DTw in Standardization and implementation (research)
- examples from ISO TC184/SC4 and Arrowhead fPVN

Torbjörn Holm, TBH Konsult

TBHK

INTO THE FUTURE

General overview of Digital Twins according to ISO/DTR 24464:2024

# Digital Twin - definition

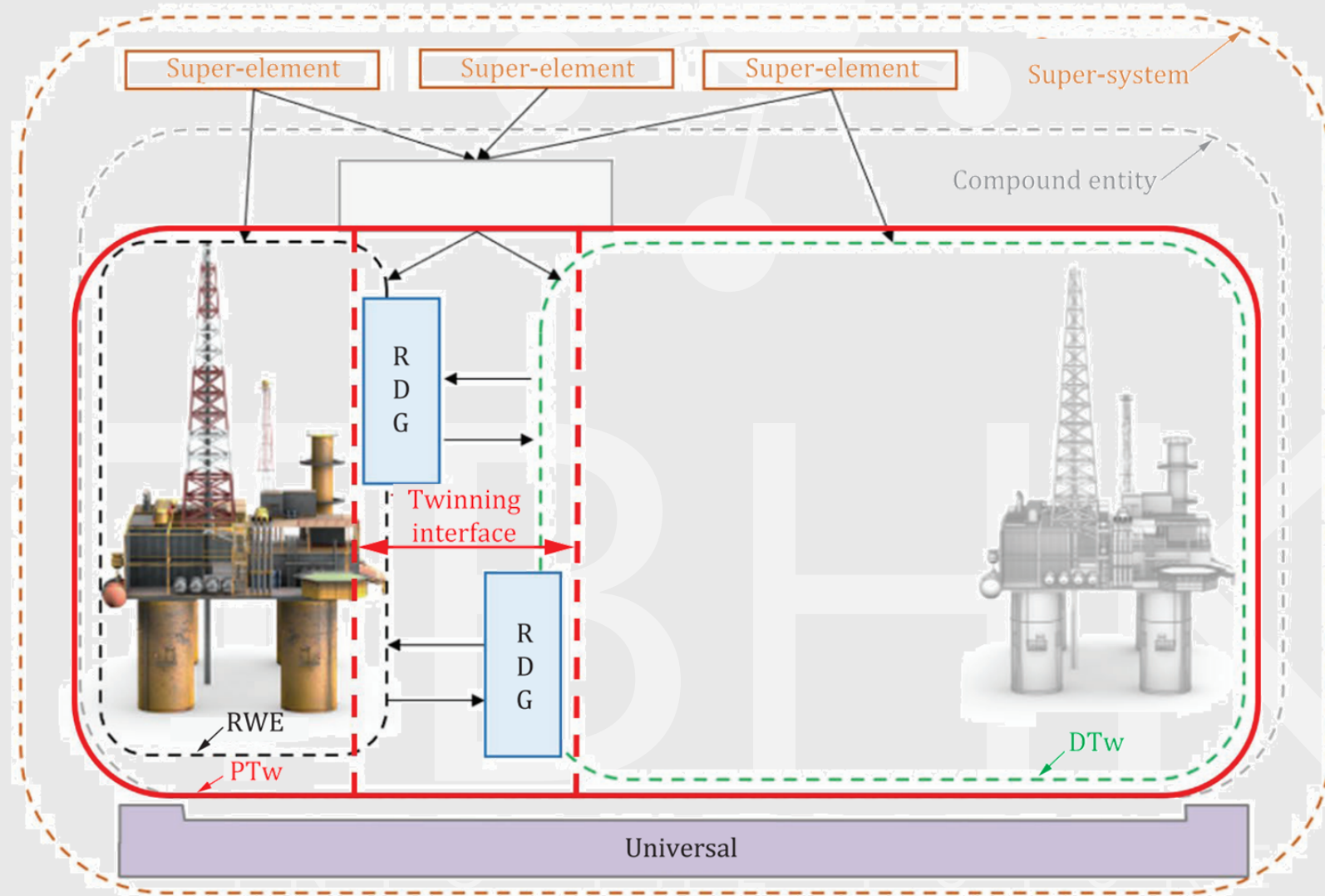| Source	Definition
ISO/IEC 30173:2023 (JTC1/SC41/WG6)	Digital representation of a particular entity or process with data connections that (1) enable convergence between the physical and digital states at an appropriate rate of synchronization, (2) has the capabilities of connection, integration, analysis, simulation, visualization, optimization and (3) provides an integrated view throughout the life cycle of the entity or the process
IEC 60050-8312, Part 831: Smart city systems	Formal, explicit, computer-readable and computer-executable representation of an object or system
ISO/TR 24464:2020 *	Compound model composed of a physical asset, an avatar and an interface
ISO/TS 18101-1: 2019	Digital asset on which services can be performed that provide value to an organization
ISO 23247-1 *	Fit for purpose digital representation of an observable manufacturing element with a means to enable convergence between the element and its digital representation at an appropriate rate of synchronization
ISO Smart Manufacturing Coordinating Committee *	Fit for purpose digital representation of some realized thing(s) or process(es) with a means to enable convergence between the realized instance and digital instance at an appropriate rate of synchronization
Digital twin consortium	A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity.

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The Twin types
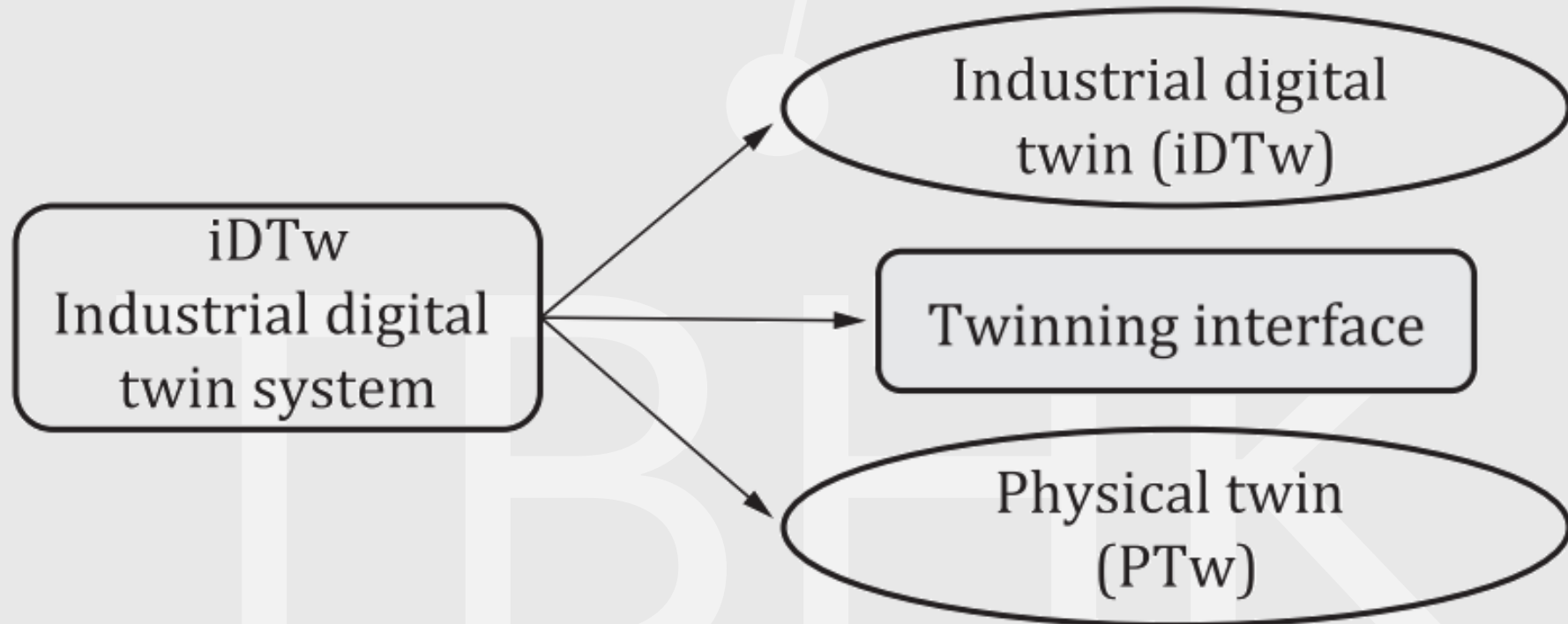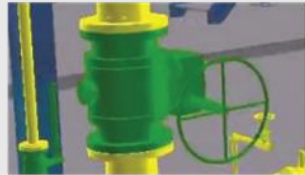
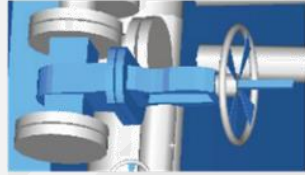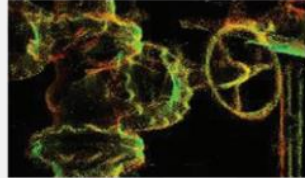# A Digital Twin system components
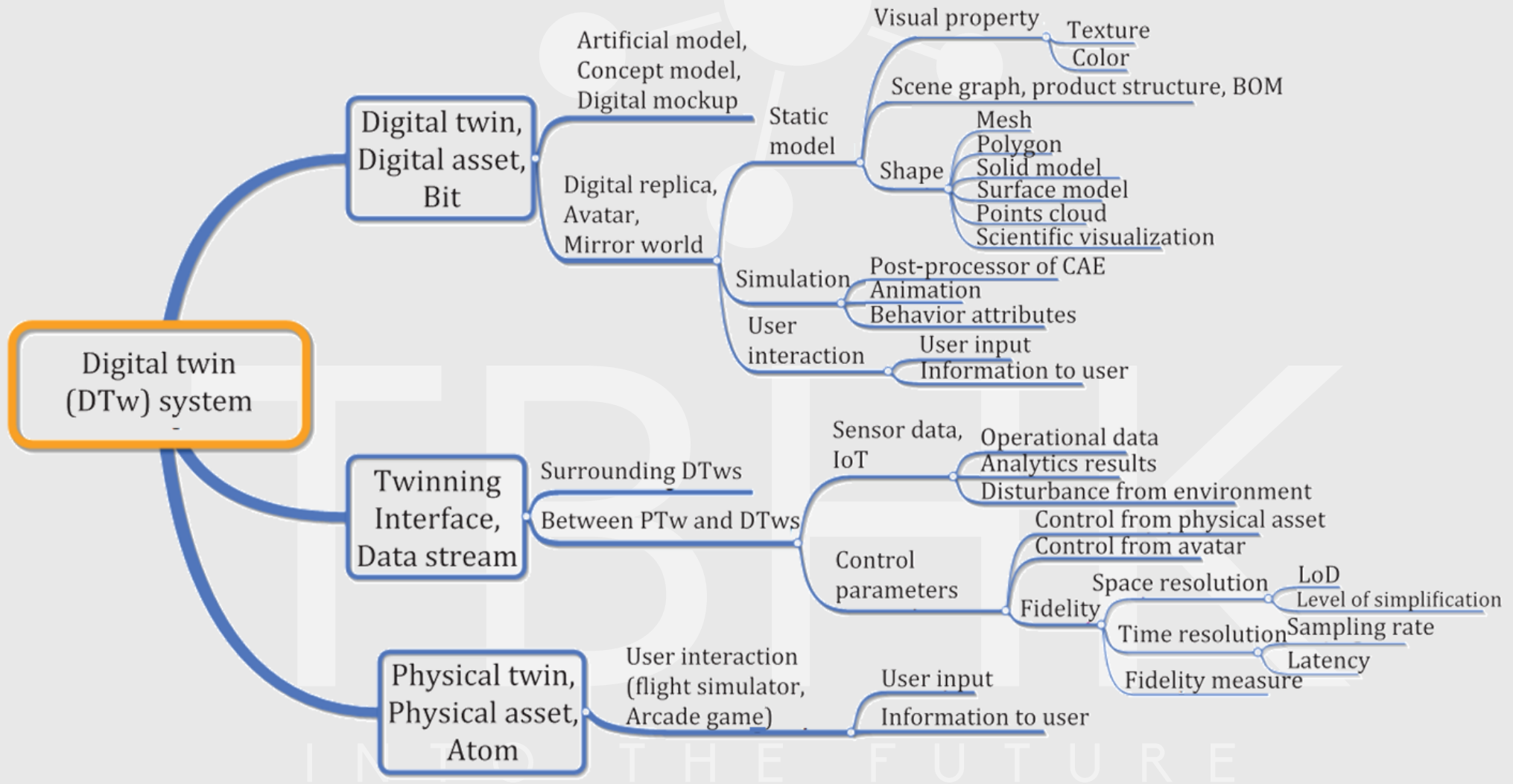
A DTwin according to ISO 23247 series
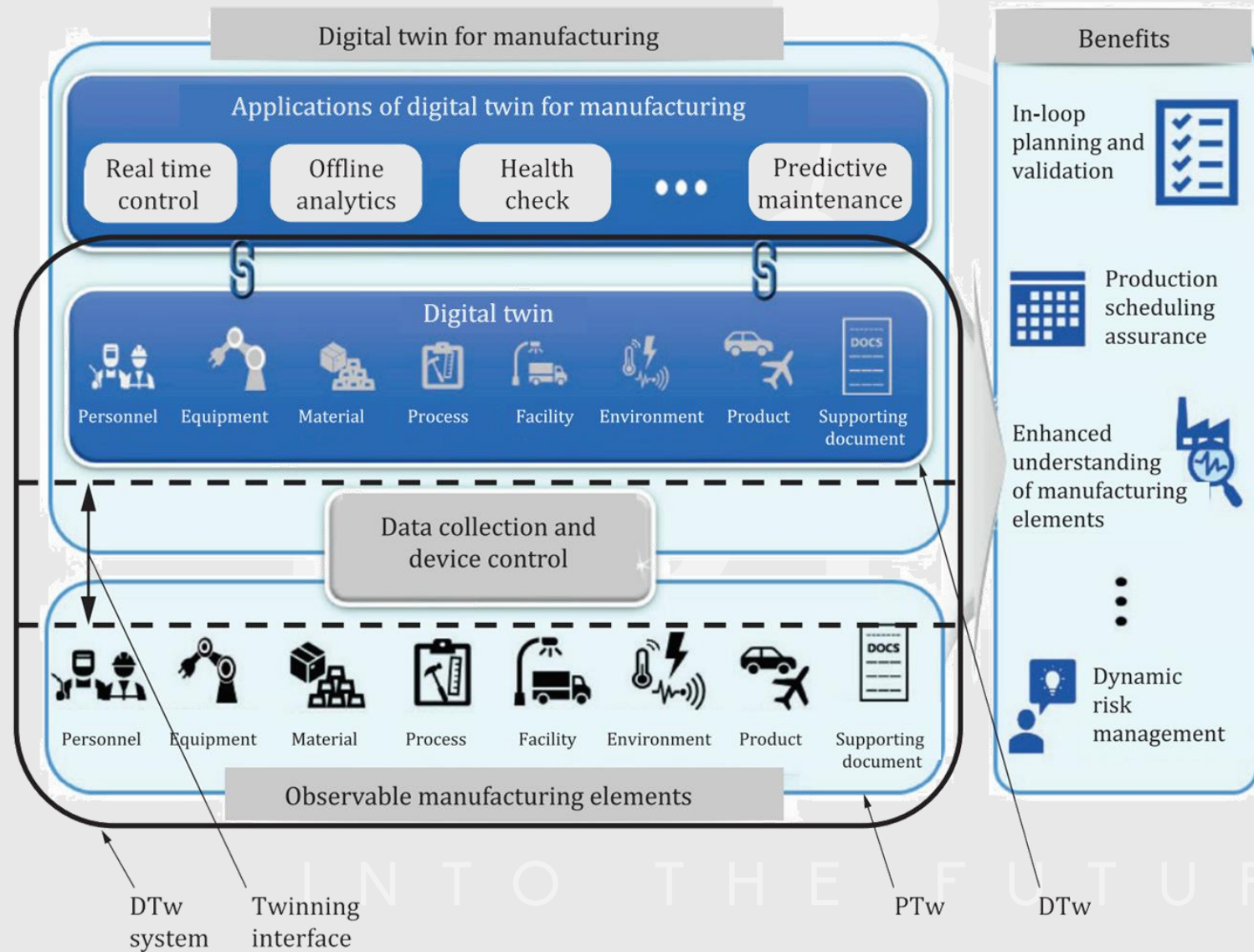
The digital twin reference architecture
(ISO/IEC 30188,recently started in JTC1)

Level of Detail

No	Type	Description	Example (Valve)
1	Symbol-level model (basic design stage, send to manufacturer)	Simple model (3-dimensionalized symbol from P&ID) Model in default libraries (known as catalogue model) provided by a PlantCAD system.	
2	Production model (production design stage of plant)	Model that a plant manufacturer re-models based on vendor-package (collection of 2D drawings, simplified symbol model) of equipment. The product model which is suitable for plant manufacturer.	
3	Handover model (reconstructed model from scanned data)	Model that a plant owner or operating company requests. Has different LOD depending on the requests.	
4	Scanned model (during or after construction)	A points cloud model from 3D scanning during or after manufacturing or construction of the plant It shows additional material such as insulation material surrounding the equipment.	
5	Detailed model from manufacturing (vendor)	Detail model of vendor for producing the equipment Contains all (geometric/non-geometric) information about the product, e.g. internal geometric information as well as detailed surface information. Due to security issues, only vendors have the model.	

Domain DTw for manufacturing ... but

ISO ISO 23247 1-4 Manufacturing scope

- ISO 23247-1: General principles and requirements for developing digital twins in manufacturing;

- ISO 23247-2: Reference architecture with functional views;

- ISO 23247-3: List of basic information attributes for the observable manufacturing elements;

- ISO 23247-4: Technical requirements for information exchange between entities within the reference architecture

ISO 23247-1: General principles and requirements for developing digital twins in manufacturing 1(2);

Applications of the digital twin

- Real-time control
- Monitoring
- Off-line analytics
- Predictive maintenance
- Health check
- Engineering design
- Production control
- Video surveillance

Benefits of the digital twin

- In-loop planning and validation
- Production scheduling assurance
- Enhanced understanding of manufacturing elements
- Dynamic risk management
- Part/assembly traceability
- Process traceability

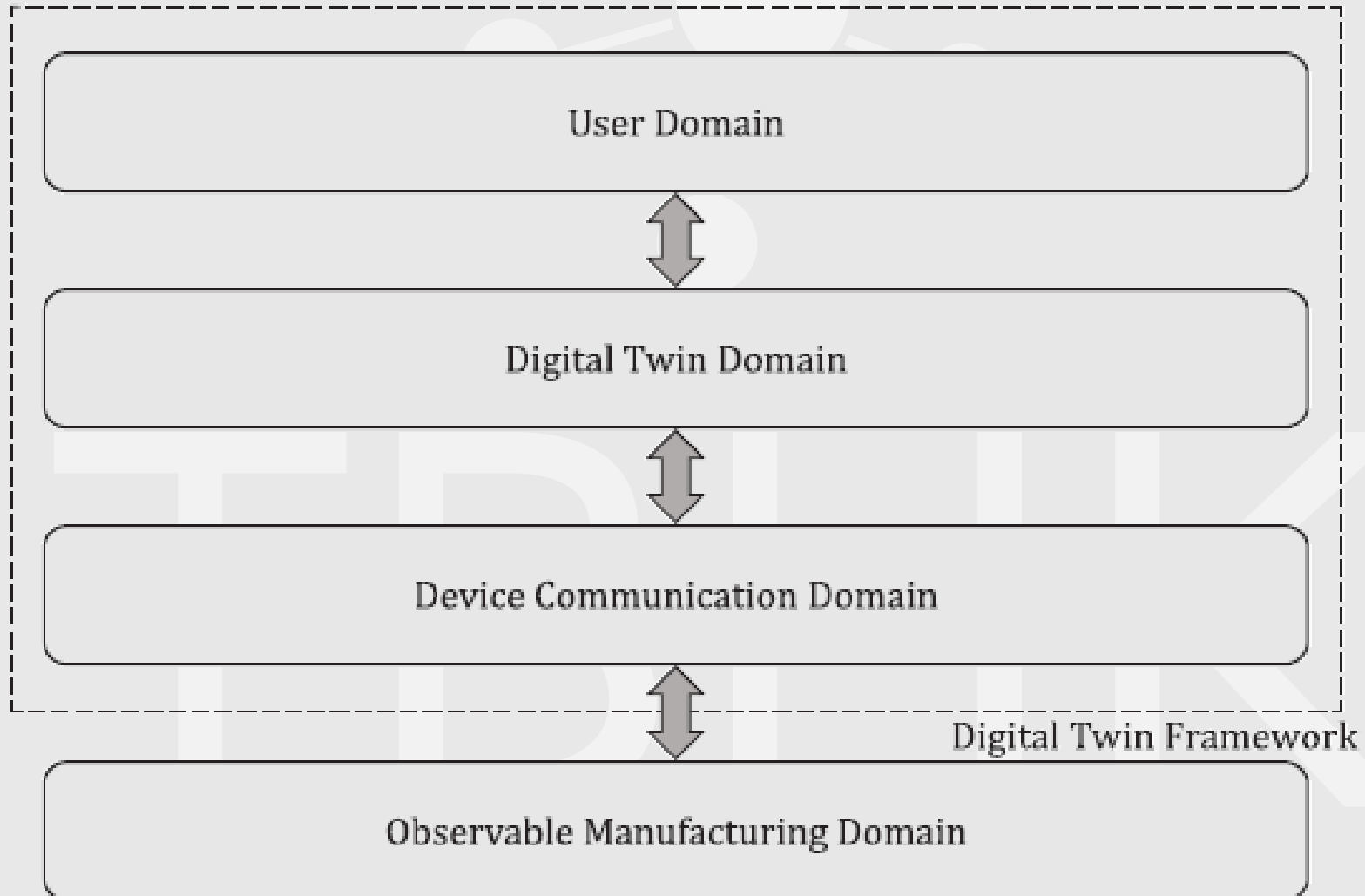## Observable manufacturing elements

- Personnel
- Equipment
- Material
- Process
- Facility
- Environment
- Product
- Supporting document

# ISO 23247-1: General principles and requirements for developing digital twins in manufacturing 2(2);

General principles of the digital twin framework for manufacturing

- Overview
- Limitations and boundaries of the digital twin framework for manufacturing
- Requirements of the digital twin for manufacturing
  - Accuracy
  - Communication
  - Data acquisition
  - Data analysis
  - Data integrity
  - Extensibility
  - Granularity
  - Identification
  - Management
  - Product life-cycle
  - Security
  - Simulation
  - Synchronization
  - Viewpoint
  - Hierarchical modelling of digital twin for manufacturing

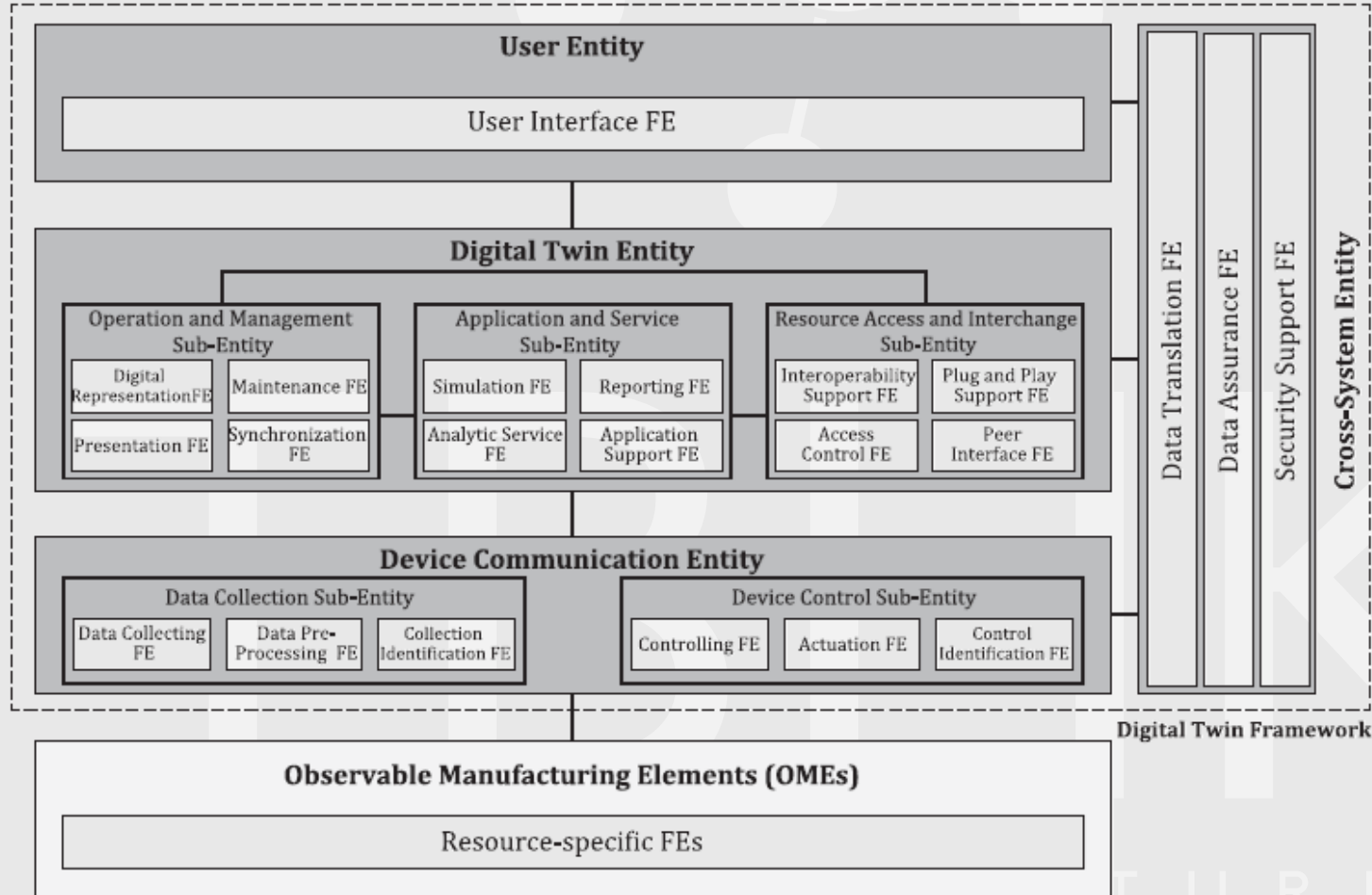# ISO 23247-2: Reference architecture 1(3);

ISO 23247-2: Reference architecture Entities 2(3);
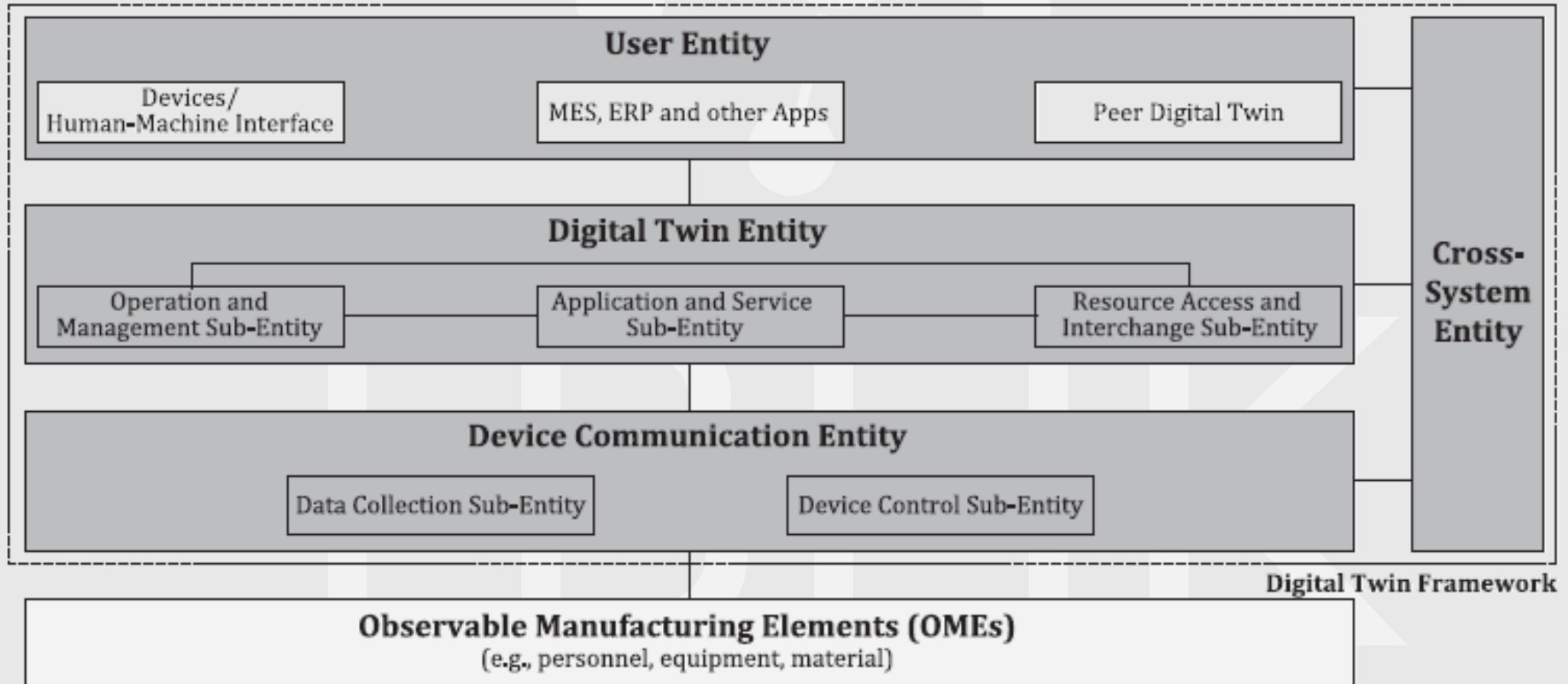
# ISO 23247-2: Reference architecture Functional Entities 3(3);

ISO 23247-3: List of basic information attributes for the observable manufacturing elements;

Information attributes of the OMEs

- General
- Personnel information
- Equipment information
- Material information
- Process information
- Facility information
- Environment information
- Product information
- Supporting document information

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify the equipment in a specific enterprise, e.g.: — UUID — asset ID	— UUID: e88561dc-2401-4f9a-961c-e90e6424b1dd — asset ID: dtm-200327-11
Characteristics	Functionalities, features of the equipment, e.g.: — milling — turning — grinding — pressing	milling
Schedule	A plan for carrying out manufacturing activities, e.g. Monday to Friday first shift	Maintenance for Machine #1 is scheduled on every Sunday.
Status	A current state of the equipment, e.g.: — on/off — working/breakdown — energy usage (unit: kWh) — temperature (unit: °C, °F) — noise level (unit: dB)	— on — energy usage: 10kWh — temperature: 25 °C
Location	Location information of the equipment, e.g.: — GPS coordinates — postal address — ISO 6709 — relative location	— Relative location — Machine #2: Work Unit #2 in Room #3
Report	An activity report of the equipment engaged in manufacturing, maintenance, etc.	— May 14th, 2019 9 AM to 6 PM: Regular Maintenance — May 14th, 2019 11 AM: Machine #1 reports high temperature.
Relationship	Relationship information between the equipment and other OMEs	— Machine #1 operates with Material #2. — Machine #1 is operated in WorkCenter #5.

ISO 23247-4: Technical requirements for information exchange between entities within the reference architecture
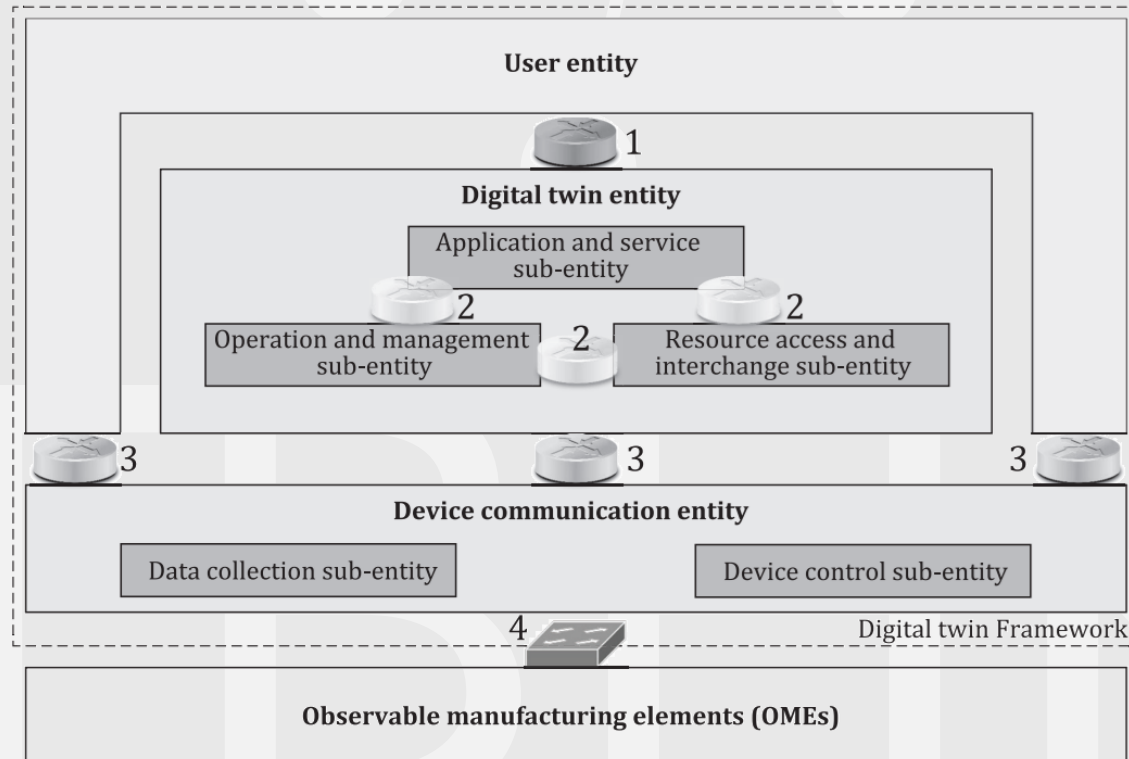
Key

1	user network
2	service network
3	access network
4	proximity network

The Arrowhead fPVN 9.2 Digital Twin

The Digital Twin in Arrowhead fPVN Use case 9.2
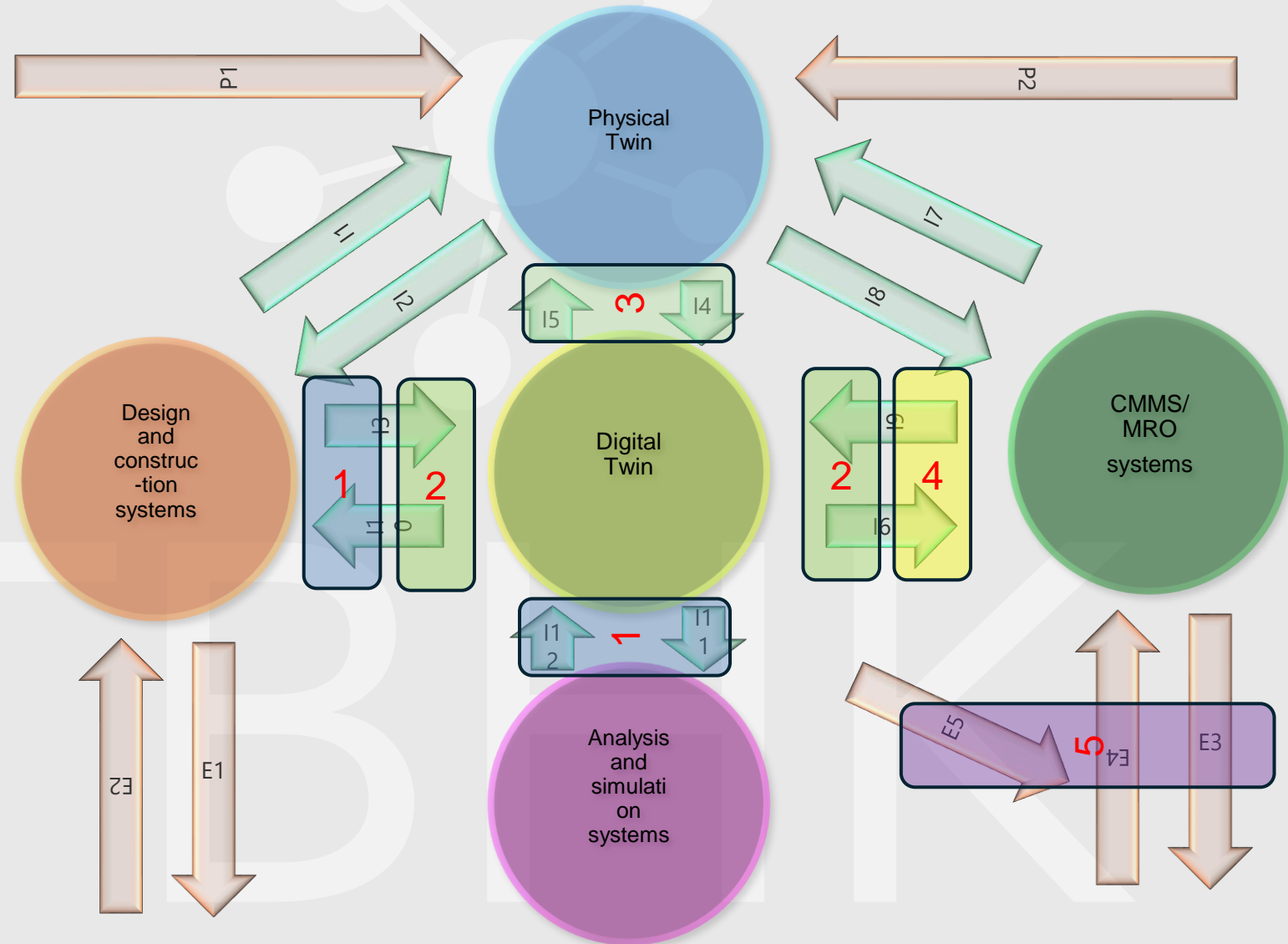
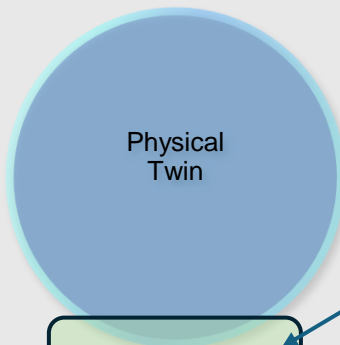# DT knowledge graph, GraphDB, SPARQL endpoint & Cadmatic eShare
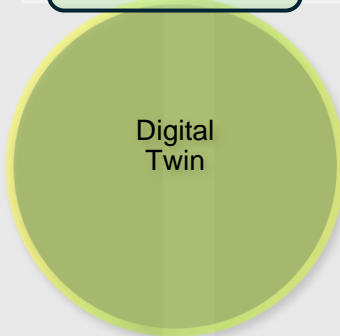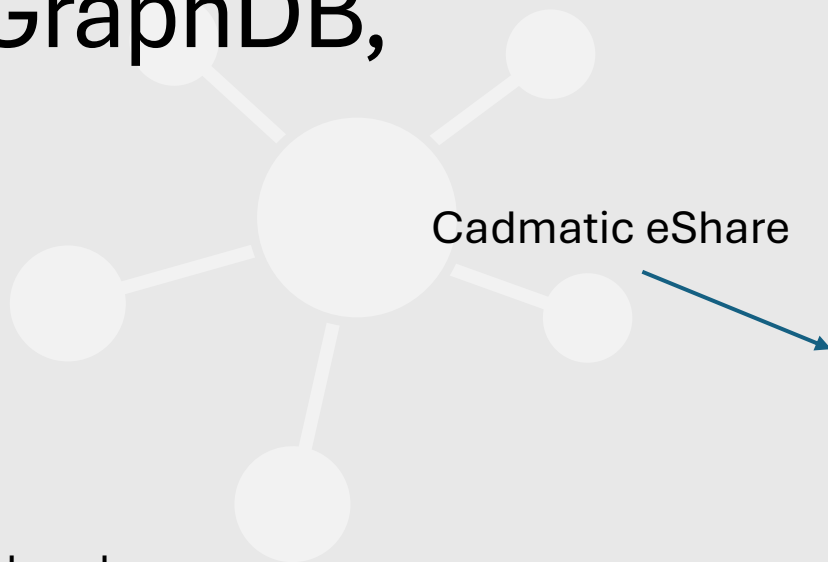

Cadmatic eShare

stordenso
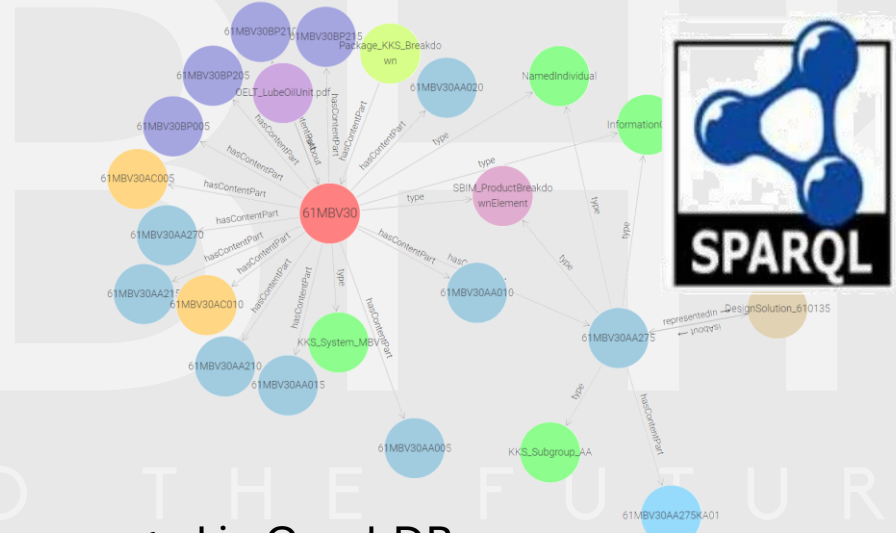Pulp mill bleaching system

Physical Twin

Arrowhead Microservice Technology

Digital Twin

Arrowhead Digital Twin Knowledge Graph managed in GraphDB

Summary

- There are many different standards in the area of Digital Twin, and there is a lot of knowledge and experience to retrieve from them

- The standards defined in ISO/IEC JTC1 and ISO TC184/SC4 play nicely together, the JTC1 standard is more and the TC184/SC4 standards are more oriented to production/manufacturing plants

- The Arrowhead fPVN Digital Twin take this one step further combining Digital Twin architectures with formal OWL 2 DL ontologies (Industrial Data Ontology) to enable reasoning and inferencing on a continuously updated Digital Twin.