Professionals to share their knowledge & experience
May 3 & 4
CIMdata -eurostep-

AEROSPACE & DEFENSE PLM ACTION GROUP

The Digital Transformation Digital Thread
A PLM Ecosystem Perspective

Dr. Robert Rencher, Associate Technical Fellow – Systems Engineering, The Boeing Company

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Speaker Profile

Dr. Robert Rencher
Associate Technical Fellow – Systems Engineering, The Boeing Company

As a Sr. System Engineer, Robert provides leadership in facilitating a common understanding, strategic roadmap, and functional utilization of Digital Twins and Digital Threads standards across Boeing and the aerospace industry. Robert represents Boeing to the aerospace and defense industry standards bodies (AIA, SAE International, Object Management Group, and the A&D PLM Action Group) to establish standards for the design and operational deployment of digital twin and digital thread. In prior assignments, Robert's design and technical expertise has been applied in the identification, validation, and integration of strategic Information Technology solutions for Boeing and the aerospace industry.

BOEING

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Aerospace & Defense PLM Action Group

Founded in February 2014

Mission

An association of aerospace & defense companies within CIMdata's globally recognized PLM Community Program, which functions as a ***PLM advocacy group*** to:

- Set the direction for the aerospace & defense industry on PLM-related topics that matter to members
- Promote common industry PLM processes and practices
- Define requirements for common interest PLM-related capabilities
- Communicate with a unified voice to PLM solution providers
- Sponsor collaborative PLM research on member-prioritized industry and technology topics

Website: www.ad-pag.com

Members

AIRBUS, BOEING, EMBRAER, GE Aerospace, Gulfstream A General Dynamics Company, Pratt & Whitney, Rolls-Royce, SAFRAN

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Abstract

- This presentation will address the utility of the digital thread in context of the A&D PLM ecosystem, and the need to incorporate digital thread definitions into the enterprise business architecture. The content of the presentation is reflective of the PLM-AG Digital Twin/Thread working group recent findings regarding the use of business architecture frameworks and methodologies to model and design digital threads within the ecosystem.
- Four key issues will be discussed and recommendations proposed to improve the utility of the digital thread in the A&D ecosystem.
- The concept and constructs of the digital thread introduce change to the business and its processes, system definitions, and technology. Each of these changes will need to be identified and incorporated into business, system, and technical architectures. The ecosystem use of digital thread requires interoperability within participants in the A&D ecosystem.

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Agenda

- The Digital Thread Issue
- Digital Twin / Digital Thread Project Overview
- Phase 3 – Digital Twin/Thread Business Architectures & Methodologies
- Phase 4: Digital Twin/Thread Comparative Analysis of Industry Standards
- Key Concepts – Phase 5 and Beyond
- Next Steps
- Q&A

The Digital Transformation Digital Thread Issue

- Digital Thread in the context of the PLM Ecosystem.
  - The digital twin, facilitates the simulation of the product, production facilities and systems across the product lifecycle from design, manufacturing, and operational performance to final disposition.
  - Business architecture frameworks and methodologies are used to model value and the functional design of digital threads within the ecosystem. System Engineering and Information Technology methodologies are used to define the system and technology requirements.
  - The digital thread enables digital twin simulation across the PLM lifecycle. The digital thread facilitates the harvesting of data from Internet of Things (IoT) enabled devices.
- How real is this?
  - The current digital thread concept is a continuation of aerospace industries' efforts to facilitate the transparency and integration of disparate heterogeneous legacy systems.
  - Architectural frameworks and methodologies that define (model) enterprise systems need to be revised to incorporate the definition, functionality, and structure of the digital thread within the ecosystem. This is closely aligned with business and data architectures.

Digital Twin / Digital Thread Project Overview

Project Purpose

- Define the objectives, requirements, and roadmaps for Digital Twin/Digital Thread solutions for creating and managing the digital representation of a product through the product lifecycle within the A&D ecosystem.
- Identify, define and demonstrate use case level value propositions.
- Validate benefits to the PLM ecosystem.
  - Improved data portability and transparency of PLM events
  - Reduced operational friction resulting in lower operations costs
  - Improved product operational transparency resulted in improved safety, operational efficiencies, and product design

Digital Twin / Digital Thread Project Overview

Project Approach

- Agile methods employed to publish at the speed of consensus
- Release five position papers addressing varying aspects of Digital Twin / Digital Thread concepts and capabilities related to the aerospace industry.
  - Phase 1: Digital Twin/Thread – Research & Scoping
  - Phase 2: Digital Twin/Thread Position Paper
  - Phase 3: Digital Twin/Thread Business Architecture / Methodologies paper
  - Phase 4: Digital Twin/Thread Comparative Analysis of Industry Standards paper
  - Phase 5: Value proposition of the Digital Twin/Digital Thread to the A&D industry
  - Phase 6: Forward looking Digital Twin/Thread Strategy and Roadmap
  - Phase 7: Project Consolidation
- Scope the project to deliver value early and iterate.
  - Scope to the A&D industry
  - Time box the effort to approximately 24 months

Digital Twin / Digital Thread Project Overview

Project Team

- Airbus
  - Etinne Roblet
  - Frederic Feru
  - Kevin Fowler
  - Simon Rince
  - Pierre Sollier
- Boeing
  - Robert Rencher
  - Kenny Swope
- Pratt & Whitney
  - Boris Toche
  - Robert Gutwein
  - Jayendra Ganguli
- Rolls-Royce
  - Mark Heyman
  - Swala Harling
  - Andy Hutsby
  - Steve Carter
- SAFRAN
  - Aude Abadie
  - Sebastian Soulie
  - Thomas Federici
- CIMdata
  - Don Tolle
  - Charles Ditchendorf
  - Ken Versprille
  - Kim Smargiasso

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Phase 3 – Business Architectures & Methodologies

Scope

- Business architecture framework communities promote an evolution of frameworks and methodologies that align with best practices preceding digital transformation and digital twin/thread constructs within the A&D industry.
- Any definition of the digital twin/thread introduces the need to verify that specific architectural constructs will in fact support the digital twin composition, decomposition, system, and subsystem interactions.
- Architectural constructs define the digital twin, digital thread-enabled interactions with the digital twin, associated environment, and other digital twin simulations.

Phase 3 – Business Architectures & Methodologies

Evaluation of Frameworks and Methods

Evaluated using the Digital Twin/Thread definition framework: Business, System, and Technical perspective

Digital Twin/Thread Definition Framework

		Supplier	OEM				Customer/User/Owner/Operator		
		Part/ Component/ Material	Requirements	Design	Engineer	Manufacture	Operation	Maintenance	Disposition
Business	Artifacts								
System	Models and Data								
Technical	Tools and Methods								

Phase 3 – Business Architectures & Methodologies

Findings

- Though there was an absence of the terms *digital twin* and *digital thread,* the team identified the following objectives for a successful digital twin / digital thread Business Architecture Frameworks and Methodology
  - The business architecture defines the digital twin/thread purpose and objective.
  - The system architecture facilitates the definition, utilization, and integration of the digital twin and digital thread.
  - The ecosystem of digital twins and digital threads is self-regulating; regulation is achieved by way of agreed-to industry standards and requirements.

Phase 3 – Business Architectures & Methodologies

Additional considerations

- Given the disruptive potential of digital twin/digital thread concepts, a reexamination of the business process comes into play as enabling technology creates new solutions
  - Internet of Things: The ability to instrument practically any product/system and provide feedback to the design lifecycle via connected devices challenges existing thinking behind digital twin use cases of enhanced product development.
  - Information security: The increasing sophistication of digital twins create technical and legal challenges to be resolved as more functionality and sensitive information is codified in the product itself.
  - Artificial Intelligence / Machine Learning: With maturing data sets and increasing skills, AI / ML has a prominent place in the value proposition for digital twins.
  - Interoperability Standards: The digital twin has diminished value if the business case is compromised by poor data quality and inconsistent data standards. The digital thread operates on data interoperability standards.

Phase 4 – Digital Twin/Thread Analysis of Industry Standards

Overview and status

- Objective – Phase 4 goal is to research and identify existing digital twin and digital thread standards, evaluate these standards for applicability and utilization against the defined digital twin and digital thread requirements and definitions.
- The team conducted an initial search of existing digital twin and digital thread standards-based industry standards organizations within the A&D industry and on the familiarity and knowledge of the team.
- Existing architecture frameworks are being evaluated as a method of organizing digital twin and digital thread standards
- Phase 4 position paper is in final review – publication anticipated in Q3 2023.

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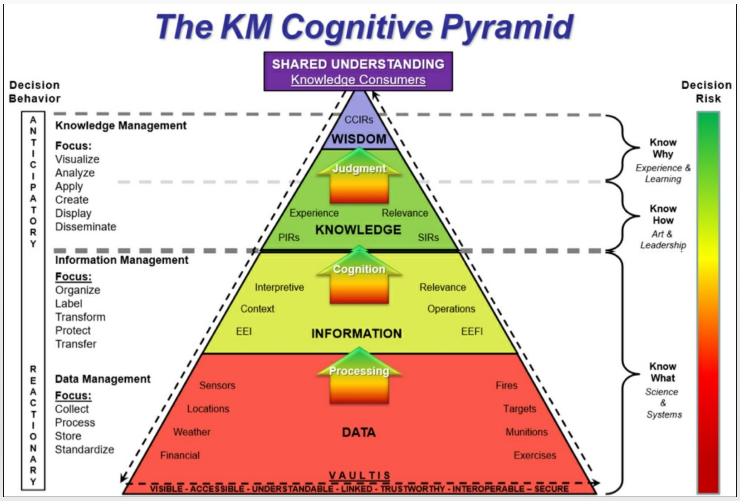
Key Concepts – Phase 5 and Beyond

Four Key Concepts

- Rethinking Our Thinking About Data
- Knowledge Capture
- Defined Scope of Digital Thread Utility
- Digital Transformation

"If you want people to make the right decisions with data, you have to get in their head in a way they understand. The way to do that has been with stories"
Miro Kazakoff – MIT Sloan

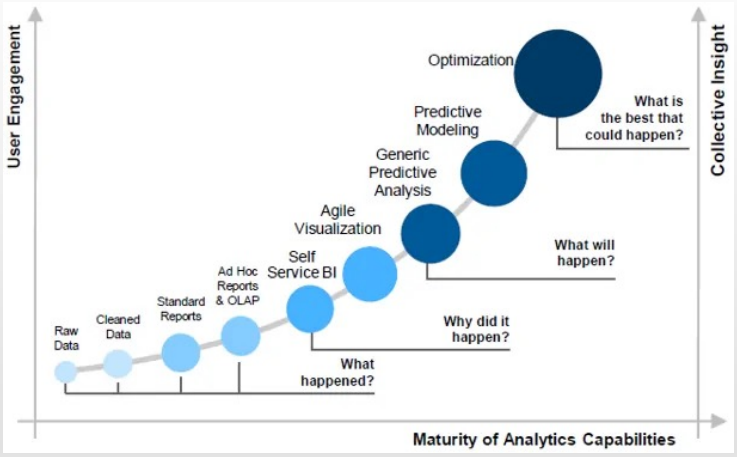
Where are we with Data, Information, and Knowledge?



Source: Matthew.viel - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=110373265

- Matured capability of distribution and transformation of information
- Industry transitioning from information management to knowledge acquisition and knowledge management
- Use of the model to represent the understanding of knowledge
- Knowledge model defined in the context of information constructs: relationships of data and information

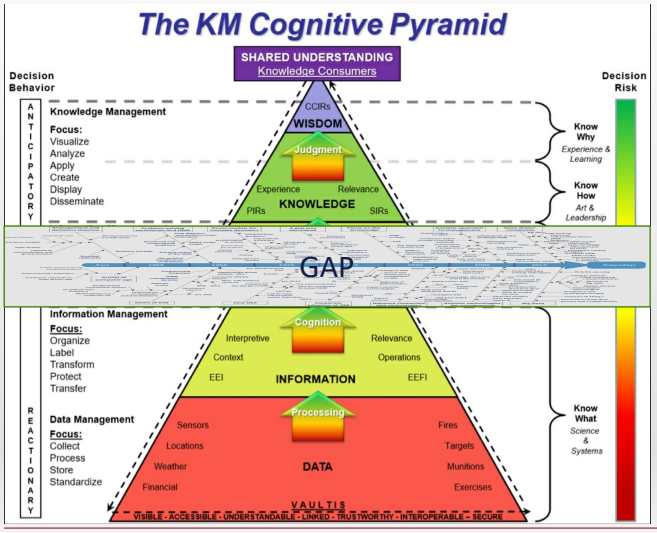
Technical Complexity over time



- Exponential increase in system complexity to transition data to information, information to knowledge
- Predictive Knowledge – Knowledge of what will happen next

Source: https://nttdata-solutions.com/us/blog/the-meaning-of-discovery-analysis-in-business-intelligence/

Capability Gap



- System and technical transition from information management to acknowledgment
- Current system designed around data and information management paradigm
- Knowledge models defined in the context of legacy system capabilities
- Capability gap forming - Utility of information systems to implement knowledge models

Key Concepts – Phase 5 and Beyond

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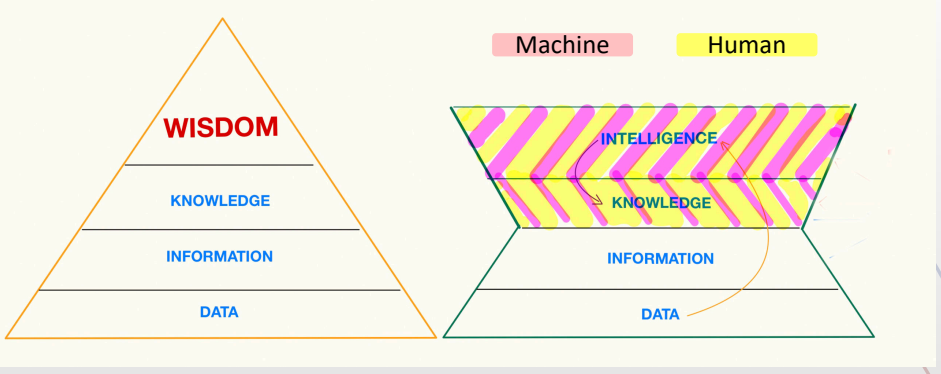
Knowledge Capture Challenge



"On the left, a classic representation of the knowledge pyramid, rooted in data, processed to become information whose meaning creates knowledge. The purple lines highlight the role of machines, greater in the intelligence space but significant in the knowledge space. Yellow lines represent human contribution"
Roberto Saracco – 2022 IEEE Digital Reality

Transparent Knowledge

- Tacit knowledge is 'knowledge that cannot be captured through words alone'. This series explores how expertise is tacit, why the research around extracting tacit knowledge is more important than the literature on deliberate practice, and how to go about acquiring tacit knowledge in the pursuit of skill acquisition.

- https://commoncog.com/an-easier-method-for-extracting-tacit-knowledge/
- https://commoncog.com/the-tacit-knowledge-series/

Key Concepts – Phase 5 and Beyond

Four Key Concepts

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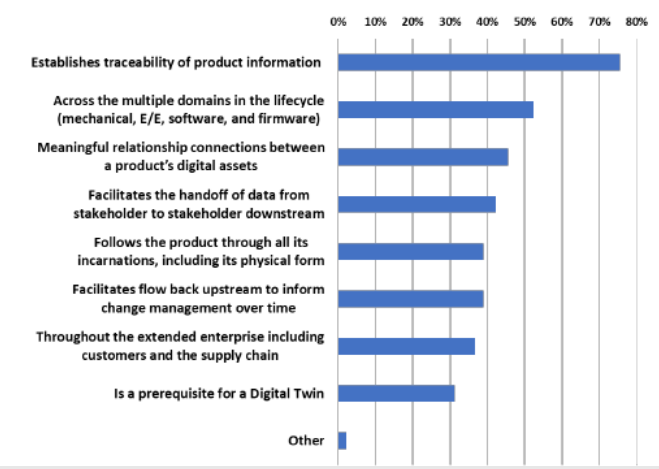
Defined scope of digital thread utility

- How extensible is the digital thread?
  - Enterprise. The user communities contributing to and leveraging current digital thread implementations are primarily Engineering and Manufacturing – Expand the community by defining and deriving value from the digital thread.
  - Ecosystem. Clear indication that digital thread investment within the ecosystem is poised for rapid growth. With initial implementations in the digital supply chain and product lifecycle management. Targeted digital thread solutions provide proof points of value and essential learnings.
- Constraints of practical digital thread utility
  - Today
    - Trade Agreements
    - Intellectual Property / Patents / Licensing
  - Tomorrow (Three to Five years)
    - Ecosystem Network Partner Agreements
    - Smarter Contractual Agreements

PLM AG Digital Thread Survey: Significant Characteristics



- Aerospace and Defense Industry perspective of Digital Thread value
- Bi-directional Product transparency, traceability, and provenance
- Integrated Ecosystem

Key Concepts – Phase 5 and Beyond

Four Key Concepts

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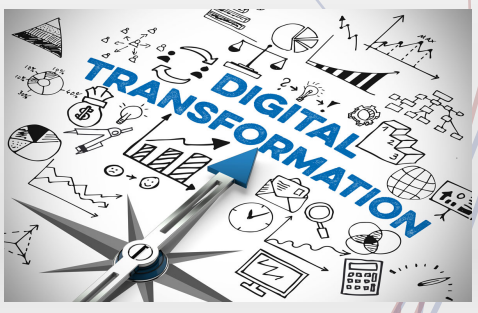
Digital Transformation

- Effectivity of Digital Transformation Highly Influenced by
  - Enterprise Culture
  - Leadership (Adaptive)
  - Diversity of Team (Technical, Geographic, Culture, Generational)
- Expected Digital Transformation Outcomes
  - Improved Operational Efficiencies
  - Technological Infusion
  - Increased Product Awareness
- Unanticipated Digital Transformation Outcomes
  - Reorganization of Organizational Structures
  - Cross Organizational Collaboration
  - Greater Interdependency on Industry Ecosystem



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Next Steps

- Completion of Digital Twin Digital Thread Phase 4 – Standards Framework Q2 2023
- Initiate Phase 5 – Digital Twin/Digital Thread Value Proposition Q3/Q4 2023
- Phase 6: Forward-looking Digital Twin/Thread Strategy and Roadmap 2024
- Special Topics
  - Knowledge at Large – Capturing knowledge from knowledgeable workers
  - Successful approaches to knowledge capture – People/Process
  - The System Engineer and the Enterprise – Five-year scenario
  - Post Sales / As Flown / As Maintained Digital Twin/Thread
  - AI-enabled Digital Twin
  - Cognitive Digital Twin