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DIGITAL MODEL
Product Data
+
DIGITAL THREAD
Traceability
+
DIGITAL TWIN
Configuration
=

Context

The Digital Thread as the Foundation of the Omniverse

The PLM Vision Becomes Reality

PLM Road Map™ & PDT Europe 2025

PLM's Integral Role in Digital Transformation From Strategy to Execution

Elevating PLM to an Enterprise Business Solution,
the PLM Professional's Road Map to Success

CIMdata® 5 & 6 November -eurostep-

Prof. Dr.-Ing. Martin Eigner
EIGNER ENGINEERING CONSULT
Baden-Baden

Professor Dr.-Ing. Martin Eigner

1968 – 1971 Toolmaker

1971 – 1976 University of Karlsruhe (TH)
Studies in Mechanical Engineering and Economy

1977 – 1980 University of Karlsruhe (TH)
PhD Institute of Computer Applications in Design

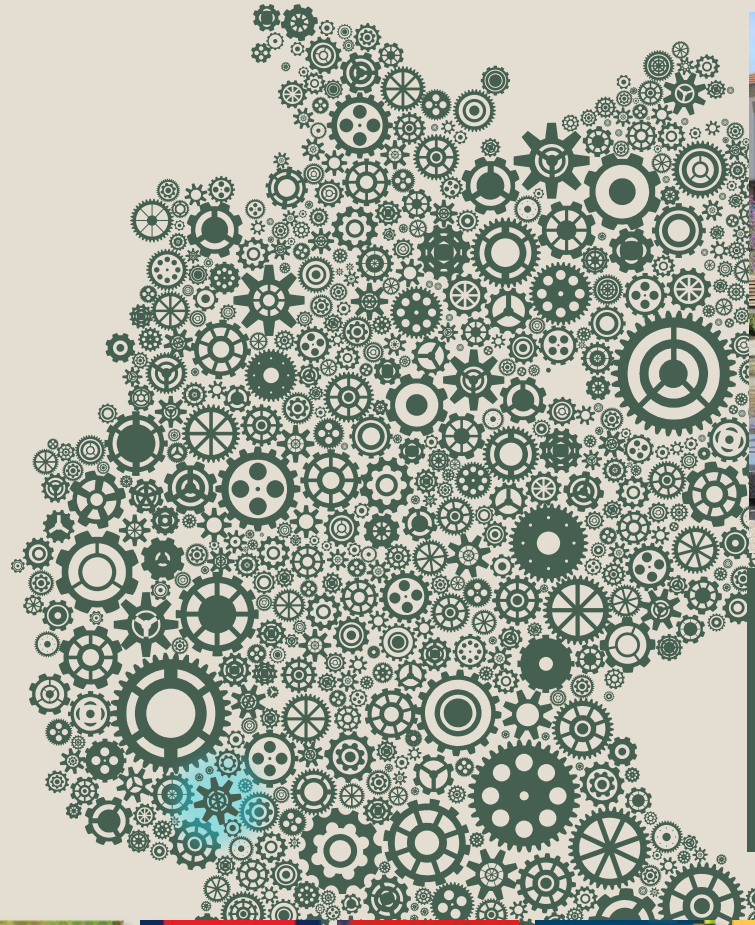
1980 – 1985 Robert Bosch GmbH
Head of Department Technical IT and
Organization, Electronic Predevelopment

1985 – 2003 Eigner & Partner GmbH, AG, Inc.
Solution Provider for PLM Solutions
Until 2001 chief executive office
Until 2003: chairman of the board / CTO

since 2003 EIGNER Engineering Consult (CEO)
Consulting Company for Engineering Processes
(PLM, CM, ERN/ECM, MBSE, BOM, MPP, ERP-Interface)

since 2004 University of Kaiserslautern
until 10/17 Institute of Virtual Product Engineering (VPE)

since 1992 University of Karlsruhe (TH) Guest Professor
since 1999 TU Sofia, Bulgaria Visiting professor
since 2017 EGE-University, Izmir Guest Professor
Since 2014 Honored Member of the ProSTEP Association
Since 2020 Beirat der Zeitschrift ZwF



2009 Awarded with
UNICUM Germany`s Professor of the Year 2009
2014 „Lehre Plus“ award of the
University of Kaiserslautern
for „Industry 4.0“, Information Technology and Crowd Engineering

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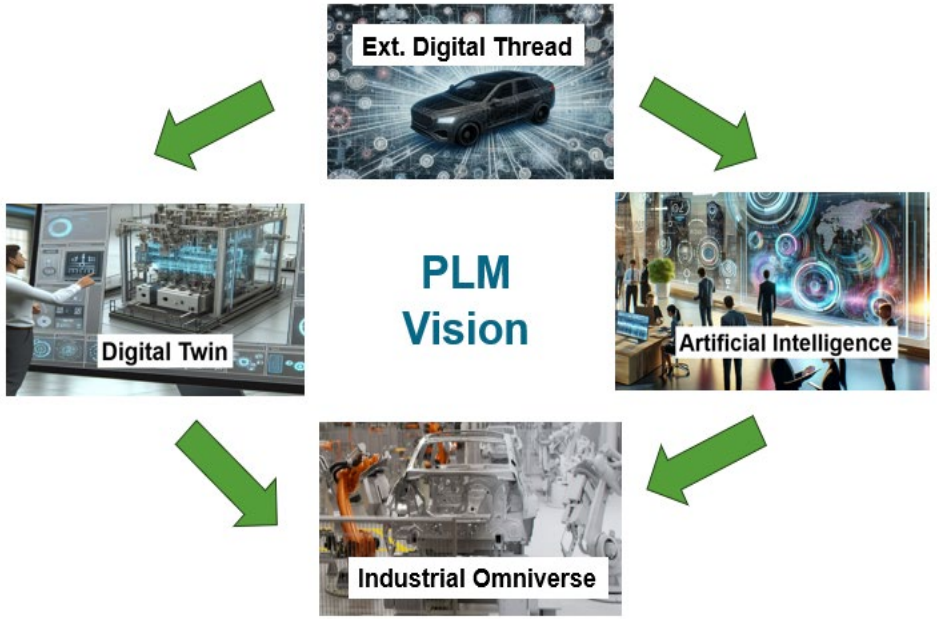
Agenda

- The history of PDM/PLM
- The difference between the PLM-Vision and the PLM-Systems
- The current landscape of PDM/PLM
- How we are able to realize our PLM-Vision
- **The Extended Digital Thread**
- **Artificial Intelligence**
- **The Digital Twin**
- **The NVIDIA Omniverse**
- **Summary and Outlook**



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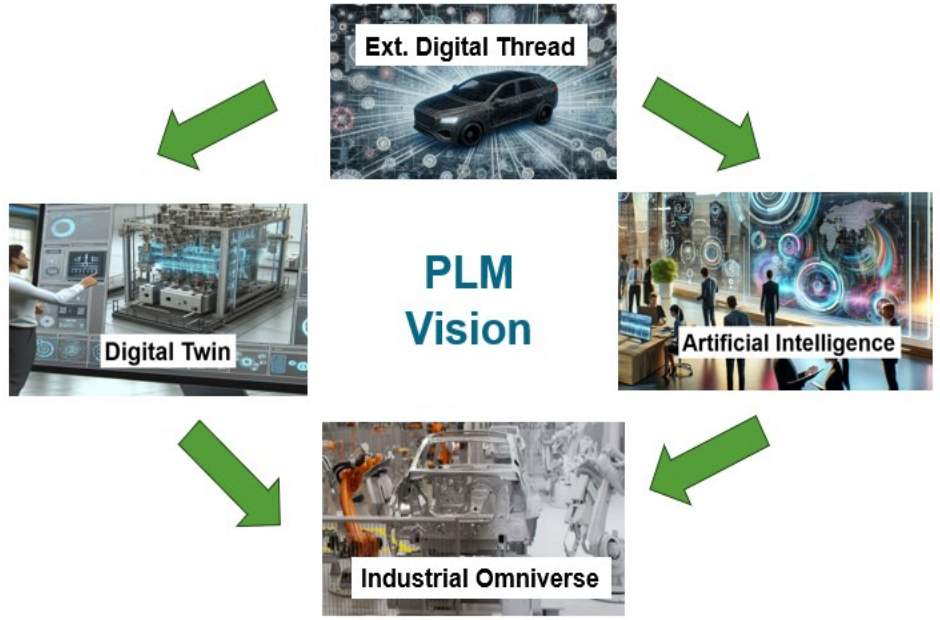
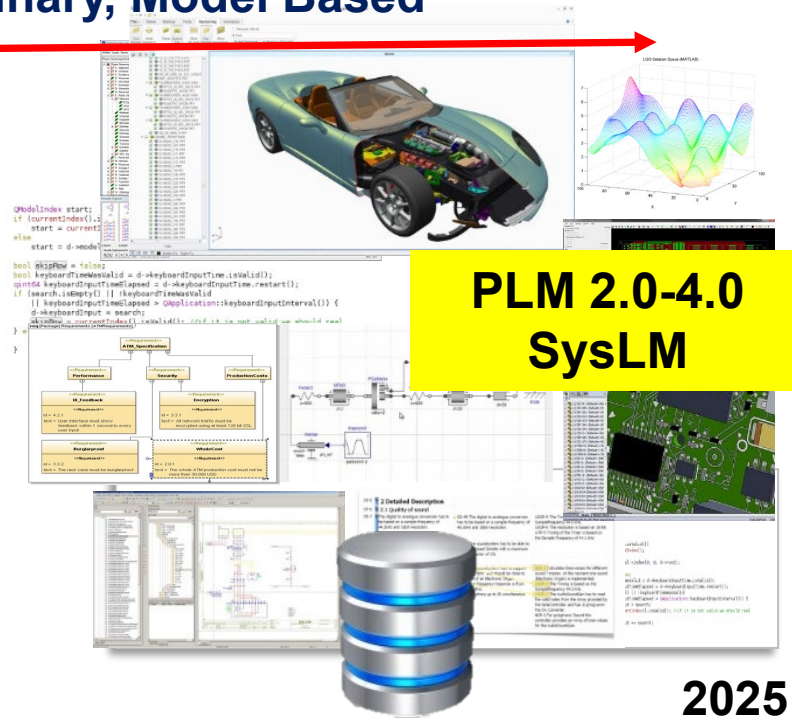


40 Years: DVS -> PDM -> PLM -> ?

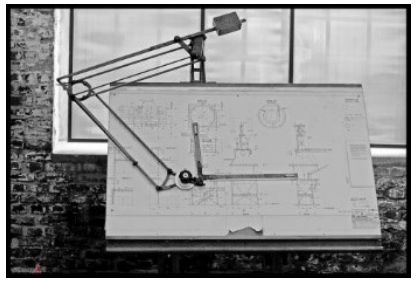
Interdisciplinary, Model Based

Mechanic-focused, Document-centric



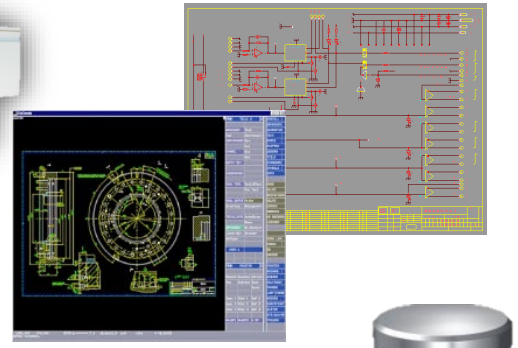
PLM 2.0-4.0
SysLM

Drawing Archive



1980

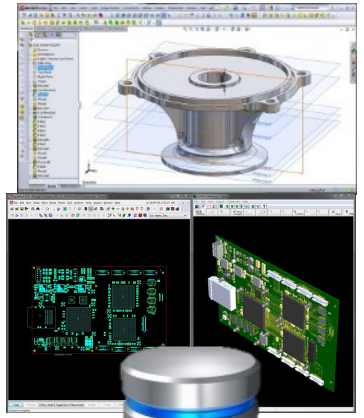
2D M-CAD/E-CAD



DVS
EDB
EDM

PDM

3D M-CAD/E-CAD/CASE



PLM

2025 +

Smart Products,
Connected,
Intelligent
Cybertronic

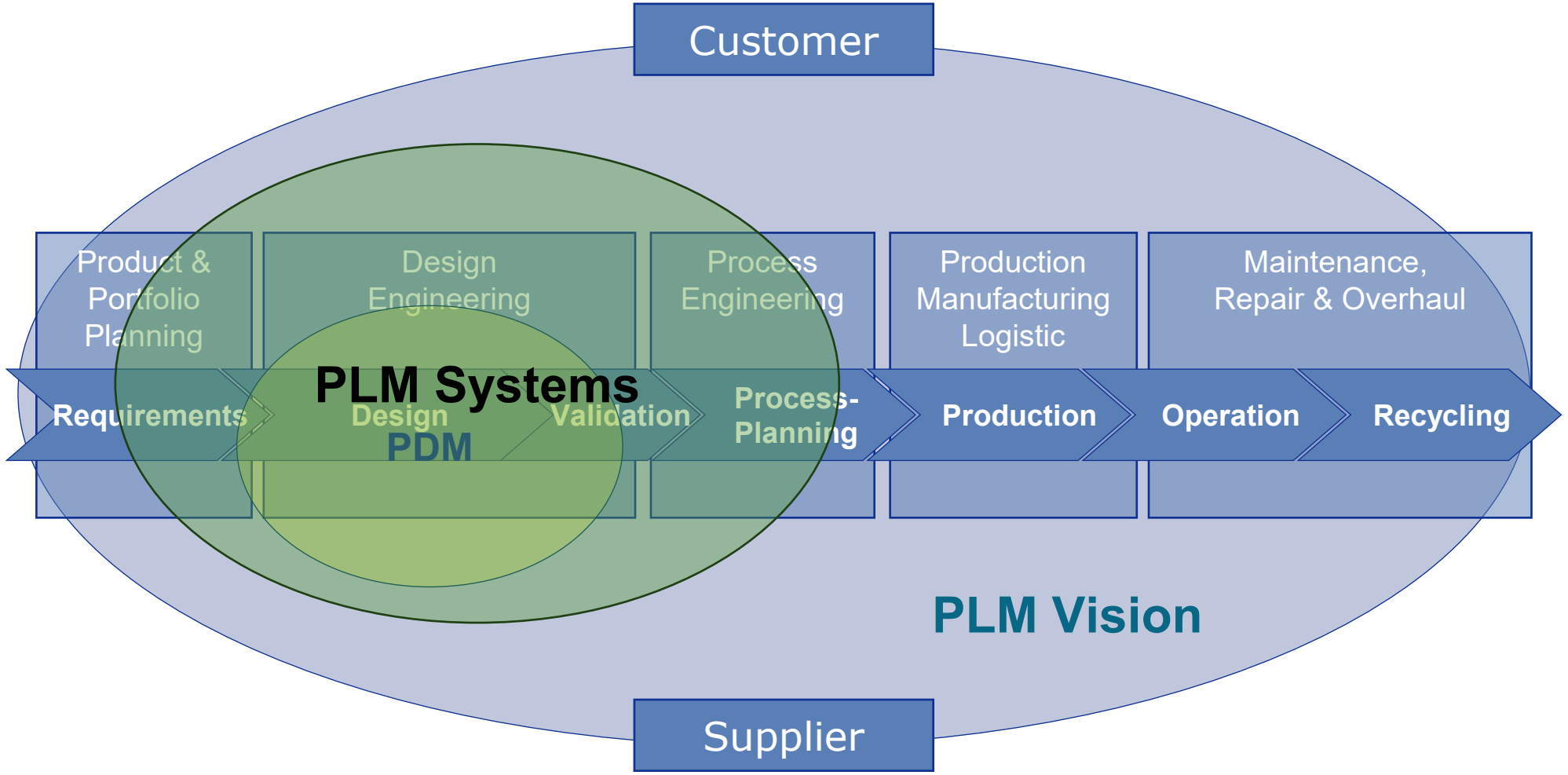
Mechanical
Components

Mechanical and
Electrical
Components

Mechanical,
Electrical/Electronical
Software
Components

PDM, PLM-Vision and PLM-Systems

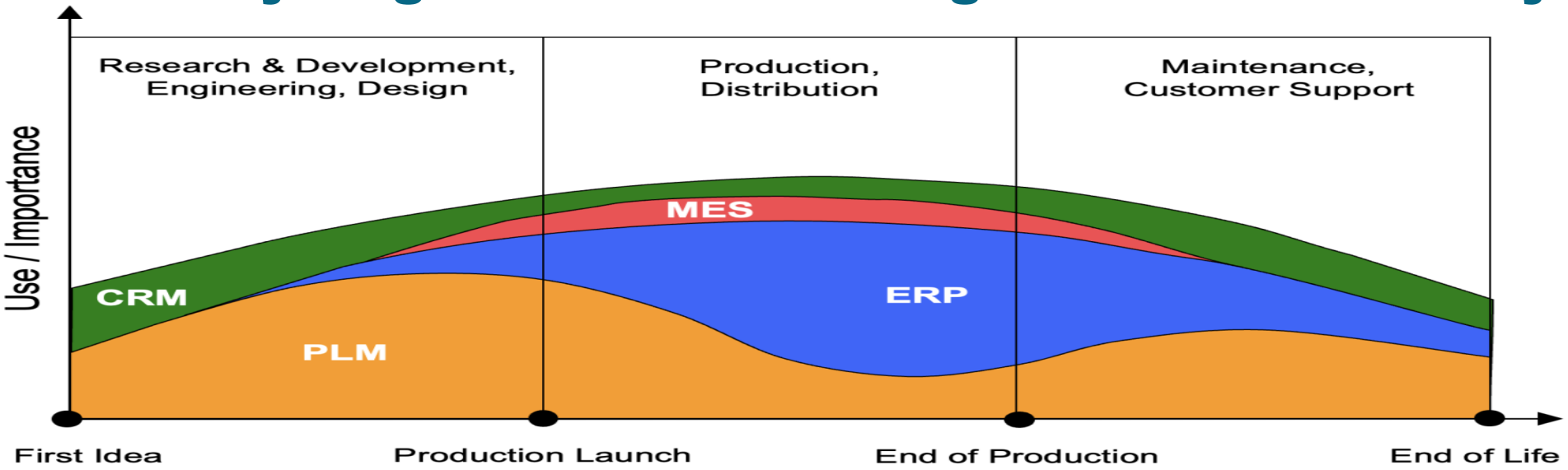
Product Lifecycle Management (PLM) vs. Product Data Management (PDM)



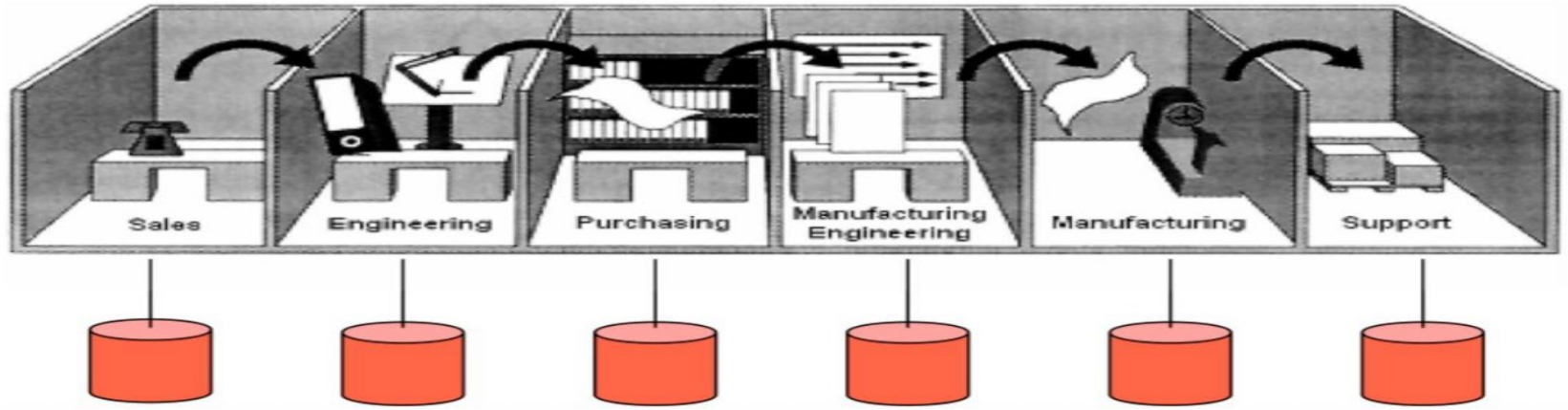
The Current Landscape

- Fragmentation and Many Legacy Systems along the Product Lifecycle
- No common engineering processes above the Legacy Systems
- Mostly Based on Old SW Technology (Monolithically SW-structure)
- Very high first-time and permanent (upgrade) effort for customization
- What is the Scope of PLM?
- Do we Really Need PLM?

Many fragmented Silos Along the Product Life Cycle



Product Lifecycle (PLC)

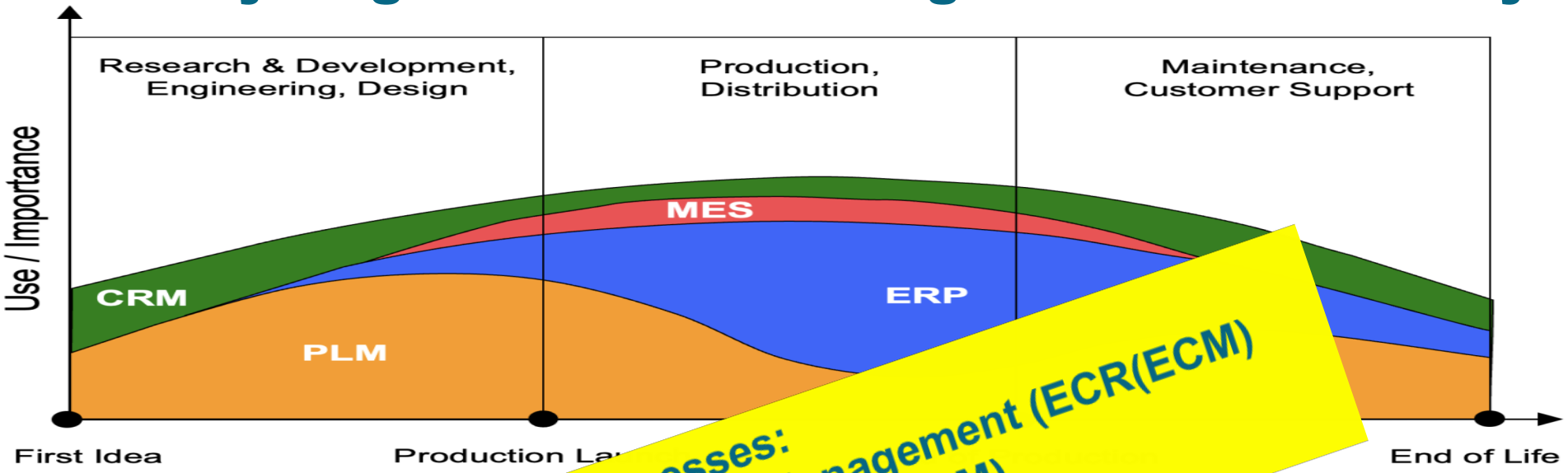


CRM/CPQ PDM/PLM SCM PPS/PLM PPS/MES MRO

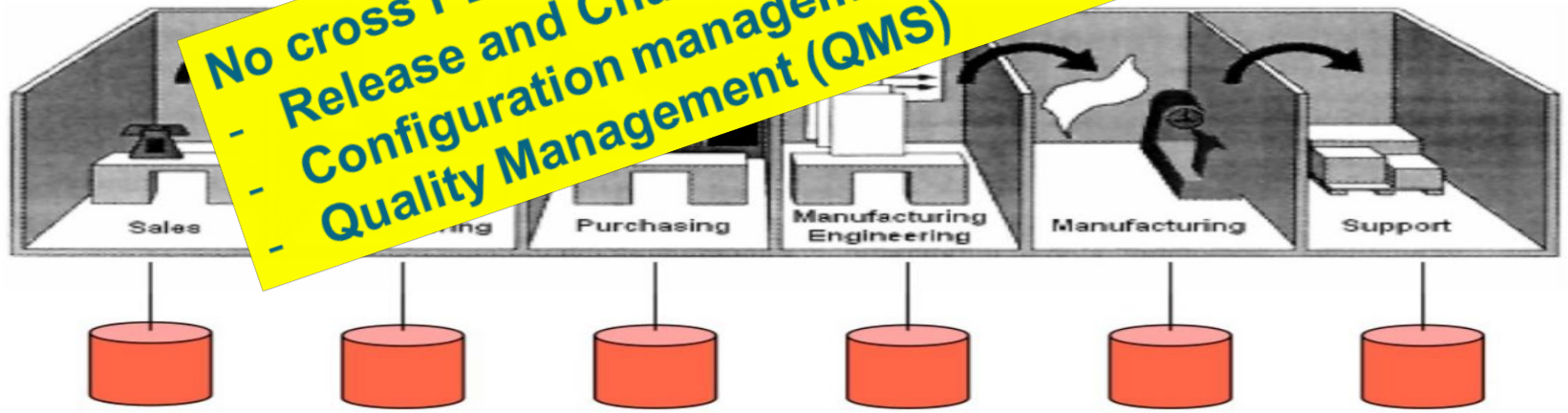
Produkt Lifecycle Management?

Nach: A. Lindenthal

Many fragmented Silos Along the Product Life Cycle(PLC)



No cross PLC-processes:
- Release and Change Management (ECR(ECM)
- Configuration management (CM)
- Quality Management (QMS)



CRM/CPQ PDM/PLM SCM PPS/PLM PPS/MES MRO

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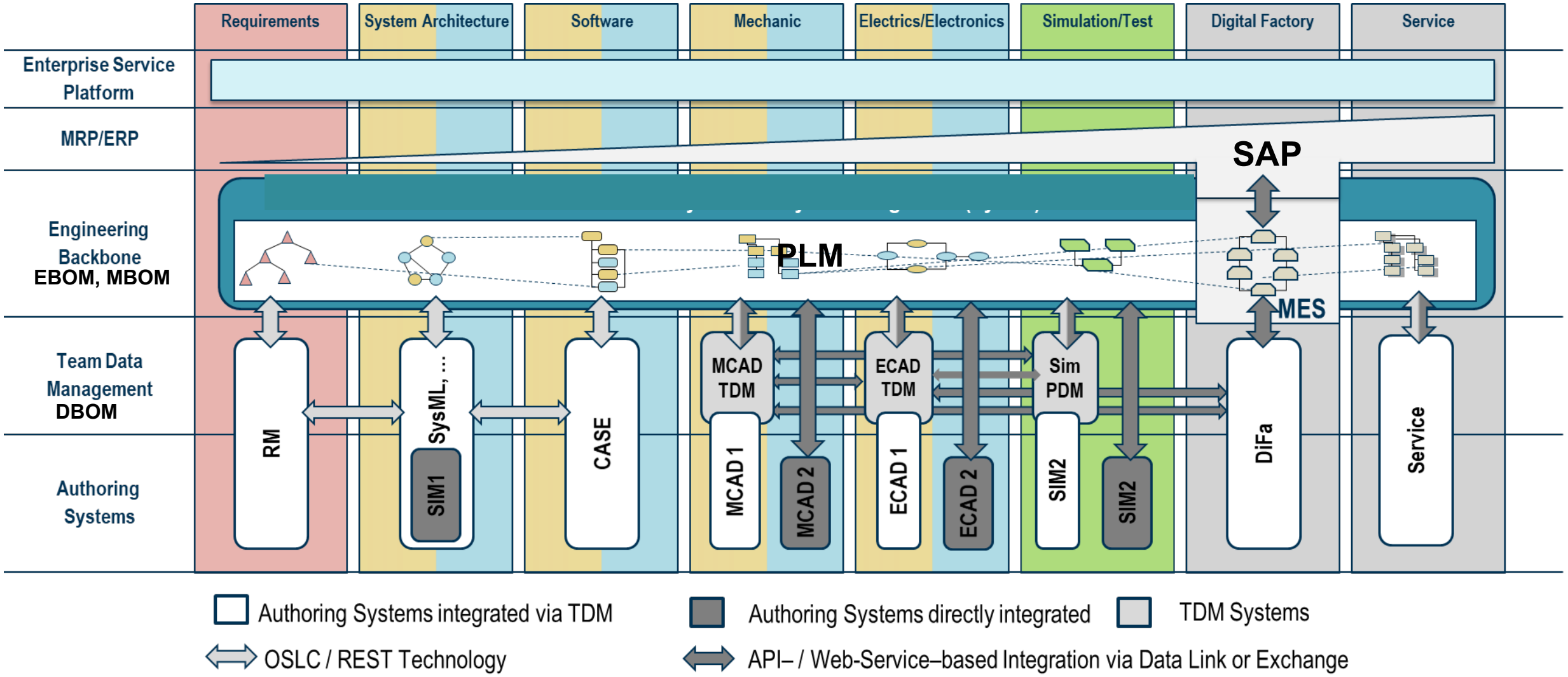
IT Architecture based on VDA 4-Level Concept
The Theory



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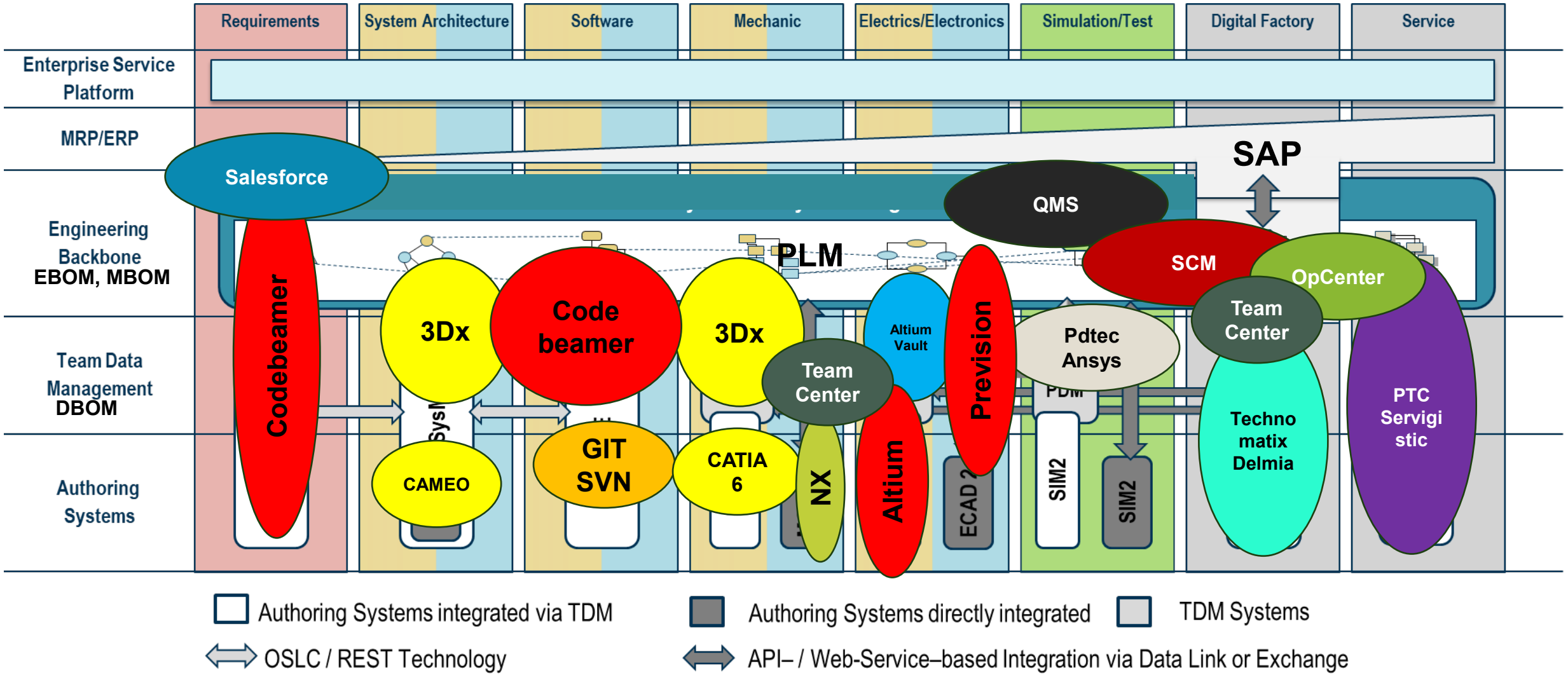
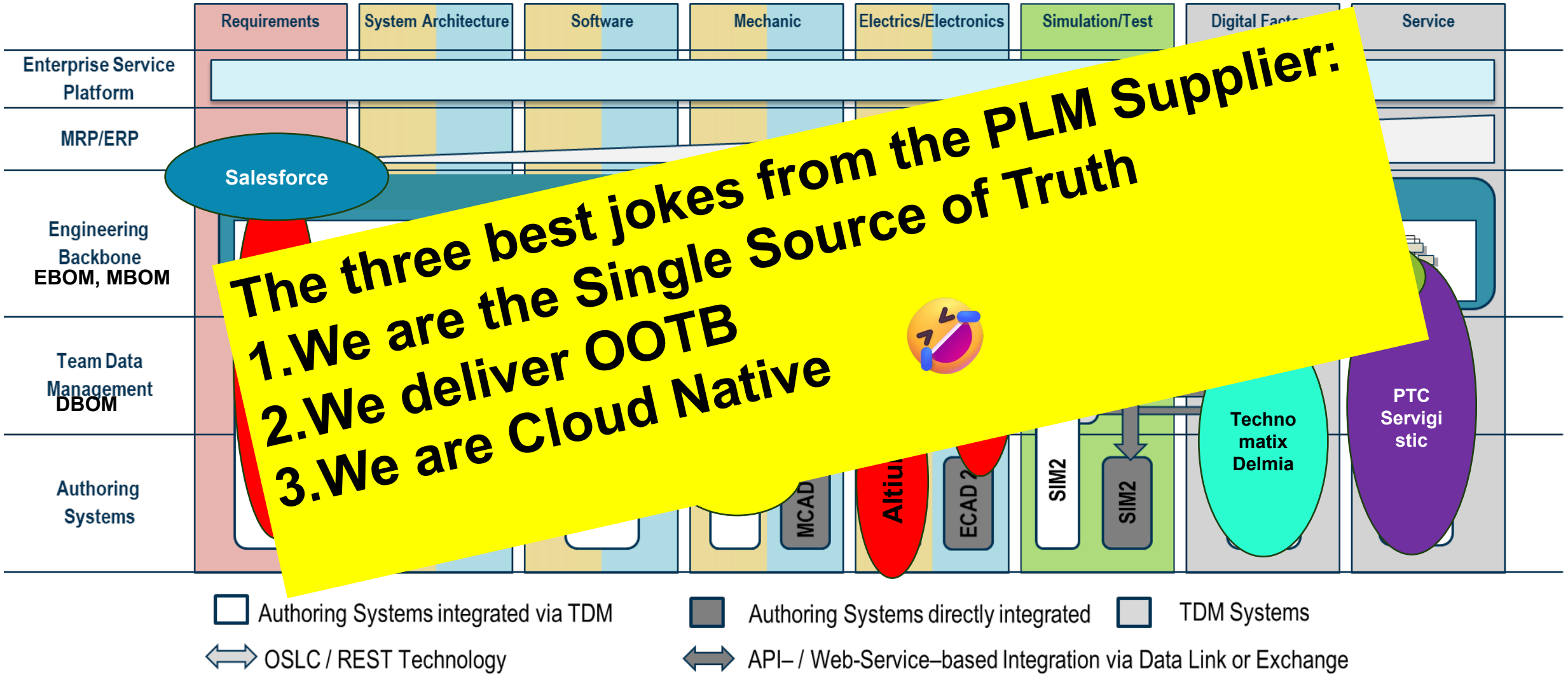
IT Architecture based on VDA 4-Level Concept
The Reality!



IT Architecture based on VDA 4-Level Concept
The Reality!



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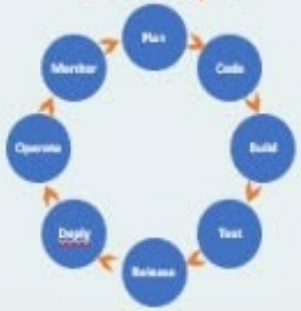
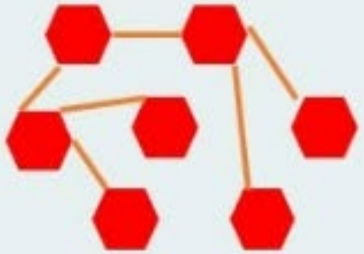
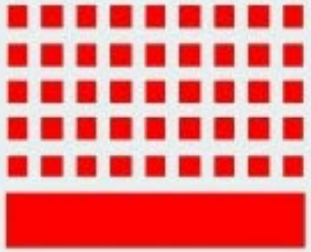
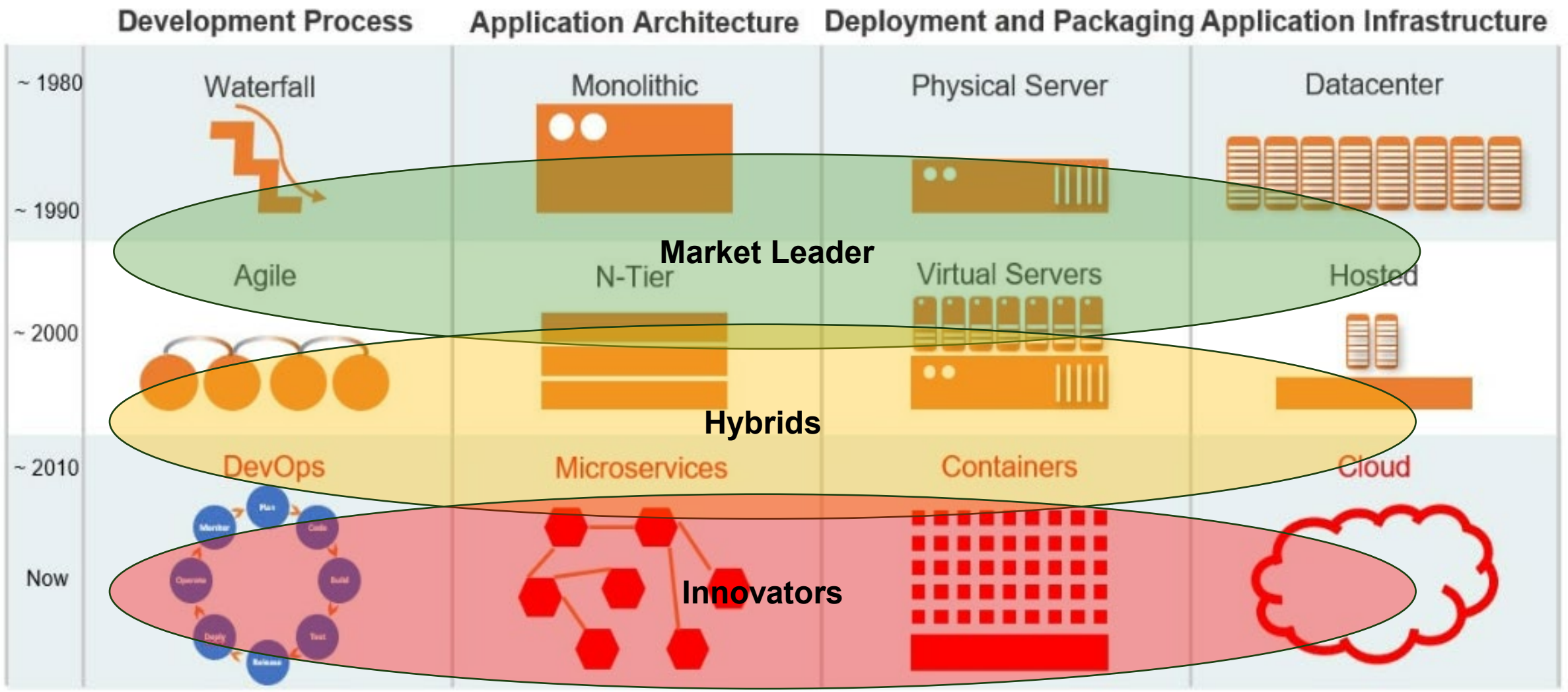
Software-Technology (Source: based on K21Academy)

	Development Process	Application Architecture	Deployment and Packaging	Application Infrastructure
~ 1980 ~ 1990	Waterfall 	Monolithic 	Physical Server 	Datacenter 
~ 2000	Agile 	N-Tier 	Virtual Servers 	Hosted 
~ 2010 Now	DevOps 	Microservices 	Containers 	Cloud 

K21Academy
Learn Cloud from Experts

Software-Technology (Source: based on K21Academy)



Do we really need PLM?

f.E.. Onshape

f.E. Propel

f.E. SAP, Dynamics 365

Typical CAD/TDM/PDM/PLM/ERP Alternatives

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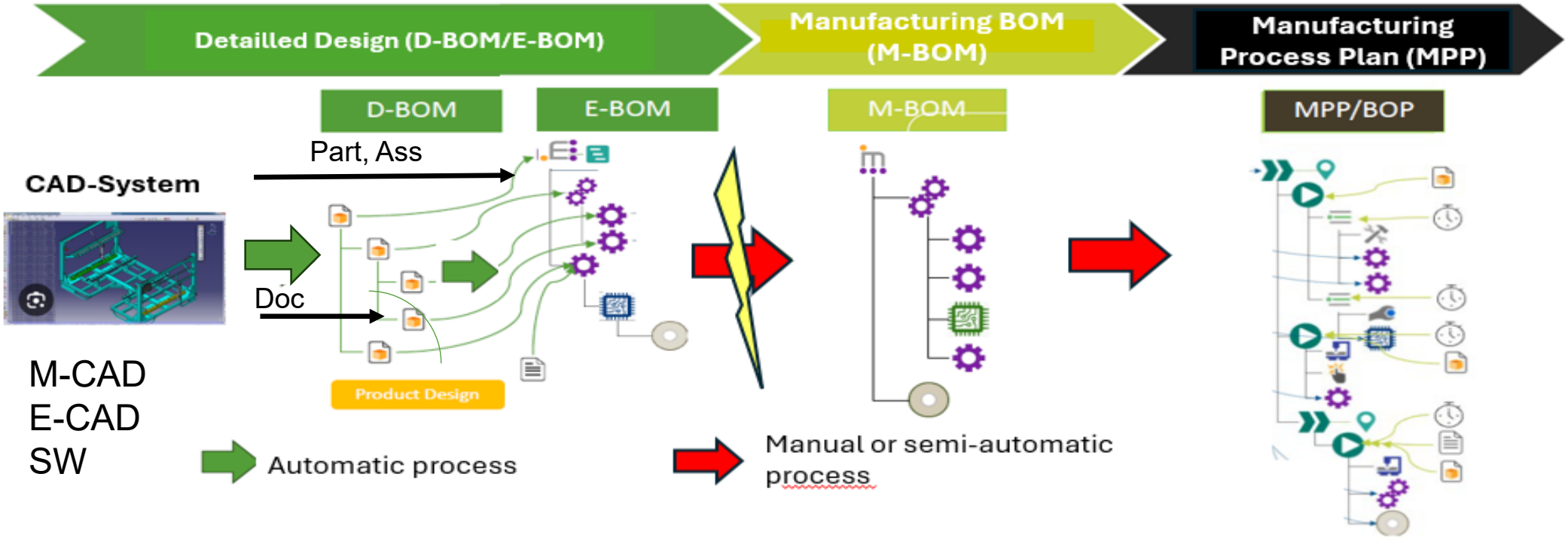
3 d) PLM → MRP/ERP

1 c) PDM → MRP/ERP

b2) ECTR → MRP/ERP PLM (SAP IPD (Public Cloud) / ILC4PEP (Premise oder Privat Cloud))

2 b1) ECTR → MRP/ERP z.B. SAP PLM (On Premise or Private Cloud)

a) CAD f.e.. Onshape → MRP/ERP (f.e.. SAP IPD oder Direct Integration (CIDEON)



How Can We Get Closer to our PLM Vision From the 90s?

- Mindshift in integrated and interdisciplinaryThinking (System Thinking)
- Model Based Design /Model Based System Engineering
- Change and Acceptance Management
- New Methodologies (Methods, Processes and Tools)
- New Software Technology
- Extended Digital Thread and Digital Twin
- Enable Artificial Narrow Intelligence
- NIVIDIA Omniverse for 3D simulation

Extended Digital Thread

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The Chief Engineer‘s Dilemma!
Traceability, Interdisciplinarity, Complexity, Sustainability

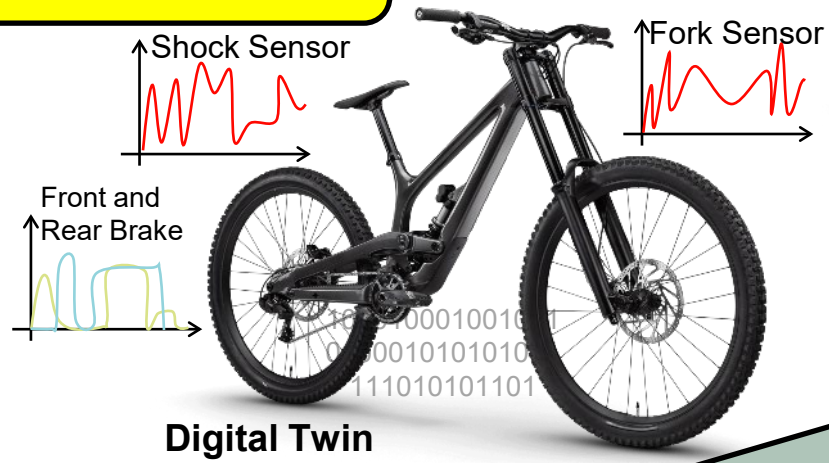
Oh no! Something's not working! **What do I need to change? What are the consequences?**

System definitions and requirements are **spread across different IT solutions**, with software in ALM, hardware in PLM, and SAP…

What is the carbon footprint?

How am I supposed to do impact analysis???

Digital Model
As-Designed



Digital Twin
As-Built

Physical Twin
As-Maintained

Failure Analysis

Digital Thread as a semantic backbone across IT-systems and silos

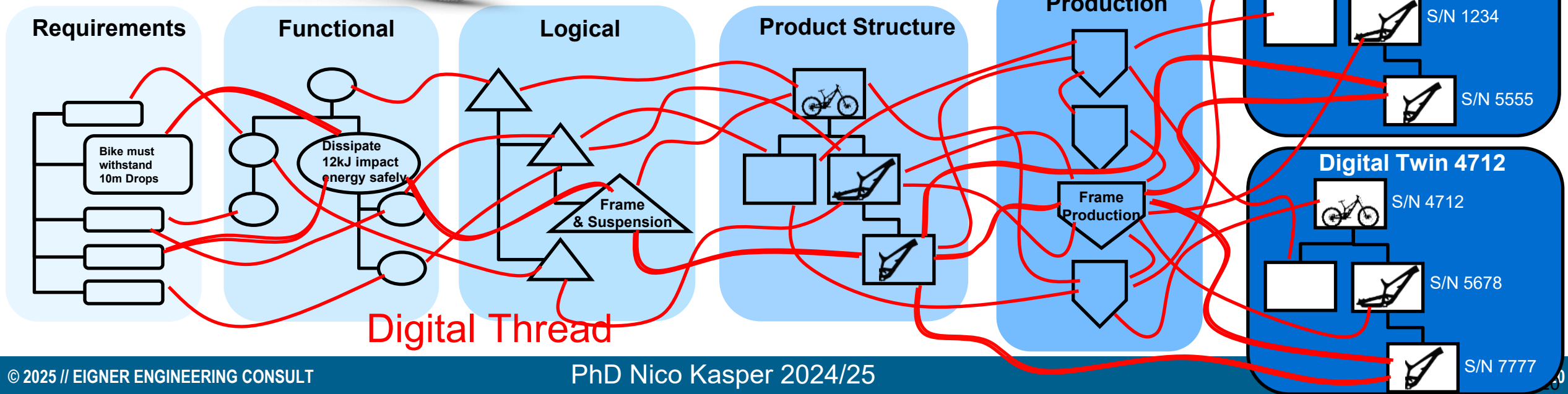
Engineering Change

The Digital Thread Connects the Configuration Items (CIs) and the Digital Twin Across the PLC

Digital Model
As-Designed

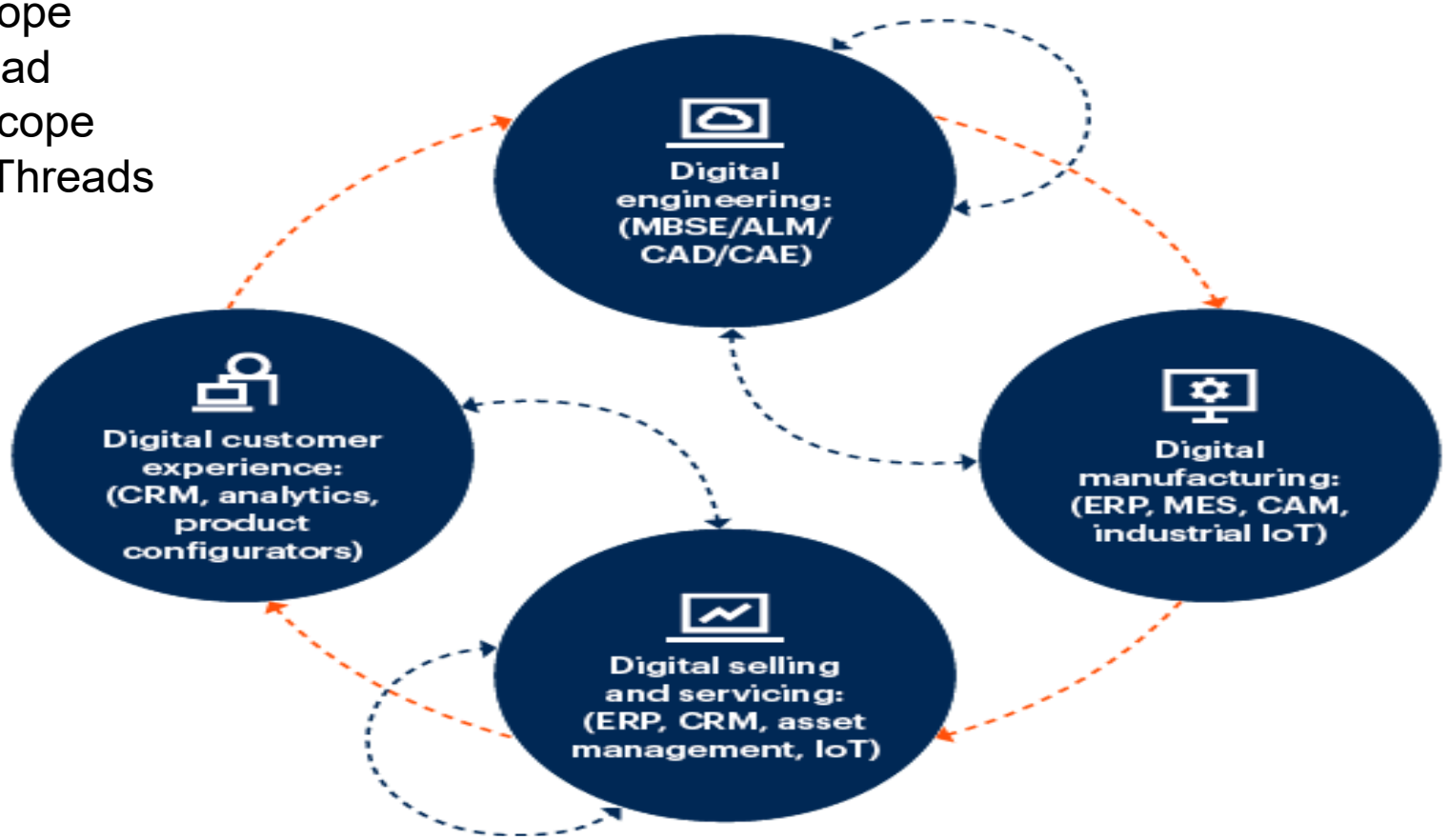
Digital Twin
As-Built

Physical Twin
As-Maintained



Digital Threads Can Span One or More Phases of the Product Lifecycle [4]

- Example of integration scope of end-to-end Digital Thread
- Examples of integration scope of different partial Digital Threads



Source: Implement Digital Threads for Long-Term Flexible Access for Critical Data, Gartner 2024, Marc Halpern et al.

The Extended Digital Thread (EDT)

- **All possible Configuration Items* (CIs) of the product and the product-related information items (resources)** along the PLC
- **All relevant Engineering and Production Processes CIs are involved (ECR, ECM, CM, QMS, MPP, …)**
- **The Interface for AI (LLM) via Model Context Protocol (MCP)**
- **Change and configuration management across different legacy systems**. Changes must be traced along the PLC
- **Guarantee for general Traceability**

* Configuration Items are technical elements along the product lifecycle which are revised according to operational agreement potential in changes and thus are subject to configuration management. The elements really affected by a change are referred to as an affected or impacted item (ISO 10007)

PLC = Product Lifecycle

The Exteded Digital Thread: CIs+ and Processes

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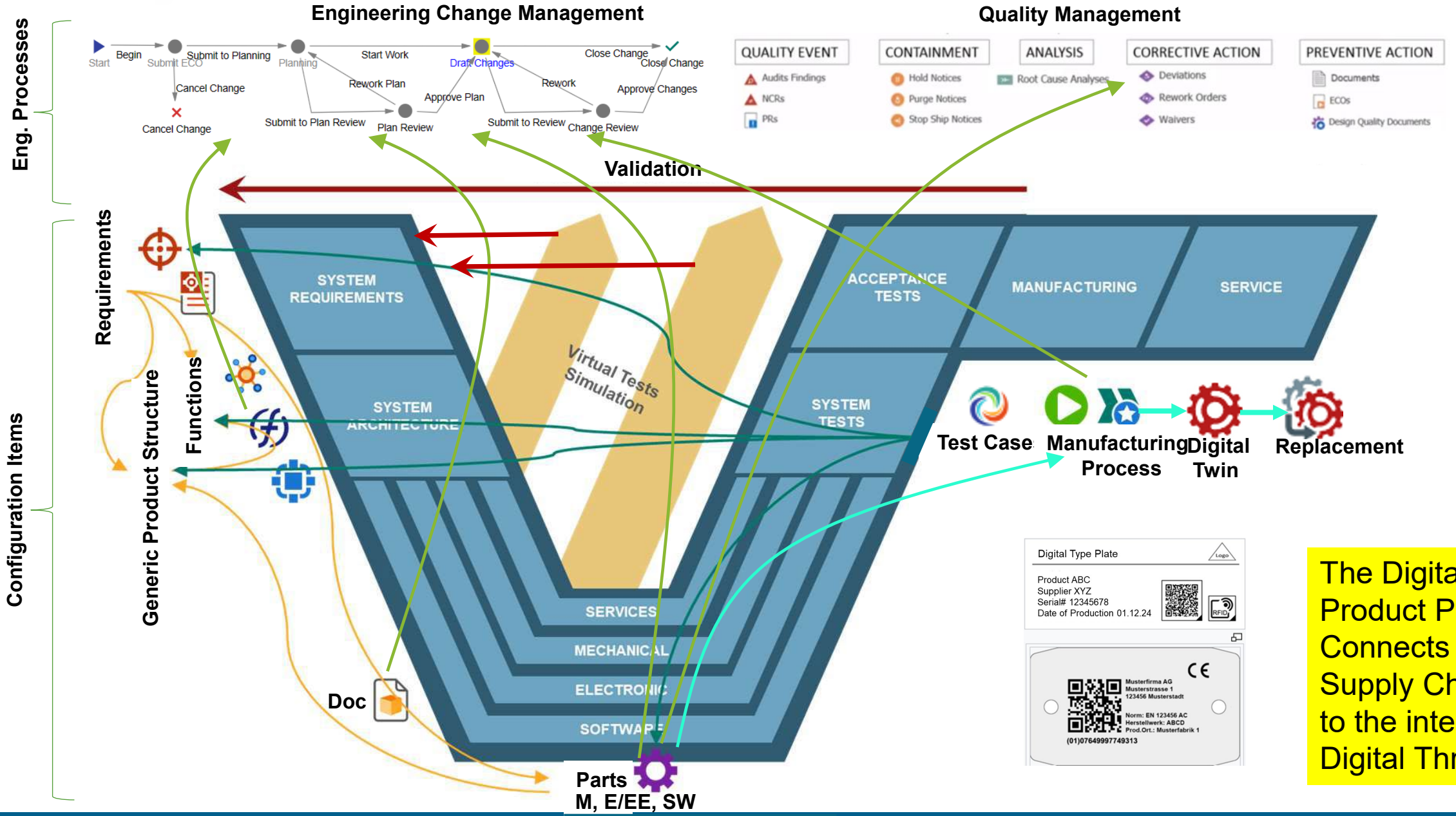
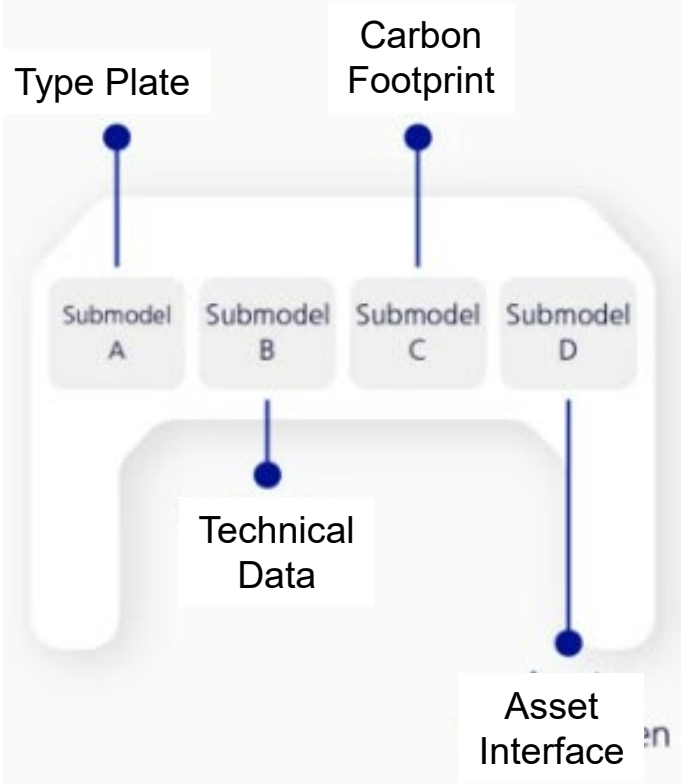


The Digital Product Pass Connects the Supply Chain to the internal Digital Thread

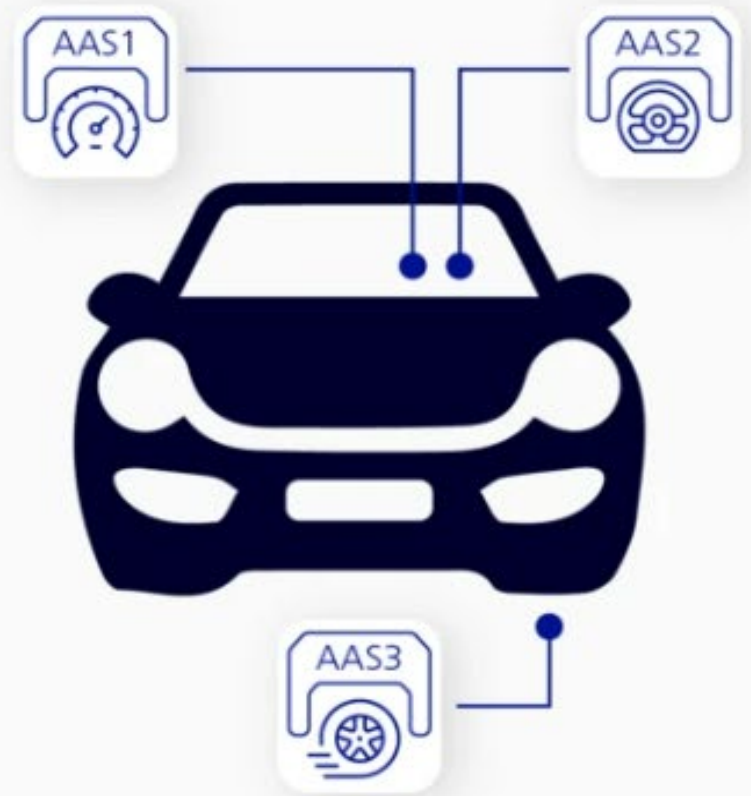
AAS Asset Administration Shell

Connects the Supply Chain with the Digital Thread (DIN EN 63278)

Repräsentation des Assets



AAS Integration



Standardisierte Apps

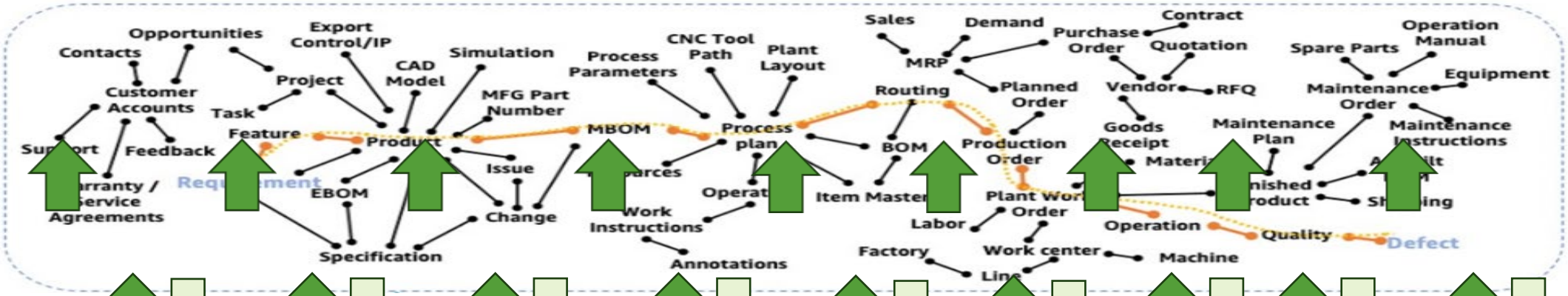
The Concept of an Extended Digital Thread (EDT)

The implementation is done using a Graph DB.

Processes

Change Management | QMS/FMEA | Impact Analysis | AI / LLM

Data Model EDT



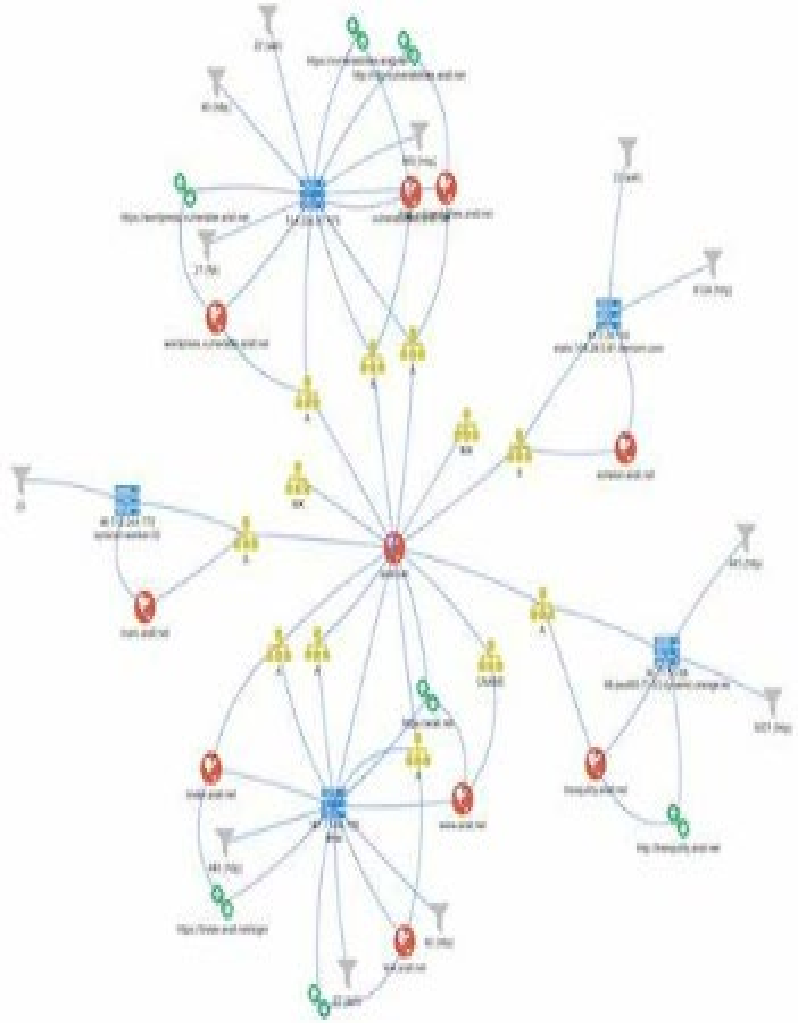
COTS

CRM CPQ | RM | SA | PDM | ALM | CAE | MPP | MRP/ SCM | MRO

Requirement Definition | System Architecture | Design Cax + E-BOM | Virtual und Physical V&V | Manufacturing Process Planning | Operation

Product Lifecycle

The Extended Digital is Realized by a Knowledge Graph



- A **knowledge graph** is a data structure that represents knowledge in a machine-readable format.
- Knowledge graphs play a crucial role **in enhancing traceability** by providing a unified framework for accessing data across legacy systems.
- The Product Knowledge Graph is building and collecting both **product and process knowledge** together.
- It is becoming **a foundation of product-related AI LLM** (Large Language Model).

Source 1: Oleg Shilovitsky, MyAgilePLM, Jan 8th, 2024

Source 2: Martijn Dullaart, ASMLShaping the future of CM | Book: The Essential Guide to Part Reidentification: Unleash the Power of Interchangeability & Traceability, Nov. 2023

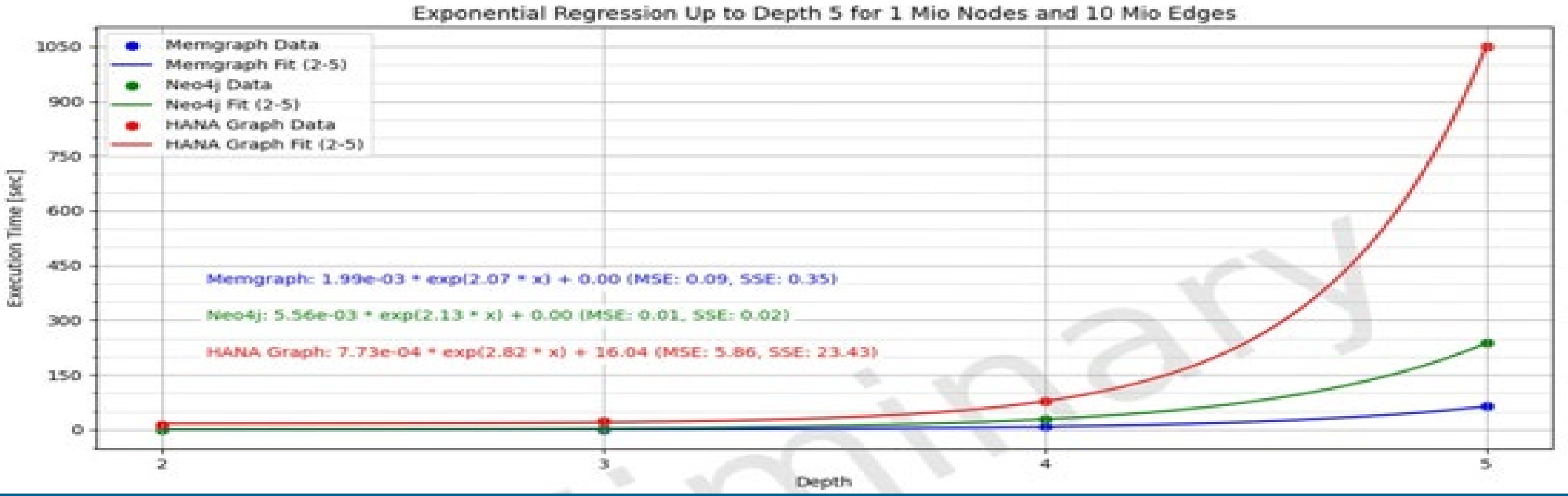
The Knowledge Graph is Realized by a Graph DB

Superior Technology: Relationships are stored directly with nodes, eliminating the need for joins.

Fast Querying: **Constraint-based filtering** is efficient due to the use of **labels** and **properties**.

Easy Customization: **Flexible schema** allows for simple configuration and customization

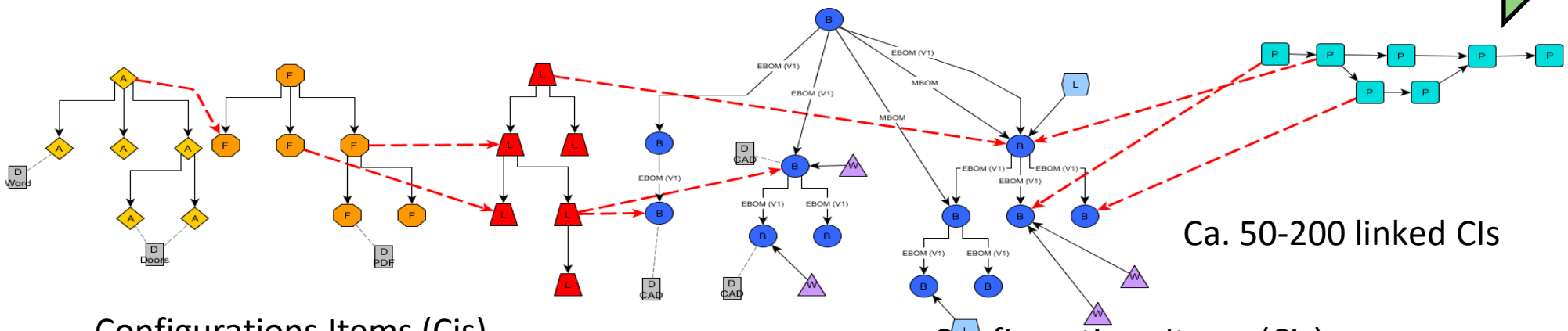
The key advantage of graph databases is the optimization for recursive operations



Digital Thread as Knowledge Graph of Connected Cis
(SAP R&D Project)

Engineering Processes: ECR, ECM, Traceability, QMS, Digital Twin Core

SW-Technologie
- Low Code
- Interactive Repository
- Graph. DB
- Microservices
- Data Linkage RDF/REST
- Easy to configure
- Open



Configurations Items (Cis)

Configurations Items (Cis)

CRM

CPQ

ALM

PLM System

Master Data
E-BOM
Documents
M-BOM
BOP/MPP

PLMSI

SAP S/4HANA

MES/MOM

SCM

Digital Factory

Prio 1 (ca 70-80% der Cis)

Digital Thread as Knowledge Graph of Connected Cis
(SAP R&D Project)

Engineering Processes: ECR, ECM, Traceability, QMS, Digital Twin Core

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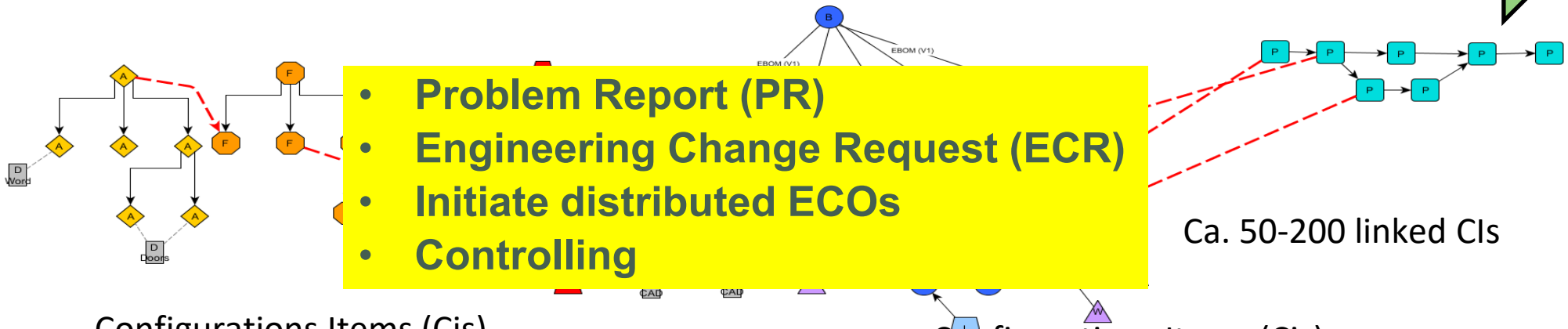


- Problem Report (PR)
- Engineering Change Request (ECR)
- Initiate distributed ECOs
- Controlling

Ca. 50-200 linked CIs

Configurations Items (Cis)

Configurations Items (Cis)

CRM

CPQ

ALM

PLM System

Master Data
E-BOM
Documents
M-BOM
BOP/MPP

PLMSI

SAP S/4HANA

MES/MOM

SCM

Digital Factory

Prio 1 (ca 70-80% der Cis)

Dimensions of Digital Thread Software

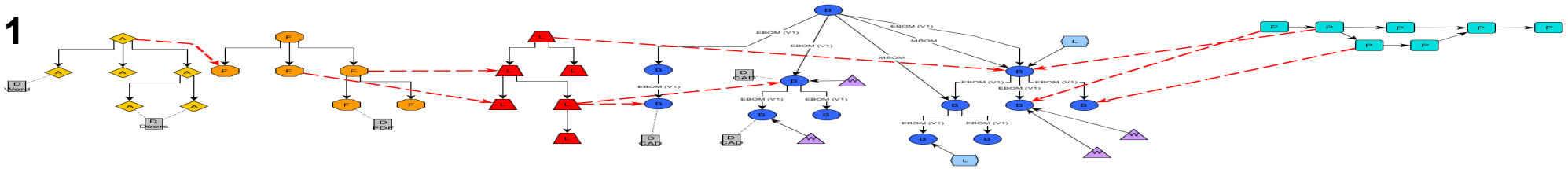
Our „Lifecycle Hub“ prototype is based on this

Digital Thread Software Classification Framework

Passive Digital Thread Data Warehouse e.g. for AI analysis and decision support	**System Behavior**	**Active Digital Thread** Enabling bi-directional exchange between authoring systems and knowledge graph
Partial Lifecycle	**Lifecycle Coverage**	**Full Lifecycle**
Fixed Data Model (Maybe customizing for On-Premise)	**Adaptability**	**Configurable** During runtime with No-/Low-Code even in Cloud
Single Database Single database handles all data types and operations	**Database Architecture**	**Polyglot Persistence** Multiple specialized databases optimized for specific use cases
Embedded in Legacy Systems (E.g. PLM, ERP,…)	**Deployment Architecture**	**Stand-Alone Solution**
On-Premise	**Environment**	**Cloud** Digital Thread as a Service

Two possible Solution for a DT/DTaaS Implementation

Solution 1

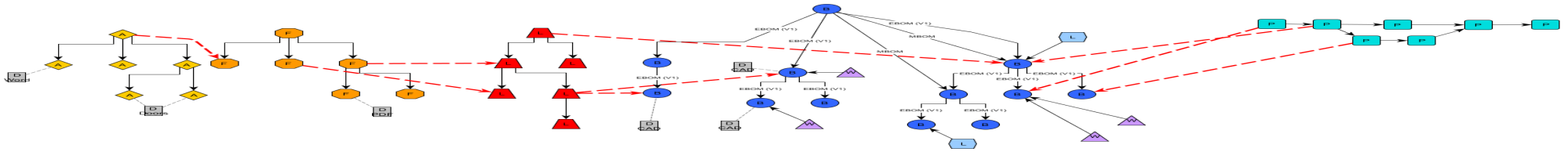


Level of DTaaS with minimal redundancy and linked data (PLM vision)

COTS Level

CRM | CPQ | RM | PDM | ERP | MES | SCM

Solution 2



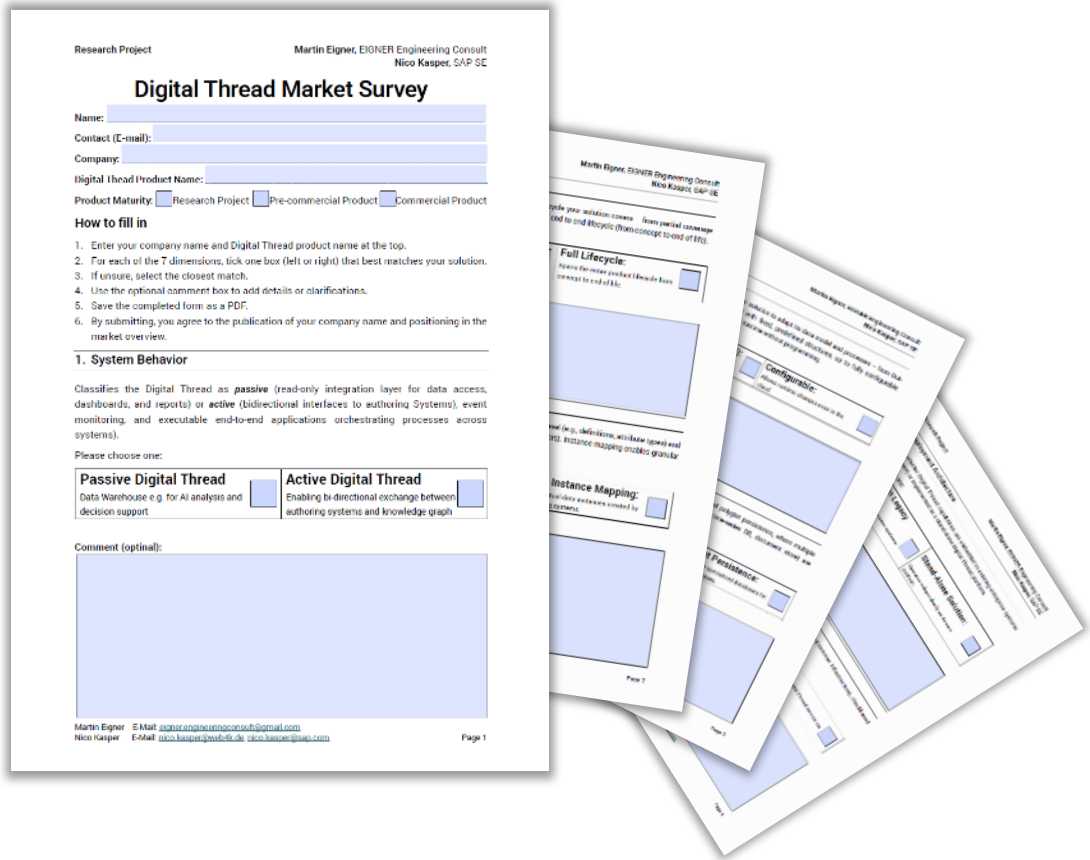
Level of DTaaS with minimal redundancy and linked data (PLM vision)

COTS Level

CRM | CPQ | RM | PDM | ERP | MES | SCM

Digital Thread Market Survey

We are currently conducting a comprehensive market study with industry partners to assess the implementation status of Digital Thread systems.



Research Project

Martin Eigner, EIGNER Engineering Consult
Nico Kasper, SAP SE

Digital Thread Market Survey

Name:
Contact (E-mail):
Company:
Digital Thread Product Name:
Product Maturity: Research Project Pre-commercial Product Commercial Product

How to fill in

1. Enter your company name and Digital Thread product name at the top.
2. For each of the 7 dimensions, tick one box (left or right) that best matches your solution.
3. If unsure, select the closest match.
4. Use the optional comment box to add details or clarifications.
5. Save the completed form as a PDF.
6. By submitting, you agree to the publication of your company name and positioning in the market overview.

1. System Behavior

Classifies the Digital Thread as **passive** (read-only integration layer for data access, dashboards, and reports) or **active** (bidirectional interfaces to authoring Systems), event monitoring, and executable end-to-end applications orchestrating processes across systems).

Please choose one:

Passive Digital Thread	Active Digital Thread
Data Warehouse e.g. for AI analysis and decision support	Enabling bi-directional exchange between authoring systems and knowledge graph

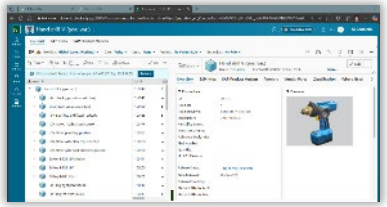
Comment (optinal):

Martin Eigner E-Mail: eigner.engineeringconsult@gmail.com
Nico Kasper E-Mail: nico.kasper@web4tk.de nico.kasper@sap.com

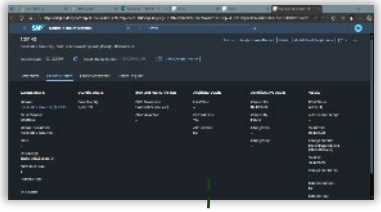
Page 1

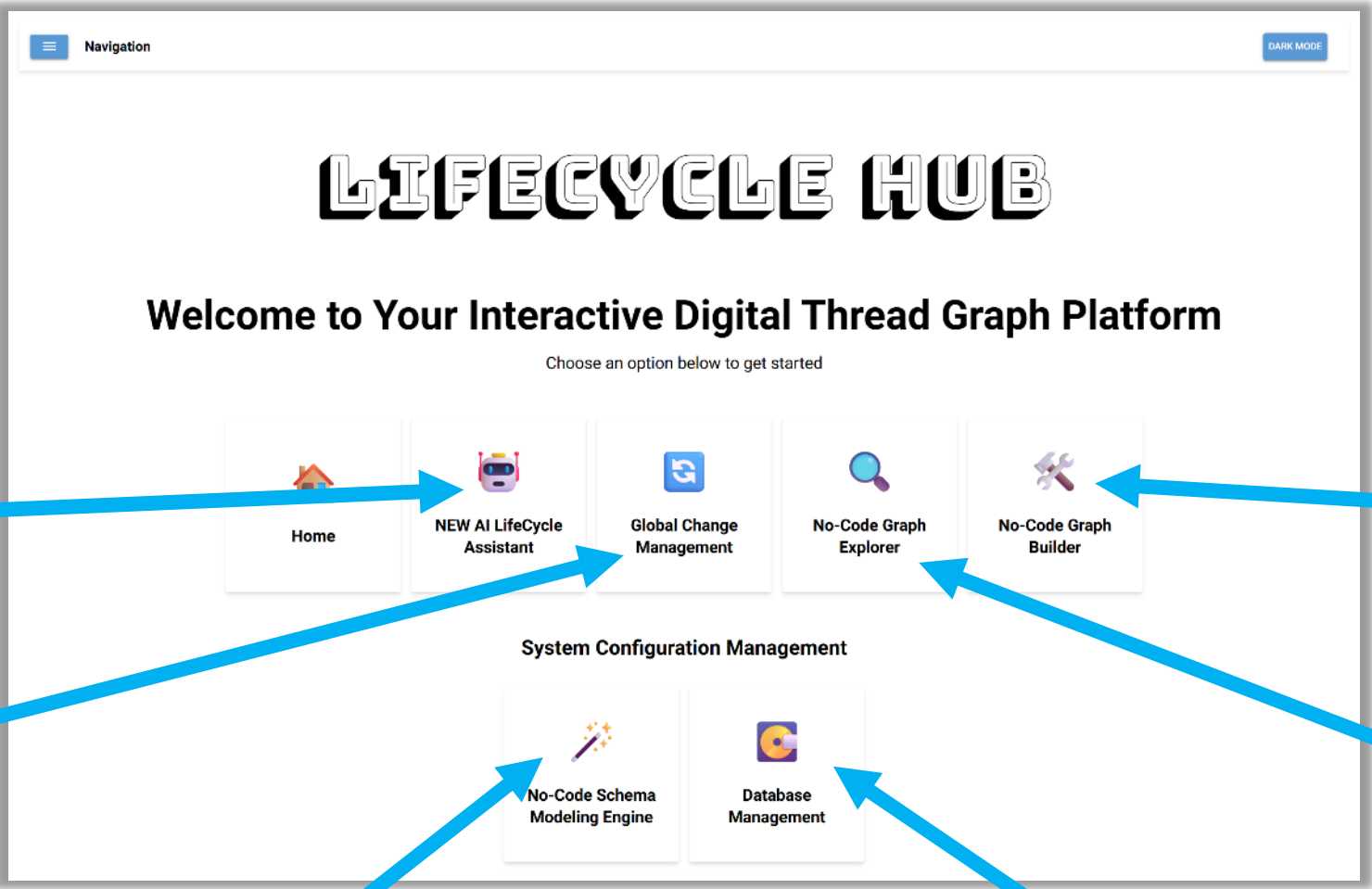
SAP R&D Project EDT (Lifecycle Hub)

Teamcenter



S/4HANA





AI-Assistant
Natural language interaction with the lifecycle data
→ Full CRUD Support

Graph Builder
UI-driven creation and linking of objects and relations without code
→ Full CRUD support

Global Change Management
Initiation and orchestration of changes across IT-Systems

Graph Explorer
Lifecycle data visualization
→ Table form
→ Graph visualization

Modeling Engine
No-Code configuration of the data model
→ Instantly propagates model updates to UI and APIs during runtime

Database Management
Polyglot persistence management
(SQL, Neo4j, Memgraph, MongoDB)

Node Filter

Node Label:

All

Edge Filter

Relationship Type:

All

Node Property Filter

Property:

All

Value:

Enter property value

Edge Property Filter

Property:

All

Value:

Enter property value

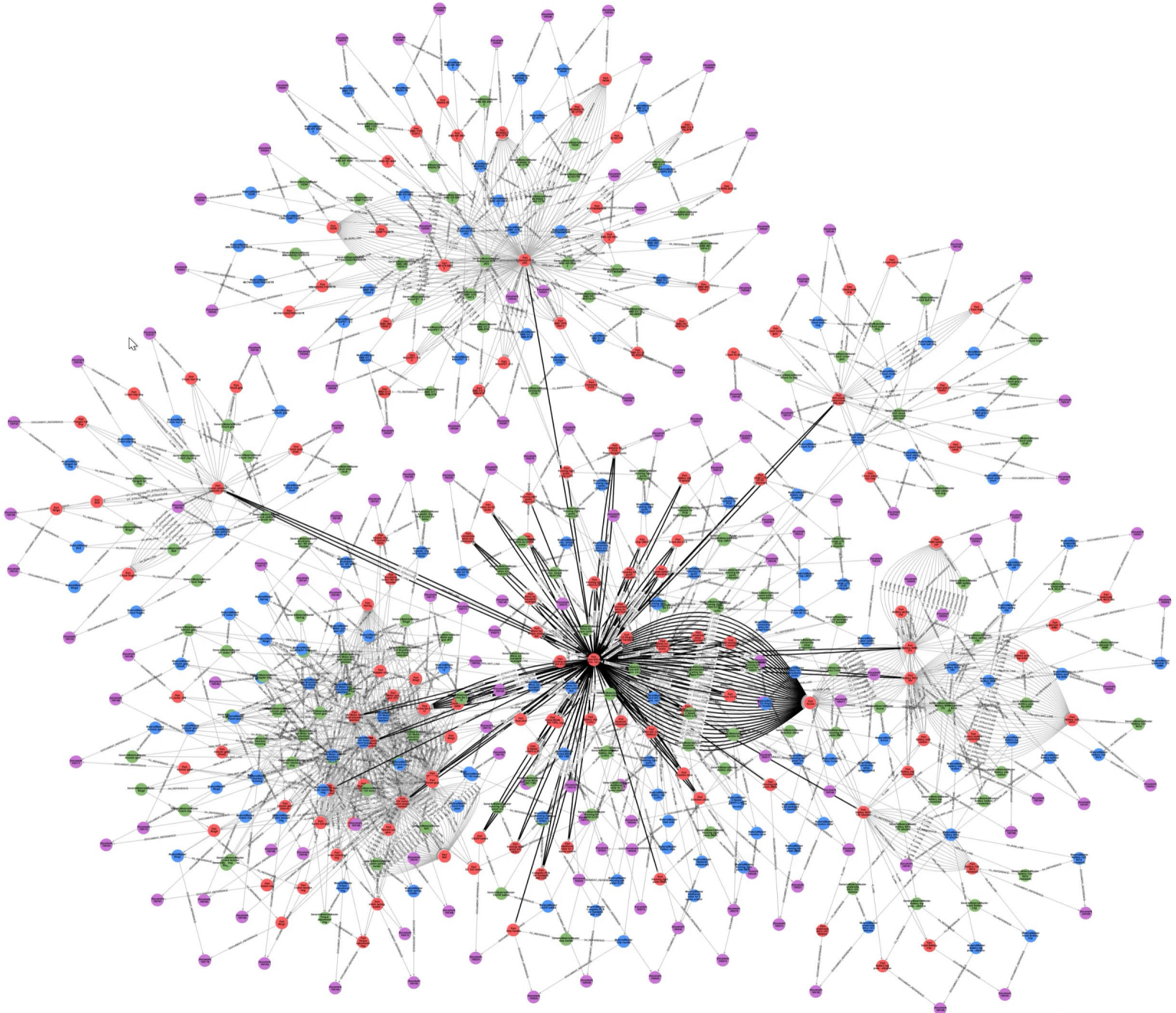
Add Filter

Filter Type:

Node Label

Add Filter

Center Graph | Rearrange



Details

UUID	36222711-d551-4377-977a-30180fc7a9c6
Label	Part
description	3-001-000305
name	Hand drill V (pos. var.)
part_number	100140
status	Released
validfrom	2024-12-01T23:00:00.000000000+00:00
validuntil	9999-12-31T23:59:59.000000000+00:00
version	C

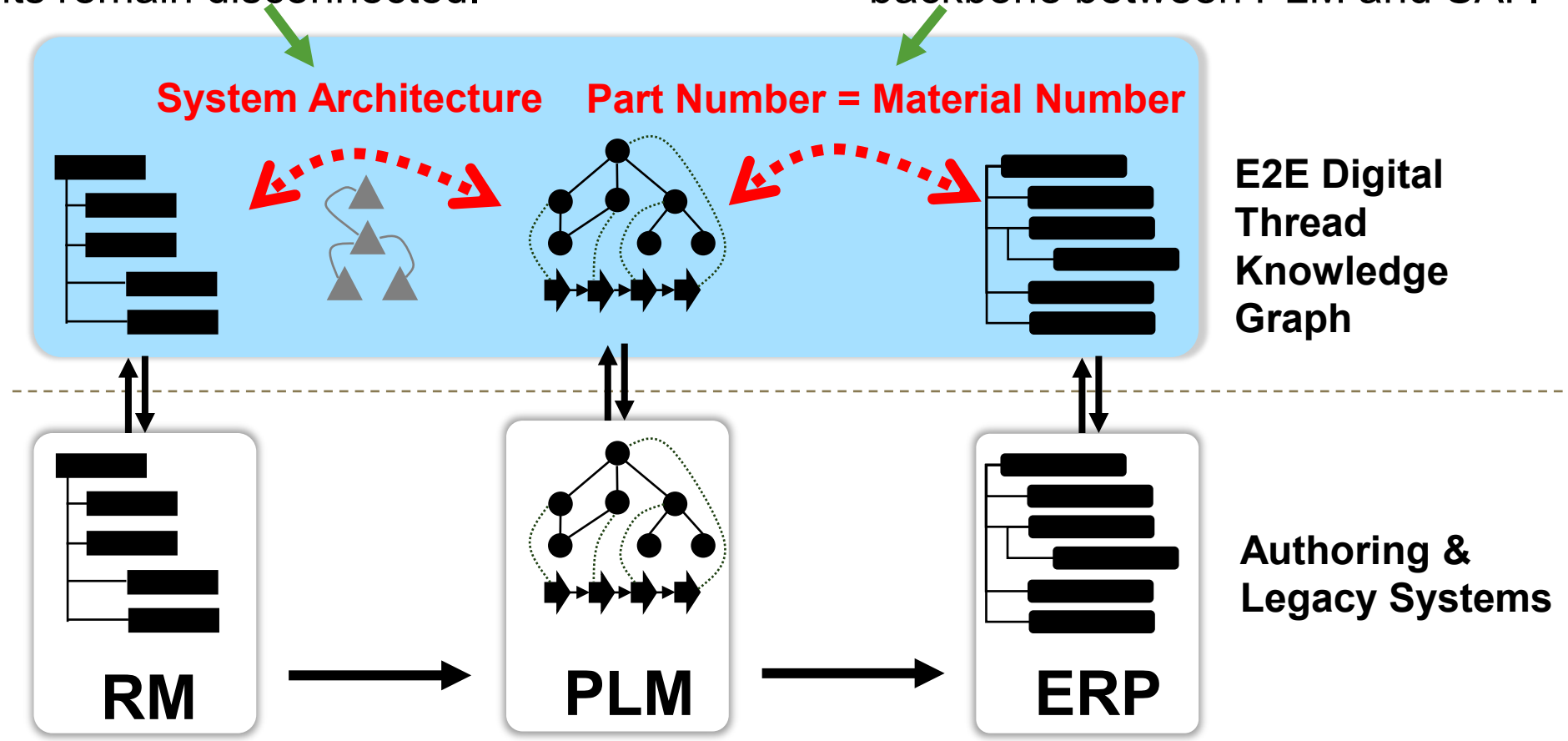
Total Nodes: **544** Total Edges: **1743**

How are Substructures from Legacy Systems Connected at the Digital Thread level? (Problem 1)

Legacy systems stay isolated without logical links.

Without system architecture, requirements remain disconnected.

Consistent IDs create the logical backbone between PLM and SAP.

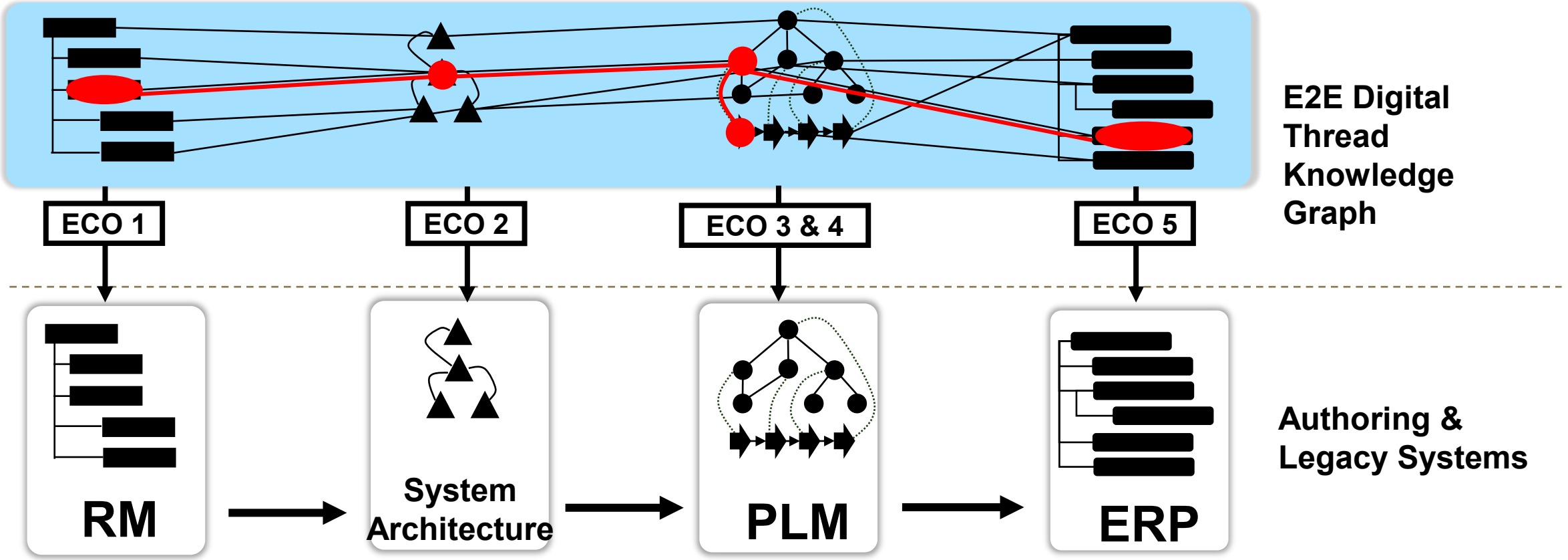


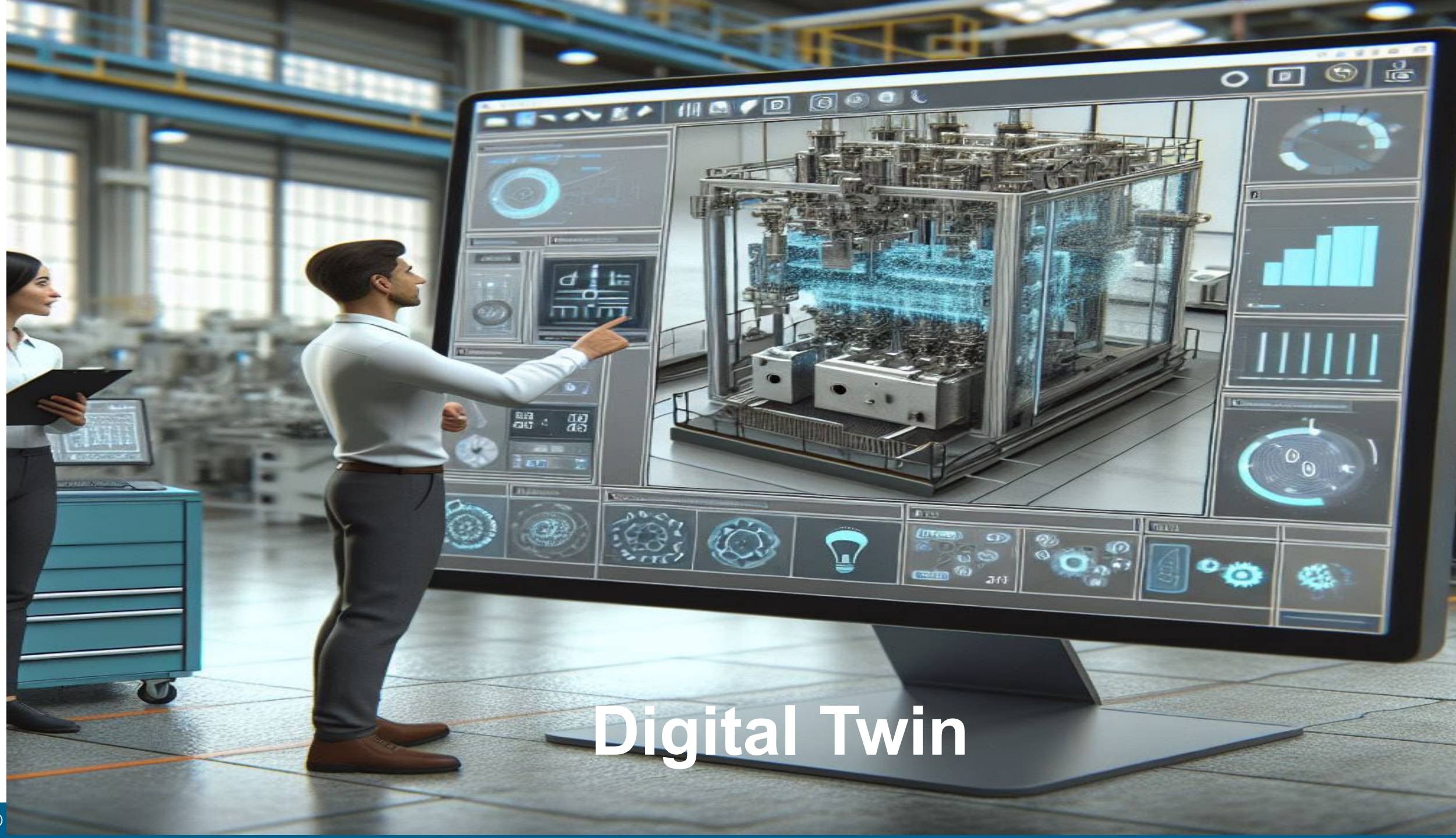
Active Interface-Based Distribution and Synchronization of ECOs to Legacy Systems (Problem 2)

After identifying the affected items, ECOs must be sent to the legacy systems.

Two questions:

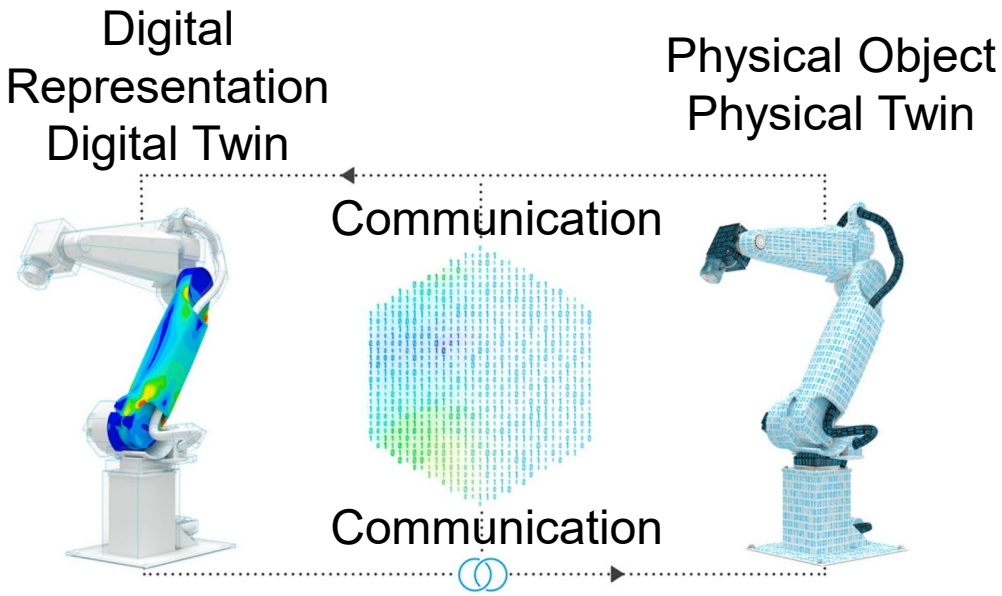
- How are ECOs executed at the legacy level?
- How is implementation status reported back?




Digital Twin

The Three Elements of a Twin Concept [3]

The Twin concept consists of three distinct parts: the physical object (Physical Twin) or process and its physical environment, the digital representation (Digital Twin) of the object or process, and the communication channel between the physical and virtual representations. The connections between the physical version and the digital version include information flows and data that includes physical sensor flows between the physical and virtual objects and environments. The communication connection is referred to as the Digital Shadow.



Types of Digital Twins [6, 7]

Component Twins

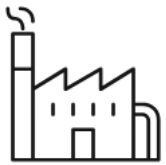
Component twins are digital models of individual components or parts, such as motors, sensors, switches and valves. They provide detailed information about a component's performance and behavior both in real-time and over time. This helps organizations monitor the health and performance of these components and make necessary changes.

Asset Twins

Asset twins are digital models of physical assets such as buildings, machines and vehicles. They provide information on an asset's operational status, performance data, and environmental conditions in real-time. This helps organizations reduce downtime and improve the efficiency of their operations.

System Twins

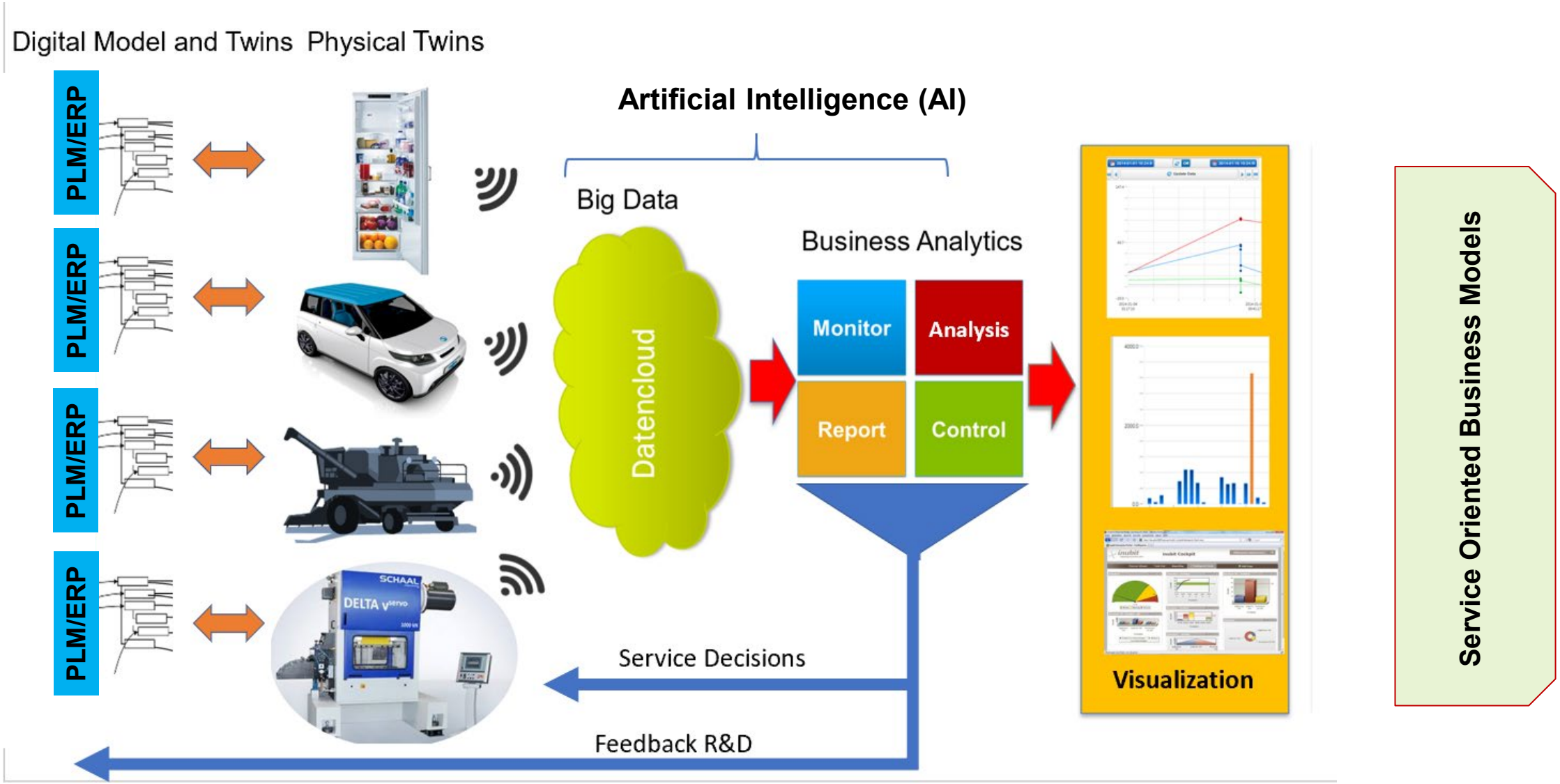
System twins are digital models of entire systems or processes. They allow organizations to monitor and analyze a system's performance and identify areas where improvements can be made. System twins enable organizations to optimize their processes and improve the way they operate.



Process Twins

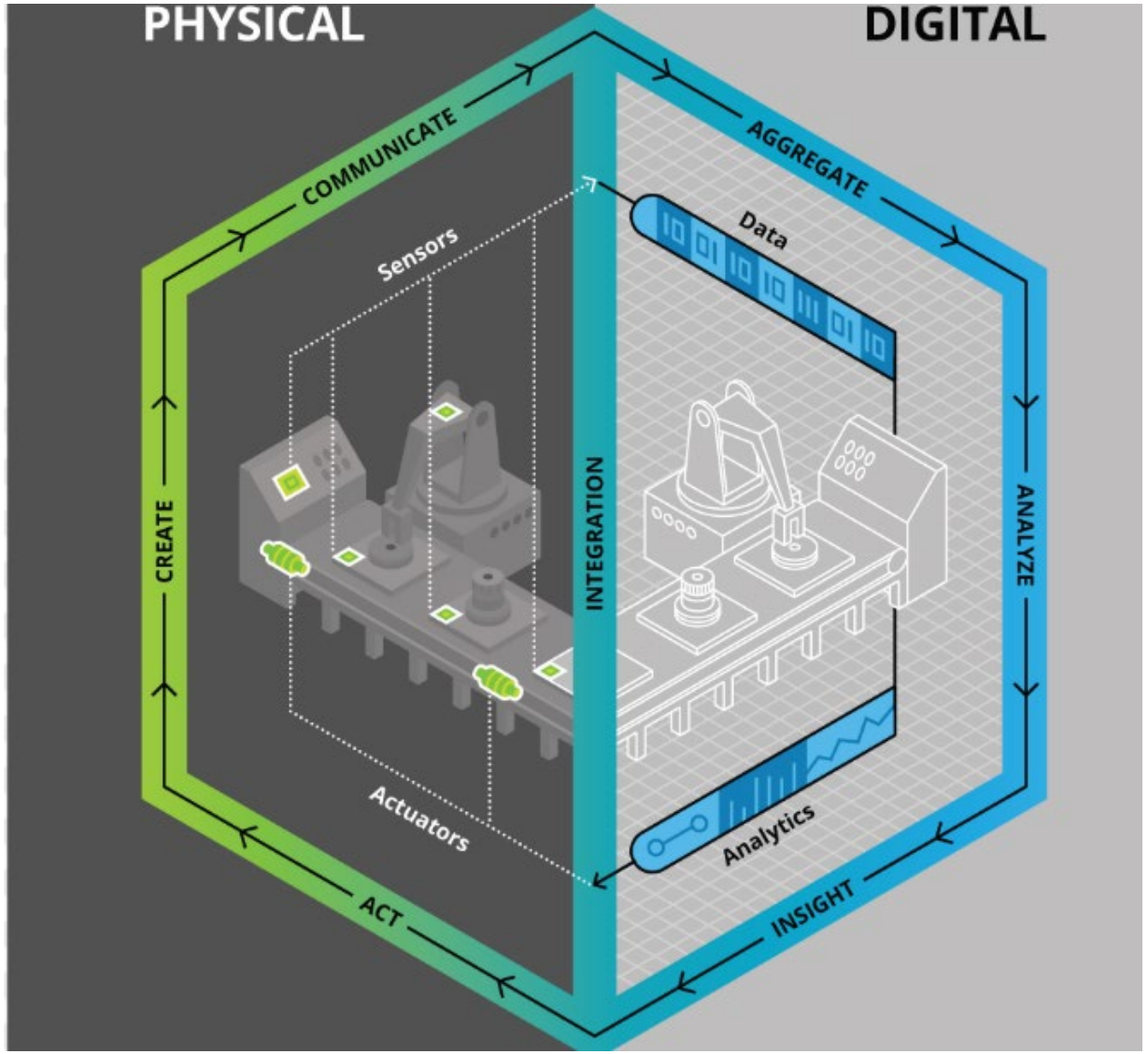
Process twins are digital models of entire business processes or customer journeys. They show how systems work together and provide detailed information on how customers interact with an organization's products and services in real-time. This helps organizations to identify areas where customer experience can be improved.

Principals of Service Oriented Business Models



Examples of Digital Twin Based Business Models [12]

- Predictive Maintenance
- Update and Upgrade on Air
- Sustainable Design
- Circular Economy
- Energy-efficient Production Control
- Multi-Criteria Assessment of Sustainability
- Virtual Commissioning
- Optimization of Energy Systems
- Optimization of Material Consumption



The Digital Twin in an Aerospace Application

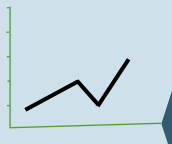
source: airbus

Time Series Data

Airspeed
Altitude
Barometric Pressure (electronic/aneroid)
Outside Air Temperature (C/F)
Fuel pressure (x number of engines)
Fuel flow (x number of engines)
Cabin air pressure (psi/hg)
Cargo air pressure; doors, bulkheads
Cabin temperature; doors, bulkhead
Cargo temperature
Fuel temperature; fuel tanks, fuel pumps
Radar air traffic – TCAS

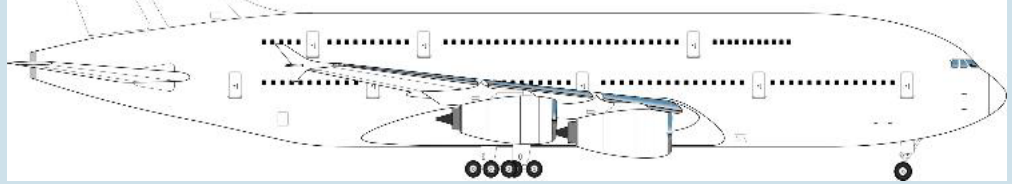
Hydraulic Pressure; brakes, flaps, spoilers, rudder, aileron, landing gear pumps
Weight sensors - landing gear
Turbines; RPM (N1/N2), Inlet- turbine pressure, Temperature, fuel burn, Voltmeter; cockpit, main bus, cabin, auxillary power, cargo, engines, APU
Generator meters (engines, APU), Electricity Load (amp/hr); flight deck, cabin, cargo
Fire sensors; cabin, cargo, engines, fuel, brakes, electronics bay, Carbon Dioxide; cabin, cargo, Magnetic Compass
GPS (satellite / terrestrial), Radio Compass (NDB)
Doppler radar; weather, lightning, downdraft (microburst)

Simulate & Analyze



PLM Platform (Context)

Digital Model Product Data + Digital Twin configuration + Digital Thread traceability



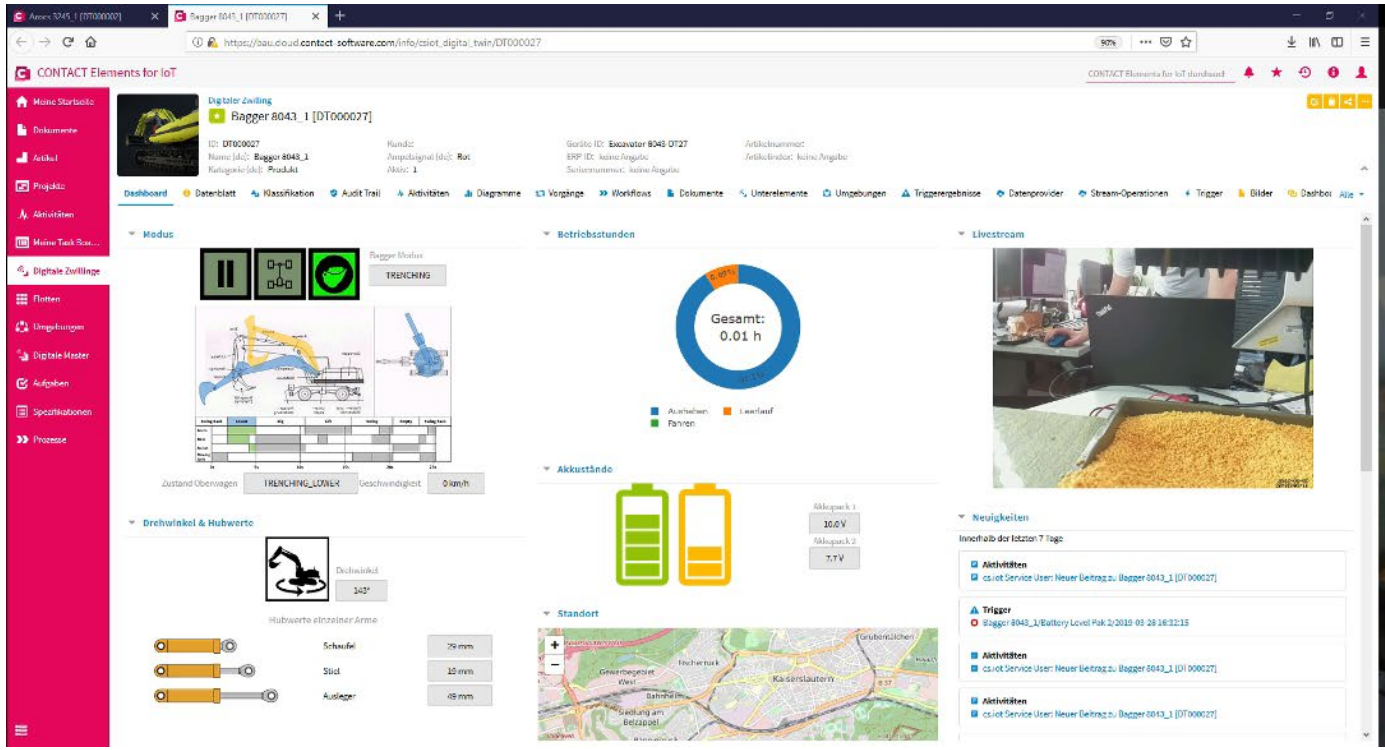
The Simulation Environment (LEGO)

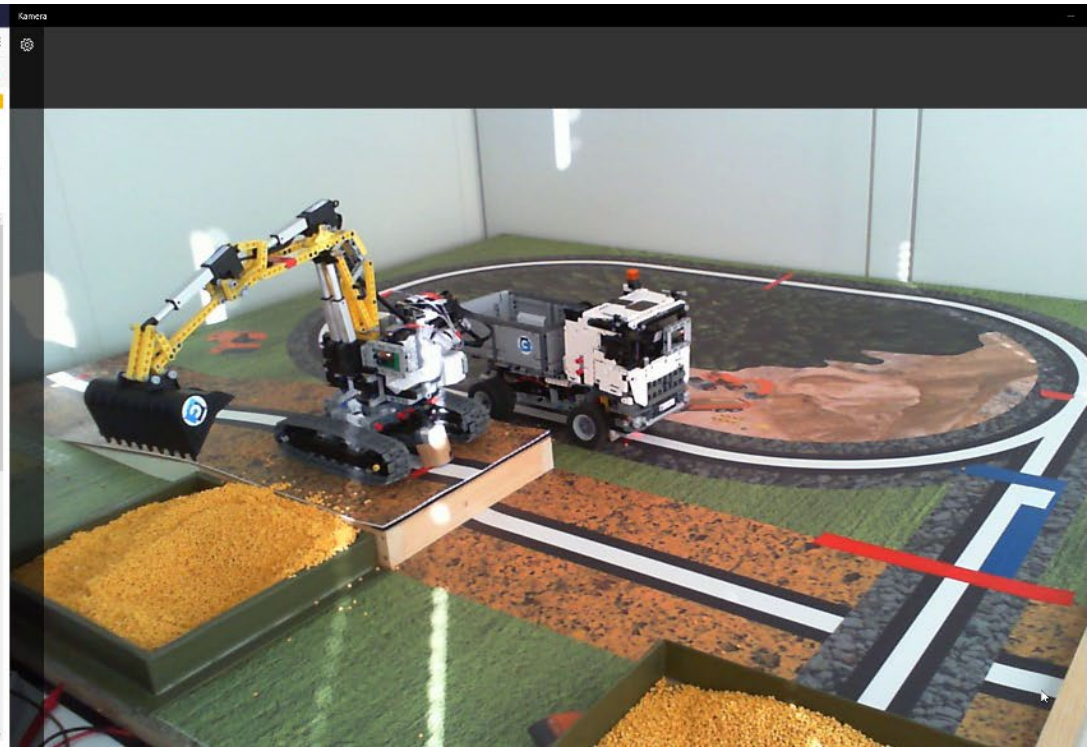
Raspberry Pi Control Unit

Dickopf, T.: A Holistic Methodology for the Development of Cybertronic Systems in the Context of the Internet of Things, PhD in: Eigner, Martin (Hrsg.), TU Kaiserslautern, Schriftenreihe VPE, Band 23, Kaiserslautern, 2020

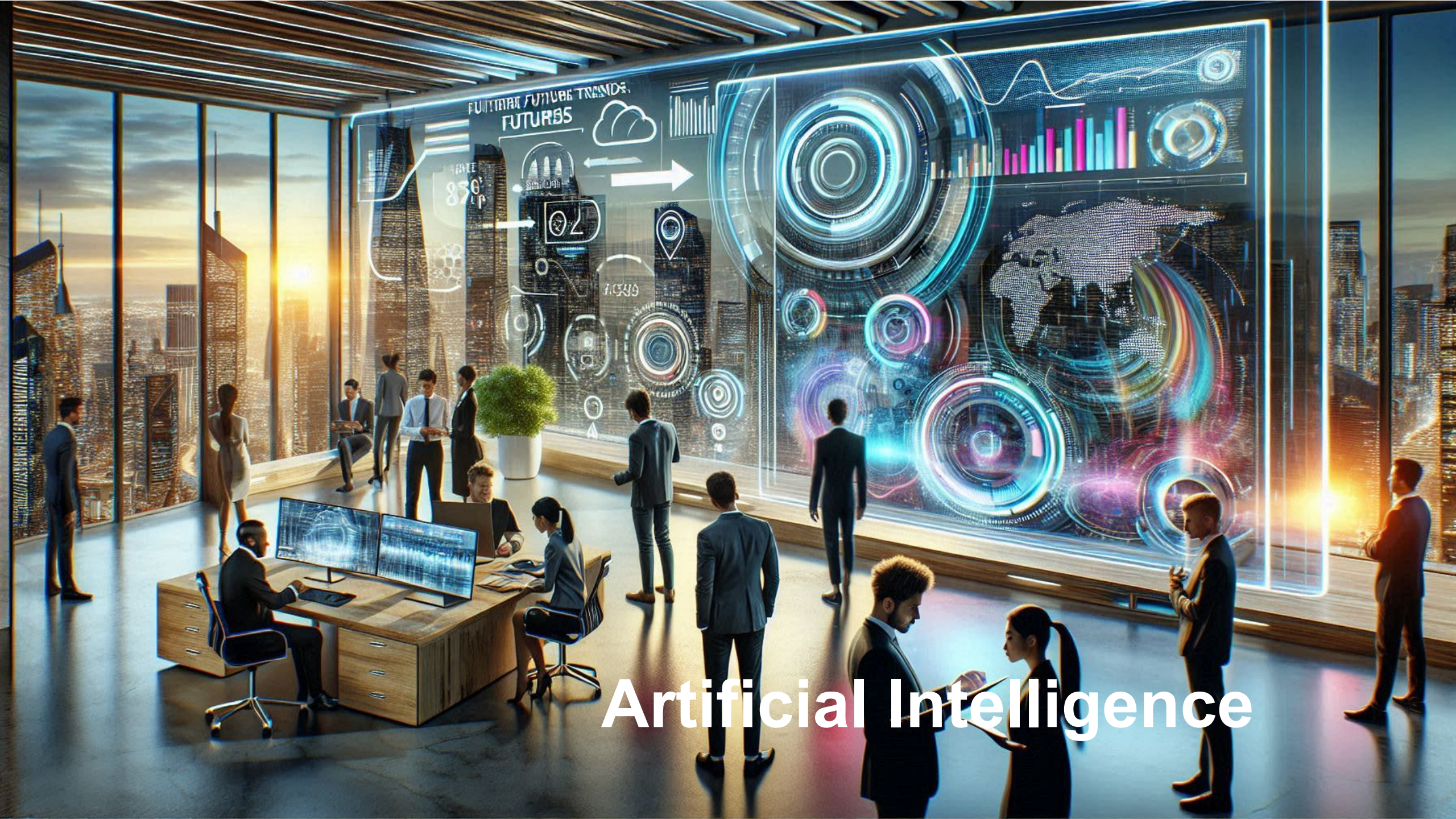
Visualization of the Feedback from the Digital Twin

The assets are only partially defined geometrically, but have been described with CAMEO and Modelica using their functions and behaviors and stored in PLM.





Dickopf, T.: A Holistic Methodology for the Development of Cybertronic Systems in the Context of the Internet of Things, PhD in: Eigner, Martin (Ed.), TU Kaiserslautern, Series VPE, Volume 23, Kaiserslautern, 2020



Artificial Intelligence

Historical Background

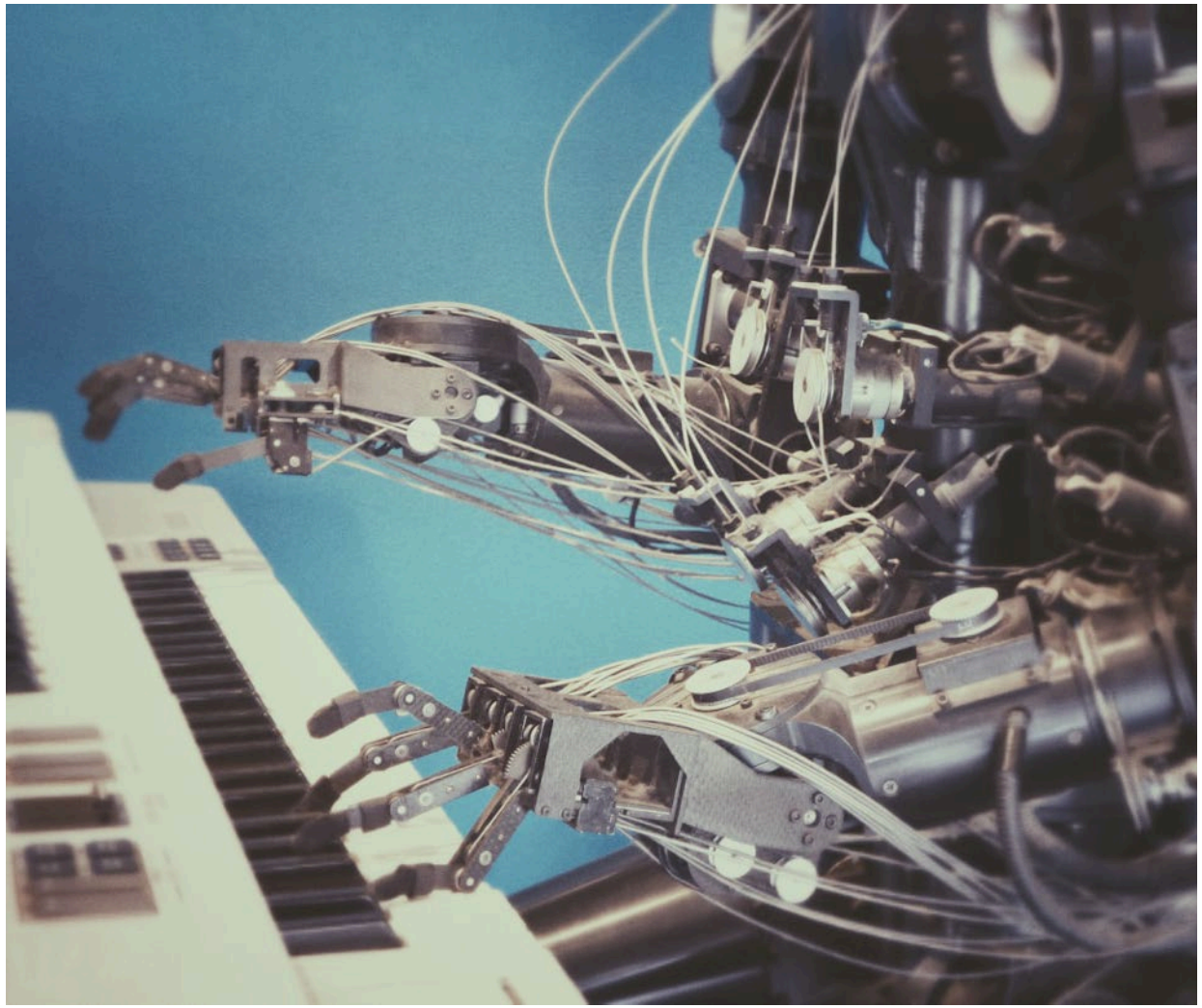
Development and Milestones

In 1948, **Alan Turing** described the possibilities that intelligent machines could achieve. In 1950, he posited that computers would reach human intelligence and could even impersonate humans. The term AI (Artificial Intelligence) was first mentioned in 1955 [**J. McCarthy, et al**.]. However, there is no universally accepted definition, only a multitude of interpretations shaped by various perspectives. This may also be due to the fact that even the term intelligence lacks a widely accepted definition.

Definition of AI

Mindsquare Definition

"Artificial intelligence describes the ability of machines to perform tasks autonomously based on algorithms and to react adaptively to unknown situations. Their behavior is thus similar to that of humans: They not only perform repetitive tasks, but also learn from success and failure and adapt their behavior accordingly."



Current Discussions

- In the scientific discussion regarding the current status and relevant research goals, there are significant differences of opinion. Some experts believe that the Large Language Model (LLM) represents a significant advance toward artificial general intelligence (AGI), while others are skeptical.
- Yann LeCun, the Chief Scientist for AI at Meta, argues that **while AGI is fundamentally possible, it is not technically feasible at this time based on LLM**. A breakthrough is still a considerable way off.
- This assessment is shared by 1712 leading researchers from the universities of Berkeley, Oxford, and Bonn. They estimate the probability that a machine will be developed by 2028 that can perform a task better than a human at 10%. For 2047, even among researchers, the probability is only 50%.

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Four Levels of Intelligence

From Human to Artificial Super Intelligence

Here we are

The four stages of intelligence describe the development from

- Human Intelligence (HI) to
- Artificial Narrow Intelligence (ANI) to
- Artificial General Intelligence (AGI) and finally to
- Artificial Super Intelligence (ASI).

These stages illustrate the progress and challenges associated with the further development of AI.

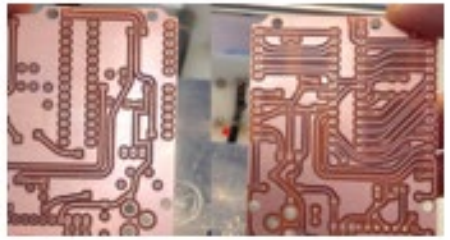
Level 1: Human Intelligence

- **Projection of light edges onto free-form surfaces** (a). Interactive displacement creates the surface changes desired by the design (EC Fiores project, RPE, RPTU).
- **Derive a digital thread** across multiple legacy systems to identify potentially affected items in the event of a change (b).
- **Generation of printable volumes** from specified parameters (nTop) (c)
- **Routing of double layer PCBs** (d),

a) Projekt Fiores, VPE, RPTU

b) PhD Nico Kasper, VPE, RPTU

c) nTop



d) JAMINDO PCBA JIADUN GAOSHI

Level 2: Artificial Narrow Intelligence in Engineering

Also known as weak AI. ANI is commonly used in engineering to perform specific tasks with high precision, high automation, and thus efficiency. Diligent, not creative. Here are some examples:

- **Predictive maintenance**: ANI systems analyze machine data to predict maintenance needs, reduce downtime, and prevent costly failures.
- **Optimization of simulations**: Computational programs with multiple interdependent parameters can achieve much higher quality and optimization goals through AI-assisted optimization.
- **Quality control**: Image recognition software is used to inspect products for defects during the manufacturing process.
- **Robotic Process Automation (RPA):** Robots are programmed to perform repetitive tasks such as welding, painting, and assembly of products.
- **Code assistant for intelligent software development**: ANI is already an essential part of software development, assisting in code completion, testing, and documentation.
- **Optimization of desktop applications** (text, images, analysis,…)

ANI Level 2: Transforming PLM into an Intelligent Backbone

🔍 Intelligent Classification

- Automates part, document, and variant classification
- Reduces manual effort and improves data consistency

🧠 Root Cause & Impact Analysis**

- Traces dependencies across domains
- Predicts downstream effects using Digital Thread

📷 Multimodal AI in Service & Manufacturing**

- Analyzes images, 3D models, and videos
- Converts field inputs into structured reports

🤖 Generative AI for PLM Interaction**

- Natural language interfaces for report creation and data retrieval
- Enhances usability for non-technical users

🧠 Process Optimization**

- Suggests actions based on structured/unstructured data
- Supports configuration and Engineering Change Management

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Level 2 (ANI) „Generate Code to transfer a BOM from OnShape to OpenBOM“ with ChatGPT

```
import requests
# Onshape API credentials
onshape_api_key = 'YOUR_ONSHAPE_API_KEY'
onshape_access_key = 'YOUR_ONSHAPE_ACCESS_KEY'
# OpenBOM API credentials
openbom_api_key = 'YOUR_OPENBOM_API_KEY'
openbom_access_key = 'YOUR_OPENBOM_ACCESS_KEY'
# Onshape document details
document_id = 'YOUR_DOCUMENT_ID'
workspace_id = 'YOUR_WORKSPACE_ID'
element_id = 'YOUR_ELEMENT_ID'
# Get BOM from Onshape
onshape_url = f'https://cad.onshape.com/api/assemblies/d/
{document_id}/w/{workspace_id}/e/{element_id}/bom'headers =
{ 'Accept': 'application/json',  'Authorization': f'Bearer {onshape_api_key}'}
response = requests.get(onshape_url, headers=headers)
bom_data = response.json()
# Load BOM to OpenBOM
openbom_url = 'https://api.openbom.com/v1/bom'headers =
{'Content-Type': 'application/json', 'Authorization': f'Bearer {openbom_api_key}'}
response = requests.post(openbom_url, headers=headers, json=bom_data)
if response.status_code == 200: print('BOM successfully loaded to OpenBOM')
else: print('Failed to load BOM to OpenBOM')
```

Level 2 (ANI) „Generate Code to transfer a BOM from OnShape to OpenBOM“ with ChatGPT

```
import requests
# Onshape API credentials
onshape_api_key = 'YOUR_ONSHAPE_API_KEY'
onshape_access_key = 'YOUR_ONSHAPE_ACCESS_KEY'
# OpenBOM API credentials
openbom_api_key = 'YOUR_OPENBOM_API_KEY'
openbom_access_key = 'YOUR_OPENBOM_ACCESS_KEY'
# Onshape document details
document_id = 'YOUR_DOCUMENT_ID'
workspace_id = 'YOUR_WORKSPACE_ID'
element_id = 'YOUR_ELEMENT_ID'
# Get BOM from Onshape
onshape_url = f'https://
{document_id}/
{ 'Acc
penBOM
_url = 'https://api.openbom.com/v1/bom'headers =
ontent-Type': 'application/json', 'Authorization': f'Bearer {openbom_api_key}'}
response = requests.post(openbom_url, headers=headers, json=bom_data)
if response.status_code == 200: print('BOM successfully loaded to OpenBOM')
else: print('Failed to load BOM to OpenBOM')
```

Do we need programmed interfaces between different Legacy Systems or can we use AI Agents

My Vision: Semantic Digital Thread Architecture based on AI

- **Integrated Data Sources: CRM, ALM, PDM, ERP, SCM:** Business-critical systems contribute structured and unstructured product-related data across the Productl Lifecycle.
- **Model Context Protocol (MCP) as Semantic Hub:** MCP serves as the unifying layer mapping disparate data to a shared ontology,enab-ling semantic alignment, context-aware linking, and harmonization of identifiers.
- **Reasoning Engine Drives Knowledge Extraction:** Inference logic applied to MCP-mapped data surfaces hidden relationships, propagates change impacts, and validates data integrity within the graph structure.
- **Knowledge Graph for Product Intelligence:** All entities and relationships are modeled graphically, creating a navigable and queryable source of truth across disciplines, timeframes, and systems.
- **Single Source of Truth (SSOT) Realized:** By anchoring data in a reasoning-supported Knowledge Graph, enterprises establish traceability, reduce duplication, and enable confident decision-making based on unified product knowledge.

My Dream:
AI-Agent for Intelligent Engineering Change Management

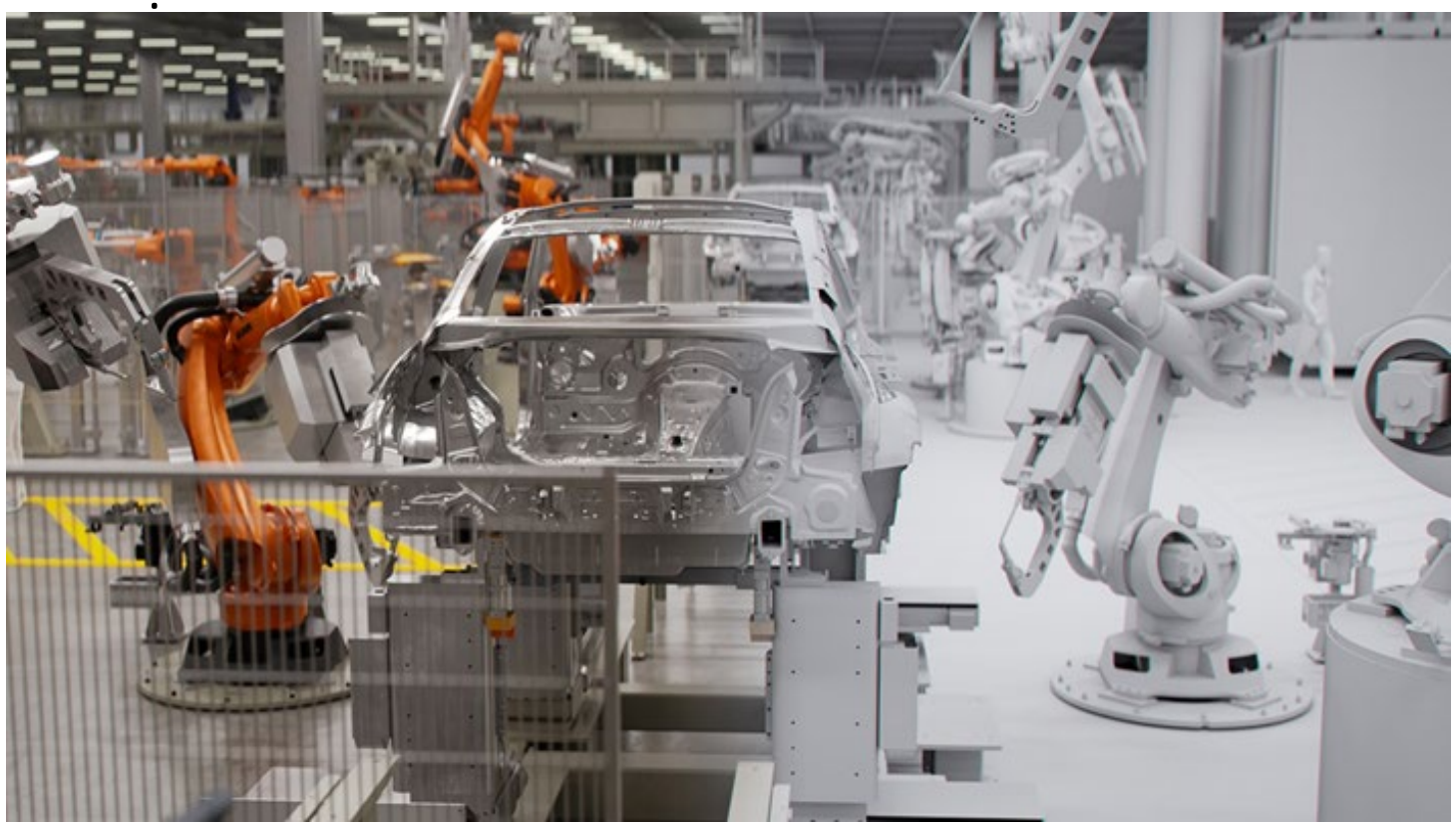
Source: Oleg Shilovitsky

NVIDIA OMNIVERSE

AI Path-Tracing USD Materials Physics

Understanding NVIDIA Omniverse

NVIDIA Omniverse is an open, extensible platform for virtual collaboration and physically accurate real-time simulations. It is based on **Pixar's Universal Scene Description (USD)** framework and connects people, applications, and AI-driven workflows in a shared environment.



Source: BMW

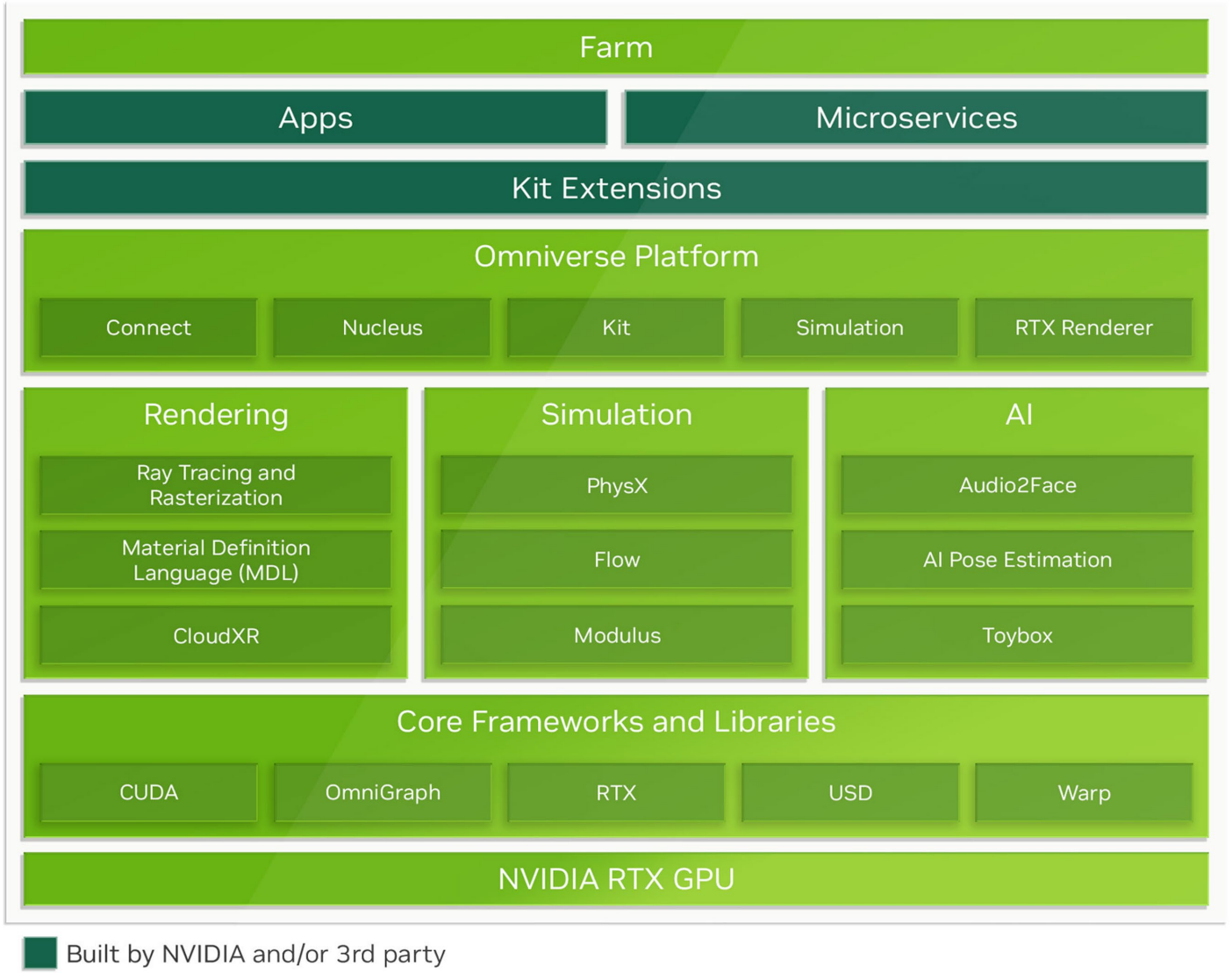
A Revolutionary 3D Collaboration Platform

NVIDIA Omniverse represents an innovative platform that enables companies to elevate the extended Digital Thread (DTaaS) and the associated Digital Twin to a new level. This technology integrates state-of-the-art simulation techniques, artificial intelligence (AI), and visualization to provide deep insights into the behavior of products and production processes

Key Features and Architecture 1

Key Features

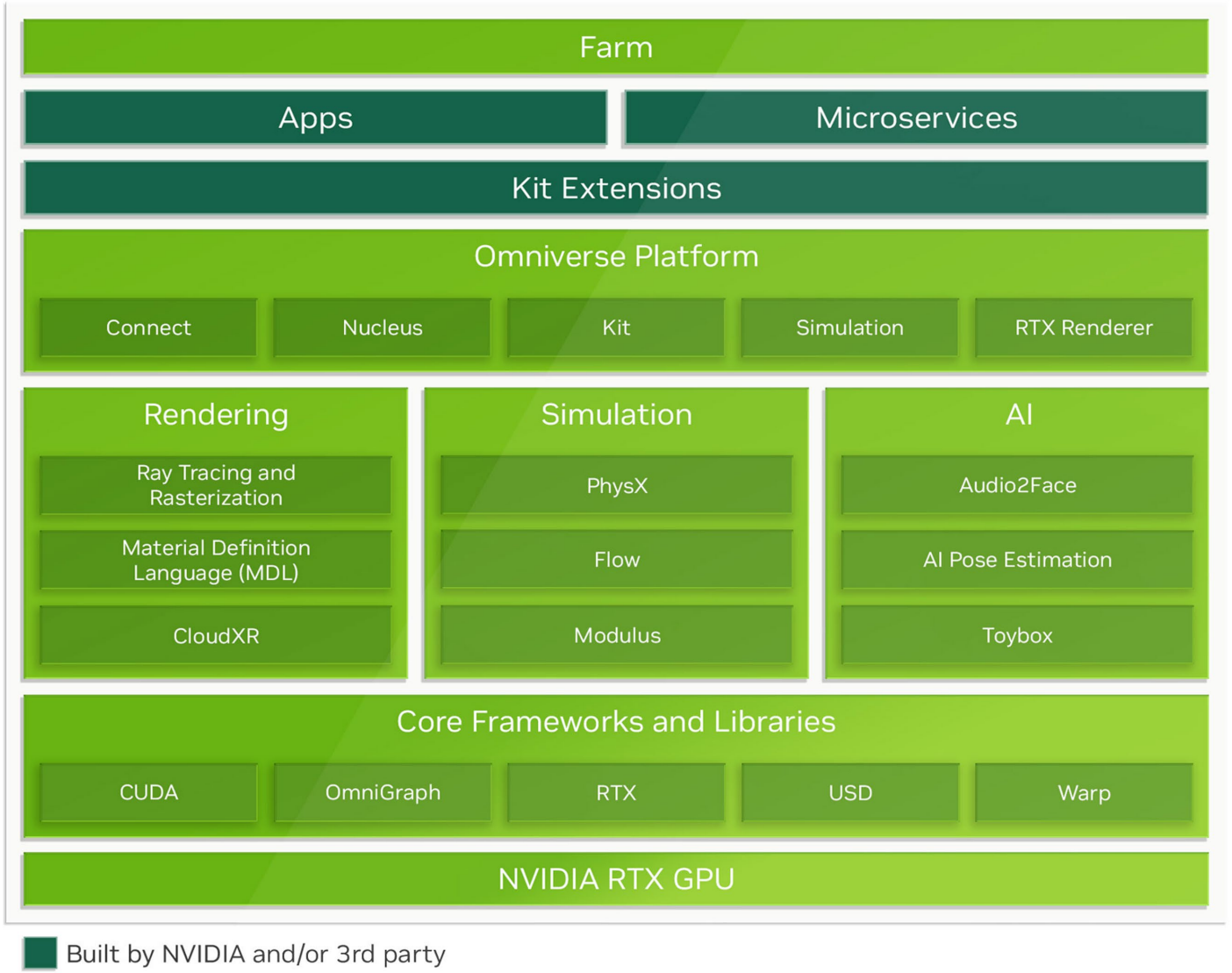
- **Real-time Collaboration:** Designers, production planners, engineers, and AI models can work simultaneously on a virtual model, regardless of location and software
- **RTX Rendering**: Photorealistic visualizations through ray tracing and AI denoising.
- **PhysX Integration:** Realistic physics simulations for robotics, manufacturing, and more based on GPU-accelerated physics engines (e.g. PhysX, MDL, Flow), .



Key Features and Architecture 2

Key Features

- **Open standards:** Based on USD (Universal Scene Description) as a data foundation, Omniverse enables the integration of different systems and software solutions, e.g. CAD, PLM, PPS, MES, or IoT platforms.
- **AI-driven technologies:** The platform utilizes AI-driven technologies to make predictions and analyses based on extensive datasets.
- **Cloud Options:** Access to powerful computing resources without local hardware



Key Modules of Omniverse

The architecture of Omniverse consists of **modular components** that can flexibly integrate into existing software ecosystems. NVIDIA sees Omniverse as the foundation for the next generation of AI-driven applications that are physically accurate, scalable, and collaborative **– a digital space where reality and simulation converge**.

Nucleus Server

Functions as the central hub for managing USD files and their version control.

Connectors

Enables seamless integration with popular tools like Blender, Unreal Engine, and Maya.

Kit SDK

Facilitates custom app development to enhance functionality within Omniverse.

Simulation Tools

Provides capabilities in physics, robotics, and digital twin simulations.

Industrial UseCases

Omniverse transforms how companies design, simulate, and collaborate.

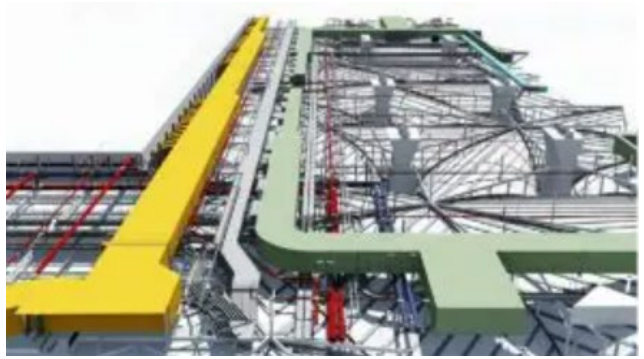
Cross-Discipline Usage

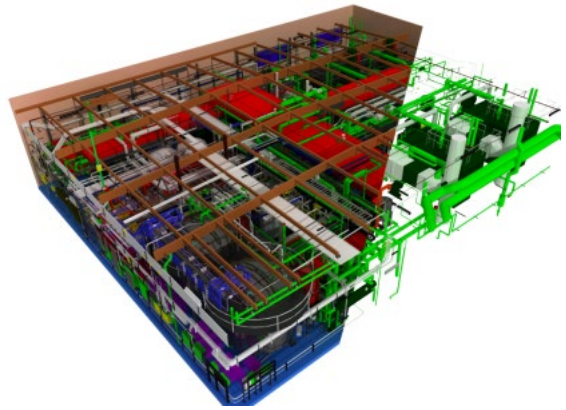
Architecture & Construction: Virtual building planning with real-time feedback.

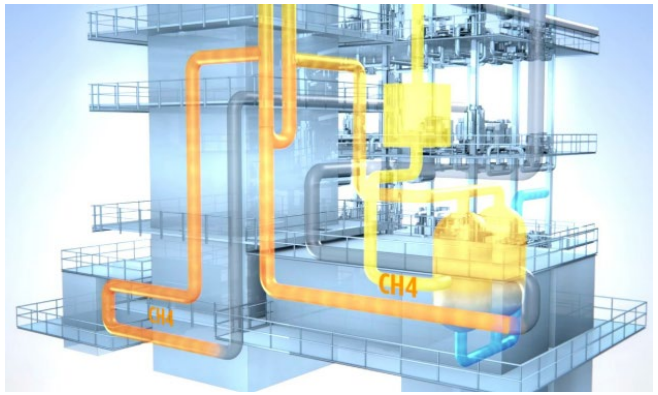
Film & Media: Collaborative 3D animation and visual effects.

Manufacturing & Robotics: Testing multi-robot fleets in virtual environments.

Marketing & Product Design: AI-powered 3D configurators for precise product visualization.







NVIDIA Industrial Omniverse + Microsoft Infrastructure

Designing, Optimizing and Operating the Factory of the Future (BMW)

BMW Group Celebrates Opening the World's First Virtual Factory in NVIDIA Omniverse

Future and Use Cases

Cross-Industry Applications

Omniverse transforms industries with virtual buildings for architecture, collaborative animation in film, and robotic simulations, enhancing workflow and creativity across sectors.

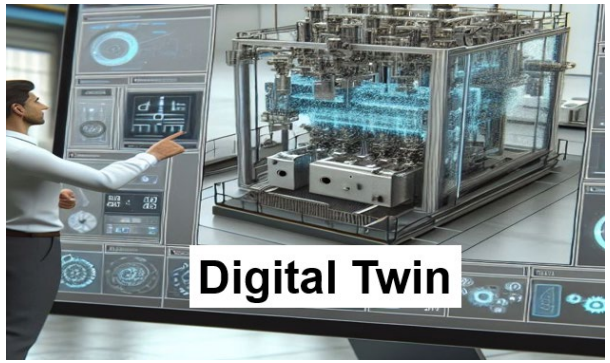
Vision for the Future

NVIDIA envisions Omniverse as the foundation for future AI-driven applications that blend reality and simulation, enabling scalable and collaborative environments for innovation.

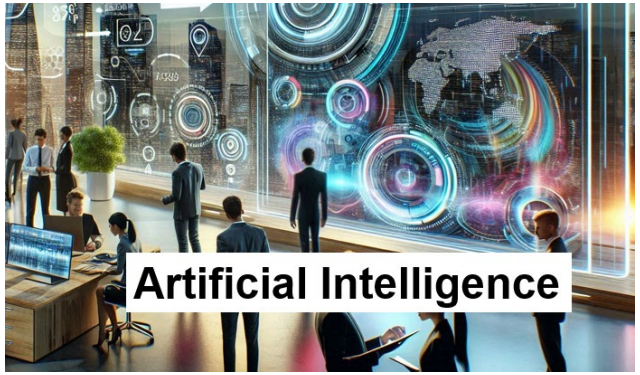
Impact on Industries

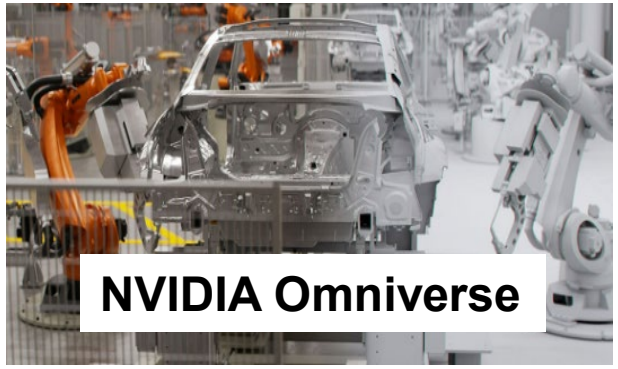
Omniverse significantly impacts sectors like construction, media, and manufacturing by providing real-time feedback, testing environments, and precise visualizations, revolutionizing workflows.

Yes, We Can Realize Our PLM Vision



PLM Vision





Summary and Outlook

The overarching Extended Digital Thread with Knowledge Graphs connected with the Digital Twin and AI (GenAI) and optionally creating an Omniverse will significantly boost business opportunities and ROI. Enhanced data connectivity and traceability will improve decision making and support AI application development. This digital transformation will revolutionize product development, optimize processes, reduce costs, and positioning companies at the fore-front of their industries…..

And we are coming back to our original PLM vision the nearest “Single Source of Truth”!

The Digital Thread as the Foundation of the Omniverse

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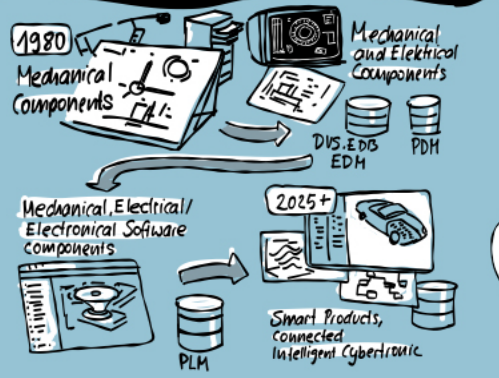
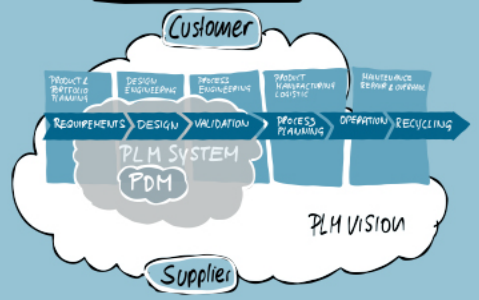
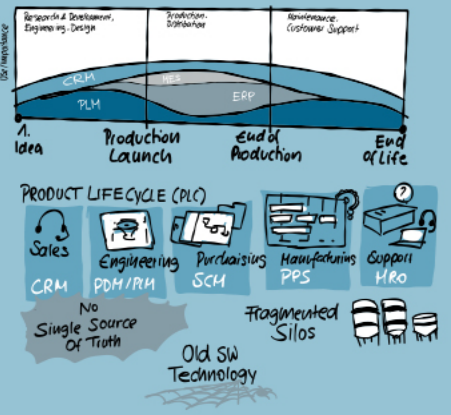
THE HISTORY OF PDM/PLM



THE DIFFERENCE BETWEEN PLM SYSTEM & PLM VISION



CURRENT LANDSCAPE OF PLM



HOW TO REALIZE OUR PLM-VISION

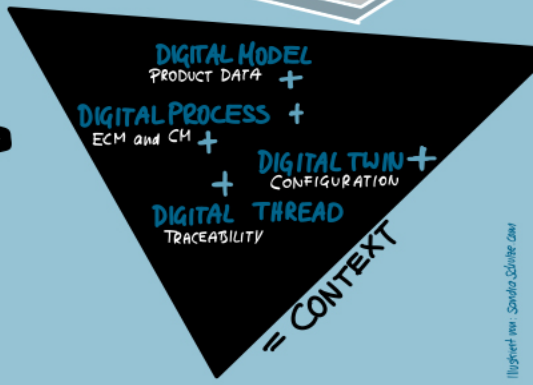
- MINDSHIFT in INTEGRATED and SYSTEM THINKING
- MODEL BASED DESIGN
- CHANGE MANAGEMENT
- NEW METHODOLOGIES (METHODS, PROCESSES, TOOLS)
- NEW SOFTWARE TECHNOLOGY
- DIGITAL THREAD and DIGITAL TWIN
- ARTIFICAL NARROW INTELLIGENCE
- NVIDIA Omniverse as UNIVERSAL 3D SIMULATION
- PLM and AI are PART OF DIGITAL TRANSFORMATION

YES WE CAN REALIZE OUR PLM VISION!

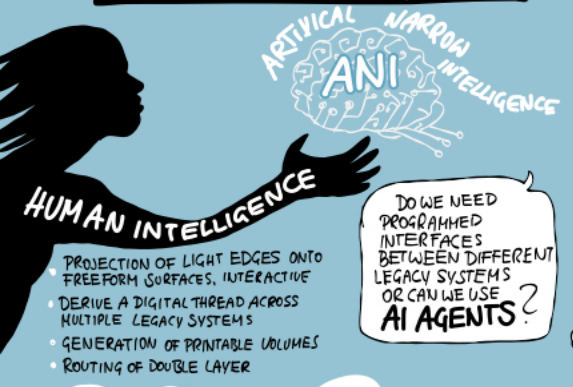
THE EXTENDED DIGITAL THREAD

1. All CIs of the product and the related information along the PLC...
2. Realized by a Graph-DB based Knowledge Graph
3. The Connection to AI (LLM)

PASSIVE DIGITAL THREAD	SYSTEM BEHAVIOR	ACTIVE DIGITAL THREAD
PARTIAL LIFECYCLE	LIFECYCLE COVERAGE	FULL LIFECYCLE
FIXED DATA MODEL	ADAPTABILITY	CONFIGURABLE
SINGLE DATABASE	DATABASE ARCHITECTURE	POLYGLOT PERSISTANCE
EMBEDDED IN LEGACY SYSTEM	DEPLOYMENT ARCHITECTURE	STAND ALONE SOLUTION
ON-PREMISE	ENVIRONMENT	CLOUD DIGITAL THREAD AS A SERVICE



ARTIFICAL INTELLIGENCE

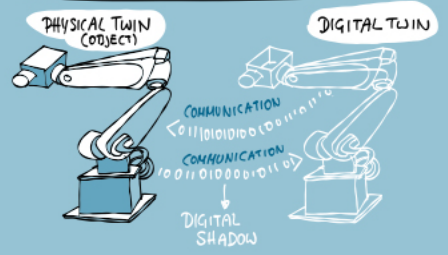


- PROJECTION OF LIGHT EDGES ONTO FREEFORM SURFACES, INTERACTIVE
- DERIVE A DIGITAL THREAD ACROSS MULTIPLE LEGACY SYSTEMS
- GENERATION OF PRINTABLE VOLUMES
- ROUTING OF DOUBLE LAYER

DO WE NEED PROGRAMMED INTERFACES BETWEEN DIFFERENT LEGACY SYSTEMS OR CAN WE USE AI AGENTS?

My dream:
AI AGENT FOR INTELLIGENT ENGINEERING CHANGE MANAGEMENT

THE DIGITAL TWIN



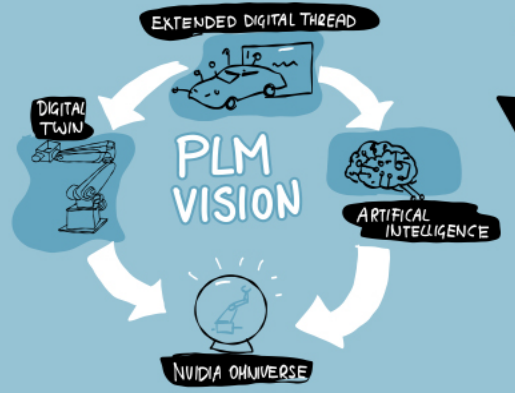
- PREDICTIVE MAINTENANCE
- UPDATE & UPGRADE ON AIR
- SUSTAINABLE DESIGN
- CIRCULAR ECONOMY
- MULTI-CRITERIA ASSESSMENT OF SUSTAINABLE
- PRODUCT CARBON FOOTPRINT CALCULATION
- VIRTUAL COMMISSIONING
- OPTIMIZATION OF ENERGY SYSTEMS FOR RENEWABLES
- OPTIMIZATION OF MATERIAL CONSUMPTION

THE NVIDIA OMNIVERSE ...

IS AN OPEN, EXTENSIBLE PLATFORM FOR VIRTUAL COLLABORATION AND PHYSICALLY ACCURATE REAL-TIME SIMULATIONS.
ITS BASED ON PIXAR'S UNIVERSAL SCENE DESCRIPTION FRAMEWORK AND CONNECTS PEOPLE, APPLICATIONS, AND AI-DRIVEN WORKFLOWS IN A SHARED ENVIRONMENT.

MODULAR COMPONENTS integrate into existing software ecosystem

FOUNDATION FOR THE NEXT GENERATION OF AI-DRIVEN APPLICATIONS. – A DIGITAL SPACE



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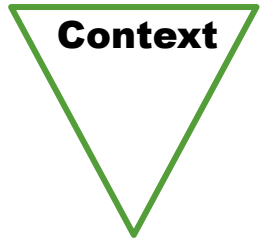
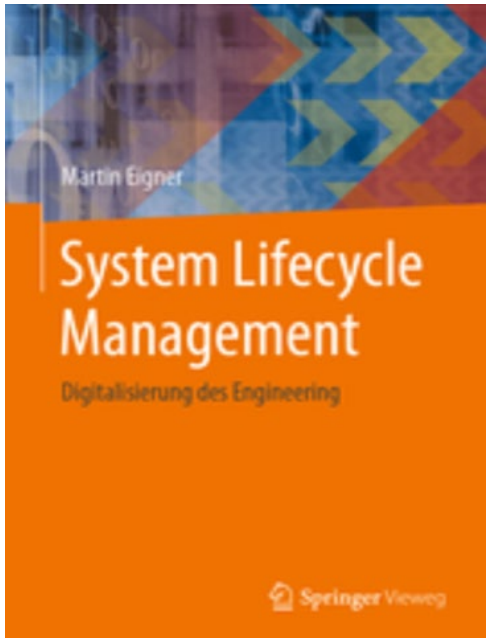
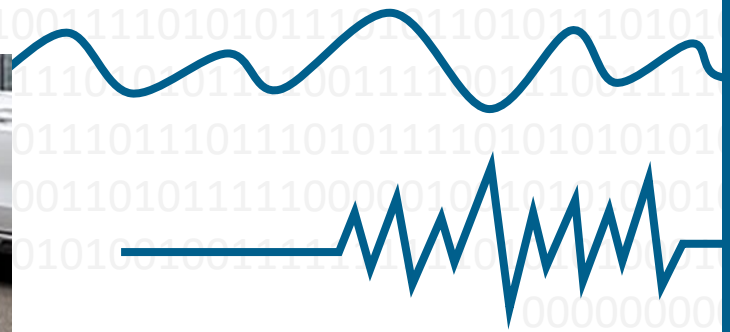
Thank You Very Much for Your Attention

DIGITAL MODEL
Product Data
+
DIGITAL PROCESS
ECM and CM
+
DIGITAL TWIN
Configuration
+
DIGITAL THREAD
Traceability
=







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