AN EVALUATION OF BIM ENABLED COST MANAGEMENT IN MEETING SUSTAINABILITY TARGETS

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ABSTRACT

With the current UK Government drive towards the adoption of Building Information Modelling (BIM), the Quantity Surveyor (QS) must possess the necessary knowledge and skills to use BIM as part of their cost management duties. For the purposes of this paper BIM contributes to Sustainable Construction Practices by facilitating efficient and effective integrated team working whereby, from the point of view of cost management, the process of planning and controlling maximises client value, minimises waste and optimises whole life cycle costs. The UK government expects cost management to utilise BIM automated quantity take-off where appropriate to facilitate Level 2 compliance by extracting 3D BIM model quantities into Excel and costing the quantities manually. BIM can directly benefit cost management by rapid and accurate automated quantity take-off; facilitating cost planning and Bill of Quantity production aimed at more effective use of resources. This paper will consider how the QS role will develop in relation to cost management in the new BIM era and how effective BIM will be in ensuring cost management helps meet sustainability-related targets. To inform the findings reported in this paper data was collected through exploratory interviews with QS's from three private practices, three contracting organisations and two experts in the field of BIM. This research suggests that whilst BIM is being utilised by the profession it is not standard in its application and not being utilised in relation to life cycle decisions thus limiting its impact on helping to meet sustainability targets.

Keywords: *BIM; Cost management; Role of a QS; Sustainability.*

1. INTRODUCTION

BIM is the new Construction industry buzz word and is seen to be one of the solutions to the construction industry's much documented problems. BIM is a 3D model designed to encapsulate data to simulate the entire construction and lifecycle of a building. As well as showing the building form and construction, the model has the potential to display scheduling, quantities and costs, lifecycle maintenance, energy consumption alongside health and safety information (Kamardeen, 2010). By offering a common platform that facilitates and encourages collaboration, it has been prophesised that more accurate, effective and better informed decisions will be made in relation to construction projects. It offers the potential to reduce waste by moving away from the traditional 2D drawings to a much more effective digital 3D environment, reducing the time spent in decision making and minimising the opportunity for errors. BIM can therefore be said to be contributing to sustainable construction practices by facilitating efficient and effective integrated team working. The changes that BIM will undoubtedly bring to the industry and current work practices is the focus of this paper, which aims to explore the impact BIM will have on the role of the QS in the UK. Particular emphasis will be given to assessing its impact on the current duties of the QS including: procurement advice, cost estimates, cost planning, value engineering, tender estimates, bills of quantities, whole life costing, budgetary control, valuations, financial reports, cash flow control and final account calculation (Cartlidge, 2013, Ashworth and Hogg, 2007). The findings reported in the paper are part of a wider research project which is currently ongoing.

The construction sector is one of the largest employers in the UK. It is estimated that the industry is made up of 300,000 firms employing over 2 million people in various roles (BIS, 2012). The value that construction brings to the UK economy is vast, accounting for approximately 6.3% of GDP in 2011 (BIS 2012). It has over a period of time been subject to numerous government reports to encourage improvements in productivity and predictability from Michael Latham's report 'Constructing the Team' (1994) to John

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Egan's reports 'Rethinking Construction' (1998) and Accelerating Change (2002) and more recently the Andrew Wolstenholme report 'Never Waste a Good Crisis' (2009). All reports conclude that the industry still has some way to go in providing a more standardised leaner industry and in resolving the issues of fragmentation and waste. In an attempt to once and for all address many of these issues the Government have recently introduced the Government Construction Strategy (2011) that identifies BIM as a tool to help improve the performance of the construction industry, reduce waste and improve collaboration. The Government set out a 5 year plan that states public funded projects over £50m (later changed to £5m) should be utilising BIM at a maturity level 2 by 2016. Level 2 maturity is a managed 3D environment with separate discipline 'BIM' tools data attached. This level of BIM may utilise construction sequencing and/or cost information. The Government, by mandating maturity Level 2, have committed construction project teams to provide their own distinct outputs by using BIM and managing it via a series of self-contained models using proprietary information connections between each of the project teams own distinct systems.

It is important that consideration is given as to how the QS can comply with BIM maturity Level 2. The UK Government Building Information Modelling (BIM) Strategy paper for the CEEC meeting (BIS, 2011), states that Level 2 may utilise time and schedule data and cost data and that QSs should be familiar with BIM, and actively develop ways in which processes can be made more cost effective, add value and be more sustainable. Cost management is an essential element within large construction projects, especially when project cost is an important criterion. QSs are responsible for this function yet a recent survey undertaken by the RICS in 2011 revealed that only 10% of QSs regularly use BIM (BCIS, 2011). It is crucial that QSs integrate BIM within cost management, or risk marginalising themselves within public projects.

2. BUILDING INFORMATION MODELLING

The collection, management and utilisation of potentially multiple data sources bring with it many problems that may be overcome by the utilisation of information modelling. BIM is not a new development its origins can be traced to the early 1970's but more recently the impetus to its application has stemmed from the Government Construction Strategy 2011. The UK Government has stipulated that BIM should be adopted on all public projects by 2016. This provides a massive incentive to contractors and construction professionals alike to arrange their organisations train their staff and develop and utilise BIM tools and techniques from 2016, not least the Quantity Surveying profession.

BIM can be said to be about information about the entire building and a complete set of design documents stored in an integrated database, where the information is parametric and thereby interconnected. All changes within the model being instantly reflected throughout the rest of the project (Krygiel *et al.*, 2008).

More recently the UK Construction Industry Strategy has set out further targets including a 33% cut in construction costs, 50% faster delivery on projects and 50% lower greenhouse gas emissions in the built environment by 2025 (Construction 2025). BIM is one of the mechanisms that the UK government are hoping will support these targets. Today sees the challenge of ensuring that efficiencies brought about by the introduction of BIM 2016 are reflected in the roles of the construction professionals. There are many benefits that can be realised by the introduction of BIM. Generally it increases the speed and accuracy by which decisions can be made which will impact on the role of the QS. In construction there are many decisions to be made through the life cycle of a building and many different software packages being utilised to support and inform those decisions. The construction industry can utilise BIM for building visualisation, design appraisal, project management, information storage and retrieval, cost estimating structural analysis, on site management, facilities management and contract preparation (Sun *et al.*, 2008).

2. BIM AND SUSTAINABILITY

The UK Government is pushing both the private and public sectors to employ more effective sustainable construction practices as it will not only help the environment but it can also improve economic profitability and improve relationships with stakeholder groups. BIM is seen to be the impetus for these new efficiencies. The potential between BIM and sustainability is just beginning to be realised (Bynum *et al.*, 2013). Holness (2008) suggested that designers should consider a building as a fully integrated dynamic design and

construction process. This could perhaps lend itself towards further life cycle analysis whereby the material schedules produce in BIM could be utilised to calculate operational efficiency and carbon usage. (Stadel *et al.,* 2011). Further developments in technology and improvements in interoperability will support BIM in assisting in the development of more efficient construction practices.

3. BIM AND THE QS

In 1971, the RICS defined the role of the QS as being associated with measurement and valuation (Nkado and Meyer, 2001). Nowadays this role has diversified to such an extent that the QS must develop a range of knowledge and understanding to satisfy the needs of a plethora of different employers and their roles. Ashworth and Hogg (2007) argued that their skills have been enhanced to meet current needs in relation to cost management of a construction project.

Cost management can be considered as the process of planning and controlling costs throughout the complete duration of a construction project (RICS, 2012). It is usually undertaken by a QS. The very term QS roughly translates into measurer and inspector of quantities. The UK government BIM adoption requirements are intended to drive the progression of BIM into cost management practice (BCIS, 2011a).

However, with the current UK Government drive towards BIM adoption the QS must now extend and refine their knowledge and understanding to ensure that they possess the necessary skills to apply BIM into cost management in practice. If cost management can be considered as the process of planning and controlling costs throughout the complete duration of a construction project (RICS, 2012), then it is necessary to assess how BIM can facilitate this process.

One of the advantages to the QS from BIM is the ability of QS or electronic quantity take-off and cost estimating (Eastman *et al.*, 2011). Eastman *et al.* (2008) stated that though most BIM applications allow direct quantity take off, additional 3rd party software is required for cost calculation and allowing linking of quantities to cost databases. Furthermore, cost can depend upon additional project specific conditions such as working space, requiring specific skills of a cost manager or estimator (Roginski, 2011, Gee, 2010).

There is still some uncertainty as to exactly what is required for cost management to achieve level 2 BIM compliance as required by 2016. The Government Construction Strategy (Cabinet Office, 2011) and the Report for the Government Construction Client Group Building Information Modelling (BIM) Working Party Strategy Paper (BIM Task Group, 2011) contain very little information about cost management. The strategy paper states that for level 2 compliance, quantities should be taken from the 3D model; suggesting BIM automated quantity take-off is required.

Currently the guidelines (BCIS, 2011a) states that level 2 may utilise programme data and cost elements and that clients should expect quantity surveyors to be familiar with BIM and actively develop ways in which processes can be made more cost effective and add value. The UK government wishes cost management to utilise BIM automated quantity take off where possible, but it is not yet a statutory requirement.

As COBie (the UK BIM Strategy recommended data exchange format) requires cost data in Excel format (BIM Task Group, 2011), then it should be possible to achieve level 2 compliance by extracting 3D BIM model quantities into Excel and costing the quantities manually. It follows that BIM can directly benefit cost management by rapid and accurate automated quantity take-off; facilitating cost planning and Bill of Quantity production. The automated quantity take off also facilitates cost control and analysis as the building model progresses, and allows easier pricing of alternative design solutions (Klashka, 2006, Eastman *et al.,* 2008). Level 3 BIM development will fully incorporate time and schedule data, cost dataand life-cycle data technology (BIM Task Group, 2011) and this will assist in fast and accurate calculation of life cycle costing (Azar and Brown, 2009, Jiang, 2011, Bartlett, 2011) which increasingly falls under the duties of cost management. Procurement and contractual advice can fall within the boundaries of cost management as the procurement strategy and risk allocation can have a great effect upon the cost of a project. There are documented examples that BIM can reduce overall project costs by between 5 and 10%, though the actual saving depends on the specifics of each project and the level of BIM integration (Eastman *et al.*, 2011, Lane, 2012). This could be considered another enabler for cost management: by formalising a

procurement strategy that integrates BIM (and the associated cost advantages); a QS will provide the client with better value for money and contribute to sustainable construction practices.

Despite the above enablers, there is a wealth of documentation to suggest that QS's within the UK are lagging behind other construction professions (Klashka, 2006, Lane, 2012, BCIS, 2011a) in their uptake of BIM. The RICS carried out a survey about the use of BIM by its members (BCIS, 2011b). This survey is especially relevant as it targeted QS's within the UK and received 153 respondents. The survey found that only 10% of respondents regularly used BIM with a further 29% having had some BIM engagement.

The NBS conducted a BIM survey with around 1000 responses from different disciplines within the construction industry of which 5% were QSs (NBS, 2012). This is supported by estimates from Davis Langdon that BIM software and training will cost quantity surveying practises £2,000 per employee, and £5,000 for a 'super user' (Matthews, 2011).

QSs may reject BIM as they feel it threatens their job due to automation (Kennett, 2010, Rendall, 2011). This urgently needs to be investigated as QSs are expected to utilise BIM models on public funded projects by 2016. Should the industry fail to take advantage of BIM, architects and contractors may start to provide cost management duties based upon BIM models themselves, reducing the requirement for QSs to undertake this role (NBS, 2012, Rendall, 2011).

5. RESEARCH METHODOLOGY

The research methodology adopted must "be appropriate for the questions that you want to answer" (Robson 2002, p.80). The research methodology adopted is a pragmatist/post-positivist research philosophy to facilitate the linking of practice and theory using a mixed methods approach. It is important for this research that theory and practice are not kept separate. "We cannot afford to ignore theory for the sake of just the facts" (Ryan 2006, p.2).

The research was divided into 2 stages. The first stage covered a critical analysis of current literature and thinking in the field and the second stage qualitative data was gathered by undertaking semi structured interviews with BIM experts and QSs in the industry that reflected both the contractors and the clients' viewpoint in relation to the role of the QS.

The interview questions focussed on what these organisations understand by BIM and how BIM can be used by QSs in relation to cost management. Eight (08) interviews were undertaken with a selection of personnel from the construction industry. The eignt interviewees were spilt into 3 sets in order to effectively compare the findings.

The sets were as follows:

- Two (02) experts in the field of BIM
- Three (03) representatives from contracting organisations
- Three (03) representatives from private practice QS

The data were analysed using thematic analysis, with NVIVO10 utilised as a tool to support this process. The key themes were analysed across the three sets and were quantified by producing thematic profiles identified against the number of "passages" relating to each theme.

6. RESULTS

6.1 HIGH LEVEL THEMES

Four high level themes were derived from the interviews. Figure 1 provides a thematic diagram of the high level themes and associated sub-themes that were identified i.e. a high-level theme is "BIM impact on QS" and associated sub-themes are "traditional QS role", "benefits to QS role" and "survival of the QS".

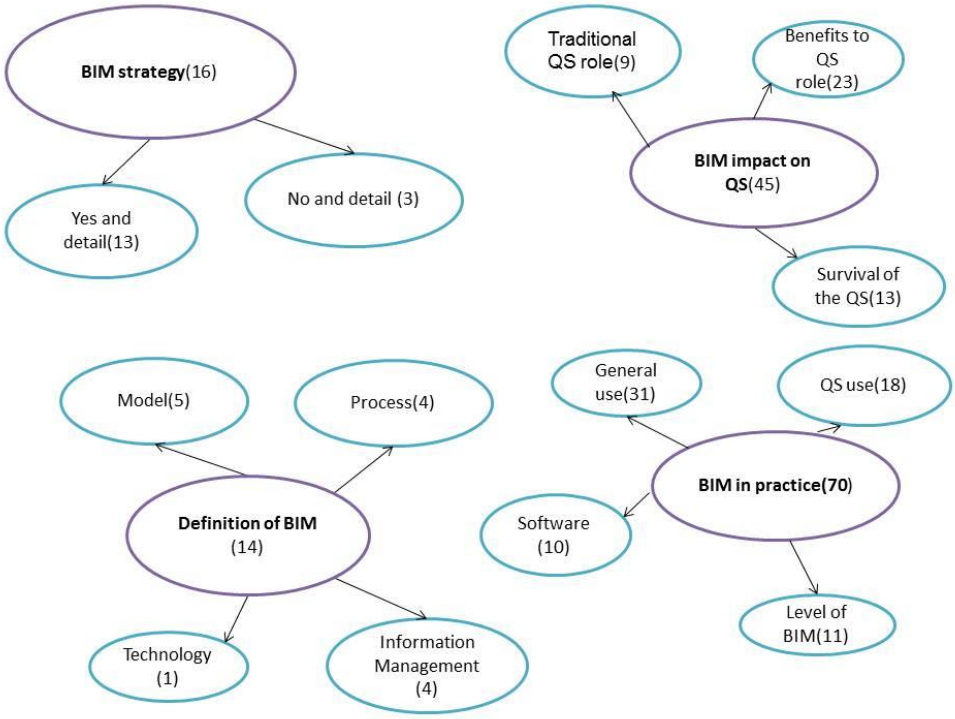

Figure 1: Thematic Diagram

A total of 145 related passages were established, in which the responses provided for each theme were fairly evenly distributed, however within each them there were distinctive differences in amount of responses from each interviewee set. This is illustrated in Table 1.

Table 1: Thematic Profile of High Level Themes

	A : Contractor	B : Expert	C : PQS	TOTAL
Definition of BIM	6	2	6	14
BIM strategy	5	3	8	16
BIM in practice	27	8	35	70
BIM impact on QS	17	7	21	45
Overall	55	20	70	145

6.2. THE DEFINITION OF BIM

The first key theme was 'the definition of Building Information Modelling', which produced 14 related passages: evenly distributed between the PQS (6 passages) and contractor (6 passages). This is illustrated below in Table 2. Sub themes were identified between the definitions in relation to how the interviewees choose to define BIM. One PQS interviewee stressed '*it's the information as everyone says, it's the "I" in BIM, so it's how you manage information throughout the life of a project'*, whilst one Contractor identified it '*as a model, and it's a set of protocols and it's also a process and it's the kind of the culture and the dynamics of the project itself*' and another commented *'the outputs from that model as a result of the process can range from anything from 2D drawings all the way through to cost estimates, programmes estimates'*. One BIM Expert confirmed '*it's a series of models it's no singular model*'. Only one passage referred to it being a technology.

Table 2: Thematic Profile: Definition of BIM

	A : Contractor	B : Expert	C : PQS	TOTAL
Definition of BIM				
Information Management	2	0	2	4
Model	2	0	3	5
Process	2	2	0	4
Technology	0	0	1	1
Overall	6	2	6	14

6.3. BIM STRATEGY

The second key was the 'the adoption of a BIM strategy', which produced 16 related passages, as shown in Table 3. It was found that all but one interviewee, a PQS, did have a BIM strategy although there was much variance in its format and visibility. One PQS interviewee identified many layers to their BIM strategy and emphasised '*Yes we've got one, well it's at two levels. At a group level we've got a whole lot of standards and protocols around delivering the project in BIM and then at a business level we've got a BIM strategy. In fact our BIM strategy is one of our strategic priorities for the business so it's something that's reported back in to the board every month*', whilst another PQS claimed '*No we don't. We do have a BIM working group. But what we do in terms of BIM, we develop strategies for clients'*.

Table 3: Thematic Profile: BIM Strategy

	A : Contractor	B : Expert	C : PQS	TOTAL
BIM Strategy				
Detail - no	0	0	3	3
Detail - yes	5	3	5	13
Overall	5	3	8	16

6.4. BIM IN PRACTICE

'The adoption of a BIM in practice' was the third theme, which produced a total of 70 related passages with four sub themes in relation to general use, level of BIM working at, current practice with the QS and the implications of the software. This is illustrated in Table 4.

Table 4: Thematic Profile: BIM in Practice

	A : Contractor	B : Expert	C : PQS	TOTAL
BIM in Practice				
General use	11	4	16	31
Level of BIM	5	2	4	11
QS use	5	2	11	18
Software	6	0	4	10
Overall	27	8	35	70

6.4.1. GENERAL USE

This sub theme received the greatest number of passages with 31 out of the total 70. A common statement was around BIM being used to aid collaboration and engagement and interaction on a project and to facilitate decision making '*throughout the entire business'*. It was also identified that BIM was being used very early on in the design process in relation to buildability and clash detection. **'***We're getting QS's to sit in on clash meetings and see when changes are made and understand reasons why the changes are made. It's as much about the beam has to be a larger beam so it will cost more but it's the associated costs, if we don't do that then the roof has to be strengthened and that will cost even more than the beam.'*

6.4.2. *LEVEL OF BIM*

All interviewees with the exception of one (01) PQS felt that they were working at between Levels 1 and 2. One PQS commented *'We work at the level of maturity that we can with the team and with the project and with the client. The majority is probably still not even at level 2'* with Contractors stating *'sort of working at about 1.8'.* This was supported by a BIM Expert *'let me tell you if everybody tells you they are at Level 2 they are lying to you'.*

6.4.3. *QS USE*

Eighteen (18) of the total seventy (70) passages related to current practice of BIM with the QS with 11 of the passages from the PQS. There was a variance in current practice and adoption of BIM. One PQS stated *' we are moving through to a BIM environment that whole kind of measurement and take off becomes much less'* whilst the Expert stressed that by adopting BIM practices this allowed them to move *'onto the big part of BIM itself , in terms of you are making more lifecycle decisions rather than just Capex decisions. It's more about total expenditure'.* This was contradicted by one PQS who stated *'I don't think our lifecycle costing team have used any models as yet.'* There was much discussion around the use of BIM for quantification particularly in relation to cost planning, with one Contractor claiming *'We're certainly using early access to quantities to test the validity of our cost plan and have been doing it right at the start of the bid on our Liverpool project'.*

6.4.4. *SOFTWARE*

Ten (10) of the total seventy (70) passages related to software with the majority 6 of the passages from the Contractor. The majority of the passages discussed the decision around purchasing and trialling software. This was by a PQS and Contactor respectively: '*we are we are starting to look at perhaps software to be able to interrogate the design and check the design for compliance and for change so that they can cost that change as well'* and '*We're looking at software fairly frequently. We've got test models.'* Others discussed formatting issues around the various software's '*it's around can our software handle it in terms of taking off information for the model, it's not just a case of is it in the right format. You know we get DWFX files'.*

6.5. *THE IMPACT OF BIM ON THE QS*

The fourth key theme was the 'the impact of BIM on the QS', which produced 45 related passages. This produced 3 sub themes in relation to Benefits of BIM to the QS role, the traditional role of the QS and the survival of the QS, as shown in Table 5.

Table 5: Thematic Profile: BIM Impact on the QS

	A : Contractor	B : Expert	C : PQS	TOTAL
BIM impact on QS				
Benefits to QS role	9	3	11	23
Survival of the QS	3	3	7	13
Traditional QS role	5	1	3	9
Overall	17	7	21	45

6.5.1. *BENEFITS TO THE QS ROLE*

This resulted in the largest number of passages with 23 out of the total 45. On the whole the passages discussed creating efficiencies in the processing of information making the QS work smarter and facilitating faster more accurate decisions. Both the Contractor and PQS believe that *'the information flows a lot faster'* affording *'the QS more time to do what's not in the model, to see the gaps, to understand where things are missing'* and move into other areas not just the measurement of embodied and operational carbon but *'even in to the quantification of water as we are starting to see small examples of people talking about embodied water and operational water.'* Improvements in the method of communication was also seen to be a key benefit to the QS as they work collaboratively to make informed decisions with a PQS stating *' BIM will help us communicate the impact of cost better. I think if we're participating in federation meetings and we*

take a more collaborative project team approach then that must help us all work faster and more efficiently' Risks were also identified as being reduced as the QS still has *'professional obligations to fulfil regardless of how the information is generated'* provided the model was set up appropriately to achieve the project outcomes. One contractor expressed some concern in relation to this *'what we find is that where the project has been set up well and where there's agreed structures and protocols around how the model would be developed then its considerably more efficient'*. This was one of the major caveats expressed by all experts that the model must be fit for purpose and set up so as to provide the appropriate information in the correct format to facilitate smarter more effective working.

6.5.2. SURVIVAL OF THE QS

Concern was expressed in relation to the role of the QS and how it must adapt in order to survive. One PQS was fearful how BIM might be used by contractors and thought it was *'just another evolution. And I think we are an adaptable service but the one thing that I think we could have as a challenge is the fact that contractors are trying to offer one stop shops'*. This was supported by another *PQS* who thought that *'we don't quite know how it's all going to fit together in terms of individual responsibilities at the moment'*.

The majority of the experts believed QS survival was about attitude and positivity. With one BIM expert stating '*I think that if QS's embrace BIM in a positive and constructive way then they've got a lot to offer the project team and the role of the QS will be strengthened. I think if QS's are negative or resistant or conservative about BIM then there is a potential that other members of the project team, and by that I mean architects, designers and structural engineers and so on will find different ways to deliver their projects. And in that sense the QS's role could be diminished'*.

All experts believed the role of the QS would survive the BIM revolution albeit in an amended form due to their flexibility and adaptability with one PQS asserting *'we might have to add some more strings to our bow'.* Whilst it was confirmed by all experts that the QS role was not endangered the QS business however was deemed to be under threat, as one BIM expert expressed *'The traditional QS firms might not survive'.*

7. CONCLUSIONS

This research suggests that whilst BIM is being utilised by the profession there is no standardise use and little evidence of it being utilised in relation to life cycle decisions. BIM has the potential to reduce the time spent by the QS in relation to the mundane routine measuring of quantities allowing cost management to be more efficient and accurate, thereby reducing waste in the construction process. There is little evidence to suggest that BIM adoption has made cost management more efficient and effective and does not as yet help meet sustainability related UK targets. BIM presents both challenges and opportunities for the profession, some have been slow to adopt and others less so. The QS profession will survive but they will need to respond to the changes brought about by BIM and adapt their practices. BIM strategy's need to be in place to support this change and people made aware of the potential of BIM to revolutionise the way in which they work.

The next stage of this research is to consider the barriers that prevent BIM-enabled construction and evaluate the changes it is likely to bring to the QS profession.

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