Scientific
Research
Publishing

Standardization of BIM Objects: Development of a Proposal for Portugal

Filipa Salvado, Maria João Falcão Silva, Paula Couto, Álvaro Vale e Azevedo

Buildings Department, LNEC, Lisbon, Portugal
Email: asalvado@lnec.pt, mjoaofalcao@lnec.pt, pcouto@lnec.pt, ava@lnec.pt

Abstract

The management of information systems contributes to the economic development of the construction sector by organizing and structuring technical and economic information. It is proposed how BIM (Building Information Modelling) and a Portuguese information system-ProNIC (abbreviation for Protocol for the Standardization of Construction Technical Information) may be interconnected. The scope of this information transmission in construction sector is a step to solve several problems that have been identified in conception of BIM models.

1. Introduction

In Portugal, the use of BIM (Building Information Modelling) methodology in the construction industry is not yet widespread [1]. However, it is unquestionable that BIM models are a reality to consider with extremely important contributions, not only for the design phase, but also for the remaining ones, contributing to the development of construction sector [2] [3]. Its implementation in the medium and long term will bring success and effectiveness to the sector, considering that it is a methodology for information and communication sharing between all stakeholders and at all phases of a building life cycle [4].

The integration of BIM models with other tools to support the construction process is important to spread their use. The existence of technical and economic structured and standardized information related to each building element is essential for supporting the designers of all engineering projects. Similarly, the use of information management systems maintains this information throughout all stages of building life cycle, improving the quality and accessibility of information and contributing to the economic development of the construction sector [5] [6]. ProNIC (Portuguese abbreviation—Protocol for Standardization of Technical Building Informa-

tion) [7] provides an important contribution with technical and economic structured and standardized information. In addition, ProNIC is already developed to work in a collaborative environment for all stakeholders.

The present communication aims to show how information management systems contribute to support the construction industry. It describes and proposes how technical and economic information about construction, existing in ProNIC, can be transferred to standard BIM objects, supporting the engineering projects and addressing the various issues that have been identified within transmission of information from the design phase to the subsequent stages of the building life cycle.

2. Construction Information Classification Systems

The Construction Information Classification Systems (CICS) have been growing and nowadays have a major role on the organization of the information that is produced by the construction sector. Since their beginning the CICS were developed to solve specific problems on the construction sector. The development of the construction brought higher complexity to design process and a bigger amount of technical information to the process. The CICS followed this development contributing to a better organization and efficiency [8].

Actually, there are some modern CICS developed internationally, that are a reference for the construction sector. Next is presented some of them, their philosophy and applicability.

Uniclass (Unified Classification for the Construction Industry) is a new classification scheme for the construction industry. It is intended for organizing library materials and for structuring product literature and project information. It incorporates both CAWS (Common Arrangement of Work Sections for building works) and EPIC (Electronic Product Information Co-operation), a new system for structuring product data and product literature. Uniclass comprises 15 tables, each of which represents a different broad facet of construction information. Each table can be used as a "stand alone" table for the classification of a particular type of information, but, in addition, terms from different tables can be combined to classify complex subjects [9] [10].

The OmniClass Construction Classification System [11] is a means of organizing and retrieving information specifically designed for the construction industry. OmniClass is useful for many applications in the area of Building Information Modeling (BIM), from organizing reports and object libraries to providing a way to roll up or drill down through data to get the information that meets your needs. OmniClass draws from other extant systems in use to form the basis of its tables wherever possible (MasterFormat for work results, UniFormat for elements, and EPIC (Electronic Product Information Cooperation) for products). OmniClass consists of 15 hierarchical tables, each of which represents a different facet of construction information. Each table can be used independently to classify a particular type of information, or entries on it can be combined with entries on other tables to classify more complex subjects.

The Industry Foundation Classes (IFC) [12] data model is intended to describe building and construction industry data. It is a platform neutral, open file format specification that is not controlled by a single vendor or group of vendors. It is an object-based file format with a data model developed by buildingSMART (formerly the International Alliance for Interoperability, IAI) to facilitate interoperability in the architecture, engineering and construction (AEC) industry, and is a commonly used collaboration format in Building information modeling (BIM) based projects. The IFC model specification is open and available. It is registered by ISO and is an official International Standard ISO 16739:2013 [13].

3. Protocol for the Standardization of Construction Technical Information in Portugal (ProNIC)

The main objective of ProNIC is to develop a CICS for the Portuguese construction, in accordance with the standards and the "know-how" about this subject.

ProNIC is a research project developed by a team of three Portuguese research, development and innovation institutes (which integrate LNEC—National Laboratory for Civil Engineering). The main purpose is to develop an information management system to support the construction industry that allows the simplification of proceedings related to contracts and make available both technical and economic information in a structured and standardized way [7] [14] in **Figure 1**.

ProNIC intends to be a system adapted to the Portuguese reality and the current practices, following the assumptions of the international standards. Given the scope of the subject, the goals are necessarily achieved through a gradual process of adaptation and transformation of information, followed by tests, corrections and validations.

SCOPE	DATABASE	USER INTERFACE	CONSTRUCTION PHASES
Building construction	Construction works items	Owner	Project
Building rehabilitation	Material details	Planning	Contract
Road infrastructures	Construction works technical details	Contractor	Construction
	Construction works economic details	Supervisor	Use
	Maintenance and Safety information	Others	Maintenance

Figure 1. ProNIC details [8].

In his base, ProNIC is a breakdown structure, commonly referred in English literature as Work Breakdown Structure (WBS). This structure may be more or less detailed in terms of associations or links established and dependent of the detailed degree desired. Contrarily to what occurs in other systems, ProNIC WBS, being the basis of all information produced, has been the object of a structured and comprehensive development in order to achieve a higher degree of detail. The task of defining the structure desegregation has been one of the main works.

The ProNIC work classification criterion presents a division by groups, subgroups and items (the construction work) assigned to a particular code (the same code is always assigned to the same construction work). An item presents the description of the construction work, which will be edited and after integrated on the Work and Quantities Statement. After the definition of an item the user can perform the measurements and the cost estimate.

Linked with the item there are files with work and material technical specifications. These files are individual and seek the principle that each type of work has a description of how it is performed (a work specification file), and files with specifications for each different used material.

ProNIC comprehend the entire construction life cycle. From above, it is verifiable that it serves first the designer and the work owner needs, mainly during the construction design and procurement. However, its structure contains features that are transversal to all the constructive process, as the work contract process (designer and contractor/sub-contractors), construction (contractor and technical supervision) and use (maintenance provisions). It is expected that, in Portugal, ProNIC will be mandatory for use in public works process.

4. Standardized Information in BIM Objects

4.1. Framework

BIM methodology presents, as main asset, the possibility of an accurate representation of the objects geometry of a construction, together with the integration of information and organized data in several dimensions [15] [16].

The constructive process starts from the owner idea of developing a project. This process gains information in different stages, information that is added to the process. The combination of documents, from drawings, images or written elements need to be defined during the design. The structural and data standardization of the attached documents has several advantages for the management of the different actors, both in terms of achievement, but also in view of a broad range of achievements that are developed by a given actors. In terms of construction sector assessment, it's possible to collect the data that will "feed" on the performance indicators [4] [6].

In this aspect, ProNIC is well developed, because it incorporates technical content and items in different documents with details about work execution, materials and costs, associated to each construction work. This information is standardized and in accordance with the engineering projects under applicable European Standard. It also includes informatics applications of different interface modules with different users allowing them to work in a collaborative environment.

These contents intend to reflect the most recent information of the European and National standards and tech-

nical applicable references. From the described, it is not difficult to understand the amount of information present in ProNIC and its articulation on the creation of a construction design. The repetition of the described procedure for all the works allows the generation of the written specification required. The work and quantities statement is another document produced as the detailed measurements and estimated budget.

4.2. Proposed Methodology

From a technological point of view it is possible, with greater or lesser difficulty, to establish a connection between BIM methodology and ProNIC with the aim to produce beneficial mutual results thus enabling time savings and improvement in quality and compatibility of the final product.

It is essential, to establish strategies and identify challenges and steps to be taken in order to proceed to the integration. A proposed methodology to realize the link between the technical contents of ProNIC and the objects of the BIM model is following presented:
1. Defining normalized procedures for the parameterization of BIM models and the type of information and level of detail in each step of construction process;
2. Implementing and defining the configuration of fundamental principles in order to obtain an evident, objective and concise information in accordance with applicable law and Portuguese reality;
3. Making correspondence between the parameterization of BIM methodology and the ProNIC classification of construction articles;
4. Associating each parameterized building BIM object with a few ProNIC articles. The engineering projects are the same in ProNIC and BIM methodology and are in accordance with the provisions of "Portaria no. 701-H/2008" (in the case of Portuguese law, transposed from the European Standards) [17];
5. Integrating the technical information available on ProNIC in each parameterized BIM object;
6. Organizing ProNIC articles associated to BIM objects with the aim to prepare the technical documents, measurement details, work quantities and budget estimates. ProNIC makes a direct connection of project information to planning and construction management modules.

4.3. Practical Example

As an illustrative example, a BIM object is presented–a window designed in appropriate software.

Associated with this BIM object, in ProNIC, there are two construction works (1.related to the frame and 2. related to the glass):
1. "Exterior window $1 $2 $3, deformation (wind resistance) class $4, pressure (wind resistance) class $5, water tightness class $6, $7, $8, $9, $10, $11, $12, air permeability class $13, $14, $15, $16 including hoops, sealants, fixations, accessories, supplies, transportation, charge, discharge and placement, according to the design detailed and technical specifications".
2. "Glass base material $1 $2 $3 $4 $5, thickness $6 [mm], $7 $8 $9 $10 $11 $12 $13 $14 $15 $16 $17 $18 including sealants, fixations, accessories, supplies, transportation, charge, discharge and placement, according to the design detailed and technical specifications".

The options, with the $ symbols represents technical specifications (**Figure 2**).

This information are in accordance with the parameters required for CE windows marking and are prescribed in European Standard (EN 13830:2003) [18], transposed to the Portuguese law.

To define a BIM object, each user must fill the technical and economic specifications according with the results of laboratory tests.

The technical and economic information available for these ProNIC items (**Figure 3**) can be used to match the corresponding BIM object.

5. Final Remarks

The ideal integration scenario, for the information system in the construction industry, is one that all actors are interconnected and work in a collaborative mode, throughout all phases of the building life cycle and all tools communicate in order to produce the desired results.

Integration of BIM models with other tools to support the construction process is essential to develop and diffuse their utilization. For this purpose, a research study is being development in LNEC for different BIM objects related to the architecture and structure projects of the building elements.
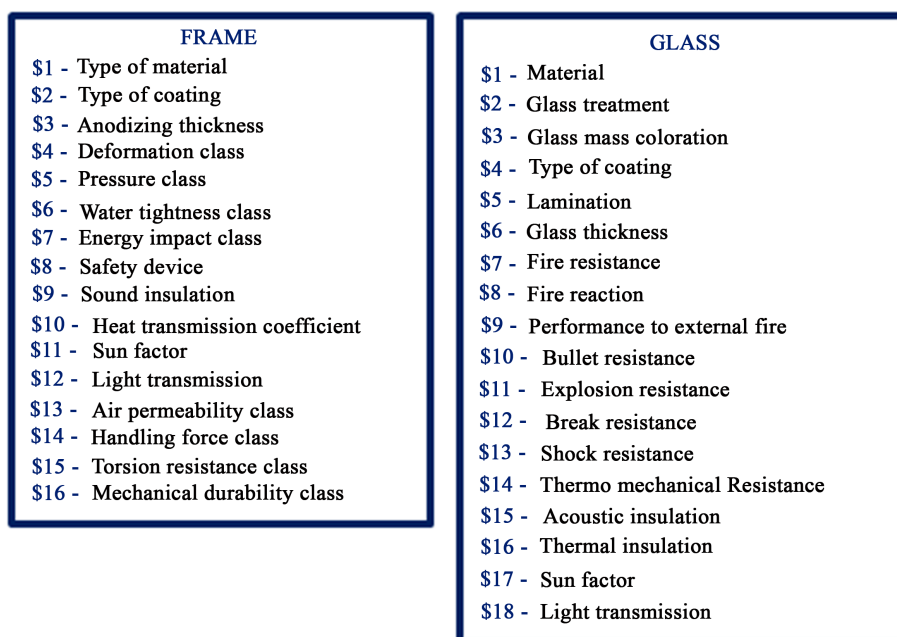
FRAME
$1 - Type of material
$2 - Type of coating
$3 - Anodizing thickness
$4 - Deformation class
$5 - Pressure class
$6 - Water tightness class
$7 - Energy impact class
$8 - Safety device
$9 - Sound insulation
$10 - Heat transmission coefficient
$11 - Sun factor
$12 - Light transmission
$13 - Air permeability class
$14 - Handling force class
$15 - Torsion resistance class
$16 - Mechanical durability class

GLASS
$1 - Material
$2 - Glass treatment
$3 - Glass mass coloration
$4 - Type of coating
$5 - Lamination
$6 - Glass thickness
$7 - Fire resistance
$8 - Fire reaction
$9 - Performance to external fire
$10 - Bullet resistance
$11 - Explosion resistance
$12 - Break resistance
$13 - Shock resistance
$14 - Thermo mechanical Resistance
$15 - Acoustic insulation
$16 - Thermal insulation
$17 - Sun factor
$18 - Light transmission

Figure 2. Type of each ProNIC technical specification for a window.

BIM OBJECT   PRONIC INFORMATION

Economic information
- Unit cost
- Resources cost
- Labor cost

Material technical information
- Material definition
- Scope
- Composition
- Characteristics and properties
- Application
- References
- Quality marking and certifications
- Manufacturing process
- Packaging receipt, storage and conservation
- Risk and safety
- Laboratory tests
- Restrictions
- Other provisions

Worktechnical information
- Work definition
- Materials
- Preparatory work
- Execution mode
- Control and acceptance
- Laboratory tests
- References
- Measuring criteria
- Risks
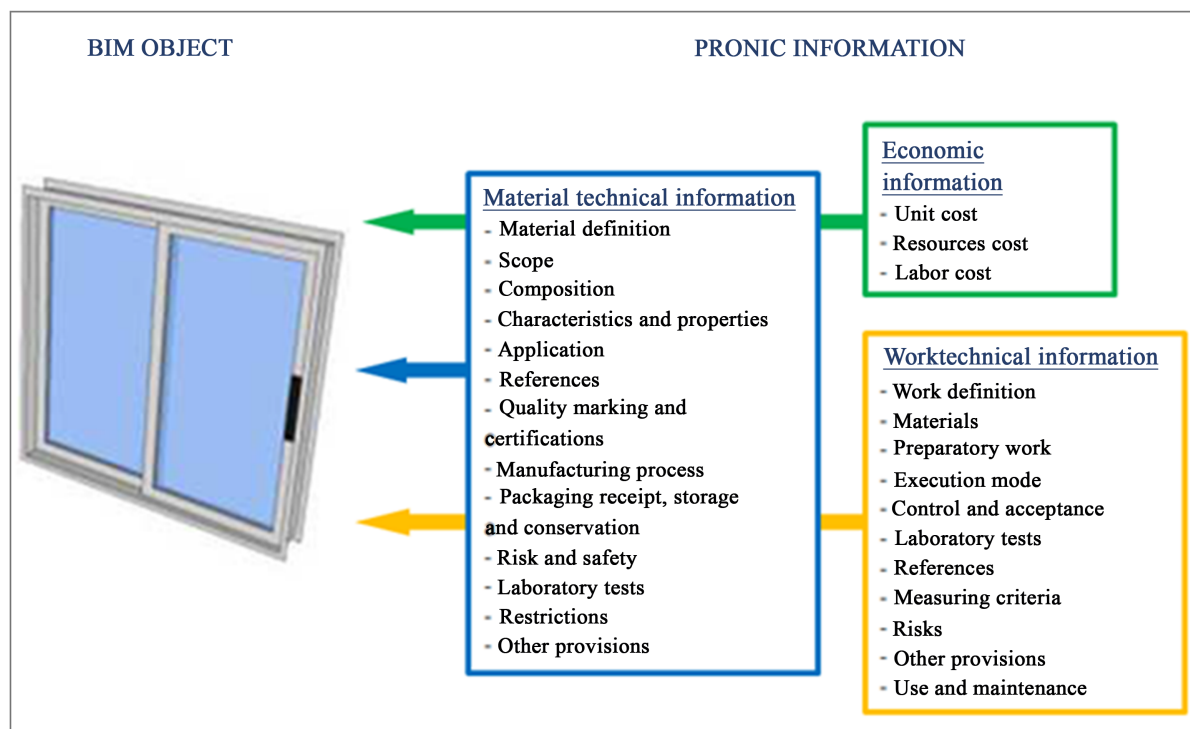- Other provisions
- Use and maintenance

Figure 3. ProNIC information to integrate a BIM object.

The example presented in this paper, though still at a preliminary stage, aims to integrate the technical and economic information already normalized for several BIM objects.

References

[1] Santos, R. and Aguiar Costa, A. (2014) BIM Development in Last Decade. *2nd BIM Internacional Conference*, Paper

EA 30, 9-10 October 2014, 123-125.

[2] Eastman, C.M. and Eastman, C. (2008) BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors. John Wiley & Sons, Hoboken, 72-73. http://dx.doi.org/10.1002/9780470261309

[3] Hollermann, S., *et al.* (2012) BIM—A Challenge for Communication between Parties Involved in Construction. *ECPPM* 2012—9*th European Conference on Product and Process Modelling*, Reykjavik, 25-27 July 2012, 833-838.

[4] Paavola, S., *et al*. (2012) BIM Technologies and Collaboration in a Life-Cycle Project. *ECPPM* 2012—9*th European Conference on Product and Process Modelling*, Reykjavik, 25-27 July 2012, 855-862.

[5] Molz, M. and Wehrle, G. (2011) More Value in 3D. *German Engineering Journal*, No. 03, 26-31.

[6] Monteiro, A. and Martins, J.P. (2012) SIGABIM: a Framework for BIM Application. *Proceedings of the XXXVIII IAHS World Congress—Visions for the Future of Housing*, Mega Cities, 16-19 April 2012, 422-428.

[7] ProNIC (Protocol for Standardization of the technical Information in Construction). http://www2.inescporto.pt/

[8] Sousa, H., Moreira, J. and Mêda, P. (2008) ProNIC and the Evolution of the Construction Information Classification Systems. GESCON.

[9] Andamp, E.A. and Häggström, L. (2016) Building Classification for BIM—Reconsidering the Framework. *Proceedings of the CIB W*078-*W*102: 2011 *Joint International Conference*, Sophia Antipolis, 26-28 October 2016. http://2011-cibw078-w102.cstb.fr/papers/Paper-20.pdf

[10] (1994) Classification of Information in the Construction Industry. Tech. Rep. 14177, ISO TC 59 SC/WG2, Oslo, International Organization for Standardization.

[11] OmniClass—A Strategy for Classifying the Built Environment. Introduction and User's Guide. Edition: 1.0.

[12] Adalsteinsson, G.O. (2014) Feasibility Study on the Application of BIM Data for Facility Management. Reykjavik University, Reykjavik.

[13] ISO 16739:2013—Industry Foundation Classes (IFC) for Data Sharing in the Construction and Facility Management Industries.

[14] (2011) ProNIC Contribution for Processes Sustainability, Universidade de Aveiro. www.centrohabitat.net/

[15] Van Nederveen, G.A. and Tolman, F.P. (1992) Modelling Multiple Views on Buildings. *Automation in Construction*, **1**, 215-224. http://dx.doi.org/10.1016/0926-5805(92)90014-B

[16] CRC Construction Innovation 2007—Adopting BIM for Facilities Management: Solutions for Managing the Sydney Opera House.

[17] Mandatory Contents of Program and Project Implementation and Standards to Adopt in the Preparation and Staging of Public Works Projects (Published by Portaria n.º 701 H/2008, de 29 de julho). Diário da República, n.º 145/2008, Série I, de 29 de julho de 2008, 5106(37)-5106(80). (In Portuguese)

[18] EN 13830:2003—Curtain Walling—Product Standard. Comité Européen de Normalisation, Brussels.