The Information Modeling and the Progression of Data-Driven Projects

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Abstract

The aim of this paper is to investigate different approaches adopted to define the content of a Building Information Model (BIM). In order to improve the effectiveness of the Built Asset during the whole life-cycle, the Construction Industry is moving towards a digital eco-system. Thus, the implementation of Data-Driven Projects based on Building Information Modeling is wide-spread and becomes more and more a mandatory requirement. The Building Information Modeling methodology is based on an Information Model that contains the updated and amended information related to the project, starting from Briefing and Conceptual Design. So to achieve a performing process, it is essential to provide any needed information at the right time. For this reason, several concepts related to the definition of data sets belonging to BIM, such as 'Level of Development' and 'Level of Detail', have been established. The main focus of this study is to provide an overview on this topic and to investigate possible different approaches. The study is based on both literature review and interviews. The findings indicate that there is not a univocal approach suitable to manage this issue, and numerous definitions and acronyms have been defined in different Countries, especially in US and in UK. However, it is possible to compare them and to find similarities. The findings can be used to gain an in-depth understanding on this topic, especially for experts who work with BIM in various Countries.

Keywords: Building Information Model, Level of Development, Level of Detail, Level of Definition, Level of Information.

1. Introduction

In order to achieve whole life-cycle effectiveness, the Construction Industry is moving towards a digital eco-system. The implementation of Data-Driven Projects based on Building Information Modeling is spreading and becoming more and more a mandatory requirement. Indeed, several Countries such as the UK, Germany, Spain and France are actively mandating governmental strategies, seeking to promote a Smart Construction Industry. The Building Information Modeling methodology is based on a Building Information Model (BIM) that virtually represents the design and project, and contains updated information (Eastman et al., 2011). In order to attain any expected outcomes, it is essential to provide needed information at the right time to the right person. For this reason, several concepts related to the definition of data within the BIM have been developed. Different data are needed for different purposes; thus, from the early beginnings it is important to clearly define the authorized uses and responsibilities. Authors themselves realized that nowadays there is not a clear understanding of these concepts and the literature does not provide enough findings. Thus, the focus of this paper is to provide an overview on this topic and to investigate possible approaches as well as similarities. Finally, a possible future scenario concerning the data management is discussed.

2. Methodology

First, in order to obtain information on the data management within Information Modeling, a literature review has been performed. The concept and application of this topic is still relatively new, thus, there are limited scientific existing studies. The literature review therefore does not include only academic publications, such as journal papers and books, but it incorporates also guidelines, specifications, protocols, standards and reports published by governments and other regulatory bodies, blogs and articles published in respected online newspapers. Different types of databases have been analysed: both scientific (e.g. *ScienceDirect*®) and non-scientific (e.g. *BuildingSMART*®) available online. The same keywords (‘Building Information Modeling’ and ‘Building Information Model’ associated to ‘Level of Detail’, Level of Development’, ‘LOD’) have been used to find references. Sixty-two documents have been analysed, but only part of them were useful for the research work and are included in the reference list. Later, semi-structured interviews were carried out with five public agencies that delivered publish standards (in UK and US) as well as with their consultants. The interviewees were selected based on their role (e.g. BIM Managers) and experience in this topic to better understand how documents and tools, related the management of data within a BIM, are implemented as well as possible benefits and challenges. The interviews were conducted in person and they were recorded. Afterwards, in order to analyse data, responses were transcribed into statements where evidence was convergent.

3. An Overview on the Progression of Data-Driven Projects

This paragraph is based on literature review and it presents the principal initiatives to support information production and exchange within a BIM. At the end of the paragraph, Table 1 summarizes such initiatives and compares different definitions, acronyms and classifications.

3.1 The origin of 'LOD': from Information Levels to Level of Detail

Denmark has been one of the first Countries to define a classification for information within BIM (van Berlo et al., 2014). The *3D Working Method 2006* introduces seven (0-6) *Information Levels* to set the content of discipline models at a given time in the design process. The Information Level is a '*stage of information content and/or quantity*' and it is related to '*individual discipline models and building elements and/or geometrically limited building sections*' (BIPS, 2007). The seven levels describe a rising degree of detailing and correspond to the traditional construction phases, but they can be customized to allocate roles based on the nature of tasks (BIPS, 2007). The document suggests to use a table in order to clarify Information Levels for each phase and working practices (BIPS, 2007). Moreover, for each Information Level the document shows *Graphical representation*, *Alphanumeric representation*, *Objective*, *Parties/responsibilities*, *Content*, *Use*, *Degree of detailing* and *Classification* to be used (BIPS, 2007). It is possible to affirm that the Information Level is related to geometrical as well as non-geometrical data that different parties can rely on. This concept has been incorporated in the Australian CRC document in 2009, but Information Levels are associated with *Model Development phases* (0-6) and *Object data levels* linked to Level of Detail (A-E). The Level of Detail refers to '*detailed geometry and with additional or different information attached to the objects*' (CRC, 2009).

In 2004 the software company Vico Software started to work on a standard apt to facilitate the management of information within a BIM (Bedrick, 2008; Vico Software, 2015). Indeed, Vico developed the Model Progression Specification (MPS) defined as '*a language that owners, designers, and builders can use to define every element and task in the building construction process. It serves as a coordination point for information about the building, what is being modeled, and to what level of detail it is being modeled, estimated, and scheduled. It provides the efficient framework for the project stakeholders – a written checklist that matures from a very schematic level of detail to a high level of detail in terms of 3D geometry, cost, and time*' (Vico Software, 2015). Vico created a standard to manage BIM in an effective way, introducing the MPS concept as well as the 'Level of Detail'. The Level of Detail plays an important role within the MPS and is defined as '*the specificity required for a particular element at a particular stage of the project*' (Vico Software, 2015). Moreover, the '*level of detail for a BIM model must correspond to the needs of the modeler, the project engineer, and the estimators and schedulers. LOD identifies how much information is known about a model element at a given time. This "information richness" grows as the project comes closer to breaking ground*' (Vico Software, 2015). Thus, for Vico the 'Level of Detail' concept is associated to the reliability of information in a particular period of time and it also refers to a quantitative aspect that progressively increases. The acronym 'LOD' for the first time is used for 'Level of Detail'.

The company Webcor Builders teamed with Vico to further develop this concept, and later they brought it to the technology subcommittee of the American Institute of Architects (AIA) California Council's Integrated Project Delivery (IPD) Task Force (Bedrick, 2008; Vico Software, 2015). In 2008 Bedrick defined the Level of Detail as '*descriptions of the steps through which a BIM element can logically progress from the lowest level of conceptual approximation to the highest level of representational precision. It was determined that five levels, from*

conceptual through as-built, were sufficient to define the progression. However, to allow for future intermediate levels we named the levels 100 through 500. In essence, the levels are as follows: 100. Conceptual; 200. Approximate geometry; 300. Precise geometry; 400. Fabrication; 500. As-built'. The definition is linked to a '*BIM element*' and not to the entire model. Bedrick (2008) also provided a definition of each level in a table and he reported some '*Authorized uses*' of the BIM. The Level of Detail can be used in two different ways: (1) to define phase outcomes and (2) to assign modeling tasks (Bedrick, 2008). In the first case, the Level of Detail of various elements must be defined because even if elements progress from one level to the next one, they can have different rates at the design develops (Bedrick, 2008). This concept is very important because it moves from the concept of scale in traditional design process where all elements are represented in a homogeneous way. Thus, it is clear that the requirement of a BIM at e.g. LOD 200 no longer makes sense. The second use, instead, deals with the ownership of the geometrical representation of elements (Bedrick, 2008). Indeed, the *Model Component Author (MCA)* is introduced as *'responsible for creating the 3-dimensional representation of the component, but not necessarily for other discipline-specific information linked to it*' (Bedrick, 2008). In this case, a separation between the geometrical representation of a component (3D geometry) and any data associated with it is clear. Thus, the MPS can track only who is in charge of the geometry creation and not who is responsible for the information, which usually is the most important part of a BIM.

3.2 The introduction of Level of Development

Later, the work performed by the AIA California Council's IPD Task Force was adopted by the AIA National Documents Committee to be developed (Bedrick, 2008). In 2008 the concept was incorporated in the *E202™–2008. Building Information Modeling Protocol Exhibit*[1] (AIA, 2008). The AIA evolved the notion into 'Level of Development' (Bedrick, 2013a). The AIA (2008) document does not contain any references to the Level of Detail and the acronym 'LOD' stands for Level of Development. The *E202™–2008* defines the protocols, expected LOD and Authorized Uses of the BIM for a specific project. Moreover, thanks to a Model Element Table, specific responsibility (Model Element Author/MEA) is assigned for the development of each Model Element to a defined LOD at each project phase (AIA, 2008). The Level of Development is defined as '*the level of completeness to which a Model Element is developed*' (AIA, 2008). The *E202™–2008* defines five progressively detailed levels (100, 200, 300, 400 and 500). Each subsequent LOD builds on the previous one and includes all previous characteristics (AIA, 2008). Moreover, for each level it gives a definition of the *Model Content Requirements* and it explains the *Authorized Uses* that can be customized (AIA, 2008). The LOD refers to the reliance on Model Elements; so, even if they could include more data than required, any user may rely only on the accuracy and completeness of the stated LOD (AIA, 2008). In the AIA (2008) document the MEA is responsible for both geometrical and non-graphical aspects of the Model Element and from LOD 200 to 500 also non-geometric data can be attached.

[1]Definitions from AIA Documents have been reproduced with permission of The American Institute of Architects, 1735 New York Avenue, NW Washington, DC 20006.

After the publication of *E202™–2008*, Vico continued to develop the MPS releasing version 2.0 in 2010 included 'Aspects' and 'Classes' concepts (Vico Software, 2015; Trimble Navigation, 2013). For each 'Classes' a *Target Level of Detail* can be defined (000, 050, 100, 200, 300, 400, 450, 500, 550, 600) (Vico Software, 2015). However, a clear definition of each Target Level of Detail is not available. In 2011 the latest version MPS 3.0 introduced different types of generic building elements called 'Primitives' (Vico Software, 2015; Trimble Navigation, 2013). Trimble Navigation (2013) developed a guide for each 'Primitives' showing Model 'Classes' with written requirements (mostly geometrical) and images. The guide (Trimble Navigation, 2013) does not provide any reference to suggested Level of Detail for each Model 'Classes'. The main focus of Vico is on 5D; for this reason the structure of MPS mainly supports effective cost and schedule evaluations rather than the overall process.

3.3 The use of LOD in several Guidelines and the introduction of 'Model Granularity' and 'Grade' definitions

In 2010, the Department of Veterans Affairs (2010) published 'The VA BIM Guide' that includes a spreadsheet, 'Object Element Matrix', to define BIM objects, properties, and attributes for each Level of Development (LoD). Both acronyms 'LoD' and 'LOD' are used and definitions of Level of Development are based on the *E202™–2008* (Department of VA, 2010). Later, the NATSPEC published the National BIM Guide (2011) including the *NATSPEC BIM Object/Element Matrix* based on the Department of Veterans Affairs matrix. In addition, the NYC DDC (2012) introduces the *Model Level of Development (LOD)* concept as '*level of detail to which a Model is developed and its minimum requirements. The Level of Development is accumulative and should progress from LOD 100 at Conceptual Design through LOD 400 at completion of Construction*'. However, it also '*describes through five categories, the completeness of elements in a Building Information Model. Completeness will range from geometric detail to element information*' (NYC DDC, 2012). There are some inconsistent aspects between the two definitions because the first refers to the '*Model*', while the second to '*elements*' of the BIM. In the appendix, there are Object requirements tables to set LOD from 100 to 400, however, the guideline presents also LOD 500; for this reason, Table 1 contains a (?). The DDC Level of Development has been developed in alignment with the *E202™–2008* and it introduces the *Model Granularity* concept as the '*representation of geometry needed to support specific BIM use*' (NYC DDC, 2012). It is associated to the '*level of detail needed*' that can '*vary by object and by model, and the BIM itself may not represent the exact design intent of real live elements*' (NYC DDC, 2012). Another US institution, the Pennsylvania State University (2012), has adopted the *E202™–2008* Level of Development standard for their projects, but it expanded the LOD 500 category (510, 520, 530, 540, 550) to more adequately meet their needs for operation and maintenance phases. Table 1 contains a start (*) under LOD 500 to remind that this level has been further developed.

In 2012, the US Army Corps of Engineers (USACE) released the BIM Minimum Modeling Matrix (M3), a spreadsheet for modeling requirements. It contains three levels of Development (LOD) from 100 to 300 (USACE, 2012) based on *E202™–2008*. Moreover, the *Element Grade (GRADE)* is added to the LOD concept because '*within each Level of Development, there is the potential to represent information in various formats. In practice, it has been proven that there*

are certain elements for which there is a greater benefit in providing 3-dimensional representation, while in others drafting or representation in the form of narratives is sufficient for a particular deliverable' (USACE, 2012). The M3 contains two columns to specify the Grade (A, B, C, '+'); there is not a column for the MEA, but a *Primary Discipline* can be set.

In the UK, the AEC (UK) Initiative released for the first time a BIM Protocol in 2009 and in 2012, published version 2.1. It introduces the *Model Development Methodology* concept that is related to the Level of Detail, also called *Grade* (AEC (UK), 2012). Even if the protocol recognizes that the '*graphical appearance is completely independent to the metadata included in the object*', there is only a classification for geometrical aspects (*G0-G3*) (AEC (UK), 2012). This concept has been included in the first version of the AEC (CAN) BIM Protocol (2012) together with new acronyms ('LOD^{ev}' for Level of Development and 'LOD^{et}' for Level of Detail). However, the last version (2014) includes only the Level of Development (LOD) concept that is related to both Model Elements and Model.

In Netherland, even if the concept of Level of Development has been used, there has been a lot of confusion on the real meaning (van Berlo et al., 2014). Thus, seven *Information Levels* (0-6) have been created following the Danish standard (BIPS, 2007) together with a matrix, a practical guide and a project template (van Berlo et al., 2014). The practical guide contains the purposed use of *Information Levels* supported by pictures and use case examples (van Berlo et al., 2014). The project template is used as a spreadsheet that holds a demarcation of the project and for each section; responsibilities, status of that model, classification system and minimal Information Level can be defined (van Berlo et al., 2014). In this case, the Information Level could be assigned to the model or part of it, and not only to Model Elements.

3.4 The new version of AIA documents and the BIMForum LOD Specification

In 2013, the AIA published three new documents related to the management of a BIM that should be incorporated into an agreement between parties and used in conjunction: *E203™–2013*, *G201™–2013* and *G202™–2013*. In addition, the AIA published the *Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents*. According to the *E203™–2013*, the Level of Development (LOD) describes '*the minimum dimensional, spatial, quantitative, qualitative and, other data included in a Model Element to support Authorized Uses associated with such LOD*'. Indeed, the Level of Development of a given Model Element informs project participants about '*how developed the information is expected to be, and the extent to which that information can be relied upon, at a particular point in time in the development of the Model*' (AIA, 2013d). Thus, the main focus of the LOD concept is still related to the reliability of data within the BIM. The new document (AIA, 2013c) defines content of model elements as '*minimum*' and not '*specific*' requirements, as reported in the previous version (AIA, 2008). There are still five levels, however, instead of '*Model Content Requirements*' (AIA, 2008) the new version (AIA, 2013c) uses '*Model Element Content Requirements*'. Starting from LOD 200, each definition (AIA, 2013a) is divided in two parts: graphical and non-graphic representation. The definition is discussed for each LOD; instead, a general statement is used to define non-graphical

information (AIA, 2013c). The structure of the Model Element Table (AIA, 2013c) is similar to the one already included in the previous document (AIA, 2008) with the exception of note sections that are added for each project milestone (AIA, 2013c). Moreover, the MEA is no longer seen as a modeler (AIA, 2008), but as a responsible party for the management and coordination of the development of elements (AIA, 2013a). For the first time, the *AIA Guide* (2013d) clearly explains the difference between Level of Detail and Level of Development making a comparison between the traditional approach and the BIM-based one, where there could be elements with high Level of Detail but very low Level of Development. The definitions of LOD in the AIA document (2013c) are a point of reference for other Countries such as France (Le Moniteur, 2014).

In 2011 a new group in the US, called BIMForum, started to work on a LOD Specification (BIMForum, 2013). In 2013, the *Level of Development Specification* was published including AIA's basic LOD definitions (2013c) for each building system and graphical examples of most of them (BIMForum, 2013). Definitions included in the *LOD Specification* (2013) were developed to address '*model element geometry*', taking into account three of the most common uses: quantity take-off, 3D coordination and 3D control and planning. The working group believed that by taking this approach, the interpretations would be complete enough to support other uses (BIMForum, 2013). Also in this case, the acronym LOD means Level of Development. The Specification should be used in conjunction with a project BIM Execution Plan, providing a '*means of defining models for specific information exchanges, milestones in a design work plan, and deliverables for specific functions*' (BIMForum, 2013). Also this document (BIMForum, 2013) provides a clear explanation on the difference between Level of Detail and Level of Development; the first can be considered as '*input to the element*', while the latter as '*reliable output*' (BIMForum, 2013). There are two main differences related to the LOD definitions between the Specification (BIMForum, 2013) and the *G202™–2013*. The first deals with the introduction of LOD 350 to enable coordination between disciplines (BIMForum, 2013). Only the *Guide* (AIA, 2013d) contains a reference to this new LOD (AIA, 20013, p. 60), even if it is not included in the *AIA Document G202™–2013*. The second difference is related to LOD 500 that has not been further defined and illustrated by the BIMForum working group (BIMForum, 2013). In 2014, a new version of the Specification was published adding new graphic illustrations in compliance with common building codes and at the end of October 2015 a new version was released with relevant updates (BIMForum, 2015). Indeed, for the first time non-graphical attributes were added and the Specification was divided in two parts: (1) Part A and (2) Part B (BIMForum, 2015). Part A, *Element Geometry*, basically defines required geometry and it is an extension of the previous version with a new appendix (BIMForum, 2015). Moreover, an interpretation of LOD definitions has been added for LOD 100, 200, 300, 350 and 400 (BIMForum, 2015). Part B, *Associated Attribute Information*, instead, is a Model Development Specification (MDS) spreadsheet that defines required attributes (numeric and/or textual) (BIMForum, 2015). Part B contains a Model Element Table where LOD, MEA and Notes can be defined for milestones (BIMForum, 2015). Moreover, there are Attributes Tables divided in three parts: attribute description, LOD profile and project-specific milestone (BIMForum, 2015). More attention should be paid while using this spreadsheet in order to create univocal information, because there is not an automatic correlation between the Model Element Table and Attributes Tables (e.g. to create consistent project-specific milestone). BIMForum Specifications have been

a point of reference for contractual documents (e.g. ConsensusDocs©301 (2015)) as well as several guidelines and protocols (e.g. Massport (2015) and Canada (AEC (CAN), 2014)). The NATSPEC (2013) published a BIM Paper on the use of BIM and LOD to promote the adoption of the BIM Object Element Matrix for non-geometrical data and LOD Specification (BIMForum, 2013) for appropriated geometry. This document should be updated to include parametric requirements of the latest BIMForum Specification (2015). In addition, the document (NATSPEC, 2013) refers to the use of 'Grade' developed by USACE (2012).

3.5 The UK introduces new definitions and acronyms

In the UK new definitions and acronyms have been set. Indeed, the *PAS 1192-2:2013* does not include the Level of Development but it defines the Level of Definition as '*collective term used for and including "level of model detail" and the "level of information detail"*'. The Level of Model Detail (LOD) is '*the description of graphical content of models at each of the stages*' and the Level of Model Information (LOI) is '*the description of non-graphical content of models at each of the stages'* (BSI, 2013). *PAS 1192-2:2013* defines seven levels of model detail and information (1-7). Moreover, Figure 20 contains example pictures for each level and other information such as permitted uses, output and parametric information (BSI, 2013). The CIC BIM protocol (2013) introduces the Model Production and Delivery Table (MPDT), a key document that '*both allocates responsibility for preparation of the Models and identifies the Level of Detail ("LOD") that Models need to meet at the project stages or data drops stated in the table*'. However, there is no any reference to the LOI. In February 2014, the Technology Strategy Board decided to develop a free-to use digital BIM tool and since October 2015, the final version of the 'NBS BIM Toolkit' has been available. Its aim is to integrate the classification system with the Digital Plan of Work to control the presence of required data at each phase. Indeed, for each stage (0-7) of the RIBA Plan of Work, the Employer's Information Requirements (EIRs) can be defined including the Level of Definition of each element. Thanks to this tool, at each stage of each project, it is possible to define details, roles, tasks and deliverables. In addition, for each deliverable a LOD, a LOI and a responsible entity should be set. The tool changed the definitions from 'Level of Model Detail' to 'Level of Detail' and from 'Level of Model Information' to 'Level of Information' but the same acronyms are used. Finally, the tool can verify a BIM against defined requirements. This tool is the first example of a digital platform for the definition of data within a BIM, taking into account the entire life-cycle of built assets. Recently, the new version of the AEC (UK) was released (2015) including definitions from the *PAS 1192-2:2013*. The protocol contains a new classification of *Component Grade* to be conformed to the Level of Detail (1-6) (AEC (UK), 2015). The acronym LOD has been added and 'Grade' is used as synonym for Level of Detail. Finally, the CPIC (2013) document requires a *Responsibility matrix for information production* to define 'who models what (the BIM Author) and to what Level of Detail (LOD)' for specific *Model Authoring* and *Model Analysis*; together with a *Task Information Delivery Plan* (TIDP) and a *Master Information Delivery Plan* (MIDP).

Table 1: Comparison of different classifications related to the management of data in the BIM

Source	Name	Authorship	Definition	Level						
Denmark: BIPS	3D Working method	Parties/ Responsibility	Information Level	0	1	2	3	4	5	6
Australia: CRC	Object data levels	Responsibility	Level of Detail	-	*A*	*B*	*C*	-	*D*	*E*
Vico Software	Model Progression Specification	-	Target Level of Detail/ Level of Detail	-	*100*	*200*	*300*	-	*400*	*500*
US: Department of VA	BIM Object/Element Matrix	Model Element Author	Level of Development (LoD/LOD)	-	100	200	300	-	400	500
Australia: NATSPEC	NATSPEC BIM Object/Element Matrix (BOEM)	Model Element Author (MEA)	Level of Development (LOD)	-	100	200	300	-	400	500
US: NYC DDC	Object Requirements	-	-Model Level of Development/ Level of Development (LOD) -Model Granularity	-	100	200	300	-	400	500 (?)
US: Pennsylvania State University	BIM Information Exchange – Level of Detail Matrix	Model Element Author (MEA)	Level of Development (LOD)	-	100	200	300	-	400	*500* *
US: US Army Corps of Engineers	USACE BIM Minimum Modeling Matrix (M3)	-	-Level of Development (LOD) -(Element Grade/Grade (A, B, C, +))	-	100	200	300	-	-	-
Netherland	Matrix and Project Template	Aspect-model	Information Level	0	1	2	3	4	5	6
US: AIA *E203™–2013*	Model Element Table	Model Element Author (MEA)	Level of Development (LOD)	-	100	200	300	-	400	500
France: Le Monieur	-	-	Level of Development (LOD)	-	100	200	300	-	400	500
US: BIMForum 2015	LOD 2015 Element Attributes Tables	Model Element Author (MEA)	-Level of Development (LOD) -Level of Detail -Element Geometry -Associated Attribute Information	-	100	200	300	350	400	500
Canada: AEC (CAN) 2014	Information exchange worksheet or modelling matrix	Responsibility	Level of Development (LOD)	-	100	200	300	350	400	500
UK: PAS 1192-2:2013	-	-	-Level of model Definition -Level of model Detail (LOD) -Level of model Information (LOI)	1	2	3	4	5	6	7
UK: CIC	Model Production and Delivery Table (MPDT)	Model Originator	Level of Detail (LOD)	1	2	3	4	5	6	7
UK: NBS BIM Toolkit	NBS BIM Toolkit	Responsibility	-Level of Detail (LOD) -Level of Information (LOI)	1	2	3	4	5	6	7
UK: AEC (UK) 2015	-	-	-(Level of Definition) -(Level of Information (LOI)) -Grade/Level of Detail (LOD)	1	2	3	4	5	6	-

Finally, it is important to take into account that CityGML (2015) has developed five Levels of Detail (LOD 0-4) to define geometrical details and semantic precision (Tolmer et al., 2014) to link BIM with Geographic Information System (GIS) data (Kang and Hong, 2015).

4. Discussion and Future scenarios: from static assembly to dynamic entities

Nowadays, there is still confusion on how to manage the content of a BIM and definitions are differently interpreted. This lack of consistent understanding could be due to the presence of different definitions and acronyms in the industry that have changed during the years, vary from different Countries and, sometime, are inconsistent. For example, the 'Level of Detail' was originally associated to the reliability of both geometrical and non-geometrical data (BIPS, 2007), but recently it deals more with the level of geometrical attributes (e.g. BIM Forum, 2015; AIA, 2013c; BSI, 2013). The same acronym 'LOD' is used for both Level of Detail (e.g. BSI, 2013) and Level of Development (e.g. BIM Forum, 2015); similar concepts are differently called (such as 'Level of Information' (AEC (UK), 2015) and 'Associate Attribute Information' (BIM Forum,

2015)); and the Level of Development is associated both to elements (e.g. BIM Forum, 2015; AIA, 2013c) and the entire model (e.g. NYC DDC, 2012; Massport, 2015).

Usually, space programming and BIM authoring follow an elemental approach mirrored in the EIRs and BIM Execution Plans. However, thanks to the BIM Toolkit, the progressive maturity of the assemblies might be decoupled. The LOD Specification allows managing the different speed on the elemental basis, whilst the NBS BIM Toolkit makes it affordable on a sub-elemental degree, because LOD and LOI could be split and data might be misaligned. Such an assumption has to be felt as disruptive, because it implies that different players could concurrently manage shareable and accountable data upon the same element or assembly according to different progressions. Thus, in spite of pursuing the traditional BIM uses, the linear progression of the design stages is clearly hampered, because the original space programs could be troubled by the architectural digital sketches as far as general construction is concerned. For this reason, Drobnik and Riegas (2015) suggest to introduce a Level of Development (LOD) 0 as well as a negative one (e.g. LOD -100) due to the complexity of the iterative design process. Meanwhile, heterogeneous elements have to be handled within a Common Data Environment (BSI, 2013) or rather, within a digital eco-system merging hardware and software on the internet of buildings, infrastructures, grids and things. Unfortunately, such a stressing elemental perspective, where the design teams are asked for anticipating the progressions and are stimulated for optioneering the solutions, is additionally burdened by the behavioral and interactive design. The simulated users' and passengers' behaviors, as well as the simulated flows and motions, engender some spatial syntaxes and options which could be, on a real time basis, interactively checked and validated by means of immersive environments (CAVEs or portable devices). Indeed, dealing with game engines, more and more, the BIM will have to take into account not only *discrete* Level of Detail, but also *continuous* LOD (CLOD) (DigitalRune, 2013). Moreover, the validation plays a key rule for the success of Data-Driven Projects and Model Checking should be used to control the content of the BIM as discussed also by Hopper (2015). Today, the control of different Levels (e.g. of Detail, Information and Development) is still difficult and the NBS BIM Toolkit tries to fill this gap. However, more effort is needed to validate the information flow related not only to EIRs, but also to the Facility Management data. In addition, the pre-occupancy management requires the involvement of potential users within the early design stages, because more and more an intelligent clientship deals with a ‘to be’ servitized and sensored built asset. Therefore, a question is arising, stemming from the aforementioned remarks: could such a design process be consistent with the traditional elemental approach centered more on static (objectual) assembly rather than on dynamic (motional) entities?

5. Conclusions

This study indicates that there is not a univocal approach to define and manage the content of a BIM and several definitions and acronyms have been defined in different Countries, especially in US and UK. However, it is possible to compare them and find similarities. Results can be used to get an in-depth understanding on this topic, especially for experts who work with BIM in several Countries. Finally, the authors believe that in the future Model Checking should be included in the process and more flexibility is needed moving from static assembly to dynamic entities.

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