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DATA CLASSIFICATION IN BUILDING DATA PROJECTS: AN INFORMATION-BASED APPROACH TO BIM PROJECTS IN FRANCE

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Abstract

Data in BIM projects include information on material characteristics, dimensions, energy simulations, equipment maintenance, occupancy patterns, space functions, etc. In these projects, the process of creating and retrieving building data is crucial for the larger construction project. The detailed review of ongoing BIM projects in France revealed how much the aforementioned process had gained weight, to the point of becoming a complete project in itself, the “building data project”. We formulate the hypothesis that building data and their classification are a suitable observatory of the system of actors working on the building construction process and their interests. Through the building data project, a whole set of new concerns are integrated into the modelling process, which was previously mainly focused on formal and functional aspects of the building. We therefore considered data classification and selection as an opportunity to explore emerging interests and requirements in the building design process. Following the analysis of databases related to 12 BIM projects in the design phase, we propose a tool for the classification of building data into multiple categories which reflect the actors' main concerns and interests.

Keywords: BIM, Building Information, Actors, classifications, database.

Resumen

Los datos del edificio en los proyectos BIM incluyen información de los materiales, las dimensiones, las simulaciones energéticas, el mantenimiento, la ocupación etc. En estos proyectos, el proceso de creación y recuperación de datos del edificio se convierte en un aspecto crucial. El análisis de varios proyectos BIM en Francia, nos ha permitido observar cómo dicho proceso ha ido ganando peso, hasta llegar a convertirse en un proyecto en sí mismo, que denominamos, “proyecto de datos del edificio”. Formulamos la hipótesis de que estos datos y su clasificación, se presentan como un buen observatorio a la hora de evaluar los intereses de los actores que trabajan en la construcción de un edificio. Mediante el proyecto de datos, se integran nuevas preocupaciones en el proceso de modelización, que anteriormente se centraba en los aspectos formales y funcionales. Consideramos que la clasificación y selección de la información en el proyecto, como una oportunidad para explorar nuevas reflexiones emergentes durante la concepción del edificio. Como resultado del análisis de las bases de datos de 12 proyectos BIM en la fase de concepción, proponemos una herramienta para clasificar esta información en diferentes categorías que representan los intereses de los principales actores del proyecto.

Palabras clave: BIM, Información del edificio, actores, clasificaciones, base de datos.

Introduction

Information-based approaches are becoming more and more relevant across fields. In fact, in his work on the “Third Industrial Revolution” (Rifkin, 2012), Jeremy Rifkin emphasized the emerging importance of information across a variety of disciplines. He highlighted how this recent shift has and is still revolutionizing and drastically altering workflow, processes, and methodologies. Within the construction field, the digital and information revolution gave rise to BIM technologies, which have dramatically modified the processes through which buildings are conceived, designed, constructed, and ultimately managed (Tulenheimo, 2015). The introduction of data into this field not only impacted the entire construction processes, but also led to the establishment and appearance of an entirely new project - which we will call *The Building Data Project* (BDP) - developed in parallel to the traditional construction project, and whose aim is to generate a database for the building.

The aim of gathering and storing building data can be traced back to the human desire to collect information. In his book, *Digital Culture in Architecture* (Picon, 2010), Antoine Picon highlights the fact that people had always had an interest in storing information, eventually leading to the creation of libraries and the later development of printing technology. Following the Industrial Revolution in the XVIII century, products that included construction elements and materials were accompanied by more and more specifications. Within the construction field, this information also increased in significance, moving from minor notes on building plans to extensive written records. After the end of the Second World War, the standardization of all this information became a necessity. As such, each field began developing and imposing its own standards and classifications. Within the building construction field most of these classifications were developed by the Construction Specifications Institute (CSI) starting with Masterformat in 1963. In the US the CSI's more recent classifications in 2010 and 2015, namely, Omniclass and Unifomat, are currently imposed in most BIM projects worldwide (Afsari & Eastman, 2016). These US classifications as well as the UK classifications like Uniclass -developed by the CPIC in England from 1997- have also been integrated into the ISO building standards -ISO 19650 and ISO 12006-. Developed in the Anglo-Saxon world, these classifications are linked to the organisation of the design process and the data used in that specific context.

In this article, we aim to gain a better understanding of the building data project in addition to its actors' interests and concerns, mainly through the development and reliance on a tool which proposes new categories based on early data classification systems in France. These categories were used to analyse the databases of 12 BIM projects. We assume that the analysis of the building database and the process through which it was created and expanded can reveal the stakeholder's interests in the building, the evolution of building construction practices, and the future management of the building. In order to analyse stakeholders' concerns we have studied different building data classifications. However, most studies on the nature of building data in France were conducted in the 80s and 90s, while researchers were trying to develop tools that allowed the development of Computer Aided Design. From these primitive classifications, researchers attempted to answer questions such as: *What kind of data? Who will use it? How to treat this data? Etc.* (Quintrand et al., 1985). Nowadays, research studies concerning data classifications relate to existing BIM tools, international standards, and interoperability formats. Therefore, in order to identify the nature of the data and relate it to the actors' concerns and interests, it would be useful to rely on the more primitive classifications which allowed architects and engineers to develop the initial tools from the most extensive set of questions.

1. How to Classify Building Data in a Building Data Project?

Information in building databases often originate from multiple heterogeneous sources and numerous actors from a variety of fields (Afsari & Eastman, 2014) (Eastman, 1999). Consistently, a single project may lead to different databases depending on the interests and needs of the actors in charge. Through the building data project these databases are created and linked to the building geometry.

1.1. The Building Data Project: Definition, Actors, Phases and Purpose

We define a project as a broad approach that aims to provide an answer to a question or to solve a problem (Boutinet, 1990) (Prost, 2014). In this particular case, the building data project aims to satisfy the informational needs, requirements, and interests of the various actors, leading to the creation of a building database. The

BDP actors, who may simultaneously be actors of the building construction project, can be categorized into two kinds: those who model and introduce information in the project through BIM software and those who decide what information to introduce depending on what BIM Uses should be implemented. The BIM Uses consists in a list included in the BIM Execution Plan that defines the main reasons behind the decision to work on BIM in this project.

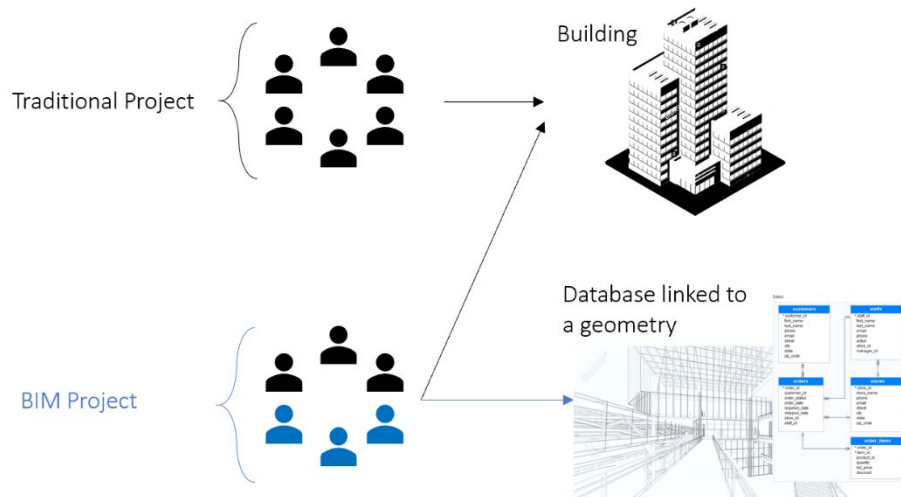


Fig. 1 Comparison between traditional Project and BIM project. Source: Prepared by the author (2020)

In a traditional project, a group of actors produce a building. However, nowadays the BIM construction project produces two outputs: the building itself, in addition to a database linked to the building's digital geometry. The building construction project and the BDP have the same temporality, they both evolve in parallel throughout the design, construction and facility management phases. Within the French context, each of the aforementioned phases is characterized by a different database and geometrical model. In fact, each of the three phases may include a different set of actors who value specific information. For example, during the construction phase, the code and location of all structural elements are extracted from the database. However, this information becomes less relevant during the remaining phases since in every phase of the construction process, the actors will change along with their needs and interests.

1.2. Building Databases in France

We start from the study of the historical background of building databases in France in order to find the way to structure, classify, and qualify the big amounts of building data that we obtain during the analysis of the BIM projects. The international benchmark for BIM nowadays in every European country is the norm ISO 19650. Regarding to building databases classifications, the ISO 19650 standard, released in December 2018, states:

“Classification of objects should be in accordance with the principles in ISO 12006-2. Object information should be in accordance with ISO 12006-3, to support object exchange.” (ISO, 2018)

Taking into account the research of Afsari and Eastman (Afsari & Eastman, 2016), this norm ISO 12006-3 (ISO, 2007) works as a support for the most common classification systems nowadays: Unifomat, Uniclass and Omniclass. However, these classifications were developed in the UK and the US, and their categories do not address the actors' interests and concerns.

As we are working with a specific system of actors which relates to the way that the construction process works in France, we decided to focus on recent French research. The POBIM project is one of the most important BIM research projects in France, a huge dictionary or census of BIM generic object properties and models. This project and the PPBIM norm are based on the norm XP P07-150 from 2014 (Lefauconnier, 2017). This

norm is an experimental French standard and there is no other document of that kind at the international level. The main objective of this project is to achieve the census of all the properties necessary to define every object, disregarding who is the actor that introduces it or why.

We also analyzed the work of BuildingSMART France, the most important organization that works on BIM development in France which is related to BuildingSMART International. This organization appeared in 1996 and its works are mainly focused on the development of IFC, in addition, they had developed researches about Interoperability, good practices, standards, collaboration, international classifications etc. Nevertheless, the research that involve good practices or work methodologies are not related to classifications and their work on international classifications relates to the Anglo-Saxon classifications: Uniformat, Omniclass and Uniclass. Finally, considering IFC, the classification of data that allows interoperability between the different formats and software in the construction field created by the International Alliance for Interoperability (IAI, 2002), it aims to define a common language for technology regardless of the software tool (Ekholm, 2005). It defined about 900 classes in order to assign a class to every designed object. These classes refer to entities in the BIM Model, and have associated properties that defined the entities' characteristics. These classes refer to any element in the project and are usually divided by disciplines (structure, electricity plumbing etc.) (Fig. 2).

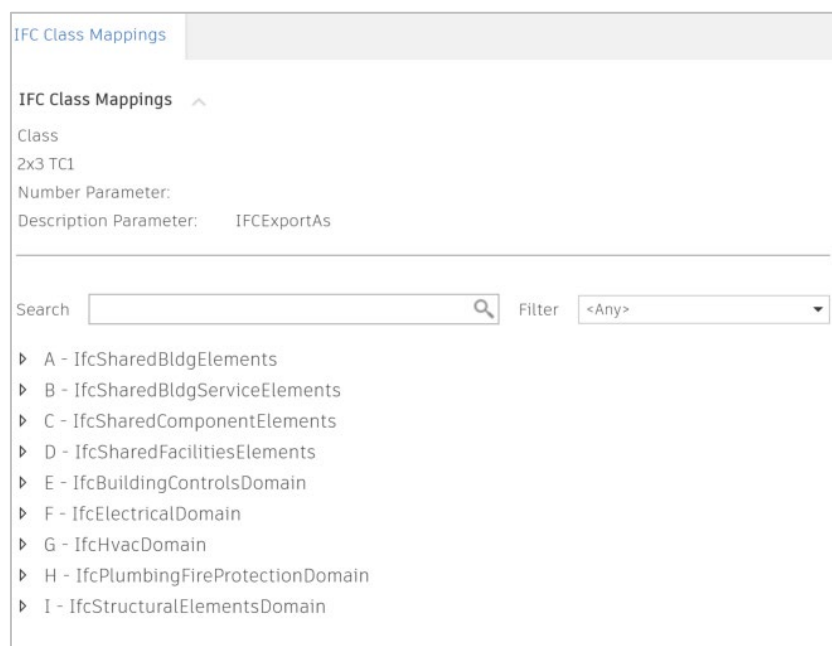


Fig. 2 Screenshot from the BIM Interoperability Tools Plugin of AUTODESK. Source: Prepared by the author (2020)

At this point we assumed that the current research is based on the existing tools, and their classifications impose the way they structure data. In addition, analysing actors' concerns doesn't seem to be a priority in the classification of building data nowadays. We hypothesized that analysing the studies that address the development of the first Computer Aided Design tools, we could find more primitive classifications that address building data nature and the actors who introduce them.

1.2.1. Early research on Building Databases in France

In the past, the development of Computer Aided Design (CAD) software in France (INPROBAT, 1986) and abroad (Eastman, 1980) involved substantial research on data classification. From 1985 to 1989, the programme IN.PRO.BAT - INformatique, PROductique et BATiment, "the Construction Plan" from the Ministry of Public Works, Housing, Urban Planning and Transport conducted important research that linked computer science and Architecture in France. Much of this research was conducted among others by the *Centre Régional de Conception Assistée par Ordinateur Midi Pyrénées* (CAOMIP), the *Centre Scientifique et*

Technique du Bâtiment (CSTB), the *Groupe de recherche pour l'Application des Méthodes Scientifiques à l'Architecture et à l'Urbanisme* (GAMSAU) and the *Centre d'Informatique et de Méthodologies en Architecture* (CIMA), in the 80s and 90s (Goulette et al., 1988) (Fregier, 1983) (Guéna & Leininger, 1986). This research on database classifications were further developed in the next years by members of the GAMSAU in Marseille, whose research was mainly focused on the building information management and description during its life cycle taking into account the actors needs and concerns (Hamani, 2005) (Ameziane, 1998) (Lasserre, 2003).

“Les informations utiles à la mission d'un intervenant peuvent être extraites selon son profil adaptatif”
// “The important information in an actor's mission could be extracted depending on its adaptative profile” (Hamani, 2005)

This sentence reveals that the actors have different missions, each of which relates to different information. As such, the actors will have varying “informational” needs and interests.

Finally, the project we rely on is the “Definition and validation of a database management system specific to the design-build project” (Ferries et al., 1985). Bernard Ferries -today, one of the representatives of BuildingSMART France- and his colleagues, proposed a data characteristics categorization after participating in all the meetings of the project stakeholders, analysed their interests and needs and finally tested a software programme used to structure building data. This data classification was divided into: Dimensional, Functional, Economical and Technical characteristics. For these researchers analysing the actors' needs was essential to provide them with the software tools which better adapt to their tasks. For us, the actors' needs are necessary in order to better understand and classify their informational interests towards the project and its future facility management. We therefore believe that the way they structured the building data can be adapted to our analysis of BIM projects since it is focused on the flow of information across the different actors, as well as their needs and interests.

2. The Development of a tool to classify Building Data based on actor's concerns

We conducted 12 case studies in order to uncover and analyse the building data introduced by all the actors during the design phase of the construction project. Furthermore, we organized and classified this data relying on previous research on building databases conducted in France.

2.1. The Building Information Hierarchy

In order to select what data from the databases of the 12 projects we were going to analyse, we had to develop and rely on a hierarchy of information. We began by analysing the data chosen and filled in by the actors according to the difficulty of its introduction. The building data project combines three types of data: "automatic", "parameterized", and "extraordinary". Automatic data are produced mechanically by BIM software; they result from modelling and most of them are dimensional data. The second type of data consists of parameters that pre-exist in the BIM software but must be filled in manually. The third type of data are characteristics that do not pre-exist in the software. These are integrated by the designers through plug-ins or by creating new parameters. Data of the latter type highlight issues for which stakeholders generally invest more time. These new parameters (Fig. 3) are accessible from the regulatory documents of the BIM project (protocol and specifications), in addition to the schedules (tables structuring the data) that have been extracted from the building information model.

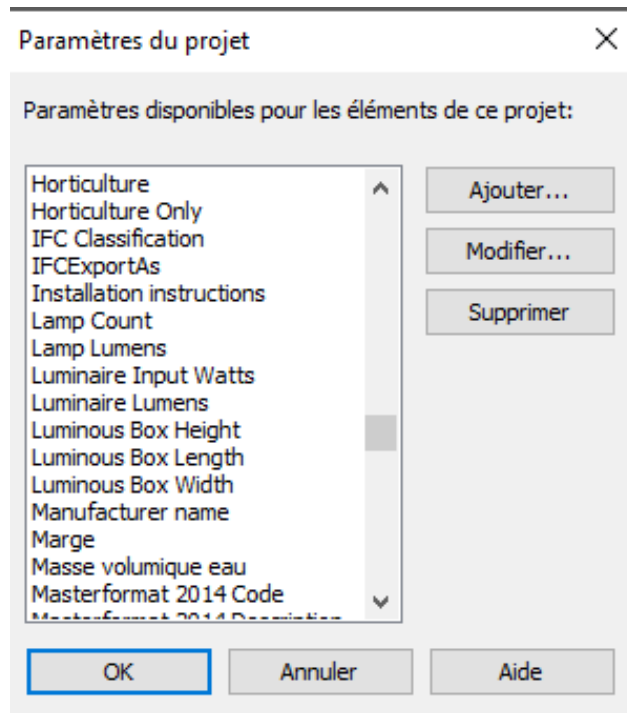


Fig. 3 Example of the new parameters in one of the case studies analysed. Source: Revit. Prepared by the author (2020)

Our research is therefore based on identifying the “extraordinary” data and classifying it under the assumption that these new parameters illustrate the main interests of the project which can’t be achieved through the existing parameters. As a first approach, we extracted all these new parameters and we classified them into the following categories: Dimensional, Functional, Economical and Technical. Afterwards, we analysed the properties that did not fit the aforementioned categorization in an effort to develop it further.

2.2. Classification of the extra-ordinary information per actor

The study results are presented in the below tables. The tables were first divided into type of information, namely: technical, dimensional, economical and functional. As most of the information was technical, this section was further divided into three new subcategories that include the characteristics of architectural elements, materials, as well as devices and machines elements. Information that did not fit into any of the existing categories was identified, leading to the creation of three new categories: regulatory information, administrative information, and geographical information. The regulatory information includes all the information related to the existing norms and regulations in the construction field. Administrative information represents all the information related to the organization of the project and to the identity and organization of the stakeholders and their files. Finally, the geographical information relates to the location, topography, in addition to any other information related to the site and the cadastral parcel where the building is going to be placed.

Even though these projects include economists who worked with BIM software, there was a lack of economical information. It is therefore possible that these actors decided to extract the dimensional information and quantities from the models in order to do their work, without introducing their results back in the BIM model. The information that was not introduced in a model cannot be considered in our analysis. However, their existence was made evident to us through the interviews that were carried out with the different stakeholders.

The analysis only includes information pertaining to the design phase of the construction project. The 12 case studies include BIM models of: architecture, structure, mechanical-electrical-plumbing (MEP), reference and site. With the exception of the architectural model, all other kinds of models were not present in every BIM construction project. Overall, we extracted the new parameters’ data of more than 50 models. We analysed the information concerning architects, engineers (structure), engineers (MEP), clients, and land surveyors.

Table 1. Extraction of "new parameters" in the analysed projects and its classification. Source: Prepared by the author (2020)

		"Extra-ordinary" Information per actor during design phase		
		Engineers (MEP)	Engineers (Structure)	Land surveyor
Dimensional		Entity height, entity width, entity length, number of lux, surface of, luminous box height width and length, total floor area, dimensional characteristics of every device length/height/width and diameter/section of canalisations.	Thickness of the slab, number of doorways, thickness, volumes, surfaces,	
Administrative		Design date, release date, name of folder, format, lot, IFC Class, level, Codes, Designation, file name, title, zone, identification, visible in schedules, level of reference, subdiscipline, number of document, commentary, views, drawing template characteristics, document status, project phase	Index, phase, level, kind of intervention, building description, kind of view, IFC Class, author, transmitter, receiver, architectural end level, Info Status, next meeting date, last meeting date, modifications, various, scale, telephone and email parameters of stakeholders,	Text, kind of procurement public/private, kind of plan, author, folder, ownership,
Technical	Characteristics of architectural elements	BIM Object category, BIM Object code	Outdoor/indoor, kind of slab, singular points, kind of beam, stairs name, tracking/identification, existing structure, reinforcement structure, URL, fire class,	Details
	Characteristics of materials	Canalisation materials, tube material, zone material, density, colour output factor, thermal insulation, conductivity, coefficient of exposure, voluminal mass,	Material description, Material class, thermal coefficient	
	Characteristics of devices, machines and building facilities	Angle of lighting, type of lighting, protocol of lighting, type of emitter, lighting measure, ventilation pressure drop, ID technical networks, kind to system, firebreaks, dimming, input WATTS, lumens, manufacturer name, reference description, product data, product GUID, product family, URL, technical description, emergency lighting, efficiency, efficacy,		
Regulatory		Master format Code, Omni class Code, Uniclass code, product certification, Unifomat II code, UNSPSC code, CIE type of lighting	Fire class, fire requirements, load requirements	
Economical		Price of lighting,	Unitary price	
Geographical		Region Name, location, coordinates	Topography, Region,	neighbourhood, land register number, street, building number, geographical impacts, postcode, city
Functional (related to spaces)		Control of lighting, Type of service, zoning, emitter zoning, smoke extraction zoning, ventilation device zoning, room lighting autonomy, switch on/off, emission place, reception place, technical files attached, calculation groups, calculation mode, daylight function, photometric file, buffer space, horticulture, installation instructions, comfort rating, air renovation rating, space needs, kind of service, programme, exposition time, room dimming, room lighting,	Number of occupants, program uses, kind of use, technical files attached, program uses name, program uses group, kind of circulation,	

Table 2. Extraction of "new parameters" in the analysed projects and its classification. Source: Prepared by the author (2020)

"Extra-ordinary" Information per actor during design phase			
	Architects	Client	
Dimensional	window height, total height, hole height, hole width, door width, door leaf thickness, door leaf height, door offset, door leaf width, different kind of surfaces, opening surface, number of doorways, width of space, girthed area, free surface, ridge height, ridge length, depth, glazing area, gross area,	Surfaces, volumes, perimeters, diameters, thickness, hole height, hole width, section dimension, opening length, opening surfaces,	
Administrative	Number of floor, description of floor, IFC Class, zone, section, sitelongname, sitename, name and type of views, commentary, index, name of schedule, drawing template characteristics, observations, building type, date, scale, index, lot, priority, project browser description, notes, to be checked, ID, document code, format, names, phase, ownership, Release, telephone numbers, sheet filter, preliminary drawing, author, audit, review, client name, units, modifications date, meetings dates, document status, client address, Client P.O., entrance level, type of drawing phase,	Level, lot, number of plan, author, commentary, ownership, nature of the building, views/sheets purpose, time, floor, index, email, telephone number, name of template, version of template, name of view, IFC Class, IFC Type	
Technical	Characteristics of architectural elements	Wall finishes by room, ceiling finishes by room, plinth finishes, floor finishes, room name, firebreaks, door beading detail, specificities, wall code, room code, ceiling code, door code, floor code, stair number, type of door, type of window, trimmings, component function, component count, component name, description, slope, weight, URL, kind of product, characteristics of sliding panels, interphone/video system in doors, electronic lock in doors, magnetic contact access in doors, security hinges in doors, card reader access, indoors/outdoors, building location, door materials, Beam radiation transmittance, mullion nature, element fire risk factor, wall infiltration, floor, serial number, thermal transmittance,	ID code, doors linear, openings height, openings linear, level of the object, zone of the object, Wall finishes by room, ceiling finishes by room, floor finishes, beam drop, id tracking element
	Characteristics of materials	Acoustic impedance, fire resistance, Material text, material description, thermal properties, density, material classification, glass composition, material per layer, nature of material, wood description, combustible material, flammable storage, material fire hazard factor, skid surface, reflectivity, thermal transmittance, translucency	Material ID assignments, thickness of materials, concrete characteristics, casing code, weight, type of materials, volume, precast material,
	Characteristics of devices, machines and building facilities	Kind of product, Air pressurization system, kind of air conditioning, on/off, artificial lighting, automatic/not automatic, kind of heating, illuminance, coated isolation, serial number, mechanical ventilation rate, wired isolation, natural ventilation, smoke stop, sprinkler protection, solar heat gain, system code, type of filter,	ID code, level of the object, zone of the object, id tracking element
Regulatory	Master format Code, Omni class Code, Uniclass code, product certification, Unifomat II code, UNSPSC code, handicapped accessibility regulations, reglementary isolation, reglementary classification, acoustic constraint room, fire constraint room, other constraint room, public security constraint room, regulatory norm applied, humidity constraint, risks constraints, fire requirements, sound requirements, load requirements, handicap accessible requirements, required slope,		
Economical	component price, Prix M.O		
Geographical	orientation, address, sector, buildable area, building height limit, external buildings shading, shared coordinates, temperature summer/winter/spring/autumn	city, region, location	
Functional (related to spaces)	Workforce, Security spaces, occupancy time and number, acoustic rating, programme surface, zone description, kind of zone, occultation, Fire rating, habitation, technical files attached, high risk spaces, schedule, conservatory measures, space division, type of space, zone decoration, servitudes, access control, fire control, function, location function, structural use, space type, type of plantation, terrace function, space fire division, kind of apartment, max. occupation, min. occupation, function ratio, typology of apartment, fire scape, kind of access control, zoning datasheet, functional links between spaces, name of program, number of program, group of program; room acoustic rating, room air conditioning, space compartmentation, space fixed furniture, space fire risk factor, handicap accessible room, kind of room ventilation, public accessibility, building security rating, space humidity, space temperature, space illuminance, kind of heating,	Operating procedure, zone type, Use/Function, occupants, permanent and occasional loads,	

3. Discussion

3.1. Comparison with the UK and US classifications

There is great value in comparing our actor-oriented categories to those included in the classifications proposed by the CSI. In the below table we have tried to match every kind of data previously identified by the other classifications to our developed categorization.

We based this comparison on the chart realized by Autodesk (Autodesk, 2016) that explains the relation between ISO 12006, Uniclass and Omniclass. To this chart, we have added Unifomat II (Afsari and Eastman, 2016), the classification most used in France, as well as our own classification categories in order to check whether their categories match ours. We observed that some of our categories could be further divided into subgroups. For instance, the administrative and general information categories include data from the construction phases, the stakeholders, the project management, and the software, in addition to the kinds of documents produced, their characteristics and their descriptions. It is therefore possible to further categorize the administrative information, similarly to the technical information, into subgroups in order to classify the data more accurately. Also, in the existing classifications, functional information is organized by the scale and the object whose function we are analysing. For example, Uniclass (Autodesk, 2016) separates the function of rooms from that of the whole complex, while our tool considers a single category for function without taking into account the scale of the space which we are analysing. As the functional information category is quite heterogeneous, it can be further developed into multiple subcategories.

Analysing the projects' contractual documents, we found that Unifomat is the most relied upon classification. This observation is supported by BuildingSMART France in its online article "Systèmes de Classification" (BuildingSMART France, 2020). The fact that Unifomat mainly considers technical information and the presence of a great number of technical parameters in the building models analysed, indicate that the technical information is nowadays the most important category. However, we can observe that technical information is not the actors' only concern as other categories are also filled with new parameters that are of interest to them.

Our categories include all the information classified in the categories proposed by Uniclass, Omniclass, ISO-12006 and Unifomat, which assures us that no type of information was excluded from our categorization. However, it is still not mature enough, and needs to be further developed and expanded. In particular, the categories and subcategories of technical, administrative and functional information must evolve towards greater specificity. On the other hand, this tool identified new categories in building data that were not being previously considered by the Anglo-Saxon classifications, namely for dimensional, economical, regulatory, and geographical information.

Table 3. Development of Autodesk Classification chart (2016) including Unifomat II and new classification. Source: Prepared by the author (2020)

ISO 12006- 2	UNICLASS 2015	OMNICLASS 2006 - 2013	UNIFORMAT II	Classification
A.2- Construction Information	FI- Form of Information	Information	-	Administrative/General Information (Project Management) and Regulations
A.3- Construction Products	Pr- Products	Products	-	Technical (Architectural and MEP objects and devices)
-	-	Materials	-	Technical (Materials)
A.4- Construction Agents	-	Disciplines	-	Administrative/General Information (stakeholders and actors information)
-	-	Oragnizational Roles	-	Administrative/General Information (stakeholders and actors functions) and economical
A.5- Construction Aids	TE- Tools and Equipment	Tools	-	Administrative/General Information (Software and technical information)
A.6- Management	Pm- Project Management	Services	-	Administrative/General Information (Project Management Services)
A.7- Construction Process	-	Phases	-	Administrative/General Information (Project Management Phases)
A.8 - Construction Complexes	Co- Complexes	-	-	Functional (global uses of the building)
A.9- Construction Entities	F-Facilities	Entities by Function	-	Functional (by areas or zones or objects)
-	En- Entities	Entities by Form	-	Technical (architectural)
-	Ac- Activities	-	-	Functional (developed in each space)
A.10- Built Spaces	SL- Spaces/Locations	Spaces by Function	-	Functional
-	-	Spaces by form	-	Technical and dimensional
A.11 - Construction Elements	EF- Elements/ Functions	Designed Elements	Substructure, Shell, Interiors, Services, Equipment and furnishing, special construction and demolition, building sitework	Technical (Architectural and MEP construction elements)
-	Ss- Systems	-	-	Administrative/General Information (Project Management Stakeholders tasks)
A.12- Work Results	-	Work Results	-	Technical (Architectural and MEP construction elements already built)
A.13- Construction Properties	-	Properties	-	Dimensional and technical (materials)
-	Zz- CAD	-	-	-

3.2. Categories based on current actors' concerns

Through this study, we were able to identify an increased interest of the construction actors on administrative and organizational project management information, in addition to regulatory and geographical information.

A significant amount of administrative and organizational data was retrieved from the “extraordinary” type of information. In the research studies conducted in the 80s and 90s on CAD software, this data was not common. However, nowadays, we can find information related to the periodicity of the meetings and the evolution of the project. Data related to project management is becoming much more common and is being introduced by all kinds of stakeholders. Considering the category of “administrative information”, the Integrated Project Delivery (IPD) proposed by the American Institute of Architects (AIA, 2007), deal with the idea that organizing all the information related to project management, stakeholders and their tasks, is crucial for the development of any construction project including BIM projects (Ilozor & Kelly, 2012) (Brioso, 2015) (Rokooei, 2015). However, the IPD is focused on economic and managerial issues of cost reduction (Kent & Becerik-Gerber, 2010). Therefore, if the building database is included in the IPD, its structure could primarily address such issues. Following the above comparison between classifications and the increased interest of stakeholders on project management issues, we believe that the “administrative information” category should include a new subcategory that allows for the analysis of the information related to the IPD separately.

Regulatory information in construction field has also become more important in the past years. In fact, the continuous development of new building certifications increased the actors' concerns regarding norms and regulations mainly related to green building and energy issues (Menet & Gruscu, 2014). As a result, regulatory information related to pre-certification (Biswas et al., 2013) (Solla et al., 2016) is in high demand nowadays in the BIM projects design phase. The possibility of certifying a building and verifying its alignment with existing regulations attracts the interests of the different stakeholders. Even though there were not many regulatory information in the analysed projects, many plug-ins have started including parameters to measure the regulatory coherence of projects through energy simulations like Insight from Autodesk or Archiwizard plug-in from Graitec. In France other plug-ins are being developed like icheck from Bureau Veritas for self-verification of regulatory compliance of BIM models taking into account the existing regulations about fire protection and accessibility. We have considered the information related to ISO and classification norms as part of the regulatory information as they try to classify the project according to international standards (Afsari & Eastman, 2016).

Finally, concerning geographical information, we find new tools which aim to link BIM information to geographical information systems (GIS) as in the case of Autodesk and its tool Autodesk Infraworks. This connection would link every building with its land's information, creating CIM projects -City Information Models-. Through such work, geographical information could become much more important for building information and vice-versa. The combination of BIM and GIS databases is been proved a source of benefits in several fields such as monitoring the construction supply chain (Irizarry et al., 2013) or creating simulations for real-time building energy performance through a Virtual Facility Energy Assessment (VFEA) tool based on a BIM-GIS approach (Wu et al., 2014).

4. Conclusion

Building data offers invaluable insights into the development of BIM projects, in addition to the future management of the building and the interests underlying its design. Through this work, it was shown that a significant number of new parameters, which relate to different categories and concerns, are being introduced in the building information models during the design phase. This effort to parametrize and insert new information in the models is therefore key to better understand the main issues that affect BIM construction projects nowadays.

Our developed categorization was helpful in determining the new approaches to BIM projects. However, this research should be expanded in the future through the analysis of the construction, and facility management phases in order to gain a deeper understanding of the actors' main concerns during the whole building life

cycle and develop a more comprehensive classification. Such an analysis will help characterize each of the construction phases according to the relied upon information and provide us with a better understanding of the project stakeholders' concerns. Furthermore, this reflection shouldn't be restrained just to the scale of the building. Understanding the relevance of GIS and the relation between the building and the city data projects, the process through which their databases are developed, the actors involved in that process, as well as their interests and needs; will help to better comprehend what kinds of buildings and cities are being designed nowadays.

Finally, this study demonstrated that the actors' interests are developing and moving away from their original emphasis on technical matters, to include regulatory, managerial, economical, and geographical concerns. The classification appears as a new tool that allows us to better measure the impact of these new concerns in the projects. The BIM technologies have imposed the importance of information in new construction projects. We find, therefore, important to create new tools that allow the evaluation of the type of information that is being introduced, as well as the identification of those who introduce it and the reasons behind that decision.

Bibliography

- AFSARI, K., & EASTMAN, C. (2014). "Categorization of building product models in BIM Content Library portals". *Blucher design proceedings*, 1(8).
- AFSARI, K. & EASTMAN, C.M. (2016). "A Comparison of Construction Classification Systems Used for Classifying Building Product Models". *In the 52nd ASC Annual International Conference Proceedings*. DOI: 10.13140/RG.2.2.20388.27529
- AIA CALIFORNIA COUNCIL. (2007). "Integrated project delivery: A guide". *The American Institute of Architects (AIA), California Council*. https://info.aia.org/SiteObjects/files/IPD_Guide_2007.pdf
- AUTODESK, (2016). "Classification Systems and Their Use in Autodesk Revit: Managing the "I" in BIM. Autodesk Whitepaper". Autodesk. Page 23
- BISWAS, T. TSUNG-HSIEN, W. & KRISHNAMURTI, R. (2013). "From design to pre-certification using building information modelling". *Journal of Green Building: Winter 2013*, Vol. 8, No. 1, pp. 151-176.
- BOUTINET, J.P. (1990). « Anthropologie du projet », Paris, France: *Presses universitaires de France*.
- BRIOSO, X. (2015). "Integrating ISO 21500 guidance on project management, lean construction and PMBOK". *Procedia Engineering*, vol. 123, p. 76-84.
- BUILDINGSMART FRANCE (2020). *Systèmes de classification*. Mediaconstruct <<https://bimstandards.fr/data-bim/systemes-de-classification/>> [24 de febrero de 2020]
- EASTMAN, C. M. (1980). "System facilities for CAD databases". *In Proceedings of the 17th Design Automation Conference* (pp. 50-56).
- EASTMAN, C. M. (1999). "Building Product Models: Computer Environments Supporting Design and Construction", 1st ed. Boca Raton, FL, USA: CRC Press, Inc.
- EKHOLM, A. (2005). "ISO 12006-2 and IFC prerequisites for coordination of standards for classification and interoperability". *Journal of Information Technology in Construction (ITcon)*, vol. 10, no 19, p. 275-289.
- FERRIES, B. MEILHAT, V. PELEGRIN, F. & COUILLET, A. (1985). « Définition et validation d'un système de gestion de base de données spécifique au projet de conception-réalisation du projet architectural », CAOMIP, Toulouse
- FREGIER, M. (1983). « Etude sur la représentation des composantes morphologiques de données du projet architectural dans un contexte de C.A.O ». GAMSAU, Plan Construction, INPROBAT.
- GOULETTE, J-P., LEGLISE & M., PEREZ, M., (1988). « Le poste architecte : spécifications, session d'utilisation, présentation de la maquette et documentation in Krépis, Rapport final de recherche », Toulouse, CAOMIP, *Rapport final d'une recherche financée par le Ministère de l'Equipement, du Logement, de l'Aménagement du Territoire et des Transports dans le cadre du programme IN.PRO.BAT.*, 45 p.
- GUENA, F. & LEININGER, J.P. (1986). « X2A : Pour un système de conception assistée par ordinateur en avant-projet sommaire de bâtiment ». Dire Plan Construction, INPROBAT.
- HAMANI, D. (2005). « Un système d'information pour le bâtiment - Elaboration d'un modèle conceptuel de données pour les ouvrages façonnés en place issus de la production de bâtiment », Thesis, Aix-Marseille 3.
- ILOZOR, B.D & KELLY, D.J. (2012). "Building Information Modelling and Integrated Project Delivery in the commercial Construction industry: a conceptual study", *Journal of engineering, project and production management*, 2 (1), 23-36.

- IRIZARRY, J. KARAN, E. P. & JALAEI, F. (2013). "Integrating BIM and GIS to improve the visual monitoring of construction supply chain management". *Automation in construction*, vol. 31, p. 241-254.
- ISO. (2018). *Organization and Digitization of Information about Buildings and Civil Engineering Works, Including Building Information Modeling (BIM)-Information Management using Building Information Modeling*. ISO 19650-2: 2018. I.S.O. Part, vol. 2.
- ISO. (2007). *Building construction: Organization of information about construction works*. ISO 12006-3: 2007. I.S.O.
- KENT, D. C. & BECERIK-GERBER, B. (2010). "Understanding construction industry experience and attitudes toward integrated project delivery". *Journal of construction engineering and management*. vol. 136, no 8, p. 815-825.
- LEFAUCONNIER, M. (2017). « Le BIM face au droit ». *Le BIM éclairé par la recherche*, par Riss, S., Talon, A., et Teulier, R., p. 91-100.
- MENET, J. L. & GRUSCU, I. C. (2014). "L'éco-conception dans le bâtiment ». *Cahiers techniques*, Dunod.
- PICON, A. (2010). « Culture numérique et architecture : une introduction ». Birkhäuser, Basel
- PROST, R. (2014). « Pratiques de projet en architecture: le tournant silencieux : essai », Gollion, Suisse: Infolio.
- QUINTRAND, P., AUTRAN, J. & FLORENZANO, M. (1985). « La conception assistée par ordinateur en architecture », Ed : Hèrmes. Paris
- RIFKIN, F. (2012). « La troisième révolution industrielle ». Les Liens Qui Libèrent
- ROKOOEI, S. (2015). "Building information modelling in project management: necessities, challenges and outcomes". *Procedia-Social and Behavioral Sciences*. vol. 210, p. 87-95.
- SOLLA, M., ISMAIL, L. H., & YUNUS, R. (2016). « Investigation on the potential of integrating BIM into green building assessment tools". *ARPJ Journal of Engineering and Applied Sciences*, 11(4), 2412-2418.
- TULENHEIMO, R. (2015). "Challenges of implementing new technologies in the world of BIM—Case study from construction engineering industry in Finland". *Procedia Economics and Finance*, 21(Henttinen).
- WU, W. YANG, X. & FAN, Q. (2014). "GIS-BIM based virtual facility energy assessment (VFEA)—Framework development and use case of California State University, Fresno". *Computing in Civil and Building Engineering*. p. 339-346.