BIM4EEB

BIM based fast toolkit for
Efficient rEnovation in Buildings

D9.7 Report on validation of harmonised open-BIM standards

This project has received funding from European Union's H2020 research and innovation programme under grant agreement N. 820660

Programmes	H2020
Call for Proposal	LC-EEB-02-2018 Building information modelling adapted to efficient renovation
Project Title	BIM based fast toolkit for Efficient rEnovation in Buildings
Acronym	BIM4EEB
Project Grant Agreement	820660

D9.7 Report on validation of harmonised open-BIM standards

Work Package	WP9
Lead Partner	Politecnico di Milano
Contributing Partner(s)	UCC, OneTeam, TUD, VisuaLynk
Dissemination Level	Public
Type	R: Document, report (excluding the periodic and final reports)
Due date	30/06/2022
Date	24/06/2022
Version	1.0

DOCUMENT HISTORY

Version	Date	Comments	Main Authors
0.1	13.09.2021	Table of content created, First draft to partners for comments	Alberto Pavan (PoliMi) Meherun Nesa Lucky (PoliMi) Simone Ciuffreda (PoliMi)
0.2	09.06.2022	Version for internal review	Meherun Nesa Lucky (PoliMi), Janakiram Karlapudi, Prathap Valluru (TUD), Seppo Törmä (VisuaLynk)
0.3	23.06.2022	Integration of comments from Hugo Grasset (SOLINTEL) and Larissa De Rosso (ACE). Ready for Submission. WP Leader's approval	Meherun Nesa Lucky (PoliMi), Janakiram Karlapudi, Prathap Valluru (TUD), Seppo Törmä (VisuaLynk)
1.0	24.06.2022	Final and formal review, plagiarism check, submission	Bruno Daniotti, Martina Signorini (PoliMi), Gabriele Canzi (FPM/PoliMi)

BIM4EEB action has received funding from the European Union under grant agreement number 820660.

EXECUTIVE SUMMARY

To advance the utilization and dissemination of the Digital Construction Ontologies (DiCon) defined in the WP3 of BIM4EEB, this deliverable offers a proposal of their contribution to the subsequent development of the EN 17632 Semantic Modeling and Linking standard (SML), in collaboration with the sister projects of the EU H2020 call LC-EEB-02-2018 “Building information modelling adapted to efficient renovation”. A proposal by BIM4EEB joined by the sister projects for a new vertical part of SML has been accepted by the CEN TC442. To facilitate the determination of the contribution of BIM4EEB in the future standardization process, DiCon and SML ontologies have been analyzed and are shown to bear enough similarities to enable the definition of an alignment. The outline of the alignment is provided in the deliverable. The alignment makes it possible to utilize the renovation specific ontology modules of DiCon in the standardization work, ranging from Processes, Agents, Information, Materials, Energy and Occupancy to Lifecycle. The collaboration with sister projects for future standardization has begun in Spring 2021 and is in progress. In addition to the CEN standardization, the properties relevant in renovations as identified in the BIM4EEB are reported for contribution to further development of IFC within buildingSmart and ISO.

PUBLISHING SUMMARY

This deliverable presents a proposal of how Digital Construction Ontologies (DiCon) can contribute to the further development of the EN 17632 Semantic Modeling and Linking standard (SML). The DiCon and SML ontologies can be aligned and a outline of the alignment is given in the deliverable. The alignment makes it possible to utilize the renovation specific ontology modules in the standardization work. Moreover, the collaboration with sister projects of the EU H2020 call LC-EEB-02-2018 “Building information modelling adapted to efficient renovation” is described. In addition, the properties relevant in renovations as identified in the BIM4EEB are reported for contribution to further development of IFC.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

The purpose of Deliverable 9.7 is to provide an analysis of the results of BIM4EEB in relation to the CEN TC442 standard on EN 17632 Semantic Modeling and Linking (SML) and to suggest how they could contribute to the evolution of that standard (Figure 1).

The SML standard includes an ontology consisting of top-level concepts to represent structured semantic life-cycle information for the built environment. In parallel to the development of SML, BIM4EEB as well as its sister projects in the EU H2020 call LC-EEB-02-2018 “Building information modelling adapted to efficient renovation” have developed mutliple ontologies to address the representational challenges in the renovation domain, which also cover a large part of the construction domain, in general.

It should be noted that the ontologies developed in all of the projects are built upon or utilize other existing and widley used ontologies that are not specific to renovation domain (Figure 1). Examples are units of measure by QUDT ontology, temporal concepts by OWL-Time ontology, provenance of data by PROV-O ontology, and sensor data by SSN/SOSA ontologies.

Existing ontologies can be used in various ways in new project: (1) importing them into new ontologies, (2) referencing their terms, (3) defining an alignment between the terms in existing and new ontologies, or (4) defining application profiles that specify how terms from different ontologies should be used together. In addition, a new ontology can copy, adapt and extend an existing ontology without directly reusing it. In the sister projects, the reuse has based on references (2), and alignments (4); also some copying and adpatation of existing ontologies has tken place.

Figure 1 shows the alignment approach used in the Digital Construction Ontologies (DiCon) developed in BIM4EEB.

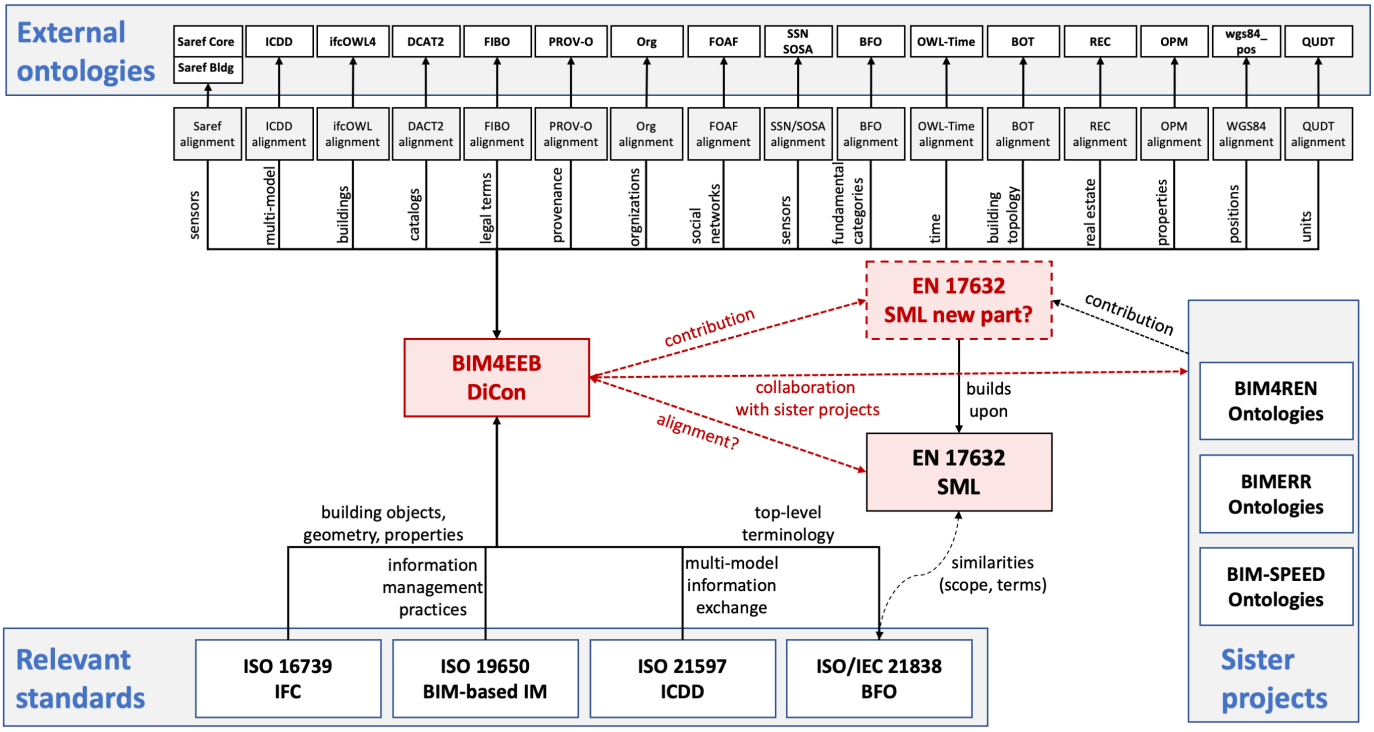

Figure 1. DiCon related to existing standards and ontologies, the sister projects, and SML

As Figure 1 indicates, there are important standards concerning information management and data representation related to the construction and renovation domain that DiCon complies with and whose impact and development must be taken into account in the future standardization work:

- IFC standard for detailed representation of buildings (ISO 16739)
- BIM-based information management standard (ISO 19650)
- ICDD Information container for linked document delivery (ISO 21597)
- BFO Basic formal ontology (ISO/IEC 21838)

The important next steps after the completion of the BIM4EEB and its sister projects is to collaborate and streamline their results with the SML standard to incorporate them into a new part of the SML standard. The work among sister projects has already started in Spring 2021.

In March 2022 BIM4EEB formally presented a new work item proposal to the CEN TC442/WG4 for a new part of the SML standard to incorporate the results of LC-EEB-02-2018 sister projects, which was accepted in May 2022. Subsequently, letters of support were sent to CEN TC442 including from participants of the sister projects.

It is obvious that the definition of a new standard ontology will be a long process and the end result will integrate contributions from sister projects as well as from many other sources. However, the work done so far provides an invaluable starting point.

1.1 Scope of the document

The objective of this deliverable is to provide an analysis and suggestion specifically from the perspective of BIM4EEB of what could be the role of its results and how to utilize them in the standardization process of the new part of SML. This deliverable will focus on the Digital Construction Ontologies (DiCon) developed in the BIM4EEB, the manner it defines the terms of the above mentioned standards, and the alignments with established ontologies. It therefore focuses mostly on the red-coloured areas of the Figure 1. The deliverable also provides an analysis of IFC properties from the perspective of renovation domain.

The deliverable first introduces the relevant standards, then presents the SML ontology, gives an overview of the work in the sister projects, and finally suggest the starting points for the alignment work between DiCon with SML. Activities at UNI, CEN and ISO tables are also reported.

1.2 Relevance to other activities and state of the art

The deliverable has relevant connections as shown in Figure 1 to important standards in the renovation and construction domain, many established ontologies, and the sister projects within the EU H2020 LC-EEB-02-2018 call.

Within BIM4EEB the deliverable D9.7 deals with the exploitation of the results created in WP3 (Linked Data and Ontologies for Semantic Interoperability) through standardization. The results of the ontology work in WP3 have been reported in the deliverables D3.1-D3.7 and embodied in the Digital Construction Ontologies (DiCon) provided in an open-source repository[1] and published online[2] under a permissive license[3].

EN 17632 SML standardization process has progresses concurrently with the BIM4EEB project and can

[1] Open-source reporitory: https://github.com/digitalconstruction
[2] Ontology publication: https://w3id.org/digitalconstruction/0.5
[3] Creative Commons Attribution License CC-BY4.0 (https://creativecommons.org/licenses/by/4.0/deed.en)

be regarded as a state-of-the-art ontology. The D9.7 analyzes and suggest a new vertical part of the standard building upon the SML standard, to further advance the state of the art.

1.3 Innovative results and progress

The innovative progress in this deliverable is to indicate – through a table of suggested alignments – how the terminology used in ISO 19650, the schema of ISO 16739, the concepts of ISO 21597, and the structure of ISO/IEC 21838 could be incorporated to future parts of SML standard via Digital Construction Ontologies (DiCon). Consequently, also the alignments of DiCon to other established ontologies can be used for the benefit of SML. There is thus a potential for the overall alignment among the standards mentioned.

The suggested alignment between DiCon and SML is enabled through the overlap of concepts between SML and BFO (both focusing on top-level categories), and the existing alignment between DiCon and BFO. The nature of that connection should be studied more closely for potential new innovations. In the future the impact of emerging RDF-Star specification on objectification of properties – and its apparently wide deployment – is likely to affect the direction of the alignment work.

2 Relationship with established ISO standards

This section provides a summary of the standards relevant for BIM-based renovation, and that have had an impact on the definition of Digital Construction Ontologies.

2.1 ISO 16739 Industry Foundation Classes (IFC)

Industry Foundation Classes (IFC) is the core openBIM standard to exchange BIM data. The organization that coordinates the development of IFC is buildingSMART International. The version IFC 4.0.1.2 has been published as a standard ISO 16739 by the ISO in committee ISO/TC 59/SC 13 (ISO16739-1, 2018).

IFC provides constructs to represent the geometric details of building design sufficiently well to enable high-quality visualizations and accurate detection of spatial clashes between models. The data model is object-oriented with specific relationship objects that enable the representation of breakdown structures and other associations. Moreover, IFC has a large collection of property sets to capture rich information contents, e.g., related to engineering parameters, energy efficiency, procurement, and so on.

The IFC schema also contains the concepts for other aspects of construction projects – such as for resources, processes, sensors, and approvals – but those parts of IFC are not widely used.

The IFC schema has originally been defined in the EXPRESS data definition language but it has been converted into an OWL ontology ifcOWL. There are converters available that also convert the IFC files into RDF that uses the terms of the ifcOWL ontology. (BIM4EEB-D31, 2019)

2.2 ISO 19650 Information Management Using BIM

ISO has published a series of standards ISO 19650 “Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling.” (ISO19650-1, 2018; ISO19650-2, 2018).

While the focus of IFC is on modelling of buildings (spatial structures, building objects, building systems, products, materials, and so on) and related construction entities (actors, events, tasks, resources), ISO19650 defines requirements for information management and information-related operations in construction domain.

Regarding renovations, there are the following areas where ISO 19650 defines relevant terminology:

- Built assetss, such as buildings and infrastructure entities
- Information model, information container, and federation
- Teams, appointments, and capabilities
- The state of information containers: work-in-progress, shared, approved, and archived

ISO 19650 covers both the delivery stage (project information delivery) and operational stage (asset information management).

According to the standard, an appointing party specifies requirements to a set of appointed parties for information delivery and management. The lead appointed party with other appointed parties in the delivery team should plan and implement information deliveries. ISO 19650 introduces concepts for the delivery team capability and capacity review, responsibility matrix, information status management, and specifies a common data environment.

In ISO 19650 the results of information delivery are represented in a named information container that is a “persistent set of information retrievable from within a file, system or application storage hierarchy” (ISO19650-1, 2018). Moreover, an information model is defined as a federated set of information containers and requirements.

2.3 ISO 21597 Information Container for Linked Document Delivery (ICDD)

ISO standard ISO 21597 "*Information Container for Linked Document Delivery (ICDD)"* (ISO21597, 2020) provides ontologies for the representation of packages containing multiple datasets and linksets that relates identifiers across those datasets.

Interlinked multi-model containers can be used to exchange complex contents (not fitting to one file) between project parties. They are especially useful to document contractual obligations and milestones within a project. Contrary to Linked Data principles (Berners-Lee, 2006) that define a simple and uniform approach to interlink data resources published online on the Web, ICDD defines an approach to interlink a closed set of documents embedded in a zip-package. For this, ICDD specifies a representation to link identifiers across different documents. Whereas linking with Linked Data Principles allows the linked entities to be retrieved, ICDD does not directly provide such a capability since the datasets can be in different data formats, some of which can be proprietary or even closed.

However, ICDD can be regarded as an evolution of the file exchange approach by extending it with the ability to exchange multiple interlinked files.

2.4 ISO/IEC 21838 Basic Formal Ontology (BFO)

Basic Formal Ontology (BFO-ISO, 2021) is a compact top-level ontology that defines a set of fundamental categories. It can be used to conceptually integrate separate domain-specific ontologies by aligning their concepts a subclasses or subproperties of the relevant concepts in the top-level ontology.

The need for a top-level ontology comes from the broad conceptual extent of the renovation domain: it covers the physical entities, spatial entities, temporal entities, properties, roles, information content entities, and so on. Basic Formal Ontology gives a time-tested definitions for these concepts.

So far, the main advantages of BFO are not related to its content but rather to facts that

- it is standardized (by ISO and IEC) and currently the only standardized top-level ontology,
- it is very widely used (e.g., in OBOFactory, Industrial Ontologies, EMMO, …),
- it is well documented. (Arp, 2015), and
- there is an active organization that maintains and further develops it (University of Buffalo).

The content-related advantages are that it is (Partridge, 2020):

- a compact ontology with only around 40 classes (Figure 2),
- a foundational ontology (based on scientific analysis of phenomena, not on linguistic criteria), and
- based on ontological realism (or materialism) that does not suppose the independent existence of mental entities that are usually much more culture-dependent and hence problematic if the goal is to achieve interoperability (Smith, 2015, 2019).

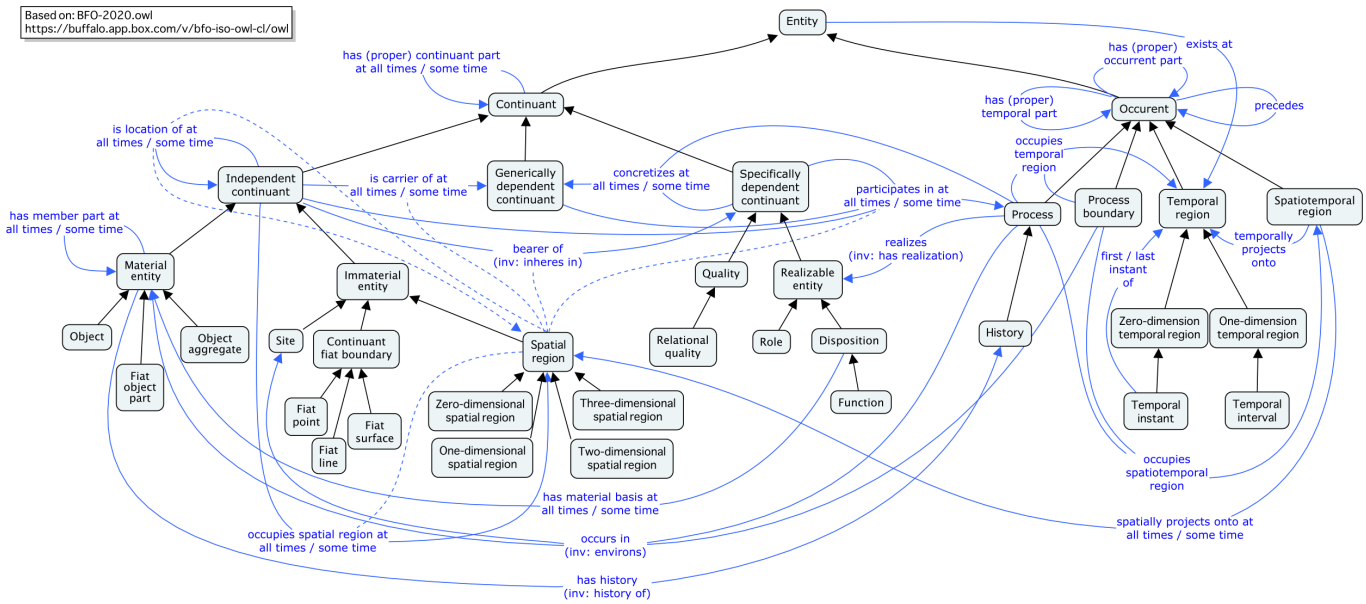

Figure 2. Basic Formal Ontology (BFO)

The foundational categories of BFO support a careful analysis of the nature of concepts. For instance, is “energy consumption” a property of something (a quality), a process, or perhaps an information content entity? Or is the term used in different ways in different situations and these meaning should be differentiated in the ontology? The carefully considered structure of BFO clearly aids in such deliberations.

2.5 Conclusions for future work (TUD)

Industry Foundation Classes (IFC) is an open BIM data model for sharing the building data. The IFC schema mainly consists of entities, and its attributes, relationships, predefined types, properties, and external references. When it comes to the building data, IFC schema covers most of the entities related to the building. If there is no appropriate building entity in IFC that address your requirements, then such entities can be represented using the IFC entity “IfcBuildingElementProxy”. A particular entity can be further described by using the attribute predefined type. As an example, IfcDoor can be further described by using its predefined types DOOR, GATE,..etc. Next important aspect in the IFC is properties. The properties can be assigned to an object through a property set. The properties which do not exist in the IFC can be assigned to the object using the custom property sets. However, renovation process is different from the new construction. It requires special set of data (entities, attributes, and property sets) from the BIM model compared with the new construction process. So, the object properties that are required during the renovation process is more helpful when it declared in the IFC as a standard property.

In this project different set of renovation data requirements are defined in the work packages 2 and 3 for the different use case scenarios. Later, these requirements are analysed, considered in the ontologies. Also, as a part of an open BIM approach these requirements are mapped with IFC entities and properties. In this process it has been noticed that some of the data is not covered in IFC for the renovation scenario. In Annex I, these properties are listed with possible type in IFC. In future, we suggest to consider these properties to add in future version of IFC for the renovation scenarios.

3 Proposal to extend SML with renovation related concepts

By giving a short summary of SML ontology, DiCon ontologies, and ontologies developed in sister projects, this section proposes a way DiCon could contribute to further development of SML. An initial alignment between DiCon and SML Part 1 is presented.

3.1 EN 17632 – Semantic modelling and linking (SML)

The draft European standard prEN 17632-1 *"Building Information Modelling (BIM) – Semantic Modelling and Linking (SML) – Part 1: Generic Modelling Patterns"* defines a generic top-level concepts for modelling built environments. It is due to a formal vote in June 2022. Figure 3 is an overview to the SML Part 1 ontology (prEN17632-1, 2021).

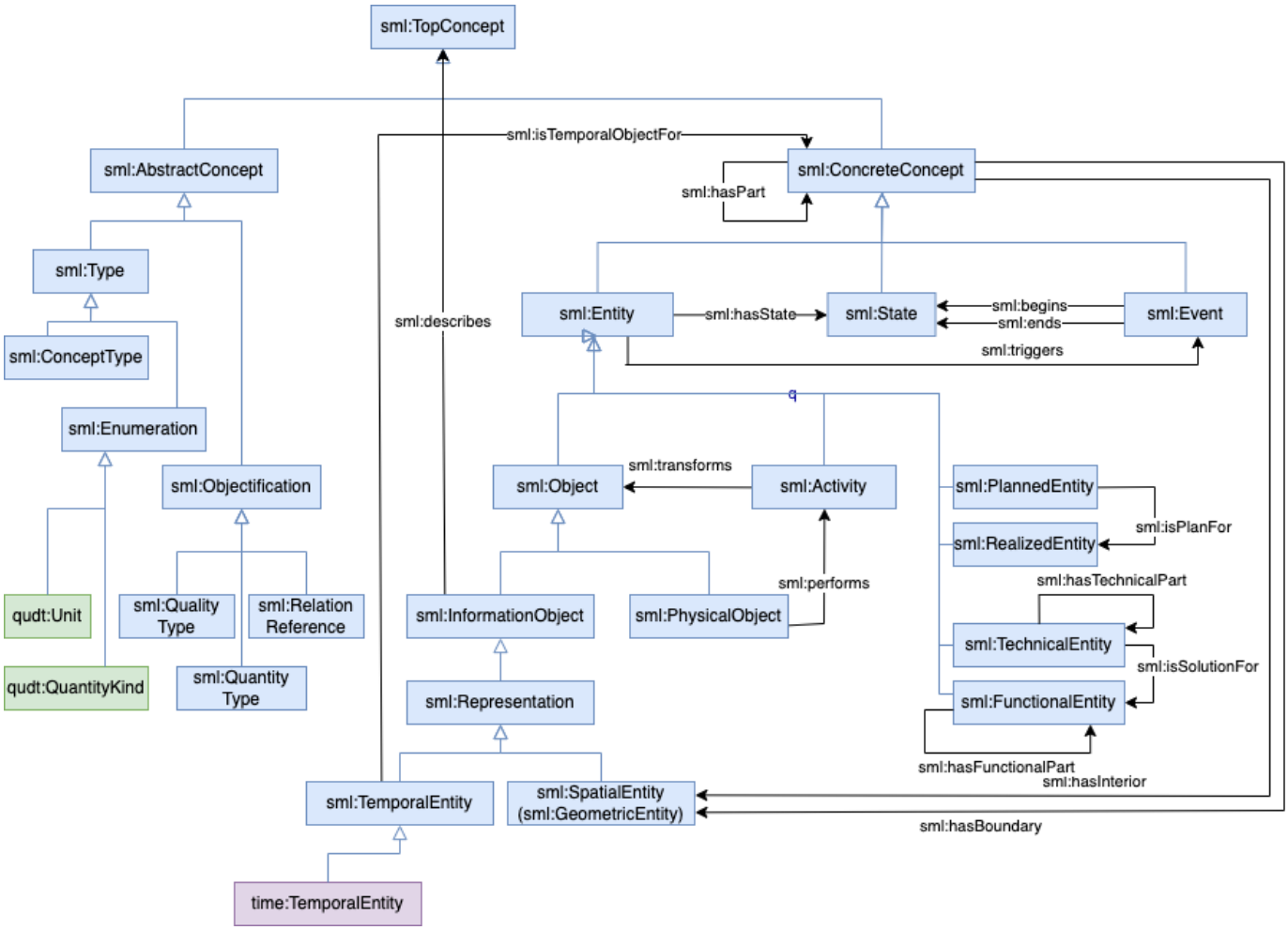

Figure 3. The classes and relations of SML

SML Part1 is a compact ontology, with only about 25 classes. It provides terms to model a domain that contains both complex structural entities that can be at different states over time, activities that act on those entities, and information entities that describe other entities. An important area is the representation of objectified properties.

The work on the part 2. of SML has begun. In May 2022 the new work item proposal for prEN 17632-2 *"Semantic Modelling and Linking, Part 2: Domain-specific modelling patterns"* was approved. The contents are listed below. In the initial proposal the bolded concepts are new ones in the SML Part2. The listing

also indicates some alignments for the concepts in SML.

- TopConcept
  • AbstractConcept
    - Type
      - EnumerationType
      - ConceptType
    - Objectification
      - QualityValue
      - QuantityValue **== qudt:QuantityValue (with qudt:numericValue)**
      - RelationReference
        - **MatterPortion**
      - **ObservableProperty (SOSA)** (modelled in SML as rdf:Property)
      - **Result (SOSA)**
        - **Sample (SOSA)**
- ConcreteConcept
  - Entity
    - Object == **FeatureOfInterest (SOSA)** == **Feature (GeoSPARQL)**
      - PhysicalObject
        - SpatialRegion
          • **Interface**
        - RealObject
          • **DiscreetObject**
            - **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

In the standardization work, the sister projects can contribute to the selection and definition of the set of new concepts relevant to renovation and construction projects.

3.2 Semantic Modelling in BIM4EEB

The main results of BIM4EEB concerning semantic interoperability are (1) the specifiction of a Linked Data and ontology framework for renovation toolkit, and (2) the definition and publication of Digital Construction Ontologies (DiCon). The framework describes how tools can share data based on ontologies and the DiCon provides the terms to use in that data.

3.2.1 The semantic interoperability framework of BIM4EEB

The key objective of the BIM4EEB project was to develop a BIM-based toolkit for efficient renovation of buildings. As the term ”toolkit” suggests, the goal was not to create an integrated set of functionalities built from the beginning to fit with each other. Rather, it indicates an open collection to tools into which different tools can be included, suiting for a particular purpose.

Since different tools need to semantically interoperate (Singh 2005; EIF 2017), with each other, a set of guidelines were specified in the Linked Data and ontology framework of BIM4EEB. The framework is more fully covered in the deliverables D3.1 and D3.6 of BIM4EEB. The architecture of the toolkit is shown in Figure 4.

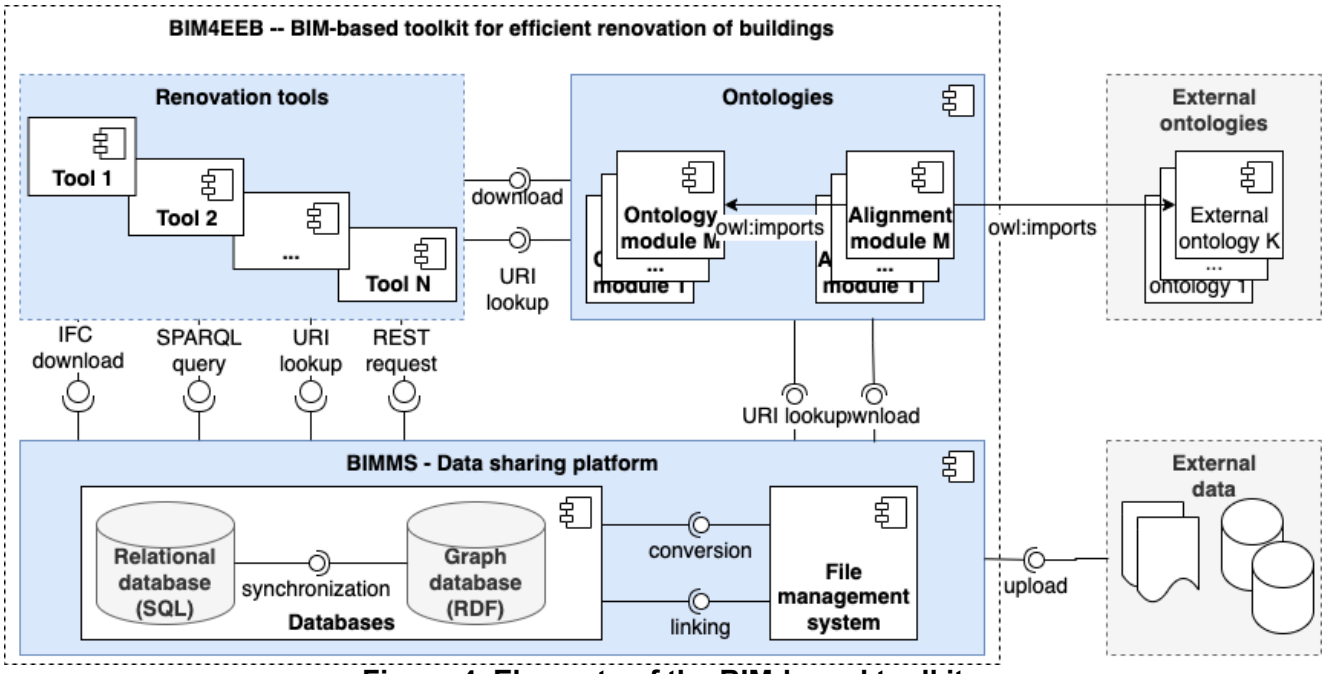

Figure 4. Elements of the BIM-based toolkit

The summary of the framework to support an open toolkit is the following:

- The framework is based on the approach of Linked Data Principles (Berners-Lee, 2006) and ontologies as the enablers of semantic information sharing and interoperability between the tools.
- As the background of the existing tools or the developer teams is mostly in traditional software solutions and practices (based on files and relational databases and formats such as XML, JSON, CSV, and SPFF), the toolkit should build a practical bridge to the adoption of Linked Data and ontologies.
- The bridge in the BIM4EEB framework is create by a data sharing platform that simplifies the adoption of Linked Data and ontologies by providing

  - a centralized data hub for the toolkit, instead of decentralized Semantic Web based data hosting approach – this is embodied in the BIMMS platform in the BIM4EEB toolkit (Figure 4),
  - automatic conversions and synchronization between the traditional file and relational database world and the Linked Data and ontology work – also taken care by the BIMMS platform (Figure 4), and
  - support for SPARQL queries over the Linked Data (Figure 4).
- The tools host their own data but share though BIMMS the portion of data that is relevant for interoperation with other tools in the renovation scenarios; that is, not all native data is shared through BIMMS.
- For semantic interoperability, the framework uses Digital Construction Ontologies (DiCon) that
  - consists of multiple ontology modules (DiCon Variables, DiCon Entities, DiCon Processes, DiCon Agents, DiCon Information, DiCon Materials, DiCon Energy, DiCon Occupancy and DiCon Lifecycle),
  - formalises the relevant terminology of ISO 19650,
  - aligns with relevant standard ontologies (ISO 16739, ISO 21597, and ISO/IEC 21838), and
  - aligns with other established ontologies relevant in renovation and construction domain (DCAT2 - Data catalogs; BOT - Building topology; OWL-Time - Temporal concepts; PROV-O - Provenance metadata; QUDT - Units of measure and quantity kinds; OPM - Property objectification; BFO - Fundamental categories; FOAF and Org - Agents and organizations; FIBO - Legal roles of agents, to define assets and ownership; SSN/SOSA - Sensor data and sensor networks; Saref, Saref4Bldg - Devices, sensors, and sensor data).

In short, the BIMMS data sharing platform allows the tools to delegate the conversion, data management and query functionalities needed in Linked Data and ontology approach to the BIMMS data sharing platform. Since these functions would in any case need to be implemented, their centralized provision by BIMMS is hugely efficient and provides the future route for the tools to fully reside in the realms of Semantic Web, Linked Data and ontologies.

3.2.2 Digital Construction Ontologies

Digital Construction Ontologies (DiCon) provide definitions for built assets, building objects and structures, project planning, construction production planning – including the agents, resources and spatio-temporal aspects – as well as phenomena related to occupancy, energy, materials and lifecycle. DiCon is based on ISO 19650 BIM/IM, ISO 16739-1 IFC, ISO/IEC 21838-2 BFO and ISO 21597-1 ICDD) and is aligned with established ontologies (e.g., OWL-Time, PROV-O and SSN/SOSA).

DiCon tries to support the representational needs of emerging *digitalized construction processes*. The use of digital technologies in different stages of construction lifecycle is growing. Examples are 3D surveying, BIM-based design and engineering, and management of procurement processes and supply-chains, systems for construction management. Large volumes of data about real-time situation is provided by mobile devices, sensors and scanning solutions. DiCon provides a common terminology to support machine-to-machine information sharing.

Digital Construction Ontologies consists of
(1) *ontology modules*: class, property, and constraint axioms,
(2) *vocabularies defining individuals:* that is, instances of classes defined in ontologies, and
(3) *alignment modules*: each of which imports both a DiCon module and an external ontology, and provides additional alignment axioms to connect their terms.

A diagram of the DiCon modules with their import relations is shown in Figure 5.

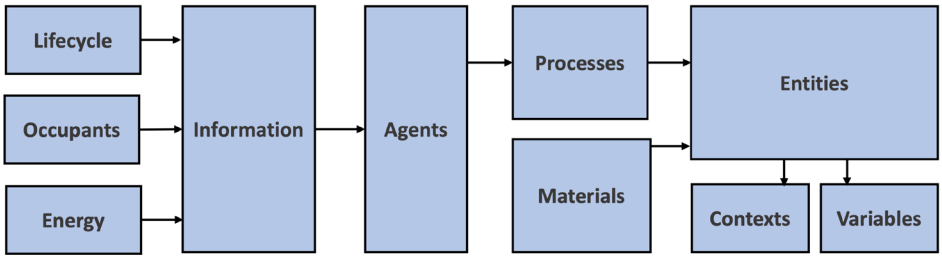

Figure 5. DiCon ontology modules

In the Figure 6 the relationships with the DiCon modules with ISO standards (in beige) and with aligned external ontologies is illustrated. The ISO 19650 does not define any ontology, but the terminology explained in the standard has influenced the definitions in several DiCon modules: Entities, Processes, Agents and Information. The other ISO standards have been utilized through alignments as shown in the upper layers of the figure. IFC in partiuclar has been utilized in the form of ifcOWL, which means the conversion of the IFC schema from Express to OWL.

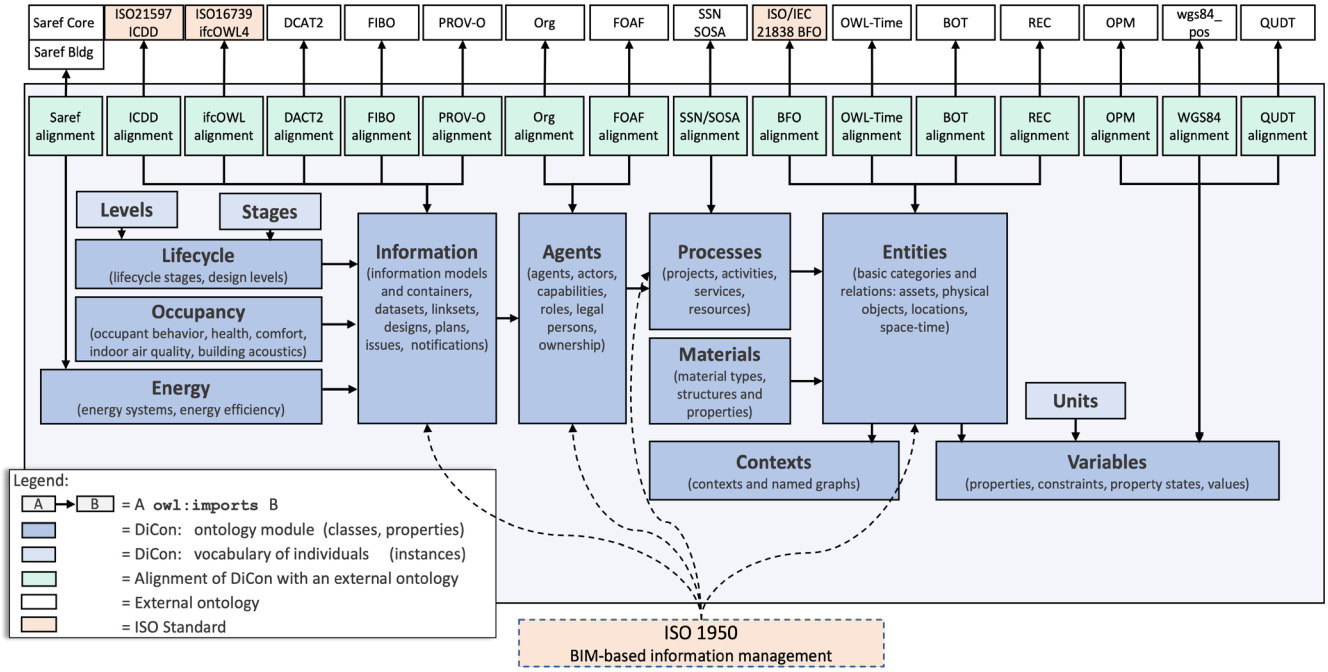

Figure 6. Digital Construction Ontologies with alignments and standards

The arrows in Figure 6 indicate the owl:import relations among the modules. The arrow points from the importing module to the imported module. The references to external ontologies are contained in the alignment modules, with the exception of referencies to individuals specified in external vocabularies (Table 1).

Table 1. Ontology modules developed in sister projects

Ontology	Description	Reused ontologies
BIM-SPEED		**No direct reuse**
Reno-Inst	Installation of windows, ETICS panels, and radiators in the context of renovation projects.	_

LCA-C	LCA and LCC assessments, the object of assessment (the building), and the products/materials used in renovation	–
BEM-Reno	A renovation ontology based on the structure of Building Topology Ontology (BOT), albeit not reusing it	Copy, adapt and extend BOT
BIMERR		**Reuse by reference**
Occupancy Profile	Occupants behavior inside buildings for the BIMERR project	Saref, Saref4Building, OWL-Time, SKOS, FOAF
Sensor Data	Sensors located inside buildings for the BIMERR project	Saref
Key Perfomance Indicator	Key performance indicators related to building renovation works	Saref, Saref4City, OWL-Time
Weather	Weather data for the BIMERR project	Geo, Saref, SSN, SOSA, Saref4City
Building	Building data for the BIMERR project	BOT
Material Properties	Properties to describe building elements in BIMERR	Saref
Annotations Objects	Annotations and extra information of building elements	–
Information Objects	Tthe files and documents attached to building elements	–
Renovation Process	The construction processes in a building renovation	Saref
Metadata	Annotations for ontology to data model transformation	–
BIM4REN		**No direct reuse**
buildings	Generic elements related to a basic description of a building. The core of the BIM4Ren, inspired by BOT	Copy, adapt and extend BOT
buildingcomponents	Components of the building that as walls, windows, ...	–
buildingsystems	HVAC, domestic hot water, lighting and appliances.	–
occupancy	Occupants and their activities within the building	–
energy	Energy modeling of the building.	–
BIM4EEB		**Reuse by alignment**
Contexts	Multi-contexts data: planned/actual, as-designed/as-built	ifcOWL
Variables	Objectified properties for time varying values, constraints and value metadata	QUDT, Geo, OPM, ifcOWL, PROV-O, SSN/SOSA, Saref
Entities	Basic categories with identifiers, classifications, breakdowns, and groupings	BFO, Geo, ifcOWL, OWL-Time, FOAF, Org, BOT, REC, SSN/SOSA, S4Bldg
Processes	Activities and resources, resource assignments, and objects of activities	ifcOWL, FOAF, PROV-O, REC, Saref
Agents	Actors, stakeholders, roles, legal persons, capabilities, capacities	ifcOWL, Org, FOAF, FIBO, ICDD, REC
Information	Information content entities, information containers, designs, plans, events, and issues	ifcOWL, PROV-O, FIBO, DCAT2, ICDD, REC
Materials	Material structures, properties and material batches	ifcOWL, BOT
Occupancy	Occupant behavior, comfort, safety and health; indoor air quality and building acoustics	ifcOWL, BOT, SOSA, REC, Saref
Energy	Energy efficiency including energy systems	ifcOWL, Saref
Lifecycle	Information over LOD levels and construction lifecycle	ifcOWL, Org

The top-level structure of DiCon which is based on BFO and aligned with it, is shown in Figure 7.

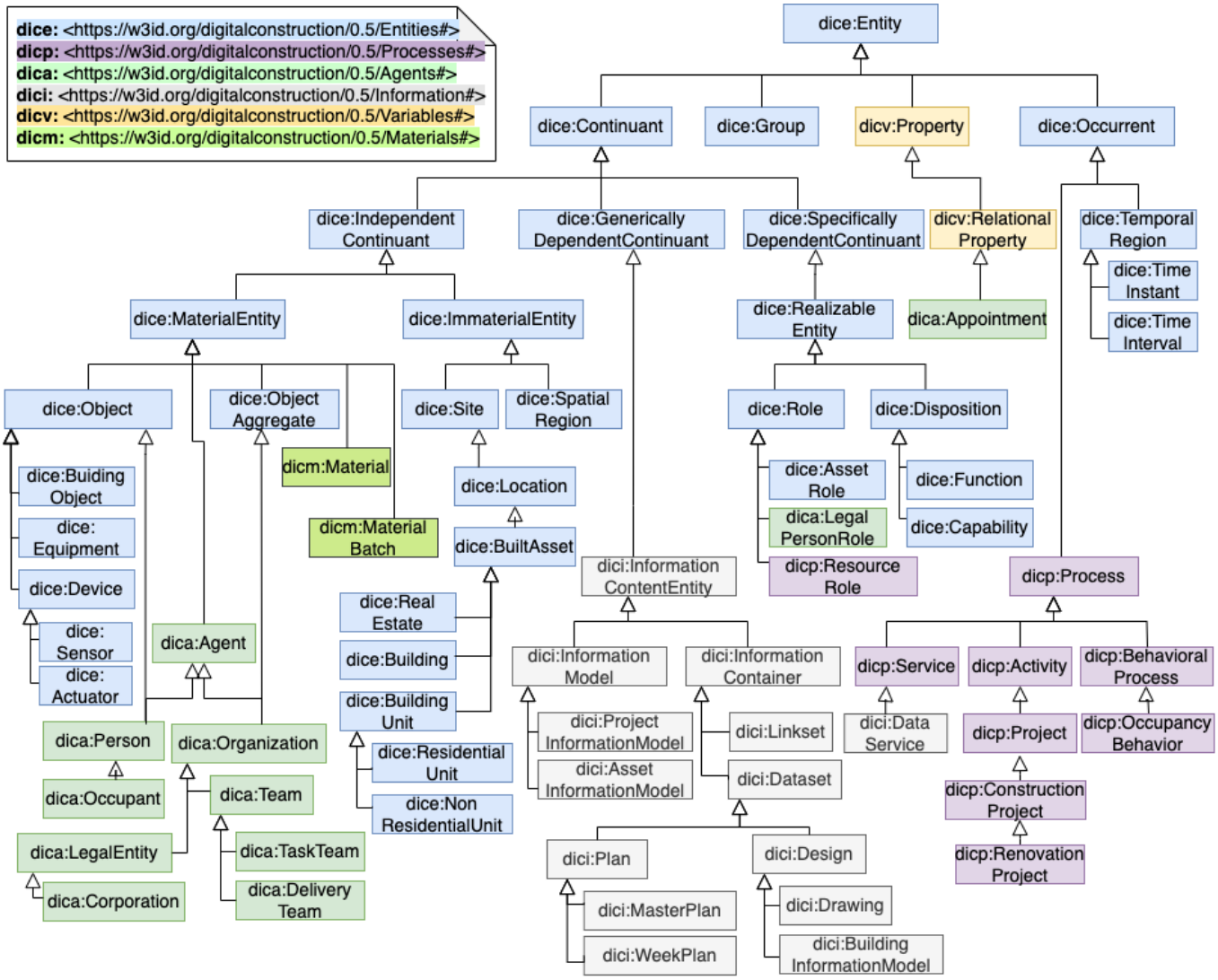

Figure 7. The core class hierarchy of DiCon

3.3 Semantic modelling in sister projects

As BIM4EEB has developed the DiCon Ontology following the semantic modelling and linked data approach, we analyzed different projects that considered the same approach for renovation scenarios. In this section we summerize the ontology developed in different sister projects.

3.3.1 BIM-SPEED

The mission of BIM-SPEED is to use BIM for deep renovations, with the goal of 60% energy saving, and to accelerate the market uptake of BIM for renovation in the EU. BIM-SPEED aims to enable all stakeholders to adopt BIM to reduce the time of deep renovations by at least 30%. The solution consist of a BIM cloud platform, a toolkit of interoperable BIM tools, and standardised methods for mapping, modelling, simulation, implementation and maintenance. BIM-SPEED has a trans-disciplinary approach

comprising the process, information technology, and social innovation as stakeholders are an important factor in the adoption of BIM.

The ontology modules developed in BIMSPEED are shown in Table 1. The modules do not directly reuse existing ontologies but one of the modules, the BEM-Reno, is an adaptation of BOT.

3.3.2 BIMERR

The BIMERR project developed an ontology network consists of multiple ontology modules, where each module models one specific domain. Table 1, provides the names and descriptions of the ontologies. The ontologies can be viewed in the link: https://bimerr.iot.linkeddata.es/index.html

Some of the ontologies have been enriched with additional annotation properties to enable the transformation to the data model required by the BIMERR Interoperability Framework.

The list of enriched Ontology modules are:

- Occupancy Profile Ontology
- Sensor Data Ontology
- Key Perfomance indicator Ontology
- Building Ontology
- Material properties Ontology
- Annotations Objects Ontology
- Informations Objects Ontology
- Renovation Process Ontology

The reuse of existing ontologies is shown in Table 1. BIMERR reuses them by referencing individual terms in its own definitions.

3.3.3 BIM4REN

This projects developed a BOT based ontology. The BIM4Ren focuses on converting ifcOWL models into the BIM4Ren vocabulary. The BIM4Ren data model[4] is used for:

- Listing the data required to run different services
- Structuring this data and linking concepts
- Categorizing concepts according to their domain of expertise
- Identifying concepts that are not present in current standards, in particular IFC4. Performed by aligning the concepts in the present data model with concepts in identified standards.

The BIM4Ren Data model (Bourreau, 2021) has been developed on three independent layers (core, product and domain) and a transversal one (utility.) This representations makes it a product-centric model as:

- the core layer is made of ontologies to relate products between them or inside a specific building context,
- the product layer is a taxonomy used to assign a specific class to a product, and
- the domain layer is used to associate properties to a product according to specific domains.

[4] https://github.com/bim4ren/DataModel

In this model full modularity has been achieved by using a multiple instantiation mecahnism that facilititate importing modules on demand. The model focuses only on residential buildings.

The ontology modules of BIM4REN are shown in Table 1. BIM4REN does not directly reuse existing ontologies but one of the ontology modules that is an adaptation of BOT.

3.4 Proposal for an integration of DiCon to EN 17632-1

The overall strategy of a possible integration of DiCon to EN 17632-1 is shown in Figure 8. There are two work areas. First, to establish the similarities between current SML ontology and DiCon through an alignment, and second, to create the new part of SML with contribution from DiCon and in collaboration with sister projects. Below these two are discussed in a more detail.

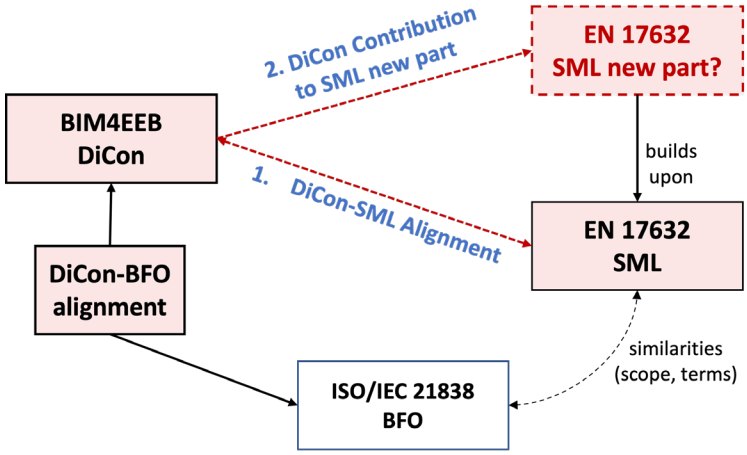

Figure 8. Proposal for possible integration of DiCon to SML

3.4.1 Dicon-SML Alignment

As a part of EN 17632, SML ontology defines the top-level concepts for the semantic models in the construction domain. The concepts, relations, and the overall structure of the SML ontology are shown in Figure 3.

The Digital Construction Ontologies (DiCon) have a top-level structure that based on the Basic Formal Ontology (BFO) that has significant conceptual overlap with SML. The BFO is again aligned with the top-level of DiCon ontology, as shown in Figure 7. DiCon follows the distinction of BFO into Continuants and Occurrents. However, at this basic level there is some slight distiction to manage artefacts (man-made things): DiCon contains the class dice:Group whose intances can include members from both Continuants and Occurrents, and the dicv:Property that can represent the qualitites of both Continuants and Occurrents.

Table 2 contains an outline of the alignment of SML and the top-level BFO concepts as implemented in DiCon. While there are still work to do with a complete alignment, it provides a good starting point.

Table 2. Outline of the alignment between SML and DiCon

dice:Entity	rdfs:subClassOf	sml:Entity
sml:Object	owl:equivalentClass	dice:Continuant
sml:PhysicalObject	owl:equivalentClass	dice:MaterialEntity

(and sml:InformationObject (not sml:TemporalEntity) (not sml:GeometricEntity))	owl:equivalentClass	dici:InformationContentEntity
sml:Activity	owl:equivalentClass	dicp:Activity
sml:Event	owl.equivalentClass	dicp:ProcessBoundary
sml:Objectification	owl.equivalentClass	dicv:Property
sml:QuantityType	owl.equivalentClass	dicv:QuantitativeProperty
sml:State	rdfs:subClassOf	dice:SpecificallyDependentContinuant
sml:TemporalEntity	owl.equivalentClass	dicp:TemporalRegion
sml:GeomericEntity	owl.equivalentClass	dice:SpatialRegion
sml:describes	owl:equivalentProperty	dici:isAbout
sml:hasPart	owl:equivalentProperty	dice:hasPart
sml:performs	rdfs:subPropertyOf	dice:participatesIn
sml:begins	owl:equivalentProperty	dice:hasStart
sml:ends	owl:equivalentProperty	dice:hasEnd

The alignment has to be fully developed, and it may require additions or changes to DiCon itself. However, the required changes do not appear significant. After the ontologies have been aligned, the other definitions in DiCon could directly contribute to the new part of the SML standard.

3.4.2 Contribution to the new part of SML

The process of creating a new part of SML will naturally require a collaborative process among many parties: the CEN TC442 members, the representative from the sister projects, and possible many other parties as well. The objectives for the new part has to be defined and the process specified. The contributions of all parties have to be collected and adjusted with those of the other parties.

DiCon has ontology modules that capture the concepts of ISO 19650, ISO 21759 and ISO/IEC 21838, and it also has alignment with many established ontologies, both of which are important contributions to the new part.

An important question is the manner in which the new ontology will connect to other existing ontologies or definitions. This concerns all the established ontologies mentioned above as well as the ontologies implemented in the sister projects. They could be used by importing them (owl:imports), by referencing their concepts (by using the URI of the concept), through alignments, or by using application profiles defined in SHACL.

3.4.3 Further factors affecting the development

The upcoming RDF-Star / SPAQRL-Star specifications by W3C (Hartig, 2017; Hartig, 2021) address the problem of objectified properties. Significant effort has been placed in this area in both DiCon and SML. It is foreseeable that the approaches to represent objectified properties both in DiCon and SML are likely to change as a result of the new specifications.

4 Conclusions

As BIM4EEB aimed to participate on the development of the Part 2 of EN17632, an Italian proposal has been made to analyse the aspects related to the renovation and efficiency improvement of existing buildings, starting from the ontology results developed and financed by the European Community, within the BIM4EEB project in EU Horizon 2020 program (grant agreement 820660). To work on this proposal, a number of collaborations has been made.

CEN/TC 442/WG 4 endorsed a favourable vote for the opening of the works of the writing of new part 2 of the EN 17632 standard (Building Information Modelling (BIM) - Semantic Modelling and Linking (SML); Part 2: domain-specific modelling patterns) at CEN TC442 / WG4, supporting the Italian proposal. On 31/03/2022 the CEN/TC 442/WG 4 has decided to use the semantics developed by the European H2020 projects to be considered as a working support for this part 2 of PrEN17632. One of the partners of BIM4EEB project, VisuaLynk confirmed their support to the introduction of the new part 2 of the EN 17632 standard at CEN TC442 / WG4.

The ontology results have already been shared and discussed with the other sister projects related to the same Horizon call: BIM-Speed, BIM4REN, BIMERR SPHERE, ENCORE. Moreover, UNI confirmed their support to bring BIM4EEB results to the discussion of their meeting UNI/CT 033/SC 05/GL 08, as a contribution to the writing of part 9 of the series UNI 11337 “Digital assets management”, the Italian national standard as annex to EN ISO 19650.

5 Bibliography

[Arp, 2015] Arp, R., Smith, B., & Spear, A. D. (2015). Building Ontologies with Basic Formal Ontology. MIT Press.

[Bourreau, 2021] Bourreau, P. and Oraskari, J., 2021. Dynamic BIM model conversion as inference-based Ontology alignment. Proceedings of the 9th Linked Data in Architecture and Construction Workshop - LDAC2021.

[Beetz, 2009b] Beetz, J., 2009. Facilitating distributed collaboration in the AEC/FM sector using Semantic Web technologies, Ph.D. dissertation, Eindhoven University of Technology, ISBN 978-90-6814-618-9.

[Berners-Lee, 2006] Berners-Lee, T., 2006. Linked Data – Design Issues, W3C Note, URL: http://www.w3.org/DesignIssues/LinkedData.html.

[BFO-ISO, 2021] BFO-ISO (2021), Basic Formal Ontology, URL: https://standards.iso.org/iso-iec/21838/-2/ed-1/en/21838-2.zip.

[BIM4EEB-D31, 2019] BIM4EEB (2019). A BIM-based framework for building renovation using the linked data approach and ontologies, BIM4EEB Deliverable 3.1, EU LC-EEB-02-2018, Project grant no 820660.

[BIM4EEB-D36, 2022] BIM4EEB (2022), Integrated Linked Data Modeling and Sharing Framework, Deliverable 3.6, Grant Agreement 820660 BIM4EEB. European Commission.

[EIF, 2017] European Union (2017). New European Interoperability Framework, Promoting seamless services and data flows for European public administrations. Publications Office of the EU, Luxembourg. http://doi.org/10.1007/978-3-319-15326-1

[Hartig, 2017] Hartig, O. (2017). RDF* and SPARQL*: An Alternative Approach to Annotate Statements in RDF. In 16th International Semantic Web Conference (ISWC).

[Hartig, 2021] Hartig, O., Champin, P.-A., Kellogg, G. & Seaborne, A. (2021). RDF-star and SPARQL-star, Final Community Group Report, W3C, URL: https://www.w3.org/2021/12/rdf-star.html.

[ISO19650-1, 2018] ISO (2018). Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) -- Information management using building information modelling. Part 1: Concepts and principles.

[ISO19650-2, 2018] ISO (2018). Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Part 2: Delivery phase of the assets.

[ISO1675, 2018] ISO (2018). Data structures for electronic product catalogues for building services, Part 1: Concepts, architecture and model, Part 2: Geometry. ISO.

[ISO21597, 2020] ISO (2020). Information container for linked document delivery — Exchange specification — Part 1: Container. URL: https://www.iso.org/standard/74389.html.

[ISO/IEC21838, 2021] ISO (2021). Information technology — Top-level ontologies (TLO) — Part 2: Basic Formal Ontology (BFO). URL: https://www.iso.org/standard/74572.html.

[Partridge, 2022] Partridge, C., Mitchell, A., Cook, A., Sullivan, J., & West, M. (2020). A Survey of Top-Level Ontologies - to inform the ontological choices for a Foundation Data Model. https://doi.org/10.17863/CAM.58311

[Pauwels, 2016] Pauwels, P., & Walter, T., 2016. EXPRESS to OWL for construction industry: Towards a recommendable and usable ifcOWL ontology. Automation in Construction, 63, pp.100–133.

[prEN17632-1, 2021] prEN 17632-1 (2021). Building Information Modelling (BIM) – Semantic Modelling and Linking (SML) – Part 1: Generic Modelling Patterns, CEN TC442, Working draft dated 2022-11-18.

[Singh, 2005] Singh, M. P., & Huhns, M. N. (2005). Service-oriented computing (pp. 410-495). Chichester: Wiley.

[Smith, 2015] Smith, B., Almeida, M., Bona, J., Brochhausen, M., Ceusters, W., Courtot, M., ... & Hogan, W. Basic Formal Ontology 2.0 – Specification and User's Guide (2015). URL: https://github.com/BFO-ontology/BFO/raw/master/docs/bfo2-reference/BFO2-Reference.pdf, 755.

[Smith, 2019] Smith, B. (2019). Ontology as Product-Service System: Lessons Learned from GO, BFO and DOLCE. Proceedings of the 10th International Conference on Biomedical Ontology (ICBO), Buffalo, NY.

6 ANNEX I – Properties that can be added in ISO standards for renovation

Table 3. Properties for a wall in a renovation scenario

Pset_WallRenovation		
Name	**Type**	**Description**
WindowsNumber	P_SINGLEVALUE /IfcInteger	Total window number per wall
DoorNumber	P_SINGLEVALUE /IfcInteger	Totaldoor number per wall
HasSkewness	P_SINGLEVALUE /IfcBoolean	Indication whether wall have skewness or not
HasExternalFinishing	P_SINGLEVALUE /IfcBoolean	Indication whether wall have external finishing or not

Table 4. Properties for a panel in a renovation scenario

Pset_Panel		
Name	**Type**	**Description**
NumberOfSides	P_SINGLEVALUE /IfcInteger	Number of sides of the panel (depends on the shape)
IsRectangular	P_SINGLEVALUE /IfcBoolean	Yes / no (other shapes: trapezoidal, triangular?)
Angles	P_SINGLEVALUE /IfcPlaneAngleMeasure	Angles between each couple of sides (all 90° for rectangular panels)
Dimension	P_SINGLEVALUE /IfcPlaneLengthMeasure	Panel size per type (lenght of sides)
Type	P_SINGLEVALUE /IfcIdentifier	Panel type and number
Number	P_SINGLEVALUE /IfcInteger	Total panel number
Joint Width	P_SINGLEVALUE /IfcPlaneLengthMeasure	Width of joints
NumberOfAnchors	P_SINGLEVALUE /IfcInteger	Number of anchors in the panel
EdgNumber	P_SINGLEVALUE /IfcInteger	Total number of edges for each facade

Table 5. Properties for a zone in a renovation scenario

Pset_ZoneSetPoint		
Name	**Type**	**Description**
HeatingSetPoint	P_SINGLEVALUE /IfcThermodynamicTemperatureMeasure	Cooling set point in oC
CoolingSetPoint	P_SINGLEVALUE /IfcThermodynamicTemperatureMeasure	Cooling set point in oC
CO2SetPoint	P_SINGLEVALUE /IfcReal	Maximum CO2-lev of the zone when CO2-controlled ventilation, in ppm
NightSetBackTemperature	P_SINGLEVALUE /IfcThermodynamicTemperatureMeasure	Set back temperature for heating between 10 PM and 6 AM
IsSetByUser	P_SINGLEVALUE /IfcBoolean	If yes then Set point set by the user.

Table 6. Properties for a space in a renovation scenario

Pset_SpaceAirQuality		
Name	**Type**	**Description**
Air Quality (8760)	P_SINGLEVALUE /IfcPositiveRatioMeasure	Real time air quality of air, %, for each hour
CO2Level	P_SINGLEVALUE /IfcReal	Measured CO2 level
MaximumCOLevel	P_SINGLEVALUE /IfcReal	Permitted maximum CO level in the space
MaximumNO2Level	P_SINGLEVALUE /IfcReal	Permitted maximum NO2 level in the space
MeasuredCOLevel	P_SINGLEVALUE /IfcReal	Measured CO level in the space
MeasuredNO2Level	P_SINGLEVALUE /IfcReal	Measured NO2 level in the space

Table 7. Properties for a space in a renovation scenario

Pset_SpaceLightingRequirements		
Name	**Type**	**Description**
MaximumIlluminanceLevel	P_SINGLEVALUE/IfcIlluminanceMeasure	Maximum illuminance levels permitted in the space
MinimumIlluminanceLevel	P_SINGLEVALUE/IfcIlluminanceMeasure	Minimum illuminance levels permitted in the space

Table 8. Properties for a space in a renovation scenario

Pset_SpaceThermalComfort		
Name	**Type**	**Description**
IndoorAirAverageTemperature	P_SINGLEVALUE /IfcThermodynamicTemperatureMeasure	Indoor air average temperature
WorkingAverageTemperature	P_SINGLEVALUE /IfcThermodynamicTemperatureMeasure	Working average temperature
Average Relative Humidity	P_SINGLEVALUE /IfcPositiveRatioMeasure	average relative humidity
AirSpeed	P_SINGLEVALUE /IfcVolumetricFlowRateMeasure	air speed at which occupants are comfort
UnsatifiedPercentage	P_SINGLEVALUE /IfcPositiveRatioMeasure	Unsatisfied percentage of occupants in the space

Table 9. Properties for a space in a renovation scenario

Pset_SpaceVisualComfort		
Name	**Type**	**Description**
AverageIlluminance	P_SINGLEVALUE/IfcIlluminanceMeasure	Average illuminance
DaylightFactor	P_SINGLEVALUE/IfcRatioMeasure	Daylight factor

7 ANNEX II – Owners' and inhabitants' needs and requirements in renovation interventions

Table 10. Owners' and inhabitants' needs and requirements in renovation interventions

Domain	Description	Type
Registry	Owner ID	VARCHAR
Registry	Owner ID$name	VARCHAR
Registry	Owner ID$fiscal code	VARCHAR
Registry	Owner ID$address of legal registration	VARCHAR
Registry	Owner ID$title of possession	VARCHAR
Registry	Owner ID$contacts	VARCHAR
Registry	Inhabitants ID	VARCHAR
Registry	Inhabitants$name	VARCHAR
Registry	Inhabitants$fiscal code	VARCHAR
Registry	Inhabitants$address of legal registration	VARCHAR
Registry	Inhabitants$title of possession	VARCHAR
Registry	Inhabitants$contacts	VARCHAR
Registry	Contractor ID	VARCHAR
Registry	Contractor$name	VARCHAR
Registry	Contractor$VAT number	VARCHAR
Registry	Contractor$data of submission	VARCHAR
Registry	Contractor$contacts	VARCHAR
Registry	Subcontractor ID	VARCHAR
Registry	Subcontractor$name	VARCHAR
Registry	Subcontractor$VAT number	VARCHAR
Registry	Subcontractor$data of submission	VARCHAR
Registry	Subcontractor$contacts	VARCHAR
Registry	Building and Construction Professionals ID	VARCHAR
Registry	Building and construction professionals ID$name	VARCHAR
Registry	Building and construction professionals ID$fiscal code/VAT number	VARCHAR
Registry	Building and construction professionals ID$agreement ID	VARCHAR
Registry	Building and construction professionals ID$data of submission	VARCHAR
Registry	Building and construction professionals ID$contacts	VARCHAR
Registry	Construction operators ID	VARCHAR
Registry	Construction operators ID$name	VARCHAR
Registry	Construction operators ID$fiscal code/VAT number	VARCHAR
Registry	Construction operators ID$agreement ID	VARCHAR
Registry	Construction operators ID$data of submission	VARCHAR
Registry	Construction operators ID$contacts	VARCHAR
Registry	Management organizational chart and responsibilities ID	VARCHAR
Registry	Management organizational chart and responsibilities ID$name	VARCHAR
Registry	Management organizational chart and responsibilities ID$fiscal code/VAT number	VARCHAR

Registry	Management organizational chart and responsibilities ID$telephone number	VARCHAR
Registry	Management organizational chart and responsibilities ID$email	VARCHAR
Registry	Management organizational chart and responsibilities ID$certified email	VARCHAR
Registry	O&M operators ID	VARCHAR
Registry	O&M operators ID$name	VARCHAR
Registry	O&M operators ID$fiscal code/VAT number	VARCHAR
Registry	O&M operators ID$agreement ID	VARCHAR
Registry	O&M operators ID$data of submission	VARCHAR
Registry	O&M operators ID$contacts	VARCHAR
Registry	Energy/Services suppliers ID	VARCHAR
Registry	Energy/Services suppliers ID$name	VARCHAR
Registry	Energy/Services suppliers ID$VAT number	VARCHAR
Registry	Energy/Services suppliers ID$type of agreement	VARCHAR
Registry	Energy/Services suppliers ID$date of submission	VARCHAR
Registry	Energy/Services suppliers ID$contacts	VARCHAR
Registry	Energy Delivery points ID	VARCHAR
Building ID	Name of the building	VARCHAR
Building ID	Main destination	VARCHAR
Building ID	Other destinations (if any)	VARCHAR
Building ID	Building category	VARCHAR
Building ID	Building permit ID (condoni)	VARCHAR
Building ID	Construction year	VARCHAR
Building ID	Last renovation (partial or general) year	VARCHAR
Building ID	Energy class	VARCHAR
Building ID	Cadastre ID	VARCHAR
Building ID	Building address (nation, province, town, post code, street/road/square, nr)	VARCHAR
Building ID	GIS coordinates (Longitude, latitude)	VARCHAR
Building ID	Height above the sea level	DOUBLE
Building ID	Distance from sea	DOUBLE
Building ID	Max number of occupants	INT
Urban and services data	City planning indexes (surface and urban destination)	VARCHAR
Urban and services data	Urban constraints (Public)	VARCHAR
Urban and services data	Easements (Private)	VARCHAR
Urban and services data	Presence and distance between the building and services in the territory	VARCHAR
Urban and services data	Connection with primary services (distance)	DOUBLE
Geotechnical/Geological data	Reason of the geotechnical or geological investigation (if any)	VARCHAR
Geotechnical/Geological data	Responsible for the investigation ID (if any)	VARCHAR
Geotechnical/Geological data	Diagnostic company ID (if any)	VARCHAR
Geotechnical/Geological data	Geological/Geotechnical report of foundation soil	
Tender Agreement	Tender agreement	VARCHAR
Tender Agreement	Tender type	VARCHAR
Tender Agreement	Timeline chart (Start-Expiry Dates Main events)	BLOB

Tender Agreement	Drawings and reports	BLOB
Accessibility	Public accessibility	BOOL
Accessibility	Accessibility for impaired people	BOOL
Maintenance plan	Agreement type	VARCHAR
Maintenance plan	Agreements duration	VARCHAR
Maintenance plan	Contractors ID	VARCHAR
Maintenance plan	Mandatory certifications to be updated (start and expiry date)	VARCHAR
Maintenance plan	Main interventions (relevant)	VARCHAR
Maintenance plan	Average annual cost of interventions realized	DOUBLE
Maintenance plan	Problems and delays	VARCHAR
Maintenance plan	Periodical issues	VARCHAR
Maintenance plan	Technical assessment	BLOB
Licenses	Certified evaluation	BLOB
Licenses	Matching certification	BLOB
Licenses	Fractionation	BLOB
Licenses	Cadastral records	BLOB
Licenses	Building license or permit	BLOB
Licenses	Regularization title concession	BLOB
Licenses	Certification of urban destination	BLOB
Licenses	Certificate of habitability	BLOB
Licenses	Technical reports	BLOB
Licenses	EPC	BLOB
Other information	Energy and Construction market	BLOB
Other information	Benchmark/statistical data for comparison purposes	BLOB
Other information	Governmental taxes and incentives	BLOB
Other information	Financial programs	BLOB
Economic data	Administrative cost	DOUBLE
Economic data	Energy cost	DOUBLE
Economic data	Insurance cost (Employee insurances; building insurance; PV insurance)	DOUBLE
Economic data	Operation and use costs (for consulting, monitoring, maintenance interventions, etc.)	DOUBLE
Economic data	Administrative costs	DOUBLE
Economic data	Total amount of works (percentage breakdown)	VARCHAR
Economic data	Infrastuctures costs	DOUBLE
Economic data	Taxes	DOUBLE
Economic data	Kind and amount of funding	VARCHAR
Renewable energy system	Renewable energy system$Plant type	VARCHAR
Renewable energy system	Renewable energy system$Distribution type	VARCHAR
Renewable energy system	Renewable energy system$Grid connection	BOOL
Renewable energy system	Renewable energy system$Type of energy produced (electricity, heating, cooling)	VARCHAR
Renewable energy system	Renewable energy system$Plant nominal power	VARCHAR
EPC general information	Energy label	VARCHAR
EPC general information	EPC number	VARCHAR
EPC general information	Type of EPC	VARCHAR
EPC general information	Issue date	VARCHAR
EPC general information	Term date	VARCHAR

EPC general information	Energy audit type	VARCHAR
EPC general information	Audit expert name	VARCHAR
EPC general information	Audit date	VARCHAR
EPC general information	Audit report	VARCHAR
Energy use	Energy use for heating	VARCHAR
Energy use	Energy use for cooling	VARCHAR
Energy use	Energy use for ventilation	VARCHAR
Energy use	Energy use for domestic water heating	VARCHAR
Primary Energy	Primary energy for heating	VARCHAR
Primary Energy	Primary energy for cooling	VARCHAR
Primary Energy	Primary energy for ventilation	VARCHAR
Primary Energy	Primary energy for domestic water heating	VARCHAR
Primary Energy	Primary energy for lighting and electrical appliances	VARCHAR
Primary Energy	Primary energy for elevators and escalators	VARCHAR
Delivered energy	Delivered energy for heating	VARCHAR
Delivered energy	Delivered energy for cooling	VARCHAR
Delivered energy	Delivered energy for ventilation	VARCHAR
Delivered energy	Delivered energy for domestic water heating	VARCHAR
Delivered energy	Delivered energy for lighting/electrical appliances	VARCHAR
Delivered energy	Delivered energy for elevators and escalators	VARCHAR
Emissions	CO2 emissions	VARCHAR
Emissions	CO2 emissions rate for surface unit	VARCHAR
Emissions	CO2 emissions rate for volume unit	VARCHAR
Energy needs	Thermal energy needs for heating	DOUBLE
Energy needs	Thermal energy needs for cooling	DOUBLE
Energy needs	Thermal energy needs for ventilation	DOUBLE
Energy needs	Thermal energy needs for domestic water heating	DOUBLE
Energy needs	Primary energy needs for heating	DOUBLE
Energy needs	Primary energy needs for cooling	DOUBLE
Energy needs	Primary energy needs for ventilation	DOUBLE
Energy needs	Primary energy needs for domestic water heating	DOUBLE
Energy needs	Total primary energy needs	DOUBLE
Systems maintenance	Systems maintenance$Company name/Contractor	VARCHAR
Systems maintenance	Systems maintenance$Agreement	VARCHAR
Systems maintenance	Systems maintenance$Agreement duration	VARCHAR
Systems maintenance	Systems maintenance$Responsible ID	VARCHAR
Systems maintenance	Systems maintenance$Maintenance ID	VARCHAR
Systems maintenance	Systems maintenance$Emergency contact name	VARCHAR
Systems maintenance	Systems maintenance$Total annual cost Delivery station	DOUBLE
Systems maintenance	Systems maintenance$Total annual cost Distribution	DOUBLE
Systems maintenance	Systems maintenance$Total annual cost Terminal	DOUBLE
Systems maintenance	Systems maintenance$Date	VARCHAR
Systems maintenance	Systems maintenance$Validity or next update	VARCHAR
Systems maintenance	Systems maintenance$Maintenance certificate	BLOB
Systems maintenance	Systems maintenance$Expiry date of certificate	VARCHAR
Systems maintenance	Systems maintenance$Maintenance report	BLOB

Energy source	List of energy sources	VARCHAR
Metering system information	Type of meter	VARCHAR
Metering system information	Period of meter	VARCHAR
Metering system information	Energy metered	VARCHAR
Renewable energy sources	List of renewable energy sources	VARCHAR
Metering system information	Type of meter	VARCHAR
Metering system information	Period of meter	VARCHAR
Metering system information	Energy metered	VARCHAR
Intended use	Rooms type	VARCHAR
Intended use	Room temperature	VARCHAR
Intended use	Room humidity	VARCHAR
Intended use	Room hourly air change	VARCHAR
Intended use	Electrical power	VARCHAR
Weather data	Degree days	INT
Weather data	Rate of raininess	DOUBLE
Weather data	Outside air temperature	DOUBLE
Weather data	Wind speed	DOUBLE
Weather data	Solar radiation	DOUBLE
Smart Indicator	Smart Readiness Indicator	VARCHAR
Smart Indicator	Other smart indicators	VARCHAR
Emobility	Electric vehicle	VARCHAR
Emobility	EV charging points	VARCHAR
Smart district	Smart district indicators	VARCHAR

8 ANNEX III – Letters for New Work Item Proposal of CEN/TC 442/WG4

VisuaLynk Oy
Holmanpää 3B
02240 Espoo
visualynk.com
+358503160979

29.03.2022

In support of CEN/TC 442/WG 4 - doc N 290, New Work Item Proposal

Dear UNI
c.a. dr. Marco De Gregorio
dr. Alberto Galeotto

VisuaLynk Oy supports the introduction of the new part 2 of the EN 17632 standard (Building Information Modelling (BIM) - Semantic Modelling and Linking (SML); Part 2: domain-specific modelling patterns) at CEN TC442 / WG4.

We confirm our support for the Italian proposal to analyze the aspects related to the renovation and efficiency improvement of existing buildings, starting from the ontology results developed and financed by the European Community, within the BIM4EEB project in EU Horizon 2020 program (grant agreement 820660). The ontology results have already been shared and discussed with the other sister projects related to the same Horizon call: BIM-Speed, BIM4REN, BIMERR SPHERE, ENCORE.

Yours sincerely,

Seppo Törmä, Ph.D.
CEO of VisuaLynk Oy
VisuaLynk Oy
seppo.torma@visualynk.com
phone: +358503160979

CEN/TC 442/WG 4 N 300

CEN/TC 442/WG 4
SUPPORT DATA DICTIONARIES

March 03rd 2022
25th meeting

Convenor : Roland DOMINICI
dominici@cobuilder.fr

Secretary : Yoann DERVIN
yoann.dervin@afnor.org

afnor NORMALISATION

CEN/TC 442/WG 4 N 300

5.1 - WI 00442021 prEN 17632 Building *Information Modelling (BIM) - Semantic Modelling and Linking (SML)*

- Project under Fromal Vote

According to the planning, the ballot should be open before the 2nd of June 2022, last 8 weeks

- Development of part 2

A working draft is available under number N 292.

This part 2 aim to answer to some of the comments received during the CEN Enquiry.
During the last WG4 meeting, experts wonder if this "domain specific" content should be included into the ongoing SML standard, or developed as a part 2.
It was decided that it should be developed as a part 2.

A draft New WI proposal is available under number N 293.
According to your feed back, the proposal was amended under number N 296 and submitted to CEN/TC 442 the 04th of march.

UPDATE 31/03/2022: The semantics developed by the European H2020 projects is to be considered as a working support for this part 2.

Milano, 31 maggio 2022

To
Prof. Bruno Daniotti
Prof. Alberto Pavan
BIM4EEB Project – Polimi
bruno.daniotti@polimi.it
alberto.pavan@polimi.it

Object: Declaration for project BIM4EEB

Dear Professor Bruno Daniotti,
Dear Professor Alberto Pavan,

thank you for the shared documentation relating to the results of the BIM4EEB project achieved so far. As I announced to you and in accordance with the convenor, prof. Mario Dejaco, I confirm that the work of your project and especially in relation to the DICO semantics and the IFC attributes for the refurbishment as well as to your Logbook scheme will be brought to the discussion in the next meetings of the UNI/CT 033/SC 05/GL 08, as a contribution to the writing of part 9 of the series UNI 11337 "Digital assets management", the Italian national standard as annex to EN ISO 19650 "Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling".

Best Regards

Arch. Marco De Gregorio
(UNI Technical Project Manager)

Prof. Mario Dejaco
(Convenor UNI/CT 033/SC 05/GL 08)

UNI Ente Italiano di Normazione
Membro italiano CEN e ISO
Via Sannio, 2 - 20137 Milano - Tel. 02700241 uni@uni.com (sede legale)
Via del Collegio Capranica, 4 - 00186 - Roma - Tel. 0669923074 uni.roma@uni.com
P.IVA 06786300159 - CF 80037830157
www.uni.com

Dipartimento di architettura, ingegneria delle costruzioni e ambiente costruito
Department of architecture, built environment and construction engineering
Prof. Bruno Daniotti

POLITECNICO DI MILANO

UNI – Italian Standard Body
2 via Sannio, 20137 – Milano (MI)
marco.degregorio@uni.com

Milan, March 24th 2022

Object: CEN/TC 442/WG 4 - doc N 290, New Work Item Proposal
Dear UNI – Italian Standard Body
2 via Sannio, 20137 – Milano (MI)

hereby, endorsing the expression of a favourable vote for the opening of the works of the writing of new part 2 of the EN 17632 standard (Building Information Modelling (BIM) - Semantic Modelling and Linking (SML); Part 2: domain-specific modelling patterns) at CEN TC442 / WG4, we confirm our support for the Italian proposal to analyse, among the specific domains, the aspects related to the renovation and efficiency improvement of existing buildings starting from the results of the works already present, and financed, by the European Community with projects related to Horizon 2020 and Horizon Europe, including: BIM4EEB.

the BIM4EEB Project Coordinator

Prof. Bruno Daniotti

Politecnico di Milano
Via Ponzio, 31
20133 Milano
Italy
tel: +39 02 23996002
email: Bruno.Daniotti@polimi.it