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Building Information Modelling: Present realities and Future possibilities

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Abstract. BIM (Building Information Modelling), a term that is drawing the attention worldwide in the construction industry and governments, is a complex concept that involves management effort, tools and applications for enhancing information flow and therefore productivity for projects. This article pretends to briefly explain BIM, its advantages, challenges and potentialities while considering the current adoption of the concept in some countries. Furthermore, the article includes suggestions for the implementation of BIM in an organization as well as in projects and a list with some useful tools for this purpose.

Introduction

In the past, the hand-drafted designs were the standard for the construction industry. Then the computer aided design (CAD) programs appeared to revolutionize the sector, after a while, CAD became the new standard, improving the efficiency and information management for projects. [10]

CAD software has upgraded a lot since then, now there are multiple functions that allow not only design but test and analyse buildings, nevertheless, there still exist opportunities for improvement. Now, the construction industry, governments and naturally, software developers are aiming to the concept of "Building Information Modelling". [4] [10]

1. BIM concept

In the construction, architectural and engineering production it is possible to find a misunderstanding of what Building Information Modelling is.

Some specialists might think and say that BIM is only software. To a certain degree it is true, during the realization of a project, software tools are needed, however, these tools are just one of the means for implement and apply a bigger concept. [4]

According to National BIM Standard United Sates, 2010: Building Information Modelling (BIM) is "a digital representation of physical and functional characteristics of a facility. As such it serves as a

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shared knowledge resource for information about a facility forming a reliable basis for decision during its life cycle from inception onward" [1]

BIM can be understood as a methodology that combines and integrates all possible information about a facility throughout its life cycle by means of collaborative work and the exchange of data between all involved participants. Every change, every input of information into the project is reflected instantly in a shared file so that everybody can be aware of it and hence adapt the design to the change. [4][7]

This integration driven by the collaborative work opens many possibilities for enhancing information management and decision making for owners, designers, engineers, constructors, facility managers, public institutions, etcetera. [7]

In the practice, BIM helps to coordinate the following aspects about a building or facility:

- Design visualization and exploration.
- Cost estimation.
- Quantification of necessary materials and components for the construction.
- Clash detection between designs (e.g. comparing predesign of a building against the as built model).
- Control and schedule the progress of the construction.
- Incorporation of additional information into the model (e.g. construction of a new additional floor in a building) [4][5][6]

2. BIM Implementation

BIM Implementation is a change in the way of working of an organization, since the most important element of it is the collaborative work, without it, any stated objective will not be feasible. Therefore, the first step to apply BIM is responsibility for both the project leader and the manager, who should encourage and motivate everyone to work as a coordinated team. [4]

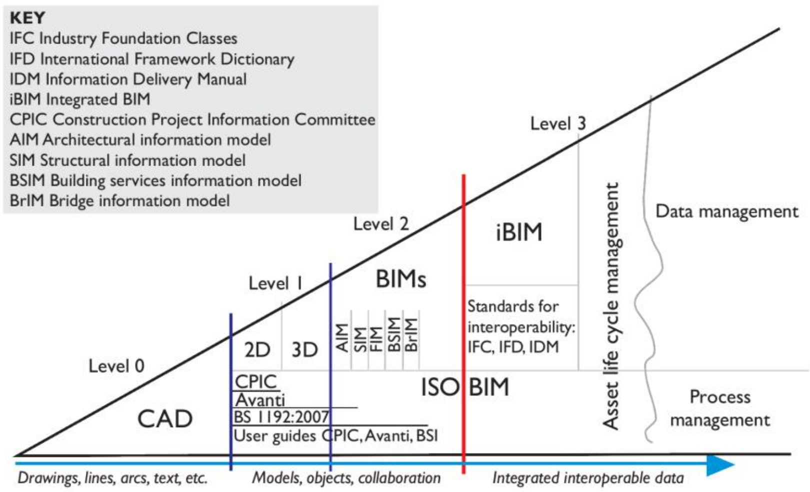

Figure 1. ['Wedge diagram' (redrawn from Bew and Richards, 2008) (Bimal Kumar" A Practical Guide to Adopting BIM in Construction Projects", Whittles Publishing, 2015)]

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On the other hand, the implementation of BIM methodology can be divided according to the maturity of the collaboration among the parts and the amount of information integrated into the model as follows:

- *Level 0:* In this level, there is no collaborative work. The model of the building is only a visual representation in two dimensions (2D) that is made with basic lines and text information (e.g. "pdf" file or architectural drawings).
- *Level 1:* Exists partial collaboration between the owner, architect and engineers. The architectural visualization of the building is more detailed with models in two and three dimensions (2D, 3D). This level is easily achievable with current available tools. Most projects are currently in this level.
- *Level 2:* The model is not only a visual representation, now the components have technical properties, for instance, the composition of the walls (e.g. Brick, concrete, etc.), mechanical resistance, fire resistance. The construction components can be divided in elements such as walls, beams, columns and list of materials can be obtained directly from the 3D model as well as schedules and cost estimation. This level represents full collaborative work among all the parties.
- *Level 3:* The update to reach this level is the collaboration in real time with a server based on the cloud that grants, for all members of the team, access to a shared file and the possibility of editing it in real time. The file should allow multidisciplinary work so that everyone, independently of their field, can use the same model for their work (e.g. engineers and architects using the same file at the same time). This level represents real time sharing and full integration of the data. [4][5]

  In this level, the problem of the compatibility arises since in the present time, making owners, designers, engineers work along in the same platform is not possible. However, there are advances and developments aiming for this objective.

In order to work with BIM at level 3, a common protocol, standard or platform is needed, therefore, one approach can be to use file-based data interoperability, this means a file format that can be compatible for importing and exporting to the different tools of the different parties involved in the project. In this context, the Industry Foundation Classes (IFC) offers a solution, being a data model that intents to describe the data used in the AEC (Architecture, Engineering and Construction) industry.

The IFC is an open and available file format standard that is registered as an ISO 16739:2013. The IFC Classes were developed to create a large set of consistent data representations of building information exchange between AEC software application, such as BIM Modelling tools and were designed to address all building information, over the whole building lifecycle, form, feasibility and planning, through design (including analysis and simulation), construction, to occupancy and operation. [13]

Usually, software applications store the building information in a native format. In order to make this valuable information available to other project participants, their software applications either all have to understand the native formats of the other applications (which is the main problem of compatibility), or preferably, they support IFC as the open format for building information models. Then, IFC can be used to exchange and share BIM data between applications developed by different software vendors without the necessity to support numerous native formats. As it is an open format, it

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does not belong to a single software vendor and therefore neutral and independent of a particular vendor's schedule and development direction. [5]

However, the file-based interoperability means only one further step in the path to achieve the greater goal of integrating the tools and collaborators for BIM.

2.1. Implementation of BIM in an organization

To implement BIM methodology inside an organization, managers can follow the next steps:

- Strategic planning of BIM in the organization.
- Creating a team for the implementation or searching a BIM consultant.
- Evaluating actual situation of BIM maturity level and setting a desired level or goal
- Creating a Roadmap (Assigning and scheduling tasks and responsibilities)
- Assessing information needs for the model: What information is needed for collect and integrate into the model, how many parameters or properties will be added.
- Creating infrastructure: Since there are various packages in the market, it is important to choose the proper software tools, fitted for the company needs. Hardware capacity and physical spaces are also an important aspect, generally the software tools require high end hardware. On the other hand, according to the complexity or the location of a project, sometimes is necessary to install an office in the site of the construction to use the equipment for BIM (e.g. mobile offices adequate in containers).
- BIM Personnel: Having the proper personnel is one of the most critical factors for successful implementation of BIM. The company should decide if they can train current personnel or hire a new qualified team. [5][8]

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2.2. BIM Implementation for Projects

After determining the valuable information for the model (construction elements, properties, technical parameters), it is necessary to decide what Level of Development (also known as LOD) is required for each element or component. [2][4]

LOD No.	Level of Development	Description
LOD 100	Schematic Design Model	Overall building massing indicative of area, height, volume, location, and orientation may be modelled in three dimensions or represented by other data.
LOD 200	Design Development Model	Model Elements are modelled as generalized systems or assemblies with approximate quantities, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements.
LOD 300	Construction Documentation Model	Model Elements are modelled as specific assemblies accurate in terms of quantity, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements.
LOD 400	Construction Model	Model Elements are modelled as specific assemblies that are accurate in terms of size, shape, location, quantity, and orientation with complete fabrication, assembly, and detailing information. Non-geometric information may also be attached to Model Elements.
LOD 500	Record Model	Model Elements are modelled as constructed assemblies actual and accurate in terms of size, shape, location, quantity, and orientation. Non-geometric information may also be attached to modelled elements.

Table 1. Levels of Development description. [AIA 2013]

Choosing the proper LOD for each element and phase of the design and construction will allow modellers to reduce the time consumption for the project, focusing in the information that is really valuable for certain elements and not investing time with additional information that is not useful neither for the customer or the constructors. [2][9]

2.3. BIM for existing buildings

So far, the benefits of BIM when creating a project starting from zero and going on from there have been mentioned, however, BIM possibilities are not constrained to new constructions. Although the application can be more complicated, already existing buildings can be modelled in order to create the digital representation of them, integrating useful information for further renovations, maintenance and operation.

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The problem with some existing buildings is the absence of information such as drawings, structural details, composition, etcetera. Similarly, if such information is available, it lacks accuracy since the changes to the structure through the years, or changes in the construction from the original design were never recorded, especially for old buildings. In this case, it is necessary to gather the whole information of the building, its geometry, shape and other characteristics such as room dimensions, size of doors, pipes and electrical equipment, etcetera. Manually doing this task includes making in-site measurements using traditional tools such as laser meter or even meter tape, a task that can be both time consuming and risky depending on the location and conditions of the structure. Additionally, manual measuring is prone to human errors due to the number of measurements needed to fully map a whole building.

In this context, technology plays a key role, since nowadays exists 3D laser scanners, a faster, more precise and even safer option than the traditional manual methods. Terrestrial Laser Scanning (TLS) or High Definition Survey (HDS) is a technology which was first introduced as a measurement tool to help surveyors to take measurements of the buildings in an accurate, reliable, and time efficient way by 1998. These laser scanners have gone through a number of changes through the years and now we are able to have such scanners which rotate in 360 degrees. The rotation in 360 degrees enables the scanner to complete the whole structure around. This technology works on basic principles of physics and science where a laser is emitted from the device which hits the objects and bounces back with all the objects placed in surrounding up to its limit. This bounced back laser thus generates a laser pulse to the scanner and the objects are recorded. The scanners are capable of recording thousands of points in one second and every point recorded has its own position, height, intelligence and coordinates. These recorded points later become the origin for the point clouds where all the points are integrated in the same local coordinates to obtain the so-called point cloud. The point clouds received are what forms or represents the building or object being scanned in the 3D space. [11]

The laser scanner, depending on the model, can scan the buildings from relative long distances (100-130 meters) allowing engineers, architects, designers and other professionals to map the buildings without exposing themselves, then preventing risky situations when the site for the measurements is considered dangerous, difficult to walk, etcetera. This is why this technology is widely used in the field of archaeology since the researchers can scan difficult to access spaces.

Nevertheless, transforming point clouds (laser scanning) to 3D BIM models without any manipulation is still a challenge but the scanning speeds up the whole process, especially for large buildings. The automated "scan to BIM" tool is still in development phase, but a good approach is to work the model in stages:

- Registration: First processing the point clouds with specialized tools such as Trimble RealWorks® to filter and clean. This means aligning the 3D points to make them visible through overlapping the successive scans from different parts of the building.
- Cleaning noises: Some undesired objects like people, cars or animals can be scanned unintentionally during the process due to the reflections of the laser in some surfaces so they need to be removed.

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- Segmentation: Smoothing the modelling to allow isolated object to be created and separated from the point cloud.
- Exportation to a BIM modelling tool: After the segmentation, the file has to be exported so it can be used in a BIM modelling tool such as Revit® Architecture to vectorize the profiles required for the 3D model and finish the desired details. [12]

There are also available tools such as EdgeWise® that runs algorithms for the detection of objects such as planes, walls, windows, pipes and cables which are available in Revit (BIM) inventory. This automatic detection is a time efficient tool which results in effort reduction during the modelling phase in Revit® Architecture. [12] Although, sometimes it is difficult to extract all the geometric information from the cloud points since the files are usually huge with an immense amount of points, furthermore, in some cases the geometric forms are not in the software library and have to be manually modelled.

On the other hand, the laser scanning method can reach high initial costs because of the BIM the 3D laser machine, the point cloud data management software, the training of the personnel and the cost of the computers running the software. Then, the cost is a major constraint for the use of this method.

However, the benefits of BIM in existing buildings cannot be neglected as it can help for the maintenance management, as-built documentation, energy management, energy rehabilitation, emergency management, renovation plans, etcetera.

2.4. Available tools for BIM

Software development is improving every day, nevertheless and unlike what BIM suggests, to the present time, there is still not a one and single tool that can handle by itself, all the multidisciplinary work from all the involved parts in a construction project.

One approach in order to address this problem is the "Model Manager". The Model Manager is a person or a team (according to the magnitude of the project) with wide knowledge about different software tools, servers and databases that can collect, check, and integrate the information received from every participant involved in the project. Thus, creating organized files for effective information management so that it can be easily shared for the interested parties. [5]

The adoption of the Model Manager can help the construction industry to take advantage of the commercially available software packages for implementing BIM despite the absence of the desired tools.

In the market, it can be found several software tools for construction projects. These are developed for specialized applications such as design, simulation, testing, among others and are used by professionals from different fields, for instance, we can mention tools for owners, engineers, architects and construction managers. [5]

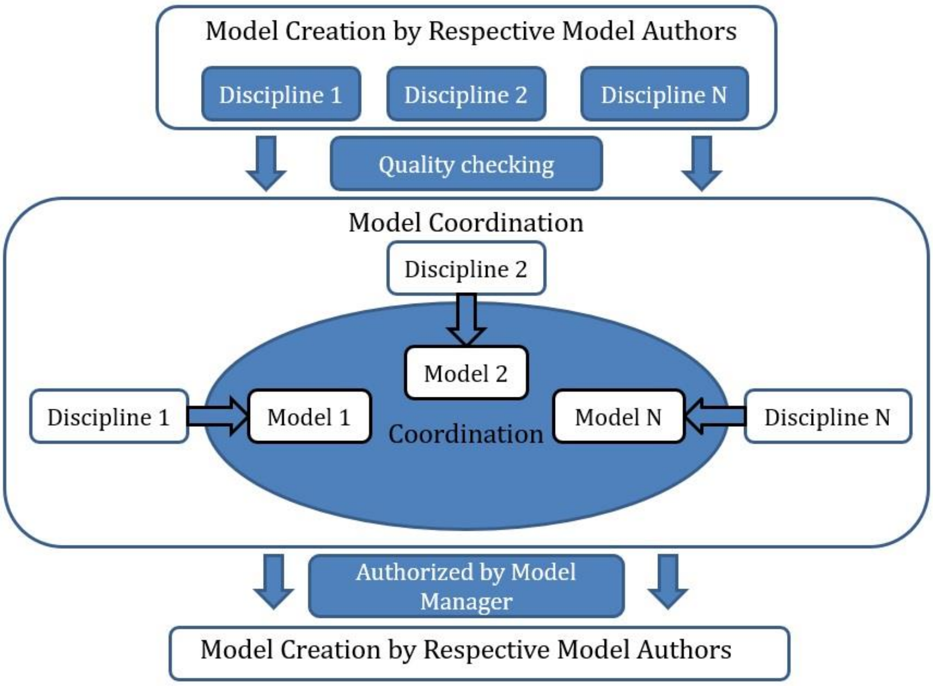

Figure 2. Model Manager workflow.
(redrawn from Sagar UB, 2014) (Sagar Ub "BIM 101: An overview for beginners", 2014)

Nevertheless, when working using only the tools from a same software manufacturer like for instance the Autodesk® suite, there are some special tools that allows coordination among the team members through uploading to the cloud all the models in order to create an integrated one that can be available for all the members even from their smartphones or tablets. Therefore, the model can be accessed from any location, anytime as long as an internet connection is available.

With such tools, it is possible for the participants to do quality control, clash detection, comments, approving designs, furthermore, the whole team is notified through the application. At the same time, such systems are based in cloud computing, which means that there is no need to install huge files for processing the information since it is retrieved from an online source in the cloud.

Some examples of these software tools are Autodesk® BIM 360™, Trimble® Connect, Graphisoft® BIMCloud®, Bentley® Suite, etcetera.

The shortcoming of the mentioned programs is that in most of the cases they are to work with software packages from the same manufacturer and then restricting its usage and compatibility with other platforms.

2.4.1. Software Tools for Owners and Building Managers

Owners are usually interested in visualizing and exploring the building designs to check if the construction is progressing according to the plan, to review the schedules, estimate costs and to audit

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trough comparing the initial model against the as built one. They also manage or control access to the servers where all the information is stored. [5][8]

On the other hand, facility managers can be interested in operational aspects such as simulation of crowd evacuation in an emergency situation, and thus, check if the design of the evacuation routes will work in an effective way. There are also available tools for creating a database with operational information that can be used to anticipate maintenance needs. [5]

Area of application	Product	Description	Manufacturer
Model viewing and examination	Acrobat Reader DC	Tools for interactive navigation in (.pdf) format	Adobe® Systems
	Design Review	Tools to navigate in standard formats like DWG, DWF. It is not possible to edit the model	Autodesk®
	Navisworks®	Model Viewer and clash detection between different files or designs	Autodesk®
Model databases and servers	ProjectWise®	Tool to store and manage access to the model and its data either at a host site or on an internal server and network	Bentley®
	EDMmodelServer™		Jotne® IT AS
Management of Facility and assets	ArchiFM	Use Building Model to generate space components and thus entering facility information to create a facility management database	Graphisoft®
	BIM 360™		Autodesk®
Crowd simulation	IES Simulex	Tool for simulation of evacuation and movement of crowds	Integrated Environmental Solutions (IES)

Table 2. Commercially available Software Tools for Owners and Facility Managers. [5]

2.4.2. Software Tools for Engineers and Architects

Engineers and Architects have a wide range of tools for their respective fields, visual design is one of the most developed fields, since some projects can be rendered to look like a real construction even in the concept design phase, helping to the cost estimation and decision-making process in early stages.

For the building structure and systems, design, testing and simulation tools are available for measure various engineering aspects such as energy performance, air conditioning, heating, mechanical resistance, acoustic analysis among others.

It is in this field where most of the multidisciplinary conflicts appear, since every professional or company usually employs their preferred tool for each aspect of the building under their limited responsibility, for instance, pipe system design, electrical and communication networks, etcetera. However, some software manufacturers offer compatibility among related tools that allow importing and exporting information from one to the other. [5]

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Area of application	**Product**	**Description**	**Manufacturer**
Predesign and Feasibility	Revit® Architecture	Architectural Modelling and parametric design	Autodesk®
	AECOsim Building Designer	Architectural and engineering Modelling	Beck Technology
	SketchUp Pro	Conceptual Design Modelling	Trimble®
	ArchiCAD	Architectural Model creation	Graphisoft®
Building System and properties design	Revit® Structure	Structural Modelling and parametric design	Autodesk®
	Revit® MEP, AutoCAD® MEP	Mechanical, electrical and networks design	Autodesk®
	Bentley® BIM Suite	Architectural, Structural, Mechanical, Electrical and Generative Components - all within the 3D modelling environment	Bentley®
	Tekla® Structures	3D Structural Modelling, Detailing, Fabrication and Construction Management	Tekla®
	MEP Modeler	3D Mechanical, electrical and networks modelling	Graphisoft®
Analysis and Simulation	Green Building Studio®	Measure energy use and carbon footprint	Autodesk®
	Revit® product family	Weather, energy, water, carbon emission analysis	Autodesk®
	ApacheHVAC	Heating, ventilation and air conditioning plant simulation	Integrated Environmental Solutions (IES)
	Acoustical Room	Acoustic Simulation and Analysis	ODEON

Table 3. Commercially available Software Tools for Engineers and Architects. [5]

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2.4.3. Software Tools for Construction Managers

Software manufacturers offer various tools for construction managers in the aspects of scheduling, cost estimation and clash detection.

Area of application	Product	Description	Manufacturer
Estimating quantity of resources	Navisworks® Simulate	3D model simulation with cost estimating for lifecycle operational cost	Autodesk®
	DESTINI Profiler	Conceptual 3D modelling with cost estimating and life cycle operational cost	Beck Technology
Scheduling	Navisworks® Simulate	Linking 3D model to popular project schedule application (e.g. MS Project)	Autodesk®
	ConstructSim®		Bentley®
	Synchro PRO	BI-directional linking to popular project schedule application (e.g. MS Project)	Synchro Software
	Tekla® Structures	Schedule Driven by link between model and project software	Tekla®
Construction Management	Navisworks® Manage	Model-based clash detection between trades	Autodesk®
	ConstructSim®	Coordination between models and disciplines	Bentley®
	Solibri Model Checker	Quality control of models based upon rule sets and spatial requirements	Graphisoft®

Table 4. Commercially available Software Tools for Construction Managers. [5]

The clash detection software is one of the most useful for implementing BIM considering it helps to identify mistakes and changes in the designs while comparing, for instance, the drawing of the architects against the drawings of the engineers. This detection makes the communication of changes among the involved parties in the project an easier task, so that everyone can adjust the model and make the necessary corrections and improving the collaborative work. [6][5]

3. BIM Statistics

The world map of BIM is very different. According to statistics there is not a unique standard which is possible to use everywhere. Furthermore, in some countries BIM standards have high level of elaboration in distinguish while in other countries it is still difficult to start using BIM as a standard. As we can see in the picture, the level of BIM development does not depend on the location. In the Figure 3 it is possible to distinguish 5 categories:

1) Open BIM Standards & Mandate
2) BIM standards obligatory in place
3) BIM standards scheduling in the future

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4) BIM Programmes planned

5)No BIM requirement [3]

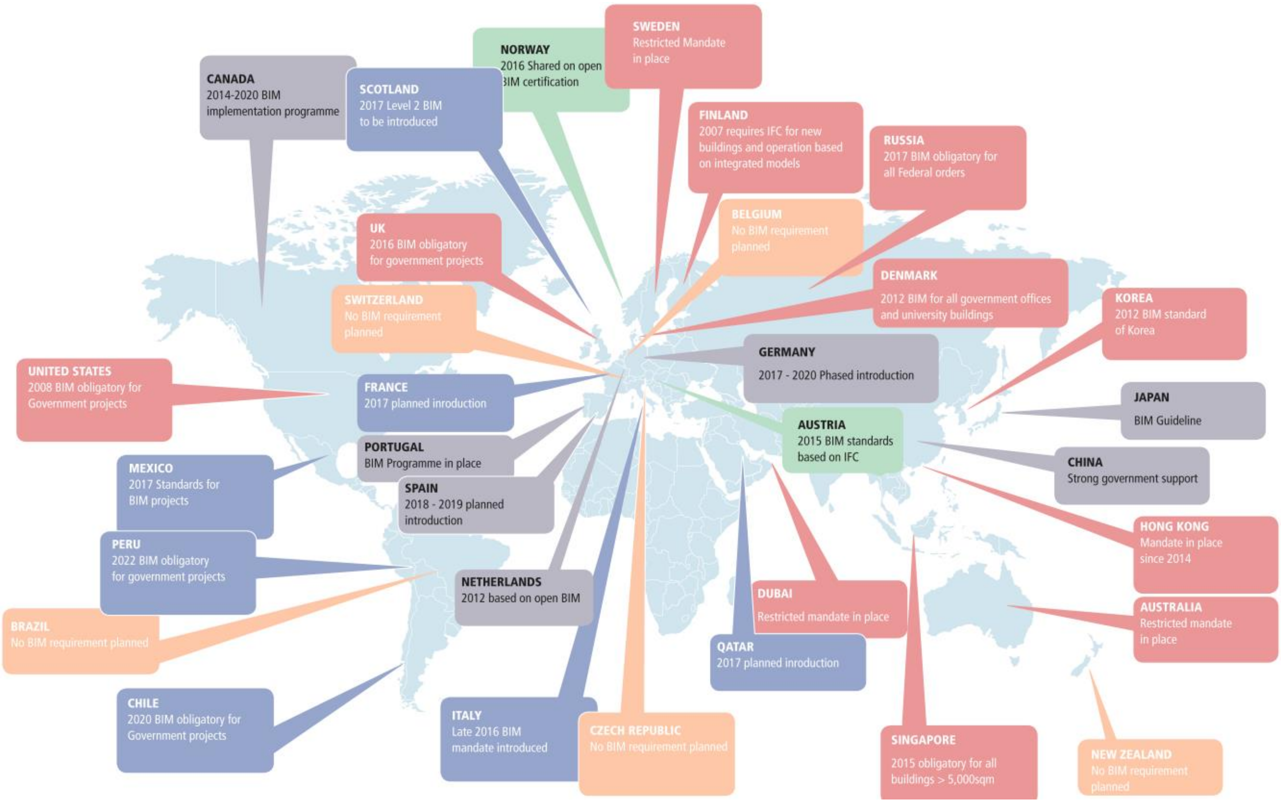

Figure 3. Overview of Global BIM Adoption.
(McAuley, B., Hore, A. and West, R. (2017) BICP Global BIM Study - Lessons for Ireland's BIM Programme. pp.9. Published by Construction IT Alliance (CitA) Limited, 2017. doi:10.21427/D7M04.)

According to the first category: the first countries that implement BIM as an open standard were Austria and Norway. Austria started in 2015 through non-profit service organizations, in comparison with Norway, where the government established a national mandate in 2016.

However, the first country that started to use BIM as an obligatory standard was Finland. For instance, Finland started pilot projects since 2001. During the time, USA, Denmark, Korea and other countries attached to the concept. In USA there was an increasing tendency for BIM implementation from 28% in 2007 to 71% construction specialists that used BIM in 2012. Denmark was also early adopting BIM in public construction and reached the amount of 1365 projects in 2007 [3].

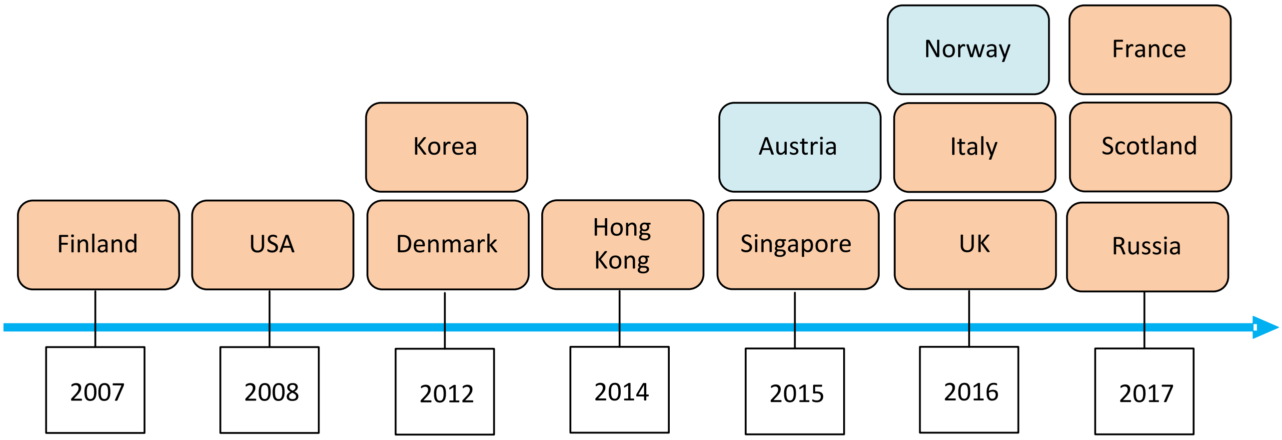

Figure 4. Open BIM Standards and BIM Standards obligatory in place.[3]

	Regulation	**Responsible organization**	**Name of standards**
Austria	2018	Austrian Standards Committee	1. ONORM A 6241-1 (2015) - Part 1: CAD data structures and building information modelling – Level 2. 2. ONORM A 6241-2 (2015) - Part 2: Building Information Modelling (BIM) – Level 3 iBIM.
Norway	Mandated in 2016	1. Statsbyg buildingSMART Norway 2. Norwegian Homebuilders Association	1. Statsbyg BIM Manual 1.2.1 (2013) 2. Norwegian Home Builders Manual Version 1.0 (2011)

Table 5. Open BIM Standards & Mandate. Main characteristics. [3]

	Regulation	**Responsible organization**	**Name of standards**
Finland	1. Senate Properties (2007) 2. Finish Transport Agency – Inframodel 3 (LandXML) (2014)	1. Confederation of Finnish Construction Industries buildingSMART (Finland) 2. Senate Properties (Senaatti)	1. BuildingSMART (InfraBIM requirements, 2015) 2. BuildingSMART (Common BIM Requirements, 2012a)
USA	Multiple Mandates through different states	1. GSA 2. USACE 3. National Institute of Building Science buildingSMART USA	NBIMS, (2015), National BIM Standard-United States, Version 3, July 2015
Denmark	Mandatory requirement since 2007 (extended adoption in 2011)	1. BIPS buildingSMART (Denmark) 2. Bygningsstyreelsen (Property Agency) 3. Ramboll	1. Danish Building Classification System and 3D Working Method guideline (BIPS, 2007)
Hong Kong	Mandate in place since 2014	1. The Hong Kong Institute of BIM (HKIBIM) 2. Hong Kong Housing Authority (HKHA) 3. Real Estate Developer Association buildingSMART (Hong	1. Construction Industry Council, (2013), Roadmap for Building Information Modelling Strategic Implementation in Hong Kong's Construction Industry, V 1.0, September 2014 2. HKIBIM, (2011), Specification Hong Kong

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		Kong)	Institute of Building Information Modelling BIM Project Specification, HKIBIM Specification (Rev 3.0)
Singapore	Mandate in place since 2015	Building and Construction Authority buildingSMART Singapore	Building Construction Authority, (2013), Singapore BIM Guide Version 2.0, August 2013
UK	Mandated since 2016	1. UK BIM Alliance 2. Construction Industry Council 3. UK BIM Task Group buildingSMART UKI	1. Cabinet Office (UK), (2011), Government Construction Strategy, UK Government Cabinet Office, London 2. BSI, (2011) A report for the Government Construction Client Group. Building Information Modelling (BIM) Working Party strategy paper, 2011 3. BSI, (2013), PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling
Italy	Mandated on projects over €5,225 million from 2016	Institute for BIM Italy (iBIMi) buildingSMART (Italy)	Unknown
Scotland	Mandated for 2017	Scottish Futures Trust	Scottish Futures Trust, (2015), Building Information Modelling (BIM) Implementation Plan, September 2015
France	Mandated for 2017	Le Plan Transition Numerique dans le Batiment buildingSMART (France)	Le Plan Transition Numerique dans le Batiment, (2015), Plan for the digital transition in the building industry, June 2015.

Table 6. BIM standards obligatory in place. Main characteristics. [3]

Other group of countries: Qatar and Chile decided to implement BIM standards scheduling them for the future. For example, Qatar is planning to build mega projects like Doha's Metro system and sporting stadiums for FIFA World Cup 2022. Similarly, Chile is planning to reach BIM implementation for public projects by 2020 and for private projects by 2025. Also, they expect to reduce the project's cost and production time by 20% with BIM implementation. [3]

	Regulation	**Responsible organization**	**Name of standards**
Qatar	No regulation to-date	Q BIM Future BIM Implementation Qatar 2017	Unknown
Chile	BIM Mandated for 2020	BIM Forum Chile National Economic Development Agency (Corfo)	Chilean 10-year BIM Plan (Soto et al, 2015)

Table 7. Future Mandates fixed. Main characteristics. [3]

Canada, Portugal, Spain, Netherlands, Germany and China, have a plan for BIM standards in the future. For example, the Canadian Institute for BIM in Canada (IBC) created a Roadmap for Lifecycle BIM to cover six areas: Engage, develop, educate, deploy, evaluate and sustain. In Portugal there is still

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absence of regulations for BIM, but it is possible to find a roadmap goals to realise the vision of a technologically advanced construction sector that will be led by progressive companies and supported by a skilled and competent workforce during the 2020s. However, in Spain BIM is recommended to use in the public sector by 2018 and obligatory to use in public infrastructure projects which cost more than two million euro. [3]

Finally, the last group, which includes: Switzerland, Belgium, Brazil, Czech Republic and New Zealand do not have BIM as a standard, only as a guide or handbook. [3]

Governments over the world understand efficiently that they can give implementing regulations for public projects, this may lead to private companies improving productivity.

	Regulation	**Responsible organization**	**Name of standards**
Canada	No regulation to-date	1. Canada BIM Council (CanBIM) 2. Institute for BIM in Canada (IBC) buildingSMART (Canada)	1. AEC(CAN) BIM Protocol (AEC-CAN, 2014) 2. Canadian BIM Practice Manual (CanBIM, 2015)
Portugal	No regulation to-date	1. BIM Forum Portugal 2. BIM Management Institute (BIMMI) 3. BIMCLUB University Initiative Portuguese Technical Committee for BIM Standardisation	Unknown
Spain	Mandated for 2018	Comisión para la implantación de la metodología BIM buildingSMART Spain Standardization Committees AEN/CTN 41/SC13	Unknown
Netherlands	No Mandate	1. BIM Loket 2. Building Information Council TNO 3. Boun Informatie Raad buildingSMART (Benelux)	BIR (2016), National Model BIM Implementation Plan (Nationaal Model BIM Uitvoeringsplan) Release 1.0 – 1 October 2016 Information Modelling BIM Project Specifi cation, HKIBIM Specifi cation (Rev 3.0)
Germany	Mandated for 2020	Planenbauen 4.0 DIN VDI buildingSMART (Germany)	Federal Ministry of Transport and Digital Information, (2015), Road Map for Digital Design and Construction: Introduction of modern, IT-based processes and technologies for the design, construction and operation of assets in the built environment
China	BIM required through the 12th national Five-Year Plan	China BIM Union	McGraw Hill Construction (2015), The Business Value of BIM in China, SmartMarket Report, McGraw Hill Construction, Bedford MA, United States

Table 8. BIM Programmes planned. Main characteristics. [3]

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	Regulation	**Responsible organization**	**Name of standards**
Switzerland	No regulation to-date	Digital Construction Switzerland Syndicate buildingSMART Switzerland SwissBIMalliance	Open BIM Guide for Switzerland (To be published in 2017)
Belgium	No regulation to-date	The Belgian Building Research Institute Association of Major Belgian Contractors buildingSMART (Benelux)	Belgium Guide to Building Information Modelling (Colophone, 2015)
Brazil	Roadmap under review / consideration	1.BIM Interdisciplinary Group 2.BIM Brazil Network	A Roadmap for BIM Adoption in Brazil (Kassem, 2015)
Czech Republic	No regulation to-date	1. The Czech BIM Council 2. Expert Council for BIM	Unknown
New Zealand	No regulation to-date	BIM Acceleration Committee	BIM Acceleration Committee, (2014), New Zealand BIM Handbook, A guide to enabling BIM on building projects, July 2014.

Table 9. No BIM requirement. Main characteristics. [3]

High developed countries like USA, Korea, Denmark, Hong Kong are pioneers in the implementation, and they are aggressively trying to implement it. For instance, some Scandinavian countries have been working with BIM standards and regulations since almost ten years ago. [3]

In summary, it will be a matter of time for BIM to become a global reality since everyone recognise it is the next logical step for the evolution of the construction industry. For example, even the emerging economies countries like Peru are planning a further implementation of the regulations and standards.

4. Challenges and possibilities of BIM

Regardless of all advantages we have described before BIM is a still in the growth phase of development. At the present moment there are challenges to overcome:

- Considering BIM is relatively new, there are some initial risks in its implementation, like professionals and customers resistance to new changes.
- Software Vendors usually advertise their software packages as if they by itself are BIM and then not focusing in the real concepts.
- Current contractual forms clearly separate and define independent responsibilities for each contracting part. However, in a BIM environment it is necessary to share responsibilities and shared risks, thus new contractual forms should be developed, as well as a new business model for the collaborative work.
- The lack of personnel with BIM knowledge and skills make companies depend on consultant services that might not fulfill our needs.

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- The intellectual property rights generated in the BIM is one of the most challenging problems for the future. In the BIM project every participant contributes to the final design, hence with all stakeholders being able to share project information and add details to the project model, the copyright limitation will be not clear, which can lead to legal disputes. To further complicate this issue, there may be inadvertent sharing of proprietary information, trade secrets, or patented processes. Confidentiality as well as ownership rights may be compromised.
- In theory, BIM relies on a single information store and tool that meets the needs of all project participants. That is still far from reality since the Interoperability conflicts should be addressed first.
- The big data needs proper Cloud technologies with enough capacity to host and protect the model files and allow various users to access and edit them at the same time.
- The new professionals should receive BIM training during their studies to work with the last technologies in industry. [5][6] [10]

On the other hand, the future of BIM is full of potentialities. We will list some below:

- Possibilities of simulating buildings operation during different conditions, for instance crowd behavior in emergency situation or rush hour.
- If we take advantage of current available technologies like QR codes, archive and share information will be easier, for instance, the operation manuals, electrical diagrams, can be accessible scanning a code instead of looking for a hard copy of the documentation.
- 3D Printers – Integration with BIM Software as a part of prototype before building construction would save time and improve productivity for engineers and designers. When the design can be rigorously tested before it is built, designers will have freedom for their creativity.
- During the project realization clients being aware all the time for the last changes would avoid false expectations.
- Virtual walking tours can become reality through virtual reality glasses, which can provide a more realistic experience, not only for owners, but for designers and engineers to detect problems and improving possibilities.
- Artificial Intelligence powered Software tools can open new possibilities for helping in the design and construction, offering suggestions for minimizing cost, increasing quality, efficiency, etcetera. For instance, machine learning that can recommend changing the shape, construction material for better resistance.
- Information can be shared for emergency services, as public information. For example, it would be possible for firefighters to pull up the building's 3D model from the city's database to identify the location of fire extinguisher, shutoff valves, and emergency exits before reaching the place of the emergency. Moreover, local governments could analyze risks from natural disasters with proper information about the buildings. On the other hand, environmental agencies can simulate energy performance and estimate carbon footprint. [5][6] [10]

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5. Conclusions

At the present time there are still some software vendors who advertise their products as BIM, while it is a big concept that is based on the collaborative work among all the parts involve in the project.

Despite there is not only one tool for BIM, is possible to implement it using the Model manager during the realization of project. This person will be responsible for collecting, sharing and information flow for each step of the project.

Statistics show that most of the developed countries already implemented BIM for large projects as well as governments require it for public contracts. However, around the globe, more and more countries are interested in implementing BIM and some of them even established roadmaps for it. This shows how important this concept have grown and that it has potential for the future.

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