

A worker wearing AR glasses is shown from the side, looking at a digital twin of a factory machine. The digital twin is a 3D model of the machine, overlaid on the real-world machine. The worker is wearing an orange safety vest and a plaid shirt. The background is a blurred factory floor.

# Digital Twins in Manufacturing Industry

University of Trieste

Presented by: Giacomo Lanza

# Your today's Speakers



Giacomo Lanza

System Architecture Engineer  
Schneider Electric

2016 - Bachelor's degree in Civil Engineering in Trieste

2018 - Master degree in Production Engineering and management

2018 - Schneider Electric in production plant

2022 - Schneider Electric in commercial company

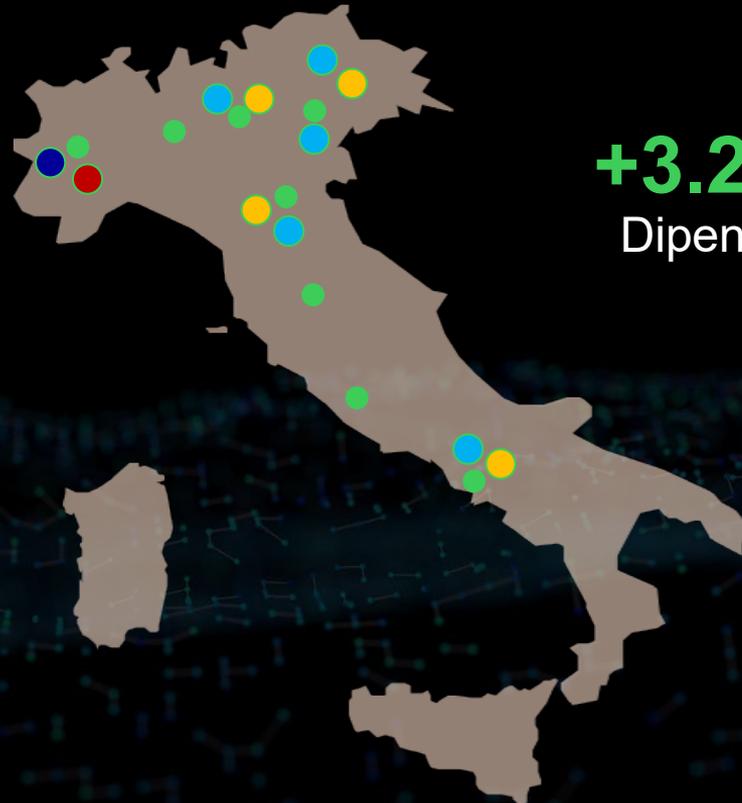


Life Is On

Schneider  
Electric

# In Italia una presenza storica importante

- 8 aree commerciali
- 5 siti industriali
- 3 Innovation Hub
- 1 centro assistenza clienti
- 1 centro logistico integrato



**+3.250**  
Dipendenti

# Sostenibilità vuol dire clima e risorse, ma anche fiducia, uguaglianza e nuove generazioni



## Assunzioni

↑ **83%**

Assunzioni  
Under 35  
2022 vs 2019



## Programma di sviluppo di giovani talenti

**6 Business Challenges**  
per l'imprenditorialità e l'innovazione

in collaborazione con  
**POLIMI GRADUATE SCHOOL OF MANAGEMENT**

## Obiettivo Gender Diversity al 2025

Nuove assunzioni/  
manager di linea / top  
manager

**50 / 40 / 30 %**

## Coinvolgimento e Fiducia



↑ **80%**

Employee engagement  
index OneVoice 2023

## Studenti coinvolti

**117k**

Portare idee innovative  
alla realizzazione.  
Nel 2022 il team Italiano  
al primo posto.



Go Green global  
contest

## Formazione

**+93K**

Ore formazione  
#SeGreatPeople  
2022



# We are an Impact Company

Our mission is to be a digital partner for sustainability and efficiency. In doing so, we pave the way for a smarter and greener future.

**DIGITALIZATION** + **ELECTRIFICATION** = **SUSTAINABILITY**  
For Efficiency For Decarbonization Smarter & Greener

- Eliminate waste
- Increase efficiency
- Optimize overall processes

- Most efficient energy
- The best vector of decarbonization



# Win with digital twins

## Multiply your R&D performance & accelerate sales

Relevance and impact of Digital Twins in the manufacturing industry	15min
Solving challenges in today's machine building	10min
How to create Digital Twins	10min
Live Demo	30min
Machine Expert Twin architectural view	10min
Future avenues	5min
Possibilities at Schneider Electric	5min
Q&A	10min

## Introduction:

- What is Digital Twin?
- Evolution from simple model to digital twin



# Definition of Digital Twin

**A Digital Twin is a digital representation of a physical system that mirrors its structure and behavior and evolves together with the real system over time.**

It combines:

- models and simulations
- real-time and historical data
- algorithms describing system behavior

to support:

- analysis
- prediction
- decision-making

throughout the system's lifecycle.

# From Mathematical Models to the Digital Twin

**A Digital Twin is a digital representation of a physical system that mirrors its structure and behavior and evolves together with the real system over time.**

How engineering models evolved:

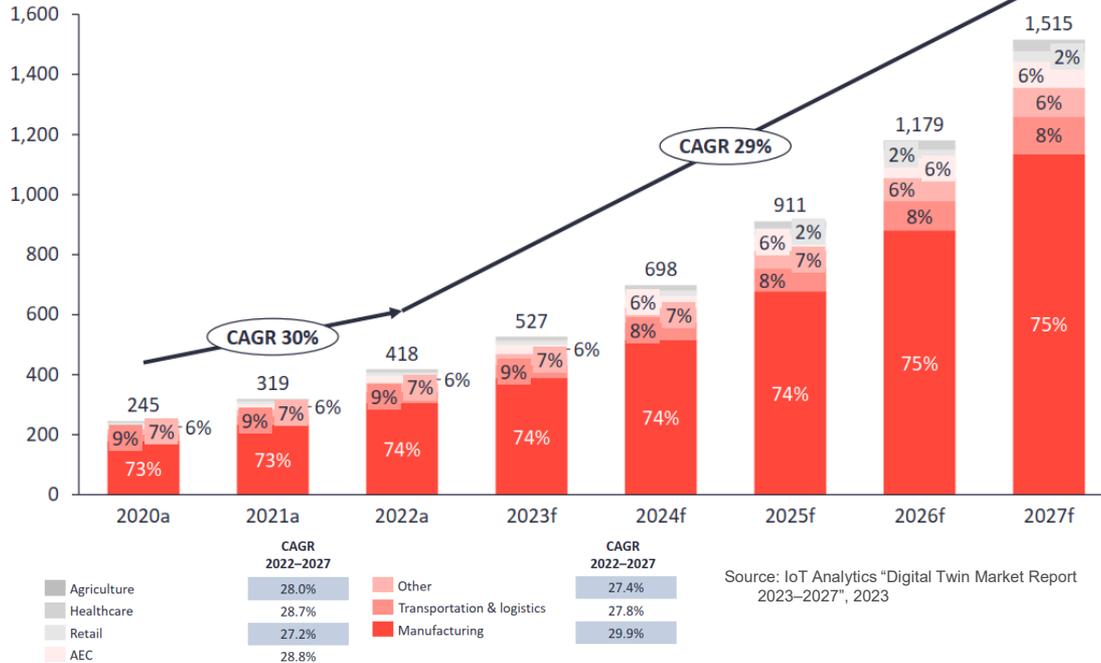
- **Mathematical models**  
Simplified equations used to describe physical phenomena
- **Simulations**  
Models executed over time to test system behavior (offline, not connected to reality)
- **Digital models (3D / CAD)**  
Geometric and kinematic representation of systems (accurate, but mostly static)
- **Digital Twin**  
A digital model connected to the real system, evolving over time and supporting decisions

# Solving challenges in today's machine building



# The global Digital Twin market

Global Digital Twin Market Size by Industry (in \$M)



Source: IoT Analytics "Digital Twin Market Report 2023-2027", 2023

- Spending for digital twin software that are used to model, setup, and manage digital twins
- Manufacturing is the largest market (74%) in 2022 and is expected to show the strongest growth until 2027 with a CAGR\* of 29.9%

➔ PAM\*\* in 2027 of 1.1\$B for manufacturing market

\* Compound annual growth rate  
 \*\* Potential available market

# Adoption rates

manufacturing companies start adopting globally

**63%** are currently developing or have already developed their digital twin strategy.

**29%** have fully implemented or are implementing a digital twin strategy for a portion of their operational assets.

**48%** of those began to invest in digital twins within the last year.

Sources:

IoT Analytics “Digital Twin Market Report 2023–2027”, 2023

IoT Analytics “Decoding Digital Twins: Exploring the 6 main applications and their benefits”, 2023

# Concept of Digital Twins in our domain



Digital twin is a virtual representation of a physical object, process, or system



Combines historical, real-time, test data with algorithms to replicate the real-world behavior

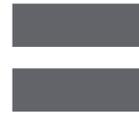
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## data structure

(names, data types, units of measurement, and other metadata)



Populate the model with data



## Visualizations, 3D

(derived from the data structure and the processed data)

## Behavioral model

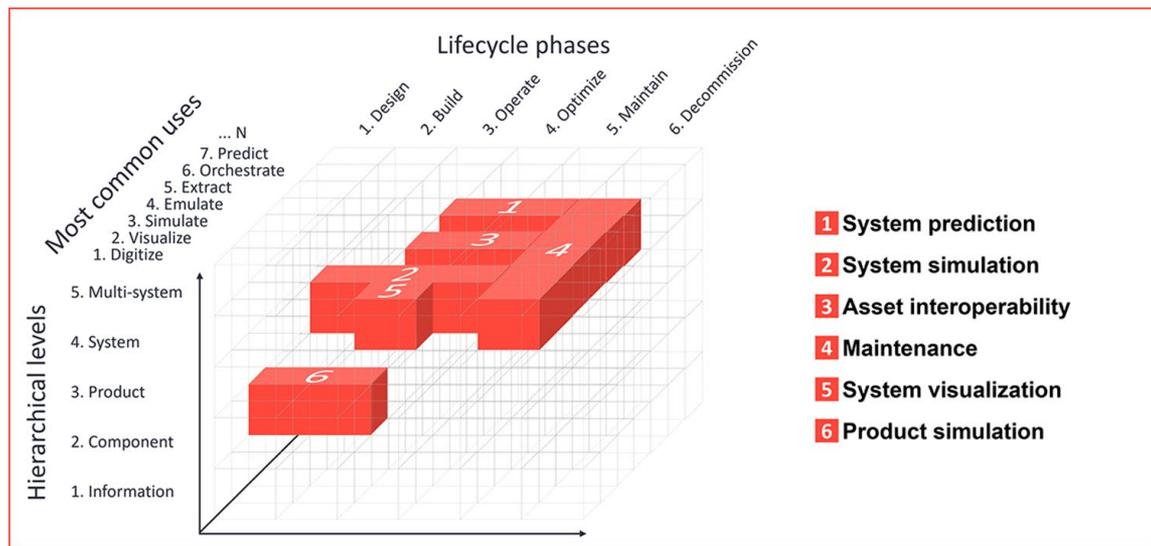
(based on algorithms and causality)

## Behavioral simulation

(Descriptive, diagnostic, predictive)

# Most common applications

IoT Analytics looked at 100 digital twin case studies and classified each project



Source: IoT Analytics "Decoding Digital Twins: Exploring the 6 main applications and their benefits", 2023

- Industry applications orient around certain use cases
- Focus on system level
- Interoperability "standards" still under definition
- Full life-cycle coverage rather an exception

# The Glossary

## Visualization

3D model representation of a future system for illustrating the overview or details for “telling” a story, demonstrating flows and functions – often extended by “taking a tour” in VR/AR.

## Simulation

Imitative representation of a system or a core area of a systems. Output of simulation scenario runs are supporting decision-making used to find the “best” solutions or assess the capacity of a solution applying statistics.

## Emulation/Virtual Commissioning

Hardware in the loop testing of software running an automation site, done by connecting the software to a 3D model using high-speed and native industrial communications, accurately depicting the function of the physical system.

## IT Testing

A subset of Emulation concerned with testing WCS/MFC/MES systems, and often also the overlying ERP system. The 3D model will behave as the equipment and PLC layer, receiving and sending telegrams as required by the native protocol.

## OT Testing

A subset of Emulation concerned with testing controls at the PLC level. The 3D model will be connected to one or more PLCs at IO-level using the PLC brands preferred protocol. Tests may range from individual components to entire PLC areas.

## Digital twinning

A digital twins are a 3D model accurately mirroring a connected physical system, including controls software. The real system is outfitted with various sensors producing data about different aspects of the physical system, such as energy consumption, speed, temperature and more. This data can be relayed to a processing system and applied to the digital model for various purposes.

# System simulation and prediction

- Used for predicting entire systems (like factory, building, wind farm, or city)
- Mainly during “build”, “operate” or “optimize” life cycle phase
- allows engineers to test “what-if” scenarios in a large setting with many more interlinked variables
- reduce costs by testing the types of assets used, key operational parameters, and other important system variables prior to making the changes
- predicting the behavior and future state of a physical system using current data and relevant records of the operational history

# Maintenance

- geared toward assuring a system's operational effectiveness, e.g., by assisting maintenance personnel during scheduled downtime or repair tasks
- Main purpose is to assist during the “maintain” phase but typically deployed during “operation” phase
- combines several use cases from visualization, simulation, (real-time and historical data) extraction, resulting in an element of prediction

# Asset interoperability

- streamline common data formats and allow for standardized data in/output
- during the “operate” or “optimize” life cycle phase
- allows for real-time extraction of data from assets along various dimensions like characteristics, properties, statuses, parameters, measurement data, and capabilities
- Digital Twin Consortium’s Interoperability framework or Platform Industrie 4.0/IDTA’s Asset Administration Shell

# Significant Value at every Lifecycle Phase

The DTCC delivers significant value **at every lifecycle phase**, whether it's during the initial concept, design, engineering, optimization, or retrofit phase — **without requiring full lifecycle coverage** to make a meaningful impact.

## Simulation

A model imitates the (simplified) behavior of a target system, including material flow, cycle times, and resource utilization.

**Simulation**  
evaluate the impact of design changes before any physical components are ordered or built

- a simulation model is created using technical specifications, CAD data, and process parameters
- model imitates the (simplified) behavior of a target system, including material flow, cycle times, and resource utilization
- Engineers use the simulation to identify bottlenecks and test layout alternatives → design **decision making tool**

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## Virtual Commissioning

Virtual commissioning integrates IT and OT by testing automation software in a virtual environment, ensuring system and software functionality before physical deployment.

**Virtual Commissioning**  
ensuring that the target system behaves as expected under all conditions

- A digital twin of the system is connected to the actual control software via real-time protocols (e.g., OPC UA, Profinet)
- the automation software is tested in a virtual environment
- Engineers validate logic, motion, interlocks, error handling, etc. → pre-deployment **validation tool of automation logic**

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## Digital Twinning

A digital twin accurately mirrors a connected system. It continuously monitors the system and evaluates the best possible settings - resulting in optimized performance - and suggests updates to the behavior of existing physical systems based on these investigations.

**Digital Twinning**  
continuously evaluates the best possible settings for a given operational system

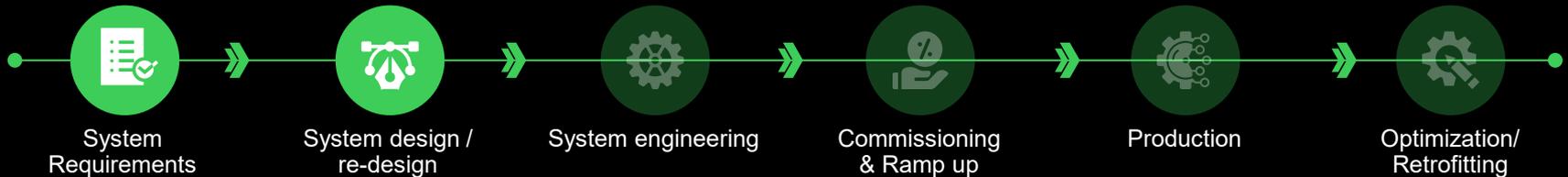
- a digital twin mirrors the physical system during operation
- Sensor data, machine states, and performance metrics are streamed into the twin
- Operators interact with the system, receiving alerts, maintenance recommendations, and optimization suggestions → operations **monitoring and optimization tool**

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# Simulation

evaluate the impact of design changes before any physical components are ordered or built

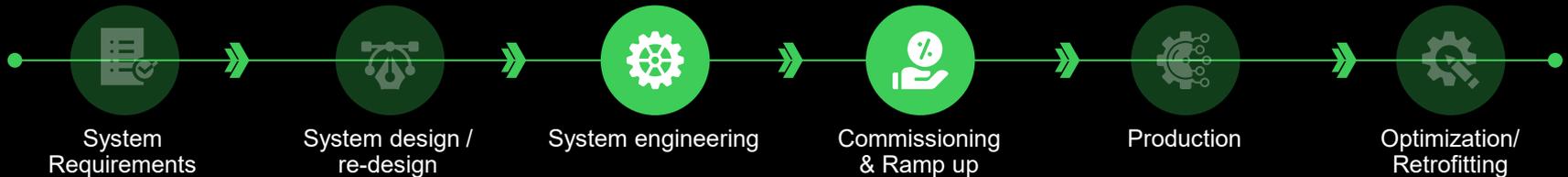
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# Virtual Commissioning

ensuring that the target system behaves as expected under all conditions

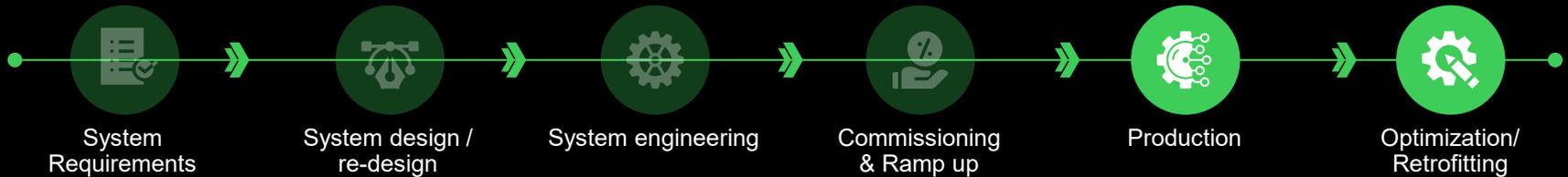
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- a digital twin mirrors the physical system during operation
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→ operations **monitoring and optimization tool**



# Digital Twins: Adoption, Use Cases, and Industrial Impact



# External market drivers meet internal challenges

- Demand for more intelligent products in a connected world
- Shortened product life cycle reduce time-to-market
- enable decision making and robust change management
- improve quality, compliance, mitigate risk

Manufacturing industry strives to create **MORE innovative products**, combined with **FASTER time-to-market** supported by **BETTER decision making**, quality and cost control.



Traditional machine design involves multiple iterations and complex adjustments

**75%**

of projects exceed budget



Engineers from different disciplines need to work closely together

**30%**

of projects are delayed



Physical testing and validation of machines is costly, complex and time-consuming

**60%**

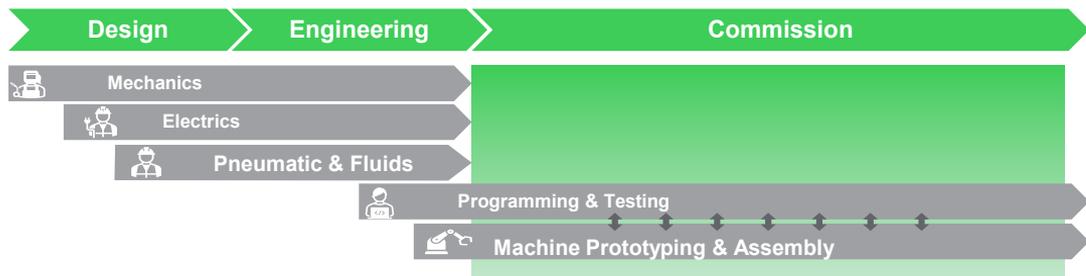
of commissioning time is used to identify and eliminate problems with controls, protocols, and integration



Unforeseen commissioning issues affect the project schedule

# Digital Twins reshape machine building

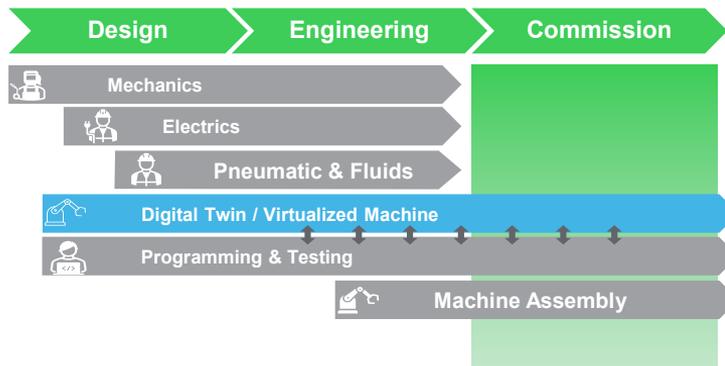
Digital Twin and smart manufacturing transform traditional sequential project workflows



## Classic workflow:

- Development follows a sequence step by step
- The domains push their results to the PLC programmers
- Program testing with all domains starts with the physical commissioning

VS.



## Virtual commission-driven workflow:

- Development follows an iterative and agile approach
- The digital twin pulls progress from the domains
- Continuous integration and validation of the domain's interoperation
- Deliver value incrementally in a collaborative manner & reduce uncertainties before doing the physical commission

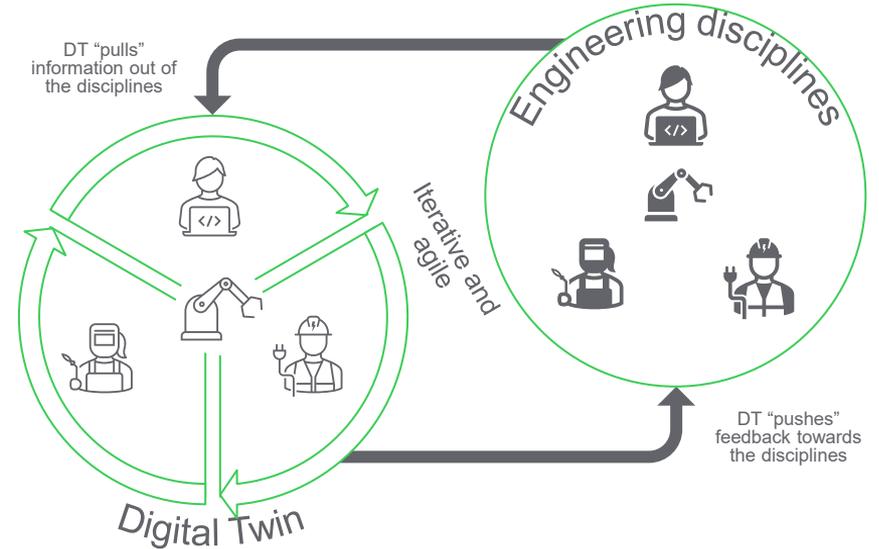
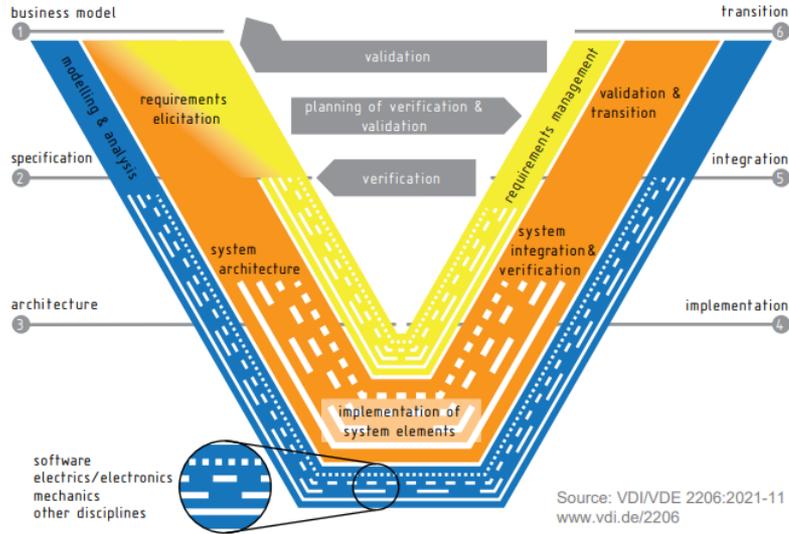
Faster time to market **50%**

Reduced quality costs **20%**

Commissioning time reduction **60%**

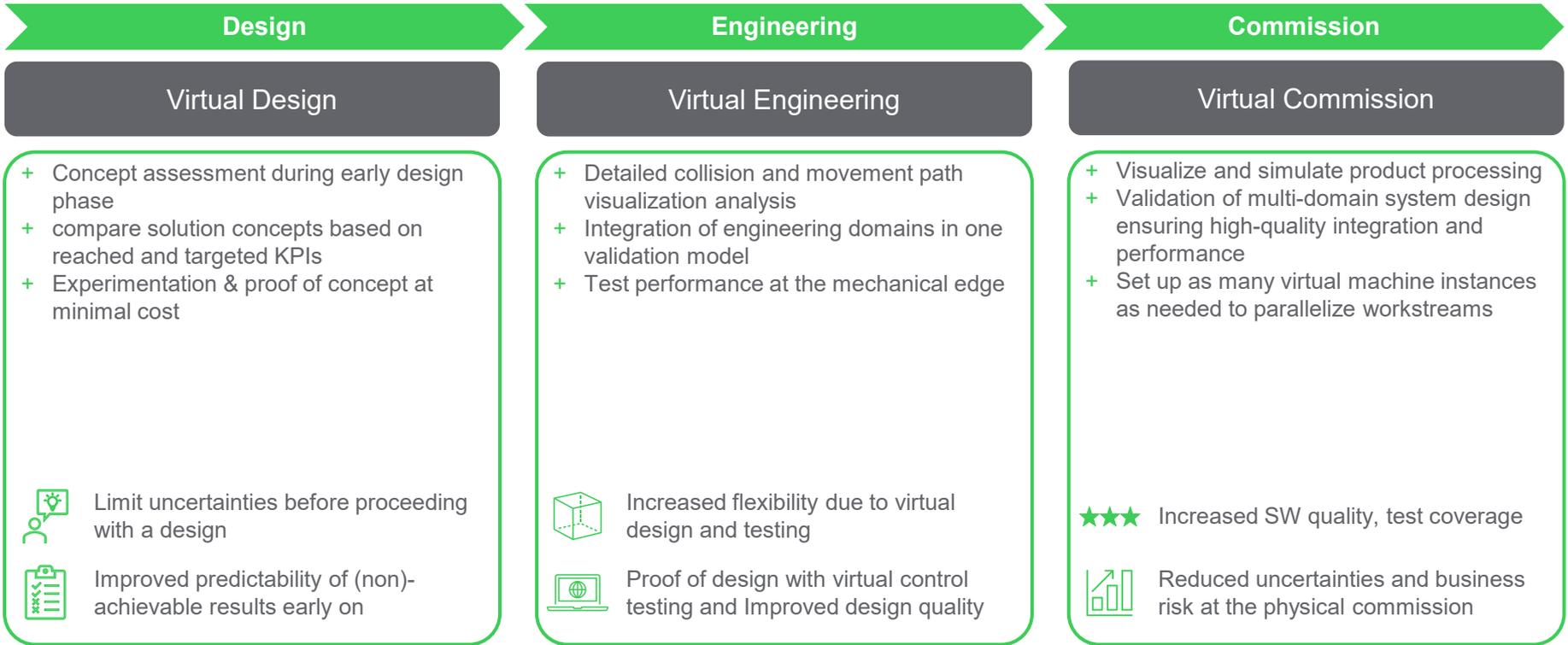
# Virtual Commissioning

Digital Twins enable more agile methodologies



# Agile methodology facilitates complex machine development

Use cases throughout the complete development phases



# Digital Twin features enable more use cases

Use cases throughout the complete machine lifecycle

## Sales Presentation

- + Demonstrate products and performance with a 3D-model based digital twin
- + Showcase in the customer's environment
- + Easily tailor demonstration with options and addons (Moving from 2D to 3D presentation)



Limited risk of misunderstandings and complaints



Bring the virtual machine to the customer

## Remote Operator Training

- + Train operators remotely & virtually on a 3D-model based digital twin
- + No need to bring trainer, operators, asset together + no risk of damage
- + Extended training content with injected errors and malfunctions including troubleshooting



24/7 availability to train on demand



Automate tracking of trained operators  
Connect operator login with training status

## Remote Maintenance Support

- + Guide local staff remotely on a shared virtual machine model
- + Connect your vendor's experts remotely with staff on premise
- + Guide local staff in maintenance and troubleshooting tasks



Be at the center of your customer's operations



Deliver best in class After-Sales

Design

Engineering

Commission

Operation

Maintenance

# Digital Twin features enable more use cases

## Use cases throughout the complete machine lifecycle

### Performance Optimization

- + Detect deviation from expected behavior during operation
- + Use the DT as training agent for AI powered analysis
- + Simulate production before executing it
- + Gather real-time data from a fleet of operational machines



Continuous analysis operational data



Optimize machine operation on the fly



Flexibly adjust machine setup and let it learn

### Asset Health Monitoring

- + Tailor maintenance activities in addition to regular activities
- + Real time component health monitoring and health check of critical components
- + Predictive maintenance to prevent a possible breakdown before it actually occurs



Increased uptime



Reduction in downtimes and maintenance costs



Valuable insights on the key components can ensure least or low bottlenecks and smooth operations

Operation

Maintenance

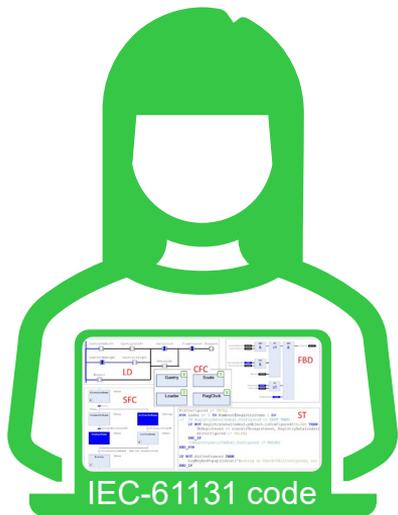
Remanufacture

# How to create digital twins ?



# How to create digital twins ?

You are an IEC application engineer or IEC developer



Real machine

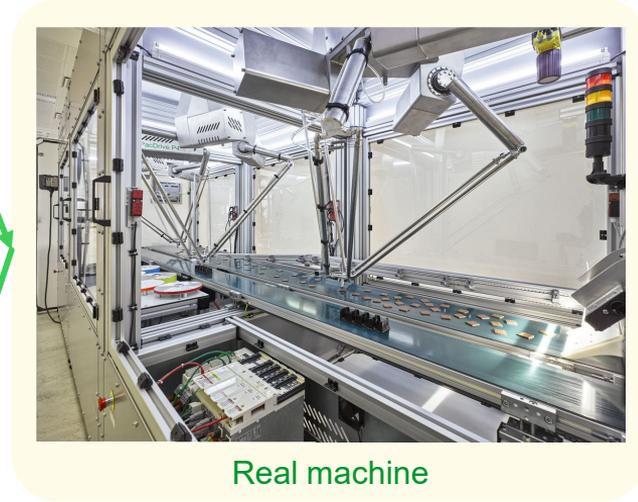
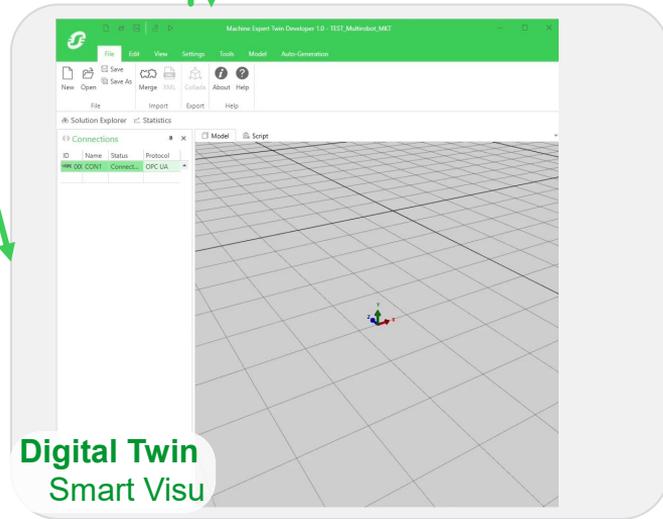
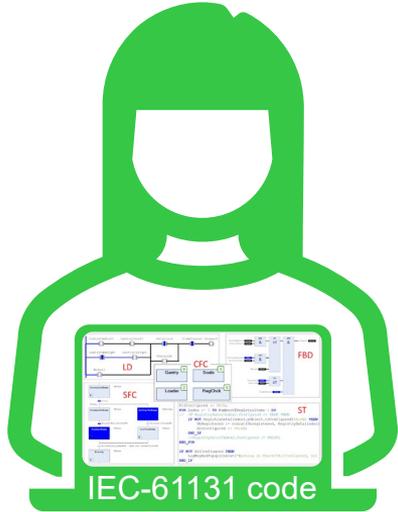
**Digital Twin**

How much time you need/have to:

- Generate a Digital twin?
- Has it a positive ROI?
- Convince Customer that you manage the request?
- How to advertise the UVP of the machine?
- Select/develop Pick logic?
- How many Robots needed?
- What is the max throughput?
- How to Unit-test?

# How to create digital twins ?

You are an IEC application engineer or IEC developer

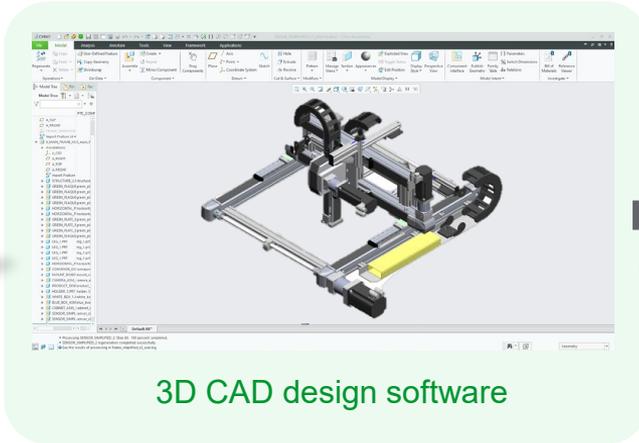


# Live Demo



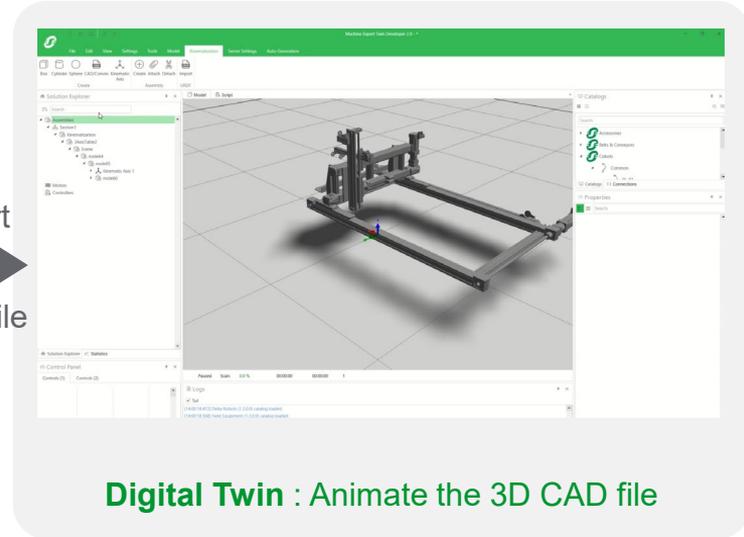
# How to create digital twins ?

You are a mechanical design engineer



3D CAD design software

Import  
CAD file

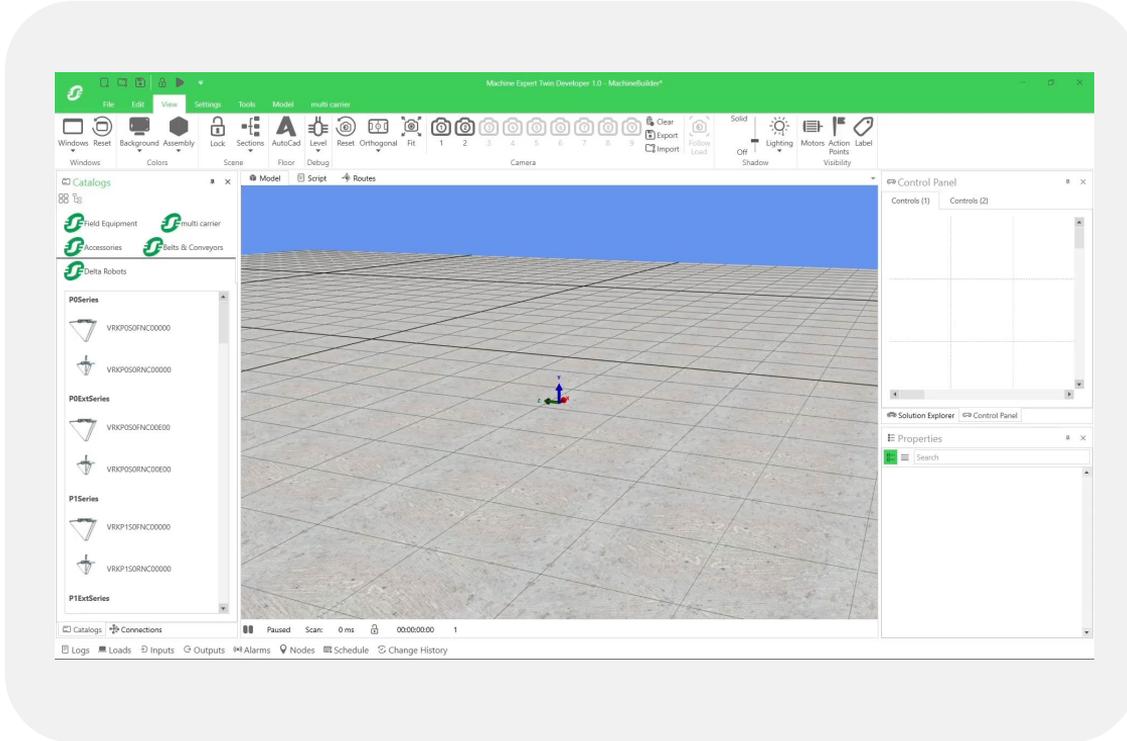


Digital Twin : Animate the 3D CAD file



# How to create digital twins ?

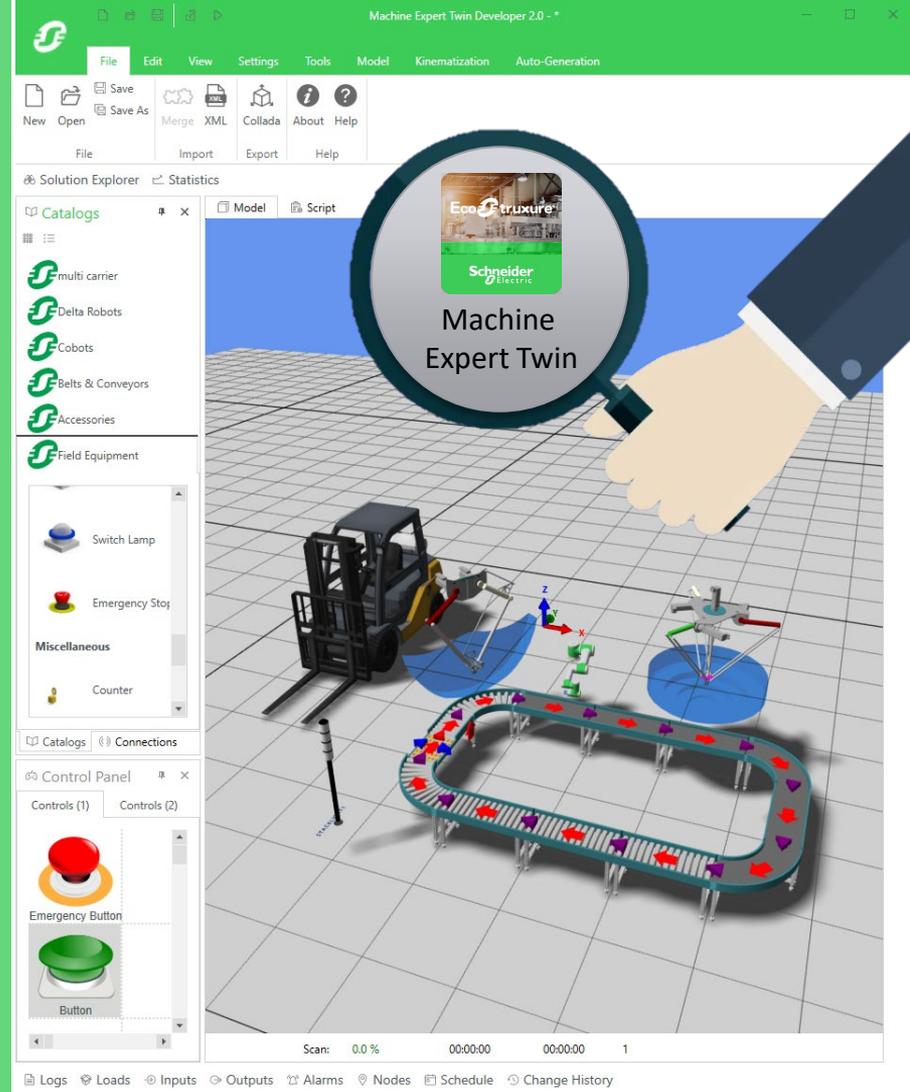
You are a salesperson



Controllers & Drives



# Machine Expert Twin Architectural View



File Edit View Settings Tools Model Kinematization Auto-Generation

New Open Save Save As Merge XML Collada About Help

File Import Export Help

Catalogs

- Field Equipment
- multi carrier
- Accessories
- Belts & Conveyors
- Cobots
- Delta Robots

VRKP6LORNCxxE00

VRKP6SOFWFxxE00

VRKP6SORWFxxE00

T1Series

T1

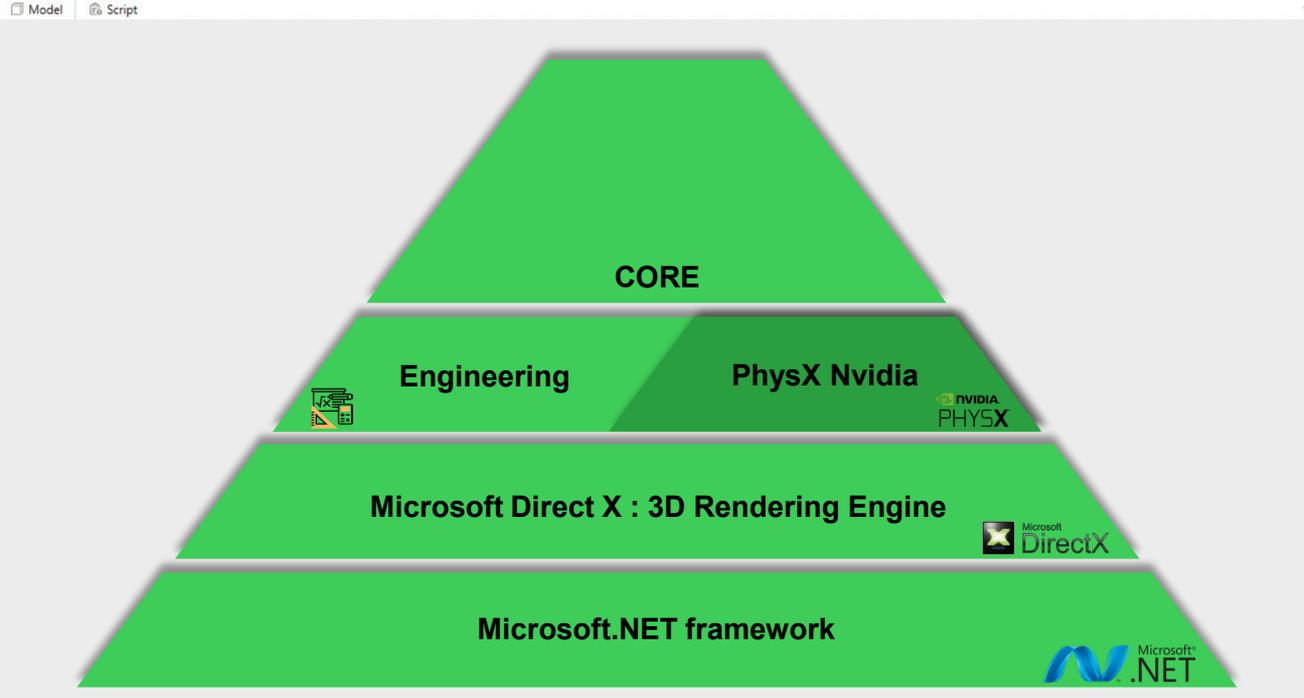
VRKT1MxFNCxx000

Control Panel

Controls (1) Controls (2)

Lamp

Emergency Button



Scan: 0.0 % 00:00:00 00:00:00 1

Logs

Tail

[14:51:04.229] Delta Robots (2.0.0.0) catalog loaded

[14:51:04.311] Field Equipment (2.0.0.0) catalog loaded

Logs Loads Inputs Outputs Alarms Nodes Schedule Change History

Solution Explorer

Search

- Assemblies
- Motors
- Controllers

Properties

Search

Catalogs

- Field Equipment
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VRKP6LORNCxxE00

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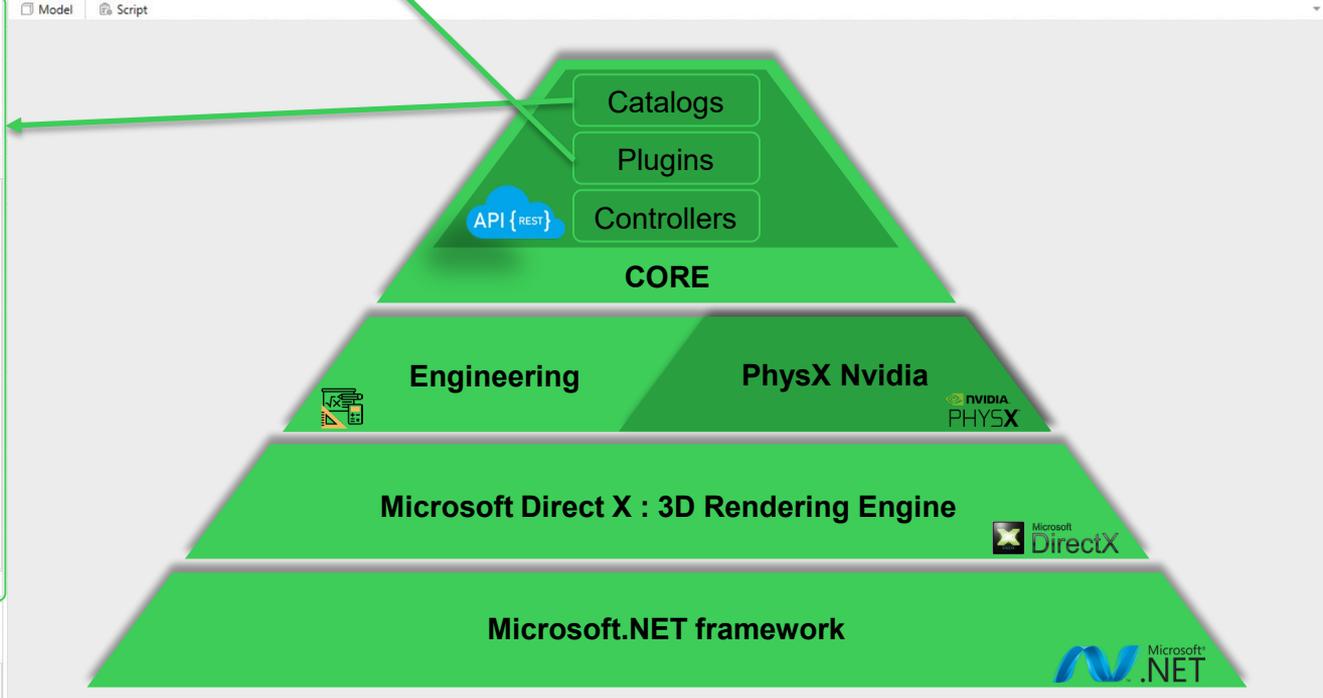
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Solution Explorer

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Solution Explorer Statistics

Properties

Search

Logs

Scan: 0.0 % 00:00:00 00:00:00 1

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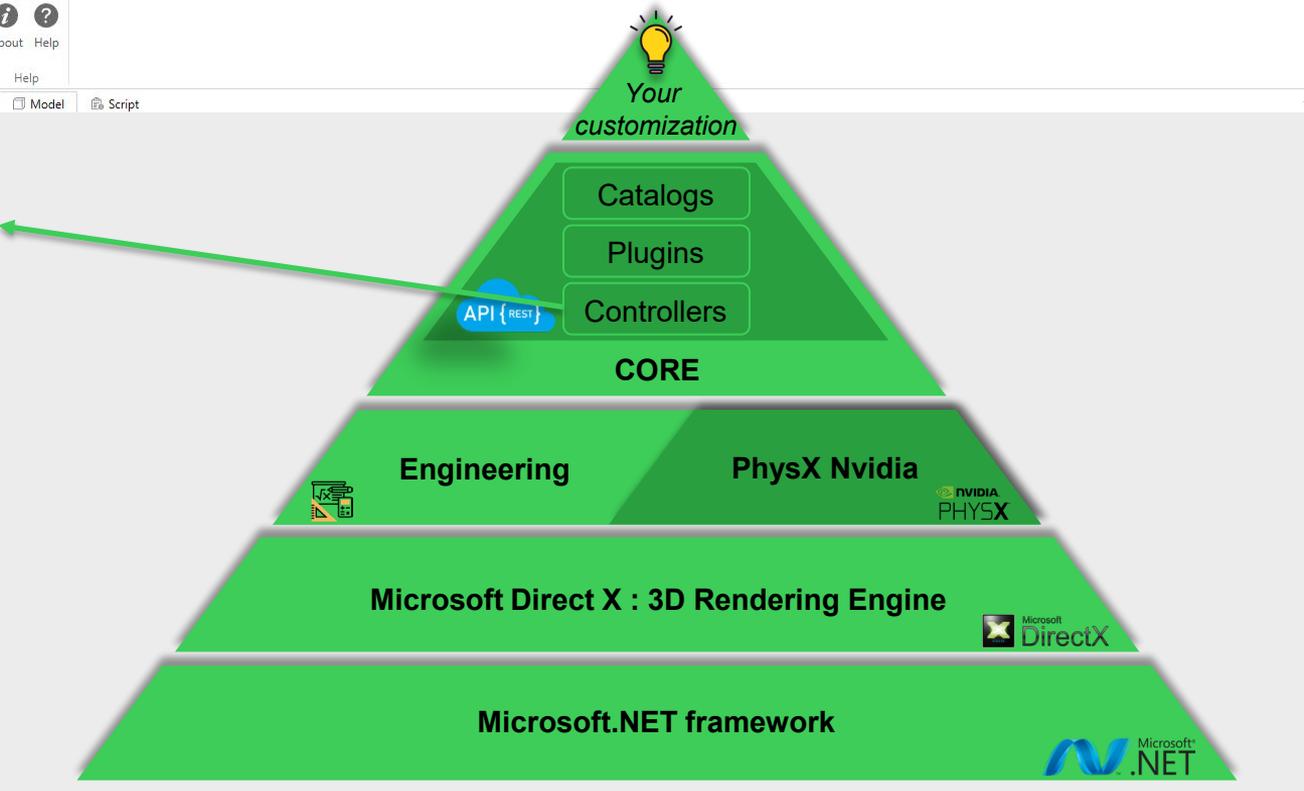
Logs Loads Inputs Outputs Alarms Nodes Schedule Change History

### Connections

ID	Name	Status	Protocol
000	CON1	Idle	OPC UA
001	CON2	Idle	Modbus TCP

Communication

- Connect All
- I/O
  - Siemens
  - Modbus
  - Serial (Raw)
  - XCom
- Tags
  - Beckhoff ADS
  - OPC UA Client
- Messages
  - STX/ETX
  - 3964R
  - RFC1006



### Solution Explorer

Search

- Assemblies
- Motors
- Controllers

Solution Explorer Statistics

### Properties

Search

### Control Panel

Controls (1) Controls (2)

Scan: 0.0 % 00:00:00 00:00:00 1

Logs

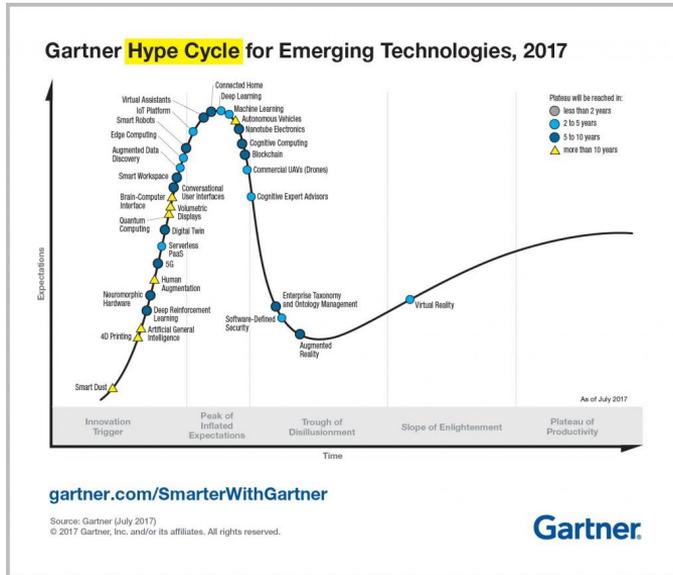
- ✓ Tail
- [08:56:35.550] Field Equipment (2.0.0.0) catalog loaded
- [08:56:35.570] multi carrier (2.0.0.0) catalog loaded

Logs Loads Inputs Outputs Alarms Nodes Schedule Change History

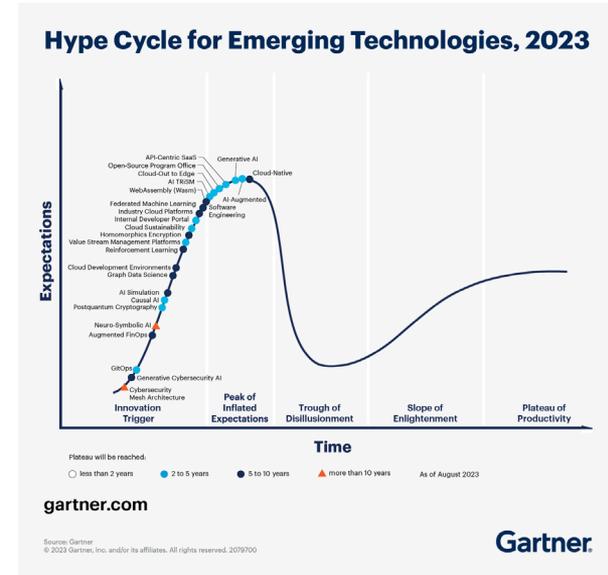
# Future Avenues of Digital Twins in Industry



# Is the hype over already?



Source: [Top Trends In The Gartner Hype Cycle For Emerging Technologies 2017](#)

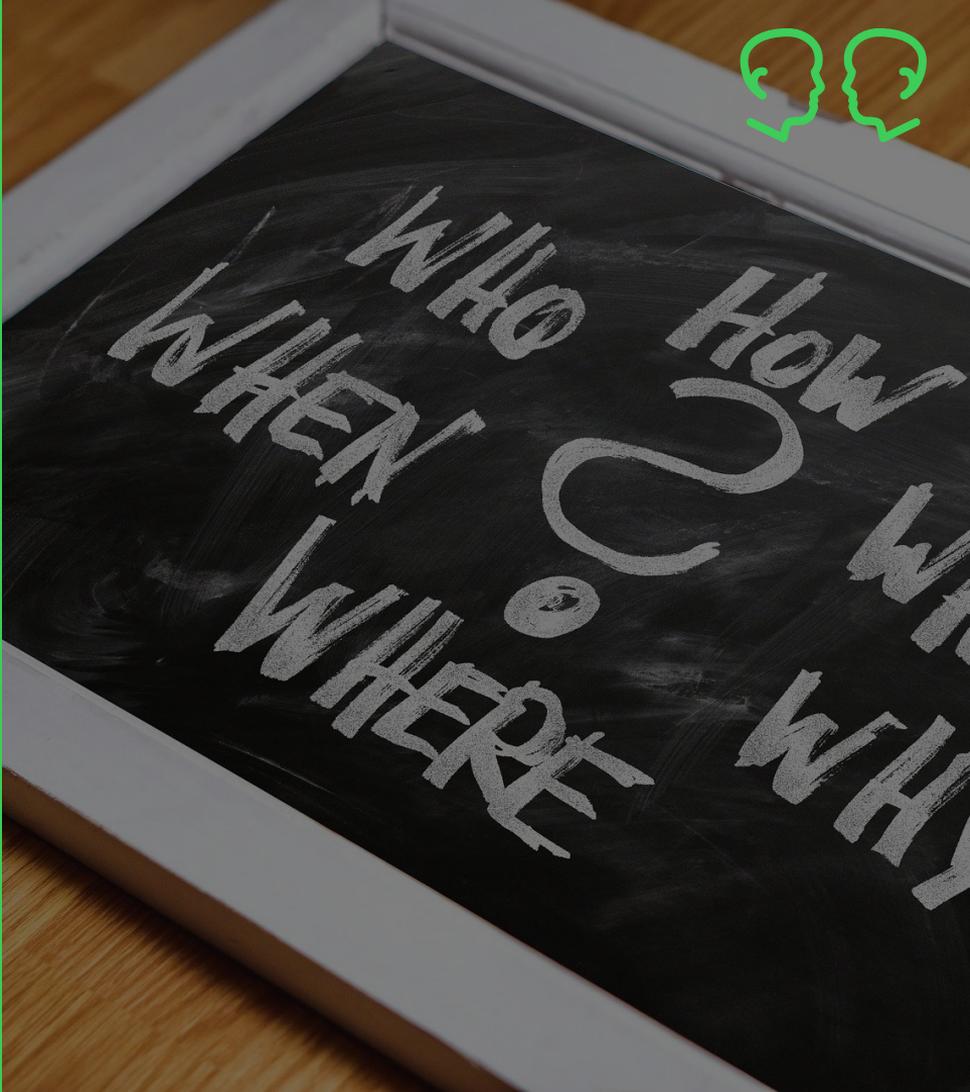


Source: [4 Exciting New Trends in the Gartner Emerging Technologies Hype Cycle](#)

# Real-world outcomes drive adoption in various fields

- **Lifecycle Management**
  - Trend towards full life cycle coverage
  - Modularization to tailor DTs to specific use cases along the life-cycle
- **Simulation and Optimization**
  - Enhanced simulation and optimization capabilities
  - test different scenarios, improve processes, and optimize resource utilization
- **Advanced Analytics and AI Integration**
  - enabling better decision-making, process optimization, and scenario planning
  - Trend towards self-learning
- **Integration with IIoT and Edge Computing**
  - more granular data collection and analysis
  - Distributed digital twinning based on use case specific needs (computational performance, latency, connectivity, ...)

# Q&A



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Electric