
**Automation systems and
integration — Digital twin framework
for manufacturing —**

**Part 3:
Digital representation of
manufacturing elements**

*Systèmes d'automatisation industrielle et intégration — Cadre
technique de jumeau numérique dans un contexte de fabrication —*

*Partie 3: Représentation numérique des éléments intervenant en
fabrication*

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

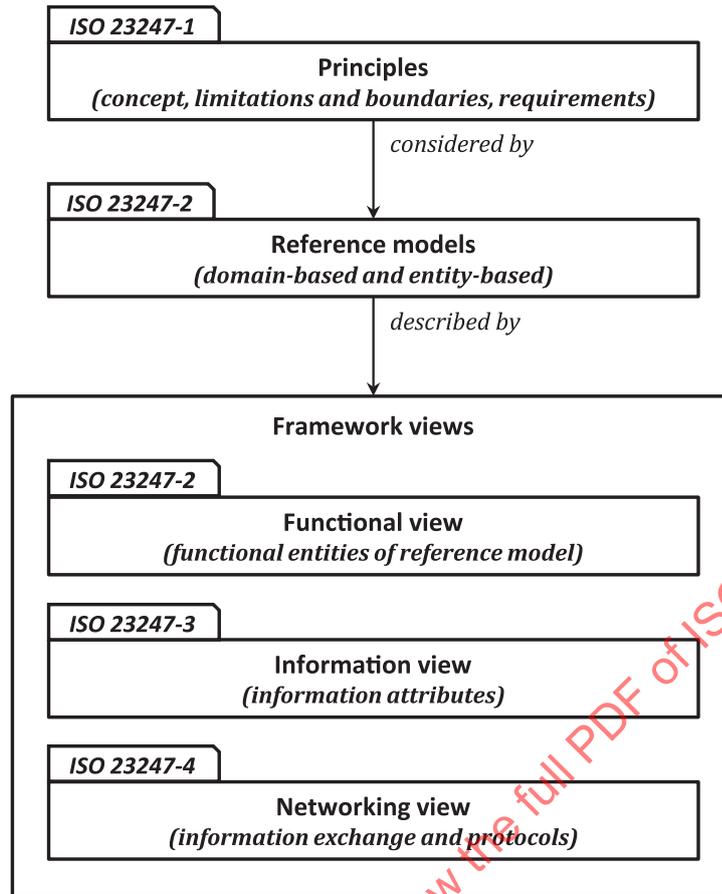


Figure 1 — ISO 23247 series structure

ISO 23247-4:2021, 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.

Automation systems and integration — Digital twin framework for manufacturing —

Part 3: Digital representation of manufacturing elements

1 Scope

This document provides a list of basic information attributes for the OMEs:

- examples of information attributes are given;
- standards that can define these information attributes are discussed in [Annex A](#).

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

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 terminology 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 information attribute

information about observable manufacturing elements (OMEs)

3.2 dynamic

<information attribute> *information attribute* (3.1) that changes during manufacturing processes

3.3 static

<information attribute> *information attribute* (3.1) that does not change during manufacturing processes

3.4 mandatory

<information attribute> *information attribute* (3.1) that must be included in any description of the OME

3.5 optional

<information attribute> *information attribute* (3.1) that may be included in a description of the OME depending on the purpose

4 Digital representation of OMEs

Digital representation of OMEs can include both static and dynamic information. Information that does not change during manufacturing is classified as static. For example, the serial number of a piece of material is static. However, the shape of the material, if it changes during manufacturing processes, is dynamic.

Pursuant to the principles defined in ISO 23247-1, this document provides a list of basic information attributes for the OMEs within the reference architecture given in ISO 23247-2.

The dark grey box in Figure 2 shows the types of OMEs that need to be represented by the digital twin entity defined in ISO 23247-2.

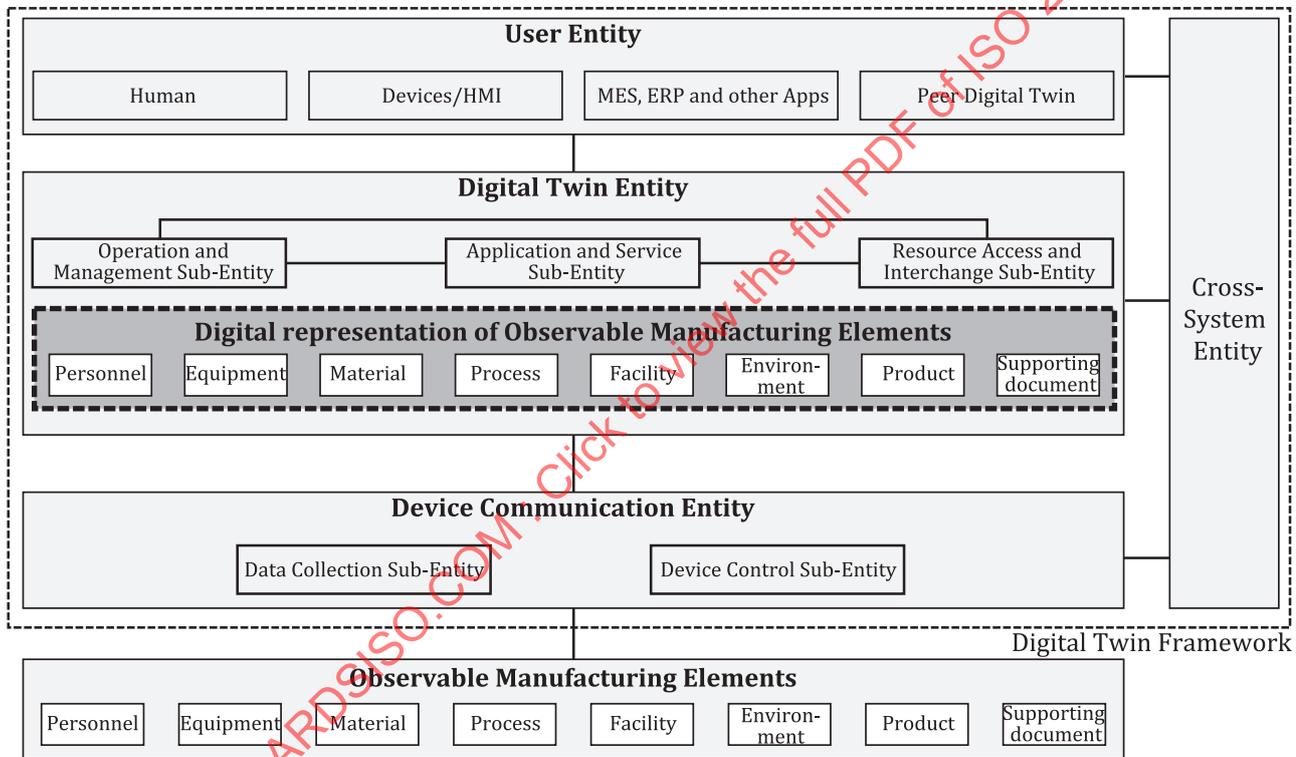


Figure 2 — Types of OMEs in reference architecture (blue-coloured box)

5 Information attributes of the OMEs

5.1 General

Standards such as IEC 62264-2, ISO 10303-238 and ISO 10303-242 contain detailed information models for representing the OMEs. Each implementation of the digital twin framework for manufacturing shall select the digital representation method most appropriate to model its OMEs.

[Annex A](#) lists some standards and technologies that can be selected for the digital representation. [Annex B](#) provides UML and XML descriptions for an example.

[Table 1](#) shows the template used to describe the information attributes. The types of information attributes are not limited to those given in [Table 1](#), but can be customized for specific use cases. The notation is taken from IEC 62264-2. Mandatory (M) or Optional (O) attributes can be selected depending on the purpose of the use cases.

Table 1 — Information attributes for OMEs

Information attribute	Description	Mandatory (M) Optional (O)
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify an OME in a specific enterprise, e.g.: <ul style="list-style-type: none"> — UUID — URL — URN — OID (ITU-T X.680 and ISO/IEC 8824-1) — domain-specific ID — ISO 29002 series or URI unique ID (used in AAS) 	Mandatory
Characteristics	A typical or noticeable feature of an OME, e.g.: <ul style="list-style-type: none"> — IEC 62264-2 (B2MML) — eCl@ss — ISO 13584-42 (PLIB) — IEC 61360 (CDD) 	Optional depending on the purpose of the use cases
Schedule	Time information bound to a manufacturing process, e.g.: <ul style="list-style-type: none"> — ISO 8601 series — start/stop 	
Status	A condition of an OME involved in a manufacturing process, e.g.: <ul style="list-style-type: none"> — VDMA 24582 	
Location	Geographical or relative location information of an OME, e.g.: <ul style="list-style-type: none"> — GPS coordinates — postal address — ISO 6709 — relative location 	
Report	Description of activities done by or onto an OME, e.g.: <ul style="list-style-type: none"> — QIF — MTConnect 	
Relationship	Connection information between two or more OMEs, e.g. IEC 62264-2	

5.2 Personnel information

Personnel includes employees who are engaged directly or indirectly in manufacturing processes. Personnel information attributes and examples are shown in [Table 2](#).

Table 2 — Information attributes for personnel

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify the person in a specific enterprise, e.g.: <ul style="list-style-type: none"> — employee ID — UUID — URL — URN — OID (ITU-T X.680 and ISO/IEC 8824-1) — domain-specific ID — ISO 29002 series or URI unique ID (used in AAS) 	<ul style="list-style-type: none"> — employee ID: 11223 — UUID: b2287ac5-9572-4e58-88e5-2ba446c630d7
Characteristics	Personal properties including skill level, classification, e.g.: <ul style="list-style-type: none"> — IEC 62264-2 <ul style="list-style-type: none"> — skill level <ul style="list-style-type: none"> — 1: master — 2: journeyman — 3: apprentice — classification <ul style="list-style-type: none"> — 1: researcher — 2: administrator — 3: technician — 4: driver 	<ul style="list-style-type: none"> — IEC 62264-2 <ul style="list-style-type: none"> — skill level: 2 — classification: 3
Schedule	A personal working schedule, e.g.: <ul style="list-style-type: none"> — ISO 8601 series <ul style="list-style-type: none"> — working — day-off 	<ul style="list-style-type: none"> — 2019-05-14-working-0800-1700
Status	A current working status	<ul style="list-style-type: none"> — 2019-05-14-onbreak-1500-1530
Location	location information of a person, e.g.: <ul style="list-style-type: none"> — GPS coordinates — postal address — ISO 6709 — relative location 	<ul style="list-style-type: none"> — Operator #1: WorkUnit #3 and 50 cm away from Robot #2.
Report	An activity report of a person	<ul style="list-style-type: none"> — 2019-05-14-8 h of work
Relationship	Information regarding collaborations among personnel and other OMEs	<ul style="list-style-type: none"> — Operator #1 is the supervisor of operator #2. — WorkUnit #3 must have at least 4 persons for safety reasons. — Operator #1 and Operator #2 are working in the WorkUnit #3. — Operator #1 and Operator #2 are 70 cm away from Machine #2.

5.3 Equipment information

Equipment is a physical element that carries out an operation directly or indirectly for a manufacturing process. Equipment information attributes and examples are shown in [Table 3](#).

Table 3 — Information attributes for equipment

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 14 th , 2019 9 AM to 6 PM: Regular Maintenance — May 14 th , 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.

5.4 Material information

Material includes physical matter that is transformed to become part or the whole of a product e.g. metal block, glass panel, chemical compound, or is used to aid manufacturing processes such as cleaning fluid or coolant. Material information attributes and examples are shown in [Table 4](#).

Table 4 — Information attributes for material

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify the material in a specific enterprise, e.g.: — UUID — bar code — RFID tag	— UUID: 0030f7a2-5266-4937-9820-168409f5e9a2 — bar code: 8809123456785
Characteristics	Features of the material, e.g.: — handle with care/fragile — toxic/non-toxic — liquid/solid/gas — plastic/steel/rubber/powder	Handle with care
Schedule	Time information of the material, e.g.: — purchase schedule — receiving/internal routing schedule — machine load schedule	Purchase: May 14 th , 2019
Status	A current condition of the material, e.g.: — tested — availability — liquid/solid/gas	Tested
Location	Location information of the material, e.g.: — GPS coordinates — postal address — ISO 6709 — relative location	Relative location Material #1: Shelf #3 in Warehouse #2
Report	A usage report of the material	May 14 th , 2019: 8 kg of Material #2 was used in WorkUnit #2.
Relationship	Relationship information between the material and other OMEs	Material #1 is operated by an operator with skill level2.

5.5 Process information

A process consists of the operations necessary to complete a manufacturing task, e.g. milling and drilling in discrete manufacturing, distillation and reaction in oil and gas. Process information attributes and examples are shown in [Table 5](#).

Table 5 — Information attributes for a process

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify a process in a specific enterprise, e.g.: — UUID — process identifier	— UUID: fb341a45-942e-4128-9878-89ab1020bca1 — process identifier: proc-20201210221020

Table 5 (continued)

Attribute	Description	Examples
Characteristics	Classification of processes including production, maintenance, quality test, and inventory, e.g.: <ul style="list-style-type: none"> — production/maintenance/quality test/inventory — milling/drilling — additive manufacturing 	Milling
Schedule	Time features of the process, e.g.: <ul style="list-style-type: none"> — periodic — single occurrence — multiple occurrence — specific time and duration 	Periodic: once a month
Status	A current condition of the process, e.g.: <ul style="list-style-type: none"> — planned — in-process — finished — incomplete 	In-process: May 14 th , 2019 09:00 AM
Location	Location information of the process to be performed, completed or on-going, e.g.: <ul style="list-style-type: none"> — GPS coordinates — postal address — ISO 6709 — relative location 	<ul style="list-style-type: none"> — Relative location: Material #10 was moved from warehouse #2 of the Daejeon branch to conveyor # 5 of factory #2. — GPS coordinates: Material #10 was moved from (36.0265009,129.3510944,14z) to (35.5357326,129.3800283,17z) — XYZ location in coordinate space: Material #10 was moved from (longitude value="- 83.6945691" latitude value="42.25475478" altitude value="0") to (longitude value="- 70.6945691" latitude value="30.25475478" altitude value="0")
Report	An output report of a process	May 14 th , 2019: Machine #2 completed MillingOperation #5.
Relationship	Relationship information between a process and other OMEs	<ul style="list-style-type: none"> — ManufacturingProcessStep #1 is executed by an operator with skill level3. — MillingOperation #1 is begun in Machine #3 and finished in Machine #4.

5.6 Facility information

Facility includes infrastructure that is related to or affects manufacturing. Facility information attributes and examples are shown in [Table 6](#).

Table 6 — Information attributes for a facility

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify a location or fixed asset within a facility in a specific enterprise, e.g.: — UUID — serial number — asset ID	— UUID: 757db0f3-4b6f-4408-903f-c82366677ac5 — asset ID: dtm-200327-010
Characteristics	Classification or features of the facility	ISO class 5 clean room
Schedule	Time features of the facility e.g.: — periodic — one-off — given specific time — duration	Periodic: once a week
Status	A current condition of the facility, e.g.: — normal — abnormal	Normal
Location	Location information of the facility, e.g.: — GPS coordinates — postal address — ISO 6709 — relative location	Relative location: Window #1 in clean room #2
Report	A report of the facility on its status, usage, etc.	The window in clean room #2 was found to be broken at 10 AM.
Relationship	Relationship information between a facility and other OMEs	— Clean room #1 is evacuated when the temperature exceeds the limits. — Vacuum for machine #12 dropped to -0.5 bar at 11 AM.

5.7 Environment information

Environment includes necessary conditions that shall be met by facilities for the correct execution of a manufacturing process. Environment information attributes and examples are shown in [Table 7](#).

Table 7 — Information attributes for environment

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify an environmental profile of a location in a specific enterprise, e.g. UUID	— UUID: 0dc7c7c8-cf7c-435b-9f81-c4d7397123db — combination of time and sensor ID: 20200327-sensor0010
Characteristics	Constraints or requirements of the environment, e.g.: — temperature — humidity — illuminance	— temperature: 25 °C — humidity: 60 % — illuminance: 60 lux

Table 7 (continued)

Attribute	Description	Examples
Schedule	N/A	N/A
Status	A current condition of the environment, e.g. <ul style="list-style-type: none"> — Normal — abnormal 	Normal
Location	A location of the environmental information observed, e.g.: <ul style="list-style-type: none"> — GPS coordinates — postal address — ISO 6709 — relative location 	Relative location: Jig bore room #3 in Building #2
Report	A report of the environment during manufacturing	The temperature in jig bore room #3 changed from 20 °C to 22 °C during manufacturing process.
Relationship	Relationship information between the environment and other OMEs	<ul style="list-style-type: none"> — Clean room should be kept at 20 °C while manufacturing process #1 is being performed. — May 14th, 2019 10 AM: Air conditioner in Facility #3 turned on and lowered the temperature in the clean room to 20 °C

5.8 Product information

A product is the desired output of a manufacturing process. Product information attributes and examples are shown in [Table 8](#).

Table 8 — Information attributes for a product

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify a product, e.g. part number, model number, batch number or serial number, in a specific enterprise, e.g. UUID	UUID: 7062255e-93d9-4055-85e9-c127b17c9883
Characteristics	Classification or features of the product, e.g.: <ul style="list-style-type: none"> — design dimensions — design colour 	Design colour: white
Schedule	Desired time of output or by-product of a manufacturing process	May 14th, 2020 10AM, intermediate between Process #1 and Process #2
Status	A current condition of the product, e.g.: <ul style="list-style-type: none"> — in-process — installed — completed — shipped — in inventory 	In-process: May 14th, 2019 10 AM

Table 8 (continued)

Attribute	Description	Examples
Location	A location of the product, e.g.: <ul style="list-style-type: none"> — GPS coordinates — postal address — ISO 6709 — relative location 	Relative location: Product #2 is in Warehouse #3.
Report	A report of activities related to the product	<ul style="list-style-type: none"> — May 14th, 2019 9 AM: Product #2 has passed QualityTest #5. — May 14th, 2019 10 AM: Product #2 has moved to Warehouse #3.
Relationship	Relationship information between a product and other OMEs	<ul style="list-style-type: none"> — Product #1 is produced by Machine #3. — Product #3 is in process on Machine #2 for Milling Operation #3.

5.9 Supporting document information

A supporting document includes any form of artefact that helps the applications of digital twin for manufacturing. Supporting document information attributes and examples are shown in [Table 9](#).

Table 9 — Information attributes for a supporting document

Attribute	Description	Examples
Identifier	A value that conforms to ISO 8000-115 used to uniquely identify a supporting document in a specific enterprise, e.g.: <ul style="list-style-type: none"> — UUID — document number 	<ul style="list-style-type: none"> — UUID : c0ff08a6-7de4-4427-9440-bbf27aed92aa — Document number: dtm-11223-doc010-200327
Characteristics	Classification of the supporting document, e.g.: <ul style="list-style-type: none"> — document format — requirements document — manufacturing plan — specification document 	Document format: pdf
Schedule	Revision time of the supporting document, e.g.: <ul style="list-style-type: none"> — periodic — one time 	Periodic: once a month
Status	A current condition of the supporting document, e.g.: <ul style="list-style-type: none"> — planned — complete — incomplete 	Complete

Table 9 (continued)

Attribute	Description	Examples
Location	Location information, e.g.: — URL — GPS coordinates — postal address — ISO 6709 — relative location	Document #2 is stored in http://acme.com/document
Report	A report of activities related to the supporting document	May 14th, 2019 9 AM: Document #2 is revised in http://acme.com/document .
Relationship	Relationship information between a supporting document and other OMEs	— May 12th, 2019 10 AM: Engineer #3 produced Document #2. — Document #3 for Drilling Operation #5 by May 31th, 2019.

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Annex A (informative)

Existing technologies for representing OMEs

A.1 General

Multiple existing standards and specifications can be used to represent OMEs. Each standard has its own characteristics and advantages. Digital twin developers should carefully consider which ones should be used for a target application. In many cases, multiple standards need to be combined because one can be most appropriate for the digital twin entity, and another can be most appropriate for the device communication entity.

[Clauses A.2](#) to [A.4](#) provide brief summaries for a selection of existing standards. This is not a complete list.

A.2 Standards tested in the use cases described in ISO 23247-4:2021, Annex A

The ISO 10303 series, known as Standard for the Exchange of Product Model Data (STEP), defines the computer-interpretable representation of product information and the exchange of product and process data (see ISO 10303-238). The objective of the ISO 10303 series is to provide a neutral mechanism capable of describing products and their manufacturing processes throughout their life cycle. This mechanism is appropriate not only for neutral file exchange, but also as a basis for implementing and sharing product databases, and as a basis for archiving. The STEP series is used for data exchange among CAD/CAM systems and between CAD/CAM and manufacturing systems. The information models for the ISO 10303 series are described using EXPRESS schemas.

- ISO 10303-238 specifies an application protocol (AP) for numerically controlled machining and associated processes. ISO 10303-238 includes the information requirements defined by the ISO 14649 series data model for numerical controllers, augmented with product geometry, geometric dimensioning and tolerancing, and product data management information.
- ISO 10303-242 specifies an application protocol for managed model-based 3D engineering. The scope of ISO 10303-242 includes products of automotive, aerospace, and other mechanical manufacturers and of their suppliers, engineering and product data, product data management, process planning, mechanical design, kinematics, geometric definition and tolerancing, and composite design.

The ISO 13399 series describes the computer-interpretable representation and exchange of industrial product data about cutting tools and tool holders (see ISO/TS 13399-60). The ISO 13399 series defines the reference dictionary for cutting items, tool items, adaptive items, etc. ISO 13399 series can be used to represent and exchange data for cutting tools.

ISO 23952 describes the general content and structure of the entire quality information framework (QIF) information model, and supports concepts in engineering applications ranging from product design through manufacturing to quality inspection.^[5] The XML-based QIF standard contains a library of XML schema ensuring both data integrity and data interoperability in model based enterprise implementation.

MTConnect provides a semantic vocabulary for manufacturing equipment to provide structured, contextualized data with no proprietary format.^[6] With uniform data defined by MTConnect, developers and integrators can focus on useful, productive manufacturing applications rather than translation. MTConnect data enables more efficient operations, improved production optimization, and increased productivity.

IEC 62541 represents the international standard of the open platform communications unified architecture (OPC-UA) which is used for vertical and horizontal communication in manufacturing and automation, providing interoperability for the world of connected systems.^[8] It has been designed for scalability and supports a wide range of application domains, ranging from field level (e.g. devices for measurement or identification, PLCs), to enterprise management support.

A.3 Standards developed by ISO

ISO 10303-235 specifies the integrated resources necessary for the representation of engineering property data for product design, product validation and other purposes. The scope of ISO 10303-235 includes information about the relationship between a product, a process and the product properties that result from the application of a process.

ISO 10303-239 specifies the application protocol for product life cycle support. The scope of ISO 10303-239 includes information for defining and maintaining a complex product and information required for life configuration change management of a product and its support solution. Also, it includes representations of product assemblies, product life-cycle, product specification, product planning, and product history.

ISO 15926-1 specifies a representation of information associated with engineering, construction and operation of process plants. This representation supports the information requirements of the process industries in all phases of a plant's life-cycle and the sharing and integration of information amongst all parties involved in the plant's life cycle.

ISO 16739-1 or industry foundation classes (IFC) consists of the data schemas, represented as an EXPRESS schema and an XML schema, and reference data, represented as definitions of property and quantity names, and formal and informative description. The IFC are an open international standard for building information model (BIM) data that are exchanged and shared among software applications used by the various participants in the construction or facility management industry sector. The standard includes definitions that cover data required for buildings over their life cycle.

A.4 Standards developed by other organizations

The IEC 62264 series is based on ISA-95. The IEC 62264 series provides a consistent terminology that is a foundation for communication between suppliers and manufacturers. IEC 62264 series also provides consistent information models and object models to integrate control systems with enterprise systems that improve communications among all manufacturing elements involved. B2MML is an XML implementation of the IEC 62264 series, enterprise-control system integration.^[15] B2MML consists of a set of XML schemas written using the World Wide Web Consortium's XML Schema language (XSD) that implements the data models in the IEC 62264 series.

The IEC 62714 series, known as automation markup language (AML), describes the data exchange format using XML schema. AML has been developed to support the data exchange and interconnect in heterogeneous engineering tools in their different disciplines. IEC 62714 series can be used to represent data exchange among manufacturing elements.

The asset administration shell (AAS) is part of the I4.0 component as introduced in IEC PAS 63088. Serializations and mappings are provided for XML, JSON, RDF, AutomationML and OPC-UA. One of its key features is the separation of the digital representation into a set of sub models. Each sub model represents a specific aspect of the asset that the digital twin is representing.

The eCl@ss (classification and production description) defines product classes and unique properties including procurement, storage, production, and distribution activities.^[18] The eCl@ss can be used to define classes and properties for manufacturing elements conformant to IEC 61360 and ISO 13584-42.

The resource description framework (RDF) is a framework for describing and merging information resources on the Web, including ones that have different schemas.^[19]

The functional mock-up interface (FMI) is an industry standard that defines a container and an interface to exchange dynamic models for Modelica simulations.^[20]

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Annex B (informative)

Example of information attributes

B.1 General

Figure B.1 shows an example of information attributes for an OME, which includes personnel, equipment, material, process, facility, environment, product, supporting document as described in Clause 5.

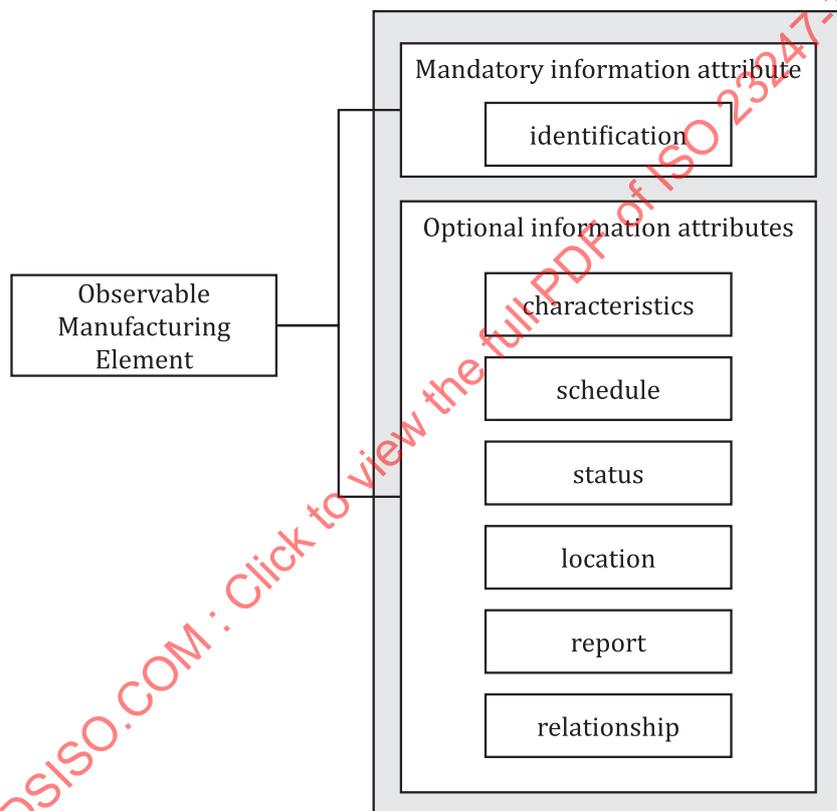


Figure B.1 — Example of information attributes for OME

B.2 Example XML for personnel

Example XML, using the description and examples for the personnel OME given in Table 2, is as follows:

```
<?xml version="1.0" encoding="utf-8" ?>
<PersonnelInformation>
  <MandatoryInformationAttribute>
    <PersonnelID>b2287ac5-9572-4e58-88e5-2ba446c630d7</PersonnelID>
  </MandatoryInformationAttribute>

  <OptionalInformationAttributes>

    <PersonnelCharacteristics>
      <skillLevel>2</skillLevel>
    </PersonnelCharacteristics>
  </OptionalInformationAttributes>
</PersonnelInformation>
```

```

<PersonnelSchedule>
  <working>
    <startdate>2020-05-30T09:30:10Z</startdate>
    <period>PT08H</period>
  </working>
</PersonnelSchedule>

<PersonnelStatus>2019-05-14-onbreak-1500-1530</PersonnelStatus>

<PersonnelLocation>
  <relative>Operator #1: WorkUnit #3 and 50 cm away from Robot #2.</relative>
  <GPSCoordinate>
    36.365609, 127.344407, 17z
  </GPSCoordinate>
  <PostalAddress>
    <CountryCode>KR</CountryCode>
    <PostalCode>34129</PostalCode>
    <Region>Seoul</Region>
    <Region>Star-Gu</Region>
    <AddressLine>218 Bom-dong</AddressLine>
    <AdditionalText>
      <workunit>WorkUnit#3</workunit>
      <workcenter>Laboratory#2</workcenter>
      <area>CMOS Facility</area>
      <site>Daejeon Expressway Plant</site>
      <enterprise>AAA Electric</enterprise>
    </AdditionalText>
  </PostalAddress>
  <gpl:GPL_CoordinateTuple xmlns:gpl="https://www.isotc211.org/gpl">
    <gpl:tuple srsName="urn:ogc:def:crs:EPSG:6.6:4326">
      35.89421911 139.94637467 17z
    </gpl:tuple>
  </gpl:GPL_CoordinateTuple>
</PersonnelLocation>

<PersonnelReport>
  <WorkReport timestamp="2019-05-14T18:19:35.153141">
    <startdate>2020-05-14T10:00:10Z</startdate>
    <enddate>2020-05-14T18:10:10Z</enddate>
  </WorkReport>
</PersonnelReport>

<PersonnelRelationship>
  WorkUnit #3 must have at least 4 persons for safety reasons
</PersonnelRelationship>

</OptionalInformationAttributes>
</PersonnelInformation>

```

B.3 Example XML for equipment

Example XML, using the description and examples for the equipment OME given in [Table 3](#), is as follows:

```

<?xml version="1.0" encoding="utf-8" ?>
<EquipmentInformation>
  <MandatoryInformationAttribute>
    <UUID>e88561dc-2401-4f9a-961c-e90e6424b1dd </UUID>
  </MandatoryInformationAttribute>

  <OptionalInformationAttributes>

    <EquipmentCharacteristics>
      <Functionality>milling</Functionality>
    </EquipmentCharacteristics>

    <EquipmentSchedule>
      <value>Maintenance for Machine #1 is scheduled on every Sunday</value>
    </EquipmentSchedule>

    <EquipmentStatus>

```

```

    <status>energy</status>
    <value>10</value>
    <unit>kWh</unit>"
  </EquipmentStatus>

  <EquipmentLocation>
    <name>relative</name>
    <value>Machine #2: Work Unit #2 in Room #3</value>
    <gps>
      <longitude>35.5357326</longitude>
      <latitude>129.3800283</latitude>
      <altitude>17</altitude>
    </gps>
  </EquipmentLocation>

  <EquipmentReport>
    <MaintenanceReport timestamp="2019-05-15T18:10:35.153141">
      <startdate>2020-05-14T09:00:10Z</startdate>
      <enddate>2020-05-14T18:00:10Z</enddate>
    </MaintenanceReport>
  </EquipmentReport>

  <EquipmentRelationship>
    <value>WorkUnit #3 must have at least 4 persons for safety reasons</value>
  </EquipmentRelationship>

</OptionalInformationAttributes>
</EquipmentInformation>

```

B.4 Example XML for material

Example XML, using the description and examples for the material OME given in [Table 4](#), is as follows:

```

<?xml version="1.0" encoding="utf-8" ?>
<MaterialInformation>
  <MandatoryInformationAttribute>
    <UUID>0030f7a2-5266-4937-9820-168409f5e9a2</UUID>
  </MandatoryInformationAttribute>

  <OptionalInformationAttributes>

    <MaterialCharacteristics>
      <Feature>handle with care</Feature>
    </MaterialCharacteristics>

    <MaterialSchedule>purchase: May 14th, 2019</MaterialSchedule>

    <MaterialStatus>Tested: May 14th, 2019</MaterialStatus>

    <MaterialLocation>
      <RelativeLocation>
        Material #1: Shelf #3 in Warehouse #2
      </RelativeLocation>
      <PostalAddress>
        <workunit>WorkUnit#3</workunit>
        <workcenter>Laboratory#2</workcenter>
        <area>CMOS Facility</area>
        <site>Daejeon Expressway Plant</site>
        <enterprise>AAA Electric</enterprise>
        <country>ROK</country>
      </PostalAddress>
      <name>gps</name>
      <value>36.365609, 127.344407, 17z</value>
    </MaterialLocation>

    <MaterialReport>
      <UsageReport>
        May 14th, 2019: 8 kg of Material #2 was used in WorkUnit #2.
      </UsageReport>
    </MaterialReport>

```

```

    <MaterialRelationship>
      Material #1 is operated by an operator with skill level2.
    </MaterialRelationship>

  </OptionalInformationAttributes>
</MaterialInformation>

```

B.5 Example XML for a process

Example XML, using the description and examples for the process OME given in [Table 5](#) is as follows:

```

<?xml version="1.0" encoding="utf-8" ?>
<ProcessInformation>
  <MandatoryInformationAttribute>
    <ProcessID>fb341a45-942e-4128-9878-89ab1020bca1</ProcessID>
  </MandatoryInformationAttribute>

  <OptionalInformationAttributes>

    <ProcessCharacteristics>milling</ProcessCharacteristics>

    <ProcessSchedule>single occurrence</ProcessSchedule>

    <ProcessStatus>
      in-process: May 14th, 2019 09:00 AM
    </ProcessStatus>

    <ProcessLocation>
      <name>relative</name>
      <value>Process #1 of Machine #2 in Room #3 is completed.</value>
      <PostalAddress>
        <workunit>Process #1 of Machine #2</workunit>
        <workcenter>Room #3</workcenter>
        <area>CMOS Facility</area>
        <site>Daejeon Expressway Plant</site>
        <enterprise>AAA Electric</enterprise>
        <country>ROK</country>
      </PostalAddress>
      <name>gps
        <longitude>35.5357326</longitude>
        <latitude>129.3800283</latitude>
        <altitude>17</altitude>
      </name>
    </ProcessLocation>

    <ProcessReport>
      <MillingOperation>
        <Event timestamp="2019-05-14T18:19:35.153141">
          <status>Completed</status>
        </Event>
      </MillingOperation>
    </ProcessReport>

    <ProcessRelationship>
      ManufacturingProcessStep #1 is executed by an operator with skill level3.
    </ProcessRelationship>

  </OptionalInformationAttributes>
</ProcessInformation>

```

B.6 Example XML for a facility

Example XML, using the description and examples for the facility OME given in [Table 6](#), is as follows:

```

<?xml version="1.0" encoding="utf-8" ?>
<FacilityInformation>
  <MandatoryInformationAttribute>
    <FacilityID>757db0f3-4b6f-4408-903f-c82366677ac5</FacilityID>
  </MandatoryInformationAttribute>

```

```

<OptionalInformationAttributes>
  <FacilityCharacteristics>
    ISO class 5 clean room
  </FacilityCharacteristics>

  <FacilitySchedule>periodic: once a week</FacilitySchedule>

  <FacilityStatus>normal</FacilityStatus>

  <FacilityLocation>
    <name>relative</name>
    <value>Window #1 in clean room #2</value>
    <PostalAddress>
      <workunit>Window #1</workunit>
      <workcenter>clean room #2</workcenter>
      <area>CMOS Facility</area>
      <site>Daejeon Expressway Plant</site>
      <enterprise>AAA Electric</enterprise>
      <country>ROK</country>
    </PostalAddress>
    <name>gps
      <longitude>35.5357326</longitude>
      <latitude>129.3800283</latitude>
      <altitude>17</altitude>
    </name>
  </FacilityLocation>

  <FacilityReport>
    <Event timestamp="2019-05-14T10:00:35.153141">
      <RelativeLocation>
        The window in clean room #2
      </RelativeLocation>
      <status>broken </status>
    </Event>
  </FacilityReport>

  <FacilityRelationship>
    WorkUnit #3 must have at least 4 persons for safety reasons.
  </FacilityRelationship>

</OptionalInformationAttributes>
</FacilityInformation>

```

B.7 Example XML for environment

Example XML, using the description and examples for the environment OME given in [Table 7](#), is as follows:

```

<?xml version="1.0" encoding="utf-8" ?>
<EnvironmentInformation>
  <MandatoryInformationAttribute>
    <EnvironmentID>0dc7c7c8-cf7c-435b-9f81-c4d7397123db</EnvironmentID>
  </MandatoryInformationAttribute>

  <OptionalInformationAttributes>

    <EnvironmentCharacteristics>
      <temperature>25 °C</temperature>
      <humidity>60 %</humidity>
      <illuminance>60 lux</illuminance>
    </EnvironmentCharacteristics>

    <EnvironmentSchedule>N/A</EnvironmentSchedule>

    <EnvironmentStatus>Normal</EnvironmentStatus>

    <EnvironmentLocation>
      <RelativeLocation>
        Jig bore room #3 in Building #2
      </RelativeLocation>
    </EnvironmentLocation>
  </OptionalInformationAttributes>
</EnvironmentInformation>

```