digital twin®
CONSORTIUM

The Evolution of the Digital Twin

Advancing Digital Twin Innovation

Dan Isaacs: CTO and GM

October 2025

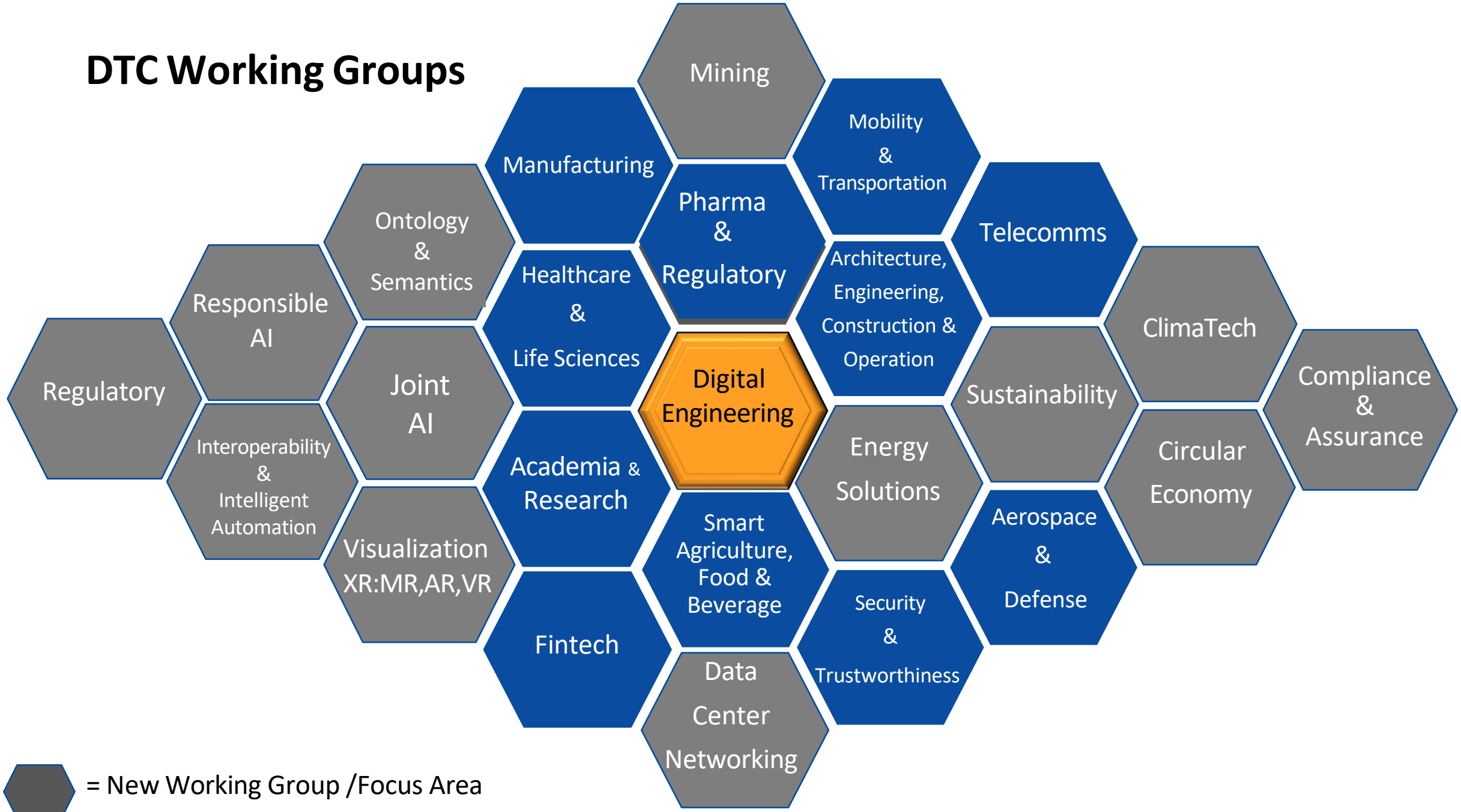
Steering Committee Members

XL Industry Members

Researchers | Technology Providers | Academia | Government | Digital Twin Users

200+ Members and Growing

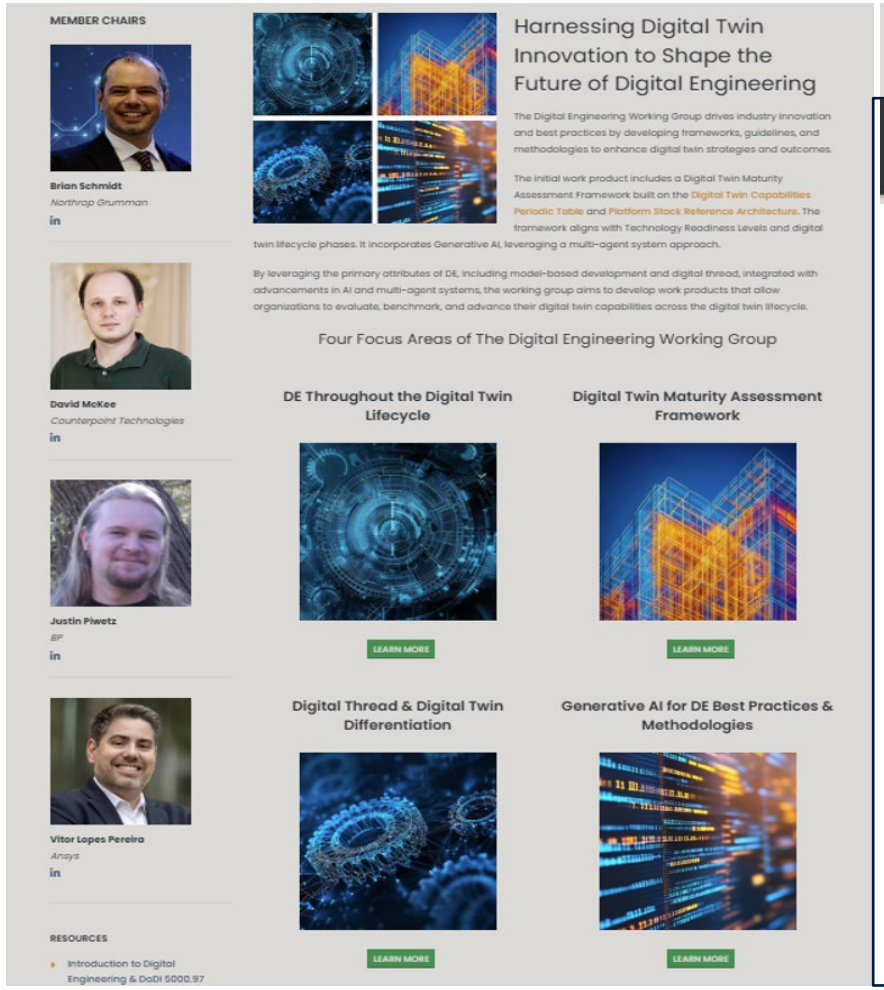
DTC Working Groups

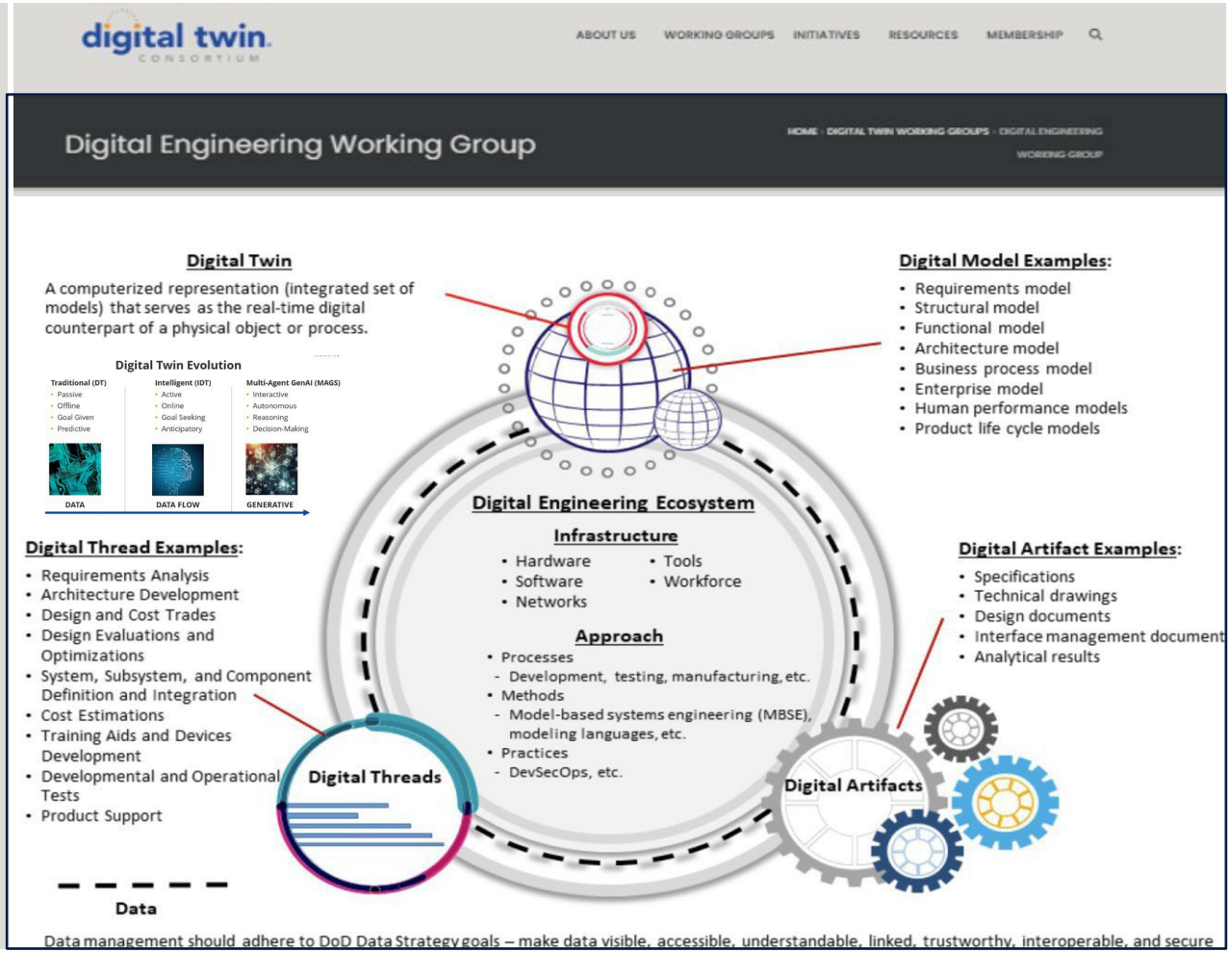


= New Working Group /Focus Area

Digital Engineering Working Group

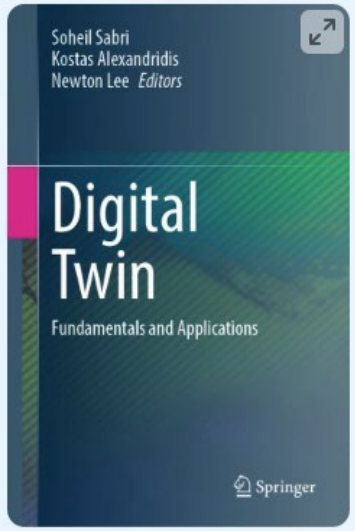
Transitioning to Joint Working Group w/ OMG DEMI





DoDI 5000.97, Digital Engineering – December 21, 2023 (whs.mil)

Digital Twin Use Cases - in Progress



Digital Twin

Fundamentals and Applications

Book | Jan 2025

Overview

Editors: Soheil Sabri, Kostas Alexandridis, Newton Lee

- Provides a well-rounded overview and demonstration of digital twin and digital transformation technologies
- Explores and showcases how digital twins advance our ability to address and solve contemporary problems
- Links state-of-the art theory, methodology, and practice across academic, governance and industry institutions

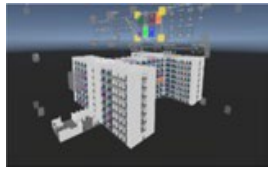
- Led by Academia & Research WG Co-Chairs
- Contributions from:
  - UCF
  - CSDILA
  - OC Survey
  - Institute for Education, Research and Scholarships
  - Georgia Institute of Technology
  - University of Leeds
  - Aker BP
  - RWTH Aachen University
  - Agile Fractal Grid
  - Digital Twin Institute

End Users – Catalyst for new Use Cases


Academia and Research


Research Institutes


Smart Cities


Smart Buildings


Aerospace & Defense


Artificial Intelligence


Open Source Developers


Financials


Healthcare


Data Centers


Manufacturing


Robotic Automation


Supply Chain


Transportation


Maritime


Airports


Oil & Gas

Renewables


Modular Nuclear Energy


Pharma


Precision Agriculture


Regulatory and Compliance


Emergency Management

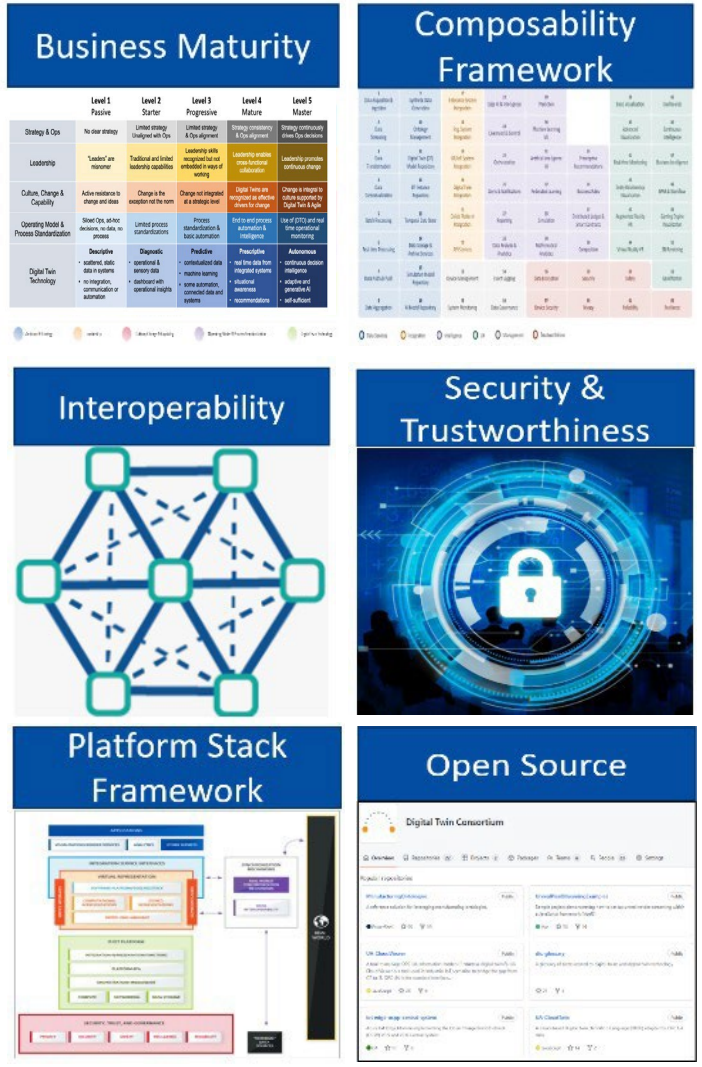

Telecomm

Structure

Member Driven

- Highly Collaborative
- Results Oriented
- Demonstrative
- Global Regional Branch Organizers
- Industry-wide Liaisons

Frameworks



Showcase

- ROC Windfarms –XMPro
- Ecol Café End-to-End Enterprise Digitalization I4.0
- 5G Secure Network –Intuitus
- Battery System Development – Dassault Systemes
- Flood Management – University of Melbourne
- Tracking Injuries in Hospitals – Axomem
- Long-haul COVID Management – Dell
- Financial Transactions – Intuitus
- Smart Airports and AR – EventSystems, others
- Intelligent Transport – Autonomy Institute

Regional Branch Coverage

Active:

USA (Northeast)
USA (Southeast)
USA (Southwest)
Canada
Chile
Spain
Netherlands
Italy
Germany
Korea
Japan
Australia/NZ
Saudi Arabia
Singapore
India
United Kingdom
Africa

Global Liaisons

American Institute of Aeronautics & Astronautics

AIoT User Group

Augmented Reality for Enterprise Alliance

Association for Smarter Homes & Buildings

American Society for Photogrammetry and Remote Sensing

Autonomy Institute

buildingSMART International

The Smart Manufacturing Institute

Centre for Spatial Data AECOs and Land Administration

CEO Leadership Alliance Orange County

The FIWARE Foundation

Global Mining Guidelines Group

International Council on Systems Engineering

Industrial Digital Twin Association

Interoperability Institute

InnovateEnergy

ISO/IEC JTC 1/SC 41

Manufacturing x Digital

National Institute of Building Sciences BIM Council

Open Applications Group

Open Health Systems Laboratory

Open Industry 4.0 Alliance

OPC Foundation

Post-Industrial Institute

Smart Cities Council

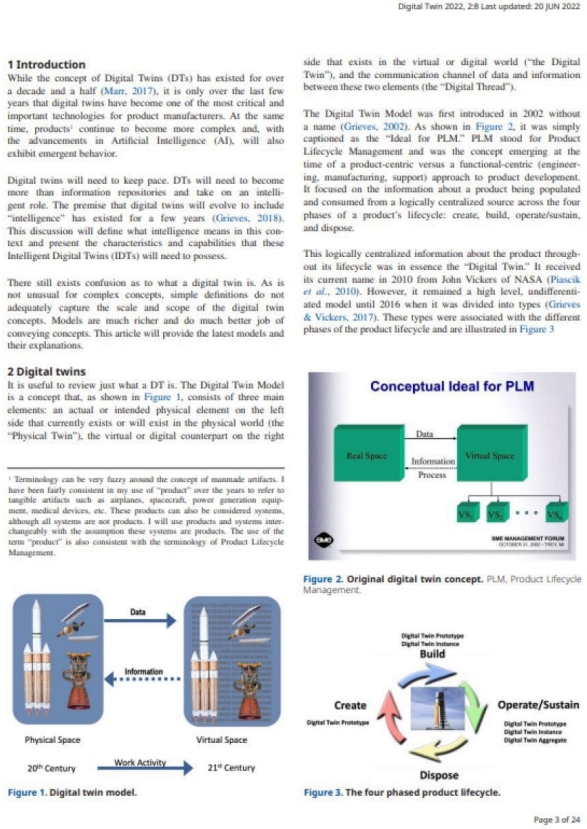
Spatial Web Foundation

Texas State CIEDAR Consortium

Evolution towards Intelligent Digital Twins

Intelligent digital twins and the development and management of complex systems – Dr. Michael Grieves

Research Gate# 360863845



Digital Twin 2022, 2:8 Last updated: 20 JUN 2022

1 Introduction

While the concept of Digital Twins (DTs) has existed for over a decade and a half (Marr, 2017), it is only over the last few years that digital twins have become one of the most critical and important technologies for product manufacturers. At the same time, products[1] continue to become more complex and, with the advancements in Artificial Intelligence (AI), will also exhibit emergent behavior.

Digital twins will need to keep pace. DTs will need to become more than information repositories and take on an intelligent role. The premise that digital twins will evolve to include "intelligence" has existed for a few years (Grieves, 2018). This discussion will define what intelligence means in this context and present the characteristics and capabilities that these Intelligent Digital Twins (IDTs) will need to possess.

There still exists confusion as to what a digital twin is. As is not unusual for complex concepts, simple definitions do not adequately capture the scale and scope of the digital twin concepts. Models are much richer and do much better job of conveying concepts. This article will provide the latest models and their explanations.

2 Digital twins

It is useful to review just what a DT is. The Digital Twin Model is a concept that, as shown in Figure 1, consists of three main elements: an actual or intended physical element on the left side that currently exists or will exist in the physical world (the "Physical Twin"), the virtual or digital counterpart on the right side that exists in the virtual or digital world ("the Digital Twin"), and the communication channel of data and information between these two elements (the "Digital Thread").

[1] Terminology can be very fuzzy around the concept of manmade artifacts. I have been fairly consistent in my use of "product" over the years to refer to tangible artifacts such as airplanes, spacecraft, power generation equipment, medical devices, etc. These products can also be considered systems, although all systems are not products. I will use products and systems interchangeably with the assumption these systems are products. The use of the term "product" is also consistent with the terminology of Product Lifecycle Management.

The Digital Twin Model was first introduced in 2002 without a name (Grieves, 2002). As shown in Figure 2, it was simply captioned as the "Ideal for PLM." PLM stood for Product Lifecycle Management and was the concept emerging at the time of a product-centric versus a functional-centric (engineering, manufacturing, support) approach to product development. It focused on the information about a product being populated and consumed from a logically centralized source across the four phases of a product's lifecycle: create, build, operate/sustain, and dispose.

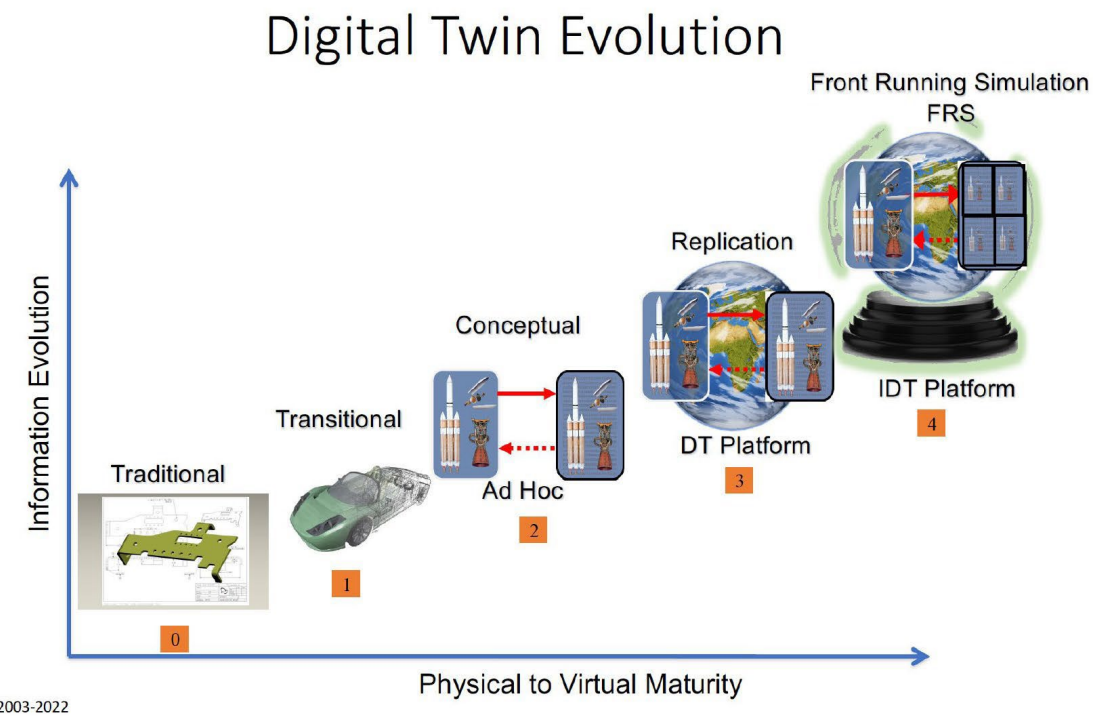
This logically centralized information about the product throughout its lifecycle was in essence the "Digital Twin." It received its current name in 2010 from John Vickers of NASA (Piascik et al., 2010). However, it remained a high level, undifferentiated model until 2016 when it was divided into types (Grieves & Vickers, 2017). These types were associated with the different phases of the product lifecycle and are illustrated in Figure 3

Figure 2. Original digital twin concept. PLM, Product Lifecycle Management.

Figure 1. Digital twin model.

Figure 3. The four phased product lifecycle.

Page 3 of 24

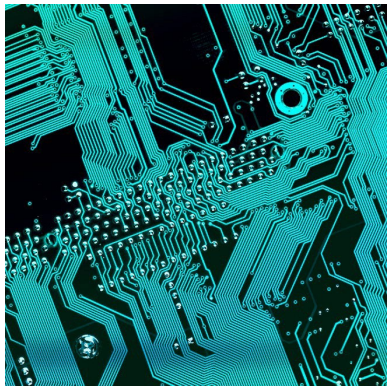


Intelligent digital twins and the development and ... | Digital Twin (digitaltwin1.org)

Digital Twin Evolution

Traditional (DT)

- Passive
- Offline
- Goal Given
- Predictive



DATA

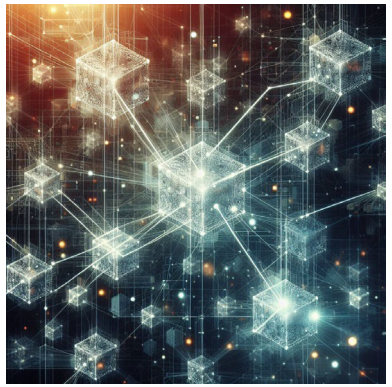
Intelligent (IDT)

- Active
- Online
- Goal Seeking
- Anticipatory

DATA FLOW

Multi-Agent GenAI (MAGS)

- Interactive
- Autonomous
- Reasoning
- Decision–Making



GENERATIVE

Adopted from: Grieves, Michael. (2022). Intelligent digital twins and the development and management of complex systems. Digital Twin. 2. 8. 10.12688/digitaltwin.17574.1.

Innovation

Emerging Trends in Digital Twin Technology

AI-Driven Digital Twins

Integration of AI enhances predictive capabilities, enabling real-time decision-making and autonomous system adjustments for smarter operations.

Multi-Agent Systems

Collaborative digital twins interact dynamically to simulate complex environments, improving accuracy in modeling and scenario testing.

Cross-Industry Applications

Digital twin technology expands beyond traditional sectors into healthcare, smart cities, energy management, and more, broadening impact.

Gen AI Capabilities

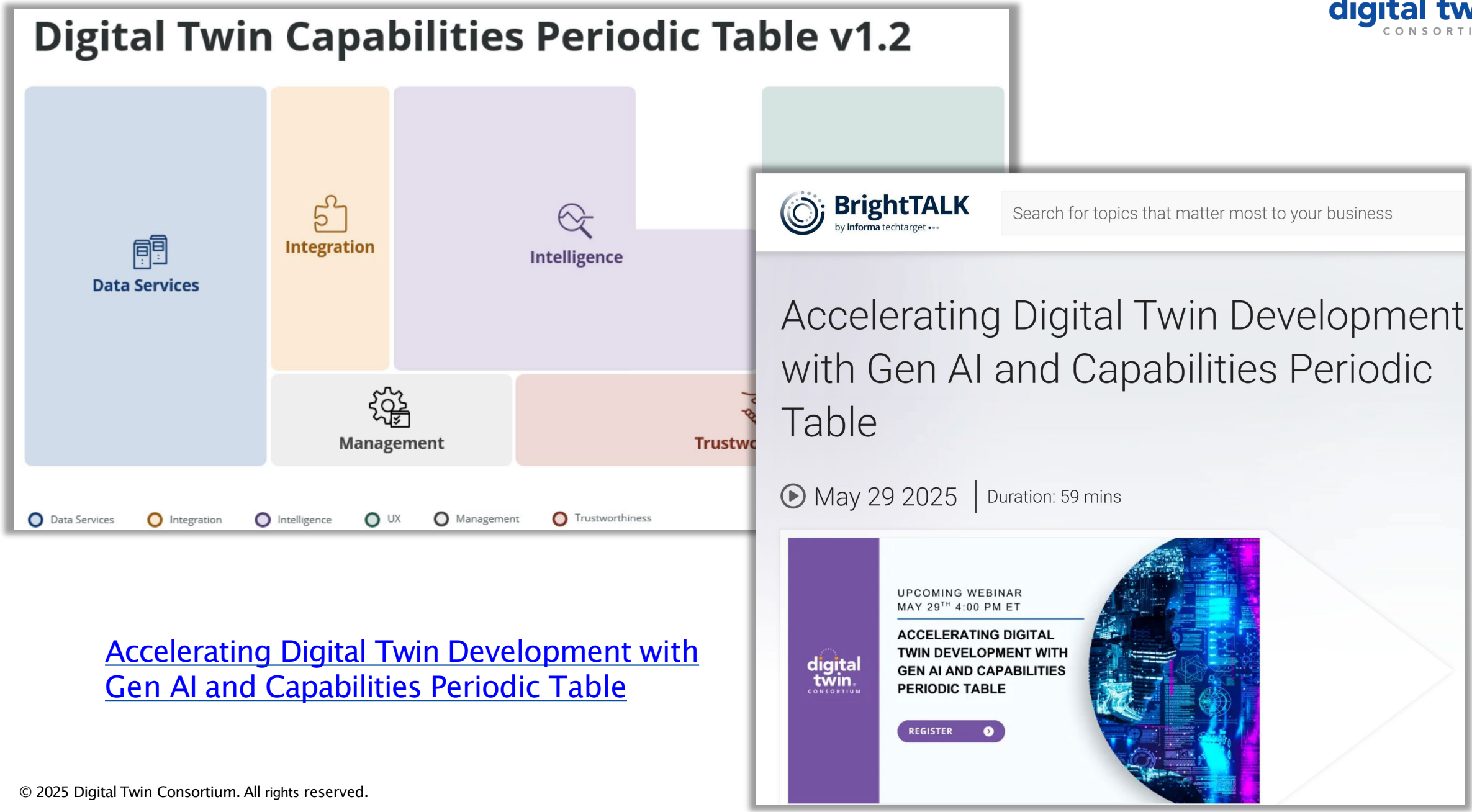
Generative AI accelerates digital twin development by automating design, simulation, and predictive analytics processes.

Sustainability Focus

Digital twins support renewable energy optimization, resource management, and environmental impact assessment to drive sustainable innovation.

Collaborative Ecosystems

Consortiums and joint working groups foster knowledge sharing, standardization, and accelerated adoption across global digital twin communities.



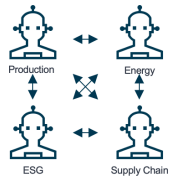
[Accelerating Digital Twin Development with Gen AI and Capabilities Periodic Table]

XMPro MAGS – Multi Agent Generative Systems

L3 - Rules of Engagement

L2 - Generative Agents

L1 - Intelligent Digital Twins



Agents That Behave

Computable Policy
- Deontic Rules
- Business Rules
- Promise Theory

Reduce Hallucinations
Provide Observability

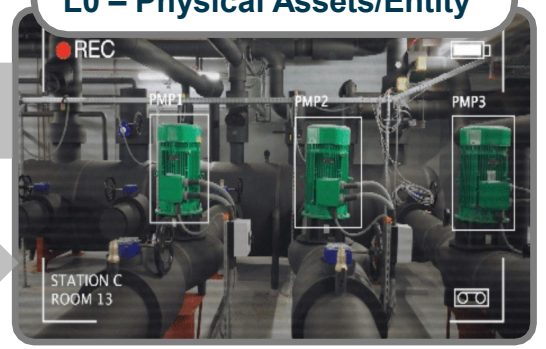
Agents That Reason

Agent Framework
- Generative Agents
- Event Swarming
- Algorithmic Business

Agents That Observe

Digital Twin Architecture
- Active, Always on
- Goal seeking
- Composable

L0 – Physical Assets/Entity



Obligation | Permission | Prohibition | Norms | Duty

Digital Twin Consortium Welcomes AMD to Accelerate AI-Powered Digital Twin Innovation at the Edge

Leading semiconductor company brings AMD Ryzen ™ AI technology and Minions framework expertise to advance intelligent digital twin systems

BOSTON, MA and SANTA CLARA, CA – SEPTEMBER 17, 2025 – Digital Twin Consortium® (DTC) today announced that Advanced Micro Devices, Inc. (AMD) has joined as a member. AMD will bring its cutting-edge AI processing capabilities and innovative edge computing solutions to accelerate AI-powered digital twin systems development and deployment across industries.

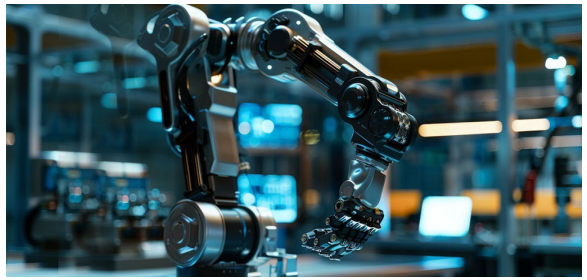
The addition of AMD is pivotal as the digital twin market rapidly evolves toward intelligent, autonomous systems powered by artificial intelligence. The company's recent breakthrough innovations include AMD Ryzen™ AI series processors and ROCm™ 7 software, the latest evolution of its open-source software platform built to unleash the full potential of AMD Ryzen™ AI and select AMD Radeon™ Graphics systems.

"What if digital twin-based Multi Agent Systems could communicate and collaborate across organizational boundaries just like humans do?"

Cross-domain integration is one of the biggest barriers to digital twin adoption at scale

Image Courtesy: XMPro

Portfolio of Announced Testbeds



COGNOS-X -Cognitive Network Orchestration System for Cross-Domain Exchange

Lead Developer: XMPro

Beyond Automation: Harnessing the Power of Digital Twins for Industry Transformation

Lead Developer: Dassault Systèmes

Geothermal Digital Twin Deployment with Decimetrix® No-Code Platform

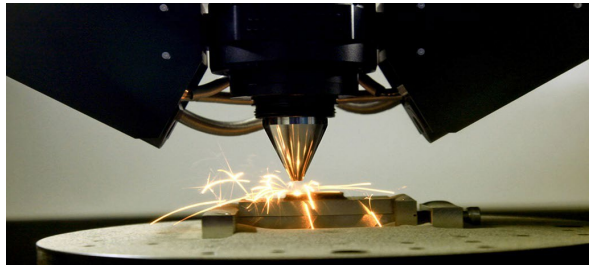
Lead Developer: Decimetrix

Axomem Axelle Gen AI Extension for Healthcare

Lead Developer: AXOMEM

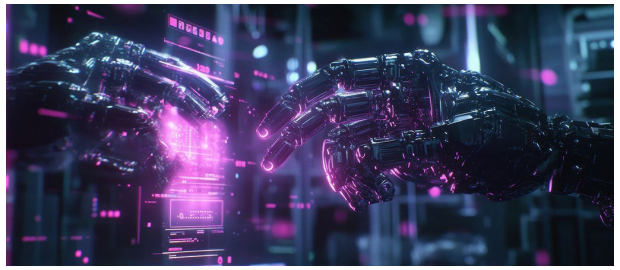
Nexus - A Crysp Blueprint for Digital Transformation

Lead Developer: Crysp, DNV, Ferdinand Steinbeis Institut



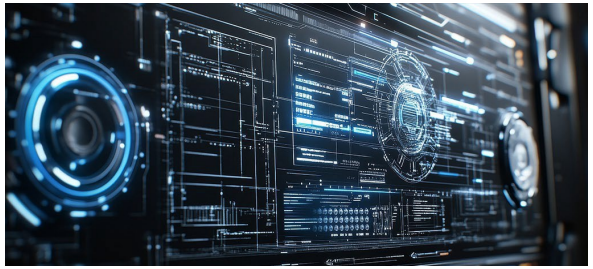
Digital Manufacturing Testbed for Flaw-free Metals

Lead Developer: Rowan University, XMPro



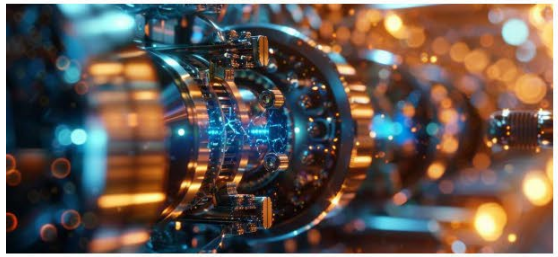
NEGOTIATE (automate negotiation with digital twins Integrating Multi-Agent systems)

Lead Developer: NEC



Giants of Oak Ridge - a Digital Engineering Ecosystem for Developing "Born Qualified" Assets, Accelerating Skills Acquisition and Workforce Development

Lead Developer: Oak Ridge High School



Rapid Disaster Manufacturing with Digital Twins

Delivering Critical Energy Components Off-Grid

Cognitive Smart Home System

Advanced Multi-Agent AI Home Automation Platform

AI-Empowered Student Guidance

Digital Twin System for Identifying Learning Triggers and Improving Outcomes

Smart City 2D-to-4D Data Transformation

Dynamic 4D Geospatial Framework

AI-Based Virtual Sensing for Industrial Assets

Real-Time Understanding for Proactive Maintenance

Rapid Digital Twin Commissioning Automation

Standards-based Digital Twin Onboarding for SME Manufacturing Equipment

Synthetic Healthcare Pathway Digital Twin

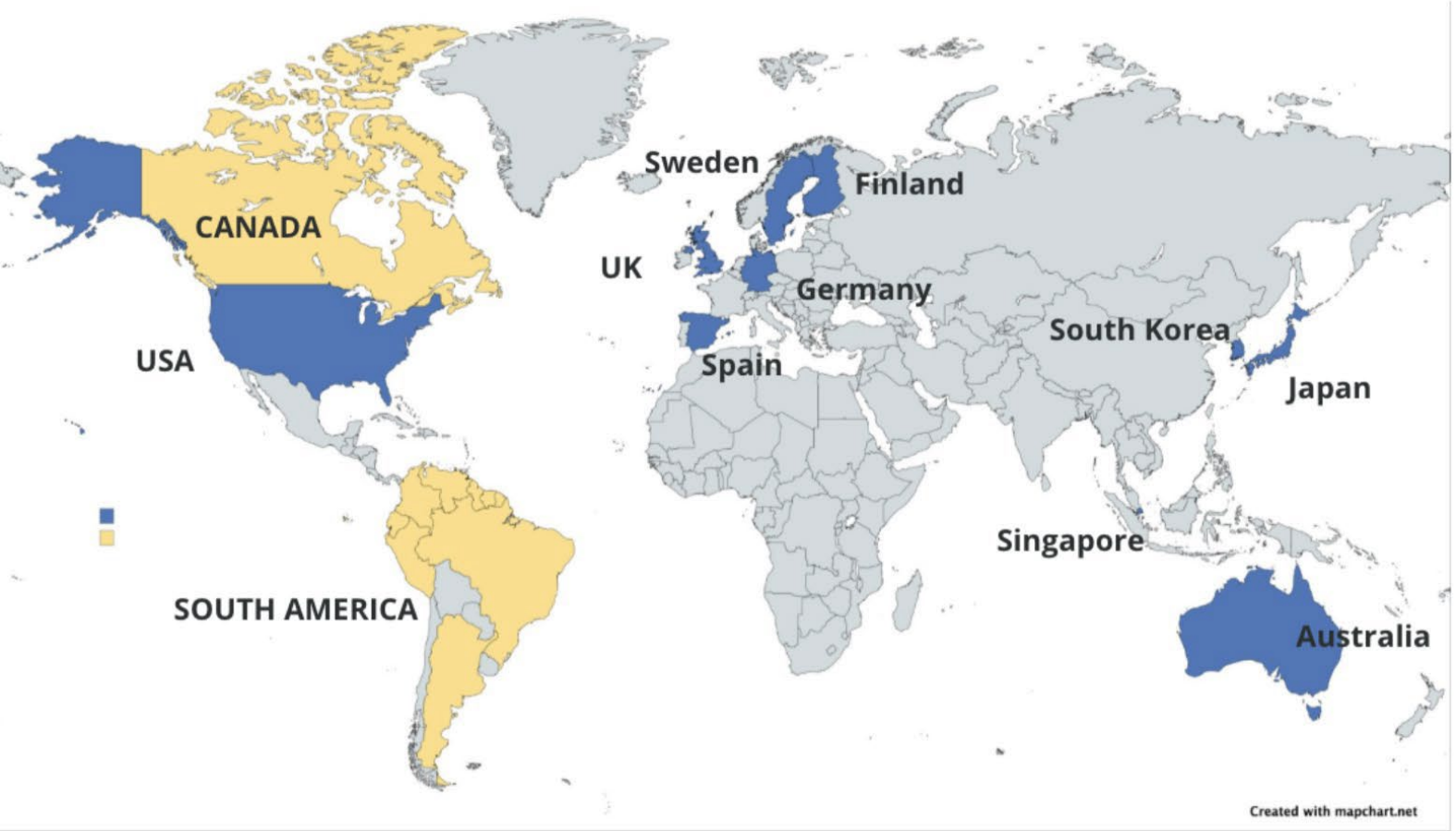
Privacy-Preserving Digital Twin for Chronic Kidney Disease Pathway Optimization

Analyzing Student Engagement with Digital Twins

Comprehensive System for At-Risk Students

Global Innovation Through Testbeds

Catalyzing AI, Collaboration, and Policy Alignment



🌍 Global Reach:

16 Testbeds
10+ Countries
4 Continents

📊 Innovation Stats:

25% agent-powered
80%+ AI/ML-driven
100% discipline-aligned

💡 Innovation Clusters:

Education & Workforce
Healthcare & Well-being
Manufacturing & Energy
Resilience & ESG Policy

Addressing Market Gaps in Digital Twin Technology

01

Standards & Interoperability

Establishing consistent vocabulary, architecture, security protocols, and interoperability standards to unify digital twin technology across industries and platforms.

02

Technology Assessment

Enabling organizations to map AI agent capabilities with digital twin infrastructure, identify technology gaps, and optimize integrated system performance.

03

Implementation Roadmap

Providing a maturity assessment framework using key performance indicators linked to technology readiness levels and digital twin lifecycle phases for strategic deployment.

04

Commercial Impact

Reducing risks with validated testbeds, accelerating time-to-value through proven methodologies, ensuring scalable architecture, and enhancing ROI predictability with KPI-based frameworks.

Digital Twin Ecosystem Expansion

Cross-Industry Collaboration

Digital twin technology is being adopted across sectors such as healthcare, aerospace, manufacturing, and smart cities, fostering diverse innovation and shared knowledge.

AI-Driven Enhancements

Integration of generative AI and multi-agent systems is automating design, simulation, and predictive analytics, enabling more intelligent and autonomous digital twins.

Sustainability Initiatives

Digital twins are supporting renewable energy optimization, environmental monitoring, and resource management to promote sustainable development.

DASSAULT SYSTEMES

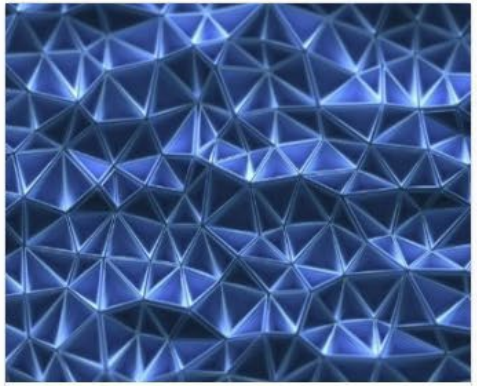
Products Industries Learn Support About

SCIENCE WEEK 2025: SCIENCE UNIV+RSES

SCIENCE IN THE AGE OF EXPERIENCE & VIRTUAL HUMAN TWIN EXPERIENCE SYMPOSIUM

29 - 31 October, 2025

SoWa Power Station, Boston, United States



Industry for Life

Industry is reinventing itself in a true Renaissance in the Age of the Generative Economy. Responsible innovations factor in a sys...

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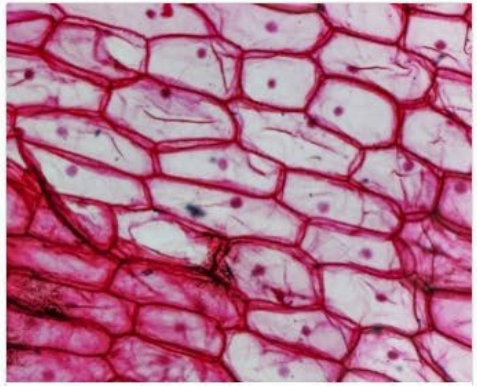

Health for Life

Health is the most integral part of life, and improving health outcomes is a global priority. The life sciences and healthcare ind...

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Planet with Life

The Preservation of our Planet is one of the most fundamental challenges of our time. Our restrictive definition of the system (or...

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New Eyes On Research

Science is always in movement. Looking for discoveries, emerging domains, and openness requires new knowledge and know-how, fuelin...

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Advancing Innovation and Business Outcomes

Innovation

Thought Leadership

Non-traditional approaches to problem solving using Unconventional thought process

Collaboration

Force Multiplier

Engage with industry leaders, innovators, researchers, and others to develop and implement advanced technology

Leadership

Establish Authority

Bring Expertise and Knowledge to forefront Drive Industry Transformation

Growth

New Revenue Sources

Ability to recognize and rapidly execute on market opportunities

Learn More:

www.digitaltwinconsortium.org

Thank You!

digital twin CONSORTIUM