FINAL
DRAFT

INTERNATIONAL
STANDARD

**ISO/FDIS
23247-2**

ISO/TC **184**/SC **4**

Secretariat: ANSI

Voting begins on:
2021-06-18

Voting terminates on:
2021-08-13

Automation systems and integration — Digital twin framework for manufacturing —

Part 2: Reference architecture

Partie 2: Architecture de référence

Reference number
ISO/FDIS 23247-2:2021(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 23247 series defines a framework to support the creation of digital twins of observable manufacturing elements including personnel, equipment, materials, manufacturing processes, facilities, environment, products, and supporting documents.

A digital twin assists with detecting anomalies in manufacturing processes to achieve functional objectives such as real-time control, predictive maintenance, in-process adaptation, Big Data analytics, and machine learning. A digital twin monitors its observable manufacturing element by constantly updating relevant operational and environmental data. The visibility into process and execution enabled by a digital twin enhances manufacturing operation and business cooperation

The type of manufacturing supported by an implementation of the ISO 23247 framework depends on the standards and technologies available to model the observable manufacturing elements. Different manufacturing domains can use different data standards. As a framework, this document does not prescribe specific data formats and communication protocols.

The scopes of the four parts of this series are defined below:

— 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.

Figure 1 shows how the four parts of the series are related.

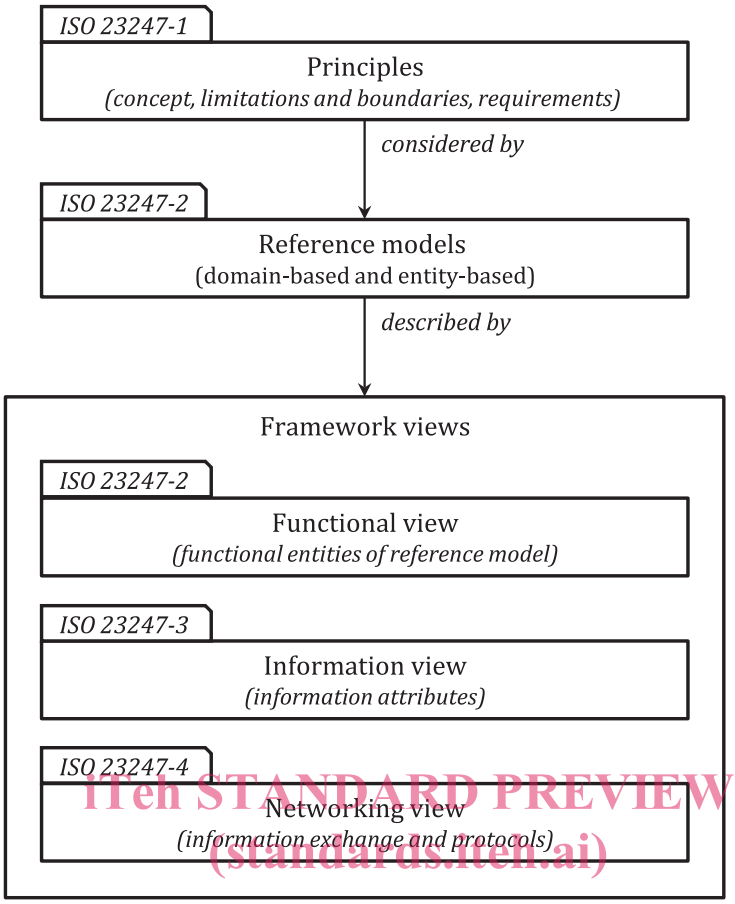

Figure 1 — ISO 23247 series structure

ISO 23247-4:—[1)], Annexes A to E, provide use cases that demonstrate the digital twin framework for manufacturing.

The use cases are in the discrete manufacturing domain and the digital twins are modelled using the ISO 10303 series. In other domains, different standards and technologies can be used. For example, in oil and gas, the digital twins may be modelled using the ISO 15926 series, and for building and construction, the digital twins may be modelled using the ISO 16739 series.

1) Under preparation. (Stage at the time of publication: ISO/FDIS 23247-4:2021.)

Automation systems and integration — Digital twin framework for manufacturing —

Part 2:
Reference architecture

1 Scope

This document provides a reference architecture for the digital twin in manufacturing including;

— reference model from domain and entity point of view;

— functional view specifying functional entities supported by the entity-based reference model.

2 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*

ISO 23247-1, *Automation systems and integration — Digital twin framework for manufacturing — Part 1: Overview and general principles*

ISO 23247-3, *Automation systems and integration — Digital Twin framework for manufacturing—Part 3: Digital representation of manufacturing elements*

ISO 23247-4, *Automation systems and integration — Digital twin framework for manufacturing — Part 4: Information exchange*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23247-1 and the following apply.

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

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

— IEC Electropedia: available at https://www.electropedia.org/

3.1
observable manufacturing domain
spatial/logical/functional area of the observable manufacturing resources

3.2
device communication domain
spatial/logical/functional area that uses sensors to collect data from the *observable manufacturing domain* (3.1) and provides services to monitor the manufacturing process and control the manufacturing devices

3.3
device communication entity
(set of) system or device providing device communication

EXAMPLE A cell controller sending instructions to the devices in a manufacturing cell, and collecting results from sensors on the devices

3.4
digital twin domain
spatial/logical/functional area that provides management functionalities for digital twins including visualization, presentation, synchronization, historical archiving, data analytics, simulation, and optimization

3.5
digital twin entity
(set of) system(s) providing functionalities for the digital twins such as realisation, management, synchronization, and simulation

EXAMPLE A system providing simulation, synchronization, and data analytics for a manufacturing cell

3.6
user domain
spatial/logical/functional area utilizing applications and services provided by the *digital twin domain* (3.5)

3.7
user entity
human users, applications, and systems that use the services provided by the *digital twin entity* (3.6)

EXAMPLE An ERP system that uses the application programming interfaces (APIs) provided by a digital twin application to update the current status of resources in its database

4 Digital twin reference architecture: Goals and objectives

The digital twin reference architecture provides guidance for implementing digital twins in manufacturing. The architecture facilitates understanding of digital twin implementation for stakeholders including device manufacturers, application developers, and users.

The digital twin reference architecture is based on the Internet of Things (IoT) reference architecture defined in ISO/IEC 30141. Pursuant to the principles defined in ISO 23247-1, this document provides guidance for designing and implementing digital twins in manufacturing.

This ddocument defines the following extensions to the requirements defined in ISO/IEC 30141:

— domain-based and entity-based reference models for digital twins in manufacturing;

— functional view for digital twins in manufacturing.

5 Digital twin reference models for manufacturing

5.1 Overview

This document specifies a digital twin reference model for manufacturing in terms of domains and entities.

— Domains divide the digital twin framework for manufacturing into areas where tasks are performed by entities.

— Entities divide each domain into system levels and subsystem levels.

5.2 Domain-based reference model

5.2.1 Domains of digital twin for manufacturing

Figure 2 shows a domain-based reference model.

The domains are classified into four categories as follows:

— user domain;

— digital twin domain;

— device communication domain;

— observable manufacturing domain.

NOTE The observable manufacturing domain is outside the digital twin framework, but is depicted to support understanding of the framework.

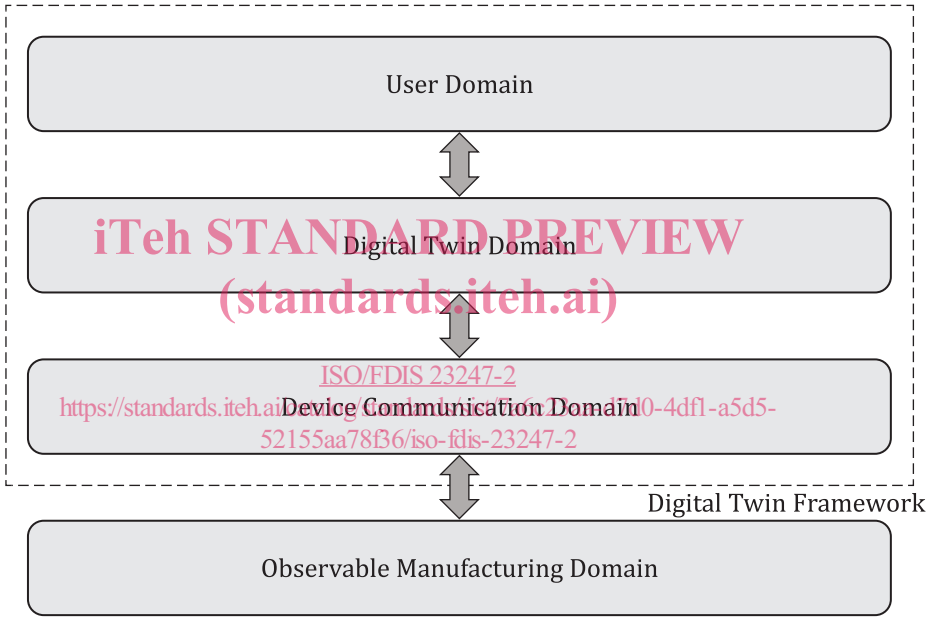

Figure 2 — Domain-based digital twin reference model for manufacturing

An implementation of the framework shall be divided into user, digital twin and device communication domains.

— The domains shall meet the requirements defined by ISO 30141.

— The entities shall divide each domain into the system levels and subsystem levels described in 5.3.

— The systems and subsystems shall have the functionalities described in Clause 6.

— Each domain shall model the information described in ISO 23247-3.

— Each domain shall be interconnected with the other domains and the observable manufacturing domain using the protocols described in ISO 23247-4.

5.2.2 Observable manufacturing domain

The observable manufacturing domain consists of the observable manufacturing resources, such as personnel, equipment, material, process, facility, and environment. The observable manufacturing domain is monitored by the device communication domain.

5.2.3 Device communication domain

The device communication domain monitors and collects data from sensor devices in the observable manufacturing domain, and controls and actuates devices in the observable manufacturing domain. The device communication domain links OMEs to their digital twins for synchronization.

5.2.4 Digital twin domain

The digital twin domain synchronizes OMEs with their digital twins. It hosts applications and services that operate on the digital twins such as simulation and analysis. It provisions the digital twins at the start of a session using data supplied by the user domain. It updates the digital twins during the session using values supplied by the device communication domain. It returns the final state of the digital twins to the user domain at the end of a session.

5.2.5 User domain

The user domain hosts applications that analyse the digital twin models for humans and systems. At the start of a session, an application supplies data to provision the digital twins. At the end of a session, an application archives the final values of the digital twins. During the session, various applications monitor the current values of the digital twins and uses those values to make decisions about the manufacturing.

5.3 Entity-based reference model

5.3.1 Entities of digital twin framework for manufacturing

The entity-based reference model divides the digital twin framework into systems and sub-systems that manage the domains described in 5.2.

Figure 3 shows the entity-based reference model. An implementation shall implement these entities or similar entities to create the functionality required for each domain.

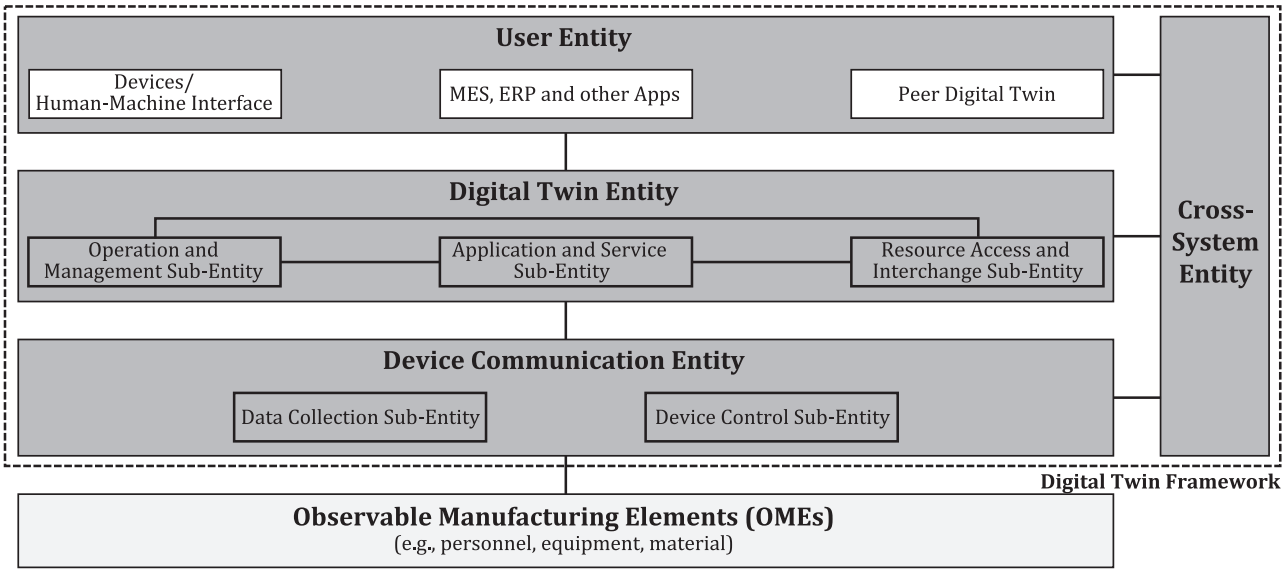

Figure 3 — Entity-based digital twin reference model for manufacturing