

2019

## What is a BIM Design Model?

James Peters

*Technological University Dublin, james.peters@mydit.ie*

Malachy Mathews

*Technological University Dublin, malachy.mathews@tudublin.ie*

Follow this and additional works at: <https://arrow.tudublin.ie/bescharcon>



Part of the [Architectural Technology Commons](#), [Computer-Aided Engineering and Design Commons](#), [Engineering Education Commons](#), and the [Structural Engineering Commons](#)

---

### Recommended Citation

Peters, J. & Mathews, M. (2019) What is a BIM design model? *CITA BIM Gathering 2019*, Galway, Ireland, September 26th. doi:10.21427/dc04-4k35

This Conference Paper is brought to you for free and open access by the Dublin School of Architecture (Former DIT) at ARROW@TU Dublin. It has been accepted for inclusion in Conference papers by an authorized administrator of ARROW@TU Dublin. For more information, please contact [arrow.admin@tudublin.ie](mailto:arrow.admin@tudublin.ie), [aisling.coyne@tudublin.ie](mailto:aisling.coyne@tudublin.ie), [vera.kilshaw@tudublin.ie](mailto:vera.kilshaw@tudublin.ie).

## What is a BIM design model?

*Authors: James Peters (1) Malachy Mathews (2)*

*School of Multidisciplinary Technologies,  
College of Engineering and Built Environment,  
Technological University Dublin, Dublin, Ireland*

*(1) E-mail: james.peters@mydit.ie*

*(2) E-mail: malachy.mathews@dit.ie*

### Abstract

The recent report into Building Information Management or BIM, by construction law experts May Winfield and Sarah Rock entitled “Winfield Rock Report” [1] 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. The ISO 19650-2 standard published in 2019, is based upon PAS 1192-2:2013. The intent of ISO 19650-2 is to provide a roadmap to facilitate the standardisation of BIM process in a uniformed fashion. A key pillar of ISO 19650 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 stakeholders. A selection of engaged professionals participated in an online survey followed by interviews with a selection of respondents to the survey. The interview findings were triangulated with a comprehensive literature review and the online survey results. These are discussed and 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 [2] was followed by the publication of the Public Sector BIM Adoption Strategy by the Government Contracts Committee for Construction (GCCC) [3] and the Roadmap to Digital Transition [4]. According to [3], 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 into the escalation of costs at the new National Paediatric Hospital [5] (NPH), makes for sober reading, and will no doubt, be added to the GCCC's list of EU reports. 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 to develop an integrated solution that best meets the required outcome. Montague, a leading BIM expert, believes that "the industry is willing to deliver this through BIM, but many on both the demand and supply sides still aren't able" [6].

The Irish architectural, engineering and construction (AEC) industry has not been subject to the level of in-depth reviews that the UK AEC industry has undergone in the last 25 years. Reports such as [7] and [8] rigorously examined on the UK construction industries performance. In response to [9], the UK government mandated that all UK government construction suppliers tendering for centrally-procured 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 the now withdrawn PAS 1192 suite of documents, 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, he did believe that "the results were still very encouraging, with close to 50% of the industry following PAS 1192-2:2013" [11].

Around the same time in 2016, a national survey in Ireland [12], revealed 55% of organisations were using PAS 1192-2:2013. This

suggests that adoption rates of PAS 1192-2:2013 in Ireland exceeded those in the UK in 2016.

The new ISO 19650-2 standard are founded on the now withdrawn publically available standard, PAS 1192-2: 2013 [13]. The "information delivery cycle" is an intrinsic part of ISO 19650-2 as it was in PAS 1192-2:2013. One of the overarching principles of ISO 19650-2 is that "the delivery of information is progressively delivered by the delivery teams" [14]. This takes the form of a federation of design intent models, commonly referred to as the "design model". PAS 1192-2:2013 requires lean principles, creating more value with fewer resources, to be applied where possible [10]. Appointed parties are enabled to produce information in an effective and efficient manner by using ISO 19650-2. The "information model is progressed by subsequent delivery teams for each appointment" [15], typically at design followed by construction stages. 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, 16] and the amount of BIM models being issued at tender stage. In [16], researchers Hore, McAuley and West reference a number of recent construction projects, to emphasise the level of BIM uptake in Ireland. Closer examination of these projects by the author, revealed several executed by the same Tier 1 contractor. This prompted the researcher to question the purpose of a design model. Figure 20 on page five of [10], defines a design model at design stage as "A dimensionally correct and co-ordinated model ...", the problem is it goes on to state what it "can" be used for. The difficulty for the reader is that the design models is federated from several models, and the scope or model content cannot and is not defined, as this would be impractical. This is where the responsibility matrix becomes so important. This paper examines the practicality of the information delivery cycle from the perspectives of different industry stakeholders, and examines if design models are not being issued at tender stage, and if not, why?

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 conflict was conducted, an area that had barely been investigated. Two different sets of questions were developed from the literature review. One set for the online survey and the other for a set of interviews. The survey and interview finding were analysed and triangulated with the literature review. The discussion and conclusions provides a snapshot of the Irish AEC industry between February and March 2019, as it transitions from PAS 1192-2:2013 to ISO 19650-2.

The survey and interview results should be of great interest to future researchers of BIM maturity in the Irish AEC industry.

## 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. He warned the industry to keep the complexities of BIM to themselves and not to burden clients with it. Seven years later in [17], Saxon 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 in enabling BIM on projects. It is clear that this contrary perspective and engagement affects how BIM is viewed and therefore defined".

The UK's BIM ambassador for growth, Saxon [17] recommends sticking to the familiar language that had been used by clients, consultants and constructors for decades. Sura 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" [19].

In replacing the PAS1192:2 suite with the ISO 19650-2, the International Standards Organisation (ISO) potentially introduces new barriers by changing the existing and introducing new terminology. Shillcock, in [18] 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 [19], they point out that terminology often becomes one of the first barriers to BIM adoption. Rossiter, the European and International Standards convenor for BIM terminology, poses the question in [20], "how can we expect to share these new developments if no one understands a word we're saying?".

The solution, according to Saxon, resides with the client, proposing that 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 [17].

### 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 [21] "the EIR is used to describe precisely what models the client requires and what the purpose of those models will".

The ISO 19650 standards stress that, on traditional projects, it is essential that the contracts reflect all parties' understanding of the deliverables and all parties' share the same understanding[15] . 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*

In [22] Lockley 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, “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. [23] 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 Lockleys examination of design teams’ practices stating in [22] “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”. He goes on further stating: “some organisations go so 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. [23] point out the dilemma for the client’s design team, where “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 by taking the approach they are only providing design intent. Lockley maintains in [22] “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. [23] “consider such practises – based strictly on design intent – to be inherently inefficient and irresponsible to clients”.

### d) *The Client Dilemma*

Deeney, Hore, and McAuley in [24], state that the very nature of the Irish construction industry is one of adversities 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 [25] agree that the client is challenged with this confrontational behaviour, noting: 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 for the industry”. [30].

Jensen in [26] 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 worth nothing however that in [27], the NBS have identified the use or ownership of the Building Information Model, appearing as a main issue in disputes for the first time.

Holzer in [28], however, 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”. Winfield and Rock recognize in [1], that the legal and contractual matters of BIM are in a state of flux and development, noting lawyers cannot engineer their client’s instructions, they are limited by the scope of instruction regarding BIM. One leading legal expert noted in [1], “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 interviewee suggested that if clients had a thorough grasp of BIM “the lawyers would then help to work towards helping that happen rather than perhaps putting obstacles in the way to protect the client from it going wrong”.

Sawhney, Khanzode and Tiwari (2017) believe that clients require independent assistance, stating that, “there needs to be an external role of Project Integrator” suggesting that the Royal Institute of Chartered Surveyors should rise to the challenge [29].

Morrell in [30], believes that the UK construction industry is challenged to identify the party that should take on the role of “integrator”. He suggests 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 in [6] believes that if directly asked, and correctly incentivised, industry would acquire the skills and deliver, but too many are not being

asked. A possible reason that the Irish government has been slow to introduce any form of BIM mandate is that until recently construction inflation was not only low, for a number of years it was negative. According to [12] “Fixed price, lump-sum contracts were introduced in 2007 as the solution to these cost overruns ... However, shortly after their introduction, the economic crisis hit with the result that not only did the expected average cost increase of 10% not materialise, but tender prices dropped by 30%” R8 [31]. The lack of a mandate is the most likely cause for there being no BIM friendly public forms of contract. As noted by Deegan in [32] firms offering BIM services in Ireland possess no reference documents or standards, however this has changed somewhat, with the publication of ISO 19650-2:2018 was published an Irish standard IS EN19650-2 which came into effect the same day.

## II METHODOLOGY AND RESEARCH METHODS

The research question, hypotheses and objectives were tested against the “FINER” points, feasible, interesting, novel, ethical and relevant, as defined in [33]. The research question developed from the author’s experience of BIM implementation in the Irish AEC industry. The hypothesis; BIM implementation was not as advanced and widespread as suggested in published reports, media publications and at conferences by the industry, as BIM models not being issued at tender stage.

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 set of questions, one for an online survey and one for the interviews. An online survey using open and closed questions, was issued to 100

members of the architectural, engineering and construction (AEC) industry with 40 responses. Semi structured interview were then held with eight engaged professionals, using a semi-structured interview approach and a series of open-ended questions.

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

## III ONLINE SURVEY FINDINGS

### a) Introduction

The online survey was the first strand of a sequential mixed method research approach. It was developed using Google Forms which allowed easy tracking of responses and generation of bar and pie charts.

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 by contacting individuals through an established social network for professionals. Individuals to identify themselves as operating in various BIM roles.

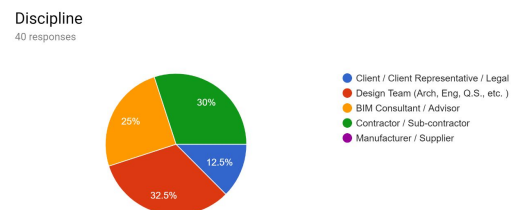


Figure 1: Breakdown of Disciplines surveyed

Survey respondents were guided to a series of questions depending on the role they selected. The questions were presented in both open and closed formats. The closed questions allowed some statistical analysis while the open questions allowed respondents an opportunity for free expression.

The survey questions predominantly focused on the recently withdrawn PAS 1192-2:2013 standard. This decision appears to be justified on the basis that only 12.5% of the respondents indicated that they were currently implementing ISO 19650-2.

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 standard and how does it compared to the PAS 1192-2:2013 document as a guide. Over 73% indicated that they were not yet using the new ISO 19650-2.

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.

Table 1 Discipline indicating expert status

Discipline	Expert Status
Client	20%
Design	33%
BIM Consultant	100%
Contractor	20%

#### c) Definition of the design model

The interviewees were asked if they believed PAS 1192-2:2013 adequately defined the design intent model. The results are presented in Table 2.

When analysed as one group 62% of respondents believed that PAS 1192-2:2013 did not adequately define the design intent model, compared to 38% who believe it did, a considerable difference when compared to the 61% of design teams' who believed it did.

Table 2 Definition of design model in PAS 1192-2

Discipline	Yes	No
Client	0 %	80 %
Design	61 %	39 %
BIM Consultant	27 %	63 %
Contractor	18 %	82 %

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 A. 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.

Who drives BIM on your projects?

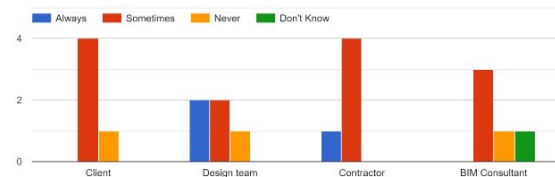


Figure 2: Client responses

#### 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 confidence 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.

Awareness of BIM contractual requirements?

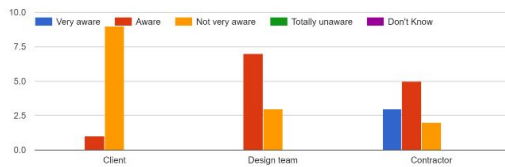


Figure 3: BIM Terminology

Respondents used a variety of sources for explanations of BIM terminology, with the majority referencing both ISO 19650-2 and PAS 1192-2:2013 standards. One respondent suggested

Does the contractor fully understand BIM terminology?

13 responses

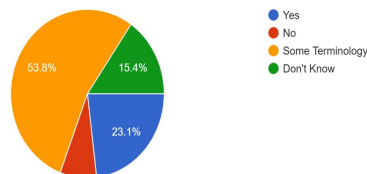


Figure 4: Clients response

that “you pick terminology up by working on projects”, only one referenced the BIM Dictionary [34].

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 to. 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.

## f) Contractual requirements

The BIM consultants firmly believed that the client had a poor understanding of BIM

Awareness of BIM contractual requirements?

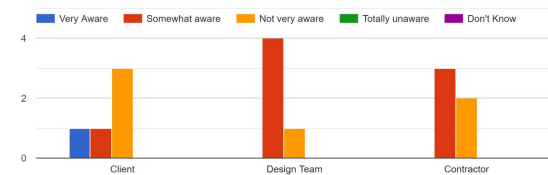


Figure 5: Clients Response

contractual requirements; refer to Fig. 5. The contractor expressed the strongest opinion; which was the client was not very aware or was totally unaware,

Awareness of BIM contractual requirements?

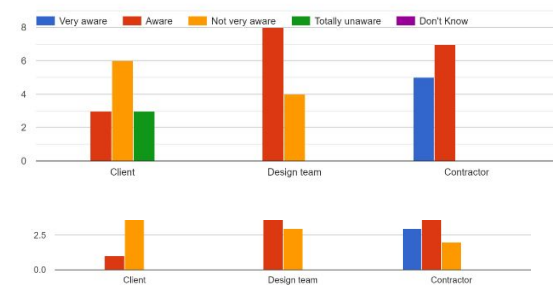


Figure 6: Contractors' response's

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

What level of input do you have into the Employers Information Requirements (EIR)?  
13 responses

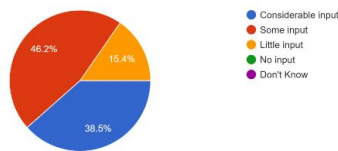


Figure 7: Design team response

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

#### g) Design responsibility matrix

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);

Does your organisation have a bespoke Design Responsibility Matrix ?  
13 responses

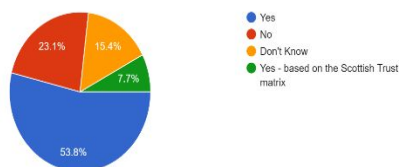


Figure 8: Design team response

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.

Does your organisation have a bespoke Design Responsibility Matrix ?  
10 responses

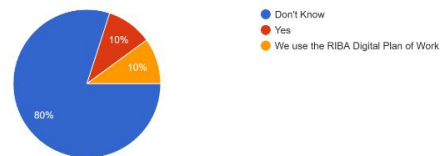


Figure 9: BIM Consultants Response

## 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 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 heart 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 was too much generic content in EIR's and that BEP's were frequently overloaded with requirements, which were not followed through on.

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". RX

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

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". RX

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 interviewee suggested that the Protocol If it's to be used with the ISO 19650 suite then the language in the protocol will need to be changed, as it is based upon the now superseded PAS 1192-2:2013 terminology [35].

One interviewee suggested that the 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". RX, or that "the contract Protocol is appended to the contract, and is often not signed until half way through the project, if at all". RX

**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 standard**

The ISO 19650-2 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 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 is a high level document, there is very little detail. The detail has to come from the country specific annex document". RX

However, others contradicted the understanding the country-specific annex would not go into this level of detail. "The Annex is not going to get into a lot of detail". RX

Two interviewees commented that ISO 19650-2 has to be generic; after all, it is an international document. Two others suggested that the level of detail needs to be more project specific.

One interviewee noted, "the standard is the standard, and that over time people will have to come up with their own documents to say this is what we deliver". R2

**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 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 methods 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 the 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 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 disadvantaged 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 with the opinion of the other disciplines. A possible reason might be

that the designers 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 interpreted by them to meet their own requirements?

One of the difficulties of transitioning to ISO 19650-2 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 from PAS 1192-2:2013 because the term “employer” no longer exists in the ISO 19650-2. 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 different stakeholders, a recurring 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 was to issue for “design intent only” or “for supplementary information”, as was done in the case of the NPH project [36].

It was suggested by a number of interviewees 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 construction strategy 2011 envisaged that achieving Level 2 BIM maturity would address the long identified and widely acknowledged problems of inaccurate, incomplete and ambiguous information [9]. 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. Yet, there is still no mandate from the Irish government on the use of BIM. Although a 2017 consultation, paper did summarise the benefits of BIM as waste reduction, and potential programme and cost savings to the client. The position paper goes on to outline the benefits and risks of BIM. One notable risk is a greater potential for claims, should a poorly prepared model be provided for tender purposes [7].

Recent amendments to the Irish government's Public Works Contract (PWC) form of contract are an acknowledgement by the government of an inability on the part of some design teams to produce complete information at tender stage. A number of interviewees supported this and by leading construction solicitors Hussey Fraser, who draw attention to the PWC guidance notes for an employer designed contract. These guidelines 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. Considering this level of scrutiny in the process, the solicitors found it difficult to reconcile the poor quality of design information made available to contractors at tender stage [37].

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 of 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 rigour in the implementation process. The NPH BIM execution plan the issued as "information supplementary to the contract design information". Despite this, 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 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[40].

Irish AEC companies operate in both jurisdictions; they adapt to changes in UK legislation and transfer learning and processes to their Irish operations, as is evidenced in [12]. 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 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 interview findings, it appears that even when a BIM model has been developed, it is rarely issued at tender stage. The GC is frequently instructed to price the project based on the 2D information only.

Eastman et al. in [23], 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 were introduced 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 which transfer risk from the GC, back to the government. The government has struggled to achieve high levels of design completion at tender stage, opening themselves to cost overruns 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 has stifled the development of BIM in the Irish AEC industry. Much of the Irish AEC industry has embraced with BIM software tools, what they need now is the government to mandate BIM, there is no excuse, we now have IS EN ISO 19650-1 & 2 enacted. Suitable documents such as NEC 4 or other alliancing type contracts must be introduced, or the government PWC forms adapted.

The introduction of the new ISO standard offers the opportunity for a fresh start. Clients, design teams and contractors should integrate ISO 19650 with their existing ISO 9001 quality assurance standards as recommended in [15]. The ISO 19650-2 standard is a high level, process driven document, which correctly avoids defining the BIM design model. Key to the success of the transition from PAS 1192-2 to ISO 19650-2 will be follow on guidance documents which released by BSI [43] and being developed by bodies such as the centre for digital build Britain.

The client should engage independent expert advice prior to appointing their design team, this expert should advise on the implementation of BIM on each project. Each project should be evaluated on its own merits. An experienced design team with the appropriate skills should be appointed; a responsibility matrix should be developed by the design team and agreed with the independent expert before the team is appointed. To ensure collaboration between the teams, the correct contractual agreements and BIM protocols should be implemented. Above all, BIM should be evaluated as the appropriate solution for each individual project.

A project information requirements document should be developed by the client with the assistance of the independent expert with input from the whole design team for each project. Comprehensive publications such as BG 6, which provides a clearly structured approach to the development of a design model in terms of mechanical and electrical services, are the benchmark for future guidance documents. The industry should work towards the development of a document similar to BG 6 for architects and structural engineers.

## REFERENCES

- [1] M. Winfield and S. Rock, "The Winfield Rock Report," UK, February 2018. [Online]. Available: [http://www.ukbimalliance.org/media/1185/the\\_winfield\\_rock\\_report.pdf](http://www.ukbimalliance.org/media/1185/the_winfield_rock_report.pdf)
- [2] N. B. Council. "National BIM Council of Ireland." NBC. <http://www.nbcireland.ie/> (accessed).
- [3] (2017). *A Public Sector BIM Adoption Strategy*. [Online] Available: <https://constructionprocurement.gov.ie/wp-content/uploads/BIM-Adoption-Strategy-Statement-of-Intent.pdf>
- [4] N. B. Council, "Roadmap to Digital Transition," in *Roadmap to Digital Transition For Ireland's Construction Industry 2018-2021*, E. a. I. Business, Ed., ed. Ireland: Enterprise Ireland, 2017.
- [5] O. C. S. Cronin, "National Paediatric Hospital Project Planning Application," in "Outline Construction Management Plan @ St James's Hospital," 2015. [Online]. Available: <http://www.nchplanning.ie/wp-content/uploads/2015/07/4-Outline-Construction-Management-Plan.pdf>

- [6] R. Montague, "BIM - State of the Nation," 5th December 2018,
- [7] S. M. Latham, "Constructing the Team," in *Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry*, ed. Department of the Environment, 1994, p. 135.
- [8] S. J. Egan, "Rethinking Construction," in "The report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction," HMSO, 1998. [Online]. Available: [http://constructingexcellence.org.uk/wp-content/uploads/2014/10/rethinking\\_construction\\_report.pdf](http://constructingexcellence.org.uk/wp-content/uploads/2014/10/rethinking_construction_report.pdf)
- [9] (2011). *Government Construction Strategy*. [Online]. Available: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/61152/Government-Construction-Strategy\\_0.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf)
- [10] PAS 1192-2:2013 (WITHDRAWN, SUPERSEDED BY BS EN ISO 19650)
- Specification for information management for the capital/delivery phase of construction projects using building information modelling (now superseded)*, T. B. S. Institute, Uk, 2013. [Online]. Available: [https://shop.bsigroup.com/ProductDetail/?pid=0000000030281435&\\_ga=2.241823367.404958148.1552823925-1255659812.1552823925](https://shop.bsigroup.com/ProductDetail/?pid=0000000030281435&_ga=2.241823367.404958148.1552823925-1255659812.1552823925)
- [11] R. E. Limited, "National BIM Report," NBS, UK, 2018. [Online]. Available: <https://www.thenbs.com/knowledge/the-national-bim-report-2018>
- [12] B. Ireland, "Digital transition Survey," 2017. [Online]. Available: <http://www.bicp.ie/digital-transition-survey>
- [13] bsi, "New iso 19650 uk transition update Q & A," C. f. D. B. Britain, Ed., ed, 2018.
- [14] *BE EN ISO 19650-1*, ISO, 2018.
- [15] ISO, "BS EN ISO 19650-2," in *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling*, ed, 2018.
- [16] D. A. Hore, D. B. McAuley, and P. R. West, "Building Information Modelling in Ireland," Dublin, 2017. [Online]. Available: <http://www.bicp.ie/irish-bim-study/>
- [17] R. G. Saxon, "Going Digital - A guide for construction, clients, building owners and their advisers.," UK BIM Alliance, UK, 2018. [Online]. Available: [https://www.ukbimalliance.org/wp-content/uploads/2018/11/UKBIMA\\_Going-Digital\\_Report1.pdf](https://www.ukbimalliance.org/wp-content/uploads/2018/11/UKBIMA_Going-Digital_Report1.pdf)
- [18] P. Shillcock. "From BS 1192 to ISO 19650 and everything in between." NBS. <https://www.thenbs.com/knowledge/from-bs-1192-to-iso-19650-and-everything-in-between> (accessed).
- [19] A. Kemp, P. Martin, P. Bhandal, S. Holmes, R. Hartwig, and D. Glennon, "UK BIM Alliance Annual Report 2018," UK BIM Alliance, UK, 2018. [Online]. Available: [https://www.ukbimalliance.org/wp-content/uploads/2019/03/UKBIMA\\_Annual\\_Report\\_2018\\_FINAL.pdf](https://www.ukbimalliance.org/wp-content/uploads/2019/03/UKBIMA_Annual_Report_2018_FINAL.pdf)
- [20] D. Rossiter. "Constructing Language Pledge." UK BIMALLIANCE. <https://www.ukbimalliance.org/project/constructing-language-pledge/> (accessed).
- [21] S. Mordue, P. Swaddle, and D. Philp, C. Wilson, Ed. *Building Information for Dummies*, 1st Edition ed. UK: John Wiley & Sons, 2016, p. 112.
- [22] P. S. Lockley. "Validating employers' information requirements." NBS. <https://www.thenbs.com/knowledge/validating-employers-information-requirements> (accessed 19.04.2019).
- [23] C. M. Eastman, P. Teicholz, R. Sacks, and K. Liston, *BIM handbook : a guide to building information modeling for owners, managers, designers, engineers and contractors*, 2nd ed. Hoboken, NJ: Wiley, 2011, pp. xiv, 626 p.
- [24] J. Deeney, A. V. Hore, and B. McAuley, "Public / Private BIM: An Irish Perspective," presented at the CITA BIM Gathering, Dublin, Ireland, 14th – 15th November, 2013. [Online]. Available: <https://arrow.dit.ie/beschrecon/51/>.
- [25] R. Kane, B. McAuley, D. A. V. Hore, and S. Fraser, "Collaborative Public Works contracts using BIM – An opportunity for the Irish construction industry?," presented at the *Proceedings of the 2nd CITA BIM Gathering*, Dublin, Nov 12 – 13th, 2015.
- [26] F. S. Jensen, "Risk, Liabilities and Uncertainties in Building Information Modelling," LAW, Department of Law, AARHUS UNIVERSITY, Denmark, RETTID 2018/Specialaefhandling 2, 2018. [Online]. Available: [https://docs.google.com/document/d/12bshehPCTXDiOuBXiYaMzk\\_ciy08DwOjUYdOEQEXYZM/edit](https://docs.google.com/document/d/12bshehPCTXDiOuBXiYaMzk_ciy08DwOjUYdOEQEXYZM/edit)
- [27] NBS, "National Construction



- Contracts and Law Report," UK, 2018. [Online]. Available: <https://www.thenbs.com/knowledge/national-construction-contracts-and-law-report-2018>
- [28] D. Holzer, *The BIM Manager's Handbook: Guidance for Professionals in Architecture, Engineering and Construction* (no. Book, Whole). GB: John Wiley & Sons Inc, 2016.
- [29] A. Sawhney, A. R. Khanzode, and S. Tiwari, "Building Information for Project Managers," in "rics.org/insights," London, 2017. [Online]. Available: <https://www.rics.org/globalassets/rics-website/media/knowledge/research/insights/bim-for-project-managers-rics.pdf>
- [30] P. Morrell, "Verdict on the construction Industry," M. Brown, Ed., 13 Oct 2016 ed. UK Construction Online: UK Construction Online, 2016.
- [31] O. o. G. Procurement, "Report on the review of the Public Works Contracts," Dublin 2, 2014. [Online]. Available: <https://constructionprocurement.gov.ie/wp-content/uploads/Report-on-the-Review-of-the-Performance-of-the-Public-Works-Contract.pdf>
- [32] K. Deegan and M. Mathews, "BIM: Building Information Management (not Modelling)," presented at the CitA BIM Gathering, Croke Park, November 23rd & 24th, 2017.
- [33] P. Farrugia, B. Petrisor, F. Farrokhyar, and M. Bhandari, "Research questions, hypotheses and objectives," *Canadian Journal of Surgery*, no. 53(4). pp. 278–281
- [34] B. Succar. "BIM Dictionary." BIME Initiative. <https://bimdictionary.com/> (accessed.
- [35] U. B. Alliance, *Information Management according to BS EN ISO 19650*: UKBIM ALLIANCE, cdbb, bsi, 2019. [Online]. Available: <https://www.ukbimalliance.org/wp-content/uploads/2019/03/Information-Management-according-to-BS-EN-ISO-19650-Guidance-Part-1-Concepts-1.pdf>.
- [36] PricewaterhouseCoopers, "New Children's Hospital Independent Review," in "Review of escalation in costs," PricewaterhouseCoopers, Dublin, 2019. [Online]. Available: [https://merrionstreet.ie/MerrionStreet/en/News-Room/Releases/20190409\\_NCH\\_Report.pdf](https://merrionstreet.ie/MerrionStreet/en/News-Room/Releases/20190409_NCH_Report.pdf)
- [37] H. F. Solicitors, "Proposed Changes to the Public Works Contracts," vol. 2015,
- [38] (2017). *Government strategy to increase the use of digital technology in key public works projects*. [Online]. Available: <https://ogp.gov.ie/ga/government-strategy-to-increase-use-of-digital-technology-in-key-public-works-projects-launched/>
- [39] R. Agarwai, S. Chandrasekaran, and M. Sridhar, "Imagining construction's digital future," McKinsey&Company, 2016. [Online]. Available: <https://www.mckinsey.com/~media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Imagining%20constructions%20digital%20future/Imagining-construction-digital-future.ashx>
- [40] R. Davies and C. Harty, "Implementing 'Site BIM': A case study of ICT innovation on a large hospital project," *Automation in Construction*, vol. 30, pp. 15-24, 2013, doi: 10.1016/j.autcon.2012.11.024.
- [41] CIC, "Building Information Modelling (BIM) Protocol," in *Standard Protocol for use in projects using Building Information Models*, Second Edition ed. Great Britain, 2018, p. 24.
- [42] C. M. Eastman, *BIM handbook : a guide to building information modeling for owners, managers, designers, engineers and contractors*, 2nd ed. Hoboken, NJ: Wiley, 2011, pp. xiv, 626 p., 8 p. of plates.
- [43] *PD 19650-0:2019 Transition guidance to BS EN ISO 19650*, ISBN 978 0 539 01770 0, BSi, UK, 2019. [Online]. Available: <https://shop.bsigroup.com/ProductDetail/?pid=0000000030380842>



## Appendix A

Responses to Online Survey Question:- 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.
16. LOD350 with accurate representations of the Design Specifications.
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.
21. Federated model involving all design models.
22. Low LOD. We do not expect much in the way of detail or clash free. This does depend on the type of project though. Commercial and industrial tend to be lower quality models from the AE than say in pharma and semi-conductor. The latter should already have gone through rigorous co-ordination, etc.
23. Never up to the standard that expected or required from the client. The GC are left with the slack.

24. The source from which all design drawings should derive from.
25. If required, as defined in the EIR, it should consist of a complete federated model along with associated documentation not necessarily within the model. This should then be taken and developed into the construction model.
26. Design models are usually not as complete or as coordinated as they should be.
27. PIM is a model including graphical and non-graphical information. Design intent model is a model developed to show the basic design requirements of a building this can also include 2D information within the model.
28. 80% design intent detail present, 20% co-ordinated.
29. PIM is not purely the DIM.

#### Appendix B

Responses to Online Survey Question:- What is your resource for BIM terminology?

1. PAS 1192
2. Level 2 BIM Docs and BIM plus Scottish Trust website
3. ISO 19650-2
4. ISO19650 / PAS 1192
5. Don't Know
6. Pas
7. Building Information Modelling
8. BIM terminology is picked up by working on BIM projects
9. Internet
10. IHS
11. ISO 19650-2 (previously PAS1192 & BS1192), BS 8541 suite, NBS and RIBA DPoW
12. PAS 1192-2:2013, Cpix, BIM Form
13. Bond Bryan
14. Web
15. Not sure what this question means
16. PASS1192-2
17. Usually NBS
18. I'm not sure I understand the question
19. Pas1192 ,NBS
20. Mixed sources
21. ? Standards
22. App & Internal dictionary document

## 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 / OPCl 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.
14. Gap in the design information.

## 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 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

#### Interview No. 4

1. Is it possible to develop a working definition of the design intent model?
2. Does Govt form of contract hinder what you put into a model?
3. In the tender period would you issue a model?

4. Reasons for not issuing a model at tender stage?
5. Bill East suggests the GC has to build their own model
6. The quality of the EIRs
7. Misunderstandings Terminology
8. The design responsibility matrix, two contracts, one with the client the other with the contractor
9. Does the GC come back with a design responsibility matrix?
10. Does PAS 1192 give usable guidance on the development of a model that is useful to the GC?
11. There seem to be a lot of gaps in the standard
12. Can we discuss the Ireland Annex to ISO 19650-2?
13. Project Integrator

Interview No. 5

1. Is it possible to develop a working definition of the design intent model?
2. Misunderstood terminology LOD
3. MPDT is vague around the responsibility of the contractor
4. Project integrator role
5. Plain Language / vagueness. Have we got too technical
6. Contractual requirements of BIM
7. Does BIM work on DBB projects?
8. Antagonism between DT & GC; does it make the DT reluctant to share the info?
9. Does BIM work on DBB projects?

Interview No. 6

1. Is it possible to develop a working definition of the design intent model?
2. Significance of the DRM
3. Are the new DRM & MPDT the same thing?
4. One comment received was that PAS 1192: was “all over the shop”
5. Design done and is handed to the contractor
6. Does the form of contract limit what you can do in the model?
7. How informed is the client?
8. Quality of the EIR
9. LOD
10. Client knowing what they want
11. Response to tender MPDT submitted
12. Signing of the contract
13. Why don't we see court cases to do with BIM?
14. Making a model useful for the GC
15. Revised PWC with BOQ
16. Plain Language
17. Does it work on a BDD?

Interview No. 7

1. Is it possible to develop a working definition of the design intent model?

Interview No. 8

1. Is it possible to develop a working definition of the design intent model?
2. Do you get many BIM Models?
3. Does it work on DBB projects?