

Digital Twins: Enhancing Lifecycle Performance

2024 Market & Industry Forum—27 March 2024

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Digital Twins: Enhancing Lifecycle Performance
PLM Market & Industry Forum
A CIMdata PLM Leadership Event

27 March 2024—Ann Arbor, MI USA

Stan Przybylinski, Vice President, s.przybylinski@CIMdata.com
+1.734.668.9922

#PLM4um

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CIMdata Defining What Comes Next in Digital Transformation

Strategic management consulting for competitive advantage in global markets

The leading independent authority on PLM and its digital transformation. We provide research, education, and strategic consulting to clients around the world.

OUR MISSION:
Maximizing clients' ability to design, acquire, deliver, and support innovative products and services.


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Key Takeaways


 *Digital Twins: Enhancing Lifecycle Performance*

- Digital transformation and multi-disciplinary lifecycle optimization are central to CIMdata’s mission and PLM definition
- The digital thread and digital twins are key parts of our Critical Dozen
- But while digital twins are being adopted, confusion still reigns about digital twin technologies, benefits, and market opportunity
- CIMdata believes digital thread is critical to digital twin success
- While the market is hard to measure, opportunities exist across the lifecycle

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Defining PLM

 *Digital transformation of the lifecycle, enabled by the product innovation platform*

PLM is...

- A strategic business approach powered by a consistent set of solutions
- Enabled by product innovation platforms that support the extended enterprise
- An approach that spans the full lifecycle, from idea through life
- Enables a set of evolving functional domains orchestrated by an extended enterprise-level “systems of systems” approach



The diagram illustrates Multi-Disciplinary Lifecycle Optimization as a central concept, surrounded by six interconnected functional domains: Portfolio & Program Management, System Ideation, System Realization, Profitability Management, Quality Compliance, and Service Management.

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Digital Everything

Cited in Industrie 4.0 vision, smart connected products one of the drivers




- Digitization
- Digitalization
- Digital transformation
- Digital manufacturing
- Digital thread
- Digital twins
 - Origins in electro-mechanical systems

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Everyone is Talking Digital Twins

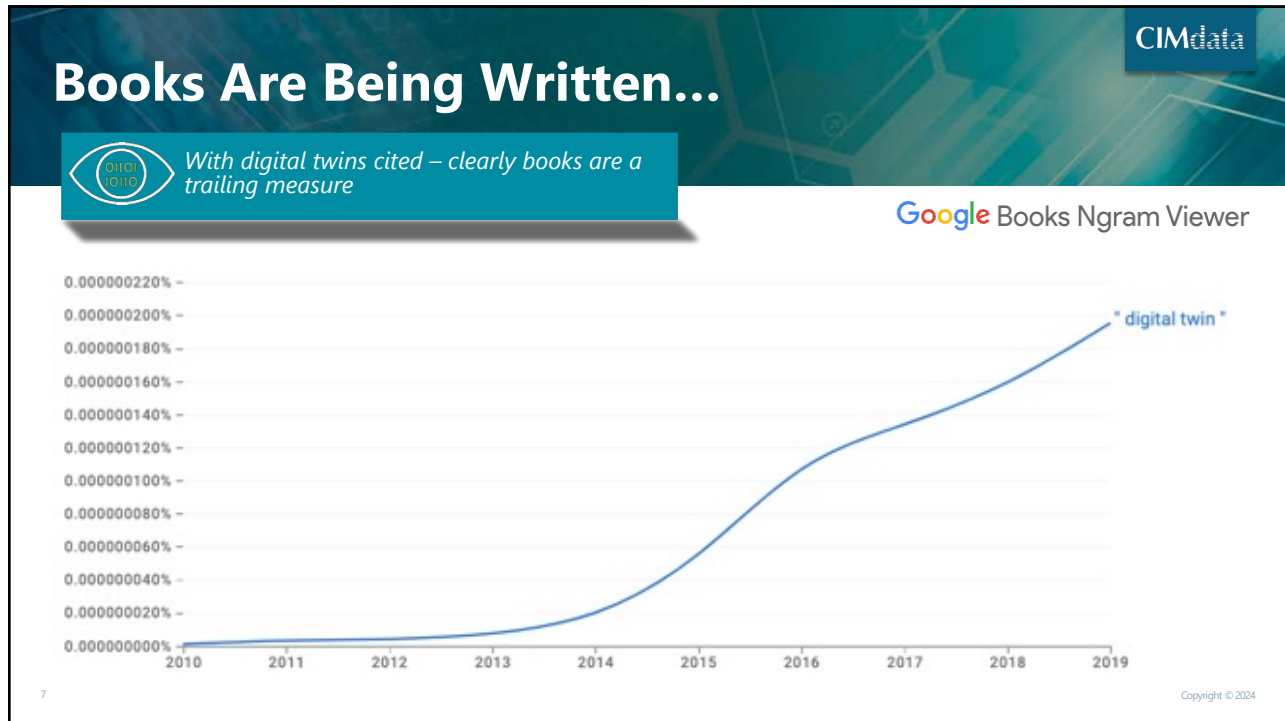
Started in discrete, twins are “fraternal” – same phrase, very different meanings



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Definitions Are Everywhere...

Many on the first search page

Google search on "digital twin", 12 March 2024

Google "digital twin" 0.31 seconds

About 24,500,000 results

A digital twin is a digital representation of a physical object, person, or process, contextualized in a digital version of its environment. Digital twins can help an organization simulate real situations and their outcomes, ultimately allowing it to make better decisions. Jul 12, 2023

McKinsey & Company
<https://www.mckinsey.com/mckinsey-explainers/wh...>
What is digital-twin technology? | McKinsey

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Organizations Emerging...



The Digital Twin Consortium the most prominent

- Founded in May 2020, operated by the Object Mgt. Group (OMG)
- Steering Committee – BP, Northrop Grumman, Dell Technologies
- Broad set of working groups
- Aerospace – AIAA, GE, Lockheed Martin, Northrop Grumman
- No auto OEMs
- Only two PLM players (Ansys, Dassault Systèmes)
- Academics, research organizations, small firms



⁹ <https://www.digitaltwinconsortium.org/>

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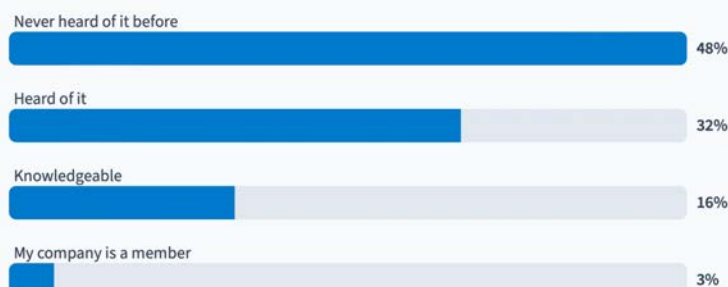
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CIMdata Foresight Poll



How familiar are you with the Digital Twin Consortium?

How familiar are you with the Digital Twin Consortium?



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CIMdata's Critical Dozen

The Top 12 Trends and Enablers of Digital Transformation

12 familiar, evolving trends & key enablers of digital transformation that you cannot, or should not, live without.

- 01 End-to-end connectivity
- 02 Data & process management
- 03 Configuration management
- 04 Bills of information
- 05 Model-based structures
- 06 Digital thread/twin
- 07 IoT & PLM
- 08 Changing views of "product"
- 09 Big data & analytics
- 10 Augmented intelligence
- 11 Data governance
- 12 Digital skills transformation

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But What Are Digital Twins?

Definitions vary, twins are "fraternal" – just some example sources of many

Forbes "...a digital twin is a virtual model of a process, product or service."

McKinsey & Company "A digital twin is a digital representation of a physical object, person, or process, contextualized in a digital version of its environment."

digital twin CONSORTIUM "A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity."

ptc "a virtual representation of a physical product, process, person, or place (commonly referred to as a spatial twin) that can mirror and measure its physical counterpart."

ALTAIR 2022 Digital Twin Report "Digital twin technology is the process of using data streams to create a digital representation of a real-world asset to improve collaboration, information access, and decision-making."

State of Digital Twin 2022

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What is the “Digital Twin Market”?



Depends on how you define the digital twin and its application

<https://www.researchandmarkets.com/reports/5146336/global-digital-twin-market-by-application>

- A recent market research report on the “Digital Twin Market” claimed it was valued at US\$10.1B in 2023 and would reach US\$110B in 2028!
- Their definition?
 - IoT & IIoT
 - Blockchain
 - Artificial Intelligence and Machine Learning
 - Augmented Reality, Virtual Reality, and Mixed Reality
 - Big Data Analytics
 - 5G
- But NOTHING about creating the Intellectual Property (IP) that powers them
- More about smart connected products

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Altair Digital Twin Global Survey



Statistically significant results from global study, well-defined sampling frames



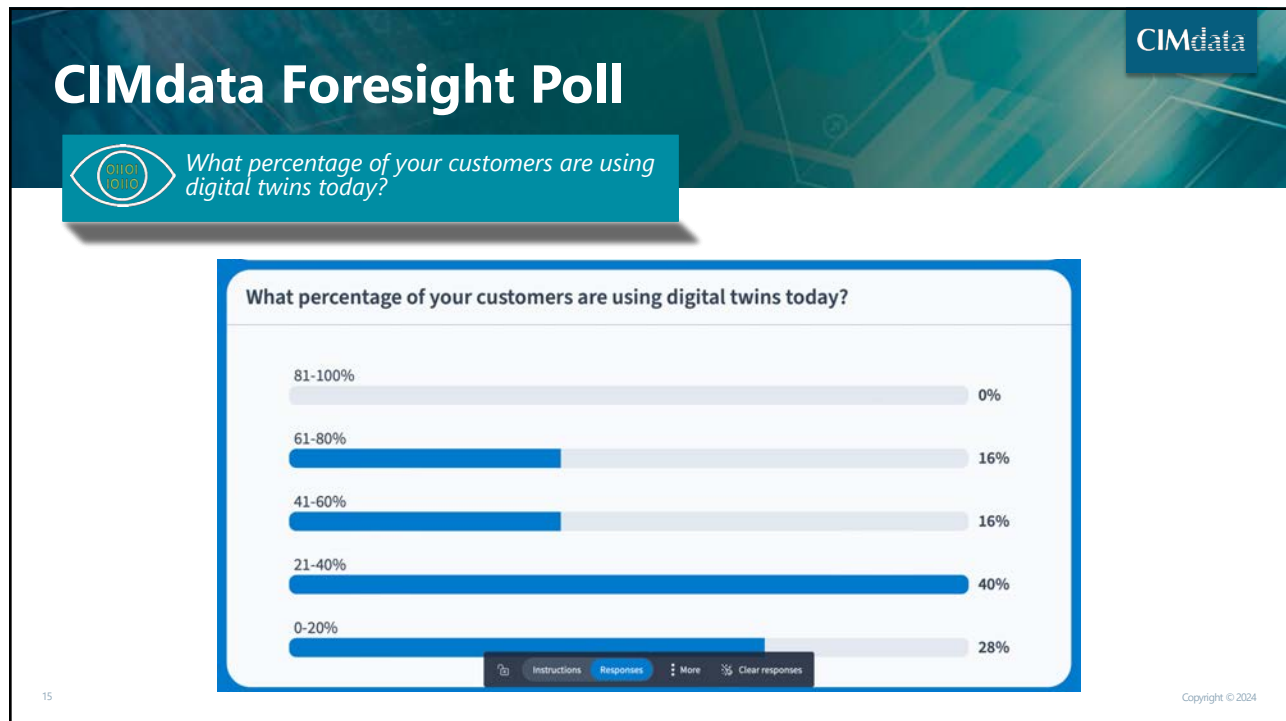
- 69% currently leveraging digital twin technology, 23% not
- 50% claimed “highly knowledgeable” but 22% said digital twin “confusing”
- Upper-level employees and user-level employees understood, viewed, and used digital twin technology differently

https://altair.com/docs/default-source/pdfs/altair_dt-global-survey-report_web.pdf?sfvrsn=b5acea9_28

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How Did We Get Here?

Innovation part of human existence, progressed to the scientific method (1 of 2)

- Humans have ideas, want to assess them
- Started with “trial and error”
- Get a little more systematic, e.g., slow, deliberate developments in building techniques
 - Romans famous for this approach
 - Facilitated by Roman concrete



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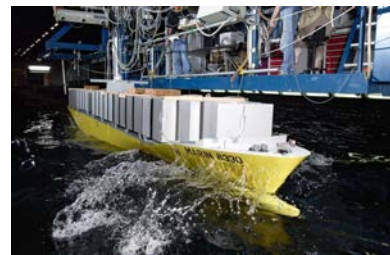
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How Did We Get Here?



Innovation part of human existence, progressed to the scientific method (2 of 2)

- Testing of life size items or scale models
- Core to a systems engineering (SE) approach
- Work on SE started in earnest in academia & industry in the 1960s
- Focus on requirements definition & validation and verification (V&V)
- Apollo built on Gemini, which built on Mercury
- Early twins (“mirrored systems”) of complex electro-mechanical machinery done by NASA



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Art Imitates Life – “Apollo 13”



Power-up procedure defined using mirrored system back on Earth



¹⁸ https://youtu.be/x9kN_AEh58c?feature=shared


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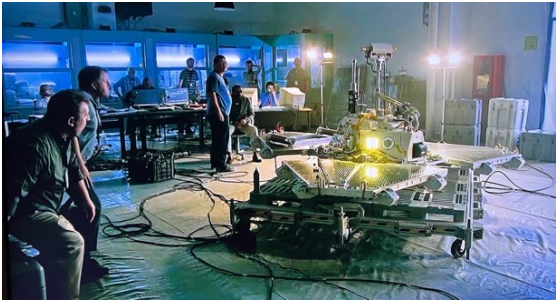

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Art Imitates Life – “The Martian”


 Mirrored Pathfinder system at JPL used to communicate with deployed system on Mars



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NASA Space Programs Set Vision

 Working in distant, disconnected environments required mirrored systems

“The ultimate vision for the digital twin is to create, test and build our equipment in a virtual environment. Only when we get it to where it performs to our requirements do we physically manufacture it.

We then want that physical build to tie back to its digital twin through sensors so that the digital twin contains all the information that we could have by inspecting the physical build.”

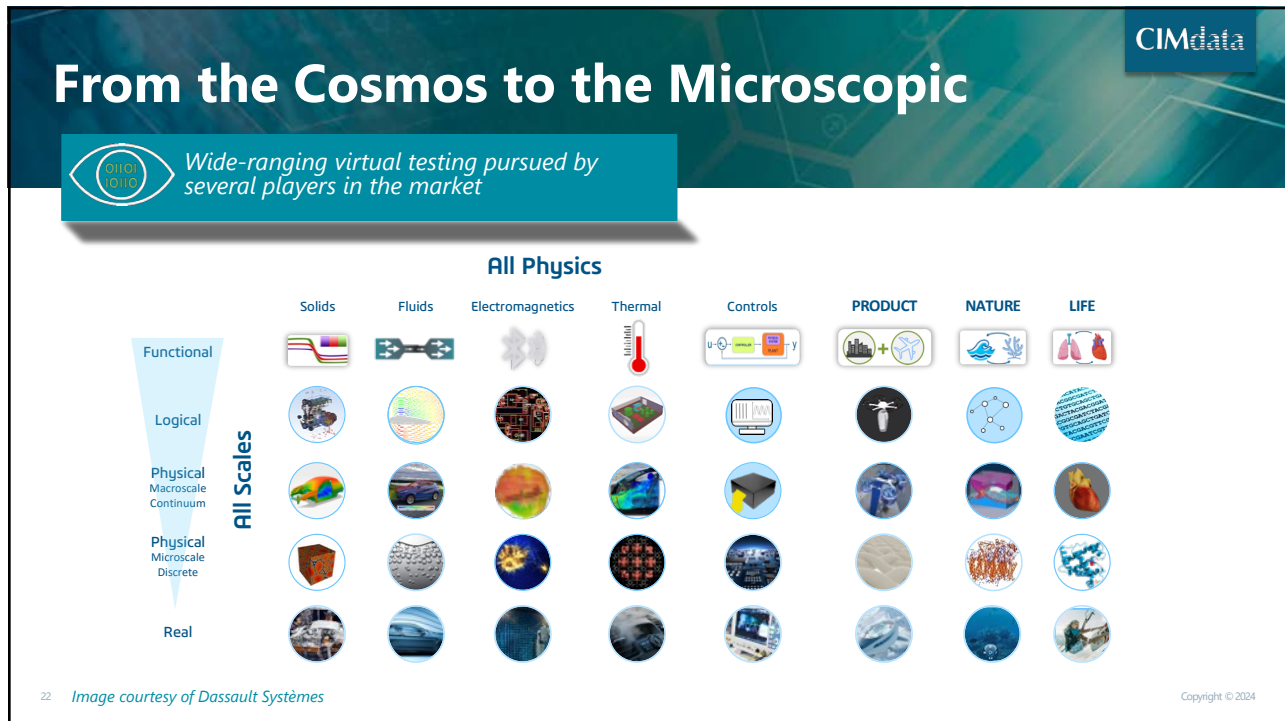
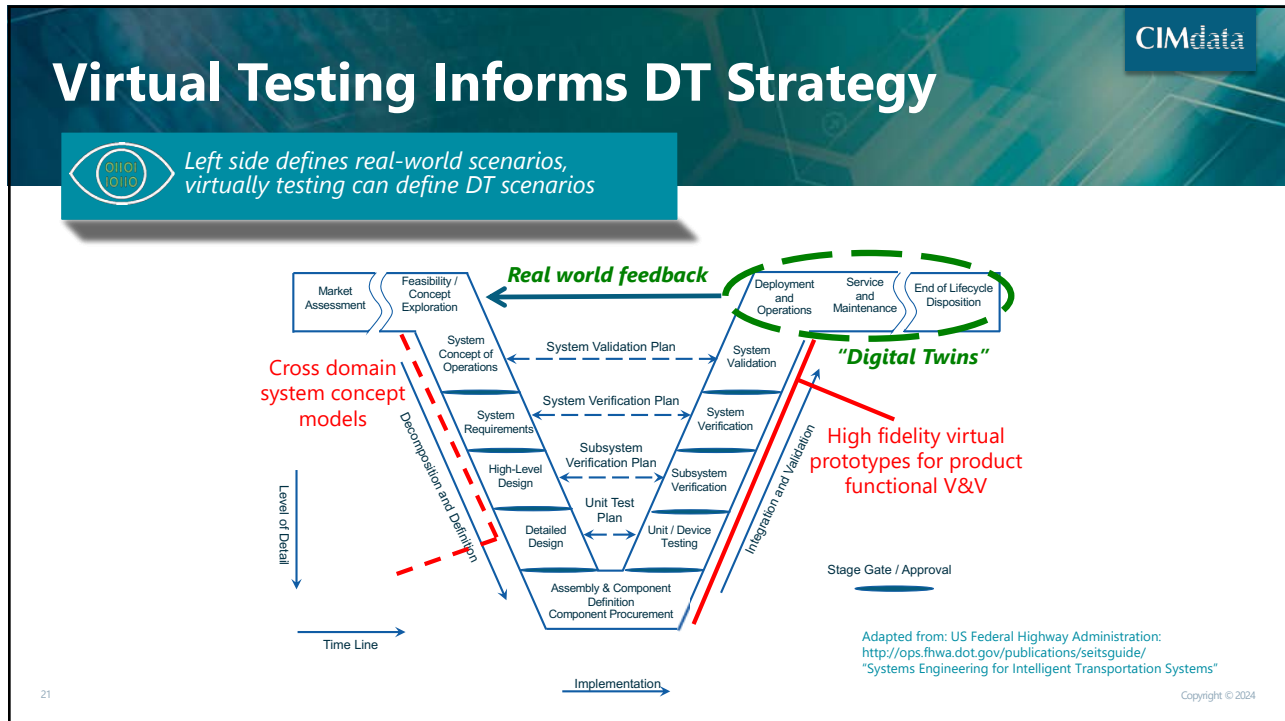


John Vickers, Manager,
NASA's National Center for
Advanced Manufacturing

20 <https://www.forbes.com/sites/bernardmarr/2017/03/06/what-is-digital-twin-technology-and-why-is-it-so-important/?sh=788735a22e2a> Copyright © 2024


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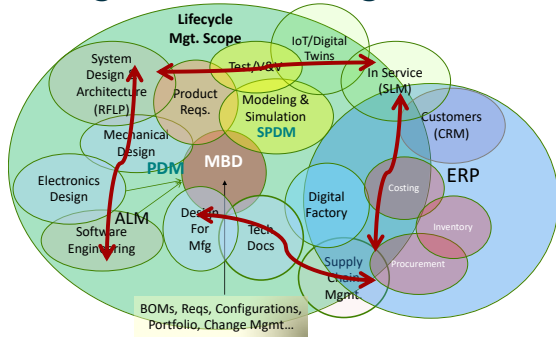


Digital Thread


CIMdata's preferred definition

- A **communication framework** that allows a connected data flow & integrated view of an asset's data (i.e., its Digital Twin) throughout its lifecycle across traditionally siloed functional perspectives.

Digital thread is enabled and supported by a robust end-to-end and connected systems model and MBSE processes



²³ Extracted from: https://www.dodmantech.com/ManTechPrograms/Files/AirForce/Cleared_DT_for_Website.pdf
 Also see: <http://www.manufacturing-operations-management.com/manufacturing/2016/04/what-is-the-digital-thread-and-digital-twin-definition.html>
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Collaborative Research Program


Study of the digital thread current state and future trends



Sponsors











Objective

The A&D PLM Action Group members and the PLM solution provider sponsors share a common objective for this research – To gain understanding of needs and opportunities within industry that will inform Digital Thread solution strategy and roadmap


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AD PAG Digital Thread Research


 *Web survey plus telephone interviews with practitioners*

- Nearly 50% do not have a common definition
- Nearly 70% of survey respondents said reducing risk top motivation; improving efficiency a close second
- Why digital thread prominent now?
 - “product complexity has continued to increase substantially” (58%)
 - “rising customer expectations, e.g., a desire to deploy digital twins” (46%)
 - “new enabling technologies have emerged” (43%)
 - “emphasis on time to market and the search for efficiencies” (42%)

25 <https://www.cimdata.com/en/aerospace-and-defense/publications/digitaltwin-digitalthread/1310-a-d-plm-action-group-digital-thread-collaborative-research-report> Copyright © 2024



Digital Twin

 *A digital representation of 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 of the Product



Digital Twin of Production



Digital Twin of Service

Digital twin is enabled and supported by a robust end-to-end and connected systems model and MBSE processes

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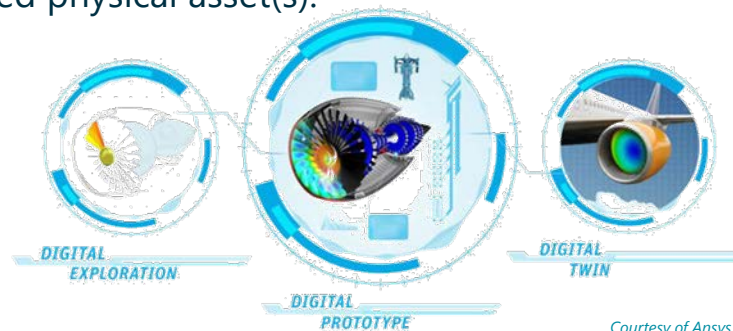
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Engineering Simulation Digital Twin



CIMdata's preferred definition

- A **physics-based virtual representation** of a physical asset or collection of physical assets (physical twin) that allows simulations of the associated physical asset(s).



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Courtesy of Ansys

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Many Types of Digital Twins



Key characteristics

- There are multiple digital twins for different purposes, each 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 its physical twin
 - The physical asset can be a plant, a ship, infrastructure, a car, etc.
- Each digital twin must communicate with its physical twin
 - It does not have to be real-time or electronic

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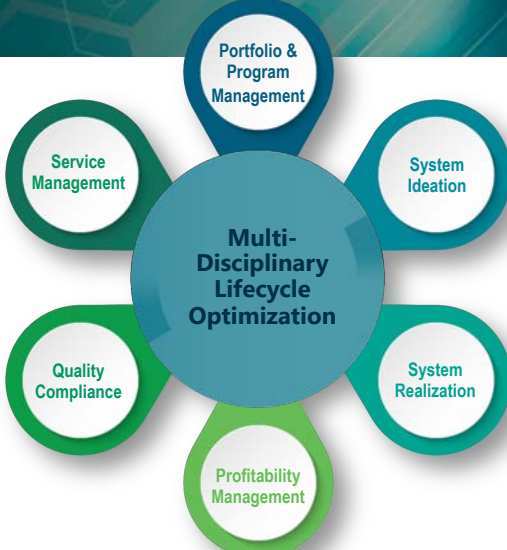
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A Key Part of Our PLM Definition

 Modeling & simulation at the heart, enables lifecycle optimization across disciplines



Modeling & Simulation Platform




Multi-Disciplinary Lifecycle Optimization

- Portfolio & Program Management
- System Ideation
- System Realization
- Profitability Management
- Quality Compliance
- Service Management

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Digital Twin Applications

 Can operate at increasing levels of value chain inclusion, scope, and sophistication

"Digital twins: The key to smart product development", McKinsey & Company, July 2023

Value chain	<i>Engineering:</i> ranging from product definition to validation and release for manufacturing	<i>Production:</i> encompassing a product, its systems, and its components	<i>Service:</i> including product sales through end of life and recycling	
Scope	<i>Component:</i> single, simple element within a product	<i>System:</i> combination of components that interact with each other to perform a specific function	<i>Product:</i> full product consisting of all systems and subsystems	
Sophistication	<i>Data foundational:</i> linking of data from various sources	<i>Traditional simulation:</i> use of simulation tools to perform analyses of design performance	<i>Automated design refinement:</i> use of predictive analytics and machine-learning technology to run automated simulation refinements and automatically produce optimized results	<i>Closed-loop real-world link:</i> use of multiple advanced simulation models that react dynamically to changing environments, regularly infused with real-world data from manufacturing and testing

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CIMdata Foresight Poll

What is the most common level of digital twin applications in your customers?

Level of Application	Percentage
Component digital twins	33%
System digital twins	50%
Full product digital twins	8%
Other	8%

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Initiated CIMdata Research

Built on previous research and knowledge of the PLM Economy offerings

- CIMdata opened two surveys on digital twins
- One for **industrial respondents**
 - The ideal respondent is knowledgeable about digital transformation, digital thread, and digital twin activities
- One for **software and service providers** enabling digital thread and digital twin capabilities

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Concluding Remarks



Digital Twins: Enhancing Lifecycle Performance

- Digital transformation and multi-disciplinary lifecycle optimization are central to CIMdata's mission and PLM definition
- The digital thread and digital twins are key parts of our Critical Dozen
- But while digital twins are being adopted, confusion still reigns about digital twin technologies, benefits, and market opportunity
- CIMdata believes digital thread is critical to digital twin success
- While the market is hard to measure, opportunities exist across the lifecycle

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Questions & Answers



What's on your mind?



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To Learn More...

 Please contact me with any questions or comments

- Stan Przybylinski, Vice President
- s.przybylinski@CIMdata.com (or stan@CIMdata.com)
- +1.734.668.9922
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