SEEDS International Conference

Developing an End-User Data Capture Methodology

Roy Whitaker, Sam Zulu and Chris Gorse

School of the Built Environment & Engineering, Leeds Beckett University, Leeds, LS2 8AG

ABSTACT

The aim of this research is to establish the extent to which end user requirements are communicated throughout the construction process. The method of inquiry is purely literature based. This research indicates that the perspectives of those involved in construction projects are widening. Whole life considerations are now requiring those with operational expertise and knowledge to be involved in decision making processes. In particular, design build and operate schemes, such as PFI developments, require facilities management involvement at an early stage to allow their operational knowledge to influence design and component decisions based on long term operational efficiencies.

The increased use of BIM in such developments also compliments a collaborative approach by endorsing the involvement of those with specialist skills and sharing rich information in timely ways throughout the development project, from inception to operation.

The process of arriving at 'informed decisions' is clearly complex due to the interactions of components relating to data, information and knowledge. This paper illustrates the need for effective communication of user requirements throughout the construction process. It demonstrates that provision for the capture of tangible data is reaching levels of maturity through the adoption of property asset management systems, platforms and tools. However, the paper raises awareness of the need for further research into how less tangible user requirements are obtained to ensure the 'voice of the customer' is heard, interpreted and communicated appropriately by construction specialists throughout the development phases.

INTRODUCTION

The fragmented nature of the construction industry has been of concern to government and the focus of numerous reports, the most seminal being Latham, (1994), and Egan, (1998),(2002). In the forward to the book Knowledge Management in Construction, Latham (2005, p. vii), describes the distinctive nature of construction projects in the way that individuals and groups are brought together, then disbanded on completion. A consequence of this disbanding is that the ability to communicate lessons learnt is often lost.

This paper is concerned with how the construction industry is evolving post the aforementioned reports and recommendation for improvements in collaborative working. Crucial to cooperation throughout project development stages is the sharing of information and knowledge. Government standards and codes of practice relating to BIM are making headway in how relevant data should be captured at appropriate stages. What is less tangible and less evident is the extent to which end user requirements, the 'voice of the customer', are captured and communicated throughout the construction phases. The aim of this research is to establish the extent to which end user requirements are communicated throughout the construction process.

Introduction to the literature reviewed

Communication in the construction industry in its broadest sense spans a wide range of considerations, which is reflected in the scope of this literature review. PFI projects are used to illustrate increasing synergy between those who commission and build properties and those who operate them. PFI projects link the constructor to operations, which in turn should stimulate greater involvement of end users in processes to stipulate operating requirements throughout the development cycle.

The rising profile of facilities management

There is evidence to suggest that the profile of facilities management is increasing as building in-use knowledge is required to inform decision-making in the design and construction stages of construction projects. This can be evidenced by the increasing number of publications that relate asset in-use requirements to the development of buildings. These include the publications:

- ISO 55000:2014 (BSI, 2014a) standard for maximising value from assets.
- PAS 1192-3:2014 (BSI, 2014b) Specification for information management for the operational phase of assets using building information modelling.
- BS 8536-1:2015 (BSI, 2015) Briefing for design and construction – Part 1: Code of practice for facilities management (Buildings infrastructure).

PPI and PFI developments provide a useful model of how the financing of construction projects is viewed from a whole life perspective (NAO, 2009, p. 9). In theory, PFI projects overcome many of the drawbacks associated with models of construction that are value engineered and handed over from the developer to

the operator on completion. However, in practice questions have been raised on the value for money of developments under PFI financing arrangement, such as the head of the National Audit Office, Amyas Morse's observations that lessons should be learnt from expensive PFI projects, and that Government Departments and the Treasury should adopt more robust measures to yield savings from PFI contracts (2011, pp. 9,10). Subsequently, the National Audit Office have released their vision, "to help the nation spend wisely", in the publication, 'Savings from operational PFI contracts' (NAO, 2013).

Emphasis placed on spending wisely encompasses expenditure over the whole life of the project. It is not restricted to the capital expenditure stages, depicted by the British Standards, PASS 1192-2 as; Brief, Concept, Definition, Build and Commission, and Handover and Closeout, but also includes the operational expenditure final stage of; Operation/ In-use (BSI, 2013). Construction Excellence (SCI-NETWORK, 2012, p. 7) estimate that occupier's business operating costs typically outweigh capital investment costs by 200 times when spread over 25 years. It is for this reason that the facilities management profession is increasingly being invited to contribute its knowledge of building in-use requirements to influence decisions made in the planning and development stages to ensure that facilities are constructed to standards that are most fit for purpose over the long term of their existence (BIFM, 2016).

The role of BIM in aiding collaborative working

We live in an unprecedented era of information technology development. While the range of actual and potential IT applications within the fields of corporate real estate construction and facilities management is vast, a development noteworthy to mention is BIM. Becerik-Gerber (2012, p. 431) makes the observations that; "In the construction industry there is a growing interest in the use of BIM in facilities management for coordinated, consistent, and computable building information and knowledge management from design to construction to maintenance and operation stages of a building's life cycle".

The UK government's BIM Task Group lends support to the importance of facilities management in helping to achieve its stated objectives to reduce capital and operating costs, as well as carbon emissions, by adopting information rich technologies. These objectives continue to include collaborative behaviours that will "change the dynamics and behaviours of the construction supply chain, unlocking new, more efficient and collaborative ways of working" (GSL, nd, p. 1). Emphasis on collaborative ways of working is significant in a number of ways. In terms of the development project overall, working in collaboration and in communication across professions will allow facilities management interaction that has not hitherto been evident. The breaking down of traditional disciplinary silo barriers will allow interaction between facilities management and other "building, design and construction professionals to promote greater collaboration and integration at each stage" (BIFM, 2016, p. 2).

'The Industrial Strategy: Government and Industry in Partnership' publication identifies BIM as a collaboration tool (*Construction 2025*, 2013). The BIM Task Group policy that calls for collaboration between those who operate and those who design and construct buildings is encompassed in the Government Soft Landings: GSL Guiding Principles (2012, p. p4).

- GSL to be a key element of the design and construction process, to maintain the 'golden thread' of the building purpose through to delivery and operation.
- Early engagement of the end user in the design and construction process.
- Commitment to aftercare post construction from the design and construction team.
- Post occupation evaluation and feedback to design/ construction teams of lessons learnt to inform future projects.
- BIM to provide a fully populated asset data set to feed into CAFM systems. Modelling will enable planning modifications. This data will be maintained throughout the building life cycle.

The BIM Task Group (*BIM Task Group*, nd) and the GSL Policies (2012) may be abbreviated to advocating the themes of; collaborative working throughout the project lifecycle while adopting information technologies to aid asset design and management. An overriding theme to these attributes is that of knowledge management, which incorporates the generation and capture of knowledge, as well as the sharing of that knowledge.

In association with the BIM Task Group, the Construction Industry Council have produced an industry guide, the 'Outline Scope for the Role of Information Management' (CIC., 2013). The guide recommends that the scope of services for information management is classified as follows:

i.   Common data environment management
ii.   Project information management
iii.   Collaborative working, information exchange and project team management
iv.   Additional services.

It is interesting that these requirement concern data, information and the communication of information. It is now appropriate to review factors relating to data, information and knowledge, including its forms, its sources, its accessibility, and its suitability.

Sharing Knowledge, Information and Data.

Property asset management systems.

The capture and sharing of asset information in the different development and operational stages of property asset management has received a great deal of attention in recent years. Figure 1.2, is taken from the BSI publication, PAS 1192-2:2013. This information delivery cycle defines project stages and shows points of information exchange. This model is concerned primarily with the capital expenditure stages, (CAPEX) 1 to 6. It provides a useful visual representation of points at which information may be inserted into a project to achieve desired operational requirements.
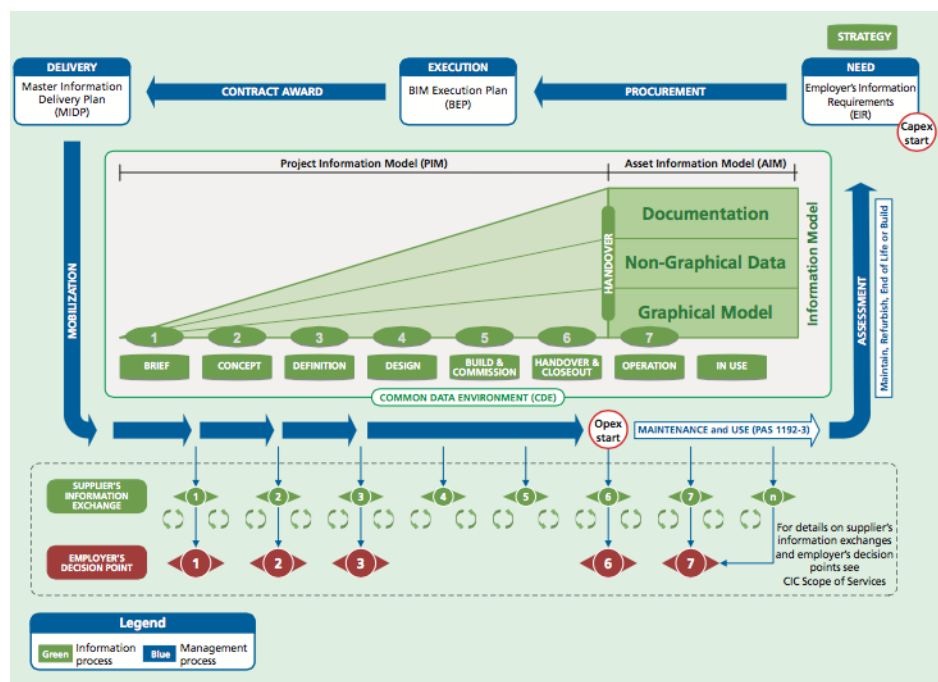

Figure 1.1. The information delivery cycle
PAS 1192-2:2013

A subsequent BSI publication, PAS 1192-3:2014 (2014b), is concerned with the operational expenditure (OPEX, stage 7), phase of the asset lifecycle. The operational phase is depicted as feeding into the employer's information requirements (EIR), and the project information model. PAS 1192-3:2014 provides extensive guidance to the management to all data exchange and management information requirements. This publication also provides direction on the integration of asset management information into BIM processes at a level of maturity that requires electronic file based information with automated connectivity. It can be seen that property asset management systems focus primarily on the lowest level of data and information sharing, that which can be expressed as data and text.

The structure of knowledge

Data

Sheehan et al. (2005, p. 51) use a pyramid model to depict how information and data sources need to be integrated to informed decision making processes. Data provides the foundation for the model, with the greatest volume. The gathering and collation of date provides structured information, which in-turn contributes to knowledge and understanding, which ultimately allows behaviours to be informed. The Oxford English dictionary (n.d.) definition of data is; 'facts and statistics collected together for reference or analysis'. Data may be referred to as codified information from this definition, which information technology is concerned with.

Data facts and statistics have a wide variety of forms. McGilvray and Thomas (2008) have defined common groupings of data relating to a business in the following ways:

> Master Data – describes people, places and things relating to an organisation. The data is usually used by multiple business processes and IT systems so standardised formats are required for integration.
>
> Transactional Data – relates to internal or external events or transactions that take place.
>
> Reference Data – are "sets of values or classification schemes used by systems, applications, data stores, processes and reports, as well as by transactional and master records". Reference data is used to classify data into identifiable groups. These reference sets are frequently created by individual organisations to suit their unique circumstances.
>
> Metadata – is 'data about data'. Metadata labels, describes or categorises other data, allowing it to be retrieved, interpreted and used for information.

While it has been noted that the development of computing applications in the construction industry in recent years is unprecedented, similar observations were being applied to manufacturing before the turn of the millennium. Baer (1991, quoted in Bryan, 1997p3) states that "the development of computer based applications for design, engineering and manufacturing has led to an explosion in the volume of product data used within manufacturing organisations". Bryan (1997) observes that the greatest demand for product data management is in the automotive and aerospace industries to manage continuous product development.

Bryan (1997) continues to define product data management as:
- The management of all product data relating to the parts, assemblies and products.
- The management of the relationships between parts in overall product design as the product structure.
- The ability to maintain configurations of parts in the product structure as a specified product definition.
- The management of processes that create, modify and delete parts and products over their respective life cycles.

Although these defined categories are concerned with manufacturing they may be applied to phases in the construction and occupation of buildings equally, commencing with the component parts, their relationship to one another in the design and construction stages, their adaptability to modification or replacement, and finally their life cycle considerations.

<u>Information</u>

In the forward to the book Knowledge Management in Construction, (Sheehan et al., 2005), Sir Michael Latham describes the distinctive nature of construction projects in the way that individuals and groups are brought together, throughout different stages of a development, then disbanded on completion. As a consequence of this dispersal the ability to communicate lessons learnt on many construction projects is often lost.

Comparisons of Bryan's (1997) observations of manufacturing in the 1990's can be applied to ways in which the construction and property management is being encouraged to develop today in terms of breaking down communication barriers through information sharing. Bryan (1997, pp. 2-23) refers to increasing customer expectations and tougher market requirements as creating an environment where products require significant customisation in the design and configuration phases to meet end user stipulations.   Also, an 'over-the-wall' approach to manufacturing is criticised for the way in which products are developed in sequence, rather like the 'silo' approach of specialists in construction. Instead, a concurrent engineering approach is advocated, whereby a multidisciplinary team is brought together from functions across the development to design products to meet downstream requirements, including lifecycle and disposal considerations.

Chimay et al (2005, p. p19) note the limitations of information technologies for providing knowledge. The point is made that it is delusional to believe that there is a seamless progression from data processing to information management and ultimately to knowledge management. Knowledge management is described as having complex characteristics that make it distinguishable from information.

<u>Knowledge</u>

Palmer and Platt (2005, pp. 7-9) concur with observations that construction companies differ from companies in other sectors in terms of projects coming to an end, teams being disbanded and people 'often having to re-invent the wheel' as a consequence of knowledge lost. Palmer and Platt (2005, p. p10) point to how these differences impact on knowledge management cultures in the construction industry, where knowledge is viewed as something to be guarded rather than shared.

In the introduction to the publication, the Business Case for Knowledge Management in Construction, Palmer and Platt (2005), provide a distinction between information and knowledge. *Information* is described as being recorded in reports and databases; it is easy to organize, share and apply to problems. *Knowledge* is said to reside in people's minds; it is based on know-how and experience. It is difficult to quantify how it is managed, but it usually emerges when people interact.

Nonaka and Takeuchi's (1995) theory of knowledge creation, cited in Egbu and Robinson (2005), provide the following classifications of knowledge creation.

	TACIT	EXPLICIT
TACIT	Socialisation	Externalisation
EXPLICIT	Internalisation	Combination

Figure 1.2 Knowledge creation theory (Nonaka and Takeuchi, 1995)

The classifications provided by Nonaka and Takeuchi (1995) are formed by interactions with the categories of knowledge; Tacit and Implicit.

Tacit knowledge is formed in individuals as a consequence of their experiences, and their reflections and interpretations of those experiences. Tacit knowledge may be explained to others, but only those with the same experiences will be able to interpret and understand what is being communicated fully.   The experience of swimming may be used to illustrate this concept. The physical reality of being in the water and co-ordinating leg, arm, torso, head and breathing actions can be explained, but only fully appreciated by those who have 'felt the experience' of swimming or attempting to swim.

Explicit knowledge, on the other hand, lends itself to communication to others, as it exists in forms that may be interpreted, held in company documents, databases and the intranet. Explicit knowledge may be employed to address standard situations that do not require innovative new ideas.

Nonaka and Takeuchi's (1995) knowledge creation theory depicts points where tacit knowledge and explicit knowledge interact. Tacit to tacit being categorised as 'socialisation'; tacit to explicit, 'externalisation'; explicit to tacit, 'internalisation' and explicit to explicit, 'combination'.

Socialisation is found in circumstances where there is social interaction in the process of passing on experiential knowledge. Craft apprenticeships are a good example of where skills are passed onto trainees through interaction with a mentor. Knowledge is transmitted through verbal communication, observation, practice, experience, feedback and reflection.

Internalisation is where explicit knowledge is converted to tacit knowledge. Egbu and Robinson(2005) use the analogy of an architect reading a manual on design standards, then interpreting explicit reference details to a design model that will meet the client's taste and style requirements.

Externalisation is described as the reverse process to internalisation. Tacit knowledge is made explicit to allow it to be shared. The example provided is when on-site discussions between an architect and a contractor form the basis for written instructions that are passed onto subcontractors.

Combination knowledge is generated through processing explicit reference sources. Individual and project team knowledge is enhanced by the activity of gathering filtering, integrating and combining details from multiple explicit reference sources, such as data banks, reference manuals, sketches, architects drawings and project plans.

The Voice of the Customer

A universal feature of all products and services is that they must satisfy user requirements if they are to be successful. A consequence of this imperative should be the application of adequate forethought to every element of building construction to allow the end product to marry with the needs and expectations of those concerned with its management and use. 'The voice of the customer' is an expression rooted in manufacturing where there is an identifiable need to produce products that customers want to buy due to their perceived superiority over competitors products. Methodologies concerned with focusing on customer requirements are now also established in non-manufacturing areas, including academic course design, group strategy identification, information technology and patient care (Shamshirsaz, 2014), (Cohen, 1995).

It is acknowledged in research that facilities managers are the principle holders of information on building asset performance efficiency. Much of this research relates to post occupation evaluation (POE), which not only recognizes how occupation information should be used to improve existing buildings, but also how this information should be used to influence the design of new construction projects. Jensen (2012, p. 170) notes that; "One of the problems in the building industry is the limited degree of learning from the experiences of use and operation of existing buildings when new building projects are planned'. He then poses the question; "can facilities management be the missing link to bridge the gap between building operation and building design?" Continuing this theme, Bordass and Leaman (2005) discuss knowledge obtained when buildings are in-use and how post occupation evaluation "feedback, follow through" information

may be used in subsequent design and construction phases to improve the quality and sustainability of our buildings. However, a study undertaken across European public authorities for the Sustainable Construction and Innovation Network (2012, p. 6) reveals that users, occupiers and facilities managers often feel 'isolated' from the capital project process as they are frequently only involved when all core decisions have been made, or perhaps when the asset is actually complete. This study (ibid) raises questions on the extent to which facilities management is positioned to represent the requirements of end users, which may represent missed opportunities given the 200:1 ratio of capital to operating costs.

DISCUSSION AND CONCLUSION

This literature research has shown the extent to which end user requirements are gaining prominence through BIM and BS standards publications. It is evident that systems and procedures for the capture, transfer and sharing of data for building operational information purposes is well considered and likely to become routine best practice as the BSI protocols become established.

What is not so transparent is how the highest level of the decision making process, knowledge of end user requirements, is shared across disciplines. This research will continue to be concerned with how user requirements that do not lend themselves to identifiable data capture streams are obtained.

The next steps of this research are twofold. Firstly, to examine existing realities for obtaining user requirements to quantify the extent to which knowledge of user wants and needs is captured or lost.

In parallel to this methodologies will be developed to strengthen the extent to which knowledge of the 'voice of the customer' is obtained, structured and managed to facilitate its communication throughout the construction processes

Bibliography

Becerik-Gerbert, B. and al., e. (2012) 'Application Areas and Date Requirements for BIM Enabled Facilities Management', *Journal of Construction Engineering and Management*.

BIFM (2016) *Operational Readiness Guide. A guide to ensuring long term effectiveness in the design and construction process.* Bishop's Stortford, England: British Institute of Facilities Management.

BIM Task Group (nd) Building Information Modelling (BIM) Task Group. Available at: http://www.bimtaskgroup.org (Accessed: 11th March, 2017 2017).

Bordass, B. and Leaman, A. (2005) 'Making feedback and post-occupancy evaluation routine 1: A portfolio of feedback techniques', *Building Research & Information,* 33(4), pp. 347-352.

Bryan, M. G. (1997) *An Approach Framework for Product Data Management.* PhD, Cranfield.

BSI (2013) *PAS1192-2. Specification for information management for the capital/delivery phase of construction projects using building information modelling.* London: British Standards Institute.

BSI 2014a. BS ISO 55000. *Asset Management.* Chiswick, London: British Standards Institute.

BSI 2014b. PASS 1192-3:2014. *Specification for information management for the operational phase of assets using building information modeling.* London.

BSI 2015. BS 8536-1-2015 Briefing for Design and Construction. *Part 1: Code of practice for facilities*

management (Buildings

infrastructure).

Author (2013) *1.: Outline Scope of Services for the Role of Information Management.* London: BL Consult and Beale and Company.

Cohen, L. (1995) *Quality Function Deployment. How to make QFD work for you.* Reading, Massachusetts

 Addison-Wesley Publishing Company.

Construction 2025, Government, H. (2013)*. London.

Egan, J., DTI (1998) *Rethinking Construction. Report of the Construction Task Force.* London: HMSO.

Egan, J. (2002) *Accelerating Change, A Report by the Strategic Forum for Construction*, London. Available at: http://constructingexcellence.org.uk/wp-content/uploads/2014/10/accelerating_change.pdf.

Egbu, C., O. and Robinson, H., S. (2005) 'Construction as a Knowledge-Based Industry', in Anumba, C., J., Egbu, C. & Carrillo, P. (eds.) *Knowledge Management in Construction*. Oxford: Blackwell.

GSL (2012) *Government Soft Landings Policy*. London: Cabinet Office. Available at: http://www.bimtaskgroup.org/wp-content/uploads/2013/02/The-Government-Soft-Landings-Policy-18022013.pdf (Accessed: 6th October, 2015.

GSL (nd) *GSL - BIM Task Group*. Available at: http://www.bimtaskgroup.org/gsl/.

Jensen, P. A. (2012) 'Knowledge Transfer from Facilities Management to Building Projects: A Typology of Transfer Mechanisms.', *Architectural Engineering and Design Management,* 8(3), pp. 170-179.

Latham (2005) 'Forward', *Knowledge Management in Construction*. Oxford: Blackwell Publishing, pp. vii.

Latham, M. (1994) *Constructing the Team*, London: HMSO.

McGilvray, D. and Thomas, G. (2008) 'Executing Data Quality Projects; Ten Steps to Quality Data and Trusted Information', Available: Morgan Kaufmann Publishers (Accessed 10th October, 2015).

Morse, A. (2011) *Lessons from PFI and other projects.* London: National Audit Office.

NAO 2009. Private Finance Projects: A Paper for the Lords Economic Affairs Commttee.

NAO, Treasury, H. (2013) *Savings from operational PFI contracts.* London: National Audit Office.

Nonaka, I. and Takeuchi, H. (1995) 'The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation.', in Press., O.U. (ed.) *Knowledge Management in Construction*. Oxford: Blackwell, pp. 34-36.

Oxford (n.d.) *Oxford English Dictionary.* 3 edn. Oxford: Oxford University Press.

Palmer, J. and Platt, S. (2005) *Business case for knowledge management in construction.* London: CIRIA.

SCI-NETWORK (2012) *Post Occupation Evaluation*. Available at: www.sci-network.eu.

Shamshirsaz, S. A. (2014) *Apply QFD methodology to capture 'unheard' voices of UK care home residents and translate them into quality measurement targets for future improvement.* PhD, Brunel.

Sheehan, T., Poole, D., Lyttle, I. and Egbu, C. O. (2005) *Knowledge Management in Construction.* Oxford: Blackwell Publishing Ltd.