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## BIMReL: a new BIM object library using Construction Product Regulation attributes (CPR 350/11; ZA annex)

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# BIMReL: a new BIM object library using Construction Product Regulation attributes (CPR 350/11; ZA annex)

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**Abstract.** The digitalisation of construction sector introduces opportunities for all the actors of AEC chain. Using the virtualisation of real entities, with models of buildings, infrastructures or of the environment (BIM: Building Information Model), it could be possible to simulate the sustainability of new property developments or renewal ones (capex/opex; BS PAS 1192-2-3 [1] [2]). With the object-oriented programming, the new ICT tools for AEC sector can rework on the data themselves, with the classes and attributes they have “learned”. At the beginning, the typology of classes and attributes were defined in BIM authoring software. To complete all the information required for every different use, the actors can find other attributes (of objects) they may need in other database existing on the market. These extended attributes could be linked to the BIM authoring objects to complete their functionality in all phases of the construction process. Thus, all the attributes of each object are now defined by the software houses, by public or private organisations (and their BIM tools) or by every single manufacturer company. However, there isn't an international standard other than the Italian UNI 11337-3:2015 [3]. To improve this status quo, increase the implementation of sustainability simulation and life cycling data management in AEC process, it is necessary to define a new specific technical standard of BIM object attributes. BIMReL is the first BIM object library that uses the common information structure and the essential characteristics for CE mark of CPR 350/2011 (Construction Product Regulation) [4], to define the attributes of the virtual objects like the real products. The architecture of BIMReL is based on the data structure of newly released Italian standard UNI 11337-3 (2019) and, as a consequence, part of the EN draft standard at European CEN 442 Technical Committee (WG 4).

## 1. State of the art

In computer-aided design (CAD) ontology we define the domain of graphic representation through geometry: vectors, surfaces and volumes. The goal of CAD software is to support the operator in the representation (graphics) of any reality: mechanics, construction, etc. The specific nature of the represented geometries is an attribute external to the CAD classes and not "understandable" by the software.

With the introduction of BIM (building information modelling) we can identify a new ontology whose domain is expressed by the reality of constructive entities: walls, windows, boilers, etc. The BIM classes do not describe geometries but real entities through "geometric attributes". A BIM class describes real entities of the real estate and construction sector through geometric and non-geometric attributes as well as with rules and topological relations[5][6].



BIM classes and objects are still predominantly covered by graphical, object-oriented software: BIM authoring software (Revit, Allplan, Archicad, Microstation, Tekla, Edificius, etc.). For this reason, the geometric attributes of a class still have an important prevalence compared to non-geometric ones in the definition of BIM objects of AEC industry (architecture, engineering and construction).

As already happened with the CAD blocks, the market immediately showed the need of specific BIM objects libraries. These include, for example: a public library such as the NBL (national BIM library) of the UK public administration, a commercial library such as BIMObject, and a commercial CAD / BIM library such as Trace Parts (born as a library of mechanical CAD blocks and now more and more a general BIM library).

Today's BIM objects are more complex than the old CAD blocks. While the CAD block is only a graphical representation of reality, the BIM object wants to simulate it, through the attributes (and methods) of its class. This paves the way for two different scenarios. On the one hand these "BIM" classes belong to an ontology defined specifically for graphic BIM software. These graphic BIM tools are designed more for the design phase than for construction and maintenance ones, as well as more concerned with the management of building components than of the buildings as a whole. Thus, the attributes of the BIM authoring software classes are often insufficient to address the needs of all the phases of the building process. On the other hand, BIM objects simulate both systems (more or less complex) that are "built" on site and finished products that are "installed" as they are on site.

Therefore, in buildings we have two types of BIM objects:

1. BIM objects that simulate a "system" (walls, floors, roofs, etc.), whose attributes are modified according to the place of production and they concern, in fact, a non-serial production (production in site).
2. BIM objects that, instead, simulate an "industrial product" (doors, windows, boilers, etc.), whose attributes are defined upstream of the site, in a factory and they concern a serial production.

The current BIM object libraries address both these types of digital objects in the same way. In addition to the specific attributes of the various BIM authoring tools, they add a series of additional standard attributes useful to complete the information for the various actors and phases but without considering the different features of the "system" or "product" which characterize them. As a result, commercial libraries of BIM objects often perform poorly.

Can be underlined three main points related to the attributes of the BIM objects included in the common libraries:

1. Common libraries structures are affected by the definition of the attributes proposed by the classes of the various BIM authoring tools.
2. They must add attributes to complete every possible use or required information without having a reference standard.
3. They do not differentiate additional attributes depending on the nature of objects in: "systems" or "products".

In this scenario, in order to limit these uncertainties, Italy has published a specific standard, starting from the definition of the non-geometric attributes of construction products, the standard UNI 11337-3: 2015 [3]. These attributes are independent from BIM authoring software, completing every necessary need. The structure of this data set is based on the construction products regulation CPR 305/2011 [4]. So as to have, as a reference, a standard recognised throughout the European market. The structure identified by Italy in 2015 currently represents the basis of the future Community standard under discussion at CEN, as well as the basis of the BIM digital object platform of the BIMReL project. In fact, BIMReL represents the first BIM object library based on the CE marking attributes.

## **2. Public and Commercial BIM Library**

On the web there are several BIM libraries. However, very few of these libraries are public. Some of them adopted a BIM approach starting from old CAD Libraries, such as Traceparts (BIM&Co [7]). Other libraries are new in the market and they usually started directly from BIM technology, like the biggest commercial one: "BIMObject" [8], and the most famous public one: UK "National BIM Library" [9]. For all of them the core market is the graphic 3D object. Thus, it represents the new service for the

new "BIM" customers and for the old CAD customers (to introduce them in the new market). Also, all BIM Libraries have an (informative) attributes section, usually linked to the graphic 3D object. In BIM methodology (starting from UK PAS 1192-2:2013 [1]) the non-graphic and non-geometrical attributes are usually defined like "informative" attributes (e.g. alphanumeric, data, etc.).

So, in the BIM scale of service measurement: LOD, Level of Development/Definition, is both a graphic/geometrical scale of attribute: LOG, Level of Geometry, and a non-graphic/non-geometrical scale of attribute: LOI, Level of Information.

The best known scale of LOD is the USA one "BIM Forum Specification" [10] (LOG, "Element geometry"; LOI, "Attribute information"). However, the BIM library usually uses a proprietary data structure and attributes set.

### 2.1. UK NBL, National BIM Library, Attribute Structure

The NBL "National BIM Library" is the public library of UK, property of National British Standard (NBS). It uses the standard attributes structure originated from PAS 1192-2:2013, which it's tools of.

So, it divides data in "Information" (LOI) and "Geometry" (LOG<sup>1</sup>) requirements. Citing the standard, it is possible to identify the concept of both information requirements and geometry requirements (Figure 1).

#### Information requirements:

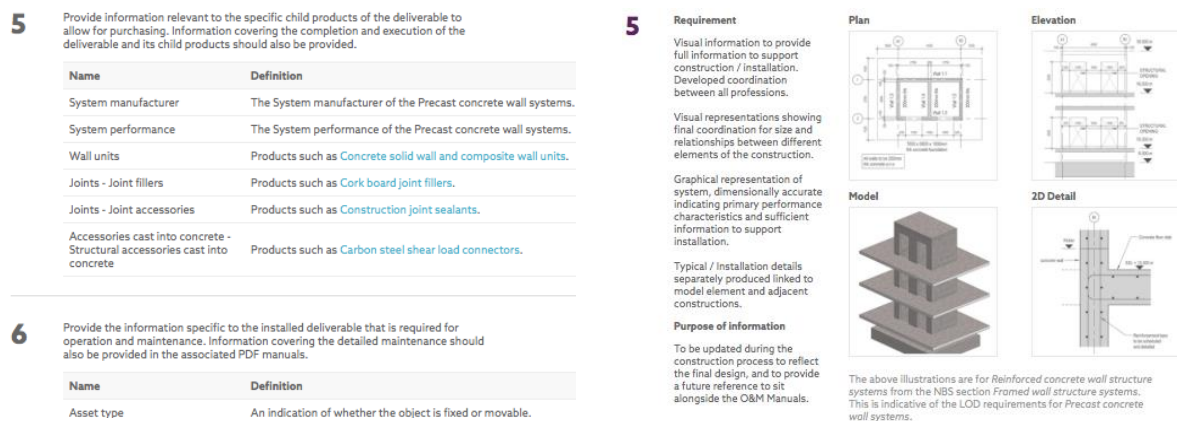
*"This section defines the requirements for the information contained within a BIM object. The scope of this section includes*

- general requirements such as property sets,
- properties and values, as well as COBie [11] and IFC [12] properties."

#### Geometry requirements:

*"The scope of this section includes general requirements such as level of geometric detail. In addition, this section defines dimensional and measurement requirements. Geometric information is divided into:*

- General geometry data.
- Shape data.
- Symbolic data.
- Surface/material data.
- Connection data."



**Figure 1.** NBL LOD attribute for BIM Object: LOD (LOG) from 1 to 6; LOI from 1 to 6.

<sup>1</sup> Note that for the British standards the international "Level of - Geometry" (LOG) is defined with the local "Level of - Detail" (LOD). So, for UK with the term "Detail" it's representing the Geometry scale of attribute

## 2.2. BIM Object, Attribute Structure

Bimobject<sup>2</sup> is the most famous and probably biggest private commercial BIM Library in the world. It's Swedish but it has local offices in other countries (USA, Europe, Asia, etc.). It uses a private standard attributes structure that originated from all the others international best practices and standards. The Library divides data in "Information" (Table 1) and "Geometry" properties but it does not define a specific LOD of Objects.

**Table 1.** Example of "Information" attribute of BIM Object Library

PROPERTY	CLASSIFICATION	LINKS	RELATED
Color - Exterior	BIMObject Category:	Product url:	Material main:
Color - Interior	IFC classification:	Installation instructions:	Material secondary:
Depth	UNSPSC name:	COBie Product Data Sheet:	Designed in:
Glazing Type	UNSPSC code:	Product certification:	Manufactured in:
Height	Uniclass 2015 Code:	Technical description:	
Method of Operation	Uniclass 2015 Description:	Instruction video:	
Thermal Break (Y/N)	NBS Reference Code:	EAN code:	
Width	NBS Reference Description:		

## 2.3. Tracepart (BIM&Co), attribute structure

Traceparts<sup>3</sup> is the most famous and probably biggest private commercial CAD (Mechanical components) library in the world. After few years from its starting time, it introduced BIM in its services to cover this new big market.

Like BIMObject it uses a private standard attributes' structure it originated from all the other international best practices and standards.

Also, it divides data in "Information" and "Geometry" properties, however it does not define specific LOD of Objects, too.

Main characteristics of Traceparts (BIM&Co) information system are:

- “each property coming from this collection has a unique identifier (The Property Code) allowing its multilingual management;
- the properties are organized by fields (thermal, acoustic, electric, etc.) for easy use and identification of properties;
- new fields and new properties can be proposed by the community;
- all IFC properties have been supported to allow objects from the platform to be inserted into a digital model to be exported correctly to IFC format;
- integration of international standards to define properties” but “it is also possible to define a set of properties for private use.”

## 3. Italian Standard UNI 11337-3 2015

The Italian Organization of Standardization: UNI, introduced BIM in the first edition of the UNI 11337 standard - part 1, in 2009<sup>4</sup>.

In 2016 UNI published a new BIM standard - UNI11337 part 3<sup>5</sup> - dedicated to define attributes of construction and MEP products for BIM uses.

The new standard was one of the results of an Italian national project (called INNOVance<sup>6</sup>) where all the construction chain actors worked to define and made the first national BIM: Platform, Library, and Project Server (CDE), in the world.

<sup>2</sup> <https://www.bimobject.com/en>

<sup>3</sup> <https://www.traceparts.com/en>

<sup>4</sup> A. Pavan, Standard coordinator

<sup>5</sup> A. Pavan, Standard relator

<sup>6</sup> A. Pavan, Project scientific coordinator

Since the beginning of the project and standard works, the first critical issue of the experts was thinking to have a standard structure of attributes over the actual different practices and standards existing worldwide.

To resolve this critical issue, the UNI and INNOVance [13] working groups chose to use the European common information structure and the essential characteristics for CE mark and the Declaration of performance of the products, according to CPR 350/2011 [4] (Construction Product Regulation).

Starting from the essential characteristics of ZA annex identified in any standard of construction product the UNI 11337-3:2015 [3] defined the structure of attributes as represented below:

- Identifying manufacturer information.
- Identifying product information.
- Technical information (Table 2):

**Table 2.** UNI 11337-3:2015 - Technical information.

Morphological and descriptive features.	Essential characteristics.
Geometry and shape.	Voluntary characteristics.
Appearance and constructive features.	Information about sustainability according to UNI EN 15804.
Dimensions.	Safety information.
Physical and chemical properties.	Packaging, movement, storage in factory and transport information.
Qualitative.	Commercial information.
Quantitative.	Additional technical information.
Tolerance.	Supplementary documents.
Main components of the product.	Attachments.
Declared performance characteristics.	Information on data reliability.

#### 4. International Standard ISO 19650 e CEN 442

The new international standard ISO 19650:2018<sup>7</sup>, in its two parts 1 and 2, introduces the concept of LOIN (Level of Information Need) upper the LOG and LOI attributes and the concept of document around them (like origin or ending of information). The ISO standard is a high-level standard and it introduces concepts more than specific guidelines. This role is entrusted to CEN, at continent level, and to UNI (or DIN, or BSI, etc.), at local level.

At European level, in the CEN technical committee 442<sup>8</sup>, the Work Group 4 (in the end of 2018) published the first draft of future standard named: "*Smart CE marking for construction products*" [14]. This standard will be a part of next European BIM standard (Figure 2).

First of all, the priority references are to the harmonized standard provisions (of Construction Product Regulation), as described in its annex ZA, to the "Declaration of Performance" (DOP) and to the EOTA information.

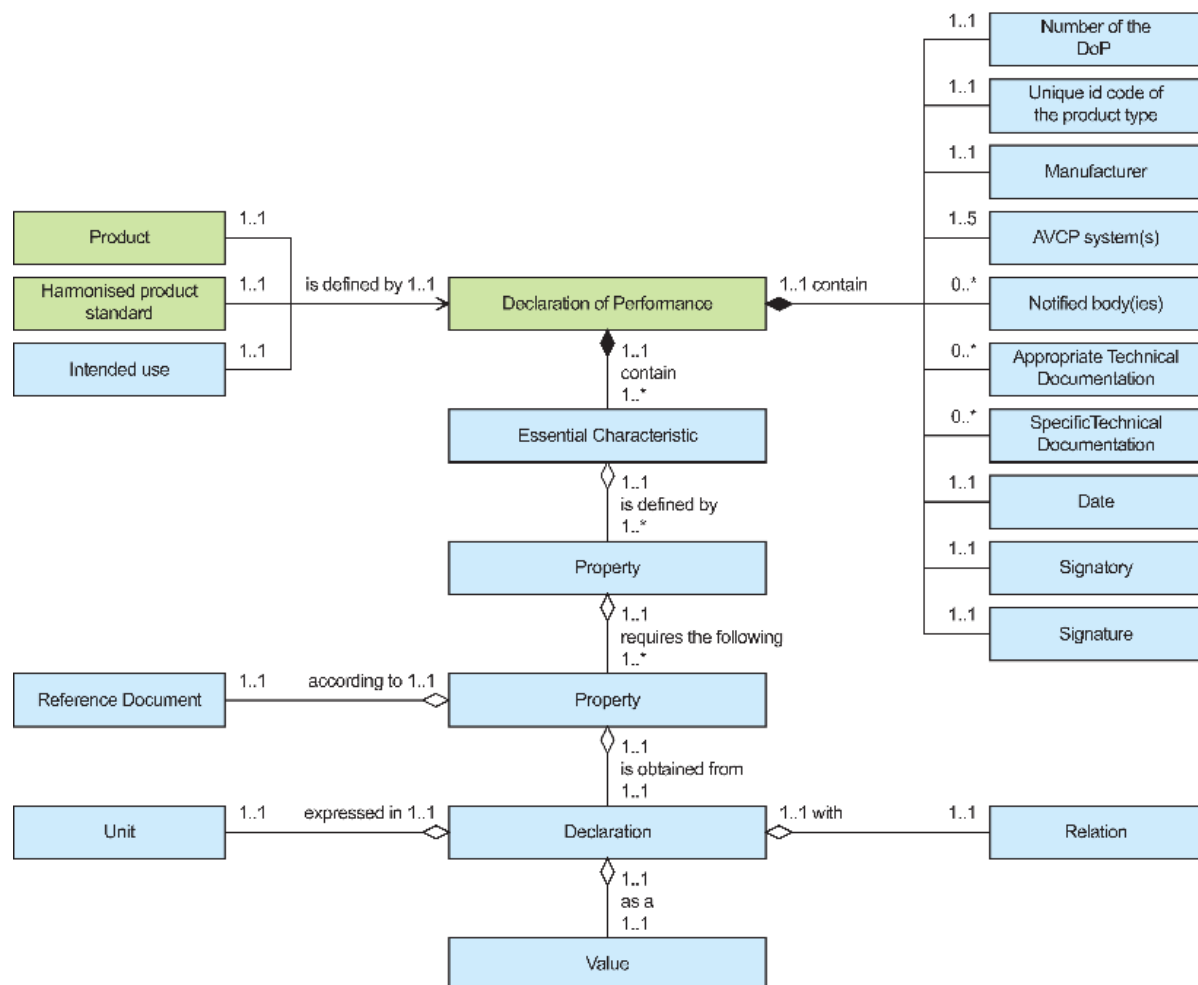
The structure of CEN attributes is represented below (Table 3):

<sup>7</sup> A. Pavan, Standard national expert

<sup>8</sup> A. Pavan, Standard national expert

**Table 3.** CEN attribute.

General information block.	Water vapor permeability.
Declared performance.	Direct airborne sound insulation.
Dimensions and dimensional tolerances.	Thermal resistance.
Configuration.	Durability against freeze/thaw.
Compressive strength.	Release of dangerous substances.
Bond strength.	Appropriate and Specific Technical Documentation.
Reaction to fire.	Signature.
Water absorption.	Additional information related to the DoP.

**Figure 2.** Smart CE marking attribute UML diagram [14].

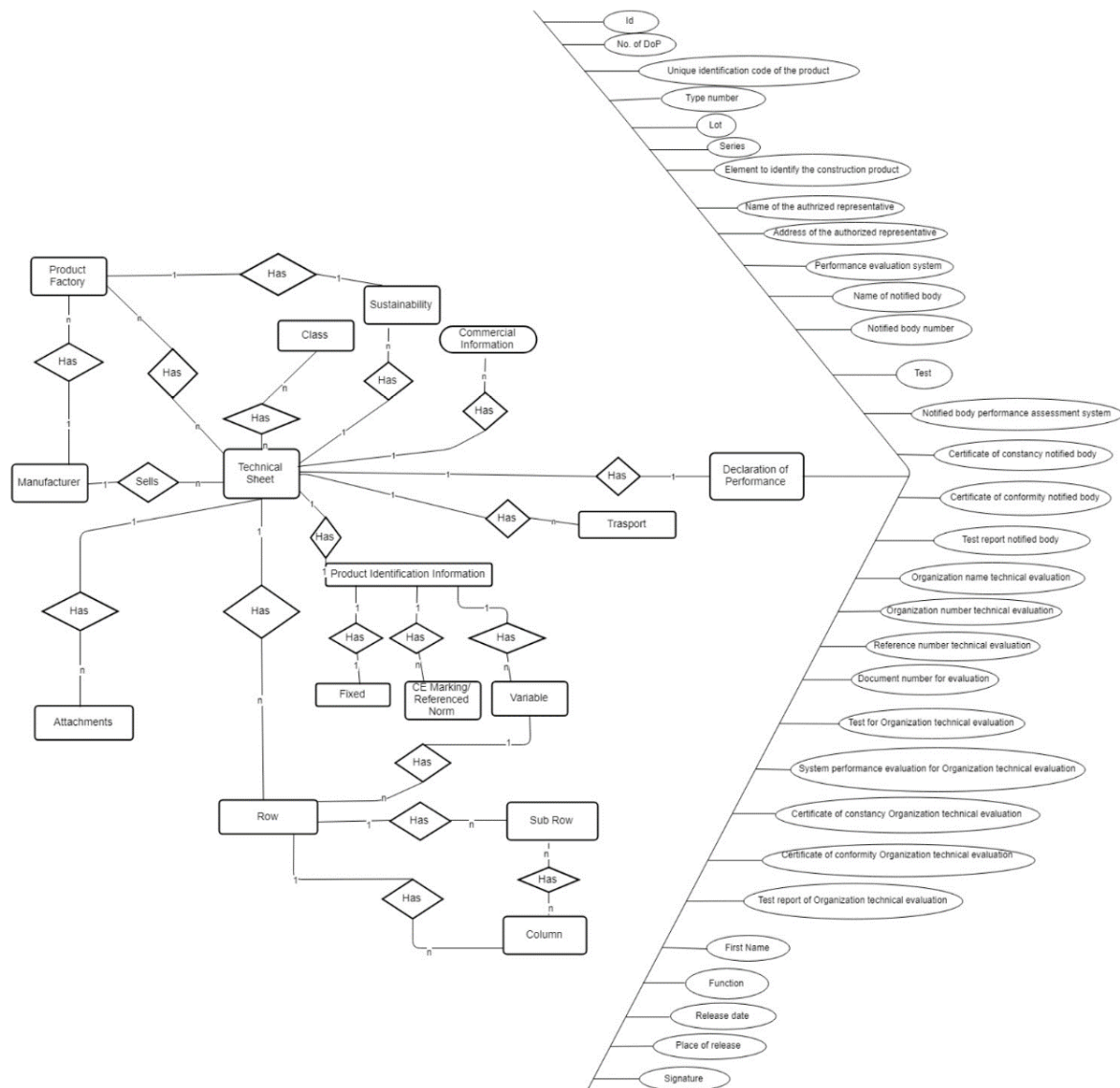
## 5. Information Structure of BIMReL Library

Due to the complex structure of the product data, it becomes necessary to represent the information in a way that can be easily understood by the users. To accomplish this purpose, the conceptual model has been developed during the system design and development phase, so that the execution of fundamental system properties can be implemented properly. Moreover, it is kept as a reference, for further improvements.

In general, a conceptual model represents 'concepts' (entities) and relationships between them. The primary objective of a conceptual model is to represent a system that is composed of concepts, to provide a way to know, understand, or simulate a subject the model represents. To facilitate the model users, the conceptual model is developed in a way that can provide an easily understandable system interpretation.

There are several ways to describe the conceptual model such as UML, ORM, Entity-Relation (ER) Diagram, etc. This work adopted the ER notation to represent the information structure of construction products for the BIMReL Library. In ER notation, the conceptual model of a construction product is described in a way where entities represent concepts, cardinality and optionality represent relationships between concepts.

In the construction industry, the manufacturers usually provide the information that represents the properties of the product through a technical sheet. They also provide the Declaration of Performance (DoP) document with the required information as presented in Figure 3.



**Figure 3.** Conceptual model of a construction product in BIMReL Library.

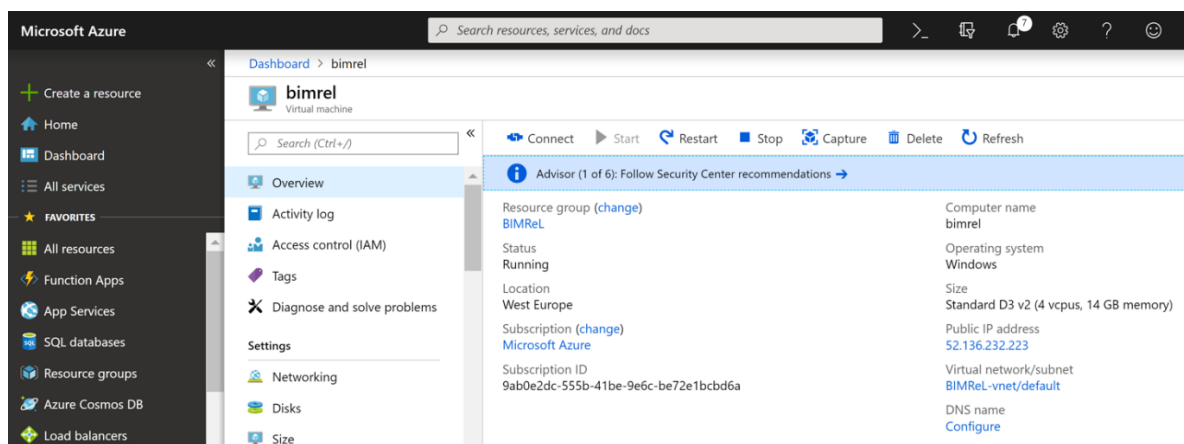
To form the system process, the relationships are combined with the entities and attributes are added to further describe the process. In Figure 3, all the entities and their relationships have been depicted, while the DoP has been represented with all the attributes to explicitly describe the process of DoP.



## 6. BIMReL Library

### 6.1. Back end

In the construction industry, involvement of stakeholders from disparate locations is needed and requires the optimization of collaboration, communication and coordination processes. Deploying systems or applications in the ‘cloud’ can enhance the project integration and collaboration. For deploying the BIMReL Library, Azure Cloud Service has been used. Azure Cloud Service is an example of Platform as a service (Figure 4), which is designed to support applications that are scalable, reliable, and inexpensive to operate. This technology has been adopted as it provides easy deployment of applications, more control on the Virtual Machines (VMs), easy to scale and more resistant to failure functionalities.



**Figure 4.** Portal of the Azure platform for BIMReL library

A SQL database for BIMReL Library has been deployed on a SQL server that has been installed on a reserved VM on the Azure Platform. This library can be remotely accessed through a provided Public IP address (as indicated in Figure 4) when the VM is in ‘run’ mode. It is also possible to ‘stop’ the VM as needed and no cost is charged for that specific period of time. The SQL database has been configured to premium service tier (i.e. 125 DTU and 250 GB of storage), that provides a reliable access to the database.

The open access base of BIMRel paves the way for future direct communication with other libraries. A structure guideline of data transaction “to and from” BIMRel will be included in the operational manual of the BIM objects DB of Lombardia region. Some data transaction tests have been carried out to and from BIM&Co Library (partner of the project under TraceParts) with great results. All the other Libraries (BIM Object, NBL, etc.) can preserve their data structure but improving their attributes and open their performances to standards only with a structured - free - connection to BIMReL.

By adopting BIM principles explicitly and having this kind of web connection to standard attributes of BIMReL, all the other Libraries could improve their services and all the construction users could have access to more information inside their favorite library.

### 6.2. Front end

For the final users, there are two ways to access to the BIMReL portal both of which are free. One access is defined to impute the products attributes and the other one is defined to get information and download (to work with) the attributes inputted before. The manufacturers could impute all attributes of their products (Figure 5) and, with them, in the same time, they can produce the declaration of performance (DOP) directly from the website.

**Figure 5.** BIMReL library page of manufacturers. Managing of product attribute

Other actors (e.g. owners, designers, constructors, etc., Figure 6) could read, use and/or download the attributes and the graphic 3D BIM object for all phases of their works or services. Standard alphanumerical attributes could live alone or linked to graphic 3D object representation. In BIMReL, any digital object (virtual product) has a different set of attributes. One for any phases of the construction and maintenance process. These set of attributes (geometric and non-geometric) are referred to the Italian scale of LOD (Level of Digital Object Development: UNI 11337-4:2017 [15]).

**Figure 6.** BIMReL library page of users. Using of product attribute.

In BIMReL, the obligatory reference to the standards has been confirmed in the scale of attributes used. Differently to all other Libraries the scale used (LOD from A to G, Figure 7 and 8) is directly referred to Italian standard UNI 11337:2017, part 4: Evolution and development of information within models, documents and objects [15] as described below.

*6.2.1. LOD A – SYMBOLIC Object.* “The entities are represented graphically by a system of geometric symbols or a representation taken as a reference without geometric constraints. The quantitative and qualitative characteristics (performance, size, shape, location, cost, etc.) are approximate.” (UNI11337-4:2017)

*6.2.2. LOD B – GENERIC Object.* “The entities are virtualized graphically as a generic geometric system or outline geometry. The quantitative and qualitative characteristics (performance, size, shape, location, orientation, cost, etc.) are approximate.” (UNI11337-4:2017)

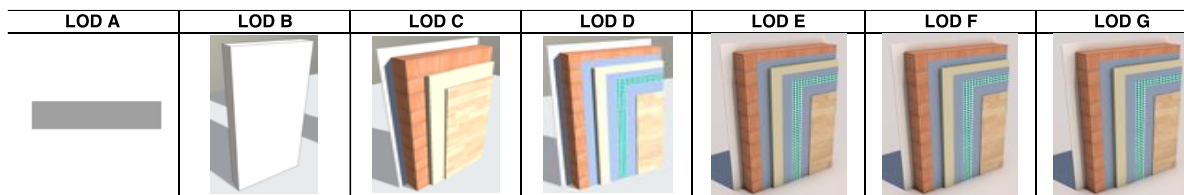
*6.2.3. LOD C – DEFINED Object.* “The entities are virtualized graphically as a defined geometric system. It defines the quantitative and qualitative characteristics (performance, size, shape, location, orientation, cost, etc.) in a generic way and in accordance with the limits of the legislation in force and the technical reference standards applicable to a range of similar entities.” (UNI11337-4:2017)

*6.2.4. LOD D – DETAILED Object.* “The entities are virtualized graphically as a detailed geometric system. The quantitative and qualitative characteristics (performance, size, shape, location, orientation, cost, etc.) are specific to a range of similar products. It defines the interface with other specific construction systems, including the approximate spaces for movement and maintenance.” (UNI11337-4:2017)

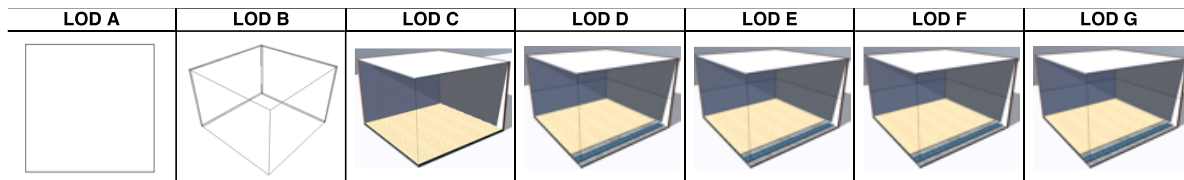
*6.2.5. LOD E – SPECIFIC Object.* “The entities are virtualized graphically as a specific geometric system. The quantitative and qualitative characteristics (performance, size, shape, location, orientation, cost, etc.) are specific to a single production system related to a defined product. It defines the details related to manufacture, assembly and installation, including the specific spaces for movement and maintenance.” (UNI11337-4:2017)

*6.2.6. LOD F – IMPLEMENTED Object.* “The objects express the virtualization verified at the specific site of the production system implemented/built (as-built). The quantitative and qualitative characteristics (size, shape, location, orientation, cost, etc.) are specific to the single production system of the laid or installed product. For each single product, it defines the management, maintenance and/or repair and replacement work to be carried out throughout the life cycle of the work.” (UNI11337-4:2017)

*6.2.7. LOD G – UPDATED Object.* “The objects express the updated virtualization of the actual state of an entity at a specific time. It is a historical representation of the passage of the useful life of a specific production system updated with respect to that which was originally implemented/built or installed. The quantitative and qualitative characteristics (size, shape, location, orientation, cost, etc.) are specific to the life cycle of a previous state. It annotates each individual (and significant) management, maintenance and/or repair and replacement work carried out over time and records the level of any degradation in progress.” (UNI11337-4:2017)



**Figure 7.** LOD example for “wall”, graphical attribute, from UNI 11337 work group.



**Figure 8.** LOD example for “room”, graphical attribute, from UNI 11337 work group.

## 7. Conclusion, explaining the discoveries of the research and its impact

There are several BIM object libraries available on the web. Although, few of them are public. They gather and manage a big quantity of objects and attributes each with a different structure. This fragmented picture does not represent the best opportunity and solution for the market players considering costs, time, quality and transparency.

BIMReL is the first BIM Library that uses the laws and technical standards to define digital object attributes and a data structure available for all the other libraries. In BIMReL, the actors of the construction sector can find a direct reference to CPR 350/2011 [4], UNI 11337-3:2015 [3], UNI 11337-4:2017 [15], UNI EN ISO 16739:2017 [12], ISO 19650:2018 [16].

Using laws and standards in any approach inside BIMReL:

- It guarantees the sector about transparency of data.
- It helps the market to reduce cost and time efforts.
- It assures the users to products quality published.

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