CIVIL ENGINEERING AND THE INTEROPERABILITY BETWEEN BUILDING INFORMATION MODELLING (BIM) AND E-PROCUREMENTСТРОИТЕЛСТВО И ОПЕРАТИВНА СЪВМЕСТИМОСТ МЕЖДУ ИНФОРМАЦИОННО МОДЕЛИРАНЕ НА СГРАДИ И Е-ПОРЪЧКИ

СТРОИТЕЛСТВО И ОПЕРАТИВНА СЪВМЕСТИМОСТ МЕЖДУ ИНФОРМАЦИОННО МОДЕЛИРАНЕ НА СГРАДИ И Е-ПОРЪЧКИ

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Резюме

Една от основните цели в правителствените проекти на Обединеното кралство е съвместното прилагане на Информационно Моделиране на сгради (BIM) и Е-поръчки. При този начин на действие, вида на извършваната работа.не е от значение. BIM е разработен предимно за да може по-бързо да се достигне до реалното изпълнение на обекта в сравнение с това чрез използване само на традиционните строителни проекти. Настоящата работа предоставя практически пример от използването на BIM и Е- поръчки в строителната практика.Този пример показва, че когато крайният срок за Е-поръчки не е спазен, се затруднява BIM изпълнението - оперативната съвместимост между 3D BIM модели и Е-поръчката е нарушена. Това показва, че значителни ползи могат да бъдат придобити от организациите приемащи nD моделиране.

Ключови думи: Информационно моделиране на сгради (BIM), BIM предимства, BIM недостатъци, BIM оперативна съвместимост

CIVIL ENGINEERING AND THE INTEROPERABILITY BETWEEN BUILDING INFORMATION MODELLING (BIM) AND E-PROCUREMENT

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Abstract

The United Kingdom Government has set targets for the implementation of both Building Information Modelling (BIM) and E-Procurement in government projects. The targets set do not take into account the types of work involved. BIM was developed mainly for building construction rather than Civil Engineering Projects. Civil Engineering is therefore trailing mainline construction in its implementation. This paper provides a practical example from industry of BIM use in Civil Engineering, details wider research into BIM and e-procurement implementation and looks at interoperability between the two. It indicates that the deadline for e-procurement has not been met and that the deadline for BIM implementation, 2016, will be difficult to achieve. The interoperability between the 3D BIM models and procurement has not been developed to any significant degree. This indicates that significant benefits could yet be accrued by organisations adopting nD modelling

Keywords: Building Information Modelling, BIM, BIM Disadvantages, BIM Implementation, BIM interoperability

1. INTRODUCTION

Computer-Aided Design (CAD) is an essential tool for the production of drawings in the Architecture, Engineering and Construction (AEC) sector. Since its introduction around 30 years ago (Aound et al., 2005a), there have been substantial developments in computing. Now that computers

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have the capability of easily producing 3D models, Building Information Modeling (BIM) allows users to incorporate intelligent information within the 3D model. Van Nederveen et al. (2009) describes BIM as a 3D model of information *"about the building itself as well as its components, and comprises information about properties such as function, shape, material and processes for the building life cycle*". Liu and Hsieh (2011) show that rather than "*creating drawings from 2D line-work"*, the project model is constructed from elements such as foundations, walls, windows, roofs and other elements. This is known as object-based modelling rather than entity-based models formed from AutoCAD, Cadkey and MicroStation. As each element in the model is intelligent (incorporating details relating to it), the model can provide information relating to all the lifecycle activities from pre-contract to demolition. Graphisoft (2012) show that the models can include features, among others such as geometry, density, modulus of elasticity, and thermal capacity, in addition to economic attributes such as supplier details, unit cost, and delivery lead time. Tse and Wong (2004) showed how this could result in automated quantity measurement. The level of detail (LOD) required within the model is normally set out using a matrix in the BIM Execution Plan.

Therefore, the detail in the model will determine the accuracy of the take-off for procurement purposes and therefore the price. Another factor is the element of interoperability between the BIM model and the pricing software. Little research has been carried out into the link between LOD and procurement in the UK in order to provide a universal solution. Prior to investigating elucidations in the methods of software for BIM use, the link to e-procurement needs to be examined. To date little by way of empirical data has been gathered on organizations that use both BIM and e-procurement in the construction process.

The UK government had already stipulated the implementation of E-Procurement for all government construction projects by 2007 and for local authority projects in England and Wales by 2010. However, Eadie et al (2012) shows that the targets set have been missed on a significant amount of UK government projects. This paper seeks to expand on those findings.

1.1. BIM AND CIVIL ENGINEERING

As BIM was originally developed and used for building construction civil engineering schemes have lagged behind in its adoption. The Construction Operations Building Information Exchange (CoBIE) formal schema for BIM exchange of data sets has not yet been fully developed for linear assets such as roads or railways. Amey Consulting were one of the first organisations to start investigating its use for purely Civil Engineering purposes with no structural element. They produced a 3D model for Dundonald Park and Ride scheme. The idea was that as a carpark was a basic civil engineering project and easily replicable that it would serve as an introduction for the organisation and allow comparison with other traditionally produced 2D schemes. Initial assessments show that the model will require substantial further work to replicate the benefits in Civil Engineering which have already been seen in construction.

1.2. BIM AND E-PROCUREMENT

One of the issues that has not been fully addressed is the interoperability between the 3D model and the pricing software. Bryne et al (2013) suggests an integrated BIM model directly updates both the schedule and budget during the change process. They further suggest this can be used by a Project Manager to demonstrate to a client how their design decisions impacted on the costs and time aspects of a project. While this is the optimum goal of BIM, little research has been carried out into whether the UK construction industry is seeking to progress to a seamless transition between the two systems. Prior to analysing the transition process this study needed to ascertain what BIM software was being used in the industry.

1.3. ND MODELLING

Definition of the term 'nD modelling' in construction widens 3D modelling to integrate other dimensions such as scheduling, costing, accessibility, crime, sustainability, maintainability, acoustics and energy simulation (Aouad et al, 2005). They further show the BIM model can further be used to determine all aspects of asset lifecycle management. This is fully supported by Monaghans (2013) who say that elements of scheduling and cost also need to be incorporated by the 2016 deadline.

While BIM has been promoted a major drawback of the systems was the lack of standardisation across platforms of 'objects' created for further reuse. Industry Foundation Classes (IFCs) were developed by the International Alliance for Interoperability (IAI) in an attempt to ensure data compatibility across the different software programmes. Buildingsmart (2014) state the IFC format is registered by ISO as ISO/PAS 16739 and is in the process of becoming an official International Standard ISO/IS 16739. (Aouad et al, 2005). In theory, IFC-based objects will allow models to be shared across the professions in the integrated design teams. They will further define their own elements of the objects within the BIM model. Most of the major BIM systems state that they provide IFC support, allowing transfer of data between various formats (AUGI, 2012; Bentley, 2007). In theory, this should enable the model to continue to evolve after the design phase and throughout the building life. However, others such as Ajam et al (2010) state that IFCs are not widely used in practice based on three case studies without gathering significant empirical data across the industry and further state existing IFC standards need to be revised or extended to get wide use. The data gathered in this paper provides empirical evidence that in the intervening years that there is still little use of links and interoperability between e-procurement and BIM.

2. RESEARCH METHOD

This research employed an examination of a case study in Civil Engineering and a structured online questionnaire disseminated through Limesurvey™ software. Limesurvey™ provides token based survey management to ensure only responses from sample organisations are collected and stored in the on-line MySQL™ database. Responses were obtained from construction organisations across the United Kingdom: England, Scotland, Wales and Northern Ireland. As companies were required to have knowledge of BIM, the sample was taken from Linkedin 'BIM Experts' group, a social networking group. Telephone contact was used to identify UK construction companies, sift and pre-notify. This ensured that organisations were from the UK and carrying out work involved with either BIM and / or e-procurement. The UK database produced a total population of four hundred and thirty nine (439) organisations. For validity and reliability a survey response of eighty two (82) was required from the data collection (Isaac and Michael 1981) to provide a margin of error of 0.10%. Ninety six responses to the questionnaire were received of which eighty four (84) responses were fully completed. Calculated based on completed questionnaires only, a 67% response rate was achieved, deemed "very good" by Rubin, and Babbie (2009).

3. FINDINGS ON BIM IN THE UK CONSTRUCTION INDUSTRY

3.1. BIM SOFTWARE

The survey produced empirical data on BIM software preferences within the UK construction industry. The statistics are shown in Table 1.

Table 1 BIM Software currently used

BIM Software Package	Number of Organisations	Percentage of response
Autodesk Revit Architectural Design	33	34.375%
Autodesk Revit Structural Design	13	13.542%
Autodesk Revit MEP Engineering	3	3.125%
Autodesk Navisworks	9	9.375%
Bentley Projectwise	4	4.167%
Tekla Structures	1	1.042%
Archicad	5	5.208%
Vectorworks Architect	1	1.042%
Nemetschek Allplan Engineering	1	1.042%
Autodesk Building Design Suite	1	1.042%
Causeway BIMmeasure	1	1.042%
Sketchup	1	1.042%
AECOsim	1	1.042%
Plant 3D	1	1.042%
Civil 3D	4	4.167%
Other – Not Specified	1	1.042%
No Answer	16	16.667%
Total	96	100.000%

This shows that although a wide variety of products are available and being used, Autodesk products are currently leading the way as far as adoption of BIM is concerned, having captured 61.45% market share. The range of organisation types using the different Autodesk products also indicates that software maturity in different specialist fields is a key issue on BIM uptake. Autodesk are currently expanding their operations into the Civil Engineering field with the purchase of SAMLeap (Autodesk, 2013) and Savoy Autotrack (Autodesk, 2012). This should increase the use of BIM within the Civil Engineering context.

3.2. INTEROPERABILITY ISSUES BETWEEN BIM SOFTWARE

The study investigated if those using BIM experienced interoperability issues between different BIM software programmes. Ninety-one responses were received to this question. Forty (40) stated that they have experienced software interoperability issues (43.956%), 28 said not experienced difficulty (30.769%) and 23 deemed it not applicable by providing no answer (25.275%). All 40 who considered that interoperability issues existed, provided comments in the follow-up qualitative question. These can be summarised under a lack of a common IFC format, export/ import problems between Revit and Bentley, Geometrical errors and data loss, backward compatibility between different versions of the same software cause issues, problems with XREFs and other contractors or customers using non-compatible software. Not everyone experiences problems with BIM interoperability with a substantial minority indicating they have no issues those who have experienced issues have common themes. If BIM is to progress, it is important to recognise and counteract these issues.

3.3. LEVEL OF ORGANISATION BIM MATURITY

The organisations were provided with a definition of each of the BIM maturity levels and asked to identify the level of BIM maturity they currently achieved. The results from completed responses are produced in Table 2.

Table 2 BIM Maturity Levels

BIM Maturity Level	Number	Percentage
0	1	1.190%
1	28	33.333%
2	44	52.381%
3	1	1.190%
Don’t Know / No Answer	10	11.905%

The results show that over half of the respondents are meeting government targets but there is still substantial work to achieve the 2016 target.

3.4. PERCENTAGE OF PUBLIC SECTOR WORK COMPLETED USING BIM AND E-PROCUREMENT

Organisations were asked to determine what percentage of work is currently being completed using BIM. From the 84 completed responses, all currently use BIM as this was part of the sift procedure. A breakdown of the percentage of their work using BIM shows 27 currently completed 1%-25% (32.143%) of their work in BIM, 22 completed 26-50% (26.190%), 13 completed 51%-75% (15.476%), 6 completed 76%-99% (7.143%) and 8 stated they completed all their work in BIM (9.524%). The remaining 9.524% were in the “did not know” category or preferred not to provide an answer.

Only 41 of the respondents used e-procurement. These were asked to provide a percentage of their work carried out by electronic means. Out of 41 respondents, 13 chose the 1%-25% category (32%), 11 chose 26-50% (27%), 10 chose 51%-75% (24%), 5 chose 76%-99% (12%) and 2 carried out 100% of their work electronically (5%).

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.

3.5. ND MODELLING USE

The next section, investigated the use of nD Modelling tools among organisations that used both BIM and e-procurement in the integration of both systems. The results show below that the majority (31, 86%) do not use nD modelling. Only 5 organisations stating they used these tools (14%). Of the 5 organisations which use nD modelling, 4 are currently at Level 2 in the BIM maturity model and receive a variety of work from the public sector. This indicates that there could be significant improvements through nD modelling adoption. In the future 42% said they would be adopting these tools, with 39% not sure and 19% with no intention of adoption.

3.7 THE INTEROPERABILITY ISSUE BETWEEN BIM AND E-PROCUREMENT

Only fifteen organisations had the confidence to answer in regard to interoperability between BIM and e-procurement. Eleven organisations considered there was (73%) and 4 did not said no (27%). The reasons provided for a lack of interoperability concentrate on a lack of skills and knowledge within the industry. This exhibits itself further in briefing data not being provided in a structured format for integration into a BIM. This shows that every organisation in the construction industry needs to have a cultural change from clients through to sub-contractors to adopt a collaborative approach to information management. The variety of interchange formats that data is being transferred in produces a problem as IFCs, iRING, ISO15926, and COBIE all have different

data structures. These all perform slightly different functions but need to be combined and standardised to allow full interoperability.

4. CONCLUSIONS

Building Information Modelling (BIM) as its name suggests was initially developed for building construction and has only recently been implemented by organisations on purely Civil Engineering Schemes. The depth of detail required for BIM to be successful in a civil engineering context needs to be further examined. This examination will take place on completion of the project. Further evidence that Civil Engineering is starting to adopt BIM is seen in that two organisations have started using Civils3D as their BIM software. Civils3D software strength is mainly in its use for civil only projects. In a wider construction context the paper examined BIM and e-procurement use within the construction industry. It can be concluded that Autodesk have captured a significant market share within the UK construction industry (61.45%) and are the leading software vendor for BIM. The flexibility and range of software provided by Autodesk is producing this market advantage.

However, the majority of those using BIM have experienced interoperability issues relating to different BIM software packages. Those whose integrated design team use similar software and do not experience issues equate to almost a third of the sample. However the current interoperability issues including backward compatibility need to be addressed as 40% of the sample had experienced problems. In order that the government targets be achieved this problem should be examined in order to provide a solution as a matter of urgency. This problem is acting as a barrier to almost 35% of the sample who are still not mature enough within their organisations with BIM implementation to meet the Level 2 2016 target set by the UK government. The usage statistics from this research show that there are still substantial benefits which can be achieved through further BIM adoption within the construction industry. Savings in costs and a more efficient project could be achieved through implementing nD modelling as companies become more BIM mature. However, the level of detail in the current BIM models and amendments and expansion to IFC standards need to be achieved before this takes place.

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