INDUSTRY 4.0 AND DIGITAL TWIN'S PLACE IN IT

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1. ABOUT PROCESS GENIUS

Finnish software company Process Genius Oy was founded in Joensuu in 2012 to develop a Digital Twin solution to enhance the interaction between humans and data in industrial settings. IoT, the Industry 4.0 era, developments in digitalization and growth in the number of software had already led to a situation where an individual working in manufacturing had too many systems and data sources to handle. We set out to solve this factory-level challenge by gathering data from different sources into an exact browser-run 3D copy of the plant.

Even when our first platforms had already been in operational use in our client factories for a while, we were still calling them a 3D overview, as the term Digital Twin only began to gain traction around 2017. Robust experience with Digital Twin solutions from the time before Digital Twins gave us an edge in industrial environments. During the last few years, we've powerfully invested and developed both our processes and the Genius Core™ platform by combining industrial expertise and experience with the latest technologies. The scalable Genius Core™ is a platform that works on a SaaS model. All five of our business sectors use the same platform. Our client companies benefit from ongoing development, with new features included in their monthly fee.

Our operations are especially well-established in manufacturing, process industries and the food industry. Additionally, our platform's moving 3D image and light simulation capabilities are utilized in specialized applications in machine and equipment sales and premises management.

Accordingly, we have experimented with utilizing XR equipment alongside our product. Today, with computing power increasing, the prices of technology falling and software evolving, we're getting ever closer to the Metaverse. The next leap that naturally follows, especially in multi-location industry, is the Omniverse. Relative to the current size of our company, we constantly invest substantial sums in product development and make sure, with a passionate approach to our craft, that when Gartner launches a term for the next step, we've already implemented that next step.

Reach out to us – we'll gladly discuss cooperation:

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2. INDUSTRY 4.0

2.1. Definition

Industry 4.0 emerged in the early 2010s, building upon previous technological advancements. The term was introduced in Germany in 2011 as a part of the government's High-Tech Strategy for 2020, which aimed to modernize the manufacturing sector and enhance Germany's global competitiveness. The development of Industry 4.0 has been a gradual process, driven by the goal of embracing digital technologies to transform and optimize industrial processes.

The Fourth Industrial Revolution, refers to the integration of advanced digital technologies and automation into industrial processes to create smart and interconnected systems. It encompasses the use of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), robotics, big data analytics, and cloud computing. This enable the automation, optimization, and networking of various aspects of manufacturing and production.

Industry 4.0 is the biggest structural change of the past 250 years — a transformation of scale, scope and complexity unlike anything humankind has experienced before.

Henrik von Scheel

INDUSTRY 4.0

2.2. Key technologies

1. **IoT**
   Enables seamless communication and data exchange among interconnected devices, enhancing monitoring, control, and efficiency.

2. **Big Data Analytics**
   Extracts insights from large datasets, driving predictive maintenance, quality control, and data-driven decision-making.

3. **AI & Machine learning**
   Enables data analysis, predictive analytics, and automation, optimizing processes and supporting autonomous decision-making.

4. **Robotics & Automation**
   Advances in robotics enhance automation, including collaborative robots and the automation of repetitive tasks.

5. **Cyber-Physical systems**
   CPS integrates physical components with software and connectivity, enabling real-time data collection and control.

6. **Cloud computing**
   Offers scalable infrastructure for data storage, processing, and collaboration among stakeholders.

7. **Additive manufacturing**
   3D Printing revolutionizes production processes, allowing rapid prototyping, customization, and reduced waste.

8. **AR & VR**
   Enhances training, maintenance, visualization, and collaboration, improving productivity and safety.

INDUSTRY 4.0

2.3. The Size of the Market

Global Industry 4.0

73,9 bil.
Market Value in 2022

165,5 bil.
Forecasted Market Value by 2026

Europe Industry 4.0

24,5 bil.
Market Value in 2020

16,4 %
Annual Growth 2020-2030

3. KEY PRODUCTS RELATED TO INDUSTRY 4.0

From our standpoint, there are currently 26 main groups of product solutions that are associated with Industry 4.0 and functionally complement the 3D Digital Twin concept.

- RTLS
- 3D modelling
- Industrial hardware
- Productivity and analytics software
- IoT solution
- Digital Twin solution
- Industrial software
- Enterprise asset Management
- OPC UA
- ERP system
- MRP system
- IT infrastructure
- Data platform
- Secure Connectivity Solution
- MES solution
- 3D printing
- 3D Digital Twin
- Cloud solution / service
- Energy management solution
- Digital work instructions
- AR & VR solution
- OEE software
- DT Collaboration
- Virtual and 3D simulation
- Consulting services
- IoT Platform

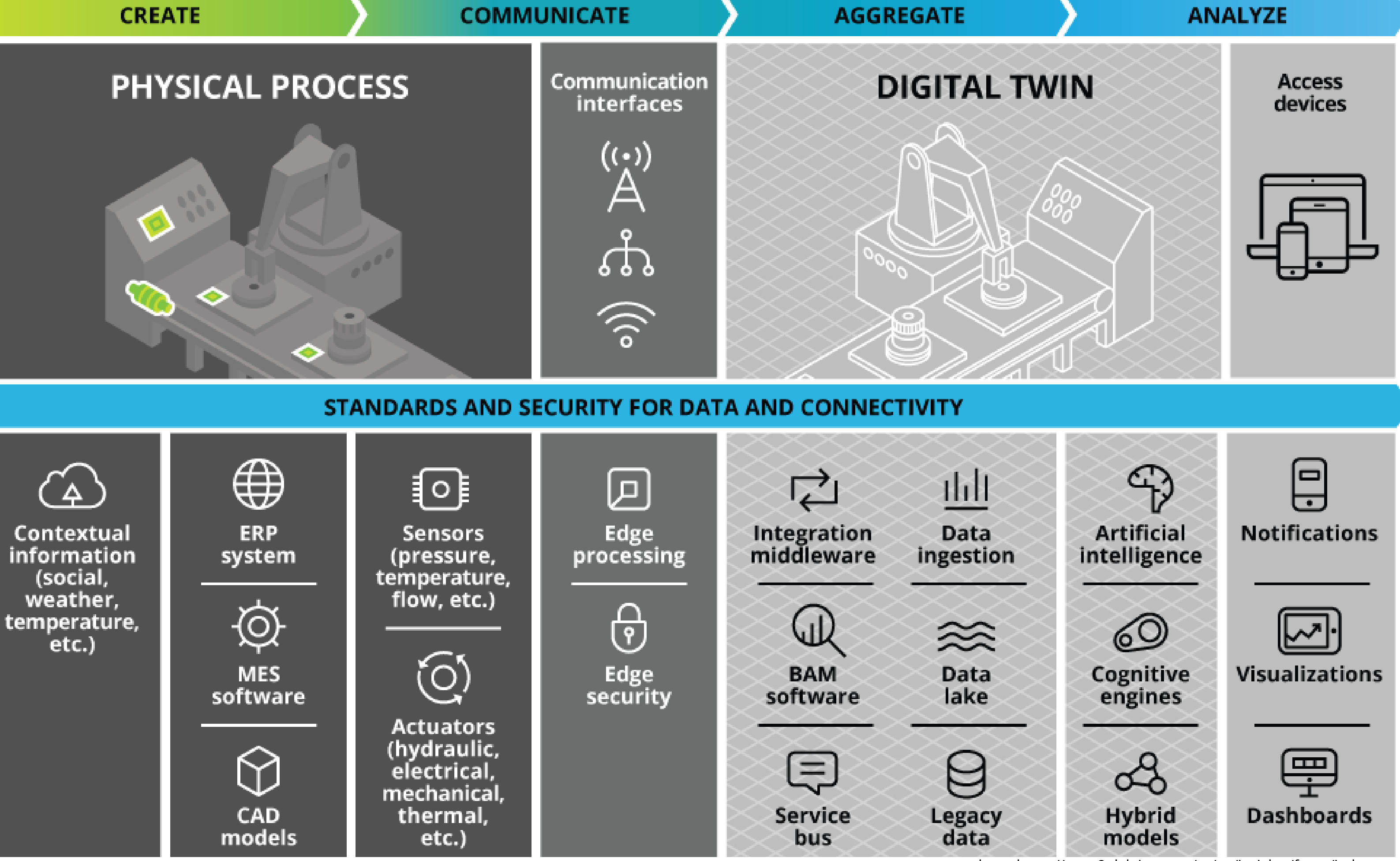


photo: https://www2.deloitte.com/za/en/insights/focus/industry-4-0/digital-twin-technology-smart-factory.html

4. DIGITAL TWIN

4.1. Definition

Digital Twin refers to a virtual replica or digital representation of a physical object, process, or system. It is a dynamic and interconnected model that mimics the behavior, characteristics, and interactions of its real-world counterpart in real-time.

A Digital Twin consists of three key components: the physical object or system itself, its corresponding virtual model, and the connection between the two. The virtual model is created using various data sources, such as sensors, IoT devices, historical data, and simulations. This virtual model reflects the physical object's attributes, performance, and behavior, enabling real-time monitoring, analysis, and optimization.

> **A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity.**
>
> Digital Twin Consortium

DIGITAL TWIN

4.2. Types

Digital Twins encompass various types based on their scope and purpose:

1. Product Digital Twins

Represents individual physical products, enabling simulation, optimization, and maintenance prediction throughout their lifecycle.

2. Process Digital Twins

Models and simulates industrial processes, optimizing efficiency and resource allocation.

3. System Digital Twins

Simulates larger-scale systems or ecosystems, providing insights for optimization and decision-making.

4. Asset Digital Twins

Focuses on individual components or assets within a system, enabling real-time monitoring and predictive maintenance.

5. Facility Digital Twins

Models and simulates buildings or facilities, optimizing energy usage, maintenance planning, and occupant comfort.

6. Human Digital Twins

Represents individuals in a digital format, integrating health data for personalized diagnostics and treatment optimization.

These diverse types of Digital Twins cater to different domains and offer valuable insights for improved performance, efficiency, and decision-making.

DIGITAL TWIN

4.2. Types

Some American companies distinguish 3 types of Digital Twin that are more related to **Manufacturing and Process industry**:

1. Status Twin

Provides a concise overview of system or process performance through visualizations and alerts for monitoring key indicators.

2. Operational Twin

Offers comprehensive information for decision support, allowing users to interact with the twin and modify operating parameters within control capabilities.

3. Simulation Twin

Utilizes simulation or AI capabilities to anticipate future states, enabling predictive maintenance, optimization, and informed decision-making.

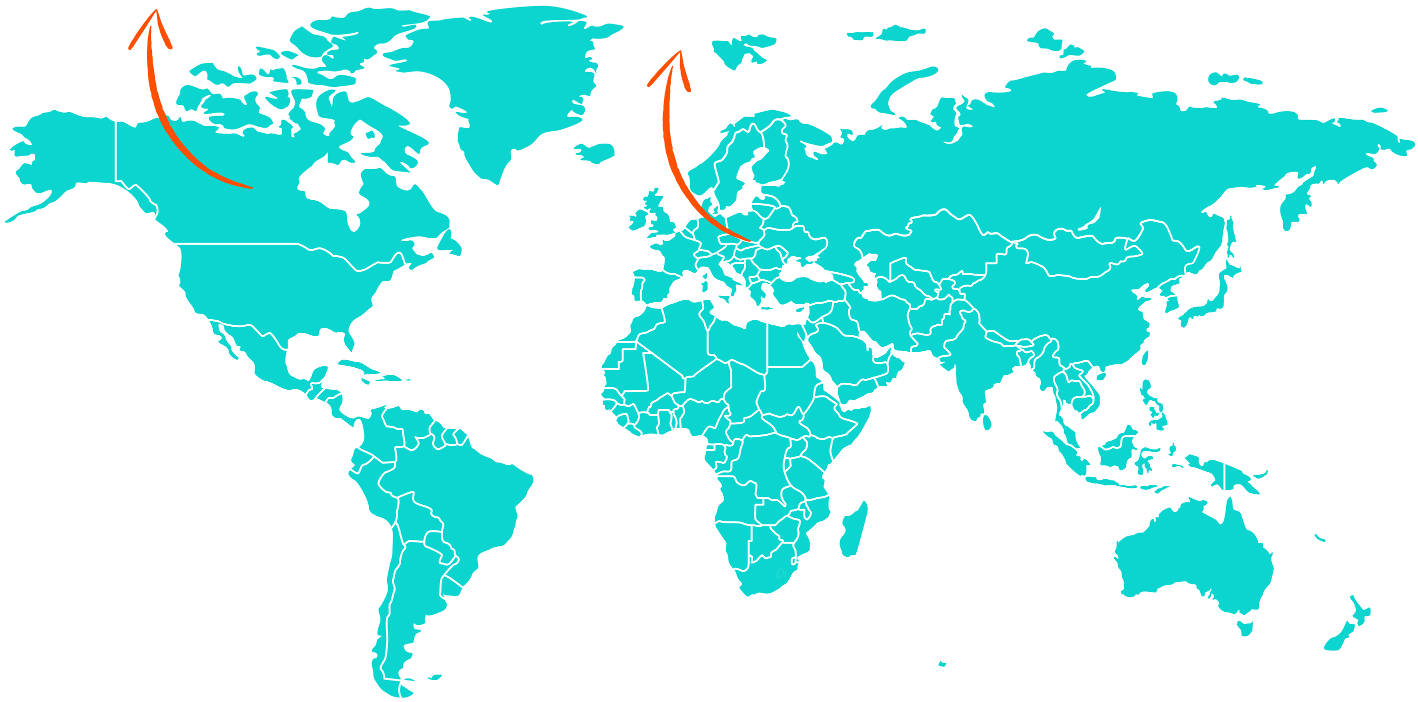
DIGITAL TWIN

4.3 The Size of the Market

North America:
Over 40% of the overall market size

Europe:
Over 20-30% of the market share

Germany & France:
Over 30% of the European market share



The global digital twin market in terms of revenue was estimated to be worth USD 6,9 billion in 2022 and is poised to reach USD 73,5 billion by 2027, growing at a CAGR of 60,6%.

> **Rising emphasis on digital twin in manufacturing industries to reduce cost and improve supply chain operations. Growing focus on predictive maintenance.**
>
> MarketsandMarkets™

5. DIGITAL TWIN
& other products

1. 3D modeling and simulation
2. Industrial software and hardware
3. OEE Software and OPC UA Software

4. AR and VR solutions
5. IoT solution and IoT platform
6. MES, ERP and MRP
7. RTLS

8. Consulting services
9. Energy Management Solutions
10. Digital work instructions

11. Manufacturing productivity and analytics software
12. Enterprise asset management
13. Data Platform

3D MODELLING AND SIMULATION

The focus of 3D modelling is on the creation of the model itself, considering aspects such as geometry, textures, materials, and sometimes animation. It serves as a visual representation of an object or scene, and it can be used for various purposes like visualization, design, and communication.

A 3D digital twin goes beyond a static 3D model by incorporating real-time data from sensors, Internet of Things (IoT) devices, or other sources. This data is used to update and synchronize the digital twin with the current state of the physical object or system. With a digital twin, users can monitor, analyze, and simulate the behaviour and performance of the physical asset in a virtual environment. This enables predictive maintenance, optimization, and decision-making based on real-time insights.

3D simulation utilizes the 3D models or digital twins as the foundation for creating simulated scenarios. By applying mathematical equations, physics, or other simulation techniques, it enables the prediction, analysis, and understanding of complex systems or phenomena. It allows users to observe, interact, and test various scenarios or parameters to gain insights and make informed decisions without the need for physical experimentation.

In summary, 3D modelling focuses on the creation of visual representations of objects or scenes, while a 3D digital twin is a dynamic virtual replica of a physical object or system that incorporates real-time data. On the other hand, 3D simulation involves running computerized models or simulations to replicate and analyze the behaviour of objects or systems in a virtual environment.

INDUSTRIAL SOFTWARE AND HARDWARE

Software

Industrial software refers to software applications or solutions that are specifically designed for use in industrial settings and sectors such as manufacturing, engineering, logistics, and process control. These software solutions are tailored to address the unique needs and challenges of industrial operations and help improve efficiency, productivity, and overall performance.

- Is used to create and develop Digital Twins. It provides the necessary tools and frameworks for modeling physical assets, simulating behavior, integrating data, and creating virtual representations.
- Enables the integration of data from various sources, including sensors, IoT devices, and other systems, into the Digital Twin. It also facilitates data analytics, allowing insights to be derived from the collected data and used for monitoring, optimization, and decision-making.
- Supports the visualization of Digital Twins, presenting the virtual models, real-time data, and analytical results in user-friendly interfaces. These interfaces enable users.

Hardware

Industrial Hardware refers to physical equipment and devices specifically designed for use in industrial settings and applications. These hardware components are built to withstand the harsh conditions, high demands, and unique requirements of industrial environments. Industrial hardware encompasses a wide range of equipment, including: Industrial Computers, Programmable Logic Controllers, Human-Machine Interface Devices, Industrial Networking Equipment, Industrial Sensors, Industrial Robotics, Industrial Power and Energy Equipment.

- Industrial hardware, such as sensors and IoT devices, plays a crucial role in collecting real-time data from physical assets and processes. This data is then used to update the Digital Twin, providing an accurate representation of the physical world.
- Enable the connectivity and communication necessary for data exchange between physical assets and the Digital Twin. This facilitates real-time updates, remote monitoring, and control of the assets within the virtual environment.
- May be connected to the Digital Twin, allowing the virtual model to control physical devices or actuate processes based on simulation results or optimization algorithms. This integration enables closed-loop control and feedback mechanisms.

OEE / OPC UA SOFTWARE

Integrating all three technologies forms a powerful ecosystem. OPC UA facilitates data exchange between OEE software and the Digital Twin, enabling real-time monitoring, analysis, and optimization of equipment performance.

OEE software focuses on measuring and improving the efficiency of manufacturing equipment. It collects data on various metrics such as availability, performance, and quality to assess how effectively the equipment is utilized. The software helps identify areas of improvement, track performance trends, and enable informed decision-making to enhance productivity.

OPC UA is an extensively used communication protocol in the realm of industrial automation. It serves as a reliable framework for secure and dependable data exchange among devices, systems, and software applications. OPC UA establishes seamless connectivity, ensuring standardized and interoperable communication across diverse platforms and vendors.

OEE software and Digital Twin technology are interconnected when simulating and optimizing equipment performance. By integrating the OEE software with the Digital Twin, manufacturers gain real-time monitoring, scenario simulation, and proactive issue identification for enhanced equipment performance.

OPC UA integration with Digital Twin technology enables seamless data exchange with other industrial systems and devices. It facilitates real-time data retrieval, historical information access, and smooth communication between the Digital Twin and physical equipment, monitoring systems, and software components.

CLOUD SERVICES

Why Cloud Services play a significant role for Digital Twins?

Cloud Infrastructure for Digital Twin Solutions: Digital twin solutions need substantial computing power and storage for data handling, simulations, and real-time interactions. Building and managing such infrastructure on-premises is costly and time-consuming. Cloud services provide a solution, offering scalability and cost-effectiveness.

Cloud Hosting and Scalability: Cloud service providers offer Infrastructure as a Service (SaaS) for hosting digital twin applications and databases on remote servers. Scalability enables companies to adjust resources based on workload, avoiding expensive upfront investments in hardware.

Data Storage and Processing: Digital twin solutions require robust data storage and processing for managing sensor-generated data. Cloud services offer scalable storage to handle increasing data volumes from physical assets represented in the digital twin.

Real-Time Data Processing: Cloud services provide real-time data processing features, such as edge computing and low-latency processing, enabling quick analysis and real-time insights for digital twin applications.

Security and Redundancy: Cloud service providers prioritize security and data redundancy, offering enhanced protection and disaster recovery capabilities. Leveraging cloud services improves the security and reliability of digital twin applications.

Collaboration and Accessibility: Cloud services facilitate easy collaboration and data accessibility from various locations and devices, benefiting stakeholders like engineers, designers, and maintenance personnel who interact with the digital twin.

AR AND VR TECHNOLOGIES

$ 4.54 bil.

Estimated global value of AR market in 2023

13,4 %

Annual growth rate (CAGR) of AR

$ 19.44 bil.

Global value of VR in 2022

$ 165.91 bil.

Estimated value of VR by 2030

31 %

Forecasted CAGR of VR

Augmented Reality (AR) refers to a technology that overlays digital content, such as virtual objects, images, or information, onto the real-world environment, thereby enhancing the user's perception and interaction with their surroundings. AR blends the physical and digital realms, providing users with an immersive and interactive experience that augments their perception of reality.

AR in the context of a 3D Digital Twin enables visualization and interaction with the virtual model in the physical world. AR-enabled devices overlay the digital twin onto the real-world object or environment, providing insights, facilitating maintenance tasks, and visualizing information in a spatial context.

Virtual Reality is a technology that creates a fully immersive, computer-generated environment that simulates a realistic or fictional world. VR aims to transport users into a completely virtual experience by stimulating their vision, hearing, and sometimes touch or movement. VR is typically experienced through headsets that block out the physical world and replace it with a virtual environment.

In the context of a 3D Digital Twin, VR offers an immersive experience within the virtual model. Users can explore, interact, and simulate scenarios within the digital twin, providing detailed inspection and training opportunities. VR enhances presence and immersion, enabling users to engage with the digital twin as if physically present in the virtual environment.

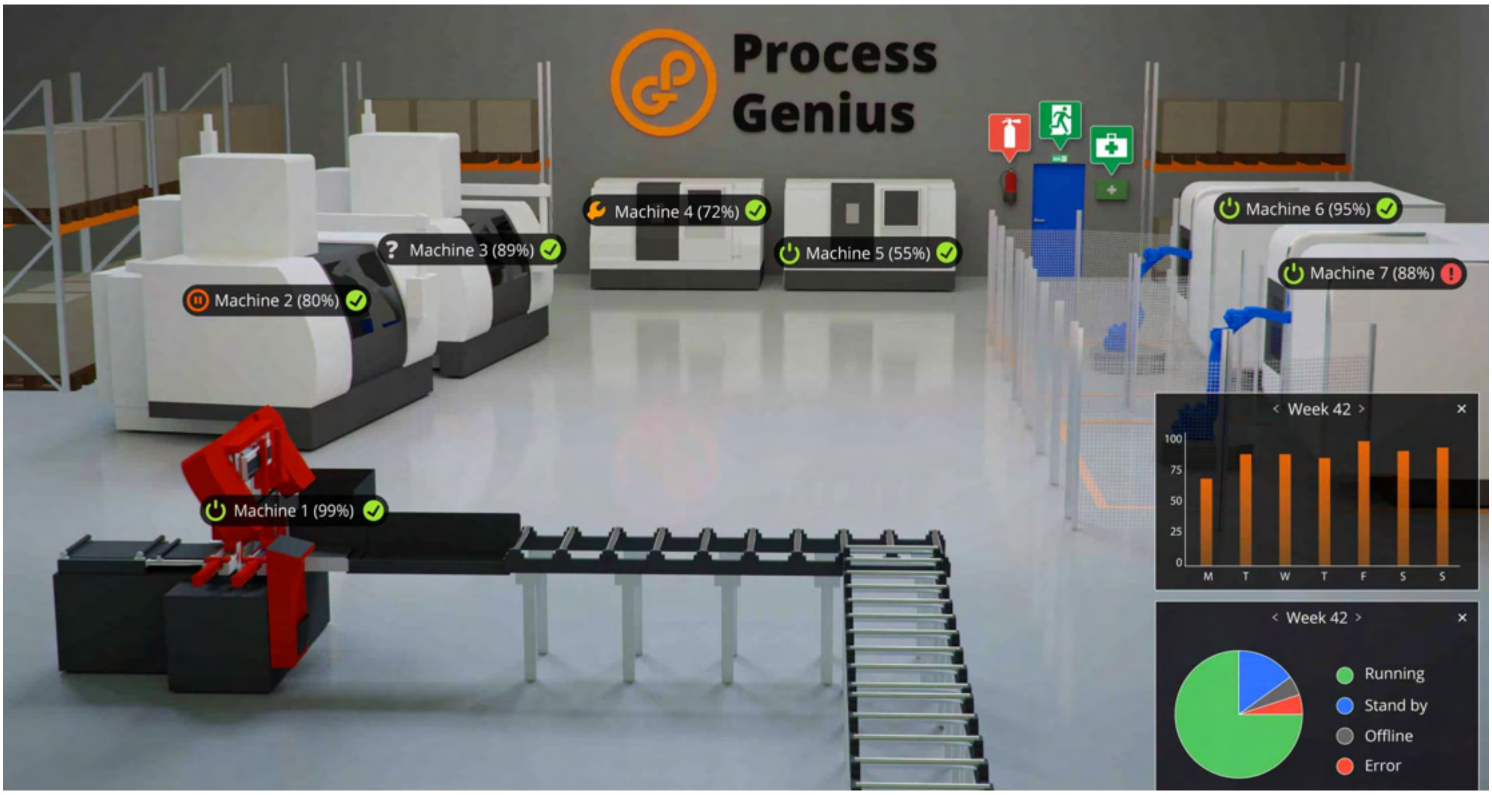
IOT SOLUTION AND PLATFORM

An IoT (Internet of Things) solution refers to a comprehensive set of technologies, devices, and systems that enable the collection, transmission, and analysis of data from connected physical objects or "things." It encompasses the integration of sensors, actuators, connectivity, and software applications to enable real-time monitoring, control, and automation of various processes.

- An IoT solution includes hardware components (sensors, gateways, devices), communication protocols (Wi-Fi, Bluetooth, cellular networks), data processing and storage capabilities (cloud platforms or edge computing), and software applications (dashboard, analytics, control systems).
- The purpose of an IoT solution is to leverage the power of interconnected devices and data to enable intelligent decision-making, optimize operations, and drive innovation.

An IoT platform is a software framework that provides the necessary infrastructure and tools to manage, connect, and analyze IoT devices and data. It acts as a central hub for IoT solutions, facilitating device management, data ingestion, storage, security, analytics, and application development.

- An IoT platform offers features such as data visualization, device provisioning, remote management, data processing, and integration with other systems.
- It serves as a backbone that enables seamless communication and data exchange between connected devices, applications, and backend systems.
- IoT platforms provide scalability, security, and flexibility to support the growing number of IoT devices and data streams.



The main difference lies in their scope and components:

- An IoT solution is a complete system that combines hardware, software, and connectivity to enable specific use cases or applications.
- An IoT platform is the underlying software infrastructure that provides the necessary tools and services to manage and analyze IoT devices, data, and applications.
- An IoT solution is more application-specific, focusing on solving a particular problem or meeting specific requirements.
- An IoT platform is a generic framework that can support multiple IoT solutions and applications, offering common functionalities and services to enable their development and operation.

An IoT solution encompasses the complete system of hardware, software, and connectivity for a specific application, while an IoT platform is the software infrastructure that supports multiple IoT solutions. Both IoT solutions and platforms play crucial roles in integrating data from IoT devices into Digital Twin models, enabling monitoring, analysis, and optimization of physical assets or processes in real-time.

Relation to Digital Twin:

- IoT solutions provide the necessary hardware and software components for data collection, connectivity, and communication.
- IoT platforms provide the infrastructure and tools to manage, process, and analyze IoT data, ensuring its smooth integration with the Digital Twin model.
- Together they enable the continuous flow of data between the physical assets, the IoT system, and the Digital Twin, enriching the virtual model and enabling real-time insights, monitoring, and decision-making.

MES,ERP & MRP:

Features and functions relative to Digital Twin

ERP

ERP is a comprehensive software system that integrates business functions, consolidates data, and enhances decision-making. It acts as a centralized platform, managing various areas such as finance, human resources, supply chain, and customer relationships. The goal of ERP is to streamline operations and improve efficiency by providing a unified view of resources and processes.

ERP integrates business functions and processes, while Digital Twin provides a virtual model for real-time monitoring and optimization.

ERP focuses on managing organizational data, while Digital Twin goes beyond by offering a dynamic virtual representation of physical entities.

MES

Manufacturing Execution System (MES) is a software-based system that provides real-time visibility and control over manufacturing operations on the shop floor. It monitors and optimizes production activities, capturing data and providing comprehensive information on performance, status, and quality.

Scope and Focus: MES manages and optimizes manufacturing operations on the shop floor in real-time, while Digital Twin models and simulates the behavior and performance of assets or systems throughout their lifecycle.

Purpose: MES enhances operational efficiency and quality control on the shop floor, while Digital Twin focuses on design optimization, predictive maintenance, and performance analysis.

Data Utilization: MES relies on real-time data from sensors and machines for monitoring and control, while Digital Twin integrates data from various sources throughout the asset's lifecycle for comprehensive analysis and optimization.

Time Frame: MES provides real-time visibility and control for immediate decision-making, while Digital Twin utilizes real-time and historical data to simulate and optimize future scenarios.

MRP

Material Requirements Planning (MRP) is a systematic approach utilized in manufacturing and production planning to efficiently manage and regulate the inventory of materials required for production. Its main focus is on analyzing demand, considering the bill of materials, and generating a plan for procuring or producing materials to meet production schedules effectively.

Contrasting MRP with Digital Twin, the latter encompasses a virtual representation and simulation of a physical asset or system, surpassing material planning.

MRP focuses on present and near-term planning, while Digital Twin is future-oriented, enabling anticipation and optimization.

While MRP relies on historical and projected data for material requirements, Digital Twin utilizes real-time data to monitor, optimize, and simulate the asset's behavior and performance.

While MRP is primarily applied to manufacturing and production planning, Digital Twin has a broader scope across industries, optimizing asset performance throughout their lifecycle.

Described products can also interact and complement each other in some cases. For example, MRP calculations can be integrated into an ERP system, MES can be connected to both ERP and MRP systems for real-time data exchange, and Digital Twin models can utilize data from ERP, MRP, and MES for simulations and analysis.

RTLS (Real-Time Location Systems)

$ 5.37 bil.

Recorded market value of RTLS in 2021

32,6 %

Annual growth rate of RTLS

$ 7.11 bil.

Estimated market value of RTLS in 2022

Real-Time Location Systems (RTLS) are cutting-edge technologies that enable organizations to track and locate assets, people, or objects in real-time within a defined space. By employing advanced tracking technologies like RFID, Bluetooth Low Energy (BLE), Wi-Fi, or ultra-wideband (UWB), RTLS captures precise location data, facilitating seamless visibility into the movement and positioning of tagged entities.

The integration of RTLS with 3D Digital Twin technology brings forth a synergistic effect that revolutionizes business operations, offering several key advantages. Here are some of the benefits this **integration provides**:

- **Enhanced Asset Tracking and Visualization:** Integrating RTLS with the 3D Digital Twin enables accurate asset tracking, optimizing inventory management, allocation, and improving operational efficiency.
- **Proactive Safety and Security Measures:** The fusion of RTLS and 3D Digital Twin enhances safety protocols, visualizing real-time locations to identify risks, ensure compliance, and respond to emergencies.
- **Workflow Optimization and Process Efficiency:** RTLS integrated with 3D Digital Twin optimizes workflows, identifies bottlenecks, and enables data-driven decision-making for resource allocation and improved customer experiences.
- **Predictive Maintenance and Asset Performance:** Real-time location data integrated into the 3D Digital Twin allows predictive maintenance, reducing downtime, lowering costs, and extending asset lifespan.
- **Simulations and Scenario Planning:** RTLS combined with 3D Digital Twin technology enables scenario simulations, evaluating configurations, testing process changes, and optimizing resource utilization for informed decision-making and risk mitigation.

CONSULTING COMPANY OPPORTUNITIES

A COMPANY SPECIALIZED IN DIGITAL TWINS

A company specializing in digital twin solutions is focused primarily on providing products and services related to the development, implementation, and deployment of digital twin technology. These companies have expertise in creating virtual replicas or representations of physical assets, processes, or systems using advanced data modeling, simulation, and analytics techniques. They may offer pre-built digital twin platforms or customized solutions tailored to specific industries or use cases.

Specialized Knowledge: These companies have in-depth knowledge and expertise in digital twin technology, including data integration, modeling, simulation, and analytics.

Technical Capabilities: They possess the technical skills and resources to develop and deploy digital twin solutions for various industries and applications.

Product-Oriented: Digital twin companies often offer proprietary software or platforms designed to create and manage digital twin models.

CONSULTING COMPANY

A consulting company, on the other hand, provides professional advisory services to businesses across various domains, including digital twin implementation. Unlike companies specializing in digital twin solutions, consulting firms offer a broader range of services and expertise, assisting clients with strategic planning, problem-solving, and decision-making.

Diverse Expertise: Consulting companies have a wide range of expertise across different industries and sectors, allowing them to provide holistic solutions to various business challenges.

Advisory Approach: Consulting firms focus on providing recommendations, strategies, and actionable insights to improve their clients' performance and efficiency.

Vendor-Neutral: Unlike specialized digital twin companies, consulting firms may not be tied to specific products or technologies, allowing them to offer unbiased recommendations tailored to the client's needs.

A company specializing in digital twin solutions is dedicated to providing technology-based solutions specifically centered around digital twin technology. In contrast, a consulting company takes a more comprehensive approach, offering a broader range of services to address various business needs, which may include digital twin implementation among other areas.

ENERGY MANAGEMENT SOLUTIONS

The main difference between an energy management system (EMS) and a digital twin solution lies in their primary focuses and functionalities:

Focus:

Energy Management System (EMS): An EMS is specifically designed to monitor, control, and optimize energy usage and related processes within an organization or facility. It gathers real-time data from various sources such as smart meters, sensors, and connected devices to provide insights into energy consumption, demand patterns, and efficiency metrics. The primary goal of an EMS is to improve energy efficiency, reduce energy wastage, and lower energy costs.

Digital Twin Solution: It combines real-time data from sensors and connected devices with advanced analytics and simulation capabilities to model and analyze the behavior and performance of the physical asset or system. Digital twins are used to optimize the performance of assets, perform predictive maintenance, and support decision-making.

Scope:

EMS: The scope of an EMS is limited to energy-related data and processes. It focuses on monitoring and managing energy consumption and may integrate with other systems like building automation or demand response systems to control energy usage effectively.

Digital Twin: Digital twin solutions have a broader scope. They can represent various assets, equipment, processes, or even entire systems. Digital twins simulate real-world behaviors and can be used for performance optimization, scenario testing, predictive analysis, and other purposes beyond energy management.

Features:

EMS: An EMS typically includes features like data collection, real-time monitoring, energy analytics, energy efficiency recommendations, reporting, and demand response capabilities. Its primary aim is to provide insights into energy consumption and enable energy optimization.

Digital Twin: Digital twin solutions leverage real-time data and simulations to offer a holistic view of the physical asset or system's performance. They can be used for predictive maintenance, process optimization, performance comparison, scenario testing, and other advanced analytics beyond just energy management.

The correlation between Energy Management Systems and Digital Twin solutions lies in their ability to enhance energy management efforts. The integration of these two technologies enables organizations to gain real-time insights, perform predictive analysis, and optimize energy consumption to achieve higher levels of energy efficiency and cost savings.

DIGITAL WORK INSTRUCTIONS

Digital work instructions are electronic or computer-based documents that guide workers through various tasks and processes in a visual and interactive format. They serve as a modern alternative to traditional paper-based work instructions, providing step-by-step guidance to operators and technicians.

Key features of digital work instructions include:

Visual Content: Digital work instructions often include images, videos, 3D models, and animations to illustrate each step of the process. This visual content enhances comprehension and reduces the chance of errors.

Interactive Elements: They may offer interactive elements like clickable links, buttons, or checklists to engage users and ensure they follow the correct sequence of actions.

Real-Time Updates: Digital work instructions can be updated in real-time, ensuring that workers always have access to the latest and most accurate information.

Version Control: They typically include version control features, allowing organizations to manage and track changes to work instructions over time.

Multi-Device Accessibility: Digital work instructions can be accessed on various devices, including tablets, smartphones, and industrial equipment, making them easily portable and accessible on the shop floor.

Integration with IoT and Digital Twin: Some advanced digital work instruction systems can integrate with the Internet of Things (IoT) and digital twin technology to provide context-aware instructions based on real-time data from equipment and processes.

Shared Data Source: The Digital Twin collects real-time data from sensors and equipment, while the digital work instructions use this data to provide contextual and up-to-date guidance to workers. This shared data source ensures that workers receive accurate and relevant information based on the current state of the assets or processes they are working with.

Context-Aware Instructions: Digital Twin's context-awareness allows dynamic adaptation of instructions based on specific equipment or processes, optimizing guidance for workers.

Predictive Maintenance Support: Digital Twins predict maintenance needs by analyzing real-time data, enabling digital work instructions to guide workers through preventive maintenance, optimizing asset performance.

Training and Simulation: Digital Twins simulate scenarios for risk-free practice, while digital work instructions provide step-by-step guidance, boosting worker proficiency and confidence.

Real-Time Guidance and Feedback: Digital work instructions sent in real-time to mobile or AR devices provide on-the-spot guidance. The Digital Twin alerts and adapts if a deviation occurs, aiding workers.

Performance Analytics: Both systems gather worker data for performance analysis, process optimization, training needs identification, and enhancing workforce efficiency.

Digital work instructions and Digital Twin solutions can complement each other and work together to enhance operational efficiency and optimize processes within an organization.

MANUFACTURING PRODUCTIVITY AND ANALYTICS SOFTWARE

Manufacturing productivity and analytics software is a type of software solution designed to monitor and analyze various aspects of manufacturing processes to enhance productivity and efficiency. It collects and processes data from production lines, machines, and other sources, providing valuable insights to manufacturers for optimizing operations, identifying bottlenecks, reducing downtime, improving product quality, and streamlining overall manufacturing workflows.

The difference between a 3D digital twin solution and manufacturing productivity and analytics software lies in their core functionalities and focus:

3D DIGITAL TWIN SOLUTION:

Focus: A 3D digital twin solution creates a virtual representation of a physical object, asset, or system in a three-dimensional (3D) model.

Functionality: 3D digital twins provide a visual and interactive representation of the physical entity, allowing users to simulate, analyze, and optimize its behavior and performance throughout its lifecycle.

Use Case: 3D digital twins are commonly used in various industries for design optimization, predictive maintenance, process simulation, and operational analysis.

MANUFACTURING PRODUCTIVITY AND ANALYTICS SOFTWARE:

Focus: Manufacturing productivity and analytics software focuses on monitoring, analyzing, and optimizing manufacturing processes and operations to improve productivity and efficiency.

Functionality: This software collects real-time data from machines, production lines, and other sources to provide insights into production performance, identify bottlenecks, and offer data-driven recommendations for process improvement.

Use Case: Manufacturing productivity and analytics software is specifically tailored to the manufacturing domain, aiming to enhance operational efficiency, reduce downtime, and improve product quality.

A 3D digital twin solution revolves around creating a virtual model of a physical entity, providing visual and interactive capabilities, while manufacturing productivity and analytics software is centered on data analysis and optimization to improve manufacturing processes.

ENTERPRISE ASSET MANAGEMENT (EAM)

Digital Twins and EAM can work together to enhance asset management practices by providing real-time insights, predictive capabilities, simulation tools, and comprehensive maintenance documentation. The integration of these two concepts allows organizations to move from reactive maintenance approaches to proactive and data-driven asset management strategies, resulting in improved operational efficiency and reduced downtime.

DIGITAL TWIN

Purpose

Digital Twins use real-time data and simulation models to mimic the behavior and performance of the physical asset. Digital Twins are used for various purposes, including design optimization, predictive maintenance, process simulation, and real-time monitoring.

Data Utilization

Digital Twins rely on real-time data from sensors and connected devices to create a dynamic virtual model of the asset. The data is used for simulations, predictive analytics, and providing real-time insights into the asset's behavior and performance.

Time Frame

Digital Twin solutions focus on both present and future scenarios. They use real-time data to simulate and predict the future behavior of the physical asset, enabling proactive maintenance and optimization.

Visualization and Interaction

Digital Twins offer a visual and interactive representation of the physical asset in a virtual environment. Users can interact with the digital twin, perform simulations, and explore different scenarios.

ENTERPRISE ASSET MANAGEMENT (EAM)

Purpose

EAM focuses on the management and optimization of an organization's physical assets throughout their lifecycle. It involves tasks such as asset tracking, maintenance planning, work order management, and asset performance analysis. The primary goal of EAM is to ensure the efficient operation, reliability, and cost-effectiveness of assets.

Data Utilization

In EAM, data is collected from sensors and maintenance activities to monitor the condition and performance of assets. It is primarily used for maintenance planning, historical analysis, and tracking asset health.

Time Frame

EAM is concerned with the present and past state of physical assets. It involves maintenance and asset management activities in real-time or based on historical data.

Visualization and Interaction

EAM typically involves data visualization for asset performance and maintenance planning. Still, it does not create an immersive virtual environment like a Digital Twin.

DATA PLATFORM

A data platform is a comprehensive and integrated solution that enables organizations to collect, store, process, manage, and analyze large volumes of data from various sources. It provides a centralized and scalable infrastructure for data management, making it easier to access, share, and use data across the organization.

Purpose

Digital Twin: A virtual representation of a physical object, asset, or system. Its purpose is to simulate, monitor, and optimize the behavior and performance of the physical counterpart throughout its entire lifecycle. Digital twins are used to gain a deeper understanding of assets, predict maintenance needs, and improve operational efficiency.

A data platform is primarily focused on managing and processing large volumes of data from various sources. Its purpose is to provide a centralized and integrated infrastructure for data storage, retrieval, and analysis, enabling organizations to make data-driven decisions and gain valuable insights from their data.

Functionality

Digital twins are built using modeling and simulation technologies, often incorporating real-time data from sensors and other sources. They provide an interactive and visual representation of the physical object or system, allowing users to analyze and interact with its virtual counterpart.

Data platforms include a range of technologies and tools for data storage, data integration, data processing, and data analytics. They may also have features for data governance, security, and data quality management to ensure data reliability and compliance.

Cases

Digital twins are commonly used in industries such as manufacturing, construction, energy, and healthcare. They are applied for design optimization, predictive maintenance, process simulation, and operational analysis.

Data platforms are used across various industries and business functions to handle diverse data sets, support business intelligence, and facilitate data-driven decision-making. They are essential for managing big data, business analytics, and advanced data processing.

Scope

A digital twin is a more specific concept focused on creating a virtual representation of a particular physical object or system.

A data platform is a broader concept that covers the infrastructure and tools for managing data across an organization or a specific domain.

A digital twin and a data platform are two separate but complementary components within the realm of digital transformation and data-driven decision-making.

6. Benefits of Digital Twin

Improved operational efficiency:
Digital Twins offer real-time insights to optimize asset performance, streamline operations, and reduce downtime. Scenario simulations aid resource allocation and process optimization.

Predictive maintenance:
Digital Twins can predict potential equipment failures and maintenance needs, allowing for proactive maintenance scheduling. This approach reduces unplanned downtime, extends asset lifespan, and lowers maintenance costs.

Enhanced product development:
In product design and engineering, Digital Twins enable virtual prototyping and simulation, accelerating the development cycle, reducing physical prototypes, and optimizing product performance before physical manufacturing.

Remote monitoring and control:
With Digital Twins, organizations can remotely monitor and control assets in real-time, even in challenging or hazardous environments. This capability enhances safety, reduces the need for physical presence, and enables remote decision-making.

Data-driven decision making:
Digital Twins generate vast amounts of data, which can be analyzed to make data-driven decisions. Organizations can identify patterns, optimize processes, and uncover new insights, leading to informed and strategic decision-making.

Improved collaboration and communication:
Digital Twins provide a common platform for various stakeholders to collaborate, share information, and gain a holistic view of assets or projects. This collaboration fosters better communication and alignment across teams.

Reduced costs:
By optimizing asset performance, predicting maintenance needs, and minimizing downtime, Digital Twins help reduce operational and maintenance costs.

Enhanced customer experience:
Digital Twins can be used to monitor products or services in real-world conditions. This data helps improve customer satisfaction by providing better products, services, and support.

Accelerated innovation:
Digital Twins foster innovation by enabling rapid experimentation, testing new ideas virtually, and promoting a culture of continuous improvement.

Sustainability and environmental impact:
Digital Twins can contribute to sustainability efforts by optimizing energy usage, reducing waste, and improving overall environmental performance.

5-10%

Reduced downtime & Increased productivity

30-50%

Saved time

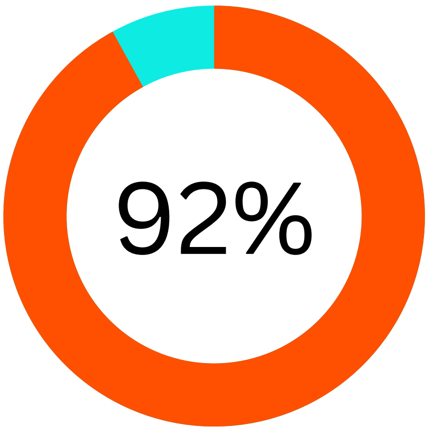
20%

Reduced costs & energy consumption saving

15%

Improve yield

According to a 2022 study conducted by the American company Altair Engineering, workers noted that the most common impacts from the technology have been real-time monitoring and control (38%), efficiency and safety (37%), and cost savings (33%).



One of the most definitive findings from this survey was that 92% of respondents that used digital twin technology (N=1,393) said it made their products and processes more sustainable.

Altair, Digital Twin Global Survey Report, 2022

According to some latest research data presented below elements were recognized by the interviewed digital twin users and providers. These realized by digital twin users' value elements were considered a reason to invest in digital twins.

Technological approach

- Streamlining and Monitoring of production lines/processes
- Improvement of productive time and capacity
- Optimization of maintenance time and costs
- Optimization of energy efficiency
- Minimization of waste
- Locating of problem areas

Digital Twin Characteristic: Internal platform (processes/factory)

Human approach

- Documentation of process history data
- Documentation of process maintenance history
- Work-flow (work shift and workload) optimization
- Process safety improvement
- Possibility to train employees with Digital Twin
- Work environment (air quality) monitoring

Rantala, Tero & Ukko, Juhani & Nasiri, Mina & Saunila, Minna, 2023. "Shifting focus of value creation through industrial digital twins—From internal application to ecosystem-level utilization," Technovation, Elsevier, vol. 125(C).

Value creation through digital twins focusing on internal platform (processes or factory).

7. Industry 5.0 and the Future of Digital Twin

Industry 5.0 traces its origins to "Industry 4.0," coined in Germany in 2011 as a future project in the country's high-tech strategy. It aimed to be widely adopted by businesses, scientists, and decision-makers, focusing on maintaining stable production employment. The goal was to improve economic and ecological aspects, aiming for green, carbon-neutral, and energy-efficient industry practices.

According to the European Union, Industry 5.0 complements the Industry 4.0 approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric, and resilient European industry.

Industry 5.0 shifts focus to research and innovation, emphasizing industry's role in serving humanity while respecting the limits of our planet.

Industry 5.0

Focus

Industry 5.0 shifts the focus towards human-centered manufacturing, where humans and robots collaborate closely to achieve higher levels of efficiency and productivity.

Human-machine interaction

Industry 5.0 emphasizes a strong collaboration between humans and machines, combining human creativity, problem-solving abilities, and dexterity with the precision and speed of automation.

Decentralization

In Industry 5.0, there is a trend towards decentralization, with edge computing and distributed networks playing a more significant role in data processing and decision-making.

Customization and flexibility

Focuses on customization and flexibility. The ability to quickly adapt production processes to meet individual customer needs is a key aspect.

Human empowerment

Industry 5.0 seeks to empower the workforce, emphasizing the importance of skilled workers and providing training to adapt to new technologies.

Industry 4.0

Focus

Industry 4.0 primarily emphasizes the integration of digital technologies and automation in manufacturing processes to create smart factories.

Human-machine interaction

Machines and systems largely operate autonomously with minimal human intervention.

Decentralization

Industry 4.0 often relies on centralized systems and data processing in the cloud.

Customization and flexibility

Aims for mass production and standardization.

Human empowerment

In Industry 4.0, automation can lead to concerns about job displacement and loss.

Sustainability

Industry 5.0 places a stronger emphasis on sustainability and eco-friendly practices. It aims to reduce environmental impact and achieve carbon neutrality through green production methods and energy-efficient technologies.

Digital twins play a crucial role in bridging the gap between humans and advanced automation technologies, fostering collaboration and cooperation. They provide real-time insights and data, allowing humans to interact with and monitor the physical world remotely. By combining human creativity, problem-solving abilities, and decision-making with the capabilities of digital twins, Industry 5.0 aims to create a more people-centric and inclusive manufacturing environment. Digital twins within Industry 5.0 facilitate improved worker experiences and decision support. Workers can utilize digital twins to simulate scenarios, optimize processes, and anticipate potential challenges. This human-machine collaboration promotes better outcomes, increased efficiency, and a stronger focus on sustainability and well-being. This accelerates the pace of development and allows industries to stay at the forefront of technological advancements.

8. Conclusion

In conclusion, the emergence of Digital Twin technology has revolutionized the landscape of Industry 4.0, providing businesses with an unprecedented level of insight, efficiency, and resilience. As the fourth industrial revolution continues to shape our world, harnessing the power of Digital Twins will be crucial for companies seeking to stay competitive, adapt quickly to changing demands, and achieve new heights of productivity.

By creating a virtual mirror of physical assets, processes, and systems, Digital Twins enable businesses to optimize performance, reduce downtime, and make data-driven decisions like never before. Moreover, this technology has opened doors to innovative applications across various sectors, ranging from manufacturing and healthcare to transportation and urban planning, enhancing safety, sustainability, and resource management.

While Digital Twin adoption is undoubtedly transformative, it also comes with its set of challenges. Privacy and security concerns, data integration complexities, and the need for highly skilled experts are just some of the hurdles that companies must navigate. Nevertheless, the benefits far outweigh the obstacles, and those who embrace Digital Twins with a strategic approach will find themselves well-positioned to thrive in the era of Industry 4.0.

As the technology continues to evolve, we can expect even greater advancements and more seamless integration of Digital Twins into everyday operations. Industry leaders and technology pioneers must collaborate to set standards, share best practices, and continue to innovate, ensuring that the potential of Digital Twins is fully realized.

Unlike standalone software products, the Digital Twin's holistic approach provides a comprehensive understanding of the entire ecosystem, enabling seamless coordination between departments and systems. This synergistic collaboration ensures that decision-making is informed, agile, and aligned with overarching strategic objectives, giving organizations a competitive edge in the dynamic landscape of Industry 4.0.

Moreover, the Digital Twin's adaptability and scalability make it uniquely equipped to address the diverse needs of industries, from manufacturing and healthcare to transportation and energy. Its versatility in replicating various assets, processes, and environments fosters innovation and empowers organizations to explore new frontiers in product development and service offerings.

Furthermore, the Digital Twin solution's long-term value proposition sets it apart from other software products. Its continuous learning capabilities, fueled by AI and machine learning algorithms, enable it to evolve alongside the physical system it represents, delivering ongoing insights and improvements that optimize performance and resource utilization over time.

In conclusion, the Digital Twin phenomenon represents a pivotal moment in the ongoing transformation of industries worldwide. Embracing this cutting-edge technology will not only pave the way for unprecedented efficiency and competitiveness but also usher in a new era of innovation and sustainable growth. The time to invest in Digital Twins is now, as the vision of a smarter, interconnected, and agile future becomes an achievable reality within the realms of Industry 4.0.

Sources for continuing investigation journey in the world of Digital Twins:

IEEE Xplore® Digital Library

IEEE Xplore digital library is a research database for discovery and access to journal articles, conference proceedings, technical standards, and related materials on computer science, electrical engineering and electronics, and allied fields.

ScienceDirect

ScienceDirect is a website that provides access to a large bibliographic database of scientific and medical publications of the Dutch publisher Elsevier.

Google Scholar

Google Scholar is a freely accessible web search engine that indexes the full text or metadata of scholarly literature across an array of publishing formats and disciplines.

Useful resources on Digital Twin

DIGITbrain is an EU innovation program which has the vision to unleash manufacturers' innovation potential through Digital Twins. The project started with 36 partners from all over Europe in July 2020 and offered the opportunity for another 35-40 companies to join the project in two open calls. Selected new beneficiaries will receive funding from the European Commission to perform experimentation to build a Digital Twin for manufacturing.

Arena2036 is an innovation and research platform located in Stuttgart, Germany. The name "Arena2036" stands for "Active Research Environment for the Next Generation of Automobiles" and represents the goal of creating a collaborative space for research and development in the automotive industry.

The Industrial Digital Twin Association is an organization that focuses on advancing the adoption, development, and standardization of digital twin technology in industrial settings.

ZVEI is a German acronym for "Zentralverband Elektrotechnik- und Elektronikindustrie e.V.", which translates to "Central Association of the Electrical Engineering and Electronics Industry". It is an industry association that represents the interests of companies operating in the electrical engineering and electronics sectors in Germany. ZVEI was founded in 1918 and has since then grown to become a major player in the German and European economies, with more than 1,600 member companies. Its members include manufacturers of electrical and electronic equipment, components, and systems, as well as suppliers of related services and technologies.

The objective of the "FabOS" project is to develop an open, distributed, real-time-capable and secure operating system for production that will be the IT backbone for the adaptable automation of the factory of the future and the foundation of an ecosystem for data-driven services and AI applications. Hybrid cloud platforms and IIoT applications are core elements of cyber-physical architectures and will form the basis of future production solutions.

With 3,600 members, the VDMA is the largest network organization and an important voice for the machinery and equipment manufacturing industry in Germany and Europe. The association represents the common economic, technical and scientific interests of this unique and diverse industry.

Let's Get Started!

Find a perfect Digital Twin solution for your factory with Process Genius.

SET A MEETING

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