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Industrial automation systems and integration — Product data representation and exchange —

Part 17: Description methods: EXPRESS to SysML CXMI transformation

Systèmes d'automatisation industrielle et intégration — Représentation et échange de données de produits —

Partie 17: Méthodes de description: Transformation EXPRESS vers SysML CXMInque

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Foreword

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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 10303 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 10303 series of international standards describe the computer-interpretable representation of product information in the exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product and independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

The EXPRESS language and the EXPRESS-G diagrams are specified in ISO 10303-11. It is used to specify the information requirements of other parts of the ISO 10303 series.

This document is a member of the description methods series. This document specifies a mapping of EXPRESS to SysML CXMI. This document supports the STEP Extended Architecture[9][10][11].

The Object Management Group (OMG) has standardized the XML Metadata Interchange specification (XMI), and the Canonical XML Metadata Interchange specification (CXMI) that integrates the OMG Systems Modeling Language (SysML), the OMG Unified Modeling Language (UML), and the World Wide Web Consortium (W3C) Extensible Mark-up Language (XML)[12]. SysML inherits the CXMI interchange capability from UML. CXMI is a mechanism for the interchange of metadata and formal diagrams between UML-based modeling tools. OMG has also standardized an CXMI compliant interchange format for the SysML thus specifying a lexical representation of SysML models based on a standardized metamodel of the SysML.

This document specifies a description method of the STEP parts family, which defines the transformation of a subset of EXPRESS constructs to SysML. Because the CXMI standard specifies the XML representation of SysML metamodel constructs, standardizing the mapping of EXPRESS constructs into SysML constructs supports the representation of EXPRESS schemas as SysML models.

The specified mapping is a one-way transformation from a subset of an EXPRESS schema to a SysML model represented by an CXMI specification. These limitations make the mapping unsuitable for the transformation of arbitrary EXPRESS schemas to SysML models.

A detailed knowledge of the of the EXPRESS and SysML languages is useful.

Industrial automation systems and integration — Product data representation and exchange —

Part 17: Description methods: EXPRESS to SysML CXMI transformation

1 Scope

This document specifies a mapping of EXPRESS (ISO 10303–11) constructs to SysML constructs for the purpose of representing EXPRESS schemas in SysML models. The specified mapping is a one-way transformation from an EXPRESS schema to a SysML information model.

The following are within the scope of this document:

— the specification of the transformation of EXPRESS constructs to SysML constructs represented in CXMI;

— the specification of the transformation of EXPRESS UNIQUE rules to SysML constructs represented in CXMI;

— the specification of the transformation of derived attributes to implement renaming to SysML constructs represented in CXMI.

The following are outside the scope of this document:

— the transformation of EXPRESS elements into SysML metamodel constructs that are not used in the STEP Extended Architecture[9][10][11];

— transformation of EXPRESS FUNCTIONS;

— transformation of EXPRESS-G to SysML diagrams;

— tools, codes, and scripts to transform an EXPRESS schema to SysML CXMI;

— transformation of EXPRESS interface specification;

— SysML constraints transformation from EXPRESS DERIVE attributes, except the ones used for renaming;

— SysML constraints transformation from EXPRESS SUPERTYPE expressions;

— SysML constraints transformation from EXPRESS GLOBAL rules;

— SysML constraints transformation from EXPRESS WHERE rules.

NOTE EXPRESS DERIVE attributes, EXPRESS SUPERTYPE expressions, EXPRESS GLOBAL rules and EXPRESS WHERE rules are transformed into OCL[2] specifications. OCL specifications are integrated in the SysML model based on a separate process.

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 10303-11:2004, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual*

ISO/IEC 19505-1:2012, *Information technology — Object Management Group Unified Modeling Language (OMG UML) — Part 1: Infrastructure*

ISO/IEC 19509:2014, *Information technology — Object Management Group XML Metadata Interchange (XMI)*

ISO/IEC 19514:2017, *Information technology — Object management group systems modeling language (OMG SysML)*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions 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 Terms related to generic concepts

3.1.1
EXPRESS
data specification language that consists of language elements that allow an unambiguous data definition and specification of constraints on the data defined

Note 1 to entry: The elements of the EXPRESS language are specified in ISO 10303-11.

3.1.2
data
representation of information in a formal manner suitable for communication, interpretation, or processing by human beings or computers

[SOURCE: ISO 10303-1:2021, 3.1.29]

3.1.3
data model
description of the organization of data in the management information system of an enterprise

[SOURCE: ISO/IEC 2382:2015, 2121422, modified — Notes 1 and 2 to entry were removed.]

3.1.4
information
facts, concepts, or instructions

[SOURCE: ISO 10303-1:2021, 3.1.41]

3.1.5
resulting CXMI
CXMI based on the transformation specification

3.1.6
information model
conceptual model of product data

Note 1 to entry: In ISO 10303, an information model is based on the Object-relationship modeling technique that organizes the product data as represented in different system aspects.

Note 2 to entry: In ISO 10303 information models may be developed using EXPRESS modeling language.

EXAMPLE Application Resource Model for ISO 10303-242 Managed model-based 3D engineering.

[SOURCE: ISO 10303-1:2021, 3.1.42 modified to detail the example]

3.2 Terms related to EXPRESS constructs

3.2.1
data type
<EXPRESS> domain of values

[SOURCE: ISO 10303-11:2004, 3.3.5]

3.2.2
defined data type
domain of values declared by the user with an identifier

3.2.3
entity
class of information defined by common properties

[SOURCE: ISO 10303-11:2004, 3.3.6]

3.2.4
entity data type
representation of an entity

[SOURCE: ISO 10303-11:2004, 3.3.7, modified — The second sentence was removed.]

3.2.5
entity (data type) instance
value of a class of information defined by common properties

3.2.6
enumeration data type
data type that has as its domain a set of names

3.2.7
aggregation data type
data type that has as its domain collections of values of a given base data type, e.g. array, list, bag, and set

3.2.8
instance
named value

[SOURCE: ISO 10303-11:2004, 3.3.10]

3.2.9
named data type
data type that may be declared in a formal specification, e.g. *entity data type* (3.2.4) and *defined data type* (3.2.2)

3.2.10
interface specification
construct which enables an item declared in one schema to be visible in another. e.g. USE and REFERENCE

3.2.11
select data type
data type that enables a choice among several named data types

3.2.12
simple data type
data type that defines the domains of the atomic data units, e.g. number, real, integer, string, Boolean, logical, and binary

3.2.13
value
unit of data

[SOURCE: ISO 10303-11:2004, 3.3.22]

3.2.14
global rule
restriction or implicit constraint that applies to one or more entities within the scope of a schema

3.2.15
local rule
assertion on the domain of every *entity instance* (3.2.5)

3.2.16
uniqueness rule
constraint assertions on the domain of an entity attribute or a combination of entity attributes for which their *instances* (3.2.8) must not be equal to every instance of the *entity* (3.2.3)

3.2.17
where rule
restriction constraint assertions on the domain of one or multiple entities and of one or a combination of these entities' attributes for every *instance* (3.2.8) of the *entity* (3.2.3)

3.3 Terms related to SysML constructs

3.3.1
Canonical XMI
specific constrained format of XMI that minimizes variability and provides more predictable identification and ordering

Note 1 to entry: A Canonical XMI file is itself a valid XMI file.

Note 2 to entry: The full definition is provided in ISO/IEC 19509:2014, Annex B.

3.3.2
association
classification of a set of tuples representing links between typed model elements

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012,11.5.

3.3.3
auxiliary
stereotype (3.3.12) applied to an abstract *block* (3.3.4) that has no properties

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, Clause 22.

3.3.4
block
modular construct used for defining an *entity* (3.2.3)

Note 1 to entry: Used for defining Application activity model concepts, Application Data Planning objects, Application Domain Model Business Objects, Core model objects and ARM in SysML Entities. They may include reference properties, part properties, value properties, and constraints. They may be specializations of other blocks.

Note 2 to entry: The full definition is provided in ISO/IEC 19514:2017, Clause 8.

3.3.5
composite aggregation
responsibility for the existence of composed object

Note 1 to entry: If a composite object is deleted, all of its part *instances* (3.2.8) that are objects are deleted with it.

Note 2 to entry: The full definition is provided in ISO/IEC 19505-1:2012, 11.4.1.

3.3.6
directed association
association (3.3.2) between a collection of source model elements and a collection of target model elements that is said to be directed from the source elements to the target elements

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, 7.2.3.3.

3.3.7
enumeration
value type (3.3.16) whose values are enumerated

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, 10.2.3.3.

3.3.8
enumeration literal
named value for an *enumeration* (3.3.7)

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, 10.2.3.3.

3.3.9
data type
<SysML> type whose *instances* (3.2.8) are identified only by their value

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, 10.2.3.1.

3.3.10
generalization
directed relationship between a more general supertype and a more specific subtype

Note 1 to entry: Each Generalization relates a specific Classifier to a more general Classifier. Given a Classifier, the transitive closure of its general Classifiers is often called its generalizations, and the transitive closure of its specific Classifiers is called its specializations. The immediate generalizations are also called the Classifier's subtype, and where the Classifier is a Class, its supertype.

Note 2 to entry: The full definition is provided in ISO/IEC 19505-1:2012, C.1.1.

3.3.11
primitive type
predefined data type without any substructure

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, Clause 21.

3.3.12
stereotype
limited kind of metaclass that cannot be used by itself, but which must always be used in conjunction with one of the metaclasses it extends

Note 1 to entry: The full definition is provided in ISO/IEC 19505-1:2012, 8.3.2.3 paragraph 6.

3.3.13
part property
property that specifies a part with strong ownership and coincidental lifetime of its containing *block* (3.3.4)

Note 1 to entry: It describes a local usage or a role of the typing Block in the context of the containing Block. Every Part Property has *composite aggregation* (3.3.5) and is typed by a Block.

Note 2 to entry: The full definition is provided in ISO/IEC 19514:2017, 8.3.2.3 paragraph 6.

3.3.14
reference property
property that specifies a reference of its containing *block* (3.3.4) to another block

Note 1 to entry: the full definition is provided in ISO/IEC 19514:2017, 8.3.2.3 paragraph 6.

3.3.15
value property
property of a *block* (3.3.4) that is typed with a *value type* (3.3.16) *stereotype* (3.3.12)

Note 1 to entry: The full definition is provided in ISO/IEC 19514:2017, 8.3.2.3, paragraph 6.

3.3.16
value type
stereotype (3.3.12) of UML Data Type that is used to define types of values that may be used to express information but cannot be identified as the target of any reference

Note 1 to entry: The full definition is provided in OMG Systems Modeling Language [6], 8.3.2.14.

3.4 Abbreviated terms

CXMI	Canonical XMI
ID	IDentifier
OCL	Object Constraint Language
OMG	Object Management Group
STEP	STandard for the Exchange of Product model data
SysML	Systems Modeling Language
UML	Unified Modeling Language
UUID	Universal Unique Identifier
XMI	XML Meta-data Interchange
XML	eXtensible Markup Language

4 EXPRESS to SysML CXMI

4.1 General

This clause describes the concepts and rules for the transformation mapping from an EXPRESS schema to a SysML model, which is physically stored in a CXMI file.

This document shall use the language construct specifications defined in ISO 10303-11, ISO/IEC 19505-1, ISO/IEC 19514 and ISO/IEC 19509.

NOTE The mapping clauses are sequentially structured to build increasingly complex transformation definitions.

This document shall be unambiguously identified in an open information system by the code defined in Annex A.

EXPRESS constructs and the equivalent SysML constructs are presented in a summarized table in Annex B.

4.2 Presentation conventions

For ease of identification, the fragments of EXPRESS, CXMI, and SysML are presented in separate boxes.

EXAMPLE 1 EXPRESS, CXMI, and SysML representations presented in separate boxes.

```
EXPRESS:
…
```

```
CXMI:
…
```



```
SysML:
…
```


The items significant to support the explanations are formatted using text effects to aid identification of the equivalent items in the EXPRESS, CXMI, and SysML fragments. When there is more than one significant item, different text effects are used for the different items. The following text effects are used:

— **Bold**;

— *Underline*;

— ***Mixed effects***.

Triple dots ("…") are used to hide content not relevant to a fragment. Curly brackets "{xxx}" are used to contain descriptive words of the content in the resulting CXMI.

EXAMPLE 2 Usage of **Bold** and Underline text effects to ease the identification of the significant items in EXPRESS, CXMI, and SysML fragments, and the usage of triple dots "…" and curly brackets "{umlid}".

```
EXPRESS:

ENTITY StepEntityName;
…
```

```
CXMI:

<packagedElement xmi:type='uml:Class' xmi:id='{umlid}' xmi:uuid='...'>
```

```
   <name>StepEntityName</name>
   …
```

```
SysML:
Class <<Block>> named StepEntityName
```

4.3 Common mapping conventions

4.3.1 Reference to external files

All the references in the SysML CXMI fragments are given as `xmi:idref` which assumes that the referenced element is contained in the same CXMI file. When the referenced element is in a different CXMI file the `href` is used instead. This will be the case for all reference to primitives and may be case for other references.

`type href` shall specify a relative reference to element:

```
CXMI:
<ownedAttribute xmi:id="{...}" xmi:uuid="{...}" xmi:type="uml:Property">
   <name>Text</name>
   <type href="../../../DataTypes.xmi#STRING"/>
   ...other tags...
</ownedAttribute>
```


`general href` shall specify relative reference to element in another CXMI file:

```
CXMI:
<packagedElement xmi:id="{...}" xmi:uuid="{...}" xmi:type="uml:Class">
  <name>DateTimeAssignment</name>
  <generalization xmi:id="{...}" xmi:uuid="{...}" xmi:type="uml:Generalization">
     <general href="../../Core_model/RequirementManagement/RequirementManagement.xmi#_18_
4_1_8e001ed_1504250730055_679435_26318"/>
  </generalization>
   ...other tags...
</packagedElement >
```

4.3.2 Treatment of Xmi:id, xmi:uuid, and UUID

A CXMI file uses xmi:id value to make references between all kinds of element. An xmi:id may be in an xmi:idref attribute.

Xmi:uuid (UUID[3]), is not relevant to be included in the mapping transformations. After the first mapping clause, this attribute will be omitted.

4.3.3 Assumed sysml:Block in fragments

For all the fragments that refer to Block, the following shows how a block is defined in the Canonical XMI. This is not repeated in the remaining examples, where only *xmi:type="uml:Class"* is included and the *sysml:Block* is assumed:

```
SysML:
```

```
Class <<Block>>
```

```
CXMI:
<sysml:Block xmi:id="..." xmi:uuid="...">
    <base_Class xmi:idref="{umlid}"/>
</sysml:Block>

<packagedElement xmi:type='uml:Class' xmi:id='{umlid}' xmi:uuid='...'>
   <name>StepEntityName</name>
   ...
</packagedElement>
```

4.3.4 Containment and reference relationships

The EXPRESS language (ISO 10303-11) does not distinguish between reference relationships and containment relationships. SysML and XSD support both types of relationship.

A reference relationship is a directed association attribute between two entities. A referenced entity by an attribute is an entity that may be referenced multiple times, and which exists standalone. Base root object entities are always referenced, never contained.

A containment relationship is a directed aggregation attribute between two entities. A contained entity is an entity that is owned by the entity that defines the containment relationship attribute. The contained entity does not exist if the containing entity does not exist. A simple type is necessarily contained.

4.3.5 Used stereotypes to represent EXPRESS concepts

Two existing UML stereotypes are used to represent specific STEP concepts:

<<Auxiliary>> stereotypes represent select data objects. Select data objects are represented as abstract Blocks in SysML.

<<Type>> stereotypes represent two specific types of Blocks:

— blocks that represent list of lists;

— block that represents Value Type in order to be able to include them as member in selects.

4.3.6 Select type and supertype

In STEP concepts, select types are not defined as entities but as types and are therefore not defined as supertypes of an entity. In SysML an entity identifies the supertype entities and select data types using the generalization relationship. For this document the term supertype excludes any select data types.

4.4 Mapping of a schema

The schema declaration shall be transformed to a `SysML package` that includes the STEP data model.

```
EXPRESS:


SCHEMA STEP_AP242_Domain_model;
           ...
```