BIM SPEED

Report on cooperation activities with standardisation bodies and recommendations on BIM for renovation

Deliverable Report D5.1

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BIM-SPEED
Harmonised Building Information Speedway for Energy-Efficient Renovation

This research project has received funding from the European Union's Programme H2020-NMBP-EEB-2018 under Grant Agreement no 820553.

Report on cooperation activities with standardisation bodies and recommendations on BIM for renovation

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Publishable executive summary

European projects, due to the public funding they receive, must ensure that the research done, and the results produced, can be shared and are easily exploitable or reusable. Relying on standards is a very good solution for that. When it comes to BIM (Building Information Modelling) methodology, the importance of standardization is even more obvious. BIM is all about interoperability, and the straight way to guarantee best interoperability possible of data exchange between tools, processes, and people, is to use, test, improve and push standards.

Task 5.1-*Cooperation with standardisation bodies* of BIM-SPEED project is dedicated to cooperation with standardization bodies. All along the project, the objective of this task is to ensure whenever it is possible, and whatever the subject they are working on, partners actively consider standardization aspects: looking for existing standards, testing them, using them, and each time there is an opportunity, promoting the work done in the project to adequate standardization committees.

This process began during the requirement and specification phases, where standards for Use Cases, BIM, Collaborative processes, numerical simulation, LCA (Life Cycle Assessment) properties, etc., were identified and investigated. During the development phase of the BIM-SPEED project, standards were used when they were corresponding to what was needed, and in other cases, internal developments got inspired by existing standards. Additionally, consortium partners that were actively participating to some standardization committees have been identified, so that they can provide a direct communication channel with the standards experts, when a question, a problem or a remark was risen by a BIM-SPEED partner.

In the end, a large number of very interesting standards (existing or still under development) were identified and analyzed, quite a good number of them were concretely used in the development of the project, and some significant contributions to standardization were achieved such as the development and sharing of 3 BIM-oriented ontologies with sister projects, or the publication on buildingSMART Use Case Management platform of a great number of standardised Use Cases (14 of them at the moment these lines are published).

Table of Acronyms and definitions

BIM	Building Information [Model | Modeling | Management]
IFC	Industry Foundation Classes
bSI	buildingSMART International
IDM	Information Delivery Manual
MVD	Model View Definition
OGC	Open Geospatial Consortium
ISO	International Organization for Standardization
CEN	European Committee for Standardization (CEN, French: Comité Européen de Normalisation)
INSPIRE	Infrastructure for Spatial Information in Europe
EeB	Energy-efficient Building
GIS	Geospatial Information System
HVAC	Heating Ventilation Air Conditioning
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
MEP	Mechanical Electrical Plumbing
R&D	Research and Development
RES	Renewable Energy Source
VR/AR	Virtual / Augmented Reality
BEM	Building Energy Model
SAREF	Smart Applications REFerence (SAREF) ontology
LOIN	Level of Information Need
EPD	Environmental Product Declaration
PCR	Product Category Rules

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1. Introduction

1.1 Objectives

The purpose of this document is to present the work done and the results achieved in Task 5.1 all along of the project. Task 5.1 is dedicated to cooperation with standardization bodies, with the following objectives:

- Identify existing standards (IFC, BCF, COBie, IFD, IDM, etc.) and those under development (Product Data Templates, PPBIM/XP P07-150 in France, etc.) with high relevance for BIM-SPEED project.
- Make sure the identified standards are correctly used and implemented in EEB renovation projects.
- Give feedback and recommendation to the standardization bodies for improvements to the current standards and contribute with inputs for professional BIM handbooks based on lessons learned from the pilot.

This final version of the document is divided into 3 main sections. Section 1 introduces the bases and motivations of the relation between a European project and standardization committees and presents the methodology and organization of task 5.1. The core of this document, section 2, presents the different phases of collaboration with standardization. Finally, section 3 gives some recommendations for a good implementation of standardization actions in a European project.

1.2 Introduction to cooperation with standardization bodies

'The Infrastructure for Spatial Information in the European Community (INSPIRE)' in the construction of the EU Digital Single Market (DSM) is an initiative by the European Commission to build a territorially unified digital market spanning the entire European Union, aimed at developing unified standards for geospatial data [1]. To overcome the challenges associated with utilizing many types of interoperability enablers to implement sociotechnical systems across borders, the Commission focused on two mechanisms 'legal and technical interoperability'.

The former 'legal interoperability' requires coordination between geographic agencies across the EU, its member states, and subnational administrations. While the latter 'technical interoperability' is crucial in setting standards for spatial production and distribution. In reference to the INSPIRE project, the Digital Single Market premise is based on the capacity for changes in legal and technical interoperability focusing on reducing barriers that constrain the supply of cross-border digital trade. In fact, the European Commission has incorporated spatial data infrastructure into a legally binding regulation. The process included a variety of stakeholders known as Spatial Data Interest Communities (SDICs), collaborating with the Legally Mandated Organizations (LMOs) of each member state in the EU (such as national geographic agencies). The assumptions are that all "Member States of the European Union develop their own infrastructures and make them interoperable through agreed technical specifications". In this context, European projects, due to the public funding they receive, must ensure that the research done, and the results produced can be shared and are easily exploitable or reusable. Relying on standards is a very good solution for that.

When it comes to BIM, the importance of standardization is even more obvious. BIM is all about interoperability, and the straight way to guarantee the best interoperability possible between tools, processes, and people, is to use, test, improve and push standards.

Error! Reference source not found. shows the most common interactions between a research project and the standardization world:

- Phase 1: During the specification phase of the research project, each requirement or use case identified shall be mapped with an existing standard solution. Project partners will consult standards and attend some standardization committees' meetings, looking for information.
- Phase 2: During the conception phase of the research project, each identified standard solution will be analysed, and challenged with the objective of the project. Project partners will need more technical support from the standardization committees in order to ensure the standard solution meets the project needs and is adequately used.
- Phase 3: During the development phase of the research project, each selected standard solution will be implemented and tested. When limitations or problems are identified, project teams will adapt by suggesting corrections or additions. When it is possible, project partners will demonstrate their on-going implementation of the standards to the corresponding committees.
- Phase 4: Finally, during the dissemination phase of the research project, the most interesting project outcomes will be pushed towards standardization committees. Depending on the outcome type, these "contributions to standardization" can be:
    - Demonstrating the standard implementation in the project through different use-cases.
    - Suggesting some corrections/additions to the standard.
    - Suggesting a new (or a new version of a) standard.

Of course, modern research projects don't always follow this kind of "linear" development process. But the presented organization can easily be adapted to "agile" methods, where several "iterations" are performed.

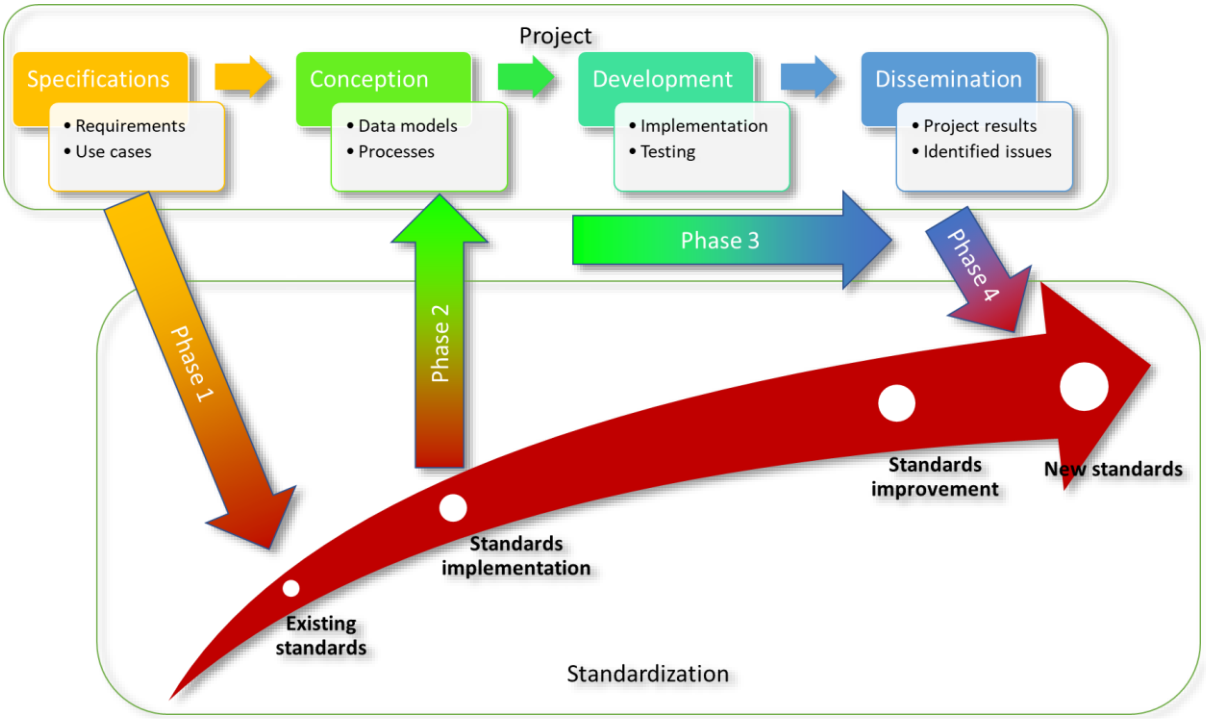


Figure 1 - Link between project and standards

Figure 2 - BIM-SPEED Use Case on UCMC Figure 3 - Detailed description of the Use Case on UCM|1} - Link between project and standards

Additionally, depending on the scope and type of project, all standardization phases may not be equally developed. But all projects should at least make sure they identify existing or under-development standards and use them when it corresponds to their needs and development strategy.

1.3 Methodology and organization

To be efficient, the "contribution to standardization" process should involve as many partners as possible. It starts with the requirement and specification tasks that will express the needs of the project. For each need, existing or under development, standards will be identified and studied. Then, during the implementation phase, technical work packages choose to use (completely or partially) some standards, or only use some interesting concepts to develop their own components. Finally, when the results of the project can be demonstrated, it offers the opportunity to provide feedback (presentations, questions, problems, new developments) to corresponding standardization committees.

Task 5.1 has been organized around 3 types of actions:

- All along the project, standardization survey.
- Participation in standardization committees' meetings.
- Project Standardization workshops (general with all partners, or specific on selected aspects).

Standardization survey aims at:

- Systematically looking for existing standards in relation to the different subjects addressed in BIM-SPEED project.
- Gathering information about these identified standards.
- Looking for the evolution of the standards on a regular base (at least annually).

During the project's lifetime, this survey was done:

- During the first year of the project, on the base of the requirements of the different work packages.
- Along the project, each time a new subject or project direction was initiated.
- During the last part of the project, a systematic update about all identified standards has been done, in order to fill this deliverable with up-to-date information.

Standardization committees' meetings participation aims at:

- Keeping in touch with standards technical evolution and orientation
- Knowing experts developing the standards
- Sharing questions/ideas / outcomes relative to BIM-SPEED project.

As coordinator of task 5.1, CSTB participate to some standardization committees' meetings, for example:

- buildingSMART International Technical Summit Spring 21
- buildingSMART International Virtual Summit Autumn 21
- LDAC2020 - 8th Linked Data in Architecture and Construction Workshop (17-19 June 2020)
- LDAC2021 / CIB W78 - 9th Linked Data in Architecture and Construction Workshop (11 - 13 October 2021)
- Several AFNOR/PPBIM (French committee mirroring CEN/TC 442 and ISO/TC 59/SC 13) committee meetings about BIM standards: ISO 23386/87 (data dictionary/product data template), ISO 19650 series, ISO 16739 (IFC),...

Standardization Workshops aim at:

- Defining the role of the different partners in the task (roles can evolve during the project).
- Identifying the standards & standardization committees of interest for the project
- Identifying the partners best suited for the collaboration with the different committees.
- Identifying the potentially standardisable outcomes.
- Defining the potential contribution strategies.

A general BIM-SPEED standardization workshop was held on September the 3rd 2021, with a representative of all partners contributing to the task: TUD, DMO, CARTIF, HTV, CYPE, MOW, ACE, REHVA, FIEC and EBC. After a presentation of the standardization strategy and the aim of the workshop, the meeting started with a round table presentation of each partner's standardization interests and knowledge

and then went on with brainstorming sessions about the most interesting standards/committees for the BIM-SPEED project, and the first identification of projects outcomes that could be promoted to standardization.
The main outcomes of this workshop are summarized in the two following tables:

- First table lists the involvement or interest of project partner in some specific standards or standardization committee.
- Second table gives a first list of identified BIM-Project outcomes that could be interesting for standardization.

Table 1: Standardization involvement

Partner	Standard / Committee	Interest / Involvement
TUB	bSI Use Case Management database	Very important for the project Opportunity to write a handbook about BIM-SPEED contribution
TUB	bSI Energy Performance Analysis WG	Opportunity to develop an MVD dedicated to renovation
TUB	bSI	Possible development of a standard for facility management
DMO	NEN (German standardization committees)	Involved in 3 specific standards: • 2660: Rules for information modelling of the built environment. • 2767: Condition assessment-built environment • 8026: Value driven property management
DMO	IDM	Putting in place a specific group for BIM-Based renovation
DMO	bSI Building Room	Willing to join the room, at international and national levels
TUB, CARTIF, DEMO, MOW, HTV, UNIVPM, STRESS, KREAN, Metabuild, UNStudio, PB40	bSI Use Case generation	Involved in the creation of BIM-SPEED bSI Use Cases published on the bSI buildingSmart website
HTV	ENCORD (European Network of Construction Companies for Research and Development)	Get needs and requirement of other actors and share feedback from the project.
EBC	Construction 2050 alliance	Share experience with other actors.
EBC	SBS (Small Business Standards)	Share standardization experience with SMI's experts

CYPE	bSI Building Room / IFC	BIM to BEM and Energy simulation
CSTB	bSI / IFC	Follow the development of the standard Involved in the test of latest versions
CSTB	ISO 23386 / 23387 / 12006-3	Contributed to the development of the standard (Through French BIM standardization committee "AFNOR PPBIM")
CSTB	LDAC (Linked-Data in Architecture and Construction)	Participation to annual conferences. Use and development of BIM ontologies

Table 2: Standardizable outcomes

Project outcome	Standard / Committee	Potential standardization strategy
BIM-SPEED Ontologies	LDAC	Presentation of the ontologies to Linked Building Data community
BIM-SPEED Ontologies	IFC / SAREF / BOT / BPO	Develop the mapping between BIM-SPEED ontologies and existing ontologies
BIM-SPEED Ontologies	Sister project	Share experience with other European projects.
Use Cases	bSI UCM	Publish ontologies and disseminate about it

We had planned to have a second standardization workshop during summer of 2022, but we finally realize it would be more efficient to have direct discussions with selected partners about their specific standardization actions and subjects. We run these dedicated actions during August and September 2022, so that we have the most up-to-date information for deliverable D5.1.

2. Cooperation with standardization phases

2.1 Phase 1 – From requirement to standards

The main objective of this first phase is to identify the "standardization needs" of the BIM-SPEED project. By analyzing the requirements and the use cases, partners identify their needs and try to map them with existing standards. This work is commonly done simultaneously in different Work packages of the project.

In this part of the deliverable, a presentation of these identified standards was made "as exhaustive as possible", and their corresponding standardization committees. For the major one, we filled in a specific table template that contains all the important information. These tables should be useful to all partners or even other projects to help identifying the best-adapted standard for a specific need.

2.1.1 Identified standards

For a better structuration of the document, we tried to group standards into different categories, corresponding to the general process of the BIM-SPEED project.

BIM Modelling of existing buildings

- **Creation of the BIM model:** Creation of the BIM model currently involves a mostly manual reverse engineering process consisting of reconstructing the model in a CAD tool, and matching it with the collected data. Some tools are emerging to help automating parts of this process, for example by proposing an automatic conversion from point clouds to BIM model ("points-to-BIM", "scan-to-BIM", "mesh-to-BIM").
- **IDM, MVD, level of information need:** the use of the IFC standard (ISO 16739-1:2018) is expected to ensure interoperability between CAD and other tools in an open environment. Current Information Delivery Manuals (IDM) and Model View Definitions (MVD) developed by buildingSMART international mostly focus on newly constructed buildings. It would be very interesting to develop IDM and MVD targeting existing buildings and renovation projects. For example, they should include a clear distinction between existing elements and design elements. The notion of Level of Development (LoD), combining the Level of Geometry and Level of information, which is part of IDM, is essential for defining the information requirements for an as-built model, as it conditions the methods to be used for data acquisition and BIM model creation. It recently evolved into the concept of the level of information need, developed by CEN/TC442/WG2 (EN 17412-1:2020) and brought to ISO/TC 59/SC 13 (ISO/DIS 7817) and introduced in ISO 19650-1:2018 clause 11.2.

Table 3 - IFC description

Standard name	IFC
Full name	Industry Foundation Classes
Version	4.0.2.1 (Version 4.0 - Addendum 2 - Technical Corrigendum 1)
Status	ISO 16739-1:2018
Documentation	https://standards.buildingsmart.org/IFC/RELEASE/IFC4/ADD2_TC1/HTML/
Ontology	https://standards.buildingsmart.org/IFC/DEV/IFC4/ADD2/OWL/index.html
Formats	Express, XSD, RDF, TTL
Description	The Industry Foundation Classes, IFC, are an open international standard for Building Information Model (BIM) data that are exchanged and shared among software applications used by the various participants in the construction or facility management industry sector. The standard includes definitions that cover data required for buildings over their life cycle. This release, and upcoming releases, extend the scope to include data definitions for infrastructure assets over their life cycle as well.
Maturity	• Widely used for building design and construction phases • Starting to be used in building operation and maintenance phase, and also in deconstruction phase.
Competitors	• Non BIM standards: Revit file format
Use for the project	• IFC model will be used when possible, for interoperability between components of the project. • A part of IFC ontology is used to describe the building structure in the data model.
Limitations	• Building element implementation details are not very well described
Potential improvements	• Better description of building element implementation details. • Ease IFC to BEM conversion.
Committees	buildingSMART International (Table 12), CEN/TC 442, ISO/TC 59/SC 13

Standard name	ISO/DIS 7817
Full name	Level Of Information Need (LOIN)
Status	ISO/DIS 7817 – Under development (Stage: 40.93).
Description	Specifies concepts and principles to establish a methodology for specifying level of information need and information deliveries in a consistent way when using building information modelling (BIM). The level of information need provides methods for describing information to be exchanged according to exchange information requirements. The exchange information requirements specify the wanted information exchange. The result of this process is an information delivery.
Maturity	Still under development, but already used in ISO 19650 series
Use for the project	For each step of a renovation project, define more precisely to right level of information.
Committees	ISO/TC 59/SC 13

Libraries of products

Use of libraries of products or generic objects is expected to streamline the process of BIM modeling in its different dimensions: geometrical information and objects properties.

They could be used with several approaches:

- Libraries intending to exhaustively reference products used in the existing buildings, at a given scale: geographical area, manufacturer's catalogue, or specific product types (e.g.: windows). Existing libraries focus mainly on current solutions and manufacturers' catalogues. The development of general scope libraries of objects found in existing buildings is likely to be time-consuming, and to require a collaboration of numerous stakeholders, both public and private, calling for the use of adequate standards.
- Dedicated libraries developed for a specific purpose and with a restricted scope (e.g.: in the design phase of a building renovation project, or to reference all the products present in the buildings of one identified owner).
- Just as what was said about BIM modelling of existing buildings, the development of libraries of objects or products to be used in renovation projects is expected to optimize the design process.

The standards identified here are those connected to libraries and dictionaries (ISO 23386:2020 for data dictionaries and ISO 23387:2020 / ISO 12006-3:2022 for product data and catalogues).

Besides standardization issues, there is a strong need for common initiatives to collaboratively create and share such libraries.

Table 4 - ISO 23386 description

Standard name	**ISO 23386**
Full name	Building information modelling and other digital processes used in construction — Methodology to describe, author and maintain properties in interconnected data dictionaries
Version	ISO 23386:2020
Status	Publish – Stage 60.60
Formats	Document
Description	This document establishes the rules for defining properties used in construction and a methodology for authoring and maintaining them, for a confident and seamless digital share among stakeholders following a BIM process. Regarding the definition of properties and groups of properties, this document provides: • definitions of properties and groups of properties as a list of attributes; • definitions of all the provided attributes. Regarding the authoring and maintaining process, this document provides: definitions and roles of applicants; • definitions and roles of experts and the commission of experts; • definitions of request's attributes; • definitions of expert's attributes; • requirements to establish the management rules to interconnect data dictionaries through the mapping process for properties and groups of properties. To apply the methodology of this document, it is presupposed that the following are in place:

	• an established governance model for a data dictionary; • a framework for a network of data dictionaries. It is not in the scope of this document to provide the content of the interconnected data dictionaries.
Maturity	Publish only 2 years ago, but very much expected. It is one of the most important layers in the construction of a real BIM environment.
Competitors	• Proprietary format use by BIM Object distribution platforms
Use for the project	• Creation of the reference dictionary containing all the properties needed by BIM-SPEED Object Library
Limitations	• Few complete implementations available so far
Potential improvements	• None so far
Committees	CEN/TC 442, ISO/TC 59/SC 13

Table 5 - ISO 23387 description

Standard name	**ISO 23387**
Full name	Building information modelling (BIM) — Data templates for construction objects used in the life cycle of built assets — Concepts and principles
Version	ISO 23387:2020
Status	Published, but being revised → Will be replaced by ISO/AWI 23387 to adapt to ISO 12006-3 new release
Formats	Document
Description	This document sets out the principles and structure for data templates for construction objects. It is developed to support digital processes using machine-readable formats using a standard data structure to exchange information about any type of construction object, e.g. product, system, assembly, space, building etc., used in the inception, brief, design, production, operation and demolition of facilities. This document provides the specification of a taxonomy model that defines concepts from ISO 12006-3:2007, i.e. objects, collections and relationships between them, to support the information need for the specific purpose of the data template. This document provides an EXPRESS specification with extensions of the EXPRESS-G notation and specification from ISO 12006-3:2007. These extensions have been provided to support market needs developed since the publication of ISO 12006-3 in 2007. This document provides the rules for linking between data templates and IFC classes within a data dictionary based on ISO 12006-3:2007. This document provides the rules for linking between data templates and classification systems within a data dictionary based on ISO 12006-3:2007. The target audience of this document is software developers and not construction industry domain experts appointed to create data templates based on sources describing information needs.
Maturity	Not very good. Published but already to be replaced. However, it is very important standard.
Competitors	• Proprietary format use by BIM Object distribution platforms
Use for the project	• Data templates for the Object Library
Limitations	• Very few implementations and testing

Potential improvements	• Adapt to new version of ISO 12006-3
Committees	CEN/TC 442, ISO/TC 59/SC 13

Table 6 - ISO 12006-3 description

Standard name	**ISO 12006-3**
Full name	Building construction — Organization of information about construction works — Part 3: Framework for object-oriented information
Version	ISO 12006-3:2022
Status	Published – Stage 60.60
Description	This document specifies a language-independent information model which can be used for the development of dictionaries used to store or provide information about construction works. The model is extended by instantiating content, such as further objects and their relationships, allowing the content to serve as an ontology, taxonomy, meronomy, lexicon and thesaurus. NOTE 1 Lexicons are resources for comprising lexical entries for a given language NOTE 2 Meronomies are type of hierarchies which deals with part-whole relationships NOTE 3 Ontologies are formal, explicit specification of a shared conceptualization. It enables classification systems, information models, object models, data templates and process models to be cross-referenced from within a common framework. This document provides the description of an API allowing the interconnection of data dictionaries as described in ISO 23386.
Maturity	• An update over an already very mature standard. It is the base for many others.
Competitors	• Proprietary format use by BIM Object distribution platforms or BIM CAD software vendors.
Use for the project	• Base for Object Library
Committees	CEN/TC 442, ISO/TC 59/SC 13

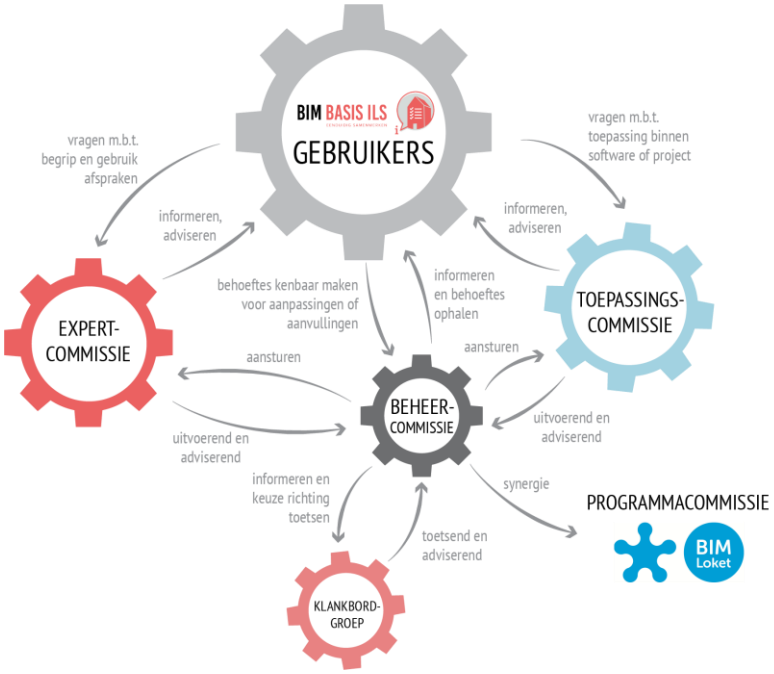
As-built BIM Passport of the existing building stock

The development of a format for an As-built BIM passport for existing residential building stock is one of the key outcomes of the project, developed in task 2.4. This development implies to define data categories, but also quality categories for the available data so that meta-information about the actuality, completeness, and usability of data can be tracked using the passport.

The development of the as-built BIM Passport draws from several existing works:

- The revised EPBD directive (2018/844/EU), which introduced the option for Member States to develop Building Renovation Passports (BRP).
- NL/fsb Joint Working Committee from Netherlands.
- Objects classification developed in IFC format by bSI.
- Standards classification codes (like Omniclass, Uniclass, ...)
- ISO 19650 for BIM process and data governance.

Standard name	NL/SfB
Full name	"Nederland de standaard voor het classificeren van elementen, materialen en detailleringen in de bouw". The abbreviation SfB comes from the Swedish committee Samarbetskommittén för Byggnadsfragor. Loosely translated into Dutch, this means the Joint Working Committee for Construction Problems. The NL-SfB is a so-called semantic standard. This means that definitions are established. It is a classification of (construction) elements. This BIM standard is used in several countries.
Version	NL/SfB update 2021 - addition of mills
Status	Active
Documentation	https://www.bimloket.nl/p/714/Documentatie https://www.bimloket.nl/p/715/Tabellen
Ontology	https://www.bimloket.nl//documents/NL-SfB_Tabel_0-4_Update-V202112.xlsx
Formats	Database
Description	NL/SfB is a classification of building components and installations (called 'elements'). This standard is widely used in the construction and installation industry when designing, realizing and managing buildings. NL/SfB has been used for many years to encode layers and objects in BIM and CAD systems and to organize information from suppliers of construction products. The coding is also used in (NEN) standards for, among other things, construction cost estimates and condition measurement of buildings and installations. NL/SFB IN THE DIGITAL WORLD After the introduction of CAD drawing in the 1980s, the NL/SfB classification has frequently served as the basis for the layering of 2D CAD. With the introduction of BIM, the application of the NL/SfB classification has only increased. Objects in BIM models are coded almost as standard in accordance with the four-digit NL/SfB element coding. This allows users to filter and sort object information in BIM models (or information models in general). For this purpose, the NL/SfB coding is prescribed in, among others, the RBS (Rijksvastgoedbedrijf BIM Standard) and market initiatives such as the BIM Basic ILS and the ILS Design & Engineering. Numerous companies set up object libraries/information systems on the basis of the NL/SfB.
Maturity	The NL/SfB is based on the international version (CI/SfB) but has changes and extensions specifically included in the NL/SfB. The Netherlands and Belgium are the only countries that still use the SfB classification method, whereby Belgium uses a literal translation of the CI/SfB. In 1996 UK said goodbye to CI/SfB and replaced it with UniClass.
Use for the project	• LCC information to be added to BIM model.
Limitations	The coding does not cover material specifications
Potential improvements	IFC-NL/SfB mapping
Committees	Since 2015, the BIM Loket has had a license from the CIB (Conseil International du Bâtiment) to distribute the NL/SfB classification standard in the Netherlands. On June 11, 2018, the CIB transferred the intellectual property of the NL/SfB, which put the NL/SfB under full management at the BIM Loket.

	This gives the BIM Loket the opportunity to actively manage NL/SfB according to its own standards, based on the BOMOS guidelines for open standards. In other words, open, transparent, with sufficient influence from users and easily accessible. The management of the NL/SfB is carried out on behalf of the BIM Loket by Keten Standaard Bouw & Techniek. More info here. 

Dynamic data acquisition and connection with BIM Model

Of interest for the BIMSPEED project are the works focusing on the link between dynamic data and BIM models.

The SAREF Ontology (Smart Appliances REFerence ontology), published by TNO, and its variant for building SAREF4BLDG, provides a shared model of consensus that facilitates the matching of existing assets (standards/protocols/data models/etc.) in the smart appliances' domain. It defines classes and properties related to how to represent devices in models of building spaces.

Table 7 - SAREF description

Standard name	SAREF
Full name	Smart Applications REFerence Ontology, and extensions
Version	V3.1.1
Status	Published
Documentation	https://saref.etsi.org/core/v3.1.1/
Ontology	https://saref.etsi.org/core/v3.1.1/saref.ttl
Formats	JSON-LD, N3, N-Triples, RDF/XML, Tutle

Description	The Smart Applications REFerence (SAREF) ontology is a shared model of consensus that facilitates the matching of existing assets in the smart applications domain. SAREF explicitly specifies recurring core concepts in the smart applications domain, the main relationships between these concepts, and axioms to constrain the usage of these concepts and relationships. SAREF has been created based on the following fundamental principles: Reuse and alignment of concepts and relationships that are defined in existing assets Modularity to allow separation and recombination of different parts of the ontology depending on specific needs Extensibility to allow further growth of the ontology Maintainability to facilitate the process of identifying and correcting defects, accommodate new requirements, and cope with changes in (parts of) SAREF
Maturity	Widely used
Competitors	SSN-SOSA Ontology
Use for the project	Base for SAREF4BLD

Table 8 : SAREF4BLDG description

Standard name	**SAREF4BLDG**
Full name	SAREF extension for building
Version	V1.1.2
Status	Published (2020-04-13)
Documentation	https://saref.etsi.org/saref4bldg/v1.1.2/
Ontology	https://saref.etsi.org/saref4bldg/v1.1.2/saref4bldg.ttl
Formats	JSON-LD, N3, N-Triples, RDF/XML, Tutle
Description	SAREF4BLDG is an extension of the SAREF ontology [1] that was created based on the Industry Foundation Classes (IFC) standard for building information. It should be noted that not the whole standard has been transformed since it exceeds the scope of this extension, which is limited to devices and appliances within the building domain. SAREF4BLDG is meant to enable the (currently missing) interoperability among various actors (architects, engineers, consultants, contractors, and product component manufacturers, among others) and applications managing building information involved in the different phases of the building life cycle (Planning and Design, Construction, Commissioning, Operation, Retrofitting/Refurbishment/Reconfiguration, and Demolition/Recycling). By using SAREF4BLDG, smart appliances from manufacturers that support the IFC data model will easily communicate with each other. Towards this aim, SAREF4BLDG should be used to annotate (or generate) neutral device descriptions to be shared among various stakeholders.
Use for the project	Could be used for dynamic data acquisition connected with a BIM Model.

Design and modelling of renovation scenarios

The design and modelling phase involves modelling one or several renovation scenarios in a CAD tool, taking the existing building model as a starting point. Several aspects can contribute to the improvement of this process:

- Import of BIM models in CAD tools: The use of Open BIM standards such as IFC allows the renovation designer to import the BIM model of the existing building in any CAD Tool, independently of the one that has been used for creating the model. Some improvement is still required in the capabilities of different CAD tools to export and import IFC files without information losses.
- Libraries of objects or products to be used in renovation projects (see part dedicated to Object Libraries).
- Data about products integration into existing buildings: For the purpose of renovation projects, the data templates and libraries should include any useful information on the technical ability to integrate the objects/products to existing buildings (e.g. technical modalities, recommendations, subjects of caution).
- Generative design, automatic solutions prescription, artificial intelligence: Finally, the development of such libraries could also foster the development of generative design solutions for renovation. On the base of performance objectives defined by the owner and designer, such tools are able to propose different renovation solutions adapted to the buildings, with possible use of artificial intelligence algorithms, and to help easily model the renovation scenario, making use of the libraries. For this purpose, products data should then include precise information about implementation modes, environmental and energy performance, or cost, in a standardized way allowing the data to be interpretable by machines.

In order to build accurate renovation scenarios, it is very important to provide and external context to the existing building. Two specific services were developed in this scope:

- GIS (Geographic Information System) surrounding service to recover geographical information directly around the building. This GIS Data Provider service uses standard WFS Protocol and return result into de-facto standard Shape files.
- Weather service to recover weather data at a certain period at the location of the building. It is based on the Mereen[1] service, which provides weather data from SYNOP and METAR weather reports from various source that archive these reports defined by WMO (www.wmo.int). The main provider of these data is NOAA (https://www.ncdc.noaa.gov/cdo-web/datasets).

Renovation-oriented BIM ontologies

Task 2.2 of the project addresses the creation of ontologies for existing buildings by defining parametric families for building materials, components, and HVAC equipment.

Several existing ontologies can be considered for these developments, the most recognized one being the Building Product Ontology (BPO) and the Building Topology Ontology (BOT).

[1] https://mereen.dimn-cstb.fr/doc/en

Standard name	BOT
Full name	Building Topology Ontology
Version	Public Draft
Status	Published on W3C
Documentation	https://w3c-lbd-cg.github.io/bot/
Ontology	http://www.w3id.org/bot/bot.ttl
Formats	Turtle
Description	The Building Topology Ontology (BOT) is a minimal OWL DL [owl2-primer] ontology for defining relationships between the sub-components of a building. It was suggested as an extensible baseline for use along with more domain specific ontologies following general W3C principles of encouraging reuse and keeping the schema no more complex than necessary.
Maturity	Commonly accepted as a reference ontology
Competitors	IFCOWL
Use for the project	Share concepts with Reno-Inst and BIM-Reno ontologies
Committees	Linked Building Data Community Group (LBD)

Standard name	BPO
Full name	BPO: Building Product Ontology
Version	V1.2
Status	Release (04.11.2019)
Documentation	https://www.projekt-scope.de/ontologies/bpo/
Ontology	https://www.projekt-scope.de/ontologies/bpo/archive/1-2/bpo.ttl
Formats	JSON-LD, RDF/XML, N Triples, TTL
Description	The Building Product Ontology defines concepts to describe (building) products in a schematic way. It provides methods to describe assembly structures and component interconnections, and attach properties to any component without restricting their types, as is often the case in template-driven product descriptions. To allow the description of complex properties, it also contains terms for unordered, two-dimensional lists.
Maturity	Commonly accepted as a reference ontology
Competitors	IFCOWL
Use for the project	Share concepts with Reni-Inst ontology
Committees	Linked Building Data Community Group (LBD)

Collaborative design process

While the previous paragraph mainly talks about tools and techniques, improving the design process in BIM-based renovation projects also requires addressing the process, and to see how it should be adapted for these projects.

Task 5.4 of the project deals with BIM-based procurement, collaboration protocols and Integrated Project Delivery (IPD). It aims to assist building owners to define procurement strategies and BIM protocols for the design and construction teams, address BIM public procurement issues and promote the transition phase to BIM for renovation, and finally assess the relevance and practical implications of IPD for renovation projects.

All these could provide input or orientations for relevant standardization bodies and public authorities. Important aspects of BIM collaboration processes in data Governance are defined in the ISO 19650 series.

Table 9 - ISO 19650 series description

Standard name	ISO 19650 series
Full name	Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling
Version	Depends on the elements of the series
Status	Published
Formats	Document
Description	Series of 5 standards addressing the concepts and principles for information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series": • ISO 19650-1:2018: Part 1: Concepts and principles • ISO 19650-2:2018: Part 2: Delivery phase of the assets • ISO 19650-3:2020: Part 3: Operational phase of the assets • ISO 19650-4:2022: Part 4: Information exchange • ISO 19650-5:2020: Part 5: Security-minded approach to information
Maturity	Widely use to implement quality BIM processes
Use for the project	All BIM processes, exchange requirements, definition of level of information need, and security aspects.
Limitations	Some parts stay rather theoretical
Potential improvements	Provide some tools or document template to implement the standards.
Committees	CEN/TC 442, ISO/TC 59/SC 13

BIM to BEM and Energy Simulation

CYPE Software applications are build up Open BIM technology, meaning that, one of the main objectives of the software is being capable of exchanging information between different software programs through the use of standardized/open formats.

All CYPE Software applications exchange information through the platform BIMserver.center, which only allows to upload and exchange of information in open and standardized formats.

The standardized formats used in CYPE software applications for BIM-SPEED are the following:

- IFC: Exported IFC4.0, imported IFC 2x3 and IFC4.0. Digital channel for information exchange between software programs
- JSON: digital channel for information exchange between software programs
- EPW: digital channel for weather information exchange
- IDF: digital channel for energy plus information input

- GLTF: analogical channel for web 3D visualization and information
- XML: analogical/digital channel for energy simulation results
- PDF: analogical channel for energy results

LCA Simulation: Need for harmonization of environmental product declarations

Independently from BIM, LCA in the construction sector still faces a need of harmonization at the European and international levels. As of 2015, a study[2] identified 39 Environmental Products Declaration (EPD) programs providing product category rules globally, among which 15 addressed the building and construction sector.

In 2013, the European Commission published guidance (GPCRD) intended to supplement existing standards for LCA-based claims, so that Product Category Rules (PCR) be developed in a consistent manner. In 2014, the European Committee for Standardization published EN 15804, a core set of Product Category Rules for EPD development in the construction sector. Other standards, for example for environmental building assessment (EN 15978) were also published by this Technical Committee. In order to enhance harmonization, the main Program Operators for EPD verification in the construction sector, together with related stakeholders, created the ECO Platform association in 2018, with members from different European countries.

Non-BIM-related LCA and EPD standards:

- ISO14020-2000: Environmental labels and declarations — General principles
- ISO14025-2006: Environmental labels and declarations — Type III environmental declarations — Principles and procedures
- EN 15804-2012 + A1-2013: Sustainability of construction works. Environmental product declarations. Core rules for the product categories of construction products
- EN 15978-2011: Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method
- ISO14040-2006: Environmental management — Life cycle assessment — Principles and framework
- ISO 14044-2006: Environmental management — Life cycle assessment — Requirements and guidelines
- ISO 21931-1:2010: Sustainability in building construction — Framework for methods of assessment of the environmental performance of construction works — Part 1: Buildings

Even though those general LCA standards are not directly relevant for the BIM-SPEED project, the increasing maturity of standardization in this field allows to better define and harmonize the information required to perform an environmental LCA and opens the way for standardization in BIM-based LCA data and processes.

Interoperability between BIM and LCA calculation

LCA data is already well developed, in the frame of EPD programs. The main issue for BIM-SPEED project is to improve interoperability between BIM and LCA calculations. Importing a BIM model into an LCA tool currently involves manually matching elements and materials of the model with the objects/materials

[2] See for example: "Type III Environmental Declaration Programmes and harmonization of product category rules: status quo and practical challenges", Journal of Cleaner Production, Volume 94, 1 May 2015, pages 235-246

database used in the tool (e.g. materialsDB.org, EDIBATEC, INIES base). The main benefit of using BIM is to automatically generate the list of elements/materials and the corresponding quantities. This manual matching is time consuming and raises reliability issues.

The process could be improved by:

- Harmonizing BIM objects data templates and LCA databases so that the information can be easily linked.
- Improving LCA tools to tend towards: i) automatic matching between BIM model elements and LCA databases, or ii) integration of LCA data into BIM models using proper data templates.

The "EPD 4 BIM" standard has just been released by ISO (ISO 22057:2022) and will offer a very good background to improve BIM to LCA evaluation process.

Table 10 - ISO 22057 description

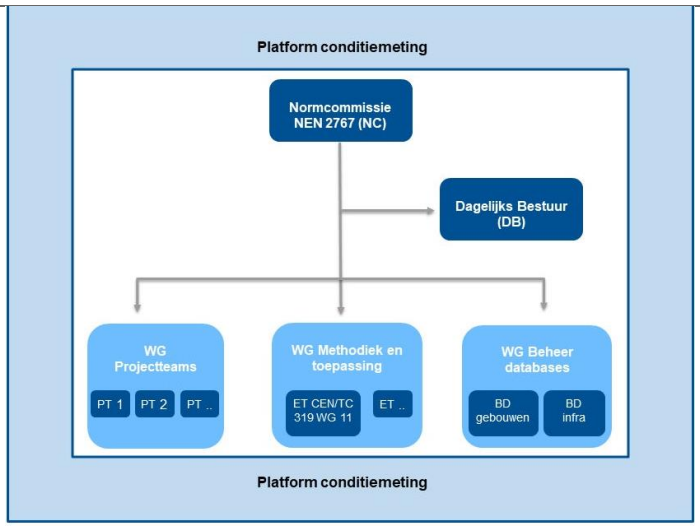
Standard name	ISO 22057
Full name	Sustainability in buildings and civil engineering works — Data templates for the use of environmental product declarations (EPDs) for construction products in building information modelling (BIM)
Version	ISO 22057:2022
Status	Published – Stage 60.60
Documentation	https://www.iso.org/standard/72463.html
Description	This document provides the principles and requirements to enable environmental and technical data provided in EPDs for construction products and services, construction elements and integrated technical systems to be used in BIM to assist in the assessment of the environmental performance of a construction works over its life cycle. This document gives requirements on structuring EPD information using a data template according to ISO 23386 and ISO 23387, to make EPD data machine-interpretable and to enable their integration into information-driven design, construction, use and end-of-life stages. This document is applicable to structuring generic LCA data for use within a BIM environment, as these data are required in the absence of suitable EPD data to enable assessment of the environmental performance at the construction works level.
Maturity	Just published
Competitors	IFC property set template and LCA property sets
Use for the project	Structure and define LCA data to be included in BIM models
Committees	CEN/TC 442, ISO/TC 59/SC 13

Cost Analysis

Task 7.3-*BIM-based Lifecycle Cost and Asset Management* of the BIM-SPEED project focuses on Life Cycle Cost (LCC) analysis of the selected energy retrofit solutions (T7.1-*Multi-criteria decision-making of renovation strategies* and T7.2-*Renovation design using building and HVAC components in BIM Libraries*), in accordance with ISO 15686-5:2017 and the Code of Practice suggested by SETAC "Environmental Life Cycle Costing". Netherland NEN 2767 was used for the development of BIM-Based LCC (D7.4) in

order to include information about the materials. The results, according to the outputs of T2.3, will estimate all the costs born during the timeframe, namely all the operative (e.g. raw materials, energy, etc.) and the investment (e.g. equipment) costs.

Standard name	NEN 2767
Full name	NEN 2767 Conditiemetingen (NEN 2767 Condition measurements)
Version	NEN 2767 consists of the following parts: • NEN 2767-1: Condition measurement built environment - Part 1: Methodology • NEN 2767-2: Condition measurement of construction and installation parts – Lists of defects (buildings) • NEN 2767-4 web application: Condition measurement of construction and installation parts – Infra deficiencies • NPR 4768: Condition Measurement – Definitions and Pictures of Decomposition and Defects Infra
Status	Active
Documentation	https://www.nen.nl/bouw/beheer-en-onderhoud/conditiemeting
Description	NEN 2767 is the standard for condition measurement. NEN 2767 is the instrument for objective and uniform measurement of the physical quality of construction and installation parts of buildings and/or infrastructure. Objectives NEN 2767 NEN 2767 has the following objectives: • creates uniformity in the condition score per building part by means of a value that expresses the technical condition of the building part. This value is a combination of the severity, extent and intensity of a deficiency; • brings insight and unity into the types of defects based on the defect parameters severity, size and intensity; • classifies the defects found and can provide support in prioritizing: ranking the need for repair of the defects found; is a tool for testing, steering and implementation for organizational units that focus on management and maintenance.
Maturity	Widely being used in the Netherlands
Use for the project	Material information for LCC analysis
Committees	The development and updating of the content of NEN 2767 is done by various parties associated with this subject, such as housing corporations, consultancy firms and governments. All these organizations participate in the so-called Condition Measurement Standards Committee and the Condition Measurement Platform.



Demonstration Use Cases

During project implementation, it was agreed with Building Smart International that its use case database will be used to document and communicate about BIM-SPEED Use Cases. This process is based on ISO 29481-1: 2016 (Building information models — Information delivery manual) and it ensures a common language and a uniform understanding of BIM applications (use cases) within the entire construction and real estate industry. This is a great opportunity for the project to standardize and share one of its most valuable achievements.

Table 11 - ISO 29481-1 (IDM) description

Standard name	ISO 29481-1
Full name	Building information models — Information delivery manual
Version	ISO 29481-1:2016
Status	Published, but being Reviewed – Stage 90.93
Description	ISO 29481-1:2016 specifies: • a methodology that links the business processes undertaken during the construction of built facilities with the specification of information that is required by these processes, and • a way to map and describe the information processes across the life cycle of construction works. ISO 29481-1:2016 is intended to facilitate interoperability between software applications used during all stages of the life cycle of construction works, including briefing, design, documentation, construction, operation and maintenance, and demolition. It promotes digital collaboration between actors in the construction process and provides a basis for accurate, reliable, repeatable and high-quality information exchange.
Maturity	• Very mature, developed and used by buildingSMART International
Use for the project	• Detailed standard description of the project's Use Cases.
Limitations	• Can be complex to use.
Potential improvements	• Provide some assistance tools
Committees	CEN/TC 442, ISO/TC 59/SC 13

2.1.2 Identified committees

For each committee responsible for an identified standard, a template table has been filled in to describe it as precisely as possible, in particular with the following fields:

- Membership: How can we become a member of this committee?
- Contribution strategy: How would we contribute to this committee
- Contributing partners: Which partners are already involved or plan to get involved, and what are their (actual or future) contributions

Table 12 - bSI description

Standardization committee	buildingSMART International
Type	BIM Pre-standardization
Standards	IFC (Table 3), IDM, MVD, BCF, bSDD.
Web site	https://www.buildingsmart.org/
Description	buildingSMART is the worldwide industry body driving the digital transformation of the built asset industry. buildingSMART is committed to delivering improvement by the creation and adoption of open, international standards and solutions for infrastructure and buildings. buildingSMART is the community for visionaries working to transform the design, construction, operation, and maintenance of built assets. buildingSMART is an open, neutral, and international not-for-profit organization.
Dynamism / activity	• Very active on standard evolution • 2 international Summits per year, plus tens of specific meetings • Several new emerging project every year
Membership	• Membership in buildingSMART International is open to companies, government bodies, and institutions from around the world. buildingSMART International offers three levels of membership. Membership is required for those parties wishing to take an active role in the development of solutions to the user or technical requirements. bSI members have voting rights in the standards committee. • Some partners of the project are buildingSMART members: CSTB, TUB, DMO, CYPE.

Contribution strategy	• Become a member of bSI or local chapter.
	• Attend project-related Working groups or rooms meetings
	  ○ First to get information about the standards.
	  ○ Later to i) promote the use of standards in the project, ii) suggest some modification/improvement of the standards, and iii) initiate de development of new standards.

Contributing partners	• CSTB:
	  ○ Member of buildingSMART France
	  ○ Participation in several working groups
	  ○ Participation to biannual bSI Technical Summit

Table 13 - CEN/TC 442 description

Standardization committee	CEN/TC 442
Type	BIM standardization
Standards	Idem ISO/TC 59/SC 13
Web site	https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:1991542&cs=100E563A3950D53807585F6A443ACB202
Description	Standardization in the field of structured semantic life-cycle information for the built environment. The committee will develop a structured set of standards, specifications, and reports which specify methodologies to define, describe, exchange, monitor, record, and securely handle asset data, semantics, and processes with links to geospatial and other external data.
Dynamism/activity	Very dynamic in the context of fast BIM development
Membership	Through national standardization group
Contributing partners	• CSTB ○ Member of CEN/TC 442 (through AFNOR PPBIN group)

Table 14 - ISO/TC 59/SC 13 description

Standardization committee	ISO/TC 59/SC 13
Type	BIM Standardization
Standards	ISO/DIS 7817 (LOIN), ISO 12006, ISO/CD 12911, ISO 16739 (IFC), ISO 16757, ISO 19650, ISO 21597, ISO 22263, ISO/TR 23262 (GIS / BIM interoperability), ISO 23386, ISO 23387, ISO 29481 (IDM).
Web site	https://www.iso.org/committee/49180.html
Description	ISO/TC59 is responsible for standardization in the field of buildings and civil engineering works. SC 13 is charged by TC 59 to focus on international standardization of information through the whole life cycle of buildings and infrastructure across the built environment: • to enable interoperability of information; • to deliver a structured set of standards, specifications, and reports to define, describe, exchange, monitor, record, and securely handle information, semantics, and processes, with links to geospatial and other related built environment information; to enable object-related digital information exchange.
Dynamism/activity	Very dynamic in the context of fast BIM development
Membership	Through national standardization group
Contributing partners	• CSTB ○ Member of ISO/TC 59/SC 13 (through AFNOR PPBIN group)

2.1.3 Identified initiatives

Even if they are not really standardization committees, some initiatives can be very interesting to follow, and also very active on some pre-standardization works.

Table 15 – UCM description

Initiative	UCM
Full Name	Use Case Management
Type	buildingSMART International project
Web site	https://ucm.buildingsmart.org/use-case-management
Description	The Use Case Management of buildingSMART has the goal to exchange experiences from already implemented or ongoing BIM/VDC projects among experts. Thus, a best practice is generated from individual practical experiences. Use cases are not related to individual project phases but consider the entire value chain (planning/construction/operation/deconstruction). Each Use Case follows a clear objective and focuses on a specific outcome or benefit. The information requirements for the various actors are determined for each project phase. It is defined who needs what information at which point in time in which format and at which level of detail in order to achieve a specific result.
Dynamism/activity	• Standardization and publication of the Project's Use Cases • Very good visibility in the Open BIM domain
Interest for the project	• Develop a standard description of the project's Use Cases • Exchange experiences around Use Cases development
Membership	• For members of bSI or active members in a bSI Room: to start a project with the UCM, just contact bSI and get full access to the UCM Co-Creation Space for free. • Companies, associations, and institutions can purchase access to the UCM and develop your own brand inside the platform • Chapter leader or part of a buildingSMART Chapter: help develop the UCM for your region and better help support your end-users.

Table 16: ENCORD description

Initiative	ENCORD
Full Name	European Network of Construction Companies for Research & Development
Type	European network
Web site	http://www.encord.org/
Description	The European Network of Construction Companies for Research and Development (ENCORD) is a network of active members from the construction industry, represented by decision-makers and executives working on research, development, and innovation (R, D & I). ENCORD has

	20 members with head offices in 9 European countries and operations worldwide. All members are major European contractors and/or suppliers of construction material and are strongly devoted to R, D & I for increased competitiveness and growth.
Interest for the project	• Reporting development done in the project • Getting advices and needs from the construction industry

Contributing partners	• HTV:
	  ○ Regular reporting
	  ○ Contribution to a paper about the need to standardized Use Cases

2.1.4 Identified sister project

The collaboration between different European projects is not really new but it seems develop very quickly over the years. Among all the subjects, different European projects can collaborate on, standardization appears to be one of the more straight forward: share what standards the different projects are interested in and gathering their effort to have a more efficient contribution totally make sense.

In the scoop of the BIM-SPEED project, it was on the subject of BIM data model ontologies that the collaboration was initiated by the SPHERE project. This "BIM Ontology sister project focus group" was composed of SPHERE, BIM4REN, BIM4EEB and BIMSPEED.

The collaboration with the sister projects took different forms:

- Specific meetings with representatives of each project to exchange about (and compare) ontologies.
- Sharing of the ontologies between sister projects to be able to compare them
- Initiation of a "white paper" on the subject (still in preparation).
- Several "joint workshops" during international conferences, under the umbrella of ECTP[3]:
  - CIB W78-LDAC 2021 – During the session dedicated to ontologies produced in European Project.
  - The final event of BIM-SPEED project during Sustainable places 2022 Conference in Nice.

Table 17 - BIM4REN description

Sister project	**BIM4REN**
Full name	BIM-Based Tools for Fast & Efficient Renovation
Type	H2020 European project
Web site	https://bim4ren.eu/
Description	BIM4REN is a H2020 funded project involving 23 partners spread across 10 countries for a 4 year long series of developments on the topic of the exploitation of BIM potential for the energy renovation of existing buildings for the whole construction value chain
Contact partners	• CSTB
Common research topics	• BIM for renovation • Property dictionary and BIM object catalogue

[3] The European Construction, built environment and energy efficient building Technology Platform (ECTP): https://www.ectp.org/

	• BIM tools to implement renovation scenarios
Standardization collaboration opportunities	• Sister project meeting about BIM ontologies
Contribution strategy	• Common communication on developed BIM tools and ontologies

2.2 Phase 2 and 3 – Adopting and using the standards

The main objectives of these second and third phases are to adopt the identified standard by participating to standardization events (committees' meetings, domain conferences, etc.) and actually use the standards in the technical developments of the project.

By attending standardization events, partners can provide interesting inputs about standards, use cases, and future evolution to the whole consortium. And this way, developers can have support when they need it.

Table 18 - Partner participation to standardization committees

Standard / Committee	Partner	Participation strategy	Expected contribution
IFC	CSTB	Attending bi-annual bSI technical summit	Better understanding of the very last and future developments of IFC standard
ISO 23386 / 23387	CSTB	Member of the French (AFNOR) certification group (PPBIM)	Follow the evolution of the standards, for example, recent restructuration of ISO 12006-3 (on which ISO 23386 is based).
bSI Use Case database	TUB	Registered user of the database	Assist partner in the publication of Use Cases.
bSI Energy performance WG	TUB	Participation to the working group	Follow the development of energy performance analysis MVD
NEN 2660	DMO	take part in this committee	Participating in their meetings and working groups, reading their drafts, and commenting.
NEN 2767	DMO	take part in this committee	Participating in their meetings and working groups, reading their drafts, and commenting.
NEN 8026	DMO	take part in this committee	Participating in their meetings and working groups, reading their drafts, and commenting.
bSI Building Room	DMO	Willing to join the Room	Address BIM for renovation aspects
Use Case database	TUB	Management of the project Use Cases	Guide partners in the publication of their Use Cases.
ENCORD	HTV	Member of the network	Report to the network about BIM-SPEED results et outcomes.
Contruction2050 alliance	EBC	Member of the alliance	Report to the alliance about BIM-SPEED results and relay members' needs
CEN/TC 442	EBC	Member of the technical committee	Follow standards evolution et express project needs.
SBS	EBC	Member of the association	Relay SMIs standardization needs and expectations.

All along the project, in the different technical tasks, many standards that had been identified were actually used, or, in some cases, are considered as necessary for future developments. Here is the list of the most important ones:

IFC

IFC has been used in the project for interoperability purposes. In sections 5.1 and 5.2 of deliverable D5.2, we explain IFC application based on extended BIM (eBIM), dynamic BIM (dBIM) and with static and dynamic MVDs. See D5.2 [3] for more details.

ISO 23386 for data dictionaries and ISO 23387 / ISO 12006-3 for product data and catalogues:

Within the context of the WP2, when Task 2.3 started, these standards were still under development. For this reason, the BIM-SPEED library was built with concepts coming from buildingSMART standards, with LCA dataset modelled according to ISO 14040/44, and LCC dataset modelled according to ISO 15686-5. Identified future work on this subject would be to adapt this Library to the new ISO 23386/87 standards.

BPO and BOT Ontologies:

Task 2.2 of the project addresses the creation of ontologies for existing buildings by defining parametric families for building materials, components, and HVAC equipment. Three different ontologies have been developed for this task:

- Reno-Inst Ontology: An ontology for installation of components in building renovation projects.
- LCA-C Ontology: An ontology for LCA/LCC assessments in renovation projects.
- BEM-Reno Ontology: An ontology for BEM development in renovation projects.

The objective of these developments was to map as closely as possible the precise domain knowledge for each data model. This is why all three ontologies were developed from scratch, but by staying as close as possible to existing identified standards:

- EN15978, EN15804, and EN15686-5 for LCA-C Ontology
- Building Product Ontology (BPO) for Reno-Inst Ontology
- Building Topology Ontology (BOT) for Reno-Inst and BEM-Reno Ontologies
- IFC for Reno-Inst and BEM-Reno Ontologies

BIM 2 BEM and Energy Simulation:

During the development of the BIM-SPEED project, several standardization actions were carried on concerning BIM 2 BEM.

One of the main challenges of the BIM-SPEED project was the interoperability between BIM modelers (CYPE Architecture, Archicad, Allplan, Revit) and Simulation Engines (such as Energy Plus). This interoperability challenge is due to the fact that, while BIM modelers work with solid geometries such as walls, slabs, windows, doors, etc. simulation engines work with simplified models that are composed by external

surfaces, internal surfaces, edges, etc. The difficulty relies on transforming complex solid geometries in simplified models for simulation.

Even though past attempts carried out during several years were made by CYPE to automatically transform a BIM Model (in IFC open format) to analytical models for simulation, the results obtained for automation were not as good as expected even though improvements on the code where maid during several years. Under CYPE's perspective, one of the main issues was the difficulty to use IFC format directly as an input of simulation engines to exchange information valuable for simulation and to write under this standard an analytical model definition.

During BIM-SPEED project, CYPE addressed once again this interoperability challenge but from a different perspective. During the project development, Open BIM Analytical model was developed. The idea for this program is to be able of reading any IFC file (must contain spaces) and transform it into an analytical model in JSON, which can easily be used as an input in any simulation engine. The algorithm automatically transform the architectural model into an analytical model once improved, but the main idea for the program is to give the users capability of correcting manually the automatically generated model in case that is necessary.

Open BIM Analytical model is a tool that allows creating of complete analytical models from scratch, allowing to correct any error that might be existing during the transformation of an architectural model to an analytical model.

LCC:

NL/SfB was used for the development of BIM-Based LCC (see D7.4 [5]). The IFC file was enriched based on the followings to provide for a systematics classification:

- NLSfB_element_code
- NLSfB_component_code
- NLSfB_decomposition_description

NEN2767was used for the development of BIM-Based LCC (D7.4 [5]) in order to include information about the materials. The ifc file was enriched based on the followings to provide for a systematics classification:

- NEN2767_material_code
- NEN2767_material_description

UCM:

During BIM-SPEED project lifecycle, 14 use cases of BIM across the EU been developed and published on buildingSMART Use Case Management platform (See D8.4 [6]).

2.3 Phase 4 – Contribution to standardization

The fourth and last phase aims to actively contribute to the standardization world. Standardization committees' processes are often very long, and it can be difficult to really bring a huge contribution during the lifetime of a European project. Nevertheless, whenever it is possible, each important

achievement of the project relative to standardization should be made public, presented, and demonstrated to standardization community. Even if these actions do not produce immediate and concrete changes in standards and standardization committees, they are very important for the long-term evolution of standardization.

The most significant contributions to standardization actions are listed in this part.

2.3.1 Publication of standard Use Cases

The Use Case Management Service of buildingSMART international enables the capture, specification, and exchange of best practices and makes them accessible to the entire built asset industry. Throughout the entire process of design, construction, and operation, the information exchange requirement must be defined for each BIM Use Case. Based on the Information Delivery Manual (IDM) methodology developed by buildingSMART, the operational processes and, as a result, the information exchange requirements are described. The exact definition of the information flow between the respective project participants enables collaborative work and the efficient and error-free exchange of data.

This initiative from buildingSMART International offers a great opportunity not only to produce a very detailed and robust description of BIM-SPEED Use Cases but also to share it with other potential users and projects.

As shown in Figure 2 - BIM-SPEED Use Case on UCM

Figure 2, 14 Use Case have been published and shared on UCM (https://ucm.buildingsmart.org/use-

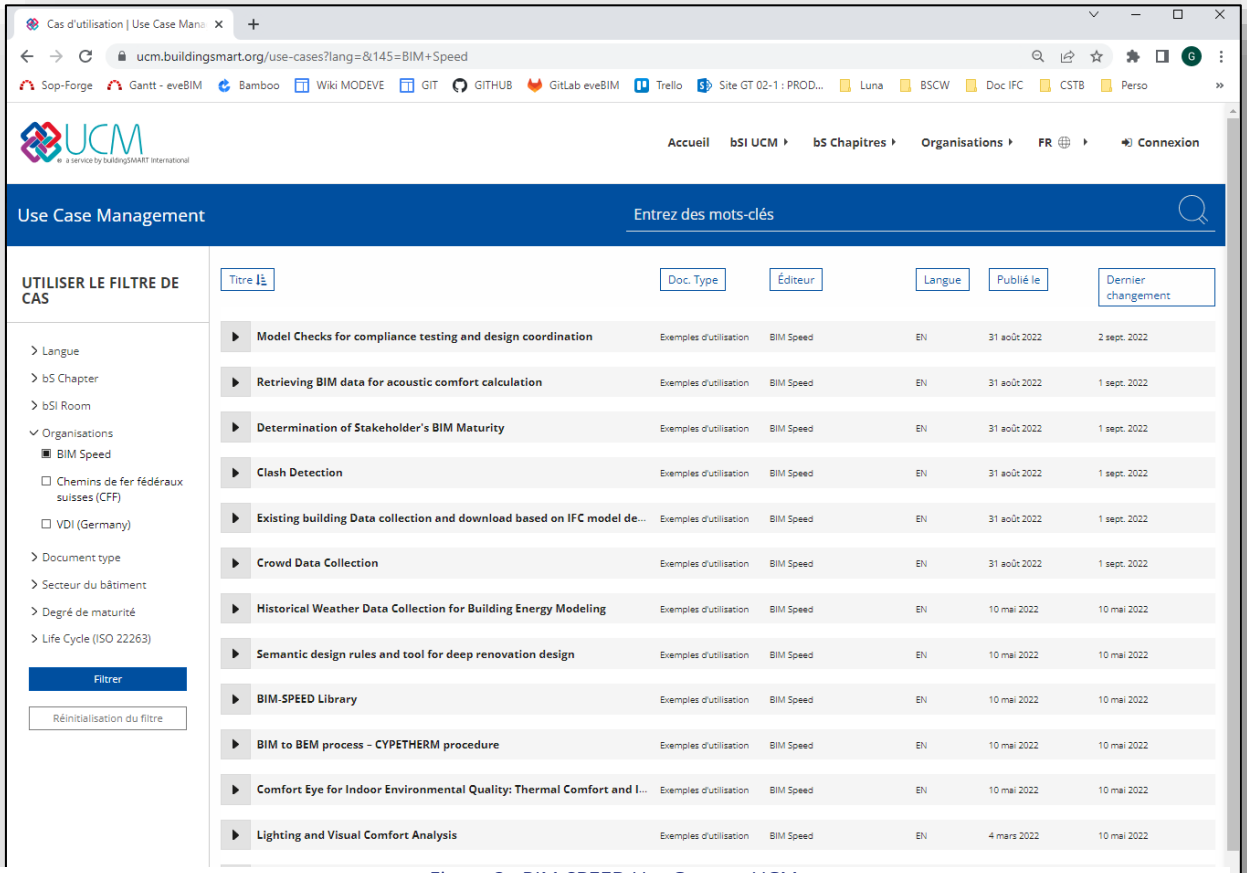


Figure 2 - BIM-SPEED Use Case on UCM

Figure 2 - BIM-SPEED Use Case on UCM

cases?lang=&173=BIM+Speed). See project deliverable D8.1 [6] for more details.

Each Use Case benefits from a complete description, based on IDM standards.

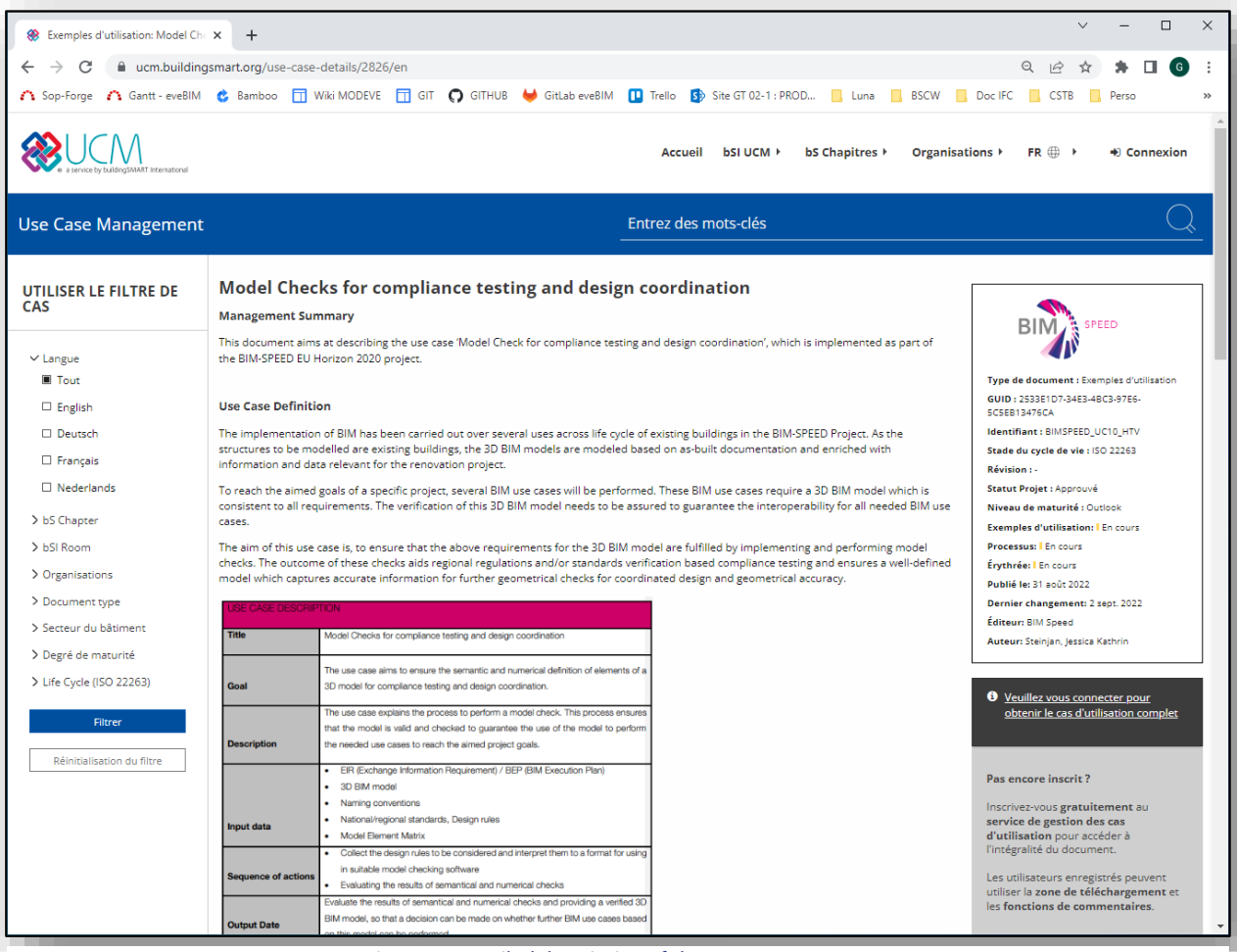


Figure 3 - Detailed description of the Use Case on UCM

2.3.2 ENCORD

The European Network of Construction Companies for Research and Development (ENCORD) is a network of active members from the construction industry, represented by decision-makers and executives working on research, development and innovation (R,D&I).

ENCORD's main objective is to be Europe's forum for the promotion of industry-led research, development and innovation in the construction sector, acting as:

- A network to exchange best practice experience, discuss strategies for the development of the construction sector and develop new ideas for research.
- An instrument to communicate directly and indirectly with the EU administration and the European research community.

During BIM-SPEED project lifetime, HTV partners, involved in this network, have reported about BIM-SPEED on a regular basis:

- in general, ENCORD is interested in every research aspect in the construction industry. Therefore, HTV has provided an overview from time to time.

- Currently, ENCORD is working on a paper about the need for standardizing use cases to speed up the preparation of projects and to optimize construction in general.

2.3.3 BIM-SPEED Ontologies

The development of project-focused data model ontologies is a very interesting subject with respect to standardization. While the immediate needs of the project often lead to very specific and pragmatic choices, it is very important to at least initiate the longer-term vision of what these developments could bring to the community.

This was typically the case for task 2.2-*BIM Family ontologies for materials, components, HVAC equipment* of BIM-SPEED project. The aim of this task was to create a very focused data model in order to map the knowledge of the domain according to the practitioners. But even if the 3 ontologies ([2], [3]) were created "from scratch", the standardization aspect was considered:

- First by identifying the existing ontologies carrying similar concepts. Even if it was out of the scope of the task, this would allow defining a mapping between BIM-SPEED Ontologies and existing ones. This would bring a very interesting contribution to existing standards.
- Then by sharing BIM-SPEED ontologies with other European projects in a "BIM Ontologies sister projects focus group". This initiative should lead to the common writing of a white paper on the subject.
- And finally, by presenting the work done in important domain conferences
    - CIB W78-LDAC 2021 – During the session dedicated to ontologies produced in European Project.
    - The final event of BIM-SPEED project was during Sustainable places 2022 Conference in Nice.

3. Recommendations

As a conclusion to this report, we found it useful to give some recommendations. First about the general management of standardization actions during a European project, and then more specifically about the standards that, from our point of view, should be considered to implement an efficient BIM-based EEB renovation project.

3.1 Efficient standardization during European Projects

Performing an efficient and well-structured contribution to standardization during a European Project can be quite challenging, and often make it difficult to find a common direction to follow. The main difficulties come from:

- The very large number of subjects, technologies, and areas covered by the project
- The very slow standardization development process can be incompatible with project timing
- The large number of different types of actors involved in the project.

But standardization is essential to the collaboration between construction stakeholders, and we believe that some quite simple actions can make it more efficient:

- Do not try to address all standardization aspects covered by the project at the same time. It is way more efficient to prioritise subjects, starting with the ones that should bring the most valuable standardization contribution.
- The duration of a European project being between 3 and 4 years, it would be very difficult to develop entirely a new standard and push him to standardization (unless the standardization process can be carried on by some partners after the project, or by another project). This is why we should focus on the identification and use of existing standards, and also the dissemination of the use of the standard that was made during the project.
- Try to involve as many partners as possible
    - Diversity of standardization approaches is often very constructive
    - SME participation in standardization should be ensured for these standards to be adapted to SME needs and widely used
- Organize dedicated workshops, really focused on standardization. It is often much more efficient than a standardization timeslot in a general project meeting.
- Try to create / animate standardization communities
    - With sister projects sharing some common standardization needs or goals.
    - By organizing joint workshops (dedicated sessions) in domain conferences.
    - Try to periodically reconsider some under-development standards. For example, in this project, LOIN (Level of Information Need) and ISO 23386/87 / 12006-3 (Data Dictionaries and Data Templates) were not mature at the beginning of the project. But they are now and it is worth saying that they are very interesting for our subjects and that they should be actively considered in future projects.

3.2 Important standards for EEB Renovation projects

Finally, from what we've learned during this project, here is a list of what we think are the most important standards for BIM-based EEB Renovation projects:

- To ensure the best overall Interoperability between software and platforms, IFC format should be used, at least as an exchange format, but also been considered as a central model (IFC ontology version).
- This central model can be extended for BIM to BEM or numerical analysis needs, by using existing ontologies (BOT, BPO, ...) or by developing new dedicated ontologies.
- Standardizing the technical information and product properties in the BIM has always been a weak link. Now that the needed standards have been developed, we should absolutely start using them to develop all product libraries:
    - ISO 23386 for structuration and management of data dictionaries
    - ISO 23387 and ISO 12006-3 for data templates and product catalogues
- Data templates specifics for LCA have been standardized in ISO 22057, which has just been released and should be very useful for future projects.
- ISO 19650 series can be very useful for the global management of BIM processes:
    - ISO 19650-1:2018: Part 1: Concepts and principles
    - ISO 19650-2:2018: Part 2: Delivery phase of the assets
    - ISO 19650-3:2020: Part 3: Operational phase of the assets
    - ISO 19650-4:2022: Part 4: Information exchange
    - ISO 19650-5:2020: Part 5: Security-minded approach to information
    - A part 6 on Health and Safety is under development.
- One very important concept introduced in ISO 19650 has been further developed into ISO ISO/DIS 7817: Level of information need (LOIN), which suggests a methodology to define the right level of information needed by each specific phase of a BIM project.
- Finally, it appears very useful to consider buildingSMART Use Cases Management (UCM) platform for all projects related to BIM. First to see if the use cases we consider using in our project had not been already standardized (huge time saving), and then to publish new use cases specifically developed for our project.

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