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What is a BIM design model?

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Abstract

In their recent report [1] into Building Information Management or BIM, construction law experts May Winfield and Sarah Rock gives reason to state that the UK architectural, engineering and construction industry or AEC, is hindered by the absence of a clear definition of Level 2 BIM. ISO 19650-2:2018 is based upon the PAS 1192-2:2013 standard[2]. The intent of ISO 19650-2:2018 is to provide a roadmap to facilitate the standardisation of BIM process in a uniformed fashion. A key pillar of ISO 19650-2:2018 is the “information cycle” and central to this is a federated set of design intent models, commonly referred to as the design model. The design model underpins the Level 2 BIM process, however different interpretations by BIM practitioners, impacts the collaborative process leading to disagreement and conflict. This paper will research the design model, focusing on design-bid-build or “traditional” projects, where the main contractor is required to develop the design model into a project information model or PIM. With the publication of the ISO 19650 standard, the AEC industry is obliged to abandon the familiarity of the PAS 1192 suite of documents. However, as was the case with the PAS 1192 suite, the new ISO 19650 standards are not intended to, and do not, provide a definitive definition of Level 2 BIM or the design model. Using a mixed methodology, this paper investigates the design model from the perspectives of different AEC industry stakeholders. A selection of engaged professionals were selected to participate in an online survey, this was followed by interviews with a selection of willing respondents to the survey. The online survey and interview findings were triangulated with a comprehensive literature review and discussed. The paper concludes with valuable insight into BIM in the Irish AEC industry at a time of transition.

Keywords: BIM, Procurement, BIM Process
I INTRODUCTION

The official launch of Ireland’s National BIM Council, was followed by the Government Contracts Committee for Construction’s (GCCC) publication of [3], a public sector BIM adoption strategy. After this, came the publication of [4], a roadmap to digital transition. We are advised in [3] that, several reports across the EU identify systemic issues in the construction process relating to its levels of collaboration, under-investment in technology and R&D; and poor information management. These issues result in poor value for public money and higher financial risk, due to unpredictable cost overruns, late delivery of public infrastructure and avoidable project changes. The recently published report [5] into the escalation of costs at the new National Paediatric Hospital (NPH), makes for sober reading, and will no doubt, be added to the GCCC’s list of EU reports to read. A key component of [3] requires clients to issue a brief that concentrates on required performance and outcome. In addition, it requires designers and constructors to collaborate in the development of an integrated solution that best meets the required outcome. Montague, a leading BIM expert, states in [6] “the industry is willing to deliver this through BIM, but many on both the demand and supply sides still aren’t able”.

The Irish AEC industry has not been subject to the in-depth examinations like those that the UK AEC industry has undergone in the last 25 years. Reports such as [7] and [8] have rigorously examined the UK construction industries performance. In response to a further report [9], the UK government mandated that all UK government construction suppliers, who tender for government projects, must be working at Level 2 Building Information Management (BIM) by April 2016. The fundamental principles for Level 2 BIM were set out in PAS 1192-2:2013, now withdrawn, which was developed in response to the UK government mandate [10]. According to Waterhouse, two years after the introduction of the mandate, the BIM adoption rates were not what the UK government expected. However, stating in [11] that, “the results were still very encouraging, with close to 50% of the industry following PAS 1192-2:2013”.

Around the same time [12], a national survey of BIM adoption in Ireland, reported 55% of organisations were using PAS 1192-2:2013. This suggests that the adoption rates of PAS 1192-2:2013 in Ireland, outstripped those in the UK in 2016.

The “information delivery cycle” is an intrinsic part of ISO 19650-2:2018 as it was in PAS 1192-2:2013. One of the overarching principles of ISO 19650-2:2018 is that “the delivery of information is progressively delivered by the delivery teams” [2]. This takes the form of a federation of design intent models, commonly referred to as the “design model”. According to [10], lean principles, creating more value with fewer resources, should be applied where possible. Appointed parties are enabled to produce information in an effective and efficient manner by using [13], where the “information model is progressed by subsequent delivery teams for each appointment”. These being the design stage and the construction stages appointments. This is where the modelling and the management aspects of information converge.

However, there appears to be a contradiction between the results of the most recent surveys [4, 14] and the extent of BIM models being issued at tender stage. Hore, McAuley and West reference a number of recent construction projects in [14], to emphasise the level of BIM uptake in Ireland. Closer examination of these projects by the author, revealed several projects were executed by the same Tier 1 contractor. This prompted the researcher to question the purpose of a design model. Page five of [10], defines a design model at design stage in Fig 20, as “A dimensionally correct and co-ordinated model…”, and outlines what it “can” be used for. According to Hooper in [15], one of the principle difficulties in realising efficiency gains through the use of BIM is… a general lack of standard terminology and methods of describing process and deliverables. A key difficulty of defining the design models is that it is federated from several different models. To attempt to generically define the scope or model content would be impractical, this is why the development of a project specific responsibility matrix becomes is so important. This paper examines the practicality of the information delivery cycle from the perspectives of different industry stakeholders when applied to traditionally procured projects. It examines the barriers preventing design models being issued at tender stage.

The paper is divided into the following sections:-

II Literature review

III Methodology and research methods

IV Online survey findings

V Interview finding

VI Discussion

VII Conclusions

A comprehensive literature review of BIM terminology and arising conflict was conducted. From the literature review, two sets of questions were developed. One set for the online survey and the other for a series of interviews. The survey and interview finding were analysed and triangulated with the finding of the literature review. The subsequent discussion and conclusions provide a snapshot of the Irish AEC industry between February and March 2019, as it
II LITERATURE REVIEW

a) Terminology

BIM terminology has troubled the industry since Morrell (2011), then the UK’s chief construction adviser, recommended that public policy be based on the use of Level 2 BIM by April 2016, warning the industry to keep the complexities of BIM to themselves and not to burden clients with it. Seven years later Saxon in [16], suggests that the industry did not take the warning seriously, stating that the BIM Task Group of 2011 “created a special language for users, … making the whole subject arcane and opaque to industry outsiders, which includes most clients”.

Leading construction lawyers Winfield and Rock provide clear evidence of the pervasiveness of the BIM terminology problem in [1]. When asked for their definition of Level 2 BIM, 44 of the UK industry’s leading BIM experts each gave a different response. The significance of this was not lost on the authors’ who stated “This goes to the core of industry problems and not to burden clients with it. Seven years later Saxon in [16], suggests that the industry did not take the warning seriously, stating that the BIM Task Group of 2011 “created a special language for users, … making the whole subject arcane and opaque to industry outsiders, which includes most clients”.

The UK’s BIM ambassador for growth, Saxon [16] recommends sticking to the familiar language that had been used by clients, consultants and constructors for decades. Sura in [19], suggests however that there is a problem with using natural language, maintaining that “it introduces a level of vagueness to communication, a common feature in the area of construction, with or without BIM”.

In replacing the PAS1192:2 suite with the ISO 19650-2:2018, the International Standards Organisation (ISO) potentially introduces new barriers by changing the existing and introducing new terminology. Shillcock in [17], believes agreement is unlikely, stating that It is no wonder that the ISO committee had to resort to country-specific annexes to clarify language, when they could not agree common terminology between jurisdictions [21].

Efforts are underway by groups such as the UK BIMAlliance to champion plain language and ensure engagement of professionals at all levels. In [18], it is noted that terminology often becomes one of the first barriers to BIM adoption. Rossiter in [19], poses the question in, “how can we expect to share these new developments if no one understands a word we’re saying”.

The solution, according to Saxon in [16], resides with the client, suggesting a key step to formalising the use of digital technology is for clients to invest in their capability to instruct their design team and constructors, to be able to define their requirements contractually

b) Information Requirements

The terminology in ISO 19650 changes from the PAS 1192-2 document, the term employer is no longer employed, it is replaced by appointing party, hence the employers information requirements (EIR) become the project information requirements (PIR).

The EIR document is crucial to the BIM process. Developed by the client, it forms part of the appointment. Mordue, Swaddle & Philp note in [20] “the EIR is used to describe precisely what models the client requires and what the purpose of those models will”.

On traditional projects it is stressed in [13], the necessity for contracts to reflect all parties’ understanding of the deliverables, and for all parties to share the same understanding. Winfield & Rock note in [1] “there must always be clear definitions of scope, deliverables and parties’ expectations within the binding contractual documents supplemented by open discussions between the parties. This could be assisted by the issue of standard form documents covering the main BIM documentation beyond the BIM Protocol, in particular BIM scopes of services, EIRs and BEP”.

c) The integrity of the design model

Lockley in [21], questions the integrity of the information delivery process suggesting that validation and/or verification of information exchanged between collaborating parties are key factors in their contractual relationships. Stating that “as the uptake of BIM begins to impact, leading-edge organisations have begun to understand the benefits and problems that BIM technologies add to this information exchange arena”. Eastman et al. [22] have pointed out the challenge for the contractor noting the traditional approach presents the greatest challenge to the use of BIM for the contractor, noting, “Because they do not participate in the design process and thus must build a new model after the design is completed”.

This reinforces Lockley’s examination of design teams’ practices stating in [21] “Many have realised that exchanging native models can dramatically increase productivity and efficiency. Others have realised that these models may contain information that they are completely unaware of, and which could invite claims against them” and that “some organisations go as far as to develop processes that automate the removal of most data from their models, just in case it may lead to litigation”.

Eastman et al. in [22] point out there is a dilemma for the client’s design team. The final design must be coordinated and outputs must contain sufficient detail to facilitate the preparation of a construction bid and at
the same eliminate liability for construction issues. They achieve this by taking the approach of only providing design intent models. Lockley in [21], maintains that “because of potential liability, an architect may choose to include fewer details in the drawings or insert language indicating that the drawings cannot be relied on for dimensional accuracy”. Eastman et al. in [22], consider such practises to be inherently inefficient and irresponsible to clients.

\section*{d) The Client Dilemma}

Deeney, Hore, and McAuley in [23], state that the very nature of the Irish construction industry is one of adversity among its stakeholders, where information is closely guarded and knowledge is seen as power. They note that this is an environment where the less information the contractor has the lesser the opportunity for them to “come at you”. Kane et al. in [24] agree that the client is challenged with this confrontational behaviour. It is noted in [30], that if the potential of BIM is to be realised on a project, “this behaviour must end, as open collaboration among project teams is fundamental to the core understanding of the overall BIM solution”.

Jensen in [25], is concerned regarding the legal implications arising from new design methods, working practices and relationships between the parties to the contract. He notes at the time of writing, “there is virtually no case law to guide parties should disputes arise”. It is noted by the NBS in [26] that the use or ownership of the Building Information Model, appeared as a main issue in disputes for the first time at 3%. Holzer however in [27], believes that part of the problem resides with the client stating "Without declared and realistic BIM objectives, project teams usually tap away in the dark as they second-guess the client’s requirements. …. BIM cannot really work without an educated client who can articulate information requirements to the project team”. He goes on that “The dilemma for the client is where to turn for guidance”. It is noted in [1], that the legal and contractual matters of BIM are in a state of flux and development, advising that lawyers cannot engineer their client’s instructions, they are limited by the scope of instruction regarding BIM. One leading legal expert in [1], noted, "when the clients aren’t sure what they are trying to do, the lawyers look at to how they protect them from things that could go wrong". The same lawyers suggested that if clients had a thorough grasp of BIM "the lawyers would then help to work towards helping BIM happen, rather than put obstacles in the way to protect the client from it going wrong". 

Sawhney, Khanzode and Tiwari in [13] believe that clients require independent assistance, stating, “there needs to be an external role of Project Integrator” and suggest that the Royal Institute of Chartered Surveyors should rise to the challenge. One consultant in [1] suggested that, any reference to the PAS standards, led inexperienced team members to think that everything in the standard is applicable. The role of an independent project integrator should minimise this happening.

Morrell in [28], believes that the UK construction industry is challenged to identify the party that should take on the role of “integrator”. He suggest that “the natural candidates should be tier one contractors, but the fear is that they’ve become so used to grinding their margin out of either their customers or their supply chain and that managing margin has now become their core business….. The challenges of putting together an integrated proposition for a client, for which they might be held accountable, lacks appeal”.

Montague suggests in [6], that if directly asked, and correctly incentivised, industry would acquire the skills and deliver, but too many are not being asked. As reported in [29], a possible reason for the Irish government has not introducing any form of BIM mandate is that until recently, construction inflation was not only low, for a number of years it was negative. Expecting an average cost increase of 10% when introducing the new form of contract, tender prices dropped by 30% due to the economic crisis. The lack of a government mandate is the most likely reason that there are no BIM friendly public forms of contract in Ireland. As noted by Deegan in [30], firms offering BIM services in Ireland possess no reference documents or standards. This has changed somewhat, with IS EN19650-2 coming into effect since January 2019, but we are still left without suitable contracts,. The dilemma for the government is does it invest in BIM at a time when construction tender prices as noted in [31] continue to rise or wait for another economic crisis.

\section*{II METHODOLOGY AND RESEARCH METHODS}

The research question “what is a BIM design model” developed from the author’s experience of a phenomenon in the Irish AEC industry. If BIM implementation is as advanced and widespread as suggested in reports such as [32], then why, aren’t there more BIM models being issued to contractors at tender stage. The hypothesis, there is a breakdown in understanding of what a BIM design model is, possibly due to poor understanding of BIM terminology. The research question, hypotheses and objectives were tested against the “FINER” points as defined in [33].

To test the validity of the hypothesis would requires a large sample of data from the AEC industry, on a subject that some might be reluctant to discuss for reasons of confidentiality. The research required a large population sample, ruling out the use of focus groups. The use of case studies had a lot of potential; however,
time constraints would make it difficult to obtain data from a sufficient number of sources, compounded by the typical prolonged duration of construction projects. To ensure a comprehensive examination of the research question suggested one-to-one interviews would be most suitable, but with this approach alone, it would be difficult to carry out stakeholder interviews and solicit feedback from a large sample of industry practitioners.

The most suitable research methodology identified, was a sequential mixed research method. This would allow a large population sample, and detailed examination of the subject through interviews. An extensive literature review was undertaken to develop two sets of questions, one for an online survey and one for the interviews. An online survey using open and closed questions was circulated to 100 members of the architectural, engineering and construction (AEC) industry with 40 responses. This was followed by semi-structured interviews with eight engaged professionals, using open-ended questions. Refer to the table in Appendix A for details of the interviewees’ experience.

A qualitative assessment of the survey and data sets was conducted. This was to establish any themes, sub-themes or common threads. The literature review survey and interview findings were triangulated, discussed and conclusion drawn.

III ONLINE SURVEY FINDINGS

a) Introduction

The online survey was the first section of a sequential mixed method research approach.

The idea behind the online survey was to seek the opinion of a large number of industry professionals from a diverse range of companies and disciplines. This was achieved using Google Forms to contact individuals in BIM roles, identified through a social network for professionals.

Survey respondents were guided through a series of open and closed questions depending on the role they selected. Closed questions to allow some statistical analysis and open questions to allow respondents an opportunity for free expression.

The decision to predominantly focus questions on the recently withdrawn PAS 1192-2:2013 standard, was justified in the survey with only 12.5% of respondents indicated that they were currently implementing ISO 19650-2:2018.

A number of respondents pointed out that the withdrawal of the PAS 1192-2:2013. To ensure the validity of the research, two supplementary questions were added, asking are you using the ISO 19650-2:2018 standard and how does it compare to the PAS 1192-2:2013 document as a guide. Over 73% indicated that they were not yet using the new ISO 19650-2:2018.

The disciplines surveyed, including their percentage breakdown are illustrated in Fig. 1. Over 70% of respondents stated that they had more than five years’ experience.

b) Knowledge of BIM

Respondents subjectively attributed their own level of BIM expertise. One respondent noted, “that there are no experts only people who want to believe they are”. The survey reveals that the majority of BIM consultants claimed expert status, significantly higher than any
other group. With the client and GC indicating low levels of competence. Refer to table 1 below.

When queried about how they would define the design intent model, there were 33 different responses from 40 respondents. A full list of the responses are presented in Appendix B. Despite the different definitions offered, 61% of respondents from a design discipline consider PAS 1192-2:2013 to clearly define the design model, yet previously indicated much lower levels of expertise than the BIM consultants did.

d) Drivers of BIM Mandate

When it came to the question of who drives the BIM, the clients indicated that they or the contractor were more likely to drive BIM on projects, see Fig. 2.

The design team believe they evenly shared the role with the client, whereas the BIM consultants disagreed, indicating that the client was least likely to drive the BIM mandate on their projects.

e) Understanding of BIM terminology

The online survey queried the different disciplines on their understanding of BIM terminology. The design teams and the BIM consultants had high confident levels; the clients and contractors’ confidence levels were much lower, with 60% of clients identified themselves as only familiar. One client commented, “people tend to make up their own terminology, which gets confusing, for example ‘BIM Coordinator’ – this is not in any of the published documents”. The majority of design teams and BIM consultants claimed they fully understood BIM terminology. Notably both disciplines had occasional to frequent disagreement with the
contractor in this regard to terminology, understandable considering the design teams believed that less than 25% of contractors fully understood the terminology. This was generous compared to the BIM consultants, who believed only 10% of contractors fully understood BIM terminology.

Respondents used a variety of sources for explanations of BIM terminology, with the majority referencing both ISO 19650-2:2018 and PAS 1192-2:2013 standards. One respondent suggested that “you pick terminology up by working on projects”, only one referenced the BIM Dictionary [34].

\( f \) Disputes arising from BIM terminology

When queried about disputes related to BIM terminology, over half identified the term LOD as a factor. Written as an open question, it was not possible to interpret which definition of LOD the respondents were referring too. This is because LOD abbreviates a number of different terms. One respondent outlined their experience as follows: “The actual terms usually aren’t an issue in our experience. The scope … can be. For example, Level of Model Definition (LoMD), Level of Detail (LOD), and Level of Information (LOI).
usually causes issues if a definition used is not clear. The LoMD in PAS1192-2:2013 is an example of a definition that leaves much to interpretation”. Yet many others see this standard as the go to place for understanding terminology.

The design and BIM consultant disciplines frequently disagreed with the contractor in relation to terminology. A full list of responses to the question “what are the most commonly disputed terms between the design team and the GC, are listed in Appendix C.

g) Contractual requirements

The BIM consultants firmly believed that the client had a poor understanding of BIM contractual requirements; refer to Fig. 5. The contractor expressed the strongest opinion; which was, the client was not very aware or was totally unaware, refer to Fig. 6. The client had little confidence in their own, or others awareness of the contractual requirements of BIM. Just under 60% of the design team believed that the client was not very aware of BIM contractual requirements.
Two thirds of the design teams stated that they had only some or little input into the EIR, see Fig. 7. While 80% of BIM consultants had some input, over 50% reported that they provided considerable input: “It depends on our role. If appointed by the client, we would have a lot of input. If we are appointed by the Main Contractor, our role would shift to understanding the EIR and developing the BIM Execution Plan (BEP) based on this information.”

One respondent said, “Most EIR’s are generated by design team and not the client – this is gradually changing though”.

The design team almost exclusively agreed that the design responsibility matrix should be developed at concept or brief stage. Over 60% of design team respondents stated that they used a bespoke design responsibility matrix; refer to Fig. 8. There is a big difference in this result when this is compared to only BIM consultant’s responses, where only 20% indicated that their organisation used a bespoke design responsibility matrix (DRM); refer to Fig. 8.

Almost all of the BIM consultants agreed that the DRM should be developed at brief stage. Only one respondent stated, “it is a live document and should be
developed at each stage” also noting, “It should start at ‘brief stage’ and be updated regularly. It should be incorporated into appointments and contacts, through the BIM Protocol”. Another pointed out that: it may need to be updated at later stages, to account for contractor design packages.

In comparison to the definition of the design model, the design team and the BIM consultants all shared a common understanding of the DRM.

IV INTERVIEW FINDINGS

a) Format of Interview

Due to time constraints, it was only possible to conduct face-to-face interviews with eight interviewees.

An informal semi-structured interview technique allowed discussions to develop with the flexibility to follow the any emerging threads. This approach allowed closer examination of topics as they arose. Some interview questions are listed in Appendix D.

All interviews were digitally recorded with the written permission of the interviewees, anonymised and securely stored online. The recording of the interviews were listen back to a number of times. Any themes and subthemes identified in each interview were noted on a spreadsheet. All of the interviews were reviewed for common threads, themes and subthemes. A selection of responses are documented below, with the respondent identified by R1, R2, etc.

b) Responses

The responses from some of the interviews highlighted that a number of Level 2 BIM projects were operating very successfully, having been established following the principles of PAS 1192-2:2013. In these projects “the clients clearly set out what is required, with definitions, they have a clear list of what they expect, the contractors fill in the BIM capability forms, and the BEP, they provide a model production delivery table (MPDT), and a responsibility matrix. ….. These projects are great, but they are rare”. R1

Another interviewee noted, “There are a number of projects out there, with BIM teams that really know what they are doing. These are usually the bigger consultants, where the protocol is issued, and contract is signed, and where the MPDT is developed, reviewed and agreed as part of the contract agreement”. R2

However, the majority of comments were less than positive about the success of BIM on projects. The reasons for this were varied, with the PAS standard coming in for some criticism. The interviews followed an open format. In an attempt to structure the information conveyed during the discussions, a number of headings have been developed.

c) The design model definition

One interviewee believed that there is a definition of the design model in PAS 1192-2:2013, suggesting that it was open to interpretation “I would say that maybe there is a lack of understanding of the definition. This doesn’t change the problem that either a lack of a definition or a lack of understanding of the definition is causing problems”. R1

While another had a different opinion “A lot of people will fall back on the PAS standard and say that this is what it says, that this is what we have to deliver, but the standard doesn't clearly define what has to deliver in terms of the design model”. R2

d) The employer information requirements (EIR)

The general feeling in relation to the EIR was that “the quality of EIR documents from clients is poor, if they existed at all”. R2 This was supported by an architect.
who pointed out “I have only been issued with one EIR in the last two and a half years, but I had developed over 20”. R3 An architect noted, “first-time EIR documents, tend to be template based and err on the side of caution, often over specifying the asset requirements”. R4 Supporting this analysis one interviewee, stating that “It is imperative that the definition of the LOD needs to be set out clearly in the EIR document, for the particular project, as there are so many different interpretations out there. What’s important is what’s in the EIR, it’s not that standards don’t matter, but then the ISO is very generic!” R5 A number of the interviewees agreed that terminology was huge confusion and generating friction, particularly the term LOD.

At the hearth of the matter was a comment from a long established BIM consultant, which sums up the consensus on EIR documents “the EIR is often left to the design team to write, resulting in an immediate lost opportunity to define the client’s requirements”. R1

A number of interviewees expressed the opinion that, “there is too much generic content in EIR’s and that BEP’s, which were frequently overloaded with requirements, that are not followed through on”. R6

Some members of the design teams were prolific producers of EIRs; however, they appeared to blame the client for unclear BIM objectives and were frequently involved in disputes with the contractor in relation to terminology – terminology which they would have been required to set out in the EIR.

e) PAS 1192-2:2013

The PAS 1192-2:2013 document came in for both positive and negative criticism. Some believed that it was too open to interpretation; another considered that it was a good start but that “it has more guidance notes than text”. R8

Another interviewee believed that PAS 1192-2:2013 established industry best practice; you cannot develop an ISO until you establish best practice. R7

The general sentiment was that PAS1192-2 would continue to influence BIM in Ireland in the medium term, even if it has been replaced, and the suggested reason for this was that “the PAS document is widely in circulation and the ISO-19650-2 comes with a fee”. R6

The Royal Institute of Architects of Ireland (RIAI) recently released a set of guidance documents to PAS 1192 suite, known as the RIAI BIM pack. A highly regarded BIM expert, referring to this set of guidance documents noted, “These documents are attempting to fill the gap between the standards and industry practice. There is still a need for a BG 6 type document for architecture and structure; that sets out how you technically develop that information”. R4

f) BEP

The BEP is developed in response to the EIR. One interviewee speculated, “effort is only put into the BEP if it is going to be part of a technical submission, and then it’s only a box ticking exercise. This is because it is going to be scored against specific marking criteria”. R7

g) BIM Protocol

The Construction Industries Council’s (CIC) BIM Protocol document was revised in 2018, some five years after the first edition. One interviewees suggested that for protocol to be used with the ISO 19650 suite, “the language in the protocol will need to be updated, as the terminology is now different”, this statement is supported by [35], the recently revised CIC protocol is based upon the now withdrawn PAS 1192-2:2013 standard.

One interviewee suggested that the BIM protocol document is not being issued “the construction industry council’s BIM protocol is the only document we have, but it is rarely issued”. R2. Another comment was that “when it is issued there appears to be a lack of follow through in relation to the protocol”. R7, or that “the contract Protocol is appended to the contract, and is often not signed until half way through the project, if at all”. R3

h) MPDT

The RM or MPDT was discussed at some length with a number of interviewees.

One interviewee believed that the MPDT “is the most important document stating what has to be delivered by whom, by when and to what detail”. R2

Another interviewee stated that No Protocol, no MPDT, result, no clarity on who is responsible for delivering what information at each project stage. R3

One other comment was that “the GC should submit comments on the MPDT at tender stage, that’s what agreements are about, but it very seldom happens … this comes down to poor understanding of how stuff works.” R1

i) ISO 19650-2:2018 standard

The ISO 19650-2:2018 document was generally acknowledged as a high-level guidance document not intended to define the Level 2 BIM or the design model. ISO 19650-2:2018 was generally acknowledged as having less detail than the PAS, yet was regarded by interviewees as being, as good a guide to the BIM process as the PAS 1192-2:2013.

One interviewee noted, “it is important to understand that ISO 19650-2:2018 is a high level document, there is very little detail. The detail has to come from the country specific annex document”. R5
j) Barriers to issue of the design model

A number of issues were identified by the interviewees from the design perspective as reasons that the design model is not issued at tender stage. Some of these are listed in below:

“All design team appointments are separate; all working to different understanding of what is required”. R3

“One of the design team is only issuing schematics, usually the mechanical and electrical, so the design is not coordinated”. R7

“That would be giving the contractor a stick to beat us with, it’s the adversarial nature of the business, and GC will use the model to identify problems”. R5

“The form of contract favours lowest price, lowest bidder then comes looking for discrepancies in the design. Even if we have something in four different places, they will say the model you didn’t show that, so we didn’t allow for it”. R4

“Completing the design in such short time frames is a Herculean task, almost impossible to be fully coordinated, prefer not to issue it unless it is right”. R4

“Exposing ourselves to risk, when we don’t need to, when it wasn’t asked for by the client. This is all about not ending up in court one day”. R1

One interviewee commented, “the GC is required to produce a Construction Model and that is something that the GC doesn’t understand, they expect that the design intent model will become the construction fabrication models through the design teams. They don’t understand that they have a role to produce a means and method model!”. R5

k) From the perspective of the GC

There are issues with the models issued by the design teams’, interviewees noted,

“If the model is issued without sheets and views, you can’t check it and if you can’t check the model, then you simply can’t trust it”. R7

“No sheets and views are issued with the model, this is because of intellectual property rights”. R2

“The model is useless, unless all the drawings are developed from it”. R8

“The models just aren’t suitable for us”. R8

The director of one prominent GC with responsibility for estimating stated; “We just aren’t seeing the models at tender stage, we are reacting to the market and the market isn’t looking for BIM”. R8

One of the interviewees noted, “the main reasons that the Irish government hasn’t invested in BIM, is the economic crisis that started in 2008 delivered them significant cost savings”. R8

V Discussion

The online survey recorded 33 different definitions of the design model from 40 individuals, with seven noncommittal responses. These results clearly indicate a problem with the definition of the design model, as set out in PAS 1192-2:2013. These results are somewhat comparable to the Winfield Rock, findings of 44 different definitions for Level 2 BIM, when examining the legal and contractual barriers to BIM implementation. This research set out to examine the barriers to collaboration on traditionally procured BIM projects caused the design model not being issued to the GC at tender stage. The concept behind the withdrawn PAS 1192-2:2013 standard and its replacement ISO 19650-2:2018:2018 was and is the efficient use of information. The special language and terminology that early adopters developed, with confusing acronyms, such as “LOD” were the first and continue to be persistent barriers to collaboration. Clients appear to be particularly disadvantage by the terminology and BIM jargon. Clients cannot engage in a process if they do not know what people are talking about. The survey indicated a majority of respondents used the PAS 1192-2 or ISO19650 as a reference source for definitions of BIM terminology. This is concerning as the terminology changes between these documents and is likely to confuse even further as it is difficult to see people disregarding PAS 1192:--2 that quickly. The appearance of the BIM Dictionary [34] only once was surprising considering so many respondents considered themselves to be BIM experts.

As indicated in the online survey finding, less than a quarter of respondents from the design disciplines believed they fully understood BIM terminology. Yet the majority of the designers’ considered the definition of the design model to be adequate which sharply contrasted the opinion of the other disciplines. A possible reason might be that the designers are have become familiar with their definition of a Design Model, after all there were 33 different definitions returned. Is it that the definition of the design model is being interpreting by them to meets their own requirements?

One of the difficulties of transitioning to ISO 19650-2:2018 is that it is a high-level document, which is light on guidance. Moreover, unlike PAS 1192-2 it
does not attempt to define the design model. One of the ISO standard’s strengths is that it minimises the amount of terminology used. It is a fresh start, and is supported by initiatives such as that by the BIMAlliance championing plain language into the BIM arena.

On the other hand, a weakness of the new ISO suite is the changes to established BIM term. An example of this is project information requirements (PIR) which replaces the employers’ information requirements (EIR) term form PAS 1192-2:2013 because the term “employer” no longer exists in the ISO 19650-2:2018. The term “employer” is replaced by the term “the appointing party” hence, the employer’s information requirements had to change, becoming the “project information requirements”. These are straightforward changes, implemented no doubt to internationalize the standard and introduce the standard to new users. However, we must question the wisdom of introducing the new term “exchange information requirements” (EIR) with the same acronym as very familiar one, it is replacing, would a term like “XIR” have been less confusing?

The online survey indicated a lack of expertise within the client discipline. This manifests itself in a lack of rigour in the application of standards to BIM projects in Ireland. While the research explored what a design model is or rather what it means to the different stakeholders, a re-occurring theme in the interviews was the lack of contractual awareness of the client. Another theme was the quality of designs expected in the time allowed, affecting the quality of the design model for tender issue, described as a “herculean” task. Releasing a design model at tender “as a coordinated model” was perceived as risky, unless the design was 100% complete. A particular risk was identified within the design team, if one of the team did not perform, the model could not be fully coordinated. The design teams were reluctant to expose their professional indemnity insurance without sufficient time, and in some cases payment for developing a coordinated model. The default position according to [36], was to issue the design model for “design intent only” or “for supplementary information”, as was done in the case of the NPH project.

A number of interviewees’ suggested that an independent BIM advisor should represent the client, and should be appointed at concept stage, before the design team briefing stage, tasked solely looking after the interests of the client.

The UK government’s envisaged in [9], that achieving Level 2 BIM maturity would address the long identified and widely acknowledged problems of inaccurate, incomplete and ambiguous information. The Irish AEC construction industry has emerged from an extensive economic downturn. In this same period, the UK government implemented their Level 2 BIM mandate. We have now transitioned through PAS 1192-2:2013 to ISO 19650-2:2018. Yet, there is still no mandate from the Irish government on the use of BIM. Although [7] did summarise the benefits of BIM as waste reduction, with potential programme and cost savings to the client, the risks of BIM are also outlined. One notable risk is, a greater potential for claims, should a poorly prepared design model be provided for tender purposes.

Recent amendments to the Irish government’s Public Works Contract (PWC) form of contract are an acknowledgement by government of an inability on the part of some design teams to produce complete information at tender stage. A number of interviewees are supported in this view by leading construction solicitors Hussey Fraser, they draw attention to the PWC guidance notes for an employer designed contract. These state that the design must be fully developed, and go through seven different stages of analysis and assessment before the invitation to tender is issued. The solicitors in [37], found it difficult to reconcile the poor quality of design information made available to contractors at tender stage with the level of scrutiny in the process.

Acknowledging that BIM is fast becoming an essential requirement for informed consumers of construction services across the globe, the GCCC note in [7], the implementation BIM on a number of high profile building projects in Ireland, including the NPH project at the St James’s Hospital campus.

One of the of Irish government’s objectives in [38], is to reduce the potential disruption that the BIM change processes might bring, both within the public sector and to the consultants and contractors that are engaged thereunder. Perhaps disruption is what we require; after all, most AEC organizations continually cope with change, the introducing of the BCAR regulations being a case in point. Surely the AEC sector would relish the prospect of change, the benefits of which are increased efficiency and competitiveness [39].

In [36], the potential dangers in going to tender without a complete design are highlighted, as are the dangers of applying BIM technology without clear client requirements and a rigour in the implementation process. The NPH BIM execution plan directed that the design model should only be issued as “information supplementary to the contract design information”. Despite this directive, the bill of quantities was developed from the design model by the client’s quantity surveyor. This approach resulted in inconsistent and incomparable measures, compared to those undertaken by the contractors, who only used the 2D drawings. We often discuss the lack of legal cases relating to BIM reaching the courts, the NPH report [40], highlights that not all BIM disputes reach the courts, the inconsistency referred to was disputed by the client but resulted in €16 million euro variation to the NPH contract for just one system.

As is evidenced in [12], Irish AEC companies operate in both jurisdictions; they adapt to changes in UK legislation and transfer learning and processes to
their Irish operations. However, the UK government not only provided comprehensive guidance and training, it offered support to assist companies to adopt BIM. As a client, they also provided projects on which BIM could be implemented. The €16 million expended on the one single variation on the NPH, would have gone a long way to develop implement a BIM mandate in Ireland.

Different understandings of what constitutes a BIM design model can lead to conflict. As the BIM model increasingly forms part of contractual arrangements, conflict will inevitably result in a growing number of legal disputes. The NBS in [11] noted as significant that 3% of those who have been in dispute report the “use or ownership of the BIM information model” as the main issue.

A number of interviewees suggested much greater rigour should to be applied to the development of the BIM Model, for it is to be issued as a contract document. Later on in the process, because the requirements the EIR are unclear they are either watered down or abandoned. This is often because the a BIM protocol is not attached to the contract, one interviewee suggested that the CIC BIM protocol [41] is “the only document we have”.

Legal issues, such as model ownership, IP rights and increased liability often hinder the continuous flow of information envisaged in the PAS 1192-2 standards. The author’s experience is supported by the findings of the interviews, it appears that even when a BIM model has been developed, it is rarely issued at tender stage. The GC is frequently requested to price the project based on the 2D information only.

Eastman et al. in [22], suggest that traditional projects are the most difficult to implement BIM on and consider the practise of issuing a design model for information only, to be inherently inefficient and irresponsible to clients. The practise of stripping out the sheets and views, as suggested by Lockley thus rendering the design model useless to the GC is even less efficient or responsible to the client. Eastman et al. in [42] maintain that this is disingenuous to the client.

The introduction of IS EN ISO 19650-1 & 2 in January 2019 means that the Irish AEC industry has a BIM standard to work too. What is required now is a form of contract that is compatible with BIM.

VII CONCLUSIONS

The Irish government introduced fixed price, lump sum contracts in 2007 as the solution to costly overruns on projects. The prolonged economic crisis which started in 2008 saw tender prices drop by 30% “delivering savings to the construction budget, this was most likely one of the main reasons the Irish government did not see the benefit of mandating BIM on public works contracts similar to the UK’s government mandate as proposed in the in [9]. Recent changes in the public works contract transfer risk away from the GC, and back to the government. Construction tender prices continue to rise. The government has struggled to achieve high levels of design completion at tender stage, opening themselves to cost over runs due to inaccurate tender pricing. The BIM process if executed correctly should increase the quality of design at tender stage. The lack of a government mandate however, has stilled the development of BIM in the Irish AEC industry. Whilst much of the Irish AEC industry has embraced BIM what they require now is leadership from the government, the largest construction client in the country. Following the enactment of IS EN ISO 19650-1 & 2, the government needs to introduce forms of contract like NEC 4, which facilitate the BIM being used on projects.

The enactment of IS EN ISO 19650-2:2018 standard provides an opportunity for a fresh start. This is however, a high-level process focused document, which rightly avoids attempting to define the BIM design model. The research question “What is a design model?” is answered in the survey and confirmed and interviews findings, it is something different to everyone. Due to the nature of construction, project teams to change all of the time. Unless the design model and BIM terminology are clearly defined on a project by project basis, the problems identified in the research are likely to persist. As recommended in [13], appointing parties all stakeholders should integrate the ISO 19650 suite of documents into with the ISO 9001 quality assurance standards. Key to a successful the transition to ISO 19650-2:2018 are the guidance documents released by BSI, and those currently being developed by bodies such as the centre for digital build Britain. Comprehensive publications such as BG 6, which provide a clearly structured approach to the development of the design model in terms of mechanical and electrical services, are the benchmark for future guidance documents and the industry should work to towards the development of a document similar to BG 6 for architects and structural engineers.

How the inexperienced client defines the project BIM requirements appears to be the primary cause for the design model not being issued at tender stage, as a contract document. Clients should seek advice from an independent BIM expert, to advise on the suitability of each project for BIM implementation and how best to proceed. The government could establish a panel of certified BIM advisers similar to the energy advice scheme, this could be grant aided and be used as a tool to drive the implementation of IS EN ISO 19650-2:2018. The standard requires the client to clearly define the project aims and hence what a design model means for each project. Such a scheme would assist client to develop their project information requirements with the assistance of an independent BIM advisor, they could then clearly communicate this to the design team in their contractual appointments.
REFERENCES


### Appendix A

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Appendix B

Responses to some of the Online Survey Question responses:- How would you define the Design Intent Model?

1. Coordinated Model with LOD of no less than 250 and LOI to adequately convey the materials and systems
2. A single federated model containing all relevant design information at minimal detail in a collaborative environment.
3. Low-medium geographical detail with medium/high non-geographical detail to allow progression in next stage.
4. A model that can be used for +/- 10% pricing and in principal works and is coordinated. But is not a construction model.
5. A model presented to the client during Concept Design.
6. Coordinated to a point where it has been demonstrated that the services installations can be accommodated in the plant rooms, service routes and risers and that the contractor will be able to develop the construction / coordination model without having to make material changes to the structure or architecture.
7. Objects used for location with embedded data for characteristics.
8. All services modelled in accordance to there P&ID, A&ID or line drawing.
9. Model that communicate the design and demonstrates that the coordination will work without modelling all details.
10. A coordinated 3D representation of the intended construction design geometry, developed to the required information specification suitable for all intents and purposes in line with the projects strategic objectives.
11. Don't Know.
12. A design model is a fit for purpose model and dimensional correct architectural and structural model. For services, the M&E services must be dimensional correct and designed to fit into the allocated space that has been allocated by the architect. The design model must include all information required to ensure that spatial allocated can be done successfully utilised by the contractor. If the services do not fit in the space then it cannot be a design model or utilised but the contractor to coordinate.
13. Model that adequately describes the physical and functional properties of a proposed building (or built infrastructures), appropriate to the contractual level of definition for the design responsibility assigned to the designer.
14. Assuming the design intent model is a discipline specific model for the purposes of this question, a design intent model is a coordinated model output that accounts for all design decisions (ex. materials, spatial requirements), considerations (ex. service distribution route sizing, regulation compliance, etc.), and relationships (ex. service zone sizing, ceiling layouts, etc.).
15. Definition should be provided as well as all other new terms to avoid legal implications.
17. I would define design intent model as that delivered to a generic performance specification standard. It represents the project delivery team’s interpretation of the client’s brief, including a generic performance specification for modelled assets. At this stage the model still a theoretical entity intended to meet industry and regulatory performance standards. The design intent model will become an as built once the procurement and installation of actual building assets has occurred. These elements will most likely have differing performance values to the design intent (generic) versions.
18. There is a new standard released for Europe to remove the National barriers, it's heading towards true collaboration.
19. LOD of the geometry and information has enough detail to demonstrate the general requirements of the design and performance criteria. It does not include manufacturers’ information.
20. Visual coordinated data rich communication platform of design and process intent.
Appendix C

What are the most commonly disputed terms between the Design Team and the Contractor?

1. BIM scope, elements to be model, information to be produced, cost of BIM
2. There are a few, but “COBie” is my favourite - usually considered as “something new, unnecessary, nice-to-have, but nobody will use it”, when in fact it is simply a series of “lists” of key information that is required (and was always required) at handover, to “operate” a building (in fact it is legally required under H&S regulations). The only difference is that it is required in an organised, structured, digital format (based on industry standards), so that it can be imported into operational systems (CAFM, CMMS, etc.) without re-typing it again. The fact that this information was previously delivered in poor, unstructured, paper-based or static formats (or possibly not even delivered at all), does not make it “new, unnecessary, or nice-to-have”. I love quotes like “we don’t do COBie”, or “if you want COBie, that will be extra”.
3. The actual terms usually isn’t an issue in our experience. The scope associated with a term can be. For example, Level of Model Definition, Level of Detail, and Level of Information usually causes issues on a project as a definition may be used that does not reflect the requirements for the project or is not clear. LoMD in PAS1192-2:2013 is an example of a definition that leaves much to interpretation and often does not reflect the information that a client actually needs.
4. What is a model - most people still see this as the Revit model and not a collection of different information sources.
5. It depends on the contract if it is clear or not. See for example my work on the many faces of LOD
6. LOD/LOI.
7. Level of Detail / Development
8. Incomplete design
9. OFCI / OPCI high LOD model production. Disjoint in the co-ordination tracker between fabrication lead in times and other trades who do not pre-fab. Other contractors who do not employ “BIM”. The totally absurd and narrow mindedness of a lot of GCs and Clients when they “demand” that Revit is the tool for BIM during pre-construction. Anyone who says this, really does not have a clue of the true meaning of BIM.
10. LOD
11. Design Intent models, and responsibility for updating same when a design change occurs
12. Level of design requirement and what is exactly to be produced, i.e. a live model as work progresses onsite or just a model once work is complete
13. Level of detail of model elements should be developed to a higher level by design team, will reduce duplication of work on an asset.
Appendix D

Interview Questions

Interview No. 1
The following questions formed the basis of the interviews:-
1. Is it possible to develop a working definition of the design intent model?
2. How would you explain why so few models are issued at tender stage?
3. Do a lot of projects start out not Level 2 BIM but sort of drift into becoming BIM Projects, it seemed like a good idea?
4. Is it right to call it Level 2 BIM when the model isn’t issued?
5. Bill East suggests that on DBB projects the GC always has to start the model again, because not involved at the design stage
6. Is PAS 1192 not supposed to pass the model on to the GC
7. Do you think that the GC has an expectation that he is going to get the model and why is it not communicated to him that he isn’t. Is there a better way of communicating this to the GC?
8. Do you believe the GC is reluctant to sign the MIDP??
9. PAS 1192 requires the MIDP to be developed and signed post contract signing.
10. Does the MIDP set out what’s in the Model?
11. When should the RM or (MPDT) be developed?
12. How do you know what the GC is planning to give the client?
13. Would you expect the contractor to submit a MPDT at tender stage with the Contractors input, does it happen?

Interview No. 2
1. Is it possible to develop a working definition of the design intent model?
2. On DBB BIM projects, can you explain why so few models are issued at tender stage?
3. When models are issued, in your experience, are they clearly defined?
4. Significance of the design responsibility matrix
5. BG6
6. Is the ref to BG6 going to be lost with the ISO release?
7. DRM at tender stage, contractually do they deal with it enough, appended to the Protocol?
8. Misunderstood terminology LOD, why are we still talking about this so far on?
9. On DBB projects the GC has to start again, usable model
10. Classification is it a good idea?
11. Does it define the design intent model?
12. Does the GC have the skills & time to utilise it at tender stage?
13. Can BIM work for Traditional projects?? When it’s supposed to be Lean

Interview No. 3
1. Is it possible to develop a working definition of the design intent model?
2. 70% of DT respondents believe PAS 1192 does define the design intent model
3. Experience of Model issued to the GC at tender stage
4. DRM is a very significant Doc, very few seemed to understand what it did, terminology, LOD. Key to the DRM Don't understand how to express it
5. How often does the MPDT go out with the model to the GC at tender stage to explain?
6. The quality of the EIR is key?
7. Plain language introduces vagueness V’s tech language is too difficult
8. ISO 19650-2:2018 is a good guide
9. Ambiguity in PAS 1192-2:2013; the less we give to the GC the better. We won’t tell them what he has to do
10. Client will have 2 contracts with the DT & the GC. on traditional projects
11. Change in contracts
12. Does BIM even work on DBB Projects, as a lean process? Bill East says the GC has to start again.
13. And anything that missed is the lead designer’s responsibility?
14. DT is wary of the GC