PLM Road Map™ & PDT Europe 2023
The Digital Thread in a Heterogeneous, Extended Enterprise Reality
A call for PLM Professionals to share their knowledge & experience
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AEROSPACE & DEFENSE PLM ACTION GROUP

The Digital Transformation – Digital Twin/Digital Thread
A PLM Ecosystem Perspective

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Speaker Profile

Dr. Robert Rencher
Associate Technical Fellow –
Sr. Systems Engineer, 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 in the aerospace and defense industry standards bodies (AIA, ISO, SAE International, OMG Digital Twin Consortium, 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

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, GE Aerospace, Gulfstream A General Dynamics Company, Pratt & Whitney Dependable Engines, Rolls-Royce, SAFRAN

Abstract

- This presentation addresses the availability and use of digital twin and digital thread standards in the aerospace industry. The presentation's content reflects the A&D PLM Action Group (AD PAG) Digital Twin/Thread project team's recent findings regarding the existence and efforts to establish digital twin and digital thread standards in the aerospace industry.
- Digital twin and the digital thread standards are an evolution of existing standards that were developed to address product definition and data management needs prior to the introduction of the concepts of digital twin and digital thread. Digital twin-relevant standards stem from simulation, system engineering, and manufacturing practices. Digital thread-relevant standards stem from data management and data architecture practices.
- The team's findings indicate a limited availability of mature digital twin/thread standards, necessitating greater attention by standards organizations that support the A&D industry.
- In conclusion, the next phases of the AD PAG Digital Twin / Digital Thread project to examine the *Digital Twin/Digital Thread Value Proposition* will be introduced

Agenda

- The Digital Thread Issue
- Digital Twin / Digital Thread Project Overview
- Phase 4 – Digital Twin/Thread Comparative Analysis of Industry Standards
- Phase 5 - Digital Twin/Digital Thread Value Proposition
- Key Concepts – Phase 6 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

Members

AIRBUS

BOEING

GE Aerospace

Gulfstream
A GENERAL DYNAMICS COMPANY

Pratt & Whitney
Rolls-Royce

SAFRAN

Invited Tier 1 Supplier

GKN AEROSPACE

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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 and 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 available at www.ad-pag.com

Phase 4

Approach

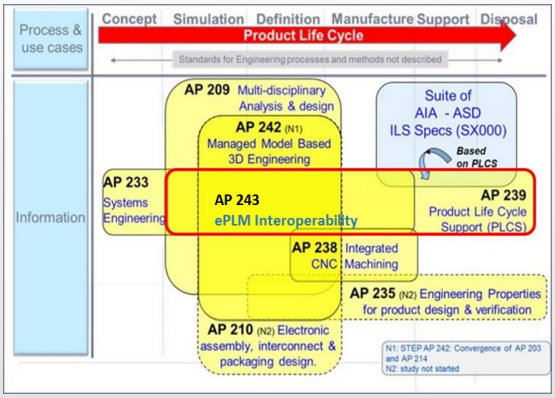
- 23 Standards organizations reviewed, e.g.,
  - American Institute of Aeronautics and Astronautics (AIAA), Aerospace Industries Association (AIA), American National Standards Institute (ANSI), Air Transportation Association (ATA) e-Business Program, International Airline Transportation Association (IATA), International Electrotechnical Commission (IEC), Institute of Electrical and Electronics Engineers (IEEE), ISO, NIST, Nuclear Quality Assurance Certification Program (NQA), SAE International
- Evaluated using the AD PAG Digital Twin/Thread Definition Framework: Business, System, and Technical perspective across product lifecycle

Digital Twin/Thread Definition Framework

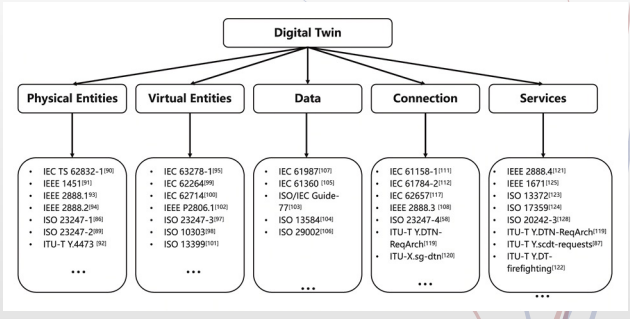
		Supplier	OEM				Customer/User/Owner/Operator		
		Part/ Component/ Material	Requirements	Design	Engineer	Manufacture	Operation	Maintenance	Disposition
Business	Artifacts								
System	Models and Data								
Technical	Tools and Methods								

Standards Frameworks

Reference frameworks from industry



STEP Application Protocol (AP) Standards



Digital Twin Standards by Type (Wang et al. (2022)

Digital Twin Standards

Utilizing the AD PAG Digital Twin/Thread Definition Framework

Digital Twin Standards Framework

	Supplier	OEM			Customer/User/Owner/Operator		
	Part/Component/ Material	Requirements	Design	Engineer	Manufacture	Operation	Maintenance	Disposition
Business Artifacts		Digital Twin Requirements	AP242, AP209, AP210 – Design Digital Twin		AP242, AP235, AP238 Manufacture/Deliver Digital Twin	AP242, AP209, AP210 – Modify Digital Twin Design		
System Models and Data		AP233 – System Engineering Digital Twin Definition						
Technical Tools and Methods				ISO 23247 – Framework for Manufacturing		AP239 – Digital Twin Support		

Digital Thread Standards

Utilizing the AD PAG Digital Twin/Thread Definition Framework

Digital Thread Standards Framework

Business	Artifacts
System	Models and Data
Technical	Tools and Methods

Supplier	OEM				Customer/User/Owner/Operator		
Part/Component/ Material	Requirements	Design	Engineer	Manufacture	Operation	Maintenance	Disposition
	SAE G-31 AIR 7367 - Requirements, Specifications and Framework of a Digital Thread						
	ISO 15704 – Requirements for Reference Architecture, ISO-18101 – Data interoperability				ATA iSpec 2200, Spec 2000, Spec 2300, Spec 2400, Spec 2500,		

Phase 4

Summary

- Digital twin standards overlap. This is most likely a function of standards bodies representing their respective standards as an ongoing development of standards from a historical perspective.
- The limited availability of mature digital twin/thread standards is an area needing greater attention by standards organizations.
- The concept of the digital twin continues to evolve. This will be a challenge to standards bodies.
- The digital twin and the digital thread are distinct aspects of digital transformation. The corresponding digital twin and digital thread standards will be distinctly different.
- Coordinating the development of the respective standards between the digital twin/thread is needed.
- Organization, definition, and enablement of the digital twin is dependent upon data and information provided by the digital thread.

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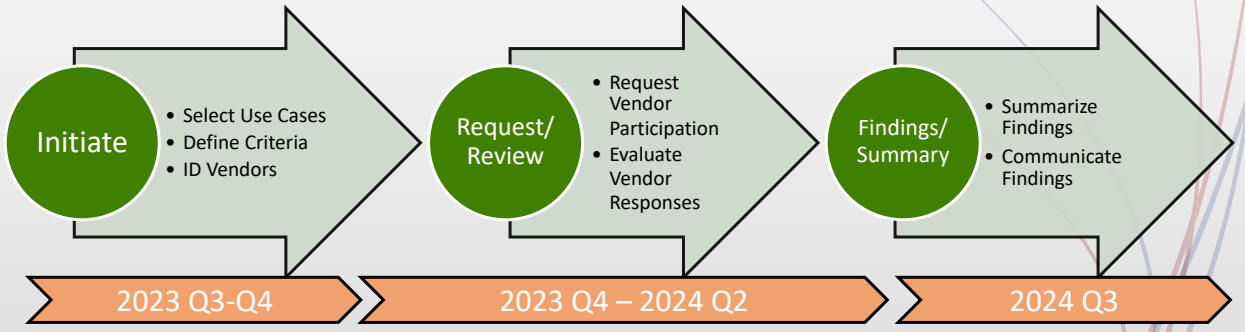
Phase 5

Objectives

- Evaluate PLM solution providers' demonstration of digital twin and digital thread capabilities following the AD PAG provided multi-phase use case demonstration methodology.
- Extrapolate the selected use cases to identify and validate digital twin/thread value propositions and evaluate the PLM solution providers' ability to define and demonstrate digital twin/thread solutions.
- Communicate with participating PLM solution providers the findings of the demonstrated digital twin/thread solution.
- Formulate the AD PAG digital twin/thread value proposition using information from PLM solution providers' demonstrations, prior AD PAG digital twin/thread phases documents, and relevant industry publications.

Phase 5

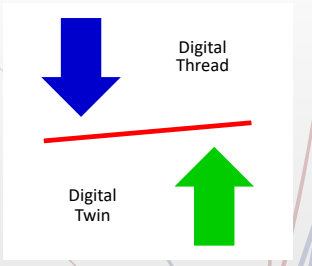
Preliminary Project Plan

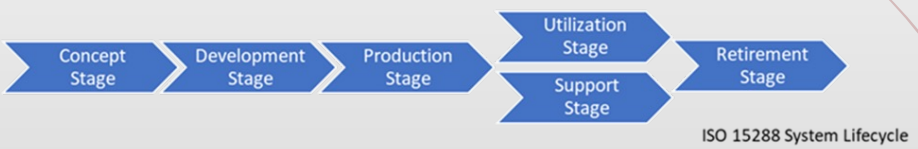


Phase 5

Initial Findings

- The value proposition of the Digital Twin is defined by the functional use information defined by the Digital Thread use case.
- The Digital Twin and the Digital Thread solution will be a composition of more than one system solution provider
- Lifecycle use-case areas of interest:



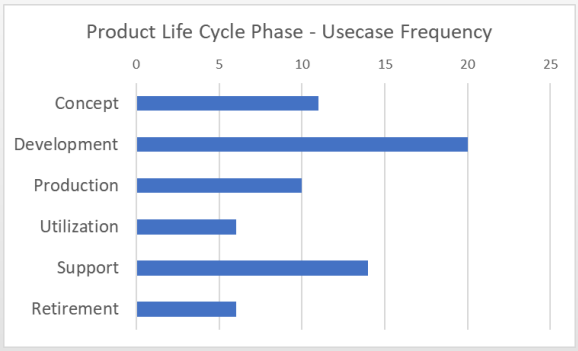


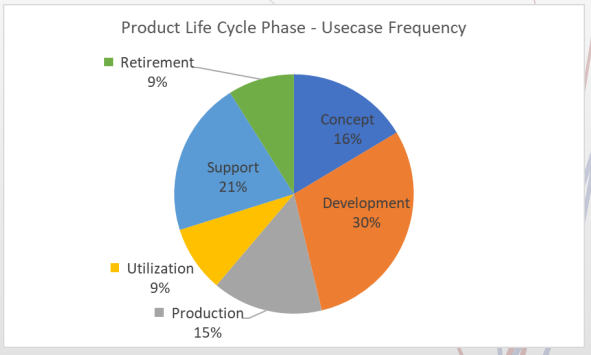
ISO 15288 System Lifecycle

Phase 5

Use Case Distribution

Of the ~30 Use cases identified





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Key Concepts – Phase 6 and Beyond

Three Key Concepts

- Forward-looking Digital Twin/Thread Strategy and Roadmap
- 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

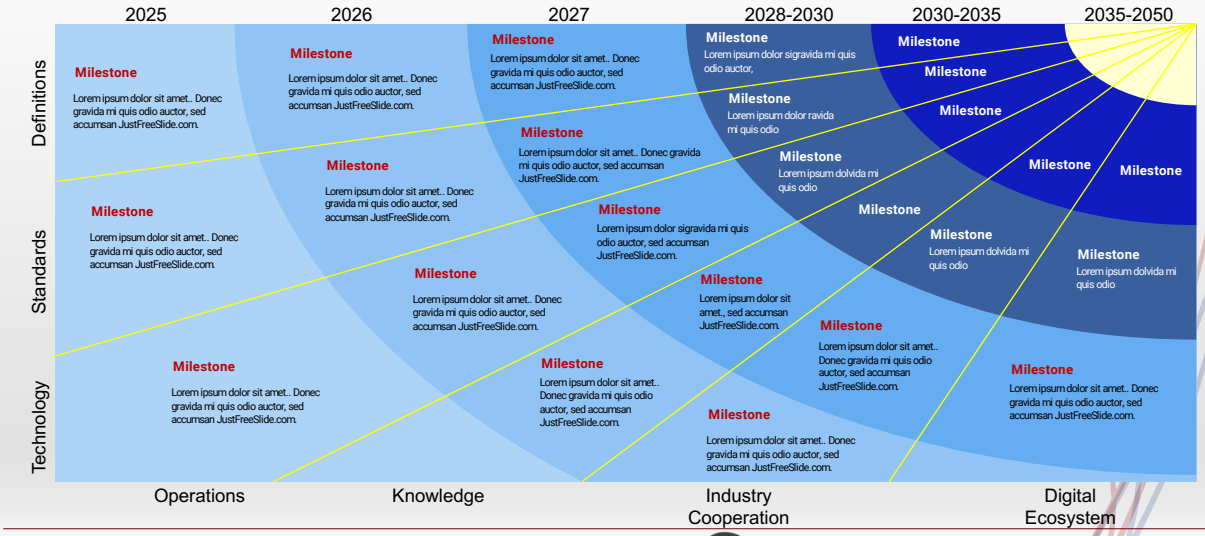
Phase 6 Key Concepts

Forward-looking Digital Twin/Thread Strategy and Roadmap

- A pragmatic perspective of when and how Digital Twin / Digital Thread concepts will be fully matriculated into the operational aspects of the aerospace industries.
- A forward-looking analysis of digital twin / digital thread opportunities and challenges.
- Multi-dimension perspective: Standards, Technology, Operations, Knowledge, Industry Cooperation, Industry Ecosystem, Definitions

Phase 6 Key Concepts

Forward-looking Digital Twin/Thread Roadmap - Conceptual



Phase 6 Key Concepts

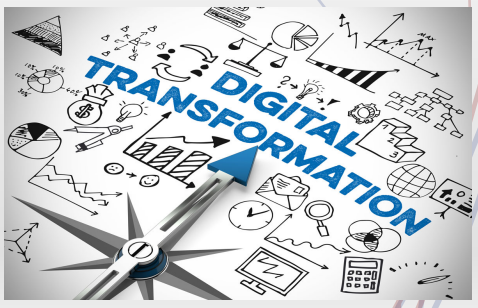
Defined scope of digital thread utility

- 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

Phase 6 Key Concepts

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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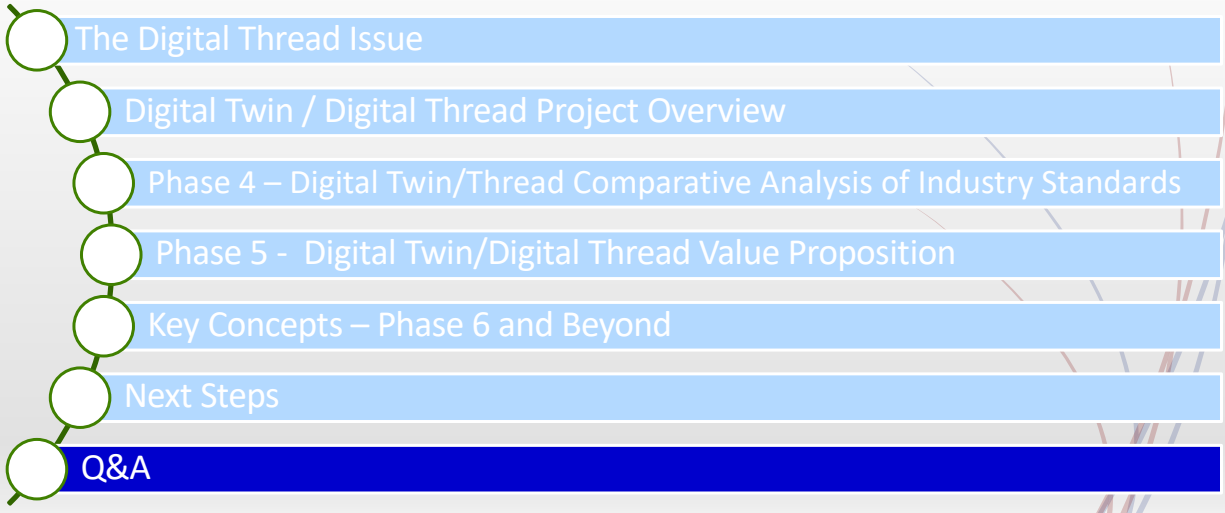
7. Q&A

Next Steps

- Complete Phase 5 – Digital Twin/Digital Thread Value Proposition Q3 2024
- Initiate Phase 6: Forward-looking Digital Twin/Thread Strategy and Roadmap Q4 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
  - Cognitive Digital Twin
  - Digital Twin / Digital Thread Locality

Agenda

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Questions and Answers
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