Integration of FM and asset management expertise in digital 3D building models

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Abstract

Purpose: The research establishes a Conceptual Process Model (CPM) as shown in Figure 1 which shows how Facility Management (FM) and Asset Management (AM) know-how, 3D laser scanning and Building Information Modelling (BIM) can be combined with virtual design and simulation techniques to help managers make better decisions about feasibility report options and to add value and optimize existing buildings performance and quality.

Design methodology and approach: Mixed methods were used including a review of BIM literature and industry best practice. Seven semi-structured interviews were held with stakeholders from different stages in the BIM process. The initial CPM was subsequently refined during the research project based on feedback from the interviews. The 3D laser scanning element of the CPM was tested using two ZHAW university buildings and the findings triangulated with a feedback mechanism to further improve the model.

Originality and findings: The findings helped to develop a model which can be used by key stakeholders as a guide when considering the integration of FM and AM know-how, with 3D scanning in the creation of a BIM model for existing buildings, which constitute approximately 98% of the building stock. The focus is on combining existing know-how with the BIM process and simulation techniques to identify, simulate and evaluate the best building improvement options for feasibility reports prior to a decision to proceed. The CPM meets the need to develop a workflow with a focus on digitalisation of the existing built environment and creation of appropriate BIM model(s). The models can then be used for simulation purposes looking at cost benefit optimisation, energy efficiency, life cycle costing (LCC) etc. as well as creating virtual walk through models that can be viewed by end users, Facility Managers (FMs) and Asset Managers (AMs) to improve workplace environments and FM and AM operation.

Keywords: Facility Management (FM), Asset Management (AM), Building Information Modelling (BIM), 3D laser scanning, CAFM, Life Cycle Costing (LCC), COBie.

1. Introduction

BIM as a concept is not new and has been gradually evolving since the earliest days of computing. It is fundamentally a process that refers to a collaborative way of working, underpinned by digital three-dimensional technologies which unlock more efficient methods of designing, creating and maintaining assets (HM Government, 2012). The levels of BIM maturity are different by industry sector as well as country. The UK construction National BIM Report (NBS, 2014) states "BIM is now an industry norm" and their research figures report "awareness of BIM is now nearly universal and has risen from 58% in 2010 to 95% in 2013". In some countries (e.g. United States, Netherlands, Norway, Australia and Finland) the paradigm shift of adopting BIM has already happened, but in other areas (e.g. the DACH region of Europe) it seems to be somewhat more restrained (Detail, 2012). Considering a typical establishment phase of five to ten years for BIM in the design and construction sector (Kiviniemi, 2013), it is anticipated most countries will also soon move to adopt BIM as the norm. Familiarisation in the FM market is slower in gathering pace as the (BIM4FM, 2013) survey of the FM supply chain shows; "61.7% of respondents held the view that BIM can support the delivery of FM. Although, it was acknowledged that just over a third of respondents 35.3%, do not yet understand the intricacies of how this will be achieved".

The role of FM, AM and BIM is gathering pace with initiatives such as in Germany; "BOOM - Building Operation and Optimization Model" (Oltmanns, 2013) and the UK "Government Soft Landings (GSL)" process which will be mandated in 2016 for all UK central government projects, for new build and major refurbishments (BIM Task Group, 2014). This will require construction companies to carry our Post Occupancy Evaluations (POE) for up to 3 years after the completion of a building to prove the building design in operation and with increased involvement of FMs and AMs as the ones who have to manage the primary cost phase (use and operation). Such initiatives recognise the value and need for FM to be involved early in the design. This is also now reflected for new-build projects in the UK RIBA 2103 "Plan of Works" especially at stages 0 and 7, and in other countries norms (SIA, HOAI, Ő-Norm etc.). This leads directly to the question "how can BIM and FM/AM know-how be used for existing buildings?" and "how can we create digital building models for existing buildings/assets?"

As data acquisition and FM related costs (maintenance etc.) is a not a negligible cost factor (May, 2012) and taking into account the key drivers impacting FM, e.g. cost, sustainability, energy management, space etc. a good starting point seems to be to have the end in mind. A lot of information is needed in digital building models during the operational phase. Due to

the fact there are a limited number of pilot projects, publications etc. dealing with this topic this paper tries to deliver a CPM, mapping out how 3D scanning for data acquisition, BIM standards as IFC, FM and AM Information know-how can be combined to optimize the operation of existing buildings and improve workplaces. It also explores the possible use of laser scanning for the "scan to BIM" creation of BIM model using a "smart workflow" (e.g. with different software products).

2. Literature review

There is often little testing of the primary product of the construction industry, "the building" done before irrevocable and often very costly decisions are made (Bazjanac, 2004). To try and address this and other issues in the UK, the Government published the Construction Strategy 2025 with four key targets 1) a 33% reduction in both the initial cost of construction and the whole life cost of assets, 2) a 50% reduction in the overall time from inception to completion for new-build and refurbished assets, 3) a 50% reduction in greenhouse gas emissions in the built environment and 4) a 50% reduction in the trade gap between total exports and total imports for construction products and materials (HM Government, 2013). They also include the strategic objective to have maturity Level 2 BIM file based rather than paper based (BSi, 2014)) for all public sector asset procurement by 2016, with equal applicability to private sector building, infrastructure, refurbishment and new-build projects. This requirement is now driving change in the construction industry which has embraced BIM. The process for specifying the information management in the construction and the operational phases of an asset or portfolio of assets as well as the collaborative production of information is outlined in PAS 1192-2 (BSi, 2013), PAS 1192-3 (BSi, 2014) and BS 1192-4 (BSi, 2014) respectively. Scanning recommendations are also made in PAS 1192-2 (BSi, 2013) specific to the "BIM Execution Plan". FM and AM are concerned with managing the key assets of an organisation at optimal whole life cost (BSi, 2014). However the integration of FM and AM expertise in the BIM process is an emerging area and there is still limited knowledge available on the subject (Kelly, Serginson, & Lockley, October 2013). To help define structured information for facilities, COBie-UK-2012 has been introduced via BS1192-4 and there are templates on the BIM Task Group website (BIM Task Group, 2014). These can be used to help capture data used in the commissioning, operation and maintenance of a project and to populate decision making tools as well as FM and AM systems (BSi, 2013). From an FM perspective the information management process must maintain the integrity of AM information to support the following activities related to AM: 1) defining AM strategies and plans, 2)

implementing AM plans, 3) managing the AM lifecycle, 4) acquiring and managing asset knowledge, 5) managing the organization and its human resources, 6) managing and reviewing risk (BSi, 2014). Ultimately FM requires an Asset Information Model (AIM), linked to various enterprise systems, to be the single source of approved and validated information related to the asset(s). This includes data and geometry describing the asset(s) and the spaces and items associated with it, data about the performance of the asset(s), supporting information about the asset(s) such as specifications, operation and maintenance manuals, and health and safety information. (BSi, 2014).

To date the tangible benefits of adopting BIM are widely debated. There is a lack of real world case studies, especially in the case of existing buildings, despite new constructions representing a small percentage of the total building stock in typical year (Kelly, Serginson, & Lockley, October 2013). From a construction perspective the added value of BIM is now becoming evident as reflected in the article "No pain, No Gain in BIM" (Trebilcock, 2014) and include benefits such as; programme optimisation, clash detection and avoidance, construction simulation, temporary works integration, rig set up, BIM to manufacture, business efficiency, increasing market penetration and product integration. However, "the largest prize for BIM lies in the operational stages of the project life-cycle" (BIM Task Group, 2014). A BIM carries all information related to the building, including its physical and functional characteristics and project life cycle information (Azhar & Hein, 2011). The benefits from an FM perspective are a bit more difficult to validate but according to (BuildingSMART, 2010) include; entering data only once and reusing it throughout the life cycle of the project, blending geospatial and building information for planning, reducing requests for information and change orders, reducing rework, improving awareness of progress and current status. The (BIM4FM, 2013) survey highlighted how FMs think they will use BIM; life-cycle management (83.6%), improving efficiencies (82.2%), cost reductions (68.5%), carbon reductions (63.3%) and other (26%). The concerns raised were; cost (50.5%), integration with current technology and CAFM (50.5%), training (34.5%), data management (33%), time (32.5%), unknown technology (30.9%) and legal issues (16.8%).

Laser ranging systems have been in use in a variety of industries for decades, with the first patented instruments appearing as early as the late 1980's. 3D scanning was first applied in the Architecture, Engineering, and Construction (AEC) industry in the 1990's (Randall, 2013). Mobile and aerial scanning are now quickly becoming the standard method for creating digital city models. Scanners are also being used in other contexts for example to allow data acquisition at crime scenes or after natural disasters, accidents or to record the

condition of road networks structural and architectural aspects of cultural landmarks and historic buildings (Randall, 2013). All these can serve as physical (digital) records. Scanning buildings has to date mostly used static terrestrial scanners based on a tripod system. One important myth to address is that scanners are optical systems, only what the scanner can "see" is captured, thus scanners cannot go through walls or other obstructions (Randall, 2013). Although static scanning technology delivers good results when scanning the outside of a building there are a number of limitations when scanning indoor locations due to the need to use "tie points" with physical targets to create a reference frame. The manual placement of the laser scanner on multiple stations interrupts the scanning and thus reduces the scanning rate (points per second). The placement of tie points requires additional manual effort. New technologies; Indoor Mobile Mapping Systems (IMMS) and Simultaneous Location and Mapping (SLAM) are emerging as the most prominent systems for indoor mapping (Thomson, Apostolopoulos, Backes, & Boehm, 2013). 3D scanning creates a foundation for a BIM approach by capturing existing conditions in a highly accurate, 3-dimensional format that can be used as a basis for developing project designs (Randall, 2013). PAS 1192-2 (BSi, 2013) also notes that a point cloud survey shall be provided to verify the completeness of the as-constructed model. For FM a key application of scanning is for as-built recording, or assessment of project performance to support project guarantees during the "as constructed" phase of a project (Randall, 2013).

3. Methodology

Mixed methods were used for the research including a review of BIM literature and relevant industry best practice. The Conceptual Process Model (CPM) shown in Figure 1 was then developed showing how FM and AM know-how, 3D laser scanning and the BIM process might be combined to offer decision makers a top level process tool to use when considering the setup of a BIM model for existing buildings and how it might be used to help optimize a buildings performance for improvement options such as energy use etc.

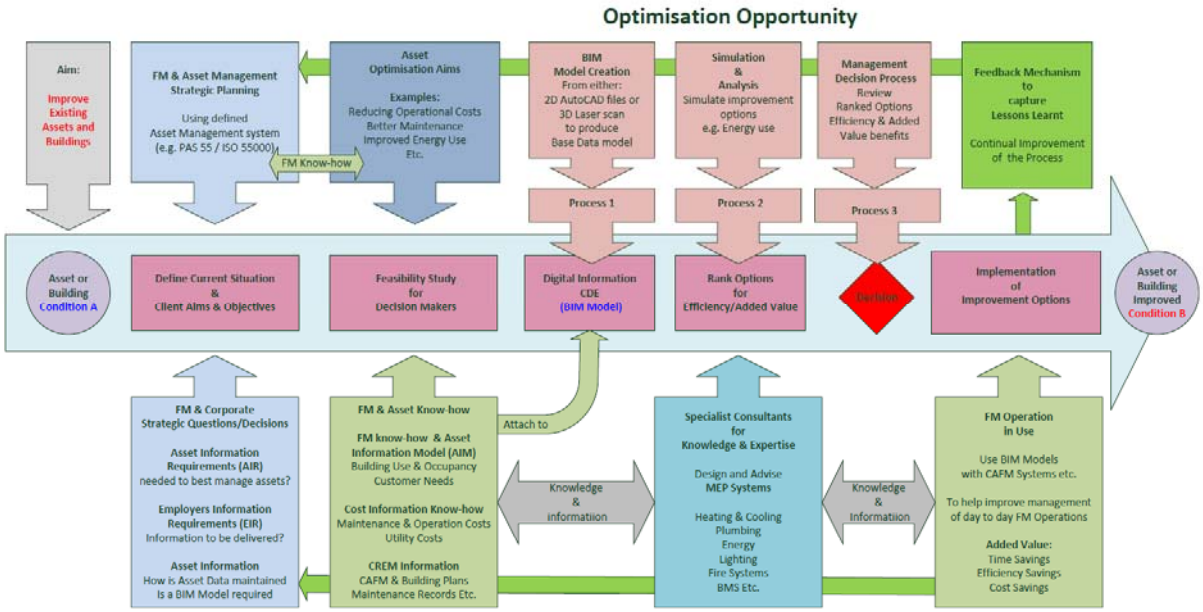

Figure 1: CPM: For the improvement of assets through the use of FM and AM know-how, 3D laser scanning and the BIM process for existing buildings

Feedback mechanism for improving the CPM

Seven semi-structured interviews were held with experts as per table 1 (stakeholders in different stages of the BIM process from Switzerland and the UK) to test the model and discuss how it might be improved. The questions for each interview were developed specific to the expert's field and experience. The draft CPM was discussed and refined throughout the interview process based on feedback and ideas created during the interview process.

Table 1: Details of the seven experts interviewed with their job title and focus of expertise

No	Job title and field of expertise
1.	**FM and real estate expert (UK):** strategic decision making with respect to a large portfolio of buildings, currently starting to use BIM in existing buildings
2.	**Architectural professional expert (UK):** advising clients about BIM responsibilities as well as 3D scanning and the creation of BIM models in Revit software
3.	**FM and real estate expert (UK):** creating BIM models clients buildings, both for new and existing buildings which are then used by their practicing FM staff
4.	**TEC engineering expert (Switzerland):** use of BIM in project management in hospitals with large TEC Engineering elements
5.	**M&E architectural professional (Switzerland):** MEP and creation of BIM models (ensuring clash detection and avoidance etc.) within an architectural context

6.	**Modelling and simulation expert (Switzerland):** simulation and modelling with the aim to make recommendations to clients about optimising their buildings
7.	**Senior project manager at the BIM Academy (UK):** focus on advising clients about BIM for the FM operational phase of buildings

The 3D scanning element of the CPM was tested using two existing buildings at the Zurich University of Applied Sciences (ZHAW). The findings were then triangulated with feedback from the interviews and the review of literature and best practice to improve the CPM.

1. Results and discussion

Two key themes highlighted in the interviews were 1) "the best way of approaching BIM is to learn by doing" (the authors agree with this) and 2) "when planning a BIM process always start with the end in mind". This is reflected in guidance from the PAS 1192-2 (BSi, 2013) which advocates following the principles of lean and ensuring the downstream uses of information are established at the start of the process in the Employers Information Requirements (EIR). The fact FM is not subject to the same obligations as the construction sector has meant FM is not yet fully engaged. This was confirmed by some interviewees who felt "FM has lost pace with industry; we should be in the driving seat not just letting the AEC industry to take the lead". The lack of engagement is also due to "a lack of good case study data on BIM especially with respect to FM". A key issue highlighted was that "many organisations are on the beginning of the BIM journey" and that there is a need to "educate staff and ensure they understand the BIM process". The GSL process means large construction companies with an in-house FM section are likely to be the first to see the real benefits of ensuring their designs are fit for purpose as they will end up living with the consequences. For smaller FM companies it may be more difficult as the question on most FMs minds is "what is the return on investment". For BIM models to be beneficial they need to be transparent with respect to the reliability and accuracy of data within them. There were some concerns raised with respect to "Issues around sharing potentially sensitive commercial data".

In addition to the two main themes above, Table 2 highlights the key findings which were established from feedback given during the interviews. This feedback was continually used to refine the CPM. A summary of key findings and observations from each interviewee are then detailed one by one.

Table 2: Summary of the key findings from interviews

No	Key findings
1.	**Communication:** is key to the success of the BIM process with the need for each stakeholder to engage and understand their roles and responsibilities in the process
2.	**Starting with the end in mind:** is key to ensure the BIM process has clear objectives and to ensure the relevant FM and AM knowledge is brought into the project as early as possible to realize the benefit to long-term operational costs
3.	**User specification and the level of information for BIM models:** needs to be clearly thought through if the models are to be accurate and useful to the FM/AM operation teams. Users need to consider how the teams will use the model(s) when specifying what information to attach to the model(s) – "what to put in and what to leave out"
4.	**Simulations:** require building geometrical and other data, but good simulations can use simplified models. Key is capturing adequate user and FM/AM operational data
5.	**BIM modelling for existing buildings:** requires a mix of methods to create accurate models; (2D plans, surveys, laser scans etc.). There is no direct tool that can create accurate plans direct from point clouds without survey validation checks. For each building clients need to evaluate the operational financial benefit to creating a model
6.	**The main benefits of the BIM process:** creating a strategic advantage in decision making and planning, transparency and ease of access to information and cost savings and efficiency of FM/AM resource in operation (especially if the BIM process can export data direct into CAFM systems)
7.	**The main barriers to BIM:** engagement with the BIM process due to complexity, education, familiarisation with the BIM language as well as client uncertainty about the business case and ROI. (If ROI can be verified it could become a key benefit)

1) FM and real estate expert (UK): "Experience has shown us communication is critical to ensuring the success of the BIM process, as we are all on a learning journey". When asked about the importance of BIM to FM/AM the response was "BIM is seen as strategic to our company as we see it will have financial implications and provide a sustainable edge in business". "We have just invested in workstations equipped with Revit software and are providing BIM training for our staff as well as familiarising ourselves with key documents such as PAS 1192-2 and PAS 1192-3". When asked about the key to making BIM work; "We need to work together with the client, architects and our supply chain to ensure every party understands their roles and is buying into the process". The key benefits were identified as

"gaining full transparency of the cost of managing assets from cradle to grave as we are driven mainly by budgets". The main benefit to clients being "improved planning of projects with better Life Cycle Cost (LCC) modelling of assets and CAFM compatibility". Another key benefit is the "potential to attach FM/AM data into the BIM model". The main barriers were identified as; complexity in terms of the "levels of data and integration of all players from inception and during design to all become familiar with the common language of BIM" and cost in terms of "who pays and what is the return on investment". For "new builds we estimate a potential increase in cost of 3-5%". For existing builds the question raised was "what advantage will the level of investment required bring us". There were also commercial concerns raised; "attaching financial data to models might be commercially sensitive".

2) Architectural professional expert (UK): A "key point which people sometimes forget is that although BIM will deliver savings in the construction phase the biggest potential savings are from FM in the operational phase". As such "it is critical the BIM process starts with the FM end needs at the start of a project". When asked what the key challenges are when working with BIM they find "clients are generally uneducated about BIM and a significant amount of our time is about getting them up to speed". The practice use scanning extensively noting "if you send out a survey team to measure a large or complex building it can be very expensive, scanning allows a one-time capture of data in great detail and avoids the need to revisit site". However people should be aware that "at the moment there is no reliable method for direct translation of point cloud data into 2D plans. Yes it is possible to use slicing techniques to produce rough line drawings but due to voids and complexity of what you see in terms of M& E equipment etc. a site validation check is still required". "We have found through experience that the best way to build a BIM model is to use a combination of 2D plans with 3D scans and on-site checking by competent architects/engineers for the detailed stuff". "We also have a library of BIM objects but often have to build these from scratch".
When asked about BIM and existing buildings; "the main problem is access to information and its management. Government databases are often poor, out of date or badly managed meaning the FM/AM information, including sometimes basic plans, can often be lacking". With existing buildings the "key question is for which buildings should a BIM model be considered, what level of information is required, at what cost and what will the benefits for the investment be". With respect to the government the view was; "There is no way they will intrusively survey stock and for some buildings, especially the older ones coming to end of

their life. For those it is not worth the money to create a BIM model". "Essentially the main barriers to BIM in my view will be proving the business case and time required for a BIM".

3) FM and real estate expert (UK): When asked about working with BIM; "At first there were no BIM guidelines; we had to learn by doing". The main reason they invested in BIM was "better and quicker access to more reliable information about assets with the ability to make better decisions about how we manage and maintain those assets and the possibility to measure the outcomes". When asked what they see as the benefits of BIM to FM; "the main benefit is around transparency and efficiency, specifically with respect to FM staff time, not making wasted journeys, better planning etc." From a business perspective; "Our FM division is focused on managing portfolios of assets for our customers. We often find the level of their existing FM information is very poor and as such we see BIM as important as we believe in will allow us a competitive advantage if we can offer a better service to our clients, showing them how their assets can be better managed". When asked about the main lessons learned when setting up a BIM; "don't model everything. You need to think through carefully what level of data you want to model and make sure you have standard naming conventions and use the same convention in your CAFM for ease of data exchange and transfer". Another key area where they have spent a lot of time is "making sure that the data from the BIM can be imported to the CAFM system where we use if for daily FM tasks and likewise that is has the 2 way capability to be moved back to the BIM, it is crucially important that the data is to be kept up to date".

4) TEC engineering expert: (Switzerland): There is "no current in-house BIM experience" and so they decided to "use the BIM process for upcoming new construction projects and are seriously considering BIM for existing buildings". They have good experience with their existing FM IT-Tools (CAFM) and "expect lots of opportunities from BIM in FM". For example they feel "enriched 3D building models will help with strategic decisions regarding how they manage buildings if they change their management approach towards their assets". They have considered "this could be done by different types of simulations and optimization-tools but they would like to see the BIM processes as a key tool to help improve coordination of stakeholders in their projects". To them a key advantage was to have "a detailed history-data-set of each building should be the basis of an integrated BIM software solution". The central question raised was "we will decide about BIM for existing buildings based on the cost-value ratio. The ratio has to be balanced at least, taking this and with all the expected

non-monetary benefits it would be something we would look to adopt". The expert would like the "BIM industry and research institutions to investigate costs and benefits of BIM for existing buildings in order to push this important BIM issue".

5) M&E architectural professional (Switzerland): They see "great potential in the use of BIM for issues such as quantity take-off, clash detection and avoidance etc." "BIM is an excellent tool for coordination and visualization allowing better decisions to be made better but only if everything is clear". "We also use the models for energy, thermal light, smoke, fire evacuation simulations and so on, however unfortunately not in the same software tool". The lack of compatibility "requires the BIM building geometry to be rebuilt because of the various software platforms". With respect to FM they feel "the FM industry needs to define its needs and specifications and think about interoperability between the BIM models and existing FM systems as the difficulty is to keep the virtual model up to date". "I think in the future, digital recordings of existing projects will become more important. In the future planning using BIM will become a very significant tool for renovation projects". "If the information content in the virtual and real buildings is consistent, a variety of benefits can be generated e.g. managing life cycle costs for components, risk assessments, etc." For us "energy and lighting simulations are at the forefront of today's applications. We can imagine that buildings in the future can be much better reviewed, and even the movement of goods and people flow can be simulated digitally".

6) Modelling and simulation expert (Switzerland): When asked what the key issues in modelling and simulation are; "knowing what you want to model and having a model that fits the simulation, or is adequate for the simulation". It is "important to understand simulations are just simulations of reality. They need to be achievable relatively quickly and to an acceptable level of accuracy at the right price". In some cases e.g. energy simulations the model doesn't have to be millimetre accurate but most be "closed" in a spatial sense. This is vital to allow the simulation software to work". "In the energy example once I have the basic geometry of a building established then I have to gather as much data as I can to feed into the model from the FM team". He has "options in the Design-build software where I can input data regarding wall thicknesses, materials, occupancy, and heat loads etc. I then play with variables and compare the result to actual energy bills to establish a model that has an acceptable level of accuracy to real life energy use". "Then and only then can I start playing with the building to see the effects of changing lights to LEDs or the façade etc.". "People are often surprised to hear for example that insulating the building may not be effective due to

rebound effects at different times of year, as less energy for heating can mean more for cooling".

7) Senior project manager at the BIM Academy (UK): "Our main focus is on putting clients in the right strategic position with respect to BIM, asset management and FM to get better value out of their assets". When asked about client issue with BIM; "We find the main issue is many clients are not educated about BIM and their role and responsibilities with respect to the RIBA Plan of Works etc." When asked about BIM for new-build and existing buildings; "We are getting more and more enquiries for existing estates and also how clients can marry together BIM requirements for portfolios of new and existing buildings. "BIM for new-builds will, like CDM, become something we do on a day-to-day basis as part of the job". "The role of BIM consultancy for existing buildings has a longer shelf life, as clients struggle to catch up with how they manage and implement BIM for these buildings and understanding what is the ROI". From a management perspective "data standards, naming conventions and structure are so important. These are critical to allow seamless and accurate updating of databases. When it comes to scanning and BIM models there is "limited opportunities to automate the scan to BIM model process due to a whole array of issues such as line of sights, dealing with voids (missed scan areas) etc.". As technology gets better we are seeing the use of smaller portable self-registering scanners (e.g. CSIRO, Zebedee system using robotic technology called Simultaneous Localisation and Mapping (SLAM).) good for internal spaces, the key is to use the laser scanners appropriately". People need to understand that the management of a building does not change. The most up to date should stay in the FM operating system; people will just use BIM as an enabler for better visualisation, workflows etc. It's about improving how you manage the building and buying into that". "For existing assets, BIM models can be simple spatial models of the building with a fairly low level of information, the rest of the information can stay in in the FM operating system (CAFM etc.)".

The 3D laser scanning of ZHAW buildings: allowed the authors an opportunity to explore the scanning process for existing buildings from a practical FM perspective. A "FARO Focus X330 scanner" was used with five control network 139mm reference spheres to allow a common coordinate frame. The use of the spheres was found to be inefficient (especially for indoor scanning) as for each scan considerable thought one has to be put into being able to see 3 spheres from a previous (This is required to link scans). This causes issues with respect to

"line of site" and linking spheres when going through doorways etc. The authors subsequently would suggest considering alternative methods for indoor scanning. The testing helped establish the time needed and the main issues; required accuracy, data acquisition, environmental and light conditions and software processing and registration of the point cloud data, filtering, classification (feature extraction/object recognition) etc. The scans were coordinated relative to each other without any geo-referencing. If the process is to be commercially viable a key factor was to understand how much time is needed for each of the process steps. To do this it is critical to establish how many scans are required and at what resolution and level of quality in order to be able to build an accurate 3D virtual representation of the building. This allows a calculation to be made of the time needed to complete the scan process. Based on supplier's advice and testing in the field approximately 25 minutes was calculated per scan; 18 minutes for actual scanning with an average logistics and set up time of 7 minutes per scan. Significant time also needs to be allowed for processing the data (which varies depending on the file size and number of scans). Experience showed this can be a slow process and prone to error.

5. Conclusion and recommendations

The practical experience gained through the two laser scanning exercises helped the authors understand the advantages and limitations of laser scanning. It became clear through discussions that scanning is a very important tool for allowing accurate measurements for modelling. In terms of the overall time to create a good model with adequate FM/AM information, the scanning element is small and as such should be considered money well spent. Clients need to have the end in mind when they consider how to create models which are accurate and have the right level of FM/AM information attached. To be commercially viable a business case should be put in place taking into account key issues such as; resources and the technology, software and computing power required which can be expensive and require significant effort to become familiar with. Clients may wish to use a third party as the time and investment cost can be significant. Specialist suppliers will be familiar with the data formats and standards and will be able to help clients' clarify their needs. Clients also need to consider how they will use and view BIM models. They may wish to invest in BIM viewer software to avoid having to purchase and maintain costly equipment and full versions of software (BSi, 2013). Increases in 3D laser scanning technology will inevitably mean cheaper scans and potentially more options in the future. The architectural interviewee experts reported a notable increase in clients wanting BIM models for existing buildings believing

they will constitute the larger market share for BIM in the future. Although it was not possible for the Authors within the time frame to actually build their own BIM Model (This is the next step) the experience gained and interviews indicate that the BIM process will offer clients and FMs many benefits. The process to automate 2D drawings from scanned data seems to have some way to go before this is possible and to get an accurate model still requires checking in the field by competent and qualified experts. The Authors believe as scanning technology develops indoor scanning will improve and so automation may become easier. It is clear communication is key and that more education is needed about BIM across all stakeholders with better case study history, especially with respect to ROI and the range of benefits for FM from scanning and BIM. Once this becomes established and driven by the government's initiative BIM will become the norm for the FM and AM industry.

Bibliography

Azhar, S., & Hein, M. a. (2011). Building Information Modelling (BIM): Benefits, Risks and Challenges. Auburn, Alabama, US: Auburn University.

Bazjanac, V. (2004). Virtual building environments (VBE) - Applying information modelling to buildings. Berkeley, California, USA: Lawrence Berkeley National Laboratory.

BIM Task Group. (4. August 2014). BIM Task Group . Abgerufen am 4. August 2014 von http://www.bimtaskgroup.org

BIM4FM. (2013). BIM4FM Overview of Survey Results. London: BIM4FM.

BSi. (2013). PAS 1192-2: Specification for information management for the capital/delivery phase of construction projects using BIM. London: BSi Standards Limited.

BSi. (2014). BS 1192-4: Collaborative Production of Information: fulfilling employers information exchange using COBie - Code of Practice. London: BSi.

BSi. (2014). PAS 1192-3: Specification for information management for the operational phase of assets using BIM. British Standards Institute. London: BSi

BuildingSMART. (2010). constructing the business case: Building information modelling. London: BSi.

Detail. (2012). Detail: Das Architekturalportal. (GmbH & Co. KG) Abgerufen am 14. July 2014 von http://www.detail.de/research/forschung-entwicklung/bim-bam-boom-das-building-smart-forum-in-berlin-020172.html

HM Government. (2012). Industrial strategy: government and industry in partnership: Building Information Modelling. London, England: Crown Copyright.

HM Government. (July 2013). Industrial Strategy: government and industry in partnership: Construction 2025. London, England: Crown copyright 2013.

Kelly, G., Serginson, M., & Lockley, S. (October 2013). BIM for FM: A review and a Case Study Investigating the Value and Challenges. Proceedings of the 13th International Conference on Construction Applications of Virtual Reality. London.

Kiviniemi, A. (6. June 2013). Abgerufen am 20. July 2014

May, M. a. (2012). The FM Guide to Information Technology. Lexington: IMFA.

NBS. (2014). NBS National BIM Report 2014. London: RIBA Enterprises Ltd.

Oltmanns. (2013). BOOM, Building Operation and Optimization. Von http://www.tekla.com/de/bim-forum-2013/presentations/oltmanns.pdf abgerufen

Randall, T. (2013). Client Guide to 3D Scanning and Data Capture: BIM Task Group.

RIBA Plan of Works 2013. (2013). RIBA Plan of Works 2013. London, England: RIBA.

Thomson, C., Apostolopoulos, D., Backes, D., & Boehm, J. (11-13. November 2013). Mobile Laser Scanning for Indoor Modelling. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

Trebilcock, P. (1. July 2014). Building.co.uk. Abgerufen am 4. August 2014 von Building.co.uk: http://www.building.co.uk/communities/construction/bim/no-pain-no-gain-in-bim/5069439.article