

LEVEL OF DETAIL SPECIFICATIONS, STANDARDS AND FILE-FORMAT CHALLENGES IN INFRASTRUCTURE PROJECTS FOR BIM LEVEL THREE

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ABSTRACT

The UK government's mandate of BIM Level Two since April 2016 in the Architecture, Engineering, and Construction (AEC) industry meant that companies need clear standards and a road map for BIM implementation, especially in terms of standards. Now the UK government is looking to start implementing BIM Level Three, which is mentioned in the Government Construction Strategy 2016–2020, March 2016. Therefore, the AEC industry needs clearer standards to go further than BIM Level Two and to start the implementation of BIM Level Three. In infrastructure and civil works, where the gap between the industry and BIM is wider than in the building environment, having clear standards covered by direct road maps and platforms is essential. This paper challenges the fitness for purpose of the current specification and standards for infrastructure areas and civil works. It will be argued that the transfer of information and processes between site works and building, in general, is not yet clear, which might complicate the implementation process; in the sense that to facilitate the implementation process in infrastructure projects, the standards might be included in the file data properties which could help all stakeholders to work in various level of detail (LOD) specifications. This paper will be considered as a contributed paper, mainly built on a comprehensive review for LOD standards for sites, land development, civil works and file-format concepts under the specific guidance for the information management requirements associated with projects delivered using PAS 1192-2; the paper will also be shared in some of the management and technical interviews with project managers and BIM coordinators from the Gulf regain project's experiences as part of the primary data. To be more practical, the paper will share a prototype of land development project developed in Muller Road, Bristol, UK, to be introduced using a visual information chart, showing the file format for the land development project's information life cycle in detail, concept design projects and the capability of current BIM platforms to help engineers to go further.

Keywords: BIM, infrastructure, level three, land development, civil works, LODs.

1 INTRODUCTION

Building Information Modelling (BIM) is defined as 3D physical properties with graphical and non-graphical information and documentation data formats for all phases of concept, design and construction [1], which is considered as a management process using specific platforms for the project life cycle, and one of the most common standards and roadmaps for implementing BIM is PAS 1192-2 2013 [1]. The LODs October 19, 2016 which was issued by BIM Forum [2], also illustrated the LODs as a part of the BIM process and they aimed to help both designer and contractor share the same platform from a standard point of view which could make the implementation processes and BIM specification for all stakeholders clear to start using BIM in deferent levels of details.

In infrastructure projects (land development, civil works and roadway) the challenges begin with communication between stakeholders and the information channels [3], which is dealt with using several platforms [4]. BIM implementation as a process or a set of tools in the field of infrastructure is still limited when compared to the building industry [5], and it mainly concerns the integrated BIM model with GIS data [6]; while investment in this sector by governments is bigger than in the building sector, in the sense that the investing in



Britain’s future report which was issued by the Chief Secretary to the Treasury by Command of Her Majesty in the UK [7] mentioned that the investment in infrastructure projects in the UK until 2020 will be around £100 billion, which should lead the engineering industry and engineering standards team to focus more on the infrastructure area.

The aforementioned leads us to ask, what happens if these stakeholders don’t have a clear commutation plan and management data channel with no compatible platform, and how can they apply the Employer’s Information Requirements (EIR) which is the first step in the information delivery cycle based on PAS 1192-2 2013 [1] (Fig. 1), as a part of BIM implementation?

2 PROBLEM STATEMENT

The Employer’s Information Requirements – Guidance Notes, version 07:28.02.13 [8] mentioned that the EIR includes three main aspects – technical, management, and commercial – and with more focus on the technical part and looking for reference number 1.1.4 which presents the level of details and development; if the stakeholders in the BIM project life cycle tree, from client, designer, QS, authorities and contractor, don’t have a clear LOD which should cover all project phases, areas (building, infrastructure, landscape and land development projects) and specifications, how are all these parties able to interact on one platform? This might make BIM implementation in the field of infrastructure from the LOD perspective unclear, and might create more difficulties when BIM Level Three is implemented.

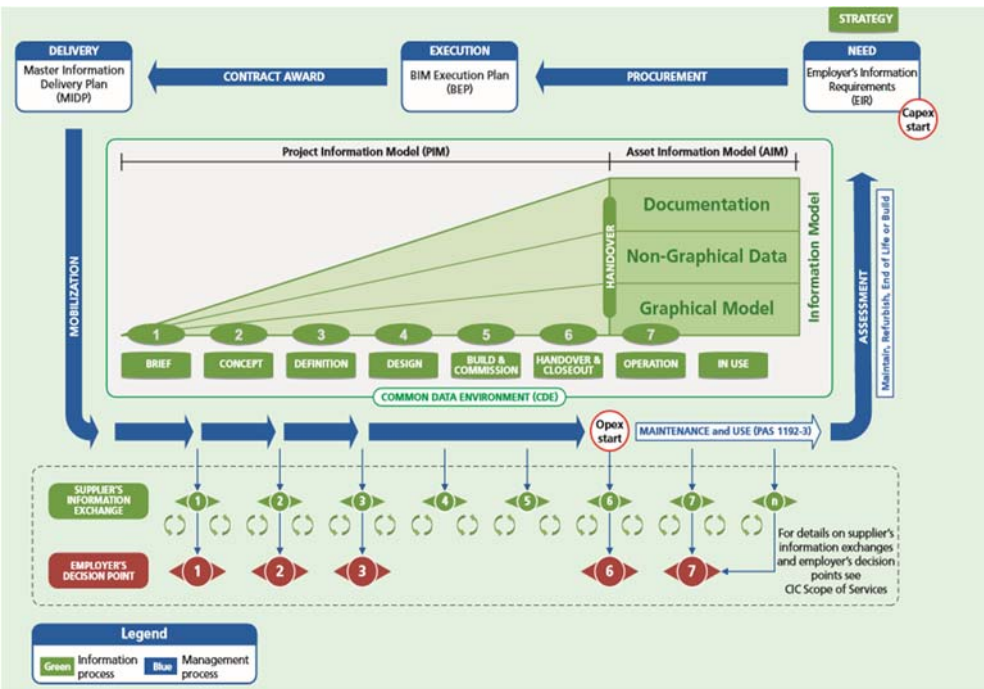


Figure 1: The information delivery cycle, PAS 1192-2 2013 [1].

On the other hand, in BIM for infrastructure there is no main platform format as to what is presented in PAS 1192-2 2013 [1] for BIM Level Three, such as Industry Foundation Classes (IFC) file format, which create difficulties in the data communication channel, especially between more than one stakeholder, as what happens in land development projects.

Thus, we are lead to ask what common file properties could be used for infrastructure as a main platform, as well as what are the main gaps that should be taken into consideration from a standard point of view to make the implementation of BIM Level Three clearer than before in infrastructure.

3 RESEARCH METHODOLOGY

This paper will be considered as a contributed paper which will mainly be built on a comprehensive review for LOD standards for site, land development and civil works and file-format concept in PAS 1192-2 2013 [1], as well as recent research and conference papers which will cover BIM in infrastructure concerning the challenges encountered during the application of the standard as a part of the implementation, or as a part of the work process.

Also, this paper will try to introduce the gaps in standards, specifications, and processes during BIM implementation in infrastructure and what the further recommendations from the industry to solve these challenges are; so, the paper will share some of the management and technical interviews with project managers and BIM coordinators from the Gulf region project's experiences as a part the primary data (see Fig. 2).

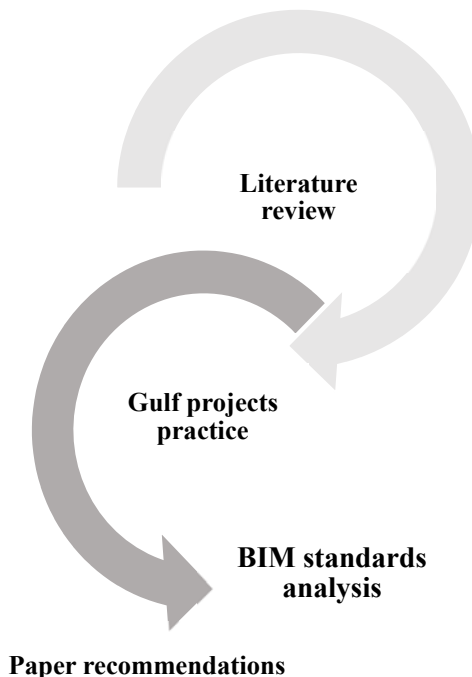


Figure 2: The paper's research methodology.

4 LITERATURE REVIEW

The way of working or handling projects in the infrastructure sector generally differs to what happens in the building sector, which might also make the effectiveness of current BIM management plans and work processes differ [7].

In 2010, Tezel et al. [9] argued that “Visual Management” in the infrastructure project life cycle is very important due to making the stakeholder communication data channel easier because of continued changes in most of the infrastructure projects, and these projects are mainly considered as a large-scale project and generally take more time than building projects from the timeline-scale point of view. A case study for the BIM implementation of a pilot project for a UK motorway, which was presented in the *21st Annual Conference of the International Group for Lean Construction 2012* [10], mentions that the first step in implementing BIM in an infrastructure project is to start from the existing plan and process, to recognize what happens in the traditional way of working in this sector, project objectives and challenges. The case study’s team claimed that one of the main challenges they encountered concerned when they had a BIM model with more than one thousand BIM parameters and elements from road, MEP utilities, and servicers, which made the project’s organization and structure difficult to be built and presented BIM 4th and 5th dimensions [11].

As previously mentioned, most BIM for infrastructure studies are focused on integrated BIM with GIS and CityGml models [12], while the challenge is one platform for BIM in infrastructure and building projects.

Looking at BIM Level Three (stage three) where the UK government is looking to currently implement it, the main point is to have “network-based integration” [13], which is mainly based on having multiple dimensional models (*nD*); but how the infrastructure could be developed for that model, or if it is based on BIM processes or if it might need a new definition for BIM platform environments (Fig. 3) to handle that needs consideration.

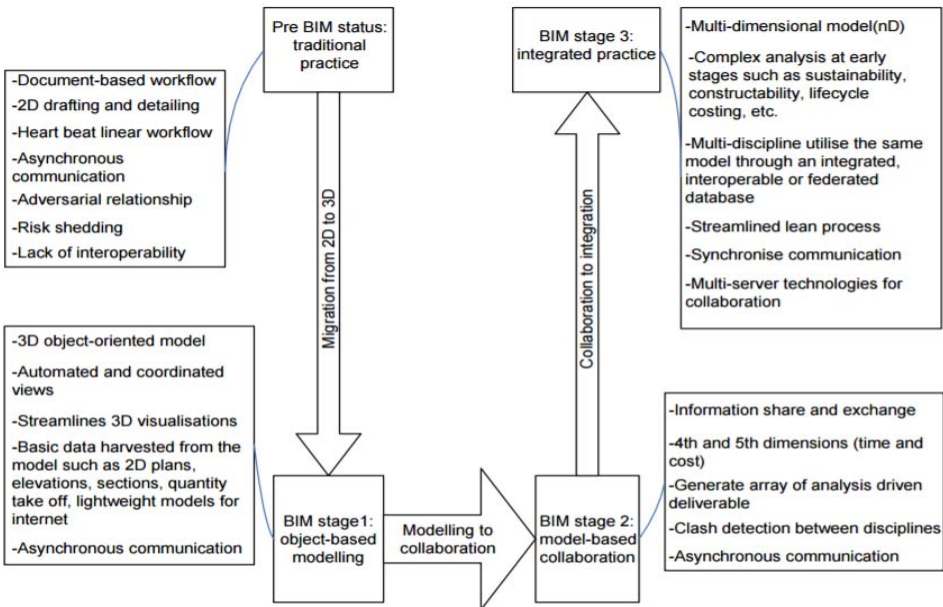


Figure 3: BIM maturity stages in BIM implementation [13].

When Khosrowshahi and Arayici [13] shared the statistics for the UK's engineering industry, concerning the main BIM tools used to prepare the BIM model (Fig. 4), they revealed that most uses of BIM technology are in the building area, while software like Civil 3D or InfraWork 360 are used more in infrastructure and are not mentioned in the results, which might lead to the new question – if the engineering infrastructure industry needs to have new platform technology covers that need or improve the existing ones to cover more than one area (Building and Infrastructure), what happens now, for example, in Revit which (in general) covers Architecture, Structure, and MEP? And also, might these results present one of the most important questions – do the standards (Process) lead the software and technology industries or do the software and technology industries lead the standards?

When looking for the distribution of researches and papers in BIM for infrastructure (Fig. 5) [14], most papers tried to cover a single area, such as a highway or earth works, while the challenges might be more concerning the integrated BIM model (infrastructure and building model) from the standards or platforms point of view.

Howard and Björk [15] argue that the challenges in BIM implementation start from information and software technology and they considered them as playing a key role in the BIM life cycle project; from this thought they recommended to improve the current BIM standards to be aligned with current BIM tools, or to drive the BIM tools industry and technology to have a federated BIM model that covers building and infrastructure models with one platform (see Fig. 6).

However, they also asked if the IFC file format can produce a federated BIM model which is not only allow to commentate but to work on it, by covering one platform for both modelling and design as well as building and infrastructure (land development projects).

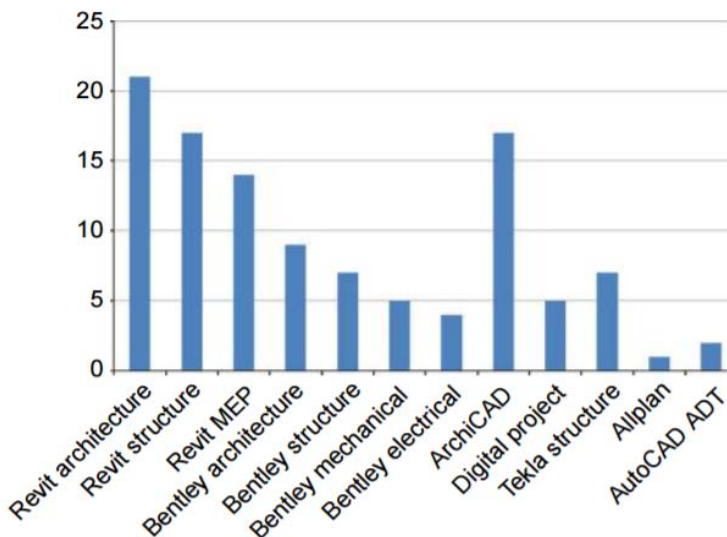


Figure 4: The distribution of the answers given by the respondents to the question: “what BIM tools or systems have you used?” [13].

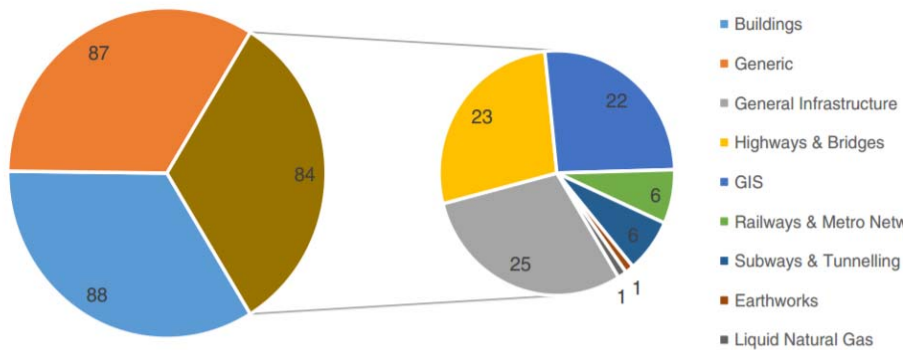


Figure 5: Distribution of publications by industry sector [14].

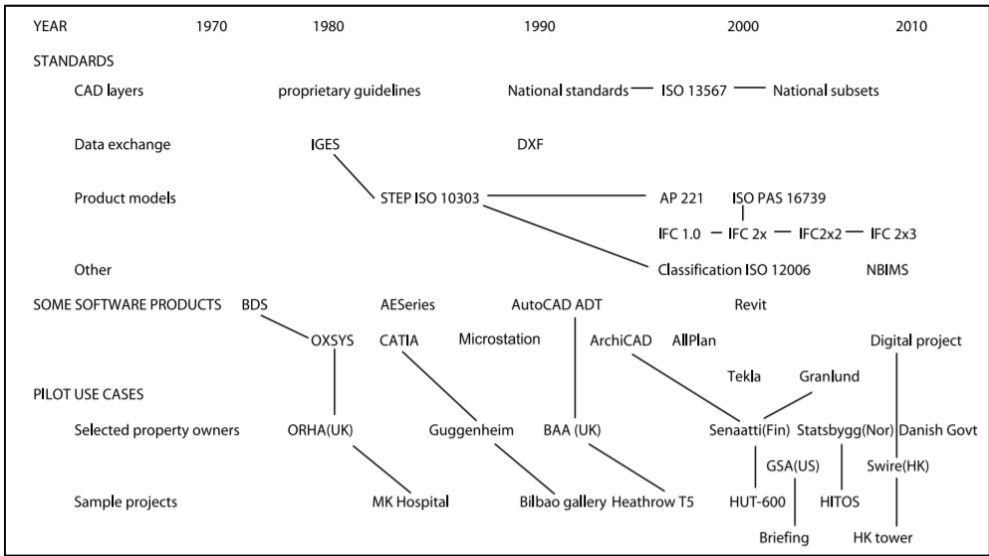


Figure 6: The framework proposed for documenting developments in BIM [15].

Golparvar-Fard et al. [16] argue that the IFC file format, which was mainly used as a main part of BIM standards to represent the BIM model as a part of life cycle project as mentioned in PAS 1192-2 2013 [1], needs more expansion to cover highway projects and delivered integrated BIM models.

Concerning the cost-related issues of BIM land development models, Zhiliang et al. [17] recommended that the IFC file format industry should be improved to handle the project costs for integrated BIM models, and should also include data such as risks, site health, and safety and quality management. However, most of the new platforms could now be exported to have an IFC file format [16], and most of them now could be imported, but the issue is the ability to change it in that environment (IFC format), not only communicate with it.



5 PRIMARY DATA (INTERVIEWS)

The interviews focused on BIM for the infrastructure project life cycle process as a part of the land development project deliverables and how it was integrated with the building life cycle sector by discussing the issues with project managers and BIM coordinators from the Gulf project's background to find out what the current challenges are and what steps the companies should take towards BIM Level three.

The BIM and Architecture Production Leader/Associate from Dar Al-OMRAN company claimed that several departments have the standards such as LODs which cover all of the project's life cycle as well as in PAS 1192-2, but he argues that the challenges might begin when the design team start looking for landscape architectural and civil works coordination to build the final/coordinated and federated BIM model.

Also, he argues that the standard doesn't cover the Landscape LODs clearly, and he recommended that the standard's team should start looking seriously into that. For example, he mentioned that in the LODs version 16 October 2016 [2] standard, only one page covers this sector (Fig. 7).

Uniformat	Omniclass
G2050	21-07 20 50 Athletic, Recreational, and Playfield Areas <i>Includes: Surfacing, fencing, equipment, grandstands and bleachers, and lighting for athletic, recreational, and playfield areas. May include: Site earthwork.</i> Associated Masterformat Sections: 01 89 16
G2060	21-07 20 60 Site Development <i>(See Fundamental LOD Definitions)</i>
G2080	21-07 20 80 Landscaping <i>(See Fundamental LOD Definitions)</i>
G30	21-07 30 Liquid and Gas Site Utilities Associated Masterformat Sections: 01 89 19
100	Narrative that references the grading model
200	Approximate sizes, vertical control, and apparatus.
G3010	21-07 30 10 Water Utilities <i>Includes: Water distribution for domestic consumption, fire fighting, and irrigation for a facility site and for multiple facilities. Includes trenching and backfilling. Includes Liquid and Gas Site Utilities Supplementary Components as appropriate.</i> Associated Masterformat Sections: 33 10 00
100	See G30
200	See G30
G3010.10	21-07 30 10 10 Site Domestic Water Distribution <i>Includes: Supply wells, piping, equipment, storage tanks, and water ponds and reservoirs.</i> Associated Masterformat Sections: 01 89 19 / 33 21 00 / 33 11 00 / 33 12 00 / 33 12 13 / 33 12 16 / 33 12 19 / 33 12 23 / 33 12 33 / 33 13 00 / 33 16 00 / 33 47 19.13 / 33 47 13.13 / 33 47 16.13
100	See G30
200	See G30
G3010.30	21-07 30 10 30 Site Fire Protection Water Distribution <i>Includes: Supply wells, piping, equipment, storage tanks, and water ponds and reservoirs.</i> Associated Masterformat Sections: 01 89 19 / 33 21 00 / 33 11 19 / 33 12 00 / 33 12 13 / 33 12 16 / 33 12 19 / 33 12 23 / 33 12 33 / 33 16 00 / 33 47 19.33 / 33 47 13.13 / 33 47 16.13
Reference Part II Attribute Tables for non-graphical information	
Back to TOC	
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Figure 7: An example of the landscape and site development LODs section in LODs version 16 October 2016 standard [2].



In addition, when the project team tried to deliver federated BIM Model Level Five (Build and Communication) based on PAS 1192-2 [1] (Fig. 8) for land development projects where the PAS mentioned that these levels are for both building and infrastructure projects, they faced a challenge in introducing one model and, as a result, they often introduced two separate models.

Also, he argues that a challenge was encountered in this area when the design team was trying to find and select the best platform for landscape design and production by looking in standards that don't mention those areas. This led to a new challenge for BIM managers and BIM coordinators who deal with the coordinated/federated BIM model, in how they will build it based on BIM standards.

In addition, the challenges have more dimensions when the architectural design and landscape teams begin looking to coordinate with the civil department, where both the design and production platforms are totally different.

The BIM coordinator in the A&H group for BIM in Infrastructure claimed that the gap in the standards appeared when the design team was looking to use BIM for infrastructure or civil works. He also argued that the challenge is not about how the design team shall implement the BIM way of thinking in the infrastructure project life cycle or not, but how they can implement the EIR plan as part of BIM standards.

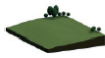


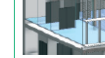


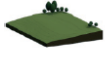
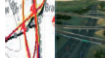
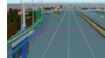
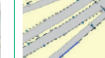


Stage number	1	2	3	4	5	6	7
Model name	Brief	Concept	Definition	Design	Build and commission	Handover and closeout	Operation
Systems to be covered	N/A	All	All	All	All	All	All
Graphical illustration (building project)							
Graphical illustration (infrastructure project)							
What the model can be relied upon for	Model information communicating the brief, performance requirements, performance benchmarks and site constraints	Models which communicate the initial response to the brief, aesthetic intent and outline performance requirements. The model can be used for early design development, analysis and co-ordination. Model content is not fixed and may be subject to further design development. The model can be used for co-ordination, sequencing and estimating purposes	A dimensionally correct and co-ordinated model which communicates the response to the brief, aesthetic intent and some performance information that can be used for analysis, design development and early contractor engagement. The model can be used for co-ordination, sequencing and estimating purposes including the agreement of a first stage target price	A dimensionally correct and co-ordinated model that can be used to verify compliance with regulatory requirements. The model can be used as the start point for the incorporation of specialist contractor design models and can include information that can be used for fabrication, co-ordination, sequencing and estimating purposes, including the agreement of a target price/guaranteed maximum price	An accurate model of the asset before and during construction incorporating co-ordinated specialist sub-contractor design models and associated model attributes. The model can be used for sequencing of installation and capture of as-installed information	An accurate record of the asset as a constructed asset at handover, including all information required for operation and maintenance	An updated record of the asset at a fixed point in time incorporating any major changes made since handover, including performance and condition data and all information required for operation and maintenance The full content will be available in the yet to be published PAS 1192-3

Figure 8: Levels of model definition for building and infrastructure projects [1].

Looking at the Employer's Information Requirements – Core Content and Guidance Notes, version 07 28.02.13, section 1.1.1, Platforms [8] (Fig. 9), where the companies are trying to match standards between that and LODs, most of the challenges begin here, when the BIM manager is looking to set data exchange format, where, in most cases, more than one company work on the same BIM project, which will increase the need for having clearer data exchange formats; this is what happens with the A&H group which mainly covers the infrastructure part of the BIM project.

While the project control manager for 2K company claimed that BIM implementation for land development projects still faces challenges and one of the main challenges is still there is a gap in building platform and infrastructure platform in file formatting as well as in the software environment, especially when the model's team prepared the federated model. However, some of these issues could be handled during the project life cycle, but when the project goes to the client and the company needs to deliver the federated BIM model or final BIM design model some of the clients asked to have the building and infrastructure models as one model in IFC file format. This being so, the client might not have any access to update the model for further stages when they are preparing for construction, and for built model levels 6 and 7 as PAS 1192-2 [1] in IFC file format where they can import it; but the issue is the ability to change it in that environment, not only communicate with it.

Reference	Item	Description	Response
1.1.1	Software Platforms	<p>Define the platform for the Building Information Model as well as other software platforms to be used</p> <p>The purpose of this section is to communicate software platforms and versions where these are known and where they might influence the preparation of a bid. Section 1.1.1 also defines content required in the BEP</p>	<p>This EIR should include:</p> <p>Platforms and versions used by the employer across the programme of projects include the following:</p> <ul style="list-style-type: none"> • Collaboration – XXX • Facilities maintenance – XXX <p>The ability of the bidder to work with these platforms should be made clear in the response.</p> <p>Details of information exchange requirements are set out in 1.1.2, data exchange format. Designers and Constructors should configure their attribute data in their models to align with the data exchange format. The BEP should set out how this will be achieved</p> <p><i>Guidance: In accordance with an open approach to software solutions, the EIRs should not dictate a software solution to the supply chain. However, depending on the stage of the project, the Employer will be able to state the versions and platforms used to prepare data drops that the bidder will receive. The employer will also be able to define the versions and platforms used for employer collaboration and facilities management.</i></p> <p><i>When appointing a design team or integrated project team, only collaboration, information exchange and FM versions and platforms should be described in the EIRs:</i></p> <p><i>Design development by the Consultant team may include the following disciplines (as required). Where design models are provided by the Employer as a data drop, The platforms/versions used to produce the design deliverables should be stated within the BEP. This information is incorporated into the contract using the BIM Protocol:</i></p> <ul style="list-style-type: none"> • Architecture • Structures • MEP • Model Coordination • Collaboration <p><i>The Constructor design development may include the following (as required). Platforms and versions should be stated in the BEP. Again, the Client should not be prescriptive regarding the software used for design or analysis:</i></p> <ul style="list-style-type: none"> • Building Physics • Environmental • Acoustic • Daylight analysis • Fire <p><i>Planning (4D) and Cost (5D)</i></p>

Figure 9: Employer's information requirements – guidance notes version 6_05.10.12 [8].



6 CONCLUSION

The challenge in BIM Level Three based on PAS 1192-2 is the corporation platforms which might be built based on people, standards and common data environments. However, most previous studies of BIM implementation for infrastructure might not have dealt with that, and have only considered the BIM software platforms integrated with GIS models.

Having a clear master plan delivery built, based on the common data environment for infrastructure and land development projects, as a part of BIM documentations and standards, might make the transition to BIM Level Three easier and clearer.

The conclusion section will present the land development project that was designed by the papers' authors for Muller Road, Bristol (UK), which was coordinated with the University of the West of England, Bristol, and introduced the master information delivery plan by addressing all the aspects, from primary and secondary research data outputs, and used the current capability of BIM tools platform (Fig. 10).

From file format point of view, the IFC file format needs to be improved to handle the updating of data during the project life cycle and needs to include data such as risk, site health, and safety and quality management.

The file format property doesn't mean the name of the software or program extensions; therefore, there is no legal accountability or bias for any engineering software company.

However, the BIM tools play a key role in BIM implementation and they will be the main challenges and will be considered significant when the AEC industry is looking to implement BIM Level Three. The engineering technology industry should take the following aspects into consideration:

- Software should be programmed for design and modelling.
- File format should be programmed to be coordinated with other platforms.
- Software should be programmed to cover all project life cycle and levels based on both PAS 1192-2 and LODs.
- File format should be programmed to be coordinated with different disciplines to achieve a common data environment platform.

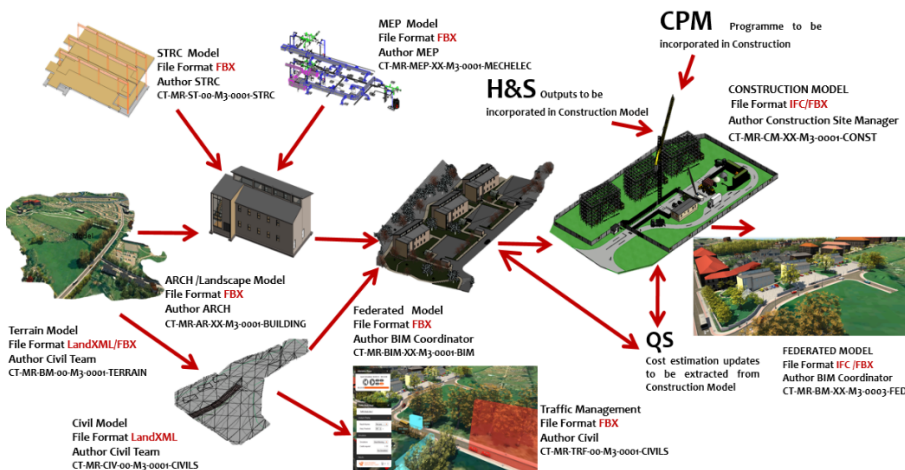


Figure 10: The Master Information Delivery Plan for the land development project carried out by the papers' authors (Muller Road, Bristol, UK).

Also, it seems the roadmap of standards or specification for BIM implementation in infrastructure or in land development projects is still not clear to go beyond BIM Level Two to BIM Level Three, in the sense that the following summarizes the challenges and proposed areas to be improved in the BIM standards and LODs:

- The PAS needs to clearly cover the infrastructure and land development areas during project life cycle in BIM levels and how the design team should cover these areas in the Asset Information Model (AIM).
- (EIR) needs to describe clearly the platforms/file formats as IFC file for all design sectors are taken into consideration for the industry limitations.
- The LODs need to cover clearly civil works/landscape and the coordinated eliminates taken into consideration for the software limitations

Finally, the standards, specifications and software engineering industry should work together to produce one platform that covers all aspects and is aligned with all needs and areas to make BIM implementation Level Three clearer and easier.

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