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Construction Operations Building Information Exchange – A State of Implementation Appraisal and Perspectives

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Abstract
Construction Operations Building information exchange (COBie) was first proposed in 2007. Since then, has COBie become a mainstream implementation? In view of this, via literature review, this paper aims at appraising the implementation of COBie by investigating the attributes of improved maintainability of buildings as the main benefit of COBie to operations and maintenance. However, focus is only on the maintainability attributes pertaining to buildings and facilities such as design, personnel and logistics. This paper also examines the issues pertaining to COBie data collection, extraction and usage. In particular, the examination is on whether COBie has become the standard electronic deliverer of initial building life cycle data and the days of boxes of paper has ended. In addition, case studies of data exchange from construction to operations are also included to complete the review. The paper finds that in all areas mentioned, which are collection, extraction and usage, more work on developing work processes and practices are needed before COBie becomes a mainstream implementation. The lack of processes development and adoption was seen to be a result of lack of demand for COBie. Alternatively, the information exchange can be outsourced to operations and maintenance information experts during the design and construction stages as project secretaries. Case studies indicate that although outsourcing is a success enabler for construction to operations information exchanges, it may significantly increase project cost.

Keywords: *COBIE, Construction Operations Building Information Exchange, Maintainability*

1 INTRODUCTION

Construction Operations Building information exchange (COBie) was first proposed in 2007. Since then, has COBie become a mainstream implementation? In view of this, via literature review and case studies, this paper aims at appraising the implementation status of COBie.

COBie stands for Construction Operations Building information exchange (COBie). According to East [1], it is an international standard that was developed to ensure that initial building life cycle data such as asset registers and warranty information are delivered electronically to facility operations and maintenance. This is to ensure that the whole life cycle of building is tracked and monitored. At the time and even today, many project closings include delivery of building data but are delivered in boxes of paper. This method of delivery is not only inefficient but also leads to difficulty in checking for data veracity. Added to this, even when the data is robust, it is usually not easily accessible as it is still paper based. This situation leads to operations and maintenance usually having to spend more man months to collect data that was already available but not readily available [1].

To improve this situation, COBie was developed as a project information standard based on various existing formats in industry and the military. COBie resulted into a set of spreadsheets that are to be filled by construction project managers. These electronic spreadsheets then became the standard for building construction to operations information exchange [1]. Yalcinkaya and Singh [2] notes that COBie however is not a de-facto standard that everyone has to abide to, but rather a guiding standard to enable more efficient information exchange. With this standard, it is particularly useful to facility system designers as a, common language, common understanding, that is invaluable when exchanging communications between different parties.

This paper will therefore discuss on the benefit of COBie in terms of improving the maintainability and costs of buildings, followed by an elaboration on the implementation status of COBie as found in the literature and case studies.

2 THE NEED FOR MAINTAINABILITY

During the life of a building, Construction Operations Building information exchange (COBie) data benefits the operations and maintenance activities by supporting the maintainability of the building. Wani and Gandhi [3] discussed maintainability as the ability to maintain or is easy to maintain. This ease is indicated by the mean time it takes to maintain or repair, where this time metric is usually called mean time to repair (MTTR). Wani and Gandhi [3] also relates that the maintainability attributes of mechanical system consist of design, tribo-concepts, personnel and logistic support. Since this paper is focusing on buildings, tribo-concept is an attribute that will not be a major concern in this paper. Thus, the main attribute for maintainability will be design, personnel and logistic support. Conferring about these attributes, it seems clear that each of these attributes require information from the construction stage to improve its maintainability.

Following from Wani and Gandhi [3], this paper suggests that for building maintenance operations to improve maintainability, building maintenance departments would need to have access to the design information of the structure, as well as have people that have the knowledge of the structure and knowledge of the many different parts of the structure. This information is particularly important as to justify why COBie was developed in the first place. With the information provided by COBie, operations will be able to improve

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maintainability because the speed and completeness of maintenance are not hindered by lack of information. Therefore, COBIE data is a structural need for operations intending to improve maintainability.

Furthermore, East [1] provided anecdotal examples of how operational problems could have been easily solved if facility, design and construction data was made available to operations. The first anecdote was about how a broken trash compactor could have been replaced in minutes but instead took two days to be replaced because the original product data could not be found. The other example given was also about unavailability of product data, where a whole boiler system faced replacement because specifications for a heating element whose manufacturer has gone out of business, could not be found. A third anecdote was that when comparing two different facility databases, namely the tenant management system and the facility management system, a space was found to be differently defined. One defines the space as a medicine preparation area and the other as housekeeping. These anecdotes further show that unavailability of correct information leads to confusion and lower maintainability. On the other hand, de Silva et al [4] identified that for buildings, the knowledge on maintainability and the tools to assess maintainability are importantly required in the building industry. However, at the time, the tools to gather the information were not available, which lead to great reluctance among practitioners to accept this requirement.

The examples and discussion aforementioned shows that maintainability of a building is related to the availability of construction data which COBie is designed to serve. Having accepted that COBie indeed is a useful activity to be undertaken by construction project managers at the behest of property owners and users, this paper hence appraises the implementation issues related to the collection and usage of COBie.

3 IMPLEMENTATION

The implementation of any data standard will involve data collection, extraction and usage. This section of the paper will therefore first look at issues of data collection as mentioned in literature and followed by data extraction and data usage issues.

3.1 Data Collection

According to Yalcinkaya and Singh [2], Construction Operations Building information exchange (COBie) has been widely accepted as a standard due to heavy interest in Building Information Modelling (BIM). This interest made possible what was paper drawing based data to be transformed to electronic versions of the data.

For example, Alnaggar and Pitt [5] investigated the use of project management methodology for COBie data collection. It was reported that a conceptual framework for COBie data collection management was achieved. Using project management methods to manage COBie was sensible in the sense that COBie's data producers are construction project managers themselves. It is observed by this paper that by using project management language, the task of collecting COBie data will be streamlined to construction but more importantly, COBie becomes a valid work breakdown structure thus is taken as a sub-project within the construction project. This is important because COBie efforts add costs to construction projects, whose returns may not be clearly seen. All in all, research on COBie collection methods and structure needs to be increased to ensure that it is made structurally a part of every project.

In addition, Jawadekar [6] carried out a case study on the use of BIM and COBie and concluded that a major contributing factor to the success of COBie implementation is clear processes for data collection throughout the project. Collecting data as an afterthought at the end of project would reduce the quality of the deliverables. Critical to process adoption however is the sponsorship of management because of the change management involved.

Yalcinkaya et al [7] also highlighted that COBie spreadsheets are usable in terms of collection and delivering of data from construction to operations. Furthermore, when Yalcinkaya et al [7] researched the usability of the spreadsheets themselves from an operational point of view, it was found that the wide availability of spreadsheets makes it a good platform to rest the data on. However, in general, Yalcinkaya et al [7] suggests that spreadsheets are not relational and when looking for multi variable data, spreadsheets are very weak in terms of the time and ease of accessing the data. This represents most of the grievances reported by operations towards COBie. Much effort has been expanded to find compatibility between COBie spreadsheets and facility systems.

In general, Dixit et al [8] has made a list of the technological issues in implementing data exchanges, such as COBie or BIM, which consist of incompatible file exchange formats, availability of multiple software platforms, interoperability between technologies, large files sizes, software issues and long adaptation times when using new technology. Incompatible file formats happen when different software are used and data needs to be exchanged between this software but data exchange becomes tedious because of different data formats. Each format needs to be translated to the other format. This would be specially tedious if the formats are from paper based systems [8].

In addition, the technological issue of availability of multiple software platforms happens when different user types use different software. For example, project managers may be using geographical information systems (GIS) which is very graphical, while facility managers use a Computerised Maintenance Management System (CMMS) which is text based. Software integration works are usually commissioned to reduce these platforms tensions [8]. Interoperability between technologies is similar to incompatible file formats but usually involves data re-entry. If a piece of data can be only be exported through re-keying into the other system, then interoperability issue has happened. For example, not all graphical software can accept photographs as input. In cases such as this, the photo needs to be redrawn for the data to be useful to the system [8].

On the other hand, large file sizes are also a real problem when handling design and shop drawings. Transferring these files over the internet may require more than normal resources. Many times these data are transferred in hard copy drawings which leads to risks of loss and theft. Miscommunication between project parties also happens due to unavailability of data caused by large file sizes [8]. Another technological issue highlighted by Dixit et al [8] is on software issues that usually revolve around software versioning. Newer software versions are at times were made not compatible to older software files, hence

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creating another source of tension [8]. The last technological issue is related to the long adaptation times that stem from building industry conservativeness in using new technology. This conservativeness may be due to need to conserve capital. However, this conservativeness and the other technological hurdles mentioned, produces some of the hurdles that are inhibiting COBie from being mainstream [8].

3.2 Data Extraction and Usage

With ownership of Construction Operations Building Information Exchange (COBie) data collection ascertained to be the responsibility of the construction project managers, it is suitable to also see if these data are easily made available to building operations and whether it improves maintainability as designed. McCormack et al [9] successfully worked on COBie spreadsheets and used an established facility management software package to map the data in the COBie datasheets and extract it into facility management software. This proves that although different facilities may have different facility management software, it is technically possible to extract COBIE data into site acceptable visual presentations in a manner that is fingertip and user friendly.

Lee et al [10] also confirms that Revit, a Building Information Modelling (BIM) software from Autodesk, could generate only five COBie datasheets although most of the information is available within the BIM system. However, through using a self-developed application, McCormack et al [9] estimate that twelve datasheets are possible to be extracted from the BIM database. Concluding that although there is no automatic generation of COBie data available commercially, Revit has placeholders for most of COBie data. Since Revit is the main BIM system in the market and as it gets wider acceptance, then so will COBie get more acceptance and implementation will become easier.

In terms of COBie usage, Lavy and Saxena [11] studied the work order processing times at university campuses that uses drawing-based approach. Instead of using surveys and interviews like most previous studies, this study extracted work order processing hours from the university's Computerised Maintenance Management System (CMMS). Although the perception of many studies indicated that COBie data, when available, will reduce work order processing time, Lavy and Saxena [11] found results that were contrary to this perception. However, accuracy of the study were doubted by the authors themselves because work order recording processes were not uniform throughout all the campuses.

Notwithstanding the above, it shows that COBie's configurations was designed on data requirements but have not encompassed the required data use processes. This leads to a need for more studies on end usage so that the COBie's promise may be accomplished.

4 CASE STUDY

A case study was conducted on a public hospital and a public university in Malaysia which implemented computerised maintenance management systems (CMMS) immediately after building handover. The case study was conducted with the CMMS implementation teams from CWorks, the company that supplied the CMMS. At both the public hospital and the public university, the construction contract has specified that warranty information and asset register data were to be delivered in electronic format together with a CMMS upon handover of

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building to facility operations and maintenance. The public university in particular also required that as-built drawings were delivered in electronic format. In its entirety, the CMMS implementation objective was to deliver a CMMS to facility operations and maintenance. The CMMS was to be pre-populated with all the contractually required data from the constructor. Therefore, the implementations in this case study are not strictly complying to the Construction Operations Building Information Exchange (COBie) standard, but it is still a construction to operations building "information exchange".

Pursuant to the previous paragraph, the main issues discovered at the beginning of the implementation were mostly software and data related. It ranged from "what data to deliver" to "what software tools to use". On the data side, many meetings between the implementation teams, the constructors and facility operations and maintenance were held as the implementation team needed to understand requirements. A noted contention point was that both constructors and facility managers did not have stable work processes to collect and deliver data electronically. The existing process was to deliver the building together with all drawings and design documents in paper form. There was a need to digitise the drawings and extract the required data into relational databases such as a CMMS for delivery to facility operations.

Another point of contention was that the data itself changed throughout the life of the project. As the project evolved, design drawings changed in a series of shop drawings to finally become as-built drawings. The pace of the drawings' changes did not reflect the pace of the project. The implementation team had to keep track and pursue data changes so that database updating remains in pace with the projects. This paper notes that instead of collecting data as it evolves, ease may be achieved if data collection is only done on as-built data. However, by collecting data at this end stage, it was judged that collection of data would be crammed in a time where responsibilities lies in a "no man's land" between construction project managers and facilities operations and maintenance. Thus, if errors are found, responsible party needed to correct the errors would not be available.

The implementation team also observed that data collection was the last task in anybody's plan. If the implementation team did not act as initiators, the data collection would have been done in an afterthought manner. Therefore, lack of demand for data collection was observed. As the issues were collected it was found that in general the issues can be grouped into the following four which are similar to the ones noted by Dixit et al [8], namely undefined workflows or processes, improper data capture, failure to update data and lack of client demand.

However, to overcome the issues raised, the implementation teams decided to implement four actions at the sites under study, namely implementation team deployment at construction stage, outsourcing of data collection and exchange to implementation team, implementation team acts as project secretary, and data stored into CMMS directly. The usual CMMS implementation that would come in post-handover, now were embedded at the construction site for the duration of the construction. The implementation team had the duty to liaise with all different disciplines at the construction site and be part data collector, part secretary to the project. They

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built the project library and extracted needed data while simultaneously acting as editors for data completeness, accuracy and veracity.

At the public university in particular, the CMMS was equipped with Building Information Modelling (BIM) capability because of the need to practise space management. Space management, which is the practice of maximising space usage in built environments, also creates a need for COBie. This modelling capability allowed for all layers of construction data to be immediately entered and ready for use. With the CMMS deployed and embedded at the construction stage, there was no system integration issues because there was nothing to integrate.

Based on the abovementioned actions, the implementation was able to bypass the implementation hurdles such as lack of client demand and undefined workflows. Technology hurdles was also heavily reduced by concentrating on one system. In this case, CMMS was deployed at construction stage and not after handover stage. The concept of outsourcing of information exchange to facility operations seems to have worked very well at the sites under study. The team's previous experiences have shown that for newly installed CMMS, the team will take at least a man-month to build their asset and warranty registers. In this case, the time to build the asset and warranty registers were much faster as it was done at construction stage. This lead to immediate, live operations for the facility operations and maintenance.

With the completed registers, facility operations were able to develop operations and maintenance manuals very quickly while the vendors were still within warranty reach. The warranty stage or Defect Liability Period (DLP) of two years produced better corrections rate as the CMMS was already fully running even at this early stage of operations. Scheduled maintenance was deployed from the beginning which reduced the risk of deferred maintenance. Maintenance scheduling was made easier and warranty management was more responsive. Finally, all results in the case study showed full and completed data exchanges without any of the issues and conflicts exhibited by the implementations studied in literature.

It is important to note though that although success was claimed in the case study, this success had a price. The cost of outsourcing increased the project costs. There were savings in the time to build asset registers but it is not known if the cost and savings were evened out or surpassed each other.

5 CONCLUSION

In conclusion, Construction Operations Building Information Exchange (COBie) brings benefits to facility operations and maintenance in terms of maintainability. Time to repair reduces when facilities are equipped with complete asset information. However, hurdles to COBie's implementation as a mainstream standard still exists in terms of undefined workflows or processes, improper data capture, failure to update data and lack of client demand. Among the hurdles mentioned, the biggest hurdle seen in the literature is the lack workable process development and adoption. Until benefits of COBie can be felt economically by both constructors and facilities operations, the acceptance of the need for COBie will continue to be low. Without this acceptance, process adoption will be low.

Without clear demand to motivate adoption of COBie, there may be a need to regulate and legislate COBie into being. Regulations were the reason why the public hospital and public university in the case study mentioned in this paper pursued the facility data required. The case study proves that demand, through nature or nurture, is a key success enabler for COBie implementation success. Alternatively, outsourcing COBie implementation is a valid option, which however may entail higher overall cost to construction projects. In outsourcing, COBie tasks are given an economic value for third party providers. This economic value becomes the demand that is required for successful implementations.

REFERENCES

[1] East, B 2013. *Using COBie.* BIM for Facility Managers, 1st Edition, New Jersey: John Wiley & Sons, pp. 107-143, 2013.

[2] Yalcinkaya, M & Singh, V.K (2015). 'Examining the Evolution of COBie Standard in Building Information Modelling for Facilities Management.', *CIB W78*

[3] Wani, M.F & Gandhi, O.P (1999), 'Development of maintainability index for mechanical systems', *Reliability Engineering & System Safety*, 65(3), pp 259-270

[4] de Silva, N, Dulaimi, M.F, Ling, F.Y.Y & Ofori, G (2004) 'Improving the maintainability of buildings in Singapore', *Build. Environ.*, 39(10), pp. 1243– 1251.

[5] Alnaggar, A & Pitt, M (2018), 'Towards a conceptual framework to manage BIM/COBie asset data using a standard project management methodology', *Journal of Facilities Management,* https://doi.org/10.1108/JFM-03-2018-0015

[6] Jawadekar, S 2013. *A Case Study of the Use of BIM and COBie for Facility Management.*LAP LAMBERT Academic Publishing.

[7] Yalcinkaya, M., Singh, V., Nenonen, S. and Junnonen, J.-M. (2016), 'Evaluating the usability aspects of construction operation building information exchange (COBie) standard', *CIB World Building Congress, At Tampere, Finland*

[8] Dixit, M.K., Venkatraj, V, Ostadalimakhmalbaf, M,. Pariafsai, F. and Lavy, S. (2019) 'Integration of facility management and building information modelling (BIM): A review of key issues and challenges', *Facilities*, 37 (7/8) pp 455-483, https://doi.org/10.1108/F-03-2018-0043

[9] McCormack, M., McAuley, B. and Hore. A.V. (2013) 'The application of COBie to Increase the Functionality of Existing Facilities Management Software', *Proceedings of the International Postgraduate Research Conference 2013, University of Salford, April 8th -10th 2013.*

[10] Lee, J, Jeong, W, Faghihi, V, & Kang, J (2013) 'Automatic Generation of COBIE Data from Revit', *Proceedings of the 30th ISAR, Montreal, Canada*, pp 653-660.

[11] Lavy, S & Saxena, N (2015), 'Quantifying the effect of using BIM and COBie for facility management on work order processing times: a case study', *International Journal of Facility Management*, 6 (1)