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**Automation systems and integration — Digital Twin manufacturing framework — Part 2: Reference architecture**

WD stage

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Foreword

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This document was prepared by Technical Committee ISO/TC 184, *[Automation systems and integration]*, Subcommittee SC 4, *[Industrial Data]*.

A list of all parts in the ISO 23247 series can be found on the ISO website.

Introduction

Digital Twin is a virtual representation of manufacturing elements such as personnel, products, assets and process definitions. Digital Twin is a living model that continuously updates and changes as the physical counterpart changes to represent status, working conditions, product geometries and resource states in a synchronous manner.

Digital Twin representations of the products and physical resources are utilized to detect anomalies in the manufacturing processes. The digital representation provides information on the physical manufacturing elements to define the dynamic behavior of the manufacturing process and results. It is an understanding of the characteristics and capabilities of these elements and how they operate and respond throughout the production lifecycle. The digital representation constantly communicates with the physical manufacturing resources through exchange of operational and environmental data.

This digital representation is utilized to achieve various functional objectives such as synchronous monitoring/alarm, manufacturing operations management (MOM) optimization, in-process adaptation, big data analytics and machine learning. The visibility into manufacturing process definition and execution enabled by Digital Twinning enhances business cooperation and multiple efficiencies.

Automation systems and integration — Digital Twin manufacturing framework — Part 2: Reference architecture

# Scope

A family of ISO 23247 standards defines a framework for Digital Twin manufacturing as virtual representations of physical manufacturing elements such as personnel, products, assets and process definitions. This document provides

* requirements for Digital Twin manufacturing realization in terms of information modelling, in-the-loop simulation, information exchange, and identification of information objects, and;
* reference architecture

# Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 30141, *Internet of Things (IoT) — Reference architecture*

# Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at <http://www.electropedia.org/>

— ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

Digital Twin

*to be imported from ISO 23247-1*

[SOURCE: ISO 23247-1, 3.x]

3.1

Digital Twin system

set of physical manufacturing entities, data collecting and controlling entities, Digital Twin (consisting of operation and management sub-system entity, application and service sub-system entity, and resource access and interchange sub-system), digital twin user entity, and network entity

3.2

digital object

digitally represented object of a physical object

3.3

physical object

physical manufacturing resources to be digitally represented such as personnel, equipment, material, and process segment

# Abbreviated terms

ASD application and service domain

ASSE application and service sub-system entity

DCCD data collecting and controlling domain

DCCDE data collecting and controlling device entity

DTUE Digital Twin user entity

FE functional entity

HIL hardware-in-the-loop

IoT Internet of Things

OMD operation and management domain

OMSE operation and management sub-system entity

PHED physical manufacturing elements domain

PMEE physical manufacturing element entity

RA reference architecture

RAID resource access and interchange domain

RAISE resource access and interchange sub-system entity

RM reference model

SIL software-in-the-loop

UD user domain

# Digital Twin Reference Architecture (RA) goals and objectives

Digital Twin reference architecture (RA) defines requirements of Digital Twin, a reference model (RM) and several of architectural views.

Digital Twin RA outlines what the overall structured approach for the construction of Digital Twin should be by providing reference architecture. In other words, Digital Twin provides guidance for the architect developing Digital Twin and aims to give a better understanding of Digital Twin to the stakeholders of such systems, including device manufacturers, application developers, customers and users.

This document has the following descriptions:

* requirements of Digital Twin in terms of information modelling, in-loop simulation, information exchange and identification of information objects;
* a Digital Twin RM, providing the overall structure of the elements of Digital Twin RA;
* a set of relevant architectural views, describing the architecture from a number of perspectives



Figure 1 – Digital Twin RA structure

Figure 1 shows how Digital Twin RA is derived from requirements that define a Digital Twin RM and one or more architectural views.

# Requirements of Digital Twin

## Information modeling

### Fidelity

Ability to describe the closeness to the physical product

### Extensibility

Ability to integrate, to add, or to replace models

### Interoperability

Ability to convert, to combine, and to establish equivalence between different model representations

### Scalability

Ability to provide an insight at different scales (from fine details to large systems)

## In the loop simulation

### Software-in-the-loop (SIL) simulation

Ability to integrate manufacturing software into a mathematical model simulation based on running manufacturing system

### Hardware-in-the-loop (HIL) simulation

Ability to integrate manufacturing hardware into a mathematical model simulation based on running manufacturing system

## Information exchange

### Timely-manner networking

Ability to exchange information within a given time using an appropriate networking protocol

### Synchronization

Ability to synchronize the status of the digital object with the status of the physical object or vice versa, using timely-manner networking

### Accuracy

Ability to keep data accurate to be exchanged

### Integrity

Ability to maintain data unchanged in exchanging procedures

## Identification of information objects

### Uniqueness

Ability to identify an information object uniquely and unambiguously

### Associated information objects

Ability to identify an association of an information object with other information objects

# Digital Twin RM

## General

Digital Twin encompasses Internet of Things (IoT) as its data colleting and controlling technology as well as conceptual background.

ISO/IEC 30141 defines IoT RM including entity-based RM and domain-based RM, and also defines RA by providing several reference architectural views including functional view, system deployment view, networking view, and usage view. By the properties of Digital Twin based on IoT, this document defines Digital Twin RM based on IoT RM.

## Entity-based RM

### Entities of Digital Twin system



Figure 2 – Entity-based Digital Twin Reference Model

### Physical Manufacturing Element Entity (PMEE)

*to be explained*

### Data Collecting & Controlling Device Entity (DCCDE)

*to be explained*

### Operation & Management Sub-system Entity (OMSE)

*to be explained*

### Application & Service Sub-system Entity (ASSE)

*to be explained*

### Resource Access & Interchange Sub-system Entity (RAISE)

*to be explained*

### Digital Twin User Entity (DTUE)

*to be explained*

### Network Entity (NE)

*to be explained*

## Domain-based RM

### Domains of Digital Twin system

*[Project leader’s note] The domains help the designer to focus on the various tasks that have to be performed, by allowing a logical (and sometimes physical) subdivision. Mainly, domains are used to sort functions in areas of responsibility. (ISO/IEC 30141)*



Figure 3 – Domain-based Digital Twin Reference Model

### Physical Manufacturing Element Domain (PMED)

*to be explained*

### Data Collecting & Controlling Domain (DCCD)

*to be explained*

### Operation & Management Domain (OMD)

*to be explained*

### Application & Service Domain (ASD)

*to be explained*

### Resource Access & Interchange Domain (RAID)

*to be explained*

### User Domain (UD)

*to be explained*

## Relationship of entity based and domain based RM

*to be explained*



Figure 4 – Relationship of entity-based Digital Twin RM and domain-based Digital Twin RM

# Digital Twin Reference Architectural (RA) views

## General

As explained in 7.1, this document defines Digital Twin functional view and networking view based on IoT RA defined by ISO/IEC 30141.

## Functional view

### Functional Reference Architecture view



Figure 5 – Functional view of Digital Twin reference architecture –
decomposition into functional entities (FE)

### Functional Entity (FE) in PHEE

#### Element-peculiar FE

This FE is physical manufacturing element specific functional entities, therefore various functions can be supported by this FE according to its capabilities. This FE is out of scope of this document.

### Functional Entity in DCCDE

#### Data Collecting FE

Data collecting FE provides data collection functionality from PMEE.

#### Data Pre-Processing FE

Data pre-processing FE provides pre-processing functionality for collected data, for example filtering and aggregation.

#### Controlling FE

Controlling FE provides functionality of controlling PMEE by the request from Digital Twin system.

#### Actuation FE

Actuation FE provides functionality of actuating PMEE by the request from Digital Twin system, similarly with controlling FE.

#### Identification FE

Identification FE provides functionality of identifying PMEE and its data to be collected uniquely and unambiguously.

### Functional Entity in OMSE

#### Synchronization FE

Synchronization FE provides functionality of synchronizing the status of the visualized digital object with the status of the physical object, or vice versa.

#### Visualization FE

Visualization FE provides functionality of visualizing a physical object as a digital object in conjunction with virtual modeling FE.

#### Virtual Modeling FE

Virtual modeling FE provides functionality of interpreting information model of a physical object to understand its physical properties, status, and so on.

#### O&M Support FE

O&M support FE provides functionalities of operating and managing a Digital Twin system.

### Functional Entity in ASSE

#### Simulation FE

Simulation FE provides functionalities of in-the-loop simulation including SIL simulation and HIL simulation.

#### Analytic Service FE

Analytic service FE provides functionality of analysing data collected from PMEE and the result of simulation.

#### Reporting FE

Reporting FE provides functionality of generating report of production result, analysis on simulation, and so on.

#### Application Support FE

Application support FE provides functionality of hosting platform for implementing predictive and reactive, open and closed loop applications (e.g., Node.js).

### Functional Entity in RAISE

#### Interoperability Support FE

Interoperability support FE provides functionality of interworking with other Digital Twin systems in conjunction with peer interface FE.

#### Access Control FE

Access control FE provides functionality of controlling DTUE’s access to PMEE in conjunction with security support FE.

#### Plug & Play Support FE

Plug & play support FE provides functionality of dynamic involvement of PMEE, i.e., joining and leaving Digital Twin system, in run time.

#### Peer Interface FE

Peer interface FE provides functionality of interfacing to other Digital Twin systems in conjunction with interoperability support FE.

### Functional Entity in DTUE

#### User Interface FE

User interface FE provides DTUE with functionality of interfacing to Digital Twin.

### Functional Entity in Cross-Entity

#### Information Exchange FE

Information exchange FE provides functionality of exchanging information among entities of Digital Twin system by appropriate networking protocols.

#### Data Assurance FE

Data assurance FE provides accuracy and integrity of data in conjunction with security support FE.

#### Security Support FE

Security support FE provides functionality of securing Digital Twin system including authentication, authorization, confidentiality, integrity, and so on.

## Networking view

### Networking Reference Architecture view

*to be explained* ***(examples are needed)***



Figure 6 – Networking view of Digital Twin reference architecture

### Proximity Network

*to be explained*

*NOTE: example Wireless Sensor Network, 5G, IoT, MTconnect??? Dedicated use only?*

### Access Network

*to be explained*

### Service Network

*to be explained*

### User Network

*to be explained*

1. (informative)

Annex title
	1. TBD
		1. TBD
			1. TBD

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