SLOVENSKI STANDARD
oSIST prEN IEC 63339:2023

01-januar-2023

Enoten referenčni model za pametno proizvodnjo

Unified reference model for smart manufacturing

Ta slovenski standard je istoveten z: **prEN IEC 63339:2022**

ICS:

25.040.01	Sistemi za avtomatizacijo v industriji na splošno	Industrial automation systems in general

oSIST prEN IEC 63339:2023 **en,fr,de**

65/946/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: IEC 63339 ED1	
DATE OF CIRCULATION: 2022-11-18	CLOSING DATE FOR VOTING: 2023-02-10
SUPERSEDES DOCUMENTS: 65/930/CD, 65/939A/CC	

IEC TC 65 : INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION	
SECRETARIAT: France	SECRETARY: Mr Didier GIARRATANO
OF INTEREST TO THE FOLLOWING COMMITTEES: SyC SM,ISO/IEC JTC 1/SC 41	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT	☐ QUALITY ASSURANCE ☐ SAFETY
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

Unified reference model for smart manufacturing

PROPOSED STABILITY DATE: 2027

NOTE FROM TC/SC OFFICERS:

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

UNIFIED REFERENCE MODEL FOR SMART MANUFACTURING

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC/ISO 63339 has been prepared committee by IEC technical committee 65: Industrial-process measurement, control and automation and by ISO technical committee 184: Automation systems and integration. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committees have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

Unified reference model for smart manufacturing

CONTENTS

Introduction

“Manufacturing” refers to a range of human activities, from handicraft to high tech, and is commonly applied to industrial production, where raw materials and parts are transformed into finished goods on small to large scale by a series of interconnected processes. Smart manufacturing (SM) is an emergent characteristic of manufacturing achieved by digital technologies, gradually built up through digital transformation, combining diversity and uniformity, demonstrating continuous value delivery by a highly complicated collection of processes interacting on different time scales. In today’s manufacturing landscape, manufacturing is no longer characterized as a set of serial processes, but instead as a highly interconnected set of distributed processes that are able to cooperate on different time scales. A set of supervisory processes achieve coordination of these distributed processes using links that enable dynamic response to changing conditions in demands, supply, environment, energy and, other human or naturally caused probabilistic events. Since these probabilistic events are not known before occurrence, they often are disruptive and result in changing conditions.

The purpose of smart manufacturing is to accommodate those disruptive events, while supporting the introduction of new technologies and methods in a coordinated manner across the variety of customers, suppliers and stakeholders at various stages in the value chain.

Building upon the common knowledge and results found in IEC TR 63319 [4] - A meta-modelling analysis approach to smart manufacturing reference models and as depicted in Figure 1, this document specifies the unified reference model for smart manufacturing (URMSM) to create purpose-specific domain and application reference models for smart manufacturing initiatives by specifying the necessary structure and terminology for expressing such models. The URMSM is applicable across the many domains and applications found within a manufacturing enterprise.

Smart manufacturing reference models (SMRM), which conform to the specifications of this document, provide SM standards developers and SM practitioners with better opportunities for implementing models of production systems and products that take full advantage of technological innovations. These innovations occur during;

- analysis and synthesis using models of manufacturing,
- application of new materials, processes and facilities for manufacturing,
- understanding the emergence of digital twin concepts and either smart manufacturing technologies.

The URMSM is not one model or one model visualization. The URMSM is a specification for a family of reference models that share structural and behavioural properties intended to promote interoperability.

NOTE Clause 8.2 provides more information regarding relationships among models and derivation relations.

The URMSM brings together concepts from existing works, both standards and practice, to support the variety of existing reference models, the adaptation of existing reference models for new uses, and the emergence of new reference models, all of which take advantage of the evolution in manufacturing technologies.

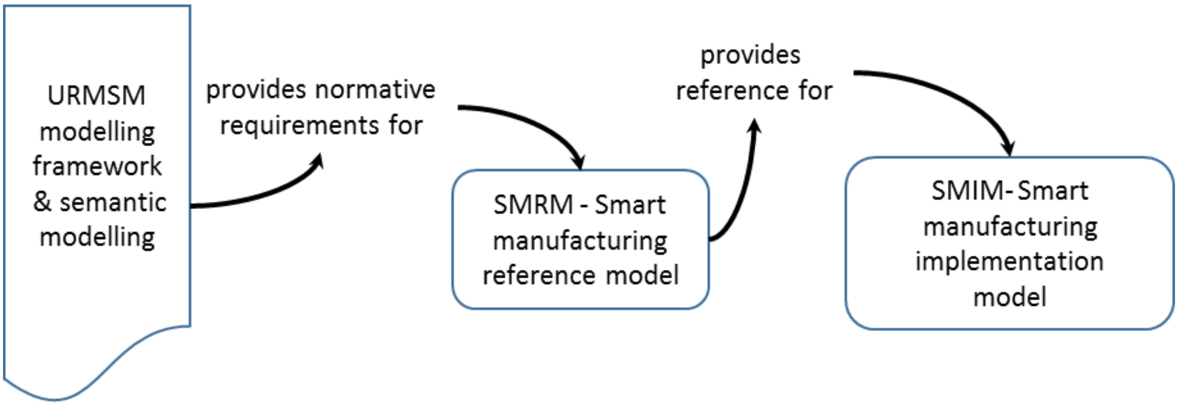

Figure 1 – Using URMSM

The model-based approach of the URMSM has two major structural components. The first is a modelling framework to support various arrangements of manufacturing elements into conceptual configurations deemed pertinent to domains of manufacturing enterprises. The second is the conceptualization of semantic models that reside within the modelling framework. A concise URMSM terminology supports both the modelling framework and the conceptual semantic models.

Since smart manufacturing is essentially a human conception of improved manufacturing technologies and practices, differences in interpretation of that concept can lead some practitioners to over-simplify the complicated nature of perspective and property interactions in today's manufacturing systems. Objectifying the notion of 'smart' for manufacturing is a challenge since developers and practitioners have been getting smarter about manufacturing for over 200 years already.

For IEC work in a domain of similar complexity, the author of [1] summarizes "smartness" in the domain of Smart Cities as: Smartness is an emergent characteristic of a system

– achieved by digital technologies,
– explicitly architected and engineered to reduce complexity,
– gradually built up through digital transformation,
– permanently demonstrating value delivery,
– combining diversity and uniformity,
– coordinating and cooperating between all the stakeholders.

Considering this characterization, the URMSM provides the means for creating reference models for smart manufacturing that enable emergence of more digitally oriented, engineered solutions for delivering additional value from manufacturing operations. The result is improved performance aspects with integrated and intelligent use of processes and resources in cyber, physical and human spheres to create and deliver products and services, which also collaborate with other domains within enterprises' value chains [2].

This document identifies a collection of criteria for arranging aspects of the smart manufacturing domain as reference models. The important relationships among manufacturing elements enable useful examination and derivation of practical designs in order to fulfil a defined purpose, and to maintain and improve the resulting system through methods for analysis and synthesis.

The URMSM provides insight into the modelling of aspects of manufacturing elements to consider when developing new elements. Smart support methods for conducting that development or modification can require an evolution from existing practice to a more unified model-based approach.

This document can be used to support the development processes of smart manufacturing, and to assure coherence and compatibility during the development of standards.

This document identifies ways to apply those aspects of manufacturing and the acumen essential to developing a smart manufacturing model for a particular industrial enterprise.

The URMSM goes beyond the representational features of manufacturing elements to enable examination of interactions among those elements through the use of models to address issues arising in the course of smart manufacturing initiatives.

Expectations regarding the outcome of a satisfactory URMSM are:

- enabling the examination of value within a value creation network;
- enabling a range of appropriate libraries such as use-cases, interface definitions, models for semantics, information and data, and international standards as modelled views relative to modelling purposes for particular smart manufacturing situations;
- enabling representation as a multi-dimensional space composed from various collections of aspects to accommodate particular modelling purposes, such as aspects of production, aspects of product, aspects of smart technology, and their relationships over their respective life cycles;
- enabling assurance that information is consistently structured using standards for information, data and modelling languages, without ambiguous meaning, by applying semantic models and techniques;
- enabling efficient usability for the creation of tailored smart manufacturing models that address a stakeholder's particular concerns.

The URMSM supports all three modalities of interoperation (unified, integrated, and federated) that can co-exist within a modelling framework, albeit with varying extents of effectiveness and efficiency (see ISO 11354). Having a formal understanding of modelling frameworks enables more effective and efficient utilization of frameworks.

Clause 4 specifies extents of conformance to URMSM based upon meeting the requirements and recommendations in their entirety, as full conformance, or for particular sub-clauses, as partial conformance.

Clause 5 presents aspects of manufacturing commonly associated with 'smart manufacturing'.

Clause 6 presents modelling concepts essential for constructing suitable reference models in the domain of smart manufacturing.

Clause 7 establishes examination and derivation criteria for interoperation of aspects in manufacturing.

Clause 8 presents ways to use the URMSM specification criteria to create purpose-specific reference models.

Clause 9 presents use cases for the URMSM and a progression of capability markers that indicate maturity in the application of the URMSM.

Clause 10 discusses ways to manipulate and use reference frameworks for extended analysis and synthesis for systems used in smart manufacturing.

Annex A presents concept areas of smart manufacturing.

Annex B provides a formal foundation for the URMSM approach including a modelling framework for URMSM.

Annex C provides an example figure of cascading reference models.

Annex D provides a summary of the meta-model for reference model analysis from IEC TR 63319 [4].

Annex E provides an introduction to the principles underlying semantic modelling.

Annex F provides a practitioner's modelling activity in a systematic usage of URMSM.

Annex G provides an extended example of the URMSM applied to a multi-dimensional manufacturing scenario.

Unified reference model for smart manufacturing

1 Scope

This document specifies the unified reference model for smart manufacturing (URMSM) using a terminology and structure, and establishes criteria for creating reference models, as specializations, that support smart manufacturing. The terminology and structure comprise a set of common modelling elements, their associations, and conformance criteria. These common modelling elements address aspects and perspectives of products and production and their lifecycle considerations.

The URMSM enables an approach for creating multiple models based upon a reference model that is sufficient for understanding significant relationships among entities involved in smart manufacturing (SM) and for the development of standards and other specifications.

The URMSM specifications in this document accommodate consistent, coherent, compatible specializations for relevant aspects of manufacturing systems consisting of equipment, products, and services within the domain of manufacturing. Provisions of this document are applicable for a new smart manufacturing reference model (SMRM) or elaboration of existing SMRM capabilities, for example, improving capabilities for analysis of opportunities and synthesis of technological advances, and improving interoperability of new and existing systems.

This document is not intended to prescribe interoperability considerations or data schemas of models. Standardization of content relative to models will be the subject of other standards and texts specific to those model domains.

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 15704:2019 Enterprise modelling and architecture – Requirements for enterprise-referencing architectures and methodologies

ISO/IEC/IEEE 42010 Systems and software engineering – Architecture description

3 Terms, definitions, and conventions

3.1 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 http://www.iso.org/obp

3.1.1
aspect
labelled designation for a collection of concepts in a particular context

EXAMPLE functional, structural, information, security, availability, customer

Note 1 to entry: An aspect is often expressed as a view across one or more model for a manufacturing system.

Note 2 to entry: Elements of an aspect can have functional, non-functional or other kinds of descriptors.

Note 3 to entry: The identification of an aspect is often the result of prior knowledge, experience and practice in the domain to which the aspect applies.

3.1.2
aspect interaction
relationship between two or more *aspects* (3.1.1) where one aspect influences or is influenced by the presence of another aspect

Note 1 to entry: Influence includes but is not limited to dependence and control.

3.1.3
business
series of processes, each having a clearly understood purpose, involving one or more person, realised through the exchange of information and directed towards some mutually agreed upon goal, extending over a period of time

[SOURCE: ISO/IEC 15944-20:2015(en), 2.2]

3.1.4
complex
<context>
decision situation characterised by unordered decision variables, and ill-defined categories, criteria and dependencies

3.1.5
complicated
<context>
decision situation characterised by enumerated decision variables, and well-defined categories, criteria and dependencies

3.1.6
concern
matter of relevance or importance to a *stakeholder* (3.1.20) regarding a manufacturing system or element thereof

Note 1 to entry: Stated concerns are useful when relevant to the purpose of the modelling effort and refer to specific rather than categorical difficulties, problems, or requirements.

Note 2 to entry: Concern expression takes many forms, including among others: as questions about features or characteristics, as a keyword label for many related matters, and as expected quality attributes of the manufacturing system or its products and services.

[SOURCE: ISO/IEC/IEEE 42010 Ed2, 3.10, added - "regarding a manufacturing system element thereof]

3.1.7
dimension
coherent collection of *aspects* (3.1.1) relevant to a *manufacturing domain* (3.1.12)

Note 1 to entry: The coherence requirement of the dimension can result in a collection of aspects that are unordered, partially ordered, fully ordered, or related in some other manner, or not ordered in any way (see 6.4 on dimensional coherence for further information).

3.1.8
element
tangible or intangible constituent of a manufacturing system or of a product

Note 1 to entry: A constituent can range from atoms of raw material or logical constructs or items of information through manufacturing models or equipment and entire factories, plants or supply chains and added value networks to finished goods, and software and services.

Note 2 to entry: While the term as defined has broad meaning, designation of a specific meaning for an element of manufacturing or manufactured product includes an adjective to constrain the meaning appropriate to that particular manufacturing element.

Note 3 to entry: Requirements expressed in a specification are the kind of information for a particular element in the manufacturing domain.

3.1.9
facet
framework composed of one or more dimension (3.1.7)

Note 1 to entry: Composition rules for coherent dimensions distinguish facets from other modelling frameworks.