



AEROSPACE & DEFENSE PLM ACTION GROUP

Aerospace & Defense PLM Action Group

Objectives, Requirements, and Roadmaps for Digital Twin/Digital Thread Solutions



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Abstract

In 2021, the Aerospace & Defense PLM Action Group (AD PAG) launched a project based on existing industry knowledge and capability of digital twins and digital threads to evaluate digital twin/thread technology capabilities against an initial set of use cases. The AD PAG sponsored a team of domain experts from the member companies to define objectives, requirements, and roadmaps for Digital Twin/Digital Thread solutions for creating and managing the digital representation of a product through the various stages of the product lifecycle. This presentation will provide an overview of the digital twin/digital thread project and key learnings from the first two phases.

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Project Leader

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Agenda

- Team
- Issue / Approach
- Definition Framework
- Definitions: Digital Twin & Digital Thread
- Observations
- Next Steps

Project Team

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The Issue

- Digital twin and associated digital thread is an industry transformative concept.
 - With the digital twin, product lifecycle transparency of design, manufacturing and operational performance can be enabled.
 - The approach has the propensity to reduce data portability friction.
- The basic premise of a digital thread enabled digital twin is that the A&D ecosystem will be disrupted.
 - Intermediaries that exist to manage data will be supplanted with improved data portability technology
 - Entirely new structures of data will be created leading to a “new normal” of data interoperability
- How real is this?
 - Is this still marketing hype?
 - Are the fundamentals in place to build stable, long lasting, means of design, production, and support?

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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

Phase 2 – Position Paper

- Objective – Author the *Digital Twin and Digital Thread Solution Definition for Aerospace and Defense* position paper.
- The variability of Digital Twin and Digital Thread needs provided the foundational understanding as to why there are several definitions for digital twin and digital thread.
- Phase 1 Digital Twin and Digital Thread Framework revised and utilized to produce Digital Twin and Digital Thread definition.
- Phase 2 in final review – publication anticipated in July, 2022.

Digital Twin / Digital Thread Definition Framework

		OEM					
		Requirements	Design	Engineer	Manufacture	Operate	Dispose
Business	Artifacts						
System	Models and Data						
Technical	Tools and Methods						

Purpose:

- Organization of definitions
- Commonality and variation of definitions
- Origin of Digital Twin in Product Lifecycle
- Origin of Digital Thread in Product Lifecycle

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 travels on interoperability standards.

Digital Twin Working Definition

A digital twin is a virtual representation of a physical entity, its behaviors, and the associated processes used to create it. It is an integration of data from various sources (i.e., digital thread) that *define a future, existing, or historic item, system, process, or service and operational environments*. Such representation, augmented with field data, provides a means of visualizing, understanding, predicting, and optimizing various aspects of the physical entity's design and behavior, as well as its fabrication, assembly, and the environment in which it is/was/will be used, maintained, and disposed of. Ultimately, a *digital twin is expected to experience every event that its physical twin experiences*, and utilized to explore situations that a physical twin has not yet experienced.

Digital Thread Working Definition

The digital thread is a *communication framework* that enables connected data flows for the integrated view of lifecycle artifacts and their resulting asset's data (i.e., digital twin) across traditionally siloed functional product lifecycle domains. This communication framework depends on standardized, model-based representations and semantic data modeling to facilitate the dynamic creation of thread context, based on multiple viewpoints. As the asset is produced, operated, maintained, and progressed through its lifecycle stages, the digital thread fabric is continually expanded to holistically merge the digital and physical worlds.

Phase 2 – Key Observations

- A product digital twin aspires to provide all the definition information available throughout the product lifecycle.
- The interdependency of the digital twin and the digital thread is recognized as being necessary to enable the digital twin's integrity and value proposition.
- The digital twin is dependent upon one or more digital threads as the method of acquiring and disseminating data/information.
- A digital thread is not sustainable without data governance.
- The digital product is enabled through the modeled orchestration of the digital twin and digital thread.
- The structure of a digital twin defines the characteristics and relationships of the digital threads when utilized by different taxonomy structures.

Digital Twin / Digital Thread: Phase 3 - Business Architecture/Methodologies

- Using the framework defined in Phase 2, the business architecture and associated methodologies required to incorporate and utilize digital twin/thread concepts within the A&D industry will be defined.
- Existing Enterprise Business Architecture Frameworks will be used to define:
 - Identify and define unique Digital Twin and Digital Thread business, systems and technological architecture and methodology constructs.
 - Review existing business architecture frameworks and associated methodologies in terms of the framework and methodology adaptiveness to digital twin and digital thread constructs.
 - Conduct a detailed review with one business architecture framework and methodology to determine how well the constructs of digital twin and digital thread would be adapted into the framework and methodology.
 - Prepare generalized recommended changes to the business architecture frameworks and associated methodologies.
- A reference model represented by the Framework will be shared.

Digital Twin / Digital Thread: Phase 3 - Business Architecture/Methodologies in Review

- *CIMdata Enterprise Application Architecture Reference Guide*
- *The Business Architecture Framework*
- *Business Architecture Framework*
- *A Review of the Seven Modelling Approaches for Digital Ecosystem Architecture*
- *A Business Ecosystem Architecture Modeling Framework*
- *Business ecosystem architecture development: a case study of Electric Vehicle home charging*
- *The Open Group Architecture Framework (TOGAF)*
- *Unified Architecture Framework (UAF)*
- *Zachman Architecture Framework*

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Digital Twin / Digital Thread: Phase 3 Business Architecture/Methodologies Alignment and Analysis

	Existing Reference Architectures								
	CIMdata Enterprise Application Architecture Reference Guide	The Business Architecture Framework	Business Architecture Framework	A Review of the Seven Modelling Approaches for Digital Ecosystem Architecture	A Business Ecosystem Architecture Modeling Framework	Business ecosystem architecture development: a case study of Electric Vehicle home charging	The Open Group Architecture Framework (TOGAF)	Unified Architecture Framework (UAF)	Zachman Architecture Framework
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Digital Twin/Thread Constructs									
Type									
Both	Ecosystem Context								
Twin	Ecosystem System Interoperability								
Thread	Ecosystem Information Interoperability								
Both	Ecosystem Operations Interoperability								
Twin	Ecosystem Functional Interoperability								
Both	Collaborative construction and reconstruction of distributed model artifacts from IoT sensor data through digital thread to digital twin								
Both	Value Representation								
Both	Interrelationship between Twin and Thread								
Both	Represent product lifecycle								
Both	Matrix of Business, System, and Technical architecture abstractions (see Phase 2 framework)								
Thread	Reconciliation of IoT to Digital Thread								
Twin	Reconciliation of IoT to Digital Twin								
Both	Reconciliation of Digital Twin to Digital Thread								
Both	Unique and Commonality of models derived from one perspective								
Twin	Decomposition of Digital Twin								
Thread	Decomposition of Digital Thread								
Twin	Distinction and derived differentiation between process, twin, system twin, asset twin and component/part twin								
Thread	Definition of atomic thread elements and dynamic combination to support of data, information and knowledge inquiry								
Twin	Three phases of model and model decomposition - current, past, future (see figure 10)								
Thread	Modeling constructs to define a communication framework								
Thread	Model the thread utilization between digital and physical models								
Thread	Model the distinction and relationship between digital fiber segments, digital threads, and digital fabric								
Thread	Model purpose built value from concept through utility of production								
Thread	Model organizational utilization of digital thread end-to-end components, as used and/or as planned use								
Both	Model complete utilization of digital threads by digital twin								

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Simplified - Phase 3 Business Architecture/Methodologies Alignment and Analysis

Digital Twin/Thread Constructs	Existing Reference Architectures								
	<i>CIMdata Enterprise Architecture Reference Guide</i>	<i>The Business Architecture Framework (BACOE)</i>	<i>Business Architecture Framework (EoLearning)</i>	<i>Seven Modelling Approaches for Digital Ecosystem Architecture (IEEE)</i>	<i>A Business Ecosystem Architecture Modeling Framework (IEEE)</i>	<i>Business ecosystem architecture development</i>	<i>The Open Group Architecture Framework (TOGAF)</i>	<i>Unified Architecture Framework (UAF)</i>	<i>Zachman Architecture Framework</i>
Description									
Ecosystem Interoperability (System, Data, Function, Operations)									
Interrelationships between Twin and Thread									
Twin/Thread product lifecycle									
Twin/Thread Decomposition									
Automatic thread element definition and dynamic utilization									
Organizational utilization modeling of digital twin and digital thread and associated sub-components, as used and/or as planned use.									

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Questions?

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