digital twin®
CONSORTIUM

TWO YEARS OF TWINS

The Digital Twin Consortium is celebrating our 2nd anniversary!

The DTC is a global ecosystem comprising industry, government, and academia. We are taking a leadership position in advancing digital twins.

Digital Twin Consortium drives the awareness, adoption, interoperability, and development of digital twin technology. Through a collaborative partnership with industry, academia, and government expertise, the Consortium is dedicated to the overall development of digital twins. We accelerate the market by propelling innovation and guiding outcomes for technology end-users.

The members are committed to using digital twins throughout their global operations and supply chains. The consortium is open to any business, organization, or entity with an interest in digital twins. Digital Twin Consortium is part of the Object Management Group®.

MISSION

As The Authority in Digital Twin™, we:

- **Build and establish** an extensive multi-faceted ecosystem,
- **Identify and fill** gaps in technology development,
- **Drive interoperability** through frameworks and open-source code,
- **Develop and advocate** consistent best-practice methodologies,
- **Work to influence** policy and standards requirements,
- **Publish and amplify** architectures, statements, and viewpoints,
- **Advance** scientific and technical research to expand the market.

CROSS-INDUSTRY COLLABORATION

The Consortium helps enterprises maximize the positive impact of digital twin technology. Within the member ecosystem, we share the lessons learned and opportunities uncovered from the digital world and apply them to the physical world.

We liaise with global technology associations and standards bodies in industries that are early adopters of digital twins. These collaborations enable us to explore synergies in domain expertise, identify new use cases, spur the development of best practices and standards requirements, and amplify progress across the emerging marketplace.

QUARTERLY MEMBER MEETINGS

The Digital Twin Consortium's 2021 Q4 Quarterly Member Meeting was our first-ever face-to-face meeting! It was held in Long Beach, CA on December 8th, 9th, and 10th. The meeting featured:

- A keynote from Amalaye Oyake from Blue Origin on the value of digital twins during the development of the Space Robot Operating System.
- A keynote from Autodesk on how the architecture, engineering, and construction giant supports digital twins.
- Working Group meetings for Technology, Terminology & Taxonomy (3T), Natural Resources, Fintech, Manufacturing, Aerospace & Defense, Infrastructure, Healthcare & Life Sciences, and Academia & Research.
- Workshops, use cases, and technology demonstrations in areas such as GIS, Edge Computing, Open Source, Virtual Reality, Academia & Research and Buildings as Batteries.
- Joint sessions on Trustworthiness and Interoperability.
- Multiple presentations from our various regional branch organizers and liaison partnerships from around the globe.
- Opportunities to network with our sister consortia from the Object Management Group umbrella: Object Management Group, Industry IoT Consortium, Augmented Reality Enterprise Alliance, and BPM+ Health.
- Interactive sessions that allowed attendees to directly participate and contribute to the discussion.

The Digital Twin Consortium's 2022 Q1 Quarterly Member Meeting was held virtually on March 8th, 9th, and 10th. The meeting featured:

- A keynote from Ger Janssen, head of the Digital Twin department in Philips Technology Research and Program Manager of Patient Digital Twin solutions.
    - Discussion on how digital twins can be used to address better health outcome, better patient and staff satisfaction against lower costs. In this presentation, Ger will share Philips' vision on digital twin, combining devices, systems, hospitals and patients and address the current status, and challenges to be solved.
- A keynote from Luther Garcia, President & CEO of Animated Insights and Christopher Pancoast, Chief Engineer, Chrysler Building.
    - A look inside how the Digital Twin has transformed The Chrysler Building, built between 1928 and 1930, into an intelligent one - driving excellence in service quality, control, and cost efficiency.
- A keynote from Amalaye Oyake, Flight Software Lead, Space Robot Operating System (Space ROS), Blue Origin.
    - Updated Presentation on the Space Robot Operating System, a new collaboration between Blue Origin and NASA. Discussion will focus on the growing complexity of space missions, the importance of open source as it relates to space station development, and the value of Digital Twins in the simulation of the Orbital Reef.
- Multiple presentations from our various regional branch organizers and liaison partnerships from around the globe.
- An introduction to the Composability Framework and ToolKit (download available and explanatory webinar on the Digital Twin Consortium Bright Talk series):
    - Utilizes the concept of a Digital Twin Capabilities Periodic Table (CPT) that provides an architecture and technology agnostic requirements definition framework.
    - The CPT framework facilitates collaboration for teams that need to create digital twin requirements specifications in large-scale, complex environments. The framework keeps the focus on the capability requirements of individual use cases. These use cases can then be aggregated to determine the overall capability requirements, the digital twin platforms, and other technology solutions that are required to address the specific business needs.
- The Q2, Q3 and Q4 meetings are all on the calendar. We invite you to save the date and join us!
    - June 21 – 23, 2022 – Q2 Member Meeting – Orlando, Florida, USA
    - Sept. 27 - 29, 2022 - Q3 Member Meeting -Leeds, UK

TWO-YEAR ACCOMPLISHMENTS

As a member driven Consortium, all working groups operate in a highly collaborative and open environment.

Established a Glossary Digital Twin Definition

This consensus-driven definition unifies an emerging industry and speeds our members' time to market: A Digital Twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity.

- Digital Twin Systems transform business by accelerating holistic understanding, optimal decision-making, and effective action.
- Digital Twins use real-time and historical data to represent the past and present and simulate predicted futures.
- Digital Twins are motivated by outcomes, tailored to use cases, powered by integration, built on data, guided by domain knowledge, and implemented in IT/OT systems.
- You can review this definition along with other terminology in our Glossary here.

Created an Open-Source Collaboration Community

Digital Twin Consortium has launched an open collaboration initiative to provide support for our communities of interest. Projects are formed around contributions from members and non-members to accelerate the adoption of digital-twin-enabling technology and techniques. Contributions may include open-source code implementations, collaborative documents for guidance and training, open-source models, or other assets that are of value to the Digital Twin community.

- If you are interested in submitting an open-source project to our Collaboration Community, you can do so here.

Released the Capabilities Periodic Table (CPT)

The Digital Twin Capabilities Periodic Table (CPT) is an architecture and technology agnostic requirements definition framework. It is aimed at organizations who want to design,

develop, deploy and operate digital twins based on use case capability requirements versus the features of technology solutions.

The CPT framework facilitates collaboration for teams that need to create digital twin requirements specifications in large-scale, complex environments. The framework keeps the focus on the capability requirements of individual use cases. These use cases can then be aggregated to determine the overall capability requirements, the digital twin platforms, and other technology solutions that are required to address specific business needs.

The CPT follows a periodic table approach with capabilities grouped or "clustered" around common characteristics. It is easy to interpret at the boardroom when explaining the business case to get funding for a digital twin project and the shop floor when gathering requirements for a digital twin application. It provides visual guidance for collaboration, brainstorming and making capability requirements explicit.

You can review and use the CPT yourself by downloading all the materials found here.

Held the Manufacturing Digital Twins Industry Information Day

In this virtual conference, experts from various segments of the manufacturing industry shared their respective companies' journey with digital twins, with a focus on challenges and requirements.

The event featured a variety of presentations including:

- The Digital T's – Threads, Twins, Technology, and Transformation
    - Dr. Don Kinard, Senior Fellow, Lockheed Martin Aeronautics Production Operations
- How Digital Twins Are Providing Real Value to Manufacturing
    - Dave Vasko, Senior Director Advanced Technology, Rockwell Automation
- Building Omniverse Digital Twins for Factory & Warehouse
    - Mike Geyer, Product Manager, Omniverse, NVIDIA
- Building and Managing a Digital Twin Based Semiconductor Manufacturing Operation
    - Paul Schneider, Principal Engineer, Intel Corporation – Manufacturing IT
- Is ISO 23247:2021 a Digital Twin Standard for Manufacturing and how does it fit with existing manufacturing standards?
    - Pieter van Schalkwyk – CEO and Founder, XMPro

Held the Alternative Energy Digital Twins Information Day

Presented by the Digital Twin Consortium's Natural Resources Working Group, the Alternative Energy Information Day brought together technologists and energy experts in an open, two-and-a-half-hour forum. The event explored the applicability of digital technologies, including digital twins, to the world of new energy.

Our keynote, presentations, and panels covered the promise of twins across the energy production life cycle in oil & gas, mining & metals, clean energy, energy renewables, and so on. We identified the commonality and differences between natural resources industries and looked at ways to create sustainability and promote a circular economy with digital twins.

The event featured a variety of presentations including:

- 5 Technology Trends Needed for Digital Twins in Alternative Energy
    - Teresa Tung, Cloud First Chief Technologist, Accenture
- Digital Twins Transform Alternative Energy Production
    - Bert Van Hoof, Azure IoT, Microsoft
- Digital Twins as Remote Operations Centers (ROCs) for Alternative Energy
    - Pieter Van Schalkwyk, CEO, XMPro
- The Role of Digital Twins in Performance-Based Simulation
    - Todd Lukesh, Digital Twin Architect, Gafcon
- Energy Transition Acceleration with Digital Twins
    - Achalesh Pandey, Research Director for industrial AI, GE
- Digital Twin Transformation for the Built Environment
    - Jade Dauser, Corporate Real Estate and Technology Leader, Ernst & Young

Expanded Our Influence Through Global Liaisons

The Digital Twin Consortium liaises with global technology associations and standards bodies in industries that are early adopters of digital twins. These collaborations enable us to explore synergies in domain expertise, identify new use cases, spur the development of best practices and standards requirements, and amplify progress across the emerging marketplace.

Current DTC liaison partnerships include:

(See next page)

- **American Institute of Aeronautics and Astronautics (AIAA)**
  - Website
  - MOU
  - Join the Joint Working Group here

- **AIoT User Group (AIoT)**
  - Website
  - MOU
  - Join the Joint Working Group here

- **Augmented Reality for Enterprise Alliance (AREA)**
  - Website
  - MOU
  - Join the Joint Working Group here

- **Centre for Spatial Data Infrastructures and Land Administration (CSDILA)**
  - Website
  - MOU

- **CESMII - the Smart Manufacturing Institute (CESMII)**
  - Website
  - MOU

- **Coalition for Smarter Buildings (C4SB)**
  - Website
  - MOU

- **Continental Automated Buildings Association (CABA)**
  - Website
  - MOU
  - Join the Joint Working Group here

- **The FIWARE Foundation (FIWARE)**
  - Website
  - MOU

- **Industrial Digital Twin Association (IDTA)**
  - Website
  - MOU

- **Industry IoT Consortium (IIC)**
  - Website
  - MOU
  - Join the Joint Working Group here

- **International Building Performance & Data Initiative (IBPDI)**
  - Website
  - MOU

- **LINUX Foundation – LF Edge/EdgeX Foundry**
  - Website
  - MOU

- **Linux Foundation - Public Health**
  - Website
  - MOU

- **Manufacturing x Digital (MXDUSA)**
  - Website
  - MOU

- **National Institute of Building Sciences BIM Council**
  - Website
  - MOU

- **Project Haystack**
  - Website
  - MOU
  - Join the Joint Working Group here

- **Royal Institute of Chartered Surveyors (RICS)**
  - Website
  - MOU
  - Join the Joint Working Group here

- **Smart Cities Council**
  - Website
  - MOU

- **Smart Water Networks Forum (SWAN)**
  - Website
  - MOU

Expanded Our Ecosystem Worldwide

The consortium also continues to rapidly evolve our global ecosystem. Through an expanding community of interest, including regional branch and liaison relationships, opportunities spanning a diverse mix of market segments and applications are open to our members. This initiative promotes members' thought leadership and awareness, opens new opportunities for involvement, and accelerates digital twin adoption.

Current and prospective Regional Branch Organizers include:

CURRENT		
Australia – XMPRO	Canada – Thynkli	Italy – Beta Factory
Netherlands – TNO	Spain – Vicomtech	UK – Slingshot Simulations

Launched Digital Twin Technology Showcases

The Digital Twin Consortium's Technology Showcase includes the Use Case Reference Library, which provides summaries of our members' proposed and real-world digital twin customer implementations. Technology Showcases currently in progress include:

Healthcare & Life Sciences	Mobility
Long-haul Covid management Bio-mimicry in life sciences Senior living / nursing facilitation	Intelligent transport Emergency comm services Smart corridors Fleet charging stations
Manufacturing	Natural Resources
Industrial automation AI real-time quality control Carbon reporting	Water management Carbon sequestrations Windfarm operations
Infrastructure / AECO	FinTech
Buildings as batteries Health assurance buildings	Financial transactions Operational resiliency Carbon credit futures

WORKING GROUP ACTIVITY

Our Working Groups collaborate to address the technology and business needs of specific vertical markets. As we move into our third year, there are several areas to get involved in within our Working Groups (WGs):

Technology, Terminology and Taxonomy (3T)

- The 3T Working Group is literally creating the foundation of a new industry. It is developing a preferred definition, taxonomy, and, ultimately, hierarchy of digital twins. This will enable the industry to speak with a common vocabulary on this concept – enabling better understanding through shared definition and vernacular. 3T subgroups include:
- The Terminology subgroup, which is working on developing and maintaining a glossary of Digital Twin and enabling technology related terms that can be used universally across the Consortium.
- The Open Source, Standards Requirements and Platform Stacks subgroup is developing their Whitepaper, A Digital Twin Reference Architecture: An Introductory Guide.
    - The role of a reference architecture is to provide a template for building solutions within a particular domain. Well known reference architectures include the Service Oriented Architecture, multiple Cloud references for

deployment patterns with the likes of Microsoft Azure, Amazon Web Services or the multitude of other providers. In this context, the Digital Twin Reference Architecture's purpose is to provide a pattern and guide for building digital twin systems and identifying the core building blocks for practitioners.

- The Joint DTC-IIC subgroup is developing their Whitepaper, System-of-Systems Metamodel for Interoperability.
  - The Digital Twin Interoperability Joint Working Group was formed by the Digital Twin Consortium (DTC) and the Industry IoT Consortium (IIC) to investigate and identify ways to address interoperability challenges when implementing digital twin systems. After careful examination and deliberation, this group determined that digital twin systems can be regarded as systems of systems; and to effectively solve interoperability challenges among digital twins requires an approach that is applicable to all systems of systems, spanning digital and cyber physical systems.
- The Business Maturity Model subgroup is developing their Whitepaper, Business Maturity Model and assessment tool.
  - Change in the digital age is happening at speed and with high frequency, creating interconnected disruptions that are difficult to identify and react to. Organizations will not be able to fully realize the benefits of Digital Twins if they are not equipped to change and mature in alignment to these developments. The Business Maturity Model will help organizations to:
    - Assess and understand the starting point
    - Assemble and align the resources needed for success implementation
    - Define the value of the Digital Twin in the form of business outcome(s)
    - Determine the best approach to building Digital Twins for the particular organization.
- The Security & Trustworthiness subgroup is developing their Whitepaper, Assuring Trustworthiness in Dynamic Systems Using Digital Twins and Trust Vectors.
  - Connected Infrastructure – and Digital Transformation more generally – promises to deliver cleaner, greener, more efficient industry by bringing data-driven operations to the real world. Smart buildings that adapt to required usage, smart vehicles that optimize transit, and smart machines that sense their environment and adapt to optimize output are all within reach.
  - By strongly connecting the virtual and physical worlds, Digital Twins are an essential part of this transition, but they need to operate at least as securely and safely as existing infrastructure. If they are to be adopted at scale, Digital Twins need an interoperable and understandable model for maintaining

security and safety assurance that satisfies all stakeholders: technical, business, and regulatory.

- The WG's recent output includes:
    - A white paper entitled "Digital Twin Systems Interoperability Framework," which provides a framework for unifying a nascent ecosystem of high-value, multi-vendor services that can seamlessly plug into a multi-dimensional, interoperable, system of systems.
    - The webinar: Unlock Transformative Business Outcomes with Digital Twin Fundamentals
    - The webinar: How System Interoperability Empowers Digital Twins
    - The definition of a digital twin.
    - An online, evolving glossary of digital twins, a definitive reference guide to digital twin technology.

Academia & Research (A&R)

The Academia & Research Working Group seeks to nurture and grow these collaborative partnerships. It is focused on enabling and assisting in establishing digital twin programs within universities and other educational institutions.

The Working Group also recognizes that the development of programs around digital twin education, training, and capability building, can be furthered through global outreach. The group collaborates with the other Consortium Working Groups, Regional Branch Organizers, and Liaisons to seek out compelling digital twin research opportunities and proof-of-concept/pilot programs with communities of like interest and Industry partners.

Through this collaboration, the Working Group works closely with both DTC Steering Committee and members to encourage the involvement of private industry to influence current and future research with Academic partners. The resulting research and education will perpetuate the evolution of digital twin technology and highlight areas of further innovation.

The Working Group is concentrating its areas of research on implementation scenarios, evaluating digital twin models, methodologies, and enabling technologies.

Aerospace & Defense (A&D)

The A&D Working Group is focusing on the applicability of digital twins across the lifecycle in various industries, including land, maritime, air, cyber, and space. The group is looking for applicability across domains (land, sea, etc.) and closer collaboration between OEMs and government.

The overall goals of the group are to help organizations improve operational efficiency: reduce maintenance costs, optimize equipment design, increase operational capacity, and improve the performance of airplanes, ships, ground vehicles, weapons, satellites, and so on.

Recently, the WG solidified its collaboration with the American Institute of Astronautics and Aeronautics, by reviewing their digital twin case studies paper. This collaboration grew into a formal Liaison agreement with AIAA.

Looking forward, the WG is in discussion with AIAA on reviewing their digital thread paper and collaborating on their digital ecosystem paper.

FinTech

The FinTech Working Group is dedicated to shaping this emerging sub-industry by publishing opinions and position statements relating to regulations, policies, and definitions. The WG is increasing the visibility of the consortium's role in the FinTech ecosystem through use cases, success stories, and position papers. It is focused on the launch and appraisal of Value Innovation Platforms, identification of gaps in standards, and reference implementations for digital twins.

The WG is not an isolated vertical but has a horizontal impact on all the consortium Working Groups. The WG is looking to import interested members and SMEs who envision the financial ecosystem impacting their WG operations. It is seeking ideas and innovative concepts that will carry their initiatives into other WGs as a basis for their assets and deliverables.

Likewise, the WG is reaching out to the established financial communities, such as the FS ISAC (35,000 members), for collaboration and cooperative opportunities to advance its unique table of initiatives. It is also identifying new techniques for collaboration such as domain mapping, tabletop exercises, roundtables, and cross-domain webinars.

Healthcare & Life Sciences

The Healthcare and Life Sciences Working Group is focused on improving patient outcomes while reducing operating margins. Healthcare-related sectors, including medical devices, pharmaceuticals, hospitals, and healthcare systems are under immense pressure to reduce expenses and improve business efficiencies while improving patient care.

The WG is continuing its enumeration and refinement of digital twin use cases and is looking to contribute to the consortium's use case library. It is looking at opportunities for matchmaking between DTC members from different verticals.

They are developing their Whitepaper, The Importance of Location in Healthcare Digital Twins.

- The importance of location related to other contextual factors within the long-term healthcare space is important for many reasons. The underlying need to use Digital Twins is tied to the fact that organizations are divided into different domains. That of the technical aspects, and that of domains regarding hierarchy, processes, and people. A long-term care facility consists of multiple domains, people, and systems all working together in a certain space and time. Location is important, not only as a metric on its own, but even more so in relation to other contextual factors mentioned in this paper.

The WG also produced a webinar, Digital Twin Technology in Healthcare & Life Sciences.

Architecture, Engineering, Construction & Operations (AECO)
The AECO Working Group focuses on how digital twins can create value in the global infrastructure and on raising awareness of the importance of the technology to the future of business. The overall goal is to create market demand for related products and services to accelerate the market.

The group delivers standardized definitions, protocols and methodologies that enable infrastructure industries to create, apply, and use precise, knowledge-rich digital twins that replicate, simulate, and evaluate the physical twin.

The WG's recent output includes:

- A Whitepaper entitled "Infrastructure Digital Twin Maturity: A Model for Measuring Progress," written to help digital twin technologists where they are on their digital twin journey and set their destination.
- A Tech Brief entitled "Infrastructure Life Cycle: A Case for Change," which describes suggestions for defining phases of digital twin development.
- A Whitepaper on Reality Capture set to be published on June 9th.

Manufacturing

Digital twins represent an enormous opportunity for manufacturers, spanning engineering, design customization, production, and operations. The Manufacturing Working Group takes a more holistic approach to processes and asset management. The Manufacturing Working Group focuses on the applicability of digital twins to the manufacturing process in various industries.

The WG is exploring the use of digital twins to accelerate product development, reduce defects, troubleshoot equipment, increase uptime, and decrease manufacturing costs.

The WG recently finalized a Manufacturing lifecycle model for digital twins and established a liaison with CESMII, the Smart Manufacturing Institute.

The WG has produced webinars including

- Leveraging Interoperable Life Cycle Digital Twins for Manufacturing
- Digital Twins Optimizing Manufacturing Supply Chains: A Use Case with Michelin.

Mobility & Transportation (M&T)

Our newest Working Group is focused on driving the global economy in a vertical market with a unique lifecycle of demands. The group is exploring enabling technologies and related business model innovations for transport hubs (airport, seaport/maritime, inland port (railway/trucking distribution centers) and intelligent infrastructure corridors (roads, highways, bridges, airways, waterways). For the transportation of cargo – goods and related services and people and livestock to urban and rural locations and transportation hubs.

The group is researching into development of appropriate use cases and pilot programs that demonstrate the value of how digital twins can be used to address impactful challenges in mobility and transportation. They are defining and identifying applications and interoperability requirements of digital twins across the M&T spectrum.

Natural Resources

The Natural Resources Working Group is striving to create more sustainable communities through digital twins. Today, digital twins are being applied during the engineering, design, construction, deployment, and operations phases of the lifecycle.

The goals of the WG are to improve production, predict and detect failures, and improve safety. The group aims to help Natural Resources sectors to deliver standardized definitions, protocols, and methodologies that increase operational efficiency to create more live able, workable, and sustainable communities.

The WG's recent output includes:

- Creation of the Digital Twin Capabilities Periodic Table (CPT), an architecture and technology agnostic requirements definition framework. It is aimed at organizations who want to design, develop, deploy and operate digital twins based on use case capability requirements versus the features of technology solutions.
- Publication of the Digital Twin Capabilities Periodic Table (CPT) User Guide.
- Webinar: Digital Twin Capabilities Periodic Table for Composable Digital Twins

Webinar: The Value of a Composable Digital Twin

Get Involved – Join the Consortium!

Build An Extensive Multi-Faceted Ecosystem

- Accelerate development and adoption
- Develop and advocate consistent best-practices methodologies
- Work to influence policies and standard requirements

Improve Interoperability of Digital Twin Technologies

- Ensure digital twin models interoperate throughout your product life cycle
- Leverage frameworks and open-source code
- Integrate existing source code into your system

Advance Scientific and Technical Research to Expand the Market

- Create a library of reference implementations for digital twins
- Publish and amplify architectures, statements, and viewpoints
- Help influence the direction of market; get your projects to market faster

ABOUT DIGITAL TWIN CONSORTIUM

Digital Twin Consortium is The Authority in Digital Twin. It coalesces industry, government and academia to drive consistency in vocabulary, architecture, security and interoperability of digital twin technology. It advances the use of digital twin technology from aerospace to natural resources.

Digital Twin Consortium is open to any business, organization or entity with an interest in digital twins. Our global membership is committed to using digital twins throughout their operations and supply chains and capturing best practices and standards requirements for themselves and their clients.

Visit www.digitaltwinconsortium.org or email info@digitaltwinconsortium.org for more information.