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

**Part 4:
Capability unit assessment for
the manufacturing application
requirements**

*Systèmes d'automatisation et intégration — Interopérabilité des
unités de capacité pour les solutions d'applications industrielles —*

*Partie 4: Évaluation des unités de capacité pour les exigences relatives
aux applications manufacturières*



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CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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 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.

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 16300 series 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;
- 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.

The ISO 16300 series also addresses software interoperability services, which include:

- access to 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 as a set of functions and services with a set of criteria for evaluating the performance of a capability provider. It is then expressed and represented as facts about the software, how and what it can do. The ISO 16100 series, which deals with manufacturing software capability profiling for interoperability, was developed with the aim of providing a standardized method to describe capabilities of manufacturing software in terms of the Manufacturing Software Unit (MSU) capability profile. In the ISO 16100 series, the software component is included in the MSU. The ISO 16100 series 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. The ISO 16100 series is used and applied as the foundation for the ISO 16300 series.

To establish the ISO 16300 series, a number of steps were required. The initial step shows what interoperability services are enabled by using software capability profiles. The subsequent steps develop concrete methods and mechanisms to provide these interoperability services. The resulting output from ISO 16300 is divided into the following 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 a software unit of an automation solution that can be mapped to the functional requirements of a target manufacturing application. This document also specifies mapping rules for composing the contents of a software unit catalogue item in terms of the properties of the capability.

ISO 16300-4:2019(E)

- ISO 16300-3 specifies the framework for verifying interoperability of capability units associated with application requirements and system solutions.
- This document (ISO 16300-4) specifies the search methodology for acquiring candidate capability units which satisfy the manufacturing application requirements from the software unit catalogues. It also describes the structure of the report.

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

Part 4:

Capability unit assessment for the manufacturing application requirements

1 Scope

This document specifies the search methodology from software unit catalogues for acquiring candidate capability units which satisfy the manufacturing application requirements.

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 16100-1:2009, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 1: Framework*

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

ISO 16100-5:2009, *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 5: Methodology for profile matching using multiple capability class structures*

ISO 16100-6:2018, *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 16300-1:2018, *Automation systems and integration — Interoperability of capability units for manufacturing application solutions — Part 1: Interoperability criteria of capability units per application requirements*

ISO 16300-2:2019, *Automation systems and integration — Interoperability of capability units for manufacturing application solutions — Part 2: Capability templates and software unit cataloguing*

ISO 16300-3:2017, *Automation systems and integration — Interoperability of capability units for manufacturing application solutions — Part 3: Verification and validation of interoperability among capability units*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16100-1, ISO 16100-6, ISO 16300-1, ISO 16300-2, ISO 16300-3 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 <http://www.electropedia.org/>

**3.1
capability class**

element within the *capability profiling* (3.5) method that represents capabilities with regard to the capability unit's role in a manufacturing activity

**3.2
capability class structure
CCS**

hierarchy of capability classes

Note 1 to entry: This structure is intended for modelling capability aggregation hierarchies in the target domains of ISO 16100-1:2009, Figure 2.

[SOURCE: ISO 16100-6:2018, 3.2, modified — The abbreviated term "CCS" has been added.]

**3.3
capability element**

element used to indicate that a particular capability is supported by the entity or manufacturing software unit to which the element belongs

[SOURCE: ISO 16300-1:2018, 3.3]

**3.4
capability profile**

instance of capability template filled with the concrete values corresponding to the target manufacturing software unit

[SOURCE: ISO 16300-1:2018, 3.4]

**3.5
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]

**3.6
capability template
template**

schema representing a capability class

[SOURCE: ISO 16300-1:2018, 3.6]

**3.7
capability unit**

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

[SOURCE: ISO 16300-1:2018, 3.7]

**3.8
manufacturing domain data
MDD**

information about manufacturing resources, manufacturing activities, or items exchanged among manufacturing resources within a particular manufacturing domain

[SOURCE: ISO 16300-2:2019, 3.9]

3.9**manufacturing domain model
MDM**

particular view of a manufacturing domain, consisting of manufacturing domain data and relationships among them, corresponding to the domain's applications

[SOURCE: ISO 16100-5:2009, 3.5]

3.10**manufacturing software unit
MSU**

class of software resource, consisting of one or more manufacturing software 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.

Note 2 to entry: In this document, "capability unit" stands for "manufacturing software unit (MSU)".

[SOURCE: ISO 16100-1:2009, 3.18, modified — The abbreviated term "MSU" has been added and Note 2 to entry has been added.]

3.11**matched MSU capability profile**

MSU capability profile which fulfils the capabilities defined in the required capability profile

3.12**software capability description dictionary**

collection of manufacturing domain data in capability elements to describe the capability of software, where all manufacturing domain data are uniquely identified

[SOURCE: ISO 16300-2:2019, 3.12]

3.13**software unit catalogue**

collection of capability profiles using the same capability template representing one or more manufacturing software units for the same manufacturing activity in the activity tree

[SOURCE: ISO 16300-2:2019, 3.13]

3.14**MSU provider**

entity that provides the *manufacturing software units* ([3.10](#)) which are registered in the *software unit catalogue* ([3.13](#))

[SOURCE: ISO 16300-2:2019, 3.15]

3.15**MSU user**

entity that uses the *manufacturing software units* ([3.10](#)) which are registered in the *software unit catalogue* ([3.13](#))

4 Overview of capability unit assessment**4.1 Brief of software unit catalogue**

The software capability description dictionary is used to understand the semantics of capability profiles in the software unit catalogue. The software capability description dictionary defines the capability elements to describe the capabilities of the software.

Figure 1 shows the software unit catalogue defined in ISO 16300-2. The software unit catalogue refers to the software capability description dictionary to translate the semantics of the capability template and the capability profiles. Each MSU has one capability profile which belongs to one capability template in the software unit catalogue. An example of a capability template is shown in Annex A.

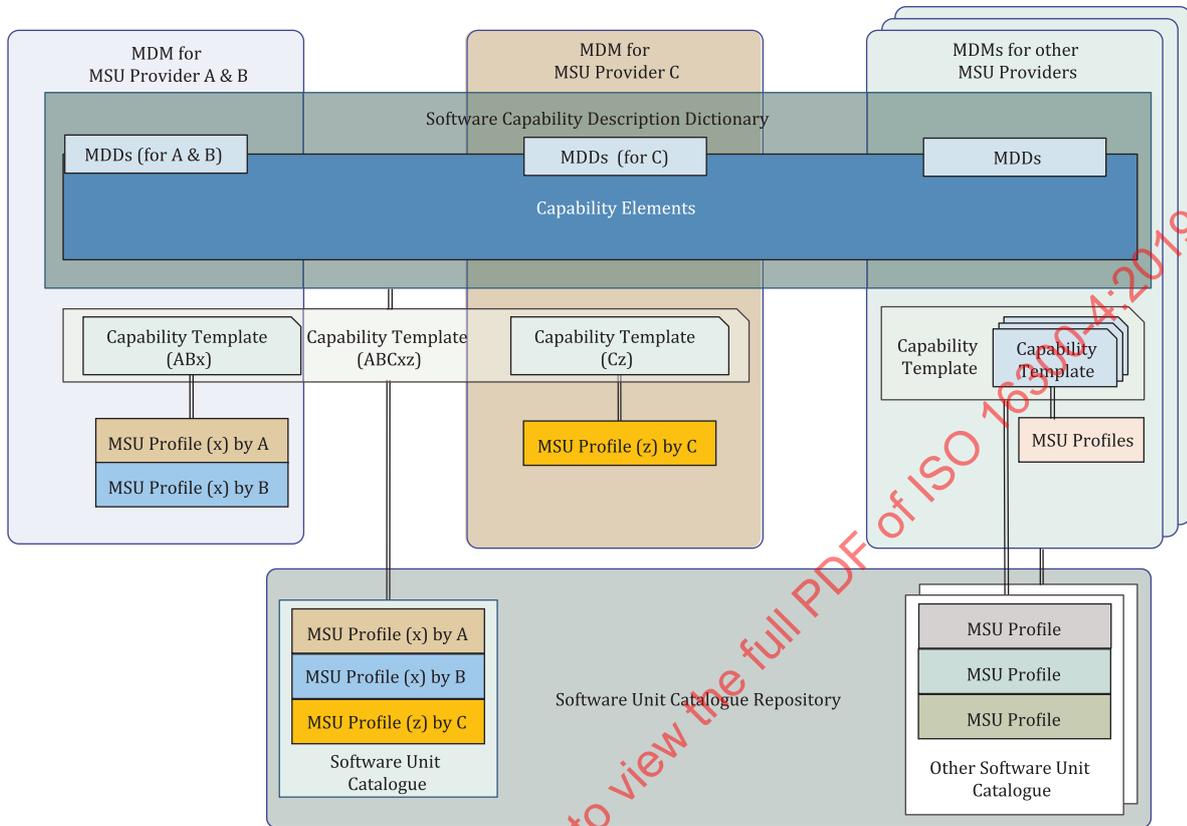


Figure 1 — Software unit catalogue

The software unit catalogues enable MSUs to be reused when developing a new manufacturing application. MSU users can retrieve appropriate MSUs through capability profiles in the software unit catalogues.

For the capability unit assessment procedure using the software unit catalogue, the following are required:

- capability profiles shall be described according to ISO 16100-3 and ISO 16100-5;
- capability profiles shall use the registered capability templates in the capability template repository;
- capability templates shall be described according to ISO 16300-2.

4.2 Overall procedure of capability unit assessment

Figure 2 shows the overall procedure of the capability unit assessment.

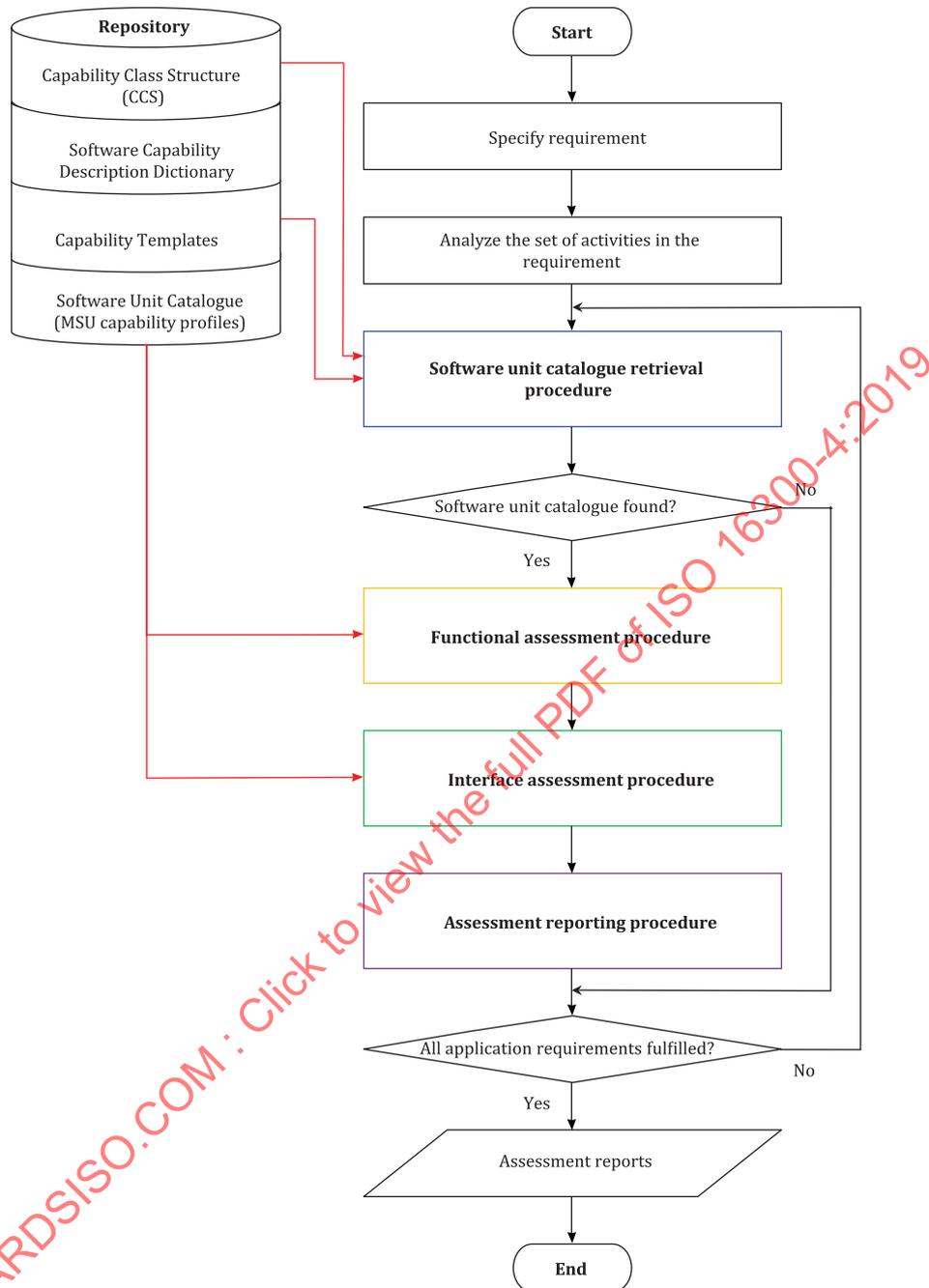


Figure 2 — Overall procedure of capability unit assessment

Before performing the assessment procedure, MSU users shall do the following:

- a) a manufacturing application requirement should be specified;
- b) the requirement shall be decomposed as a set of activities.

For each required capability profile, the MSU capability profiles in the software unit catalogue shall be assessed by the following four procedures:

- a) Software unit catalogue retrieval procedure

This procedure supports the syntax matching and the semantic matching to recognize the appropriate software unit catalogue through the capability template.

b) Functional assessment procedure

This procedure supports the functional matching of each required capability profile to the MSU capability profiles in the software unit catalogue.

c) Interface assessment procedure

This procedure supports the interface matching of each required capability profile to the MSU capability profiles in the software unit catalogue.

d) Assessment reporting procedure

This procedure supports the making of the assessment report including the result of the above procedures.

If all application requirements are assessed, then the assessment reports are the output.

The capability unit assessment shall follow the software interoperability framework based on the aspects as follows (see ISO 16300-3:2017, 5.2):

- syntax and semantics shared between MSUs;
- functional relationships between the MSUs;
- services, the interfaces and the protocols provided by the MSUs;
- ability to provide MSUs capability profiling.

5 Software unit catalogue retrieval procedure

The software unit catalogue retrieval procedure is shown in [Figure 3](#).

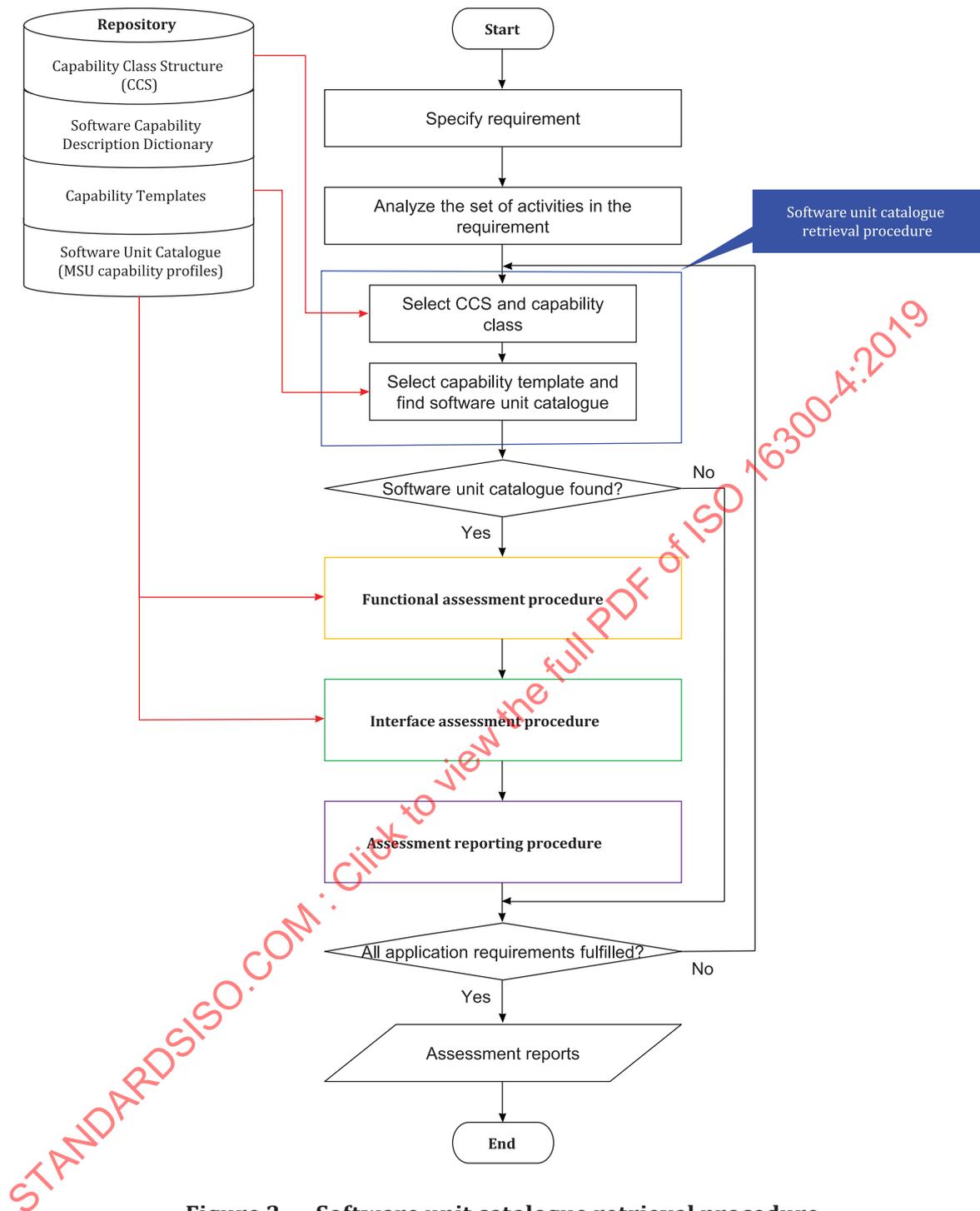


Figure 3 — Software unit catalogue retrieval procedure

- a) One activity is selected from a set of decomposed activities. Using the selected activity, the CCS and capability class which support this activity can be selected.
- b) After selecting the CCS and the capability class, a capability template can be found. Then the software unit catalogue corresponding to the capability template can be found.

If a software unit catalogue is not found through the procedures above, then the capability unit assessment is not possible.

6 Functional assessment procedure

The functional assessment procedure compares the capability elements in a required capability profile with the capability elements in MSU capability profiles. [Figure 4](#) represents the functional assessment procedure.

The functional assessment procedure supports the functional matching of each required capability profile to the MSU capability profiles in the software unit catalogue selected by the software unit catalogue retrieval procedure defined in [Clause 5](#).

- a) When a capability template is selected by the software unit catalogue retrieval procedure, the required capability profile(s) shall be created by filling out concrete values in the capability template(s) to satisfy the manufacturing application requirement. [Annex B](#) shows an example of a required capability profile.
- b) One capability profile is selected from the set of MSU capability profiles in the software unit catalogue which have not yet been assessed. Mandatory capability elements of the required capability profile shall be matched to the capability elements of the selected MSU capability profile.
- c) Are all mandatory capability elements matched?
 - 1) If yes, go to step d).
 - 2) If no, set matching result to “No match,” then go to the assessment reporting procedure (step b)).
- d) Optional capability elements of the required capability profile shall be matched to the capability elements of the selected MSU capability profile.
- e) Are all optional capability elements matched?
 - 1) If yes, set the matching result to “Complete match,” then go to step f).
 - 2) If no, set the matching result to “All mandatory match,” then go to step f).
- f) Are all MSU capability profiles matched in the software unit catalogue?
 - 1) If yes, go to the interface assessment procedure defined in [Clause 7](#).
 - 2) If no, go to step b).

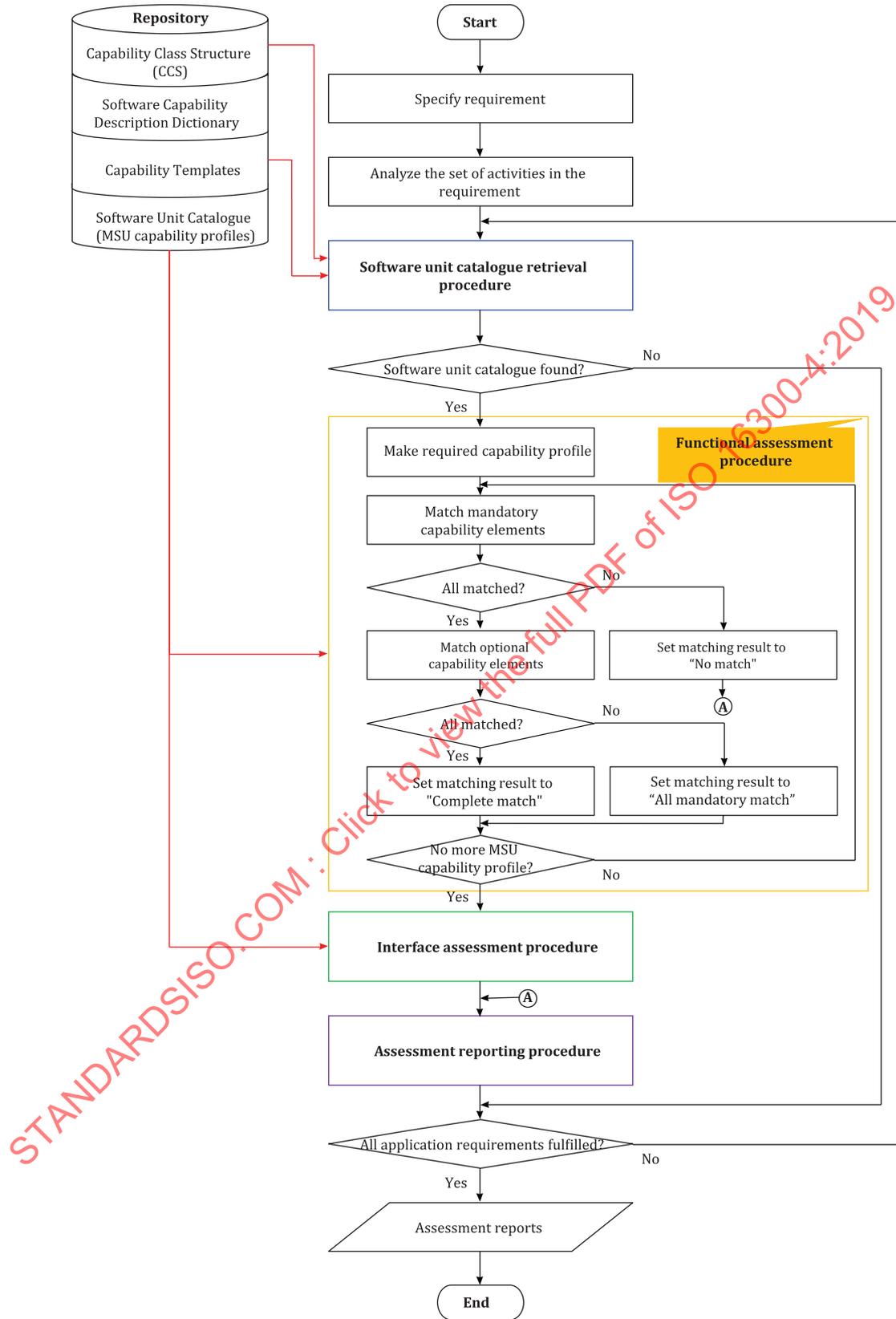


Figure 4 — Functional assessment procedure

7 Interface assessment procedure

The following interface assessment indicators shall be included in the capability template:

- communication protocol;
- data sharing method;
- data exchange method;
- service calling method.

The interface assessment indicators are compared between the required capability profile and the matched MSU capability profile.

When all MSU capability profiles in the software unit catalogue are matched to each required capability profile, the interface assessment procedure follows on the matched MSUs as shown in [Figure 5](#).

- a) One capability profile is selected from the set of MSU capability profiles which have not yet been assessed. The interface assessment indicators of the required capability profile shall be matched to the interface assessment indicators of the selected MSU capability profile.
- b) Set the matching result to “Matched” or “Not_matched” for each interface assessment indicator.
- c) Are all MSU capability profiles matched in terms of interface assessment?
 - 1) If yes, go to the assessment reporting procedure defined in [Clause 8](#).
 - 2) If no, go to step a).

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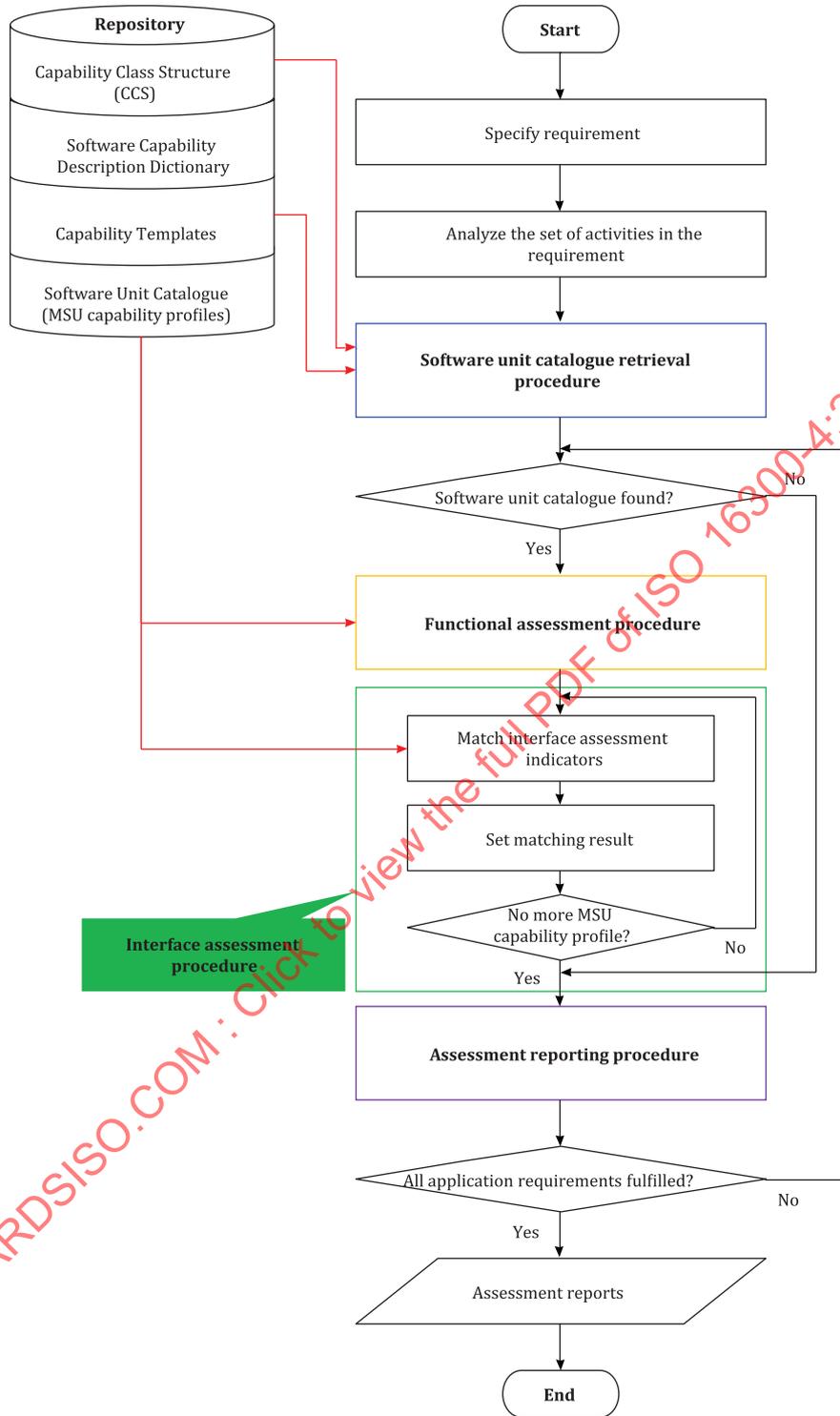


Figure 5 — Interface assessment procedure

8 Assessment reporting procedure

A manufacturing application requirement is analyzed as several required capability profiles. For each required capability profile, the assessment report is provided. The assessment report shall contain the following assessment results:

- Required Capability Profile ID

This profile contains the required capability for the functional assessment and the interface assessment.

- Software Unit Catalogue ID

This catalogue contains the candidate MSU capability profiles which fulfil the required capabilities.

- List of MSU capability profile ID

This capability profile contains the capability elements for the required capability.

- Result of Functional Assessment

- List of the Required Capability Elements

- Capability element name

- List of the Parameters

- Parameter value

- Mandatory or Optional: Mandatory/Optional

- Matching Result: Matched/Not matched

- Final Matching result of Capability Elements: Complete match/All mandatory match/No match

- Result of Interface Assessment

- Communication Protocol

- Value

EXAMPLE OPC-UA

- Matching result: Matched/Not matched

- Data Sharing

- Value

EXAMPLE DBMS

- Matching result: Matched/Not matched

- Data Exchange

- Value

EXAMPLE MTConnect

- Matching result: Matched/Not matched

- Service Calling

- Value

EXAMPLE REST

— Matching result: Matched/Not matched

Figure 6 shows the structure of the assessment report. Annex C shows an example of an assessment report. An assessment report is an output for each required capability profile. An assessment report contains one or more assessment result(s) for MSU capability profile(s).

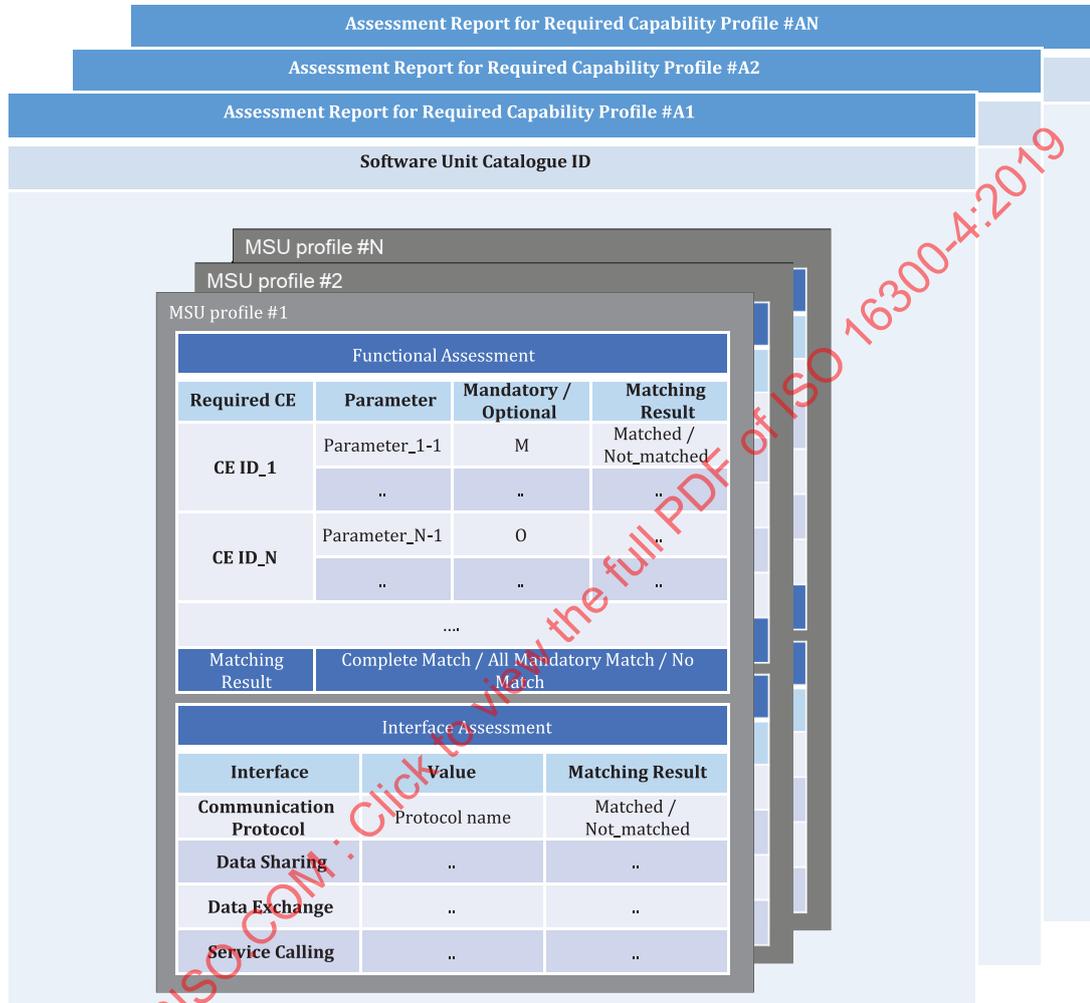


Figure 6 — Structure of the assessment report

After the MSU capability profiles for all required capability profiles are assessed, the assessment report shall be made. Figure 7 shows the assessment reporting procedure. The assessment reporting procedure makes the assessment report by integrating the results of the software unit catalogue retrieval procedure, the functional assessment procedure, and the interface assessment procedure as follows.

- a) The ID of each required capability profile is encoded in the header part of the report. In addition, the ID of the software unit catalogue retrieved by the software unit catalogue retrieval procedure is encoded in the header part of the report.
- b) The results of the functional assessment for an MSU capability profile are described in the assessment report.
- c) The results of interface assessment for an MSU capability profile are described in the assessment report.

d) Are all results for MSU capability profiles reported?

- 1) If yes, go to the next procedure.
- 2) If no, go to step b).

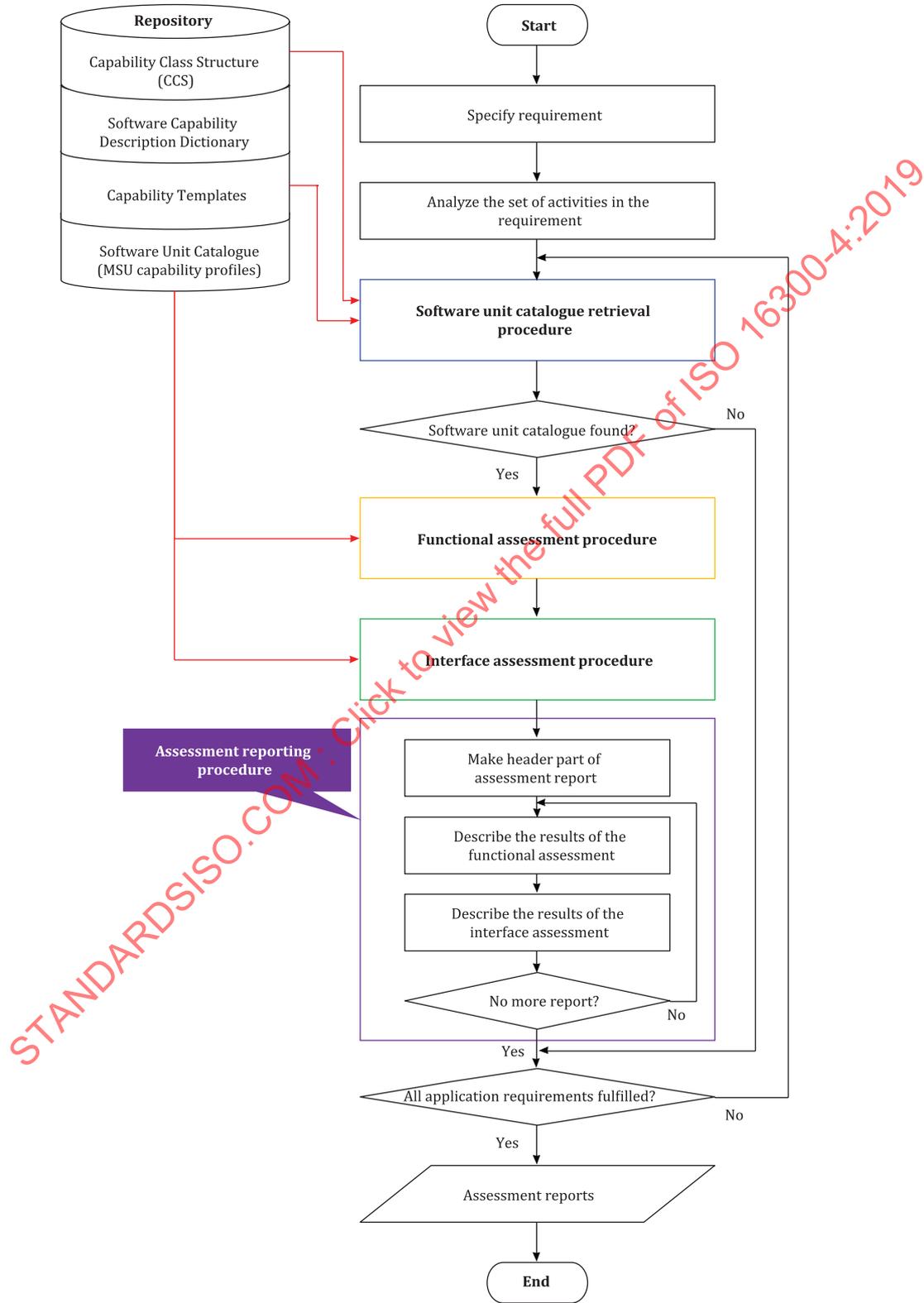


Figure 7 — Assessment reporting procedure

Annex A (informative)

Example of a capability template

The MSU provider and the MSU user use capability templates which are described by XML schemas. An example of the capability template is as follows.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="CapabilityProfiling">
    <xs:complexType>
      <xs:sequence maxOccurs="unbounded">
        <xs:element name="Type">
          <xs:complexType>
            <xs:attribute name="id" type="xs:string" use="required"/>
          </xs:complexType>
        </xs:element>
        <xs:element name="CapabilityProfile">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="Pkgtype">
                <xs:complexType>
                  <xs:attribute name="version" type="xs:string" form="unqualified"/>
                </xs:complexType>
              </xs:element>
              <xs:element name="Common" type="CommonPartType"/>
              <xs:element name="Specific" type="SpecificPartType"/>
            </xs:sequence>
            <xs:attribute name="date" type="xs:string" form="unqualified"/>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:complexType name="CommonPartType">
    <xs:sequence>
      <xs:choice>
        <xs:element name="Requirement">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="ID" type="xs:string"/>
            </xs:sequence>
            <xs:attribute name="id" type="xs:string" form="unqualified"/>
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          <xs:complexType>
            <xs:sequence>
              <xs:element name="ID" type="xs:string"/>
            </xs:sequence>
            <xs:attribute name="id" type="xs:string" form="unqualified"/>
          </xs:complexType>
        </xs:element>
      </xs:choice>
    </xs:sequence>
  </xs:complexType>
  <xs:sequence maxOccurs="unbounded">
    <xs:element name="ReferenceCapabilityClassStructure">
      <xs:complexType>
        <xs:attribute name="id" type="xs:string" form="unqualified"/>
        <xs:attribute name="name" type="xs:string" form="unqualified"/>
        <xs:attribute name="version" type="xs:string" form="unqualified"/>
        <xs:attribute name="url" type="xs:string" form="unqualified"/>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:schema>
```

```

    <xs:complexType>
      <xs:attribute name="id" type="xs:string" form="unqualified"/>
    </xs:complexType>
  </xs:element>
</xs:sequence>
<xs:element name="Capability_Class_Name">
  <xs:complexType>
    <xs:attribute name="name" type="xs:string" form="unqualified"/>
  </xs:complexType>
</xs:element>
<xs:element name="Reference_Capability_Class_Structure_Name">
  <xs:complexType>
    <xs:attribute name="name" type="xs:string" form="unqualified"/>
  </xs:complexType>
</xs:element>
<xs:element name="Version">
  <xs:complexType>
    <xs:attribute name="major" type="xs:string" form="unqualified"/>
    <xs:attribute name="minor" type="xs:string" form="unqualified"/>
  </xs:complexType>
</xs:element>
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  <xs:complexType>
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      <xs:element name="City" type="xs:string" minOccurs="0"/>
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      <xs:element name="Country" type="xs:string" minOccurs="0"/>
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        </xs:complexType>
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    </xs:sequence>
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  </xs:complexType>
</xs:element>
<xs:element name="Performance" minOccurs="0" maxOccurs="unbounded">
  <xs:complexType>
    <xs:attribute name="elapsedTime" type="xs:string" form="unqualified"/>
  </xs:complexType>

```

```

    <xs:attribute name="transactionsPerUnitTime" type="xs:string" form="unqualified"/>
  </xs:complexType>
</xs:element>
<xs:element name="ReliabilityData" minOccurs="0" maxOccurs="unbounded">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="UsageHistory" type="xs:string" minOccurs="0"/>
      <xs:element name="Shipments" minOccurs="0" maxOccurs="unbounded">
        <xs:complexType>
          <xs:attribute name="number" type="xs:string" form="unqualified"/>
        </xs:complexType>
      </xs:element>
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        <xs:complexType>
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