

THE IMPACT OF BUILDING INFORMATION MODELLING (BIM) ON PUBLIC SECTOR TENDER DOCUMENTS FOR CIVIL ENGINEERING WORKS

Robert Eadie,

School of the Built Environment, University of Ulster

email: r.eadie-r@ulster.ac.uk

Abstract: Building Information Modelling (BIM) is being made compulsory for all UK Government projects from 2016. This applies to Civil Engineering projects and has implications for the tender document content. This paper looks at the Conditions of Contract (COC) and Methods of Measurement (MOM) for Civil Engineering work in relation to BIM for the first time. The study uses two Limesurvey™ questionnaires as the data collection method. The first questionnaire garnered findings from twenty-two responses from the government department responsible for Roads construction and maintenance. The respondents from this survey provide responses from a government client perspective. The second survey gathered information from the top 100 UK contracting organisations. This produced results from a government contractor perspective. The findings indicate that the government client needs to provide more training for its personnel to ensure that they are achieving the same level of competence demonstrated in the private sector. The NEC3 conditions of contract were deemed most preferable for BIM by both the public and private sectors. However, the findings suggest that the Institution of Civil Engineers (ICE) should incorporate specific BIM related clauses in an amendment to the main document. As the Manual of Contract Documents (MCHW) is mandatory for capital projects and this is unlikely to change the paper further suggests that work needs to be carried out so that this can be incorporated within the BIM model.

Keywords: BIM, procurement, standard method of measurement, conditions of contract

1. INTRODUCTION

Civil Engineers were one of the first professions to use computers over 50 years ago (Bédard, 2006). The Use of computers have revolutionised the overall design, construction and maintenance of schemes. Recent developments have brought intelligence to 3D modelling. This is known as Building Information Modelling (BIM). Eastman et al. (2011) further indicate “*BIM is a digital representation of the building process to facilitate exchange and interoperability of information in a digital format.*” However, BIM has yet to see widespread adoption within the highways and infrastructure sector and the UK government has set a target of 2016 for BIM adoption on all government projects (Efficiency and Reform Group, 2011).

Arayici et al (2011) indicate that BIM allows improved stakeholder collaboration which transcends organisational boundaries to enhance the performance of the project during the design, tendering and construction processes. nD BIM links all the relevant information in one model. A nD holistic BIM model has been developed by the University of Salford (Xu et al, 2014). Aouad et al (2005) provide the following benefits of nD modelling:-

1. To use visualisation to appreciate and plan for the complete design, construction and demolition process
2. Review and incorporate specifications and construction information
3. Determine a set of cost options and tender via the model
4. Maximise the sustainability aspects of the project
5. Analyse potential energy and access requirements
6. Review whole life costs and facilities management needs for the project
7. Review security and Health and Safety aspects
8. Understand the building's acoustics characteristics.

The tender package documentation for highway works contain, in an addition to a pricing document, a Method of Measurement (MOM) to allow those pricing the document to determine the contents and extent of each item in the bill of quantities and a conditions of contract which contain the contractual obligations, breach of which can give rise to litigation.

The BIM model can be used in the tendering process by incorporating the important tender documentation into the model. This would include details of the MOMs and Conditions of Contract. Civil Engineering in the UK uses two main Standard Methods of Measurement (SMM): Civil Engineering Standard Method of Measurement 4 (CESMM) and the Manual of Contract Documents for Highway Works (MCHW). For Civil Engineering schemes with a substantial amount of building construction or ancillary works Standard Method of Measurement 7 (SMM7) is sometimes used. Eadie et al (2013) showed, from a consultant and contractor perspective, that CESMM was more widely used for general civil engineering projects. However, this paper seeks to fill in the knowledge gap in relation to what is currently used in the public sector. All government contracts for new works are awarded under the NEC3 conditions of contract (DFP, 2012). However, some of the maintenance work is carried out under the ICE Term Conditions of Contract.

1.1 UK Government BIM levels and Target

The UK Government is making Level 2 BIM mandatory on all publicly-funded projects from 2016 onwards (Efficiency and Reform Group, 2011).

The definition of the BIM levels in the UK by the BIM Industry Working Group (2011) are:-

Level 0 – Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely exchange mechanism.

Level 1 – Managed CAD in 2 or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.

Level 2 – Managed 3D environment held in separate discipline “BIM” tools with attached data. Commercial data managed by an ERP. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as “pBIM” (proprietary). The approach may utilise 4D programme data and 5D cost elements as well as feed operational systems.

Level 3 - Fully open process and data integration enabled by web services compliant with emerging IFC / IFD standards, managed by a collaborative model server. Could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes.

For the first time this paper investigates the level of BIM expertise in the public sector client responsible for civil engineering works.

1.2 Manual of Contract Documents for Highway Works

The MCHW is comprised of six volumes which are designed to be used alongside the Design Manual for Roads and Bridges (DMRB) (Highways Agency, 2014). The MCHW is used in all parts of the UK: The Highways Agency (HA) being responsible for England, Transport Scotland for Scotland, Transport Wales for Wales and The Department for Regional Development (DRD) in Northern Ireland.

The MCHW is updated on a regular basis (at times every 3 months). Within its contents all the requirements of the European Commission (EC), which are mandatory for all Public Procurement Bodies, are included. These include procedures for its use, the general Specification for Highway Works and its corresponding MOM, and documentation for specialist activities for geotechnical and directional drilling activities. The latest revision of the MCHW has been notified by Highways Agency (2014) to the European Union for Government contracts and is due for publication early in 2014. No investigation has taken place in literature as to the whether those operating it from a client side are following the edict to implement it 100% of the time and consider the decision to be correct in relation to its advantages over the other methods of measurement.

1.2 Civil Engineering Standard Method of Measurement

CESMM was first published in 1922 as a report called the “*Standard Method of Measurement for Building Works*” (Brook, 2008). It was made compulsory for Civil Engineering works in 1933 through inclusion in the Royal Institution of British Architects (RIBA) documentation (Brook, 2008). The first edition of the “*Civil Engineering Standard Method of Measurement*” was published in 1976 (ICE, 1976). The second edition was published in 1985 (ICE, 1985), the third in 1991 (ICE, 1991) and the current edition (CESMM4) in 2012

(ICE, 2012). This paper seeks to investigate MOM from a client perspective only as Eadie et al (2013) investigated this from a consultant and contractor perspective.

1.3 Conditions of Contract for Government Civil Engineering Works

Within the UK, a number of standard forms of contract have developed for use. NBS (2012) in the “National Construction Contracts and Law Survey 2012” survey concludes that the three most commonly used conditions of contract are the Joint Contracts Tribunal (JCT), The New Engineering Contract (NEC), Bespoke Contract forms and the Institution of Civil Engineers (ICE) standard forms. More contracts are awarded via the JCT and NEC conditions than all the remainder combined. DFP (2012) states that any other standard form of contract other than the NEC3 should only be used for construction works or services if they add value in comparison to NEC3 and only with Head of the Centre of Procurement Expertise (COPE) approval. The rationale for this is that the NEC3 is flexible due to the amount of different options in the suite (DFP, 2012, Clause 9.5). There is a recognition that initial clause in each of those options was that the contract should be conducted in a “*spirit of mutual trust and co-operation*” thus introducing an element of partnering. The breadth of options and types of contract that the NEC3 suite contains spreads the risk allocation and therefore mitigates against the risk of time or cost overruns and poor performance of projects. NEC (2013) shows how BIM can be implemented with the NEC3 conditions of contract by Z clauses and the works information bringing in the CIC protocol. What has not been investigated is what contractors consider to be the best conditions of contract to work with BIM. This paper seeks to fill this knowledge gap.

2. RESEARCH METHOD

TransportNI which is a combination of Roads Service Northern Ireland and Public Transport Finance and Governance has 2064 staff in 2014 (DRD, 2014). This is down on the figure in DRD (2012) which indicated there were 2,091 people in Roads Service, comprising 1,064 Professional and Technical, 549 Industrial, 447 Administrative and 31 Support staff. DRD (2012) showed of the Professional and Technical staff only 234 work on capital projects. It was assumed that the majority were design related and that 20% would be a reasonable over estimation as to the number of contract preparation staff. This number (47) was chosen as the maximum population. Krejcie and Morgan (1970) suggest that a sample size of 44 for this population. Contact was made with 44 Roads Service personnel who worked with the contract elements of capital projects. Responses were received from 23 giving a response rate 52.27%. Rubin and Babbie (2009, pg 117) consider a response rate of over 50% to be ‘adequate’ for the purposes of analysis.

The second part of the study also used Limesurvey™ to collect the survey data via the Internet. Contractors who had gained the status of being in the top 100 UK construction contractors were assumed to work for both private and public sectors. The “Construction Index Top 100, 2011” (The Construction Index, 2011) was used to identify organisations and pre-notification used to sift all organisations from a large sub-contracting organisations and multidisciplinary consultancy firms. This left, 74 principle contractors. All were contacted; despite Krejcie and Morgan (1970) suggesting a sample size of only 63 was needed for this population. A response was received from 30 organisations.

Both surveys responses were gathered from the chosen organisations through a web-based interface and stored these in an on-line MySQL™ database.

3. CLIENT SIDE FINDINGS

3.1 Findings on the use of BIM in Roads Service

Roads Service Northern Ireland have only started to implement BIM. This is ascertained by the response as only one out of 23 confirmed having been trained in BIM with the following question showing that this respondent was the only one currently using BIM for work purposes. When asked about the level of BIM maturity currently achieved; one stated Level 1 (4.35%), but 14 (60.87%) said they did not know and 8 (34.78%) said they did not use it. This shows that substantial work needs to be carried out to achieve the government’s own target date for full implementation of 2016. When asked about the benefits of BIM adoption in Civil Engineering projects 14 (60.87%) stated that they currently had no opinion on whether it was beneficial or not. Of the nine remaining, 3 (13.04%) considered that adoption of BIM would be

beneficial, 4 (17.39%) considered it had not proved itself yet, 1 (4.35%) considered that the costs of implementing it would outweigh the savings and 1 (4.35%) considered that BIM would be forgotten once management found something new to rave about. This indicates a cultural change is needed within the client with promotion of the benefits accrued prior to full implementation. The lack of implementation is illustrated in the number of “Don’t Know” responses when considering the impact the use of BIM has on speed and claims. When asked regarding the required time spent checking civil engineering take-off, 16 (69.56%) stated they did not know whether it speeded up Bill of Quantities production or not, 4 (17.39%) considered it did and 3 (13.04%) considered that it did not. Nineteen did not know whether BIM reduced the severity of claims but 4 (17.39%) considered that it did not. Two main reasons for this were stated, the level of detail was not sufficiently developed in the models to date and that it had not been carried out as the take-off was still by hand. It is evident that further work will be required to see if these perceptions remain once more experience has been gained on the systems.

3.2 Findings on use of different MOM’s in Roads Service

As expected the findings indicate that Roads Service personnel have a high use of the MCHW MOM with 12 (52.17%) using it 100% of the time, and 10 (43.48%) using it “80% or more but less than 100%” of the time. CESMM for private streets 5 (21.73%) and SMM7 for building construction 2 (8.70%) was used for the remaining percentage of the time. All respondents consider the MCHW is the best MOM for Civil Engineering and Highways projects. One response to the qualitative question summed up the remaining responses - *Road Service have invested significant time and resource in the development of procurement documents. These documents have a good track record for delivery. Furthermore MCHW tends to effectively cover the works elements required by Road Service. Elements of other MoM's would be used to cover works elements which are not included in the MCHW.* Client respondents were equally split in which was the simplest and most user friendly MOM.

3.3 Findings on use of different Conditions of Contract in Roads Service

There was unanimous agreement that the NEC3 conditions of contract were being used for all capital projects. However, 3 (13.04%) stated that ICE Term Conditions of Contract were still being used for maintenance work.

4. CONTRACTOR SIDE FINDINGS

4.1 Findings on the use of BIM by contractors

BIM had greater implementation on the contractor side with 18 out of the 30 (60%) having already implemented BIM to some degree to meet the government targets. From these 18, 2 (11.11%) had already achieved Level 3, and 8 (44.44%) had achieved Level 2 indicating over half of those who had implemented BIM had achieved the Government target already. The remaining 8 consisted of 4 (22.22%) at Level 1 and 4 (22.22%) who did not know. Of the ones who did not know, one is using BIM for architectural, structural and services spatial coordination, another has used it to collaborate well with a client and other contractors on the Victoria Station Upgrade Project and two have recently introduced it on a number of projects. This indicates that contractors are gearing up for the government targets quicker than the government client. This is because the contractors rely on the work for existence. All 18 respondents considered that BIM was beneficial to their organisation. A variety of reasons were provided from efficiency in the workflow through to marketing resulting from meeting the government targets. All but one stated that they would be expanding the use of BIM within their organisation. This indicates that once BIM is adopted the benefits become evident and further uses and efficiencies can be achieved. For those who had not adopted BIM a series of questions ascertained how likely they were to meet the government targets. They were asked to show on a Likert scale of 1 to 5 how likely they considered that their organisations would meet the government deadline of Level 2 BIM by 2016. They were also allowed to show that they would not be able to meet this deadline and one organisation chose this option. No organisation yet to implement BIM was certain of implementing it by the deadline indicated by nobody choosing level 5 on the Likert scale. However, 4 chose 4 on the scale and 4 chose 3. This left 2 who chose 2 and 1 who chose 1. This indicates that while they are

working towards BIM implementation unless they have already started then achieving the government target is unlikely.

4.2 Findings on the use of different Conditions of Contract

The findings show that the NEC3 conditions of contract are the single standard form most preferred for BIM adoption from a contractor perspective as 7 (38.89%) chose these conditions. However, seven (38.89%) suggested that it did not matter which conditions of contract were selected as BIM was normally incorporated with additional clauses/ appendices anyway. JCT was selected by 2 (11.11%). Two selected the following by selecting other: PPC 2000 which are partnering contract conditions and USA IPD which are USA conditions of contract not used in the UK.

5. CONCLUSIONS

As the United Kingdom has set government targets for BIM adoption by 2016 this paper examined the impact this would have on the contents of the tender package. It found that contractors were more advanced than the Government client in the implementation of BIM. This indicates that the Government departments need to do a lot more work internally in addition to setting targets. Training needs to be provided to government employees in BIM to bring them up to the same level as the contractors who need to achieve the target to remain in business. This would allow the formation of pricing documents electronically from the 3D model. However, for this to work the level of detail needs to be developed within the construction client for Civil Engineering projects. Further work will be required to see if negative perceptions from some within the client will remain once the client has more experience in BIM. All client respondents consider that the MCHW is the best MOM for Civil Engineering and Highways projects. As it is policy it is currently fully implemented through all capital projects and Roads Service personnel have a high use of the MCHW MOM. Despite the findings of Eadie et al (2013) this is unlikely to change. Therefore further work is required to fully integrate the MCHW MOM with BIM. The research further confirms that the UK government decision to implement the NEC3 conditions of contract for capital projects is in line with the BIM implementation targets. Contractors ranked it the single standard form most preferred for BIM adoption. They may have been aware of the NEC (2013) showing how BIM can be implemented with the NEC3 conditions of contract by Z clauses and the works information bringing in the CIC protocol. However, the amount of the contractors favouring other conditions of contract or considered that BIM could be used with any set of conditions indicate that it would be advisable for the Institution of Civil Engineers to issue a revision to the NEC conditions of contract to specifically allow the use of BIM with NEC contracts.

6. REFERENCES

- Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. and O'Reilly K. (2011), Technology adoption in the BIM implementation for lean architectural practice, *Automation in Construction*, Vol. 20 (2), March 2011, 189-195.
- Bédard, C. (2006). On the Adoption of Computing and IT by Industry: The Case for Integration in Early Building Design. In I. Smith, ed. (2006). *Intelligent Computing in Engineering and Architecture: 13th EG-ICE Workshop 2006*, Ascona, Switzerland, June 25-30, 2006, pp.62-73. Berlin: Springer Verlag
- BIM Industry working Group 2011. A report for the Government Construction Client Group Building Information Modelling (BIM) Working Party Strategy Paper, Available on line: <http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf> (accessed January 2014).
- Brook, M (2008), *Estimating and Tendering for Construction Work*, 4th Edition, USA, Butterworth-Heinemann.
- DFP (2012), Procurement Guidance Note PGN 01/12 Contract Management Procedures and principles, available online at <http://www.dfpi.gov.uk/pgn-01-12-04022013-con-man-procs.pdf> (accessed January 2014).
- DRD (2014), Transport NI - Who Are We?, available online at <http://www.drdni.gov.uk/index/roadsni-3.htm> (accessed January 2014)
- DRD (2012), Roads Service Annual Report and Accounts 2011-12, available online at http://www.drdni.gov.uk/2011-12_rs_annual_report_final.pdf (accessed January 2014)
- Eadie, R., Millar, P. and Harte, N. (2013) 'A comparison between CESMM3 and MCHW as methods of measurement for civil engineering work', in *International Journal of Procurement Management*, Vol. 6, No. 5, pp.523-543.

- Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011) *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, 2nd Edition, USA: Wiley.
- Efficiency and Reform Group,(2011), Government Construction Strategy, Cabinet Office, UK:London.
- Krejcie, R and Morgan, D (1970), Determining Sample Size For Research Activities, in Educational and Psychological Measurement, Vol.30, pp.607-610, Available on-line at <http://opa.uprrp.edu/InvInsDocs/KrejcieandMorgan.pdf> (accessed January 2014).
- Highways Agency (2014), Manual of Contract Documents for Highway Works, Available on-line at <http://www.dft.gov.uk/ha/standards/mchw/index.htm> (Accessed January 2014).
- ICE(1951), Standard Method of Measurement of Civil Engineering Quantities, London, Telford
- ICE (1976), CESMM : Civil Engineering Standard Method Of Measurement, London, Telford
- ICE (1985), CESMM2 : Civil Engineering Standard Method Of Measurement, 2nd ed, London, Telford
- ICE (1991), CESMM3 : Civil Engineering Standard Method Of Measurement, 3rd ed, London, Telford
- ICE (2012), CESMM4 : Civil Engineering Standard Method Of Measurement, 4th ed, London, Telford
- NBS (2012), National Construction Contracts and Law Survey 2012, Available on-line at <http://www.bsria.co.uk/download/asset/nbs-contract-law-survey.pdf> (accessed January 2014)
- NEC (2013) use BIM with NEC3 contracts: An NEC document, available online at <http://www.neccontract.com/documents/AApril2013%20files/HOWBIM.pdf> (accessed January 2014).
- Rubin A, and Babbie E.(2009), *Essential Research Methods for Social Work*, USA, Cengage Learning.
- Xu, H., Feng, J., and Li, S. (2014) Users-orientated evaluation of building information model in the Chinese construction industry, *Automation in Construction*, Vol.39(1) April 2014, Pages 32-46.