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BIM: Building Information Management (not Modelling)

Kevin Deegan
Technological University Dublin, kevin.deegan@tudublin.ie

Malachy Mathews
Technological University Dublin, malachy.mathews@tudublin.ie

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Author 1: K. DEEGAN, kevin.deegan@dit.ie
Author 2: M. MATHEWS, malachy.mathews@dit.ie

School of Multidisciplinary Technologies,
Dublin Institute of Technology,
Ireland.

Abstract. Being aware of something is not the same as having knowledge of or ability in the selected subject matter. Much of the Irish Architecture Engineering & Construction (AEC) industry is now aware of Building Information Modelling (BIM) as highlighted in a national survey from an Academic Industry Body (2016) which shows that a total of 90% of respondents reported that their awareness of BIM has improved to some degree in recent years. However, it is a legitimate question to ask if the industry does have knowledge and understanding of the processes? Defining these processes would be: knowing the difference in maturity levels; adhering to associated standards of that level; producing the associated documentation in accordance with those standards; and managing and sharing the information correctly.

BIM software is being utilised throughout industry. One of the key findings of this paper concluded that 100% of respondents of a survey conducted by the author have a stated use of 3D BIM Modelling Software with 86% of respondents using Revit. However, it is important to realise that this is not doing BIM, as Donoghue (2015) highlights that Revit is a tool that merely enables the BIM process. These figures would highlight that the use of software is not a major issue when it comes to BIM implementation.

The literature review outlines these BIM processes. Surveys have been conducted to date that highlight the level of adoption of BIM within the industry, however, some conflicting information has materialised. The author will critically analyse these national surveys and outline the results of a targeted survey that was aimed at industry to identify the level of these processes being implemented. Some of the key findings of this paper concluded that the level of BIM that companies say they are operating at conflicts with the procedures followed and documents produced within that company in alignment with that level. The results of this targeted survey shown a lack of knowledge and ability to implement these processes within their BIM operational level.

This research paper set out to investigate levels of knowledge of BIM process in the Architecture & Engineering industry in Ireland

by breaking down BIM into technologies and process and breaking down process in accordance with PAS 1192-2:2013 to achieve a more specific understanding of the current state of BIM implementation in Ireland. A quantitative research methodology was used to investigate the problem and results and conclusions are presented in this paper.

Keywords: BIM, BIM Process, BIM Technology

1. Introduction

Change is difficult in any industry where embedded practice is the result of considered decision making brought together from applied experience. However, with the proper guidance and support put in place, change can have a smooth transition. With regards to BIM, "understanding it is essential to the successful adoption of it" (Cunningham, McClements, McKane 2015, pp. 24). The UK Government BIM mandate outlined to the industry that BIM is a requirement on major public projects from April 2016. In saying that, the UK Government did not stop there and provided all the necessary guidance, training, support, etc. for companies to seek in order for them to move towards BIM. The abundance of support that is on offer enabled organisations to understand the processes involved with this adoption.

An example from Ireland, where there is not a BIM mandate in place, is the amendment of the Building Control Act 2007, which introduced the Building Control Amendment Regulations, otherwise known as BC(A)R (2014). The amendment of this act produced new roles: Assigned Certifier and Designed Certifier: which in turn introduced new responsibilities including production of commencement notices, production of certificate of compliance on completion, production of inspection plans, to name a few. An online Building Control Management System (BCMS) was then set up in order to collate the upload of required statutory certificates, documents and keep record of each project. This amendment was introduced to promote good practice and accountability within the construction industry, to improve health and safety, to reduced disruptions and to acknowledge the rise of technology. The industry came to terms with these new procedures as it had no choice but to, therefore change was essentially in effect.

The industry can transition to BIM just like BC(A)R, if the proper departments in Government and independent organisations stepped in and created a structure that would ease this transition. To understand the BIM Management Process, it is important to realise that the process does not just involve the use of software; it also contains many aspects of information management. As Ravenscroft (2016a) highlights, "We don't all have to know how to operate BIM software, but everyone needs to understand the information workflows, collaborative practices and terminology that Level 2 has introduced". Cunningham et al. (2015) "suggests that software training can be gained from software companies or specialist consultants" (p. 25) but

also suggests that "information management training would be more pertinent as information continues to increase in quantity and complexity" (p. 25). Cunningham et al. (2015) also highlight that the top two barriers to BIM adoption are the lack of expertise and inadequate level of understanding of the BIM processes.

This paper's main objective is to outline the processes involved in information management in BIM, and then to critically analyse where the industry lies in terms of BIM adoption with emphasis on both technology and process. Further analysis will conclude with a targeted survey to determine the level of understanding of these processes.

2. Literature Review

2.1. BIM MANAGEMENT PROCESS

The National Building Specification (NBS) (2016a) had acknowledged that in order for the Architecture, Engineering, and Construction & Operations (AECO) industry to operate a full collaborative working environment, compliant BIM milestones were required. These were introduced in the forms of 'levels' and range from Level 0 to Level 3 with the latter being the highest achievable BIM compliant level. Each level evolves from the one previous which forms the progression to the full collaborative working environment which an organisation can highlight as their BIM operational level.

The NBS (2016a) along with many online resources (Professional Construction Strategies Group (PCSG), 2016a & Succar, 2010) explain these levels in more detail:

- **Level 0** - the simplest form and "effectively means no collaboration" (NBS 2016a).
- **Level 1**: *Object Based Modelling* - the level which much of the industry is now currently operating at; whereby production information is managed through a Common Data Environment (CDE) and is mainly represented in 2D CAD drafting. This stage would also include basic data schedules such as doors, windows, finishes, etc. Although this level is BIM level 1, it is considered Pre-BIM in terms of collaboration and information exchanges, and there is "no significant model based interchanges between the different disciplines" (Succar, 2010, pp. 7).
- **Level 2**: *Model Based Collaboration* - this level requires all project stakeholders to work collaboratively by exchanging all information in a common file format "which enables any organisation to be able to combine that data with their own in order to generate a federated BIM model". An example of this would be federating a Revit Architecture model with a Revit Structure model. This stage allows for the generation of 4D BIM (time analysis) and 5D BIM (cost estimating), which for example, can be produced in software such as

Navisworks. All associated information and documentation is then managed through a CDE and the Information Management processes are outlined in the PAS 1192 suite of standards.

- **Level 3**: *Network Based Integration* - the level regarded as the "holy grail" in BIM; which requires all disciplines to work collaboratively on a single integrated project model stored in a central model server.

Since the UK Government BIM Level 2 mandate came into effect in April 2016 "there has been confusion over what are the specific requirements to be met in order to achieve BIM Level 2" (Building Research Establishment (BRE), 2014). In order to understand the requirements of this level, one would have to comprehend the many standards associated with it; with the primary standard related to this level being PAS 1192-2:2013. This "provides specific guidance for the information management requirements associated with projects delivered using BIM" (BSI, 2013, p. v). McAuley et al. (2015) recognise that since the Irish Government usually follows closely with the UK with regards to regulations adoption, it would be more beneficial for the Irish AEC sector to adopt PAS 1192-2 as it is heavily linked with the UK construction sector.

An online step by step guide for using BIM on projects (PCSG, 2016b) has been developed in a plain language format and aligned with PAS 1192-2 and the 2013 Royal Institute of British Architects (RIBA) Plan of Work. This guide takes users through the BIM Level 2 workflows (Ravenscroft, 2016a).

2.2 THE BIM LEVEL 2 SUITE OF STANDARDS

A website developed by the British Standards Institute (BSI) for guidance on BIM Level 2 adoption (BSI, 2016) includes all these documents and standards which are available to download from the website. Figure 1 displays the standards associated with BIM Level 2 with an explanation of each following:

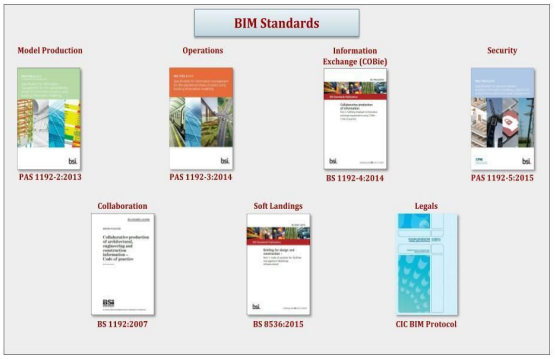

Figure 1 - Cover pages of the BIM Level 2 Standards and what each is used for. Adapted from BSI (2016).

- *PAS 1192-2:2013 & PAS 1192-3:2014*: Harty, et al. (2016) outlines that the primary functions of PAS 1192-2 are to provide general industry guidance for collaborative working and information

management on BIM projects. These standard aides in the development of the Project Information Model (PIM).

PAS 1192-3:2014, however, extends the information management concepts covered in PAS 1192-2. "It sets out the need for information requirements and for an information model that is focused on the operational phase of an asset or portfolio of assets" (BSI, 2014a, p. ix). This then ties into the federated PIM in order to form the Asset Information Model (AIM). "The purpose of the AIM is to be the single source of approved and validated information related to the asset(s)" (BSI, 2014a, p.ix).

- *BS 1192-4:2014:* This document defines expectations for the exchange of information throughout the lifecycle of a facility. Construction Operations Building information exchange (COBie) provides a common structure for the exchange of information about new and existing Facilities, including both buildings and infrastructure (BSI, 2014b, p.1). "The use of COBie ensures that information can be prepared and used without the need for knowledge of the sending and receiving applications and databases" (Manning, 2014).
- *PAS 1192-5:2015:* "specifies requirements for the security-minded management of projects utilizing digital technologies" (BSI, 2015a, p. 1).
- *BS 8536:2015:* "gives recommendations for briefing for design and construction to ensure that the design takes account of the expected performance of the asset/facility in use over its planned operational life" (BSI, 2015b, p. 2). Manning (2015) points out that the standard refers to the principles of Government Soft Landings (GSL). To support better outcomes for our built assets during the design & construction stages; GSL, powered by a Building Information Model ensures value is achieved in the operational lifecycle of an asset (BIM Task Group, 2016).
- *CIC BIM Protocol*: This protocol is developed on behalf of the Construction Industry Council (CIC) and the BIM Task Group and forms part of the contract. "The Protocol is based on the direct contractual relationship between the employer and the supplier" (Manning, 2015). This protocol outlines obligations, liabilities and limitations on the use of the models generated by the project team, while also enabling the client to request the adoption of a particular way of working (CIC, 2013). CIC (2013) also highlights the requirement for the employer to appoint an Information Manager which is a prerequisite role of all BIM projects.

  Another main requirement associated with the CIC BIM Protocol is the production of the Model Production Delivery Table (MPDT) which "allocates responsibility for preparation of the models and identifies the Level of Detail (LOD) that models need to meet at the project stages" (CIC 2013, p. vii). The MPDT is appended to the CIC BIM Protocol which forms part of the contractual agreement. An example of this MPDT is attached to Appendix 1 of the CIC

BIM protocol (CIC, 2013).

Appendix 2 of the protocol is the outline information requirements. This enables the input of important project wide information requirements which requires that all project team members adhere to. Information includes standards, parties, outline EIR's and project procedures (CIC, 2013). Also, an example of this is attached to the protocol.

2.3. PAS 1192-2 – THE WHO, WHAT, WHEN & HOW OF THE BIM PROCESS

BSI (2013) highlights that not all construction information has to be delivered in a BIM format in order to comply with PAS 1192-2:2013. Details of these information exchanges and collaboration procedures are provided in BS 1192:2007 which provides standards and processes "for managing the production, distribution and quality of construction information including that generated by CAD systems" (Harty et al. 2016,). These processes would have been adopted prior to the introduction of BIM and was considered a substantial step forward for construction information management flow (Harty et al. 2016,). This indicates that collaboration and documentation management has been achieved within the industry regardless of the uptake of BIM or not, and following this, the PAS 1192 suite of standards allowed for the collaboration and data management in order to achieve compliance with BIM Level 2. According to Harty et al. (2016), "PAS 1192-2:2013 and BS 1192:2007 are mutually interdependent as the only tried and tested standards which support the UK Government's BIM strategy to achieve Level 2 compliance".

2.3.1 Information Delivery

It is important to understand that the BIM process is very similar to the more traditional process. Table 1 outlines these similarities.

TABLE 1. Similarities of the BIM process and the traditional process. Adapted from "Bamboozled" by BIM Terminology (2016)

Step	Traditional Process	BIM Process
1	Brief - Clients describe what they want	Employers Information Requirements (EIR) - Client describes what they want
2	Suppliers will provide information on how they will deliver project	BIM Execution Plan (BEP) - Suppliers will provide information on how they will deliver project. Pre-contract BEP initially with a more detailed Post-contract BEP once appointed.
3	Pre-qualification - to determine if the proposed team are capable of delivering	BIM Capability Assessments by means of Pre-Qualification targeted survey (PQQ) which form the Project Information Plan (PIP) - to determine if

	the project	the proposed team are capable of delivering a BIM project
4	Contract awarded	BIM Protocol that includes the Master Information Delivery Plan (MIDP) - outlines the terms of the contract and who does what, when & how.
5	Appointment of lead coordinator (usually lead designer)	BIM Manager - manages and coordinates the project
6	Central repository for project information - usually stored on central servers and information provided through requests for information (RFI's) and then emailed or posted.	Common Data Environment (CDE) - all project information stored in cloud based servers allowing all stakeholders to manage, view and comment on

Information is delivered through a number of documents and activities within the overall BIM process. The following outlines, in more detail, some of the main documents and aspects associated with information delivery for BIM Level 2 compliance:

- *Employers Information Requirements (EIR)* - Pringle (2015) highlights that the core purpose of an EIR is to document the information requirement and to outline the information management requirements. This document is reviewed by potential project bidders to which they respond with their Pre-contract BEP (Pringle, 2015). BSI (2013) Section 5.3 specifies what is to be included within the EIR, which ranges from levels of Model Definition, to training requirements, to collaboration process. McAuley et al. (2015) stress the importance of an EIR, stating that "if clients do not ask the right kind of questions at the beginning, they are not going to get the right results" (p. 151).
- *BIM Execution Plan (BEP)* - This is divided up into two sections: the Pre-contract BEP, and the Post-contract BEP. BSI (2013) specifies that the pre-contract BEP should "demonstrate the supplier's proposed approach, capability, capacity and competence to meet the requirements of the EIR" (p. 12). The main purpose of the BEP is to map out roles, responsibilities and time frames for information delivery (Harty, et al. 2015). PCSG (2016c) outlines what is included within the pre-contract BEP:
    - PIP setting out capabilities including technology,

resources and information management
    - Collaboration goals
    - Project Milestones
    - Deliverable Strategy

The post-contract BEP then "sets out how the information required in the EIR will be provided" (PCSG 2016c). BSI (2013) Section 7.2 specifies the requirements of the post-contract BEP which incorporates management, planning and IT solutions.

- *Master Information Delivery Plan (MIDP)* - PCSG (2016d) outlines this as the "primary plan for the preparation of the project information from the supplier's perspective". The MIDP is developed from a series of Task Information Delivery Plans (TIDP's) which are developed by each team associated with the project. They outline the responsibilities and deliverables of the teams and how they are managed (PCSG 2016d). However, a new online tool developed by the NBS (2016b) allows project managers to create a project to manage all these issues which, in turn, reducing the amount of work in generating the document. This tool also "provides step-by-step help to define manage and verify responsibility for information development and delivery at each stage of the asset lifecycle" (NBS 2016b). Specifically, "It provides a single and central place to document; What, When, & by whom" ("Bamboozled" by BIM Terminology, 2016).
- *Common Data Environment (CDE)* - Boxall (2015) states simply that "a CDE is a collaborative environment that everyone uses, following guidance given under PAS 1192-2, to coordinate information with all project stakeholders". It is used for a number of things, including; to collect data, manage and monitor documentation, perform graphical model mark-ups, store project details, and allows communication through all project stakeholders (Boxall, 2015). BSI (2013) Section 9.2 specifies the CDE structure to follow in order to manage the process more efficiently. This includes the use of specific folder names which represent different stages of the project; and naming conventions to distinguish the different revisions of documents and models. These are outlined in Section 9.3 of PAS 1192-2:2013. CDE's have been developed to improve the traditional information flow and to deal with issues associated with the management of those flows (Harty et al., 2016).
- *Levels of Model Definition (LoMD) or Level of Detail (LOD)* - Harty et al. (2016) points out that the purpose of these are to assist the design team in specifying the content and information of the Building Model at different stages of the design and construction project. These stages relate to the seven 'data drop' stages outlined in PAS 1192-2:2013:

1. Brief

2. Concept
3. Definition
4. Design
5. Build & Commission
6. Handover & Closeout
7. Operation & In use

LoMD can be split up into two: detail and development. These are often confused. Harty et al (2016) outlines the difference: detail relates to "how much detail is incorporated in an element"; while development refers to the "level of reliable and validated data output embedded in an element". These stages are outlined as LOD 1-7 and are explained further with graphical illustration in figure 20 of PAS 1192-2 (BSI 2013, p. 35). It is important to note that the LOD for each data drop is outlined in the EIR. This helps the employer to decide in whether the project should proceed to the next stage.

Templates for Pre-& Post-contract BEP's have been developed by The Construction Project Information Committee (CPIC) (2016) and can be downloaded free of charge from their website, while guidance notes for the development of an EIR have been developed by the UK BIM Task Group (2016) and can be downloaded free of charge from their website.

2.3.2. BIM Roles

Since the uptake of BIM across the world, many new roles have materialised. BSI (2013) outlines many of these roles with a description of their responsibilities; however, as Mathews (2015) points out, they are very generic in their description. It is important to note that professionals within the AEC sector who are not educated or trained in BIM should not feel intimidated from the adoption of BIM. According to Mathews (2015, p. 41) "to do BIM, you bring knowledge from your domain and develop new skills." It is these professionals who need to understand that their role is important in making the industry move forward to embrace BIM fully.

Although one of the main roles outlined in BSI (2013) is the Information Manager, Harty et al. (2016) points out "that none of the UK's leading BIM specialists even use the terminology 'information manager', and instead describes the roles within a three-tier system: a BIM Technician; a BIM Coordinator, and a BIM Manager". The role of the BIM Manager has soared to the top of this pile across the industry in both the UK and Ireland over the last few years (Harty et al., 2016). Mathews (2015) also acknowledges these main roles and proposes the industry focus more on promoting them as opposed to all others outlined in PAS 1192-2. Mathews (2015) defines these roles in relation to levels of education and levels of experience coupled with a primary domain degree: for example, a BIM technician requiring a Level 7 degree; a BIM Coordinator requiring a Level 8 degree and at least one year office experience; and the BIM Manager requiring a Level 9 degree with

three to five years office experience. Table 2 outlines the responsibilities involved for these main roles.

TABLE 2. Outline of major responsibilities for the main roles associated with BIM. Adapted from CITA (2015a), Joseph (2011), Donoghue (2015), and Mathews (2015)

Role	**Responsibilities**
BIM Technician	○ BIM Content Development ○ BIM Modelling ○ BIM Coordination (Potentially, depending on experience) ○ Reports to BIM Coordinator
BIM Coordinator	○ BIM Content Development ○ Design/Model Coordination ○ BIM Training ○ Liaising with Project Team ○ Assist in Managing CDE ○ Setting up Project & BEP ○ Clash Detection ○ Quantity Take-offs ○ Project Design ○ Participating in Project Meetings
BIM/Information Manager	○ Setting up and managing the CDE ○ Initiate PIP ○ Managing Information Exchanges ○ Implementing BIM Protocol & Contracts ○ Liaising with Project Team ○ Prepare Project Outputs (Data Drops & MIDP) ○ Risk Management ○ Budget & Performance Management ○ Oversee Project Meetings ○ BIM Content Development ○ Project Design

The role of the BIM/Information Manager can vary depending on the size of the company. Harty et al., (2016) goes into more detail and draws attention to two types: firstly, the explicit BIM Manager; usually conducting BIM operations on a daily basis which typically occurs within a large-scale AEC firm; and secondly the embedded BIM Manager who performs BIM operations when needed by either a single individual or collectively by multiple members of a SME AEC firm. Although the BIM/ Information Manager has no design responsibilities and all model coordination and clashes are conducted by the BIM Coordinator (Donoghue, 2015); within a SME, the BIM/Information Manager's role can also be undertaken by the Design Lead since roles tend to overlap due to the organisations size and

versatility of personnel (Harty, et al. 2016). The role of the BIM/Information Manager is a fundamental aspect of the contractual agreement, and its appointment is to be made by the Client/Employer (CIC, 2013).

"Explicit or embedded, the BIM/Information Manager's role in a BIM collaborative environment is critical to the setup of the CDE, the flow of information and the compliance with agreed protocols and procedures" (Harty, et al. 2016).

3. BIM Adoption in Ireland

There is a widely accepted notion in the industry of Ireland that BIM is not fully adopted due to a number of reasons including lack of education, misunderstanding and awareness (McDonald, M. & Donoghue, S. 2013, and McAuley, B., Hore, A., Deeney, J. 2013). A recent national survey from an Academic Industry Body to benchmark the level of BIM adoption in Ireland was presented to BIM Ireland Magazine in 2016. 57 responses were obtained from a sample size of 97 targeted professionals in the AEC sector (2016). The survey highlights that 90% of respondents were at Director, Principal or Associate level (2016). According to this survey, 57% of respondents reported that their awareness of BIM has improved in recent years and are using BIM on a number of projects, with a further 33% saying they use BIM on some projects. This equates to a total of 90% claiming to have increased awareness of BIM and using it to some degree (2016).

If the previous figures were to be compared to the UK's national BIM adoption survey which has been produced yearly since 2011 by the NBS; it claims, from a response rate of over 1,000 individuals, that 54% are aware of and using BIM (NBS, 2016). Although the UK's construction sector is far greater in size than Ireland, it would seem that the UK's awareness and ability to do BIM would be much higher considering they have a Government mandate in place and have developed all the necessary standards and procedures. Looking back at Ireland's figure of 90% being aware of and using BIM (2016), and with no mandate in place, it generates more questions as to how such a large percentage are using and understanding BIM. Without discrediting the results of the survey itself, the problem could very well lie with the respondents, and basically comes down to them not fully realising what they are answering when saying they can do BIM.

A further question within the survey points out that 55% of respondents use PAS 1192-2:2013 (2016). This draws attention to BIM Maturity Levels. Since PAS 1192-2:2013, among others, is the official standard that provides guidance to achieve BIM Level 2, it is worth noting that in this survey it shows that less than two-thirds of those doing BIM are using this standard. It would be correct to say that the 55% using this standard are achieving BIM Level 2. However, this would not be the case, as only a very small percentage of firms have officially reached this level within Ireland, therefore leading the conclusion that only small aspects of PAS 1192-2:2013

are being used. The remaining one-third of respondents, without using PAS 1192-2:2013 would be considered only achieving BIM Level 1. As previously noted, although a BIM Maturity level, this is regarded as pre-BIM and is considered to be where most of the industry lies.

The use of this standard should go hand in hand with doing BIM at all levels and it shows that maybe the majority of respondents were not fully aware of what doing BIM entails which therefore lead to some misleading responses. The 2016 survey failed to address what specific aspects of BIM were being utilised and to what level. This paper will address this further by determining understanding, knowledge and ability of BIM Information Management across a targeted sample of the Irish Architecture & Engineering sector. Another point to address from this national survey (2016) is that the majority of respondents were top level within their companies (90%); it fails to clarify the level of understanding and ability they had with regards to BIM. If this is compared to a survey carried out by the Institute of Structural Engineers in the UK which had a response rate of 750; it outlines that only 9% of Principals or Directors have received BIM training, with over 50% of those trained in BIM being graduate or technician level (Ravenscroft, 2016b). A clearer understanding of BIM uptake and knowledge within the industry could have been more beneficial coming from more respondents at graduate and technician level.

McAuley et al. (2013) also highlight that the respondents of their interviews acknowledged that there is no need to adopt BIM since clients are not requesting it. The national survey (2016) also acknowledged this a number of years later, and reveal from their survey that the biggest barrier of all is that clients are unaware of the value of BIM. However, this seems to conflict with the next question on the survey which asks if organisations are experiencing an increased demand for BIM from clients. Results from this national survey show a significant 80% of respondents reporting an increase in demand (2016). It is important to foresee these conflicting answers prior to sending out targeted surveys, as again, it asks the question; do respondents really understand what they are replying to?

McAuley et al. (2013) and McDonald & Donoghue (2013) further stress that in order for the industry to adopt BIM and reap the rewards, more education is required. McDonald & Donoghue (2013) outline that 83% of participants of a targeted survey revealed that AEC employers now require that employees have certain BIM competencies. This shows that the industry is acknowledging the need for BIM specialists. The question that remains is; do these employers actually understand what they are requesting? A further acknowledgement of the national survey (2016) is that it is based on individuals, rather than companies; of the 57 respondents, there could easily be the situation where a number of these are from the same company. This would have a negative impact on the results, as the larger firms who have invested heavily in BIM could have a handful of directors or associates who participated in the survey, thus leading to responses from a smaller amount of organisations across the industry.

3.1 BIM FOR SMALL TO MEDIUM ENTERPRISES (SME's)

The industry national survey also puts forward an open-ended question to determine how respondents see a potential BIM roadmap for Ireland being led. One response outlined the following: "The issue is that many practices have been decimated by the recession and BIM is a significant investment which favours larger practices therefore making the pitch all the more difficult for smaller organisations" (2016). This highlights a major issue within the industry which needs to be addressed. It seems to show that SME's are slow in the uptake of BIM and maybe falling behind. SME firms are the backbone of any AEC sector as they provide a large percentage of firms within the industry while also employing the majority of the workforce. The European Builders Confederation (EBC) (2016) acknowledge this; and outline that there are 3 million AEC enterprises in Europe with SME's making up 99.9%, which equates to approximately 2,997,000 firms. These provide 80% of the construction industry output and employ 70% of the workforce (EBC 2016). In terms of SME's in Ireland, Kennedy (2014) outlines that 99.7% of the Irish workforces are SME's with the construction sector accounting for 18.7% of this.

Cunningham et al. (2015) have acknowledged that publications and seminars have increased BIM knowledge, thus reducing the barriers to adoption, but information has failed to filter down to smaller businesses. "The main challenge for small and medium sized businesses isn't actually spending money on software: it's spending two days a week for a few months to truly understand what BIM means for you" (Pickford. 2015). This statement is important as the recommendations of this study would be suited to address this issue.

4. Research Methodology

4.1 QUANTITATIVE

Research enabled the author to analyse existing literature that outline the processes to be used, while also critically reviewing existing surveys conducted to date on BIM adoption in Ireland. The results of authors targeted survey were then used to determine the industry's understanding of BIM processes. This type of survey design "provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population" (Creswell, 2014, p. 201). This choice of methodology "allows for greater objectivity and accuracy of results" (University of Southern California, 2016)

4.2 STUDY POPULATION & SAMPLING

The population in this case is considered to be the AEC sector of Ireland, but in order to focus on one particular area, a sample set of Architecture and Engineering SME's were chosen to participate in the survey. The sample

was compiled from the websites of the main representative bodies of the Architecture & Engineering sector of Ireland; the Royal Institute of Architects of Ireland (RIAI) and the Association of Consulting Engineers (ACEI) respectively. For this research, it was only necessary to obtain the information from those who offered BIM as a service. Approximately 50 Architectural & Engineering firms who offered this service were then individually contacted to explain who the author was, and the reasoning for the survey. These phone calls provided contact information for a BIM representative of the company to conduct the survey, to which the targeted survey was then forwarded to. This provided a more personal level approach to gaining information and also provided some feedback from those conversations with regards to BIM and the industry. It concluded with a response rate of 23 architectural and engineering organisations.

It is important within this research to make sure there is only one respondent from each company, and since the questions are all based on BIM processes and BIM technology, the respondent should be considered the BIM professional within their company. More conclusions for industry adoption can be made from 50 different firms across the country, rather than 50 individuals from say 10 firms. Those 10 firms could be large multi-disciplinary firms who have utilised BIM and its process to its fullest and could have a several directors or BIM specialists. It would reduce conclusions on industry wide adoption.

4.3 DATA COLLECTION

For this targeted survey, the questions required to cover the majority of aspects associated with the BIM process as outlined in this paper. These questions were divided up into 6 different sections:

1. Company Profile
2. Software
3. BIM Levels / Standards
4. Information Sharing
5. Documents
6. BIM Training

The sections consisted of approximately 5-10 questions each which were based on multiple choices, yes/no, timeline scale or check box answers, in turn providing a quick response time which was appealing to the respondents. The variations in the amount of questions per section depended on whether answers were ‘yes’ or ‘no’, as some ‘yes’ answers would generate sub questions. At the end of each section, the respondent had a chance to provide comment or feedback in relation to that section. Google Forms was utilised for the generation of the targeted survey.

4.4 DATA ANALYSIS

Along with the collection of data, Google Forms was also used for analysing

the data. After forwarding the survey to the sample, Google Forms collects responses and allows the author to view a summary of these in different chart formats. However, analysis of the data does not stop there, as Forms allows one to link summary of responses to Google sheets. When all responses are published to a Sheet, more analysis can be done from here. It allows the author to: find correlations between questions; use filters to create data sets associated with a specific identifier (word); sort out the data sets; use explore function to ask questions which in turn generates charts from highlighted cells within the spreadsheet.

5. Findings & Discussions

5.1 KEY FINDINGS

One of the primary objectives of this paper was to identify whether or not the industry understands the processes behind BIM rather than just using its associated software. Referring to the 6 sections within the targeted survey, the key findings resulted from sections 3, 4 and 5. These sections were focused on determining whether processes and procedures were followed, while also establishing whether associated documentation was produced on their BIM projects. Results outlined that a total of 17 (73%) companies regard themselves as operating at BIM Level 2, with 5 (21%) operating at BIM Level 1, leaving one (6%) company as non-applicable. The next step from this question was to ascertain what documents and procedures were produced/used from each of these companies in relation to their level of operation. Figure 2 and Figure 3 show the results for BIM Level 1 companies and BIM Level 2 companies respectively.

In relation to the organisations regarding themselves operating at BIM Level 2, it can be seen from the table that the number of associated documents being produced does not correlate with the amount of organisations operating at that level. Although some respondents have declared they operate at Level 2 and do in fact produce/use the majority of the associated documents and procedures in their BIM projects, the overall results have left the author to believe that some of these organisations do not really understand what is involved with operating at BIM Level 2: for example, a number of respondents outlined that they operate at Level 2, but do not produce a BEP, a MIDP, or even manage a CDE. These are essential requirements associated with this level as outlined in PAS 1192-2:2013. Responses have indicated that the majority of organisations are aware of some of these documents; in saying that, being aware of is not the same as understanding their use, or possessing the ability to produce them.

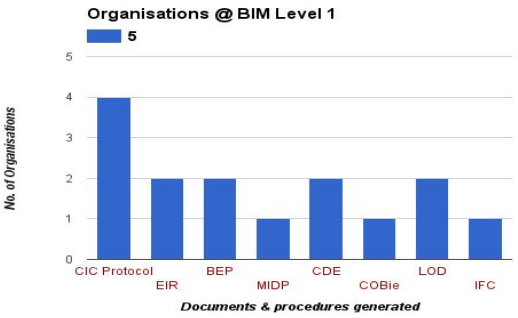

Figure 2 - Documents & procedures generated from BIM Level 1 firms. Adapted from targeted survey.

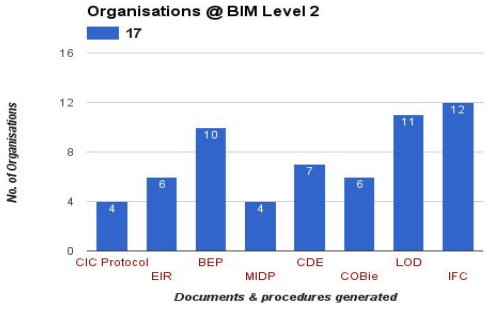

Figure 3 - Documents & procedures generated from BIM Level 2 firms. Adapted from targeted survey.

5.2 STATISICAL ANALYSIS

The sample produced responses from 23 organisations: 74% being architectural practices with 26% engineering firms. Figure 4 highlights the size of these in terms of employee numbers and shows that the majority who responded were from micro to small sized organisations. Respondents who represented their respective firms were from a wide range of roles:

- BIM Manager - 7
- BIM Coordinator - 2
- Architect - 4
- Partner / Director - 5
- Architectural Technologist - 2
- BIM Implementation Manager - 1
- Associate - 1
- IT Manager - 1

Figure 5 outlines the BIM roles adopted within their company. It is evident that many of the roles discussed in this paper are being adopted within industry.

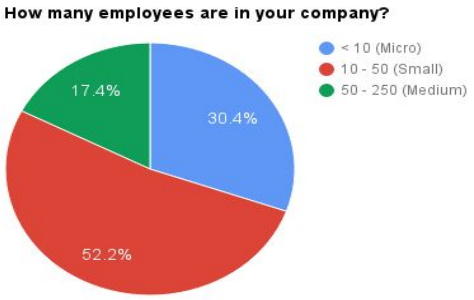

Figure 4 - Organisation size. Adapted from targeted survey.

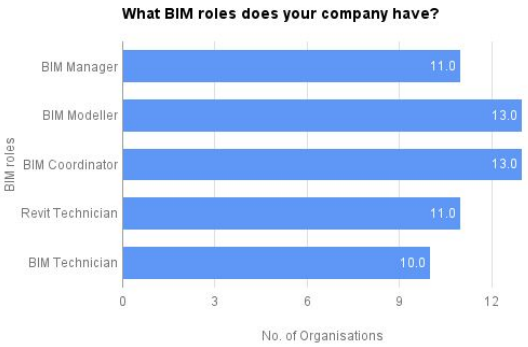

Figure 5 - Roles within organisations. Adapted from targeted survey.

In terms of software use, only three organisations have ceased using 2D CAD, with the remaining 20 all still using Autodesk AutoCAD. However, responses show that although the majority still use 2D software, 3D software is being used across the board with Figure 6 highlighting that Autodesk Revit is the most used. Further questioning on the use of 3D software was to determine whether it is being used in a collaborative setting. Figure 7 outlines these numbers. These figures show that all firms have an understanding of the software associated with BIM, with a number of them also performing some level of collaboration. However, as we can see from figures 2 and 3, the majority of respondents would end their BIM capabilities there since not much of the processes are applied. In relation to further BIM software use, 70% of respondents claim to be using model checking software with Autodesk Navisworks being used in 15 organisations. Solibri and Revit make up the remaining responses.

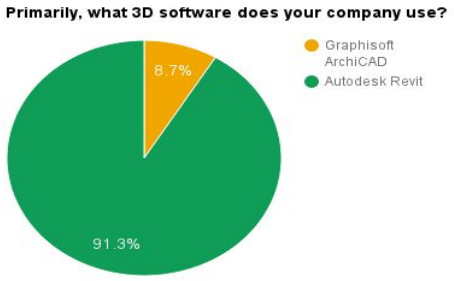

Figure 6 - 3D Software use. Adapted from targeted survey.

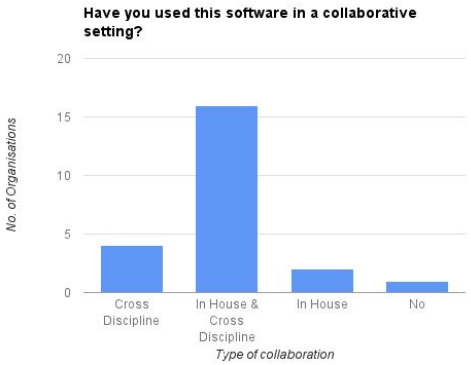

Figure 7 - Collaborative use of 3D software. Adapted from targeted survey.

There has been a significantly high response of those who are aware of the Digital Plan of Work, totalling 74%; however, just 47% of these are actually using it on their BIM projects. It was important to establish whether this has improved project planning within the organisations. Responses showed that only 60% of those utilising this application believe it has improved the process. This opens up a number of questions as to why some do not think it has improved the process since it was designed to do just that. Another advantage of the DPoW is to enable managers to produce the MIDP's. If this is compared to how many firms produce MIDP's, which is only five overall, one would conclude that the DPoW is not fully understood or the ability to use and manage it is not possessed within the industry.

5.3 INTERPRETATION OF RESULTS

The results highlighted in the key findings would imply that not many of the processes are fully understood in industry. A chance to provide feedback and comments from the targeted survey highlighted that some respondents feel the level of complexity is not required due to the size of their organisation. However, a number of micro firms within the sample have outlined that due to their full adoption of BIM processes they are now in a position to tender for projects in the UK, thus increasing their workload and turnover. These firms would also be the front runners in terms on BIM use should Ireland introduce a mandate.

The main research objective was to investigate levels of knowledge of BIM process in the AEC industry in Ireland by breaking down BIM into technologies and process and breaking down process in accordance with PAS 1192-2:2013 to achieve a more specific understanding of the current state of BIM implementation in Ireland. Much of the findings would correlate with the literature in regards to software use. However, a major barrier highlighted in the literature suggests that cost is a main issue with buying software; however, the targeted survey reveals that all respondents are using BIM's associated 3D software. These findings would affirm the initial prediction that the processes associated with BIM are less understood. The results highlight that the majority of respondents are aware of the many processes involved, but have yet to implement them into their BIM projects.

A primary trend had materialised from the targeted survey. Although the majority of the respondents are aware of each of the following processes outlined in figure 9, results show that those who are BIM specialists within their company are more knowledgeable of the processes than the more senior Partners / Directors, therefore having the ability to implement those processes within their BIM projects. Figure 8 shows the comparison between BIM specialists and Senior Partners/Directors which is represented by the red and blue line respectively which is to be read in conjunction with figure 9.

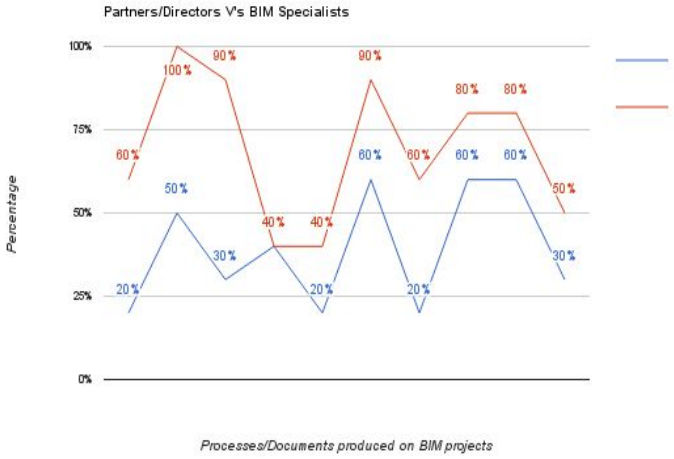

Figure 8 - graph outlining the comparisons between senior partners/directors versus BIM specialists. Adapted from targeted survey.

Figure 9 - outlining the comparisons between Partners/Directors and BIM specialists in terms of BIM processes implemented. Adapted from targeted survey.

The author acknowledges the limitations of the survey. The findings are from a small sample within a large population. However, the sample only applied to those offering BIM as a service. With this in mind, the results of this targeted survey were considered appropriate to determine the lack of understanding in the BIM processes. In terms of BIM awareness, all organisations but one has attended BIM conferences or seminars and results show that 87% of respondents have completed BIM training with 80% of these claiming to have trained in both processes and technology use.

6. Conclusion

The literature review has outlined the processes involved with complying with BIM Level 2 which it can act as a guide for industry. Existing surveys have acknowledged BIM adoption, but have failed to dig deeper in order to understand what aspects of these processes are implemented. Firms offering BIM services in Ireland possess no reference documents or standards and instead refer to UK suite of PAS 1192 standards. Ireland has an opportunity to follow suit with BIM standards adoption from the UK, as it has followed suit with several regulations in the past and has adopted many of its processes, especially in the building sector (McAuley et al. 2015).

It is important to consider this for Ireland's future since the possibility of a similar mandate is not unlikely. Therefore, it would require companies to know all these processes and how to implement them. The UK BIM Level 2 mandate is in effect, and they have recently outlined their strategy for BIM Level 3 by 2020 (Cunningham et al. 2015). The results of this targeted survey show that our industry as a whole is a long way off in understanding the processes behind BIM Level 2, never mind BIM Level 3. Changes to training methods are required in order to make industry aware that BIM is much more than just the use of software. It is important that our AEC industry does not fall too much behind our neighbours. More care is needed to promote BIM in the right context to reduce the misunderstanding of what doing BIM is. Aspects outlined in this paper such as the documents and information management formats associated with BIM Level 2 require specialised training in themselves.

A proposal for a solution to this problem is the use of lunchtime Continuing Professional Development (CPD) events. Results of the targeted survey show that 70% already participate in these CPD's in order to continue their professional knowledge in a wide range of areas, including: technology, systems, products and processes. The market requires tailored specific CPDs

at low cost or free which will bring pieces of knowledge in to build up the whole BIM picture to a firm. The author recommends that careful consideration be used by organisations within the training sector to draw up plans that can change this industry understanding of and ability in producing these processes. CPD's are conducted within a firm for usually an hour during lunch, and are conducted by manufacturers free of charge in order to pass on information and entice the firm to specify their product or system within their projects. The same can apply for BIM processes. A number of structured CPD events could be proposed to firms to tackle areas the firms are less knowledgeable about. Some examples of one hour CPD events could be structured around the following:

- Production and use of an EIR.
- Production and use of a BEP.
- Production and use of a MIDP.
- Setting up and managing a CDE.
- Breaking down the PAS suite of documents.
- Understanding COBie.
- Managing the DPoW.

However small the project, the above processes could be implemented within the firm, in turn generating templates for those organisations. These templates can therefore be used towards more complex projects in the future or if a mandate becomes a reality.

Initially, the author envisaged identifying the lack of understanding of the BIM processes by those offering a BIM service within industry, but also wanted to identity why more organisations have not adopted BIM. The main aim of better education in the form lunchtime CPD's was to also be proposed for those who have not adopted BIM as it would guide them towards best practice. The heavy focus on software within training courses and seminars may have misled a lot of the industry into thinking that software is the main aspect of BIM. It draws the reader back to a statement from Macdonald et al. (2013) who acknowledge that BIM is not being adopted across industry due to education, misunderstanding and awareness of its processes. Further research in this area can be conducted to determine at a more in-depth level as to why it is not adopted by some firms. Recommendations proposed within this paper can also be utilised to spread more knowledge of BIM process to firms who have not yet adopted it.

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