SLOVENSKI STANDARD
oSIST prEN 17632-2:2023

01-julij-2023

Informacijsko modeliranje gradenj (BIM) - Semantični standard za modeliranje in povezovanje (SML) - 2. del: Domensko specifični vzorci modeliranja

EN 17632-2 Building Information Modelling (BIM) - Semantic Modelling and Linking (SML), Part 2: Domain-specific modelling patterns

Gebäudeinformationsmodellierung - Semantische Modellierung und Verknüpfungs, Teil 2: domänenspezifische Modellierungsmuster

Modélisation des informations du bâtiment (BIM) - Modélisation sémantique et liaison (SML), Partie 2 : modèles de modélisation spécifiques à un domaine

Ta slovenski standard je istoveten z: **prEN 17632-2**

ICS:

35.240.67	Uporabniške rešitve IT v gradbeništvu	IT applications in building and construction industry
91.010.01	Gradbeništvo na splošno	Construction industry in general

oSIST prEN 17632-2:2023 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 17632-2

April 2023

ICS

English Version

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Ref. No. prEN 17632-2:2023 E

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European foreword

This document (prEN 17632-2:2023) has been prepared by Technical Committee CEN/TC 422 “Building information modelling (BIM)”, the secretariat of which is held by SN - Norway.

This document is currently submitted to the CEN Enquiry.

Introduction

The abstract language and generic modelling patterns are already defined by the EN 17632-1:2022.

Early practical industrial application showed that there is a ‘gap’ between these abstract/generic patterns and the real-world modelling needs in the built environment sector.

This document defines domain-specific extensions of the generic top level information model defined in EN 17632-1:2022. These extensions are especially relevant for the modelling of assets/products in the built environment. These extensions will support to close this gap.

This way, stakeholders in the built environment like owners, contractors and suppliers do not have to ‘reinvent the wheel’ for themselves for these new/extended modelling patterns.

By agreeing these patterns, stakeholders-specific data models will become even more pre-integrated easing future asset/product data exchange/sharing and data integration/innovation in findable, accessible, interoperable and reusable (FAIR) ways.

The extended standardized modelling patterns introduced in this document may be applicable to other industry sectors as well.

1 Scope

This part 2 will provide extended semantic modelling patterns for (at least) the following domain-specific asset aspects:

— Support for distinction between two subtypes of physical objects: spatial regions and real (“tangible”) objects; the latter being discrete or continuous (“bulk matter”);

— Support for the materialization of physical objects, adding generic chemistry aspects directly relevant for the built environment dealing with materials like concrete, steel, wood and asphalt;

— Support for the interaction between objects including connections, interfaces and ports. Interactions being defined as activities where material, information, energy or forces are transferred;

— Support for the definition of unstructured, human-interpretable, requirements, coming from appointing party needs, laws & regulations or sector recommendations;

— Support for implicit groups having no explicit members (to model situations like “all main girders of some steel bridge”);

— Support for the explicit modelling of measurements reusing the existing W3C SOSA ontology (as a lightweight but self-contained SSN core ontology).

— Support for spatial geometry (location/shape) reusing OGC GeoSPARQL (GML/WKT) and the WGS84_pos ontology (GPS)

These modelling patterns (in **bold** below) can all be positioned in the global modelling framework provided in the form of a taxonomy by Part 1. These leaf concepts form the primary table of content of this part 2.

- TopConcept
  - AbstractConcept
    - Type
      - EnumerationType
      - ConceptType
    - Objectification
      - QualityValue
      - QuantityValue **== qudt:QuantityValue (with qudt:numericValue)**
      - RelationReference
        - **MatterPortion**
      - **ObservableProperty (SOSA)**
      - **Result (SOSA)**
        - **Sample (SOSA)**
  - ConcreteConcept
    - Entity
      - Object == **FeatureOfInterest (SOSA)** == **Feature (GeoSPARQL)**
        - PhysicalObject
          - **SpatialRegion**
            - **Interface**
          - **RealObject**
            - **DiscreteObject**
              - **Sensor (SOSA)**
            - **AmountOfBulkMatter**

        - **Matter**
          - **PureSubstance**
            - **ChemicalElement**
            - **ChemicalCompound**
          - **Mixture**
            - **HomogeneousMixture**
            - **HeterogenousMixture**
        - **Connection**
        - **Port**
    - InformationObject
      - Representation
        - GeometricEntity == **Geometry (GeoSPARQL)**
        - TemporalEntity
      - **Requirement**
  - Activity
    - **Interaction**
    - **Observation (SOSA)**
    - **Procedure (SOSA)**
  - FunctionalEntity
  - TechnicalEntity
  - PlannedEntity
  - RealizedEntity
- State
- Event

NOTE 1 The reused SOSA and GeoSPARQL entities will be kept separate. That means that the actual supertypes as indicated above will not be modelled. Instead domain-specific concept can be subclasses or individuals can be multiple typed.

NOTE 2 Some of the information needs might be resolved by extending existing language level constructs (like in the case of implicit groups just adding some attributes for existing classes or containers or the use of SHACL rules to represent structured requirements coming from clients, building laws and regulations or from building sector recommendations). Finally there is a lot of ‘pattern potential’ under ‘DiscreteObject’ and ‘SpatialRegion’ in the built environment (road networks, tunnels, bridges, buildings, installations). Care is taken not to cross existing standards boundaries.

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 for this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 17632-1:2022, *Building information modelling (BIM) - Semantic modelling and linking (SML) - Part 1: Generic modelling patterns*

ISO 6707-1, *Buildings and civil engineering works — Vocabulary — Part 1: General terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6707-1 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
amount of bulk matter
real object consisting of a continuous amount of non-formal matter, primarily held together by external forces (gravity or confinement)

3.2
chemical element
pure substance made up of atoms with the same atomic number

NOTE 1 to entry: A chemical element cannot be decomposed by chemical reactions.

3.3
chemical compound
pure substance that consists of two or more chemical elements that have a chemical bond with each other

NOTE 1 to entry: In a chemical compound, the elements occur in a fixed ratio. A compound can be decomposed into simpler substances through chemical reactions.

3.4
connection
physical object (real object or spatial region) that connects two other physical objects and over which interaction takes place, namely the transfer of matter, energy, information or forces

3.5
discrete object
real object consisting of a continuous amount of rigid matter, held together primarily by internal forces (gravity or electromagnetic force)

3.6
interaction
activity being a combination of sub-activities performed by physical objects between which a transfer of matter, information, energy, or force occurs, typically over a connection or interface (directly or through ports)

3.7
interface
spatial object, typically a thin 2D physical space (but also 0D or 1D) that connects two physical objects or ports of physical objects through which a static or dynamic interaction or interaction between those elements can take place

3.8
matter
chemical substance
pure substance, chemical compound or mixture from which real objects are made

3.9
mixture
combination of two or more different pure substances without the molecules losing their identity

NOTE 1 to entry: A mixture is characterized by the molecules participating in it and the ratio of their amounts.

3.10
port
physical or logical point of interaction as part of a physical object where, through a connection or interface, an interaction can take place

NOTE 1 to entry: In the case of forces, it is mainly a matter of static force transfer such as constructive connections where the ports of both sides of the connection or the interface can be linked to properties of the port, such as occurring allowable force, fastening method, shape and standards.

EXAMPLES A cover layer is the port of the asphalt construction in the interaction with vehicles, vice versa in the same interaction the contact surface of the tire is the port from the vehicle.

3.11
pure substance
chemical substance that has a similar chemical composition and recognizable uniform and isotropic properties

3.12
real object
amount of matter
physical object ('retaining shape' or non-'retaining shape') that is (or can be) tangible and visible in reality, man-made or naturally occurring

NOTE 1 to entry: Examples of man-made physical objects include bridges, tanks, and devices.

NOTE 2 to entry: Examples of physical object that have arisen naturally are terrains, banks, water bottoms and trees.

3.13
spatial region
physical object that encloses a particular area such as a room, roadway, and river, that is bounded by real objects or other spatial areas (e.g. by usage or convention) and that contains primarily liquid or gaseous amount of matter

NOTE 1 to entry: Typically in a spatial region there is a gravitational field that differentiates between below, above and lateral. As a result, the orientation of a spatial area is usually a relevant aspect.

4 Symbols and abbreviated terms

4.1 Symbols

This document does not contain any symbols.

4.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

0D/1D/2D/3D	0/1/2/3-dimensional
ALIM	asset lifecycle information modelling
bSI	building smart international
FAIR	findadable, accessible, interoperable and reusable [go-fair.org]
GPS	Global positioning system
IFC	industry foundation classes [bSI]
OGC	open geospatial consortium
OWL	web ontology language [W3C]
RDF(S)	resource description framework (schema)
SKOS	simple knowledge organization schema
SML	semantic modelling and linking
SOSA	sensor, observation, sample, and actuator ontology [W3C, OGC]
SSN	semantic sensor network ontology [W3C, OGC]
W3C	world wide web consortium

5 Semantic extensions for the built environment

5.1 Spatial regions versus real objects

First of all, the physical objects (functional or technical, planned or realized) are optionally, disjointly divided into spatial areas that are not directly tangible and tangible real objects. (Figure 1, 'dashes' indicate relevant properties (attributes or relations)).

- PhysicalObject
  - SpatialRegion
    - hasPart SpatialRegion
    - isBoundBy PhysicalObject
    - contains RealObject
  - RealObject
    - hasPart RealObject
    - consistsOf Matter
    - AmountOfBulkMatter
    - DiscreteObject

Figure 1 — Division of physical objects into spatial and real

This devision can be regarded as an extra systems engineering dimension orthogonal with planned/realized and technical/functional introduced EN 17632 Part 1. Its enables the modelling of basic "realized/technical/real" entities towards "planned/functional/spatial" entities. In short: from acreage modelling towards fullscale Asset Lifecycle Information Modelling (ALIM) (Figure 2).

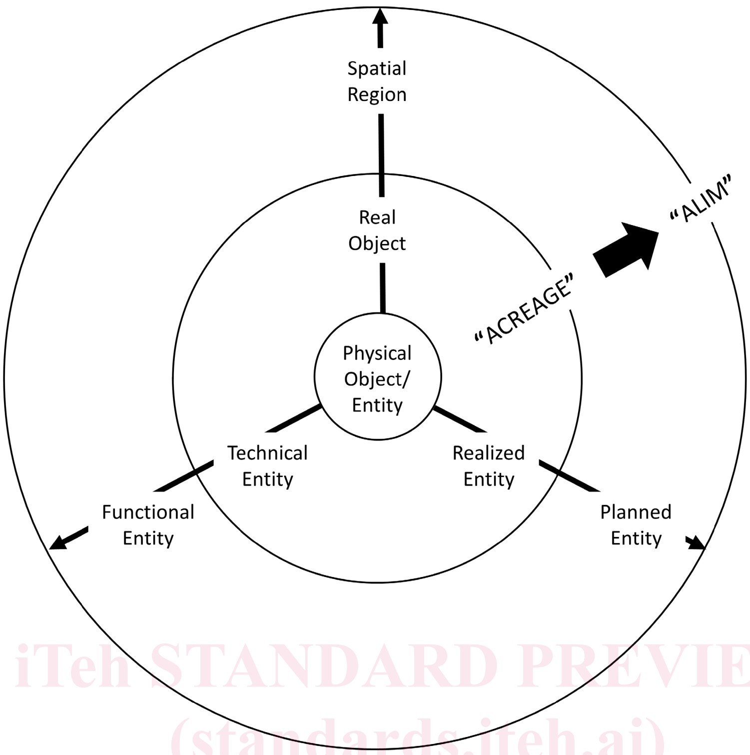

Figure 1 — Extra systems engineering dimension

DiscreteObject ('shape retaining') and AmountOfBulkMatter (non-'shape retaining') are further specializations of RealObject.

NOTE 1 A physical object is therefore broader than just 'an embodiment of masse/energy'. Meaningful ('semantic') physical spaces/times (unlike abstract mathematical spaces/times) are also included here under physical object.

NOTE 2 A (semantic) temporal region would also have been relevant (such as 'The Middle Ages') but is not included here.

NOTE 3 The 'contains' relation for a spatial region can be used for real objects located in that region and for the typically gaseous amount of bulk matter present in that region.

NOTE 4 The 'consistsOf' relation towards matter is only relevant for technical objects (not functional objects).

NOTE 5 OGC's GeoSPARQL [2] has a spatial object: 'geo:SpatialObject', defined as: "the class spatial object represents everything that can have a spatial representation. It is a superclass of feature and geometry". So this is a much broader definition than our spatial region. For example, our real object is also a spatial object in this interpretation.

EXAMPLE 1 (real objects) Examples of real objects are bridge, bridge deck, pavement, wall, floor.

EXAMPLE 2 (spatial regions) IfcSpace is used in ISO 16739-1:2018 to model a spatial area in a building. Other examples of spatial areas are roadway, lane, tank content, area, funnel, corridor and free space profile.

EXAMPLE 3 (amount of bulk matter) Examples of amounts of bulk matter are an amount of air in a spatial region, an amount of liquid in a pipe or river, and an asphalt batch.

5.2 Materialization of physical objects

Matter is seen as a special case of a physical object (also called a 'pseudo-object') and is divided according to Figure 3 (schematic) and Figure 4 (model-based).

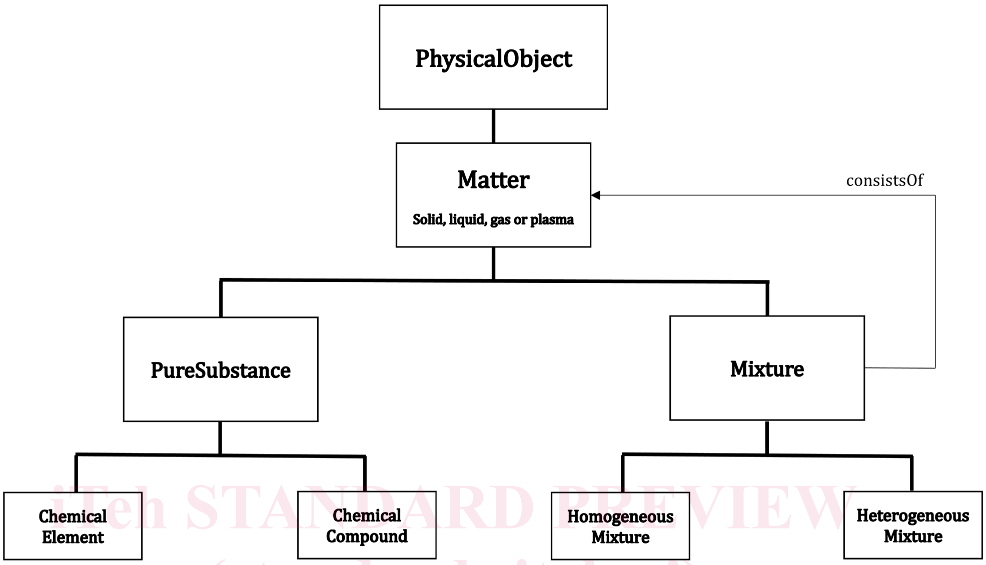

Figure 2 — Devision of matter

- PhysicalObject
  - Matter
    - chemicalFormula String
    - aggregationStateType AggregationStateType
    - PureSubstance
      - ChemicalElement
      - ChemicalCompound
    - Mixture
      - consistsOf Matter
      - HomogeneousMixture
      - HeterogeneousMixture

Figure 3 — Matter taxonomy

NOTE 1 Exotic states of matter such as 'Bose–Einstein condensates' not relevant for construction are left out for simplicity.

A predefined subtype of RelationReference is MatterPortion. This is an objectification of the consistsOf relation towards Matter. A predefined metadata attribute is 'portion' being a unitless ratio like a percentage).

NOTE 2 A MatterPortion can indicate a fragment of a certain substance in a mixture or other matter portion.

EXAMPLE (matter) Examples of chemical elements are oxygen (O_2) and hydrogen (H_2). An example of a chemical compound is water (H_2O). Examples of mixtures are cement, an asphalt mixture such as ZOAB-16, steel, concrete, composite, sand and crushed stone.

NOTE 3 Matter can be transformed (creation, modification, deletion) by an activity. Specifically, matter represents all the intensive (bulk) properties of a physical object (real object or mixture). This means that all physical processes that have to do with heat, light, electrical conduction, sound, etc. also take place via (interaction with) matter. And processes such as evaporation, freezing, melting, boiling also affect the state of matter (as a result of which in some cases the object suddenly transforms from 'shape retaining' to non-'shape retaining', for example the melting of an ice floe/glacier).

NOTE 4 A chemical formula is optional as it is only relevant for technical matter.

NOTE 5 The state of aggregation depends on the initial conditions with regard to atmospheric pressure and temperature.

5.3 Interaction between objects

In integral design (especially for electrical/hydraulic installations) and demountability in sustainable recycling (material passports), the correct modelling of interactions over connections and related transfers between physical objects is becoming increasingly important.

Static models of assets are increasingly moving towards dynamic (simulation) models in which behavioral aspects (ventilation, drain water, lighting, skid resistance, etc.) are included.

The ambition level of asset management is shifting from factual status information to behaviour, deviations, causes, effects, risks, measures, etc., and requires more knowledge/data about the connections between all these topics.

Existing traditional connections such as energy transfer between rooms in buildings and forces transfer in support systems of civil structures are then no longer sufficient.

Figure 5 describes the theoretical patterns to position these connections in general.

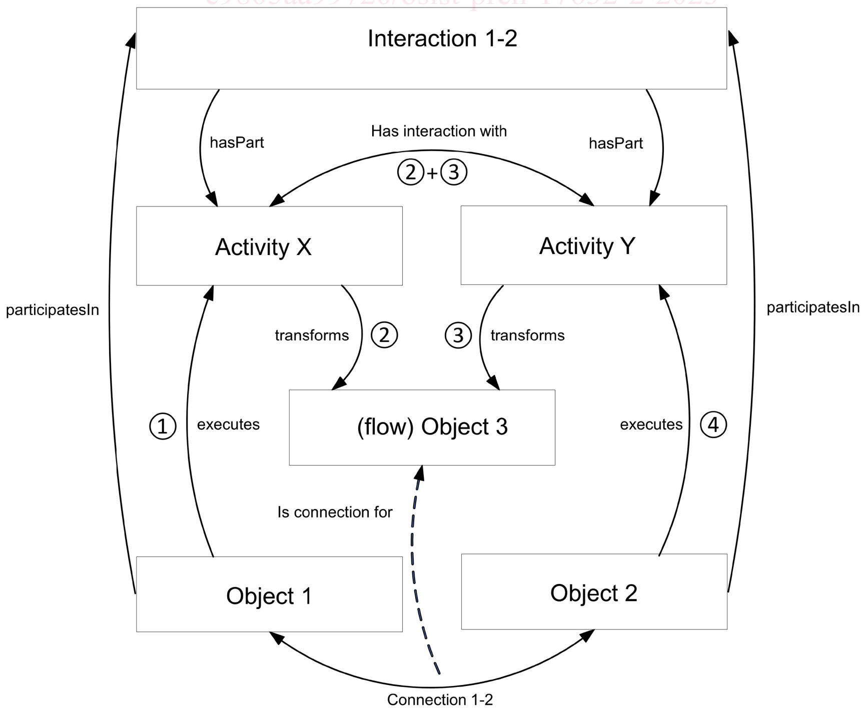

Figure 4 — Interactions over connections

The ‘Connection 1-2' (between object 1 and object 2) is a derived 'shortcut' for the existing chain of relations as numbered in Figure 5:

1. executes;

2. transforms;

3. isTransformedBy (the inverse of transforms);

4. isExecutedBy (the inverse of executes).

or using a 'sub-shortcut':

1. executes;

2. 2.+3.: ‘Has interaction with’;

3. isExecutedby.

From this theory there is a connection between objects if there are two activities, respectively executed by these objects, which are related through a third passive object, being a flow (material, information or energy) or force, which is transferred from the one to the other. These two activities are both part of an Interaction, in itself also an activity, in which these two objects participate.

It is precisely this 'Interaction' and 'Connection' between physical objects that is explicitly addressed here in part 2.

To this end, we first introduce an Interaction as a specialization of an Activity. We also introduce a participatesIn relation to indicate that physical objects participate in such an interaction.

Interactions have a transfer type that must be the same in an interaction. Options for this type are: material flow, information flow, energy flow and force transfers from one physical object to another.

This activity modelling is optional. The connection between the objects is also optional, but is more easily applied. This connection between physical objects can be established in several ways. Five options are discussed below.

Option 1: Without an explicit 'Connection' physical object, but directly via a relation 'isConnectedTo' (Figure 6).