

# ОБРАЗОВАНИЕ, НАУКА, ИНОВАЦИИ

## СБОРНИК НАУЧНИ ДОКЛАДИ

ПЕТА НАУЧНА МЕЖДУНАРОДНА  
КОНФЕРЕНЦИЯ НА ЕВРОПЕЙСКИЯ  
ПОЛИТЕХНИЧЕСКИ УНИВЕРСИТЕТ



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# AN INVESTIGATION OF INTEROPERABILITY ISSUES BETWEEN BUILDING INFORMATION MODELLING (BIM) AND E-PROCUREMENT

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## Abstract

The European Union has set a target of 2016 for all government procurement to be fully electronic. A target of 1<sup>st</sup> April 2016 has been set for the United Kingdom Government departments for the implementation of Building Information Modelling (BIM). However, Grilo and Jardim-Goncalves (2010) show that interoperability issues exist due to the heterogeneous nature of applications and software systems used across the construction industry. As the deadline approaches the paper results show that there has been an increase in different BIM enabled softwares being adopted. It further indicates that the Industry Foundation Classes (IFC's) adopted in BIM use are still causing problems such as 50% of respondents losing information and therefore need further work. There is a lack of use of both BIM and e-procurement together in many organisations indicates that there is much efficiency still to be achieved as software develops. In this regard the level of development is very important. Over half of the sample consider that this is decided by the client and discipline specific levels are suggested at 350. This level is required to get the balance between electronic transfer and manual input.

## Keywords

Building Information Modelling; Disadvantages; BIM Implementation; BIM interoperability

## 1. Introduction

Succar (2009) defines Building Information Modeling (BIM) as a “*Computer Aided Design (CAD) paradigm*” incorporating “*a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle*”. The incorporation of

information from a range of sources has led to interoperability issues. However, little work has been carried out into investigation of the number of BIM software programmes to see whether it is increasing or decreasing since the Level 2 BIM target of 2016 was set (Efficiency and Reform Group, 2011)

In construction this is further compounded by the number and variety of design and construction stakeholders all with their own processes and software making collaboration difficult (Marshall-Ponting and Aouad, 2005). This paper investigates the significance of the issues around interoperability.

### 1.1 Industry foundation classes

One of the proposed ways of addressing interoperability is with the use of Industry Foundation Classes (IFCs). These are produced by BuildingSMART who were originally named the Alliance for Interoperability (AIA) (Eastman, 2011). BuildingSMART provide updates to the IFC format with the latest being the 2014 IFC4 Improvements (buildingSMART, 2014). Eastman (2011) defines an IFC as an open and neutral data format that comprises all information linked to the properties and geometry of a particular BIM model. Most of the software products with the exception of some bespoke BIM specific softwares now have the ability to export to this format. As it is an open standard it can be used in interoperability between software free of charge and has become one of the most popular standards (Varkonyi, 2010). Laakso and Kiviniemi (2012) however point out that its success will depend on

implementation of software vendors across the entire AEC industry. The revisions of the standards indicate that there are still issues to be sorted out in this regard. These issues relate to interoperability between different versions of the same software and between software produced by different vendors. This paper seeks to investigate what these issues are. There is a paucity of literature in relation to the construction industries perception of IFC's and whether they are successful in relation to solving interoperability issues raised in BIM.

### 1.2 BIM and e-procurement

Grilo and Jardim-Goncalves (2010) show that interoperability issues exist in the implementation of these two processes and state in the defence of their paper that little empirical data exists on the issues surrounding this. Grilo and Jardim-Goncalves (2011) also finds "A review of the literature reveals that no efforts have been directed to the application of BIM for e-procurement." Costa and Grilo (2013) looked at the way by which BIM models can be used in procurement and proposed a framework to allow interoperability which incorporates Model-Driven Architecture (MDA), Service-Oriented Architecture (SOA) and cloud Computing. Studies by Sattineni and Bradford (2011) and Bryde et al. (2013) identify that the estimating, quantity take-off and cost estimation processes can be automated using BIM software. However, the accuracy of these processes is determined by the level of detail within the model (Sabot, 2008). This is further emphasised by Monteiro (2013) who concludes many software programs have limited options and capabilities, while proposing the following benefits:-

- Increased accuracy in most measurements;
- Direct linkage of the model extracted quantities to planning software;
- Comparison of measurements from different phases;
- Extracting partial or total quantities relating to a given spatial area;
- Margins of error often below 1% for the major groups of materials;

- *Extracting information beyond typical measurements, such as the number of openings or number of beams with a particular material characteristic, among others.*

However, little examination has been conducted in the construction industry on the use of both systems on live projects and what issues are experienced during operation.

### 1.3 Levels of development

The Level of Development (LOD) within a model is defined by the Level of Development Specification (BIM Forum, 2013). The LOD is important as it stipulates the level of detail for each element within the model. This is the basis for Quantity Take-Off and cost estimates. Therefore, as the model evolves through the design stage and more details are embedded a more accurate cost estimate can be developed (Autodesk, 2013). The LOD levels are:-

- *LOD 100 The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements.*
- *LOD 200 The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.*
- *LOD 300 The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.*
- *LOD 350 The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.*

- *LOD 400 The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.*
- *LOD 500 The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.*

However, while these are defined this paper seeks for the first time to determine BIM users perceptions of the LOD required to achieve a successful take-off. The LOD required by each profession to achieve a successful project is also determined for the first time.

## 2. Research method

This research was conducted through an initial telephone sift of the top 100 architectural (105 names) and engineering (100 names) consultancy practices in the UK. This determined two things: 1. the company policy would allow a member of the organisation to complete a questionnaire and 2. The respondent had the expertise in BIM and e-procurement to answer the questionnaire. For 51 architects firms and 31 engineering practices it was against company policy to complete the survey. A further 35 architectural practices and 45 engineering practices did not have the expertise to complete the survey. This left only 43 organisations which had the capacity and willingness to take part (19 architectural organisations and 24 engineering practices). All of these were sent a piloted questionnaire. The original questionnaire had only minor edits after the pilot. The structured online questionnaire was disseminated through the Limesurvey™ software. Of the 19 architects contacted 13 responded equating to a response rate of 68.4 %, and 20 of the 24 Engineering firms responded equating to a response rate of 83.3%, which is deemed very good and excellent respectively (Rubin and Babbie,2009).

## 3. Findings on BIM

### 3.1 BIM software

The survey produced empirical data on BIM software preferences within the UK construction industry (Table 1).

**Tab. 1. BIM Software currently used**

Software Product	No.	%
Autodesk Navisworks	24	74
Autodesk Revit Architectural Design	18	55
Autodesk Building Design Suite	18	55
Autodesk Revit Structural Design	13	39
Autodesk AutoCAD Architecture	12	35
Sketch-up	12	35
Autodesk Civil 3D	12	35
Autodesk Revit MEP Engineering	11	32
Solibri Model Checker	9	26
Bentley Projectwise	6	19
Autodesk Robot Structural Analysis	5	16
TeklaBIMSight	5	16
IES Solutions Virtual Environment VE-Pro	5	16
Autodesk Plant 3D	4	13
Bentley Architecture	3	10
Bentley Structural Modeler	3	10
Tekla Structures	3	10
AECOSim	3	10
Vectorworks Architect	2	6
CADMEP (CADduct / CADmech)	2	6
Glue (by Horizontal Systems)	2	6
Synchro Professional	2	6
Bentley Hevacomp	2	6
RhinoBIM (BETA)	1	3
Bentley RAM, STAAD and ProSteel	1	3
NemetschekScia	1	3
Gehry Technologies - Digital Project Designer	1	3
Vico Office Suite	1	3
Vela Field BIM	1	3
Causeway BIMmeasure	1	3
Autodesk Ecotect Analysis	1	3
Autodesk Green Building Studio	1	3
DesignBuilder	1	3
ADB	1	3
Codebook	1	3
Autodesk Recap	1	3
CSC Fastrak	1	3
Autodesk Inventor	1	3
Content Studio	1	3

Table 1 indicates that as the target for BIM implementation approaches an increasing number of BIM enabled software packages are

being adopted. Eadie et al (2014) showed that industry had adopted 16. The results of this study show that in the past year this number has increased to 39. As the number of packages being adopted increases the importance of the interoperability aspects also increase. Grilo and Jardim-Goncalves (2011) show that the software vendors address interoperability issues between their own products but tend to not deal with issues relating to other vendors' products relying heavily on Industry Foundation Classes (IFC) for transfer.

Table 1 further shows that many organisations are now adopting more than one piece of BIM enabled software. While this may be for a variety of reasons the interoperability aspects are highlighted as design teams are now specifying software for particular projects to get round this issue. Table 1 indicates Autodesk software still has the majority share of the market despite the advent of OpenBIM.

### 3.2 Significance of interoperability

IFC's strive to provide interoperability between software packages. However, despite this 74% of users had experienced interoperability issues. The types of issues most regularly highlighted were losing information (50%), losing shared co-ordinates on their own (9%) and losing shared co-ordinates and further information (14%) and a lack of format interoperability (14%). Another issue revealed through the qualitative question was that different formats were not interoperable; an example of which included the lack of backward capability on Autodesk products (14%). Another item examined has been the multiplication of different bespoke software programmes that create issues (4%) and the different capabilities of packages (4%). The corruption of files during transfer was highlighted (5%). All of these relate to the output and input from IFC files designed to solve interoperability issues.

The study further asked how participants thought the issues above could be resolved. The results showed that 80% of respondents agreed on three key solutions to increase software interoperability. These were further software development (30%), software vendors

working together (25%) and improved open file formats or IFC's (25%). The remaining 20% suggested better software considerations (10%), bespoke software add-ons (5%) and training and transparency between software (5%).

### 3.3 Industry foundation classes (IFC)

The participants were asked if they are currently using IFC's to help interoperability. The results show that 45% of participants currently use IFC's for interoperability purposes. Of the 45% who use IFC's, exactly half (50%) have experienced issues with their use. This indicates that there is still work to be done. However, on the positive side, 71% consider IFC's increase interoperability to an acceptable level.

Participants that experienced interoperability issues were asked to provide examples of issues experienced when using IFC's. Some examples given were:

- *Missing stairs when exporting to IFC;*
- *Poor translation of geometric properties;*
- *Elements that are in Revit model don't show up in the IFC model. Data inputted into an element not transferring out to the IFC model;*
- *Objects not appearing correctly or missing when imported. Whole models importing as generic models;*
- *Inability of IFC to export user defined parameters;*
- *Using Uniclass with IFC and aligning this with COBie;*
- *Geometry does not export accurately i.e. chamfers on columns.*

The participants were also asked if they could provide comments on how they believe the issues detailed above might be addressed or rectified. The responses follow:

- *Improve IFC format & further development of IFC class*
- *The software vendor to enhance software*
- *Over time and a lot of testing and finding best practices (and not just within the company, across all the users who are collaborating within the model).*

**3.4 Interoperability between BIM and e-procurement**

For the first time this study investigated the use of e-procurement in conjunction with the BIM process. It found that only 13% of organisations in the top 100 architecture and engineering practices in the UK have integrated the two processes.

The results indicate that only 6% of the respondents use their 3D models to output quantities with 74% indicating that they do not use their BIM models for this function and 20% were unsure whether the information in the BIM model was automatically used to create a bill of quantities for e-procurement.

The lack of organisations using both BIM and e-procurement shows that there are many benefits in relation to efficiencies and communication still to be obtained by full adoption within the construction industry.

The results improved when participants were asked if they shared a BIM model through the e-procurement process at tender stage. These show that 16% of the participants have used a BIM model as part of the tender package, 58% who have not shared a model and 26% unsure.

Qualitative questions resulted in the following benefits being identified:-

The participants that stated they have shared a BIM model were asked to list the benefits that they have experienced. The comments that the participants provided on sharing a model during the procurement stage include:

- *Better understanding;*
- *Less clashes and better anticipation of materials;*
- *Ease of distribution;*
- *Reduced queries.*

The participants were asked if they believe that the introduction of BIM will ultimately increase the accuracy of Tender Documents. The results show that 74% of the participants consider the introduction of BIM will ultimately increase the accuracy of Tender Documents with only 10% believing it will decrease accuracy and 16% unsure. Feedback on why this is the case centred on the collaborative aspects of BIM, the automation of

export of both graphical and non-graphical model data depending on the LOD for quantity extraction, better phasing and understanding of the construction process, and less need for changes. One respondent went as far as stating in a BIM model with automated take-off: *Quantities should be 90% accurate before the contractor makes allowances for practicalities.*

**3.5 Level of development**

The LOD is therefore vital to the overall success of the interoperability between the processes. The majority of respondents (52%) consider that the LOD should be decided by the Client. The second highest bracket was project managers responsible 19%, followed by 16% who consider the Project/Design team should have this responsibility. The two lowest values were the Government with 10% of responses and the design team leader with 3%. Each of the participants was asked to what LOD the model should be developed to depending on their discipline. Results are shown in Table 3.

Table 2 indicates that the predominant mean LOD by discipline is 350 with slightly less (300) for Architects and slightly more (400) for project managers.

**Tab. 2. Level of Development**

Level of Development percentage by discipline						
	100	200	300	350	400	500
BIM Consultant	0	18	27	<b>18</b>	9	27
Architect	0	11	<b>44</b>	22	11	11
Structural Engineer	0	0	17	<b>50</b>	17	17
Civil Engineer	0	0	20	<b>40</b>	20	20
M&E	0	33	0	<b>33</b>	0	33
Project Manager	0	0	33	0	<b>33</b>	33
Quantity Surveyor	0	0	0	<b>100</b>	0	0
Facilities Manager	0	0	0	<b>100</b>	0	0

**4. Conclusions**

The interoperability between Building Information Modelling (BIM) and e-procurement has been inadequately researched.

This paper has shown its increased significance in the United Kingdom as the 2016 BIM implementation deadline for public sector contracts approaches. This is due to the increased use of a greater diversity of BIM-enabled software packages with the findings showing that 16 software packages determined in Eadie et al (2014) has now increased to 39. This emphasises the need for software vendors to address the need of providing interoperable solutions to maintain collaboration on projects which is the main impact of BIM implementation (Eadie et al, 2013).

IFC's were produced to attempt to provide the required interoperability between the software packages. However, there is still work to be completed with these as 74% of users had experienced interoperability issues. Over 50% of these related to loss of data which is directly related to the IFC format. It was suggested by respondents that further work needs to be carried out by Software vendors to address this issue both internally within versions of their own software package and with other software vendor's packages. Examples of major omissions and changes were provided but liability for issues rising has still to be determined.

Currently only 6% of organisations adopt an interoperable solution between BIM and E-procurement even though major process improvements are possible with increased understanding of the process and more accuracy achieved.

Lastly the paper examined the LOD required for outputting of quantities and successful completion of the project. It found that clients should set the level of detail and that the mean LOD for all professions should be approximately 350 with the architectural models slightly lower at 300 and the project manager slightly higher at 400. This indicates that the Facilities Management element cost savings determined by Eadie et al (2013) are foremost in the user's perceptions.

Further work needs to be carried out into how the suggestions on improvements to IFCs can be implemented.

## References

- [1] Autodesk, (2013). Model Based Estimating and Quantity Take-off, Available on-line at <http://bimcurriculum.autodesk.com/lesson/lesson-3-model-based-estimating-and-quantity-takeoff> (accessed April 2015).
- [2] buildingSMART (2014). Industry Foundation Classes (IFC) data model, available on-line at <http://www.buildingsmart.org.uk/about> (accessed April 2015).
- [3] BIM Forum, (2013). Level of Development Specification, available on-line at <http://bimforum.org/wp-content/uploads/2013/08/2013-LOD-Specification.pdf> (accessed April 2015).
- [4] Costa A. and Grilo A. (2013). BIM-Based E-Procurement: An Innovative Approach to Construction E-Procurement, The Scientific World Journal, Article ID 905390, available on-line at <http://www.hindawi.com/journals/tswj/aa/905390/ref/> (accessed April 2015).
- [5] Eadie, R, Heanen, A and Hall, J (2014). Civil Engineering and the Interoperability between Building Information Modelling (BIM) and E-Procurement, In: Proceedings of the 9th International Conference on Civil Engineering Design and Construction (Science and Practice), Varna, Bulgaria. Научно-технически съюз строителство в България
- [6] Eadie, R., Browne, M., Odeyinka, H., McKeown, C., and McNiff, S. (2013). BIM implementation throughout the UK construction project lifecycle: An analysis, In Automation in Construction, Vol.36, 145-151.
- [7] Eastman, C., Teicholz, P., Sacks, R. and Liston, K., (2011). BIM Handbook: A Guide to Building Information Modelling. 2nd ed. John Wiley and Sons Inc, New Jersey, USA.
- [8] Efficiency and Reform Group,( 2011). Government Construction Strategy, Cabinet Office, London, UK.
- [9] Grilo, A. and Jardim-Goncalves, R., (2010). Value proposition on interoperability of BIM and collaborative working environments. Automation in Construction, Volume 19, pp. 522-530.
- [10] Grilo, A. and Jardim-Goncalves, R., (2011). Challenging electronic procurement in the AEC sector: A BIM-based integrated perspective. Automation in Construction, Vol. 20, pp. 107-114.
- [11] Laakso, M. and Kiviniemi, A., (2012). The IFC standard - A review of history, development, and standardization. Journal of Information Technology in Construction (ITcon), Vol.17, pp. 134-161.
- [12] Marshall-Ponting, A. and Aouad, G., (2005). An nD modelling approach to improve communication processes for construction. Automation in Construction, Volume 14, pp. 311-321
- [13] Rubin, A. and Babbie, E. (2009). Essential Research Methods for Social Work, USA: Cengage Learning.
- [14] Sabol, L., 2008. Challenges in Cost Estimating with Building Information Modeling, Washington: Design + Construction Strategies, Available on-line at [http://www.dcstrategies.net/files/2\\_sabol\\_cost\\_estimating.pdf](http://www.dcstrategies.net/files/2_sabol_cost_estimating.pdf) (accessed April 2015).
- [15] Sattineni, A. and Bradford, R., (2011). Estimating with BIM: A survey of US construction companies. IAARC, pp. 564-569 Available on-line at [http://www.irbnet.de/daten/iconda/CIB\\_DC23693.pdf](http://www.irbnet.de/daten/iconda/CIB_DC23693.pdf) (accessed April 2015).
- [16] Varkonyi, V., (2010). 'Open by Design' AEC Magazine. Available on-line at: <http://aecmag.com/case-studies-mainmenu-37/397-open-by-design> (accessed April 2015).