INTERNATIONAL STANDARD

ISO 16300-3

First edition
2017-10

Automation systems and integration — Interoperability of capability units for manufacturing application solutions —

Part 3: Verification and validation of interoperability among capability units

Systèmes d'automatisation et intégration — Interopérabilité des unités d'aptitude pour la fabrication de solutions d'application —

Partie 3: Vérification et validation de l'interopérabilité au sein des unités d'aptitude

Reference number
ISO 16300-3:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*.

A list of all parts in the ISO 16300 series can be found on the ISO website.

Introduction

ISO 16300 addresses requirements of users and suppliers of manufacturing software regarding the interoperability of software in the area of industrial automation.

User interoperability requirements include:

— integrating an automation application system by combining capabilities of a set of software components provided by various sources,

— substituting another software component in a software unit to provide an equivalent capability required by the automation application system,

— integrating the capability of a software unit from one resource system platform to another platform,

— validating and verifying the capability of a software unit to meet the automation application system requirements.

Supplier requirements include:

— representing the set of capabilities provided by a software component used in a software unit,

— verifying software component capability as a part of a required software unit capability,

— cataloguing a software unit in terms of its capability for interoperability in an automation application system to support wide distribution.

ISO 16300 also addresses software interoperability services which include:

— accessing the description of a software capability to enable interoperability assessment,

— enabling the search and location of candidate software units and components, preferably automatically, using search engines,

— representing the dependencies between software components for an automation application hosted on a particular system platform.

Software capability is first defined in terms of the potential function. It is then expressed and represented as facts about the software, how and what it can do. The ISO 16100 series was developed with the aim of providing a standardized method to describe capabilities of manufacturing software in terms of the MSU (manufacturing software unit) capability profile. In ISO 16100, the software component is included in the MSU. ISO 16100 also provides a way to exchange an MSU's capability as information by means of a capability profile. Software capability profiling is the basis for providing the above-mentioned software interoperability services. ISO 16100 is used and applied as the foundation for ISO 16300.

To establish ISO 16300, a number of steps were necessary. The initial step shows what interoperability services are enabled by using software capability profile. The following steps develop concrete methods and mechanisms to provide these interoperability services. The resulting output from ISO 16300 are several published parts.

ISO 16300-1 specifies a framework for describing an automation solution in terms of a set of capabilities provided by a set of MSUs. The framework also defines a set of capability elements and composition rules to represent the interoperability criteria in terms of the automation system capability requirements of an enterprise application.

ISO 16300-2 specifies the template definition to describe the capability of software unit of an automation solution that can be mapped to the functional requirements of target manufacturing application. It also specifies mapping rules for composing the contents of a software unit catalogue item in terms of the properties of the capability.

ISO 16300-3 specifies the framework for verifying interoperability of capability unit associated with application requirements and system solution.

ISO 16300-4 specifies the search methodology for acquiring candidate capability units which satisfies the manufacturing application requirements from the software unit catalogues and also describes the structure of the report as an outcome of the search, indicating the extent to which the candidates from the software unit catalogues correspond to the manufacturing application requirements.

Automation systems and integration — Interoperability of capability units for manufacturing application solutions —

Part 3: Verification and validation of interoperability among capability units

1 Scope

This document specifies a framework for verifying and validating the interoperability of manufacturing capability units (MCUs) having a set of capabilities that meet the functional requirements of a target manufacturing application solution.

The verification and validation framework describes the use of the interoperability criteria in ISO 16300-1 and the steps to be performed.

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 16100-1, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 1: Framework*

ISO 16100-2, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 2: Profiling methodology*

ISO 16100-3, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 3: Interface services, protocols and capability templates*

ISO 16100-6, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 6: Interface services and protocols for matching profiles based on multiple capability class structures*

ISO/IEC 25000, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE*

ISO/IEC 25010, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16100-1, ISO 16100-3, ISO 16100-6 and the following apply.

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

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

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

3.1
capability class structure
hierarchy of capability classes

[SOURCE: ISO 16100-6:2011, 3.2, modified — The Note was deleted.]

3.2
capability profiling
selection of a set of offered services defined by a particular interface within a software interoperability framework

[SOURCE: ISO 16100-1:2009, 3.5]

3.3
interoperability validation
procedure which examines the implemented interoperability mechanisms to determine the extent to which they are compliant with a set of quality characteristics (reliability, security, performance, time response, etc.)

Note 1 to entry: These quality characteristics are considered as pertinent for the expected behaviour of the current manufacturing application processes.

3.4
interoperability verification
procedure of checking that the designed interoperability of manufacturing processes match the corresponding implemented interoperability mechanisms

3.5
manufacturing application requirements document
MARD
document specifying necessary processes to be designed and implemented in order to meet the targeted manufacturing goal, and also specifying various resources to be available to accomplish processes execution

3.6
manufacturing capability unit
MCU
manufacturing unit of a type (i.e. mechanical, electrical, electronic, hardware, and/or software, etc.) intended to support the execution of a particular manufacturing task.

Note 1 to entry: Manufacturing capability unit is a resource capability unit or a process capability unit.

3.7
manufacturing process capability unit
MPCU
process capability unit of a type (i.e. mechanical, electrical, electronic, hardware, and/or software) corresponding to the execution of a particular manufacturing process

3.8
manufacturing resource capability unit
MRCU
manufacturing capability unit (3.6) of resource (i.e. human, energetic, mechanical, electrical, electronic, hardware, and/or software, etc.) supporting the execution of manufacturing application (process, activity or task)

3.9
manufacturing capability profile
concise representation of a *manufacturing capability unit* (3.6) to meet a requirement of a manufacturing application

[SOURCE: ISO 16100-1:2009, 3.21]

3.10
manufacturing software
type of software resource within an automation system that provides value to a manufacturing application (e.g. CAD/PDM) by enabling the flow of control and information among the automation system components involved in the manufacturing processes, between these components and other enterprise resources, and between enterprises in a supply chain or demand chain

[SOURCE: ISO 16100-1:2009, 3.16, modified — The Note was deleted and "(e.g. CAD/PDM)" was added to the definition.]

3.11
manufacturing software unit
MSU
class of software resource, consisting of one or more *manufacturing software* (3.10) components, performing a definite function or role within a manufacturing activity while supporting a common information exchange mechanism with other units

Note 1 to entry: A software unit can be modelled using UML as a software object.

[SOURCE: ISO 16100-1:2009, 3.18, modified — The acronym MSU was added to the term.]

3.12
matcher
mechanism set to compare an offered *manufacturing capability profile* (3.9) with a required manufacturing capability profile

[SOURCE: ISO 16100-3:2005, 3.1.6, modified — The verb "set" was added after "mechanism" and the adjective "manufacturing" was added before "capability profile" twice.]

3.13
matching level
<profile> qualitative measure of how closely a capability profile of a *manufacturing software unit* (3.11) meets the software functional requirements of a manufacturing activity

[SOURCE: ISO 16100-3:2005, 3.1.7]

3.14
MSU interoperability
capability of a *manufacturing software unit* (3.11) to support a particular usage of an interface specification in exchanging a set of application information (services) with another manufacturing software unit

[SOURCE: ISO 16100-3:2005, 3.1.8, modified — The word "(services)" was added to the definition.]

4 Symbols and abbreviated terms

MARD manufacturing application requirements document

MCU manufacturing capability unit

MPCU manufacturing process capability unit

MRCU manufacturing resource capability unit

MSU manufacturing software unit

OPM object process model

UML unified modelling language

5 Interoperability of MSUs

5.1 Interoperability background

A manufacturing application is developed to realize a product which meets its predetermined specifications as a result of the application execution. The invoked specifications elaborated according to the expectations of the product customers or users, include required characteristics to be assured by the targeted product without exceeding the fixed limits of manufacturing costs and delays.

The development of a manufacturing application generally starts with elaborating a subsequent requirements specification which is described in MARD. This document includes the architectural, functional, and qualitative specifications to be met by the concerned application. In respect to MARD, the application design is then elaborated using adequate formalisms for various design artefacts addressing mainly:

— the application global structure;

— its capability units;

— their interdependencies; and

— its configuration and deployment.

The adopted design formalisms are generally graphical and textual those are to describe manufacturing processes as well as the related design artefacts in detail.

The 16300 series addresses the requirements of users and suppliers of manufacturing applications regarding the interoperability of MCUs in the area of industrial automation. User requirements include:

— building a manufacturing application system by combining capability units;

— selecting appropriate capability units, substituting one capability unit with another; and

— verifying capability unit in reference to the required capability profile.

Supplier requirements shall specify the precise capability of their corresponding interoperability.

The manufacturing application processes shall be composed of designed and planned activities and operations of various types (human, mechanical, electrical, hardware, networking, and/or computing, etc.). For each process, the manufacturing application design indicates its functional role inside the manufacturing application, its individual control flow as well as its underlying specific activities and functions. For the manufacturing processes implementation, the design shall specify the required manufacturing resources and their specific capabilities considered as necessary for the manufacturing execution. These manufacturing resources are of different types (i.e. mechanical, electrical, hardware, networking, software, etc.) (see ISO/TR 18161), where corresponding capabilities units shall be described using the dedicated profile template presented in Annex A. A capability unit profile includes several fields describing various structural, functional and qualitative characteristics of manufacturing resource unit capabilities.

To accomplish the specified manufacturing goal, the design of manufacturing processes shall indicate the required interoperability specifying when, where, and how the processes interoperate. It shall indicate the concerned types of required interoperability related to message communications, data sharing, data exchanges, or service calling, etc., between interacting manufacturing processes. Subsequently, a capability unit profile specifies its provided facilities and mechanisms for interoperability. Also, the manufacturing application execution is associated with various implemented or coded processes activated to behave according to the process designed model. They shall interact using interoperability mechanisms and facilities as decided at the application design phase. Manufacturing resources related to manufacturing processes such as devices, hardware units, software units, etc., shall interact using various types of interoperating facilities indicated as a part of the capability profile.

5.2 MSU interoperability verification and validation

Since the processes are executed using a set of appropriate MRCUs, the verification of processes interoperability should examine the MRCU profiles used, to check whether they provide the required processes interoperability.

The interoperability of MCUs should be recognized by the individual MCU capability profiles that contain a set of MRCU profiles.

This document focuses on MSUs interoperability verification and validation. For the design and development of the framework, the subset MSU is considered as being a major and central part of the MCU. In this document, only the interoperability of MSUs is considered for verification and validation.

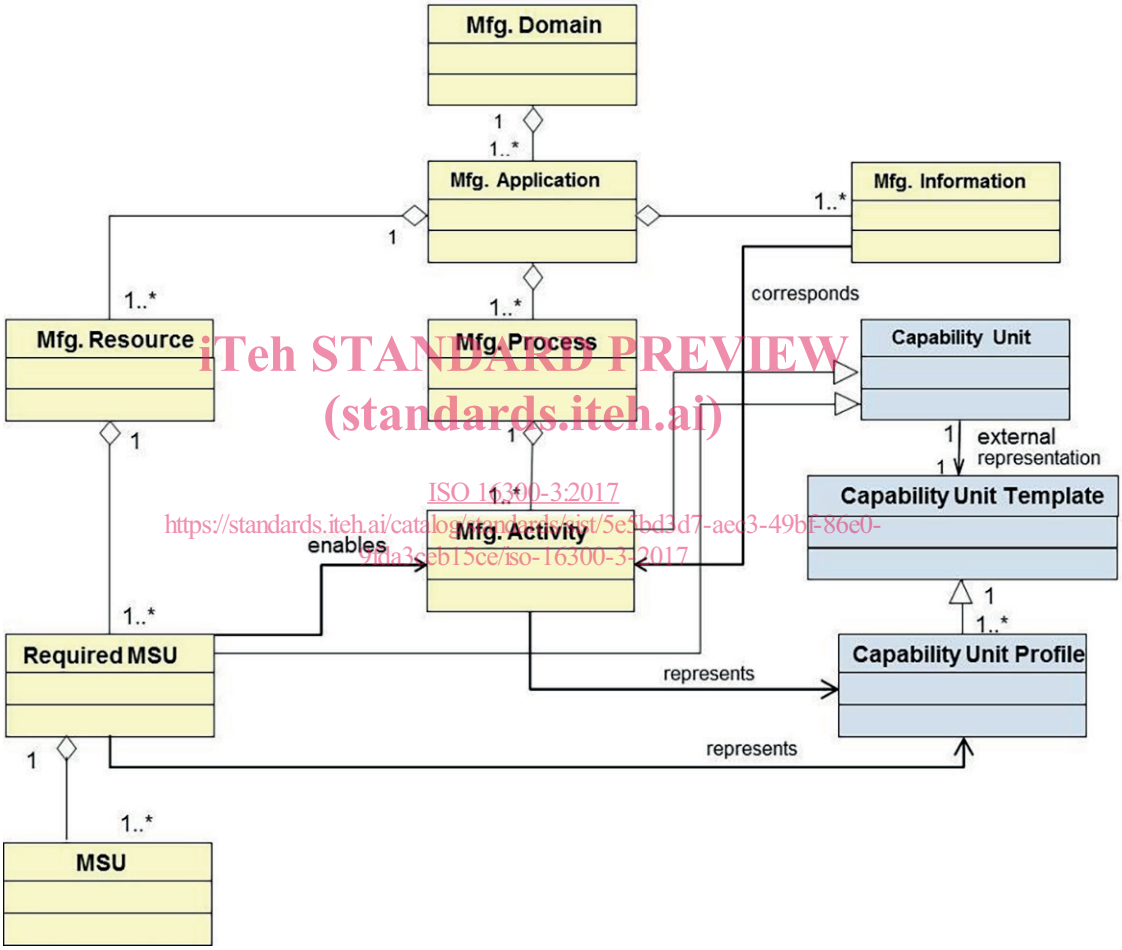

Figure 1 — Main description entities of MCUs general context

The procedure for verification and validation shall be described as a set of steps to follow, applied on associated artefacts, to verify and validate the interoperability among designed processes and the corresponding required MSUs. The MSUs are to be developed or already implemented and ready to be reused.

Starting from the interoperability framework of ISO 15745-1 and ISO 16100-1, a software interoperability framework is described based on the aspects related to:

— the syntax and semantics shared between MSUs;

— the functional relationships between the MSUs;

— the services, interfaces and protocols provided by the MSUs;

— the ability to provide MSUs capability profiling.

The last aspect dealt with at length in the ISO 16100 series. Nevertheless, the verification and validation processes of interoperability among MSUs are concerned by the whole set of these enumerated aspects.

The verification and validation processes of interoperability among MSUs shall be necessary to check the extent to which the effective working interoperability among MSUs implements its design and meets the interoperability requirements. In the general context of MSUs within a manufacturing domain application (Figure 1), application artefacts shall be issued from three major development phases corresponding to three description levels: requirements definition level, design level, and implementation level. Four major sets of artefacts called A, B, C and D, defined in Table 1, shall be considered for interoperability verification and validation.

Table 1 — Four major sets of artefacts

Set of artefact	Description
A	composed of design schemas of expected activities of MSUs and associated interoperability mechanisms that shall be designed to meet requirements of data sharing, messages exchange, services invocation and exchange, or procedure call which can occur among MSUs.
B	composed of code parts implementing the effective capabilities of MSUs and working interoperability mechanisms permitting to concerned MSUs to accomplish associated activities
C	composed of the quality model elements specifying the expected interoperability quality criteria as they shall be fulfilled by the implemented interoperability mechanisms and services. These criteria and corresponding characteristics, sub-characteristics and properties shall be specified according to ISO/IEC 25000 quality model with effective quality characteristics, sub-characteristics, and properties of implemented MSUs interoperability (see Annex B).
D	composed of the quality reports providing the numerical values or ranking values of effective quality characteristics specified in the instantiated quality model.

Sets A and B are composed of artefacts corresponding to the design of expected interoperability mechanisms necessary for the targeted execution of the current application. Sets C and D correspond to the designed interoperability quality and the quality of its corresponding working implementation.

The term “expected” refers to what was adopted at the design level and shall be met at the implementation level. Therefore, the expected interoperability shall describe different types of interoperability mechanisms adopted and designed to be implemented for the operating MSUs.

The term “effective” refers to what was implemented according to the interoperability design and how the required types of interoperability mechanisms were effectively implemented to meet their description at the design phase.

The first type of compliance assessment between two artefacts sets A and B is the goal of interoperability verification process. This compliance shall be achieved by examining the matching level between the design artefacts with the corresponding implementation artefacts. The design of individual MSUs shall take into account the specification of their individual capability profile.

The second type of compliance assessment shall be based on examining that the quality design of interoperability described by the artefacts of set C matches the quality of effective interoperability described by the artefacts of set D. The assessment of the compliance level shall be the goal of the interoperability validation process.

5.3 Interoperability levels

The interoperability quality shall depend to the level of interoperability occurring between MSUs. Major interoperability levels are considered in Table 2.

