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# The application of industry standards as an alternative to in-house proprietary standards within the AEC industry

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**Abstract** The move from traditional 2D Computer Aided Design (CAD) practices towards Building Information Modelling (BIM) has witnessed some practices trying to adopt and update their own in-house CAD standards. These standards are wholly inadequate for working in a collaborative BIM environment and mean that they repetitively create and re-create local, non-reusable, non-interoperable solutions to the same problems, which leads to the employees potentially having to learn a new collaborative process every time they have to work with a new project team.

Collaborative standards help teams produce information through a standardised process, so as to ensure the same form and quality to enable information to be used and reused without change or interpretation. These standards permit common ways of creating, storing, and accessing, exchanging and communicating built asset information. This allows the supply chain to organise itself around defined roles and further permits diverse project teams to have a mutual understanding and trust with each other. This can therefore result in improvement across the board that include better teamwork, better scheduling, better risk management and better costs control.

This paper will present the case for companies to move from existing in-house CAD Standards towards more rewarding collaborative Industry standards. The data collation methodology included an in-depth questionnaire that investigated the practice of using in-house standards. The results have indicated that a more robust direction is to adopt an industry standard in order to ensure a more rewarding BIM process.

*Keywords* Building information modelling, BIM Collaboration Standards,

## I INTRODUCTION

The AEC industry is in the midst of change with the adoption of BIM within the sector. Companies that used to work in isolation now find themselves working as part of project teams. This new method of working requires them to share large amounts of information. To do this efficiently they require a structured process for collaboration. In-house proprietary standards, although they might form part of an ISO 9001 certification, are no more than documented practices and are unsuitable for working collaboratively, as different companies will have their own ways of working.

Philp (2014) has stated that UK BIM has been on the move in the previous 12 months, and the 'what' and the 'why' of BIM have largely been relegated and replaced with the 'how'; the authors

believe this 'how' needs to be formalised into industry standards [1].

Working to an industry standard seems to be the most obvious way of companies avoiding continuously changing the way they work for every project they participate in, but the industry seem slow to adopt these standards. Structuring this information in a standard form will promote certainty, quality and trust within the project team.

## II LITERATURE REVIEW

### a) Introduction

Collaborative standards seek to help teams produce information using standardised processes and agreed standards and methods, to ensure the same form and quality, enabling information to be used and reused without change or interpretation. Collaborative standards require mutual understanding and trust

within the team and a standardised process, if the information is to be produced and delivered in a consistent and timely manner. The advantage of this way of working include fewer delays and disputes within the team, better management of project risk and better understanding of where costs are being incurred [2].

#### *b) Rationale for Using Industry standards*

BIM involves the use of a set of process standards to provide a common way of creating, storing, accessing, exchanging and communicating built asset information [3]. Process standards are associated with the method and organisation of production activities. In preconstruction practice for instance, process standards might refer to the structured ways of interaction between professionals involved in the creation, storage and exchange of construction information [4]. BIM process standards are increasingly influencing and shaping the construction process. Such change in the process of construction could be beneficial to achieving efficiencies in construction and improve quality.

Appropriately drafted schedules of service, BIM protocols, together with wider adoption of existing standards will provide a support infrastructure to both pull and push by enabling the construction client to clearly and consistently define requirements whilst allowing the supply chain to organise itself around well-defined roles [5]. Good standards provide clear requirements that set minimum conformity specifications and strike the right balance between too many and too few varieties. Whilst standards often define minimum requirements, products may often exceed these requirements and offer enhanced levels of performance [6].

The transition from traditional drafting to 3D modelling will require software, training, and hardware but effective use of BIM requires that changes be made to almost every aspect of a firm's business [7]. Process standards will reduce the time and cost of these changes, as process standards are associated with the method and organisation of production activities [4]. Standards need to be seen to be used by the top firms and should have support from clients, industry bodies and governments [8]. Howard & Björk believe that standards development should be by experts from the construction industry [8].

In the NBS BIM report only 24% agreed that the current level of standardisation is right, suggesting that the construction industry needs to implement a greater degree of standardisation for BIM adoption to be successful [6]. It appears that the industry could benefit from a clear set of guidelines

outlining an effective strategy and methodology of implementing BIM at the organisational level [9].

#### *c) Importance of standards for collaboration*

Standards facilitate collaboration between teams involved in construction practice. BIM process standards allow engineers to integrate information to create a single 3D digital object [4]; Howard & Björk believe standards are critical when communication is between different specialists, internationally and over long periods takes place, as diverse and changing project teams depend upon standards [8].

NBIMS-US discuss how the danger of poor standards in collaboration could lead to individuals in business and individual project teams continuing to repetitively create and re-create local, non-reusable, non-interoperable solutions to the same problems. Businesses will continue to take longer than necessary to get to market with new products and services because it will take far longer than necessary for parties collaborating on a project to share their ideas and communicate specific results [10].

Construction projects are becoming increasingly complicated in nature, requiring more specialist discipline input, resulting in a much greater volume of technical information, which in turn needs to be coordinated and kept up to date and relevant through the life cycle of a project. In such contexts conventional project filing systems and information work-flows are becoming unmanageable and there appears to be a need for user-friendly practice guidelines to supplement existing standards [11].

The heart of BIM is information. The extent to which the information in a model is accurate, content rich and standardised relates exactly to how useful the model will, or will not, be [6]. BIM process standards are used to structure information-sharing activities. Empirical evidence suggests that BIM process standards enhance interactive learning processes because they facilitate internal and external interactions with sources of knowledge [4].

British Standards Institution (BSI) state that standards encourage standardisation and are focused on the production, exchange and use of information as a means of delivering improved performance across the whole life of a building. Vast amounts of information are created during the construction phase but much is lost or wasted. The industry needs to safeguard against information loss and start managing and analysing information digitally. BIM is not architecture, it is data management. By standardising the information within objects, they can be compared and an appropriate selection for the project made [5].

*d) Benefits of applying standards*

BSI states that the benefits of using standards can include fewer delays and disputes within the team, better management of project risk and better understanding of where costs are being incurred. Looking at the benefit of just implementing standards, a National Institute of Standards and Technology (NIST) report suggests that 2% greater efficiency could be achieved immediately and 10% after a few cycles [2] [12]. The greatest benefit from BIM would accrue over the lifetime of the building [8].

Khosrowshahi and Arayici believe the National CAD Standard (NCS) Version 4.0 will further streamline communication among stakeholders, they believe this improved communication through this standard is intended to reduce errors and lower costs for all disciplines [13].

The British Government believes that level 2 BIM, which is collaborative BIM based on the standard PAS 1192-2, will address the problem of information that is inaccurate, incomplete and ambiguous, which results in unnecessary additional capital delivery costs amounting to 20–25% [2]. NBIMS-US state that without standards more errors and omissions than necessary will be incorporated into designs only to be discovered during construction, where they are very costly to correct. A Standard Framework and Guide to BS 1192 also shows that inaccurate, incomplete and ambiguous production information causes many problems on site. The impacts on the project are late delivery and increased cost, but they estimate higher than PAS 1192-2, with the amount to be approximately 25–30% of the construction costs [3].

The main beneficiary of standards is the client, followed by the facility managers, but all in the supply chain could benefit [8]. Construction projects are costing too much and taking too long as a consequence of unnecessary omissions and errors in project documentation and sub-optimal coordination of design information between consultant disciplines, these issues can be addressed by process standards to improve the project documentation [11].

A lack of trust in the information means that quantity surveyors/cost planners commonly use traditional quantification methods, rather than the automated quantities capabilities of BIM models due to concerns over the accuracy of the information in the model [14]. The mistrust is also described by NBS, where they state that every time a different practice applies their own 'standard' to the upstream data, they have to start again with trust of the model, and often it is this that drives the behaviours of the QS practitioner towards the traditional paper-based outputs [6].

BIM models require the input of vast amounts of complex information from a wide range of project

participants. The quality, comprehensiveness and accuracy of this information are crucial to the successful use of the model. Smith states that research has shown that one of the major concerns with BIM models is the quality of the model, and if parties do not trust the information in the model then it has consequences [13].

*d) Barriers to implementing standards*

Maradza et al. state that participants complained that clients were inconsistent, resistant to embracing BIM process standards and they tended to use their own process standards. This meant that the firm's employees had to forget and learn anew each time they had to interact with a different client. This limited the firm's ability to exploit user and producer relations. This reveals a deeper problem which stems from a limited understanding of standards. Even though the firm through the BIM manager contributes to Industry standards, implementation in projects is slow due to resistance from project managers. This could also explain the lack of consistency in the implementation approach considered by the whole firm. As a result, it may be impossible for the standard to be fully exploited to support interactive learning [4].

The application of standards is dependent on many often poorly understood or articulated factors. The maturity model is used to identify where standards and associated tools and guides are applied to develop a coherent solution to inform the delivery process [5]. Standards are generally supported but not applied rigorously. They are nominally supported; no one is against them but few apply them comprehensively. Official endorsement, preferably by ISO, can give wide recognition [8].

The lack of compatible systems, standards and protocols, and the differing requirements of clients and lead designers, has inhibited widespread adoption of a technology in construction projects [15]. Developing universal standards is essential for the construction industry. Any ICT standards must ensure collaboration and continuing commitment among the participants. Effective management and administration of the ICT standard roll-out is also necessary for marketing and for spreading information, so that the standards become widely known and accepted in the industry. Hore and West also state that the ultimate goal is not only to have ICT standards in place, but also to provide the impetus to ensure that as many stakeholders as possible use them. How this might be achieved is also part of the project and its success will be judged by the extent of the adoption of the standard by the industry [16].



*i) Summary*

The authors found that advantages of using process standards are many but there is limited evidence of these in case studies. The literature review shows that standards facilitate collaboration between teams and allow for a more integrated team, with better project execution, with improved management of project risk and costs. The information is critical to the process standard; if this information is not standardised it can cause trust issues.

### III METHODOLOGY

The authors' primary data collation methodology involved mixed methods approach of both quantitative and qualitative data collection techniques. The two methods of information gathering were:

1. Informal semi-structured focused interviews: Questions were flexible and open ended, allowing for a more complex response with the goal being to extract their tacit knowledge on this subject. A diverse selection of interviewees were chosen that included representatives from international and domestic based professionals
2. Online questionnaire with convenience sampling: The questionnaire questions were developed from the literary review and the responses from the semi-structured exploratory interviews. As the research was on international standards it was felt that a large convenience sample of respondents with BIM experience was required. Invites to the questionnaire were published on construction industry groups with BIM knowledge on the social media site LinkedIn.

The responses were triangulated the authors developed an intellectual discussion of the data through a holistic approach of triangulating the data from the literature review, and the primary research. This enabled the testing of relationships with data synthesis to produce more insightful secondary trends.

### IV PRIMARY RESEARCH

*a) Interviews*

Three face-to-face semi-structured exploratory interviews were conducted to acquire a better knowledge of standards, in particular PAS 1192-2. The approach was to ask two broad questions on standards and PAS 1192, with 'What' or 'Why' sub-questions to obtain further detail [17]. The resulting discussion was distilled into two topics relevant to this paper, which are summarised in the next sections.

The interviewees were chosen for their vast experience with BIM, interviewee 1 is a lead project information manager at a large international construction company. His experience included working on projects in both Australia and the UK and also helping firms implement BIM methodologies. Interviewee 2 was a managing partner of an Irish architectural BIM design house that provides managed BIM production, support and training services, this practise has been leading the development and adoption of BIM in Ireland since 2009. He is also the chairman of the RIAI practice committee for BIM, and coordinator of the Construction IT Alliance (CITA) BIM Group. Interviewee 3 is the director of BIM EMEA (Europe, the Middle East and Africa) at a large international construction company and seconded to the Cabinet Office's Efficiency and Reform Group, where he is head of BIM implementation. He is also Chair of the UK BIM Task Group, BIM2050 and various BIM steering groups.

*i) Implementation of standards*

Interviewee 1 warned that "standards are borne of malpractice" and "a standard should only represent the lowest level of what's required." He added about the danger of companies "integrating standards and not letting anybody know where differences are" will cause downstream problems. He elaborated "it's much wiser just to stay transparent about it, even from an internal management point of view."

Interviewee 2 commented that companies "all come up with their own standard. What is needed is an industry standard." and states that companies "think they have a standard of their own,... if they are the only ones using it it's not a standard." Interviewee added if "a standard is based on consensus.... that's a standard practice or a common practice by definition." Interviewee 3 believes that "everybody within the supply chain should be working to the same standards."

It is consistent throughout the interviews that everyone in the industry needs to be using and adhering to the same standard. Interviewee 1 feels that standards are there to stop people going wrong and they only need to specify minimum requirements. Interviewee 1 warns of the risk of merging industry standards into in-house standards and Interviewee 2 also identifies that in-house standards are not the direction for the industry. He believes the industry should start using common standards, and that a universal standard automatically strengthens the standard. Interviewee 2 believed that an industry standard is needed, not use of in-house standards.

ii) *Achievement of standards*

Interviewee 1 stated that “ultimately consistency gives rise to predictability, to transparency to some degree, and if there are two things that every client wants on any given project its certainty and transparency”. He stated that “if you can make something more predictable, make it more certain, then that makes for a better result.”

On the general question on standards Interviewee 2 states they bring “consistency, with a quality approach, so people know what to expect, guidance and quality of information and, finally, better understanding.” He believed that “if you don’t have consistency you have confusion and misunderstanding, you have disputes and problems.”

Interviewee 2 stated that companies want consistency, they want a clear level of understanding of what has to be provided and when. Interviewee 3 also stated that standards give consistency of approach, which he thinks it is very important that every company is following the same process, and believes it helps to take the waste out of the process.

It is quite clear from all the interviewees that consistency is what is wanted and needed from a standard. Interviewee 1 and Interviewee 2 look for better outcomes by referring to better results and reduced disputes and problems. Interviewee 1 wanted predictability, transparency and certainty; Interviewee 2 similarly wanted guidance, quality and better understanding of the information.

b) *Questionnaire*

The questionnaire consisted of 10 questions, which was piloted to 7 industry/academic colleagues. After the pilot study was completed the questionnaire was then distributed on LinkedIn. The purpose of the survey was to investigate industry standards and their international context, with data gathered on company locations, types and markets. There were 140 international respondents. The data was collected using google forms and collated in excel with the output graphs created using pivot charts.

The following data has been extracted from the questionnaire results to best suit the subject of this paper.

i) *Question 1: What sector of the construction industry do you work in?*

The results show a balanced distribution of the AEC sector but there was a low response for the FM sector.

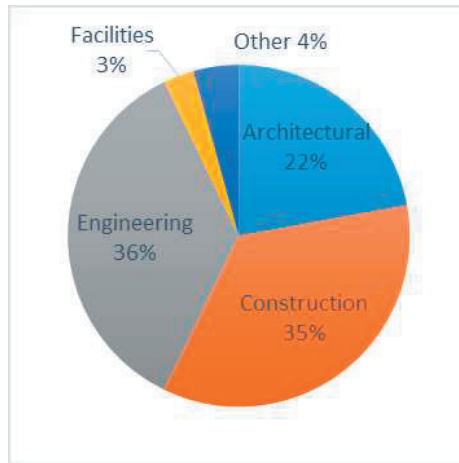


Fig. 1: What sector of the construction industry do you work in?

ii) *Question 2: Currently what level of BIM is your company at?*

The purpose of this question was to investigate the respondent’s BIM Maturity Level, as defined by the BIW Group [13], Fig. 2 shows that 87% of the sample have indicated that they are level 1 and above. With 16% state they are operating at level 3 but this figure is optimistic considering Level 3 BIM has only been recently detailed in the UK.

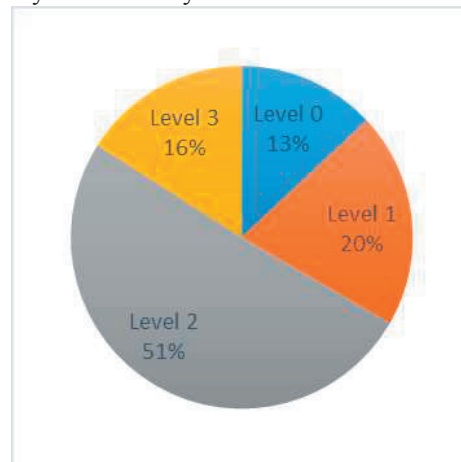


Fig. 2: Currently what level of BIM is your company at?

iii) *Question 3: What is the current Industry standard based on in your company?*

This question asked the respondents to identify the industry standard that they are currently applying. The respondents had a choice of various standards that are available from around the world and also had the option to add a response under the ‘Other’ category. Responses under ‘Other’ were reviewed and filtered to their most suitable response.

Fig. 3 show the results for only the respondents that indicated they are BIM Maturity Level 1 and above i.e. that are required to be using an industry standard. A large number, 48% of respondents indicated that they use no or ‘non-standard’ industry standards, e.g. ‘In House’, these standards are inadequate for them to achieve BIM Maturity Level 1 and above.

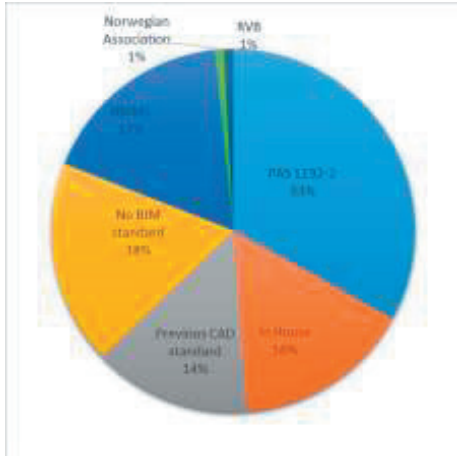


Fig. 3: What is the current industry standard based on in your company?

v) *Question 4: In terms of information, what areas have been improved through industry standards in your company?*

The final question on the questionnaire looked for the respondent’s opinion on how information is affected when industry standards are applied within a company. The results were then filtered to respondents who have indicated they had adopted an industry standard, as represented in Fig. 4 and Fig. 5. Fig 5 excluded “Do not have a BIM standard”, “Previous CAD standards” and “In-house standards”. This clearly shows that respondents that use an industry standard believed that they get better outcomes when using a standard.

It is evident in Fig. 4 and Fig. 5 nearly all of the same items appear for users that do not use industry standards but in a different order.

Although the question in Fig. 5 directly references industry standards, respondents that answered they do not use an industry standard also responded high for some of the elements. The authors believe this indicates that respondents believed that industry standards will improve information even though they do not use them.



Fig. 4: In terms of information, what areas have been improved through Industry standards in your company? 1 Strongly disagree, 2 Disagree, 3 Neither/nor, 4 Agree and 5 Strongly Agree. (Respondents that use an industry standards)



Fig. 5: In terms of information, what areas have been improved through Industry standards in your company? 1 Strongly disagree, 2 Disagree, 3 Neither/nor, 4 Agree and 5 Strongly Agree. (Respondents that used no industry standards)

## V THE TRIANGULATION OF RESULTS

### a) *Rigour Interview*

To add rigour to the research a final interview was undertaken with an Irish industry expert working in the BIM environment. This was a structured interview based on statements from the findings from the questionnaire and the interviews.

Interviewee 4 is the BIM manager for a large Irish contractor. He has extensive experience in managing large BIM projects and has been at the forefront of BIM in Ireland for several years.

### b) Standards

Howard & Björk state that standards are generally supported but not applied rigorously [8]. This is shown clearly in the questionnaire with only half the industry applying standards and with standards shown to improve information in all areas; even respondents who do not use a standard responded that information would be improved.

Interviewee 2 discuss how companies “have a standard of their own” and refers that “if they are the only ones using it it’s not a standard” Maradza et al. [4] state that clients were resistant to embracing BIM process standards and they tended to use their own process standards. This meant that the firm’s employees had to readjust their ways of working for every new client. NBIMS-US [10] state that poor standards in collaboration could lead to individuals in business and individual project teams continuing to repetitively create and re-create local, non-reusable, non-interoperable solutions to the same problems.

Interviewee 2 believed that an industry standard is needed. This call for the use of standards was not evident in the results of the survey where only 52% of the industry that is level 1 and above are using standards. Interviewee 4 added that in-house standards are not standards and wonders if companies realise the benefits of operating within an industry standard.

Interviewee 1 stated that “a standard should only represent the lowest level of what’s required.” This is echoed with NBS, who believe that good standards provide clear requirements that set minimum conformity specifications [6].

Interviewee 3 believed that “everybody within the supply chain should be working to the same standards.” with Howard & Björk believing that all in the supply chain could benefit [8]. This was further echoed by BIW Group who state that good standards allows the supply chain to organise itself better [5].

### c) Value Adds of Using Standards

The top 5 value added areas in the Questionnaire were investigated further; ‘Clarity’, ‘Quality’, ‘Accuracy’, ‘Consistency’, “interoperability”, with ‘Interoperability’ scoring the highest.

Clarity is referred to in NBIMS [10] and Smith [13]. Interviewee 4 strongly agreed with this and links it with accuracy, stating, “it is achieved to a high standard in” the UK BIM industry standard.

Quality was stated by Maradza et al. [4] and NBS [6]. It was also stated in the interviews by Interviewee 2. Interviewee 4 firmly agreed that a standard allows a QAQC (Quality Assurance and Quality Control) procedure.

Accuracy was stated to help with trust by Smith [14], BSI [2] and NBS [6]. Interviewee 4 believed this is “particularly true in” the UK BIM industry standard.

Consistency was the favourite response by the interviewees for what standards achieve, with all three stating this as the most important item in a standard and is referenced in NBIMS. Interviewee 4 agrees emphatically, stating “standards equals consistency.”

Interoperability was also identified by NBIMS-US [10] and Howard and Björk [8]. Interviewee 4 firmly agreed with interoperability.

## VI CONCLUSION

It is clear that industry standards will improve information and are to the companies’ advantage, as they will save time, reduce disputes and improve project outcomes. Information when produced with standards will be readily available, reusable, searchable and interoperable. The industry is in agreement with this, as the questionnaire has highlighted that all respondents, even if they do not use an industry standard, understand that information will improve.

However the industry is still not adopting these standards, as evident from the primary research. If companies fail to move from in-house standards, which are now proving inadequate for working collaboratively, this may result in further uncertainty and render them uncompetitive in the new team centric construction projects.

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