

Bridging the lifecycle: A case study on facility management infrastructures and uses of BIM

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Abstract

Purpose – The purpose of the paper is to study conditions of BIM implementation in facility management specifically from the point of view of different groups of FM practitioners, and the facility management infrastructures already in use.

Design/methodology/approach – A literature review is done of the gap between the uses BIM in design, and in facility management. The key professional groups of facility management in the Premises Centre of the City of Helsinki were interviewed on the information tools they use, and the needs and impediments of BIM implementation in the FM. Cultural historical activity theory is used as a theoretical framework.

Findings – The literature discussing the BIM implementation tends to omit the analysis of the existing facility management information systems and software tools in use. The challenge in the BIM implementation is in which ways the relevant information included in BIM models could be integrated with these systems. No well-articulated problems or developmental contradictions came up that would demand the investment in the BIM implementation.

Practical implications – The results call for experimenting with incremental implementation of BIM in different FM activities and in the FM information infrastructures in use.

Originality/value – The paper studies empirically different facility management activities and information systems used by them. Such studies are needed for a realistic view of the potential integration of the BIM information to FM information systems.

Keywords Building information modeling, facility management activities, facility management information systems, activity theory, integration of BIM and FM information systems, life cycle

Paper Type Research paper

Introduction: Approaches to implementing BIM in facility management

Building Information Modelling (BIM) is defined as an approach that involves applying and maintaining an integral digital representation of all data over the lifecycle of a building (e.g. Gu and London, 2010; Shen *et al.*, 2010; Miettinen and Paavola, 2014). Since most lifecycle costs are spent in facility management (Lewis, Riley and Elmualim, 2010), the implementation of BIM in facility management (FM) and maintenance is seen to be essential.

Simultaneously with this vision, the existing literature acknowledges an information gap on BIM use, from the design and construction stages to FM and operations. Owners are reluctant to implement BIM (Bosch, Volker and Koutamanis, 2015, p. 332), the uses of BIM in FM are in their infancy (Eastman, Teicholz, Sacks and Liston, 2011, p. 170), the implementation of BIM in FM processes is 'limited to an experimental scale' (Codinhoto and Kiviniemi, 2014, p. 1), and there is a 'lack of real-world cases and proof of positive return to investment' (Becerik-Gerber, Jazizadeh, Li and Calis, 2011, p. 438). The lack of evidence of the benefits of BIM in the operational stage 'generates scepticism within managers' (Codinhoto and Kiviniemi, 2014, p. 9). A literature review summarizes (Volk, Stengel and Schultmann, 2014, p. 122): 'Facility managers, owners of existing buildings, deconstructors and consultants are scarcely using BIM and are not fully integrated in BIM development and implementation yet.'

Initiatives towards bridging the gap have been taken by national governments (e.g. the UK government's BIM initiative), industry associations and BuildingSMART International by creating standards for information handover from design and construction to facility management (East *et al.*, 2013). The most important of these, COBie, not only defines the form and contents of the information included in the handover data, but also provides a model for data handover, defining a series of predetermined information exchange or 'data drops' that are required in the process (Alwan and Gledson, 2014).

Consequently, the study and development of models and tools for the handover process has become an important framework in making sense of the implementation of BIM in FM. Love *et al.* (2013 and 2014) have developed a

framework for assessing a benefit realization of BIM implementation in FM based on a resource-based theory of a firm. Whyte and Donaldson (2014) analyse the contractual conditions of digital-model data distribution, and Olatunji and Akanmu (2015) the legal implications of using digital models across different life cycle stages. Whyte, Lindkvist and Jaradat (2016) studied the handover in the London Olympic Game projects in the spring of 2011. The focus was in improving delivery practices. The analysis, however, did not extend to the use of data handed over to the operation and FM practitioners (*ibid.*, 13).

The studies on BIM in FM have thus far primarily produced conceptual models and frameworks validated by interviewing BIM and FM specialists (e.g. Motawa and Almarshad, 2012; Wang, Wang, Wang, Yung and Jun, 2013). Wang *et al.* (2013) provide a conceptual framework of how FM managers could be involved into the design phase. These models and frameworks have mainly adopted a managerial view: the alleged agent in FM tends to be an asset manager or an owner. For example, Becerik-Gerber *et al.* (2011, p. 439) call for a 'visionary owner that could lead and guide the process from the beginnings to end' and which 'should have enough resources and time to investigate the possible benefits, and to provide training to project stakeholders and their personnel'. Few studies have been done on the work and needs of different groups of FM practitioners (Lee and Akin, 2009; Korpela, Miettinen, Salmikivi and Ihalainen, 2015). Reliable accounts are lacking of authentic BIM use in FM activities or even real-life experiments of implementation (Becerik-Gerber *et al.*, 2011; Miettinen and Paavola, 2014).

Anderson, Marsters, Dossick and Neff (2012) report an experiment in which COBie-BIM data was created and used in the Facilities Services of the University of Washington (Anderson *et al.*, 2012). The experiment did not attempt to create a BIM-based facility management system. The university facility management units had created their own 'hybrid' systems for collecting and managing data. The project was about distributing BIM COBie data 'across the owner's distributed information technology infrastructure'. Information was transferred to the 'software systems that people are already using' (p. 689). The authors state (Anderson *et al.*, 2012, 693):

In contrast to current BIM theories, where design and construction models coalesce into one operations BIM, what is striking (...) is how information from design and construction process is disaggregated and distributed across the operational functions such as Fire Alarm, Plumbing, and Controls and fans out into a wider spectrum of distributed databases than either of the previous two phases of design and construction.

An IT solution tailored to meet different divisional requirements creates 'a tension with a merely centralized solution that the COBie BIM suggests' (ibid). The authors conclude that the idea of a single central BIM 'is 'an ideological pitfall', that, being unwieldy, will remain unrealized'. According to them, the emerging BIM paradigm is 'a distributed model' in which effort and input from each group (division) in the owner's organization is needed (Anderson *et al.*, 2012, p. 695).

Arayci, Y., Onyenobi, T. and Egbu (2012, p. 59) suggest that BIM should prove itself more beneficial for FM than the computer-aided facility management systems presently in use. By interviewing IT and FM specialists they vision in which way BIM can support various FM tasks. They provide a vision of BIM potentialities on the FM task level. However, the paper does not address in which way BIM models created in design can be integrated to the existing computer-aided FM systems.

Solutions have also been sought for specific maintenance activities, such as the completion of work orders related to target equipment (Lee and Akin, 2009; Korpela *et al.*, 2015) and the development of solutions based on augmented reality (Lee and Akin, 2011; Koch, Neges, König and Abramovici, 2014). Such new technologies will be, without doubt, a part of future FM information systems.

The article contributes to the ongoing discussion by examining how different groups of professionals working in the Premises Centre of the City of Helsinki interpret why, whether and in which ways BIM knowledge produced in design and construction could be used with the existing FM information systems in use in the Premises Centre. First, it asks what information tools the different groups of FM practitioners use and what challenges they see in these tools' development

and integration. Secondly, it describes how these different groups were using BIM, and how they saw challenges and potentialities of uses of BIM.

The theoretical approach of the study

The theoretical framework of this paper is cultural-historical activity theory (Leont'ev, 1978; Engeström, Miettinen and Punakivi, 1999). Its main concepts are object-orientedness and the cultural mediation of activity. The object of an activity and the use value to be created is the motive of the activity and defines the activity. It is the 'why' of an activity and a horizon for practical actions. An activity is always mediated by cultural means, signs and tools that form systems of instrumentalities characteristic to that specific activity.

We utilize this framework in three ways. First, we use it to disassemble the abstraction 'owner' or 'facility manager' frequently used in the literature by analysing the various activities of the Premises Centre of the City of Helsinki. Each of these activities has a specific object and outcome, such as the preparation of project plans for the decision making of the city council, the coordination of the design and construction of projects, or the preparation of the rental contracts for city services and maintenance (see Figure 1). They have therefore different information needs, and the practitioners involved in them use information systems in different ways.

Second, according to the principle of *mediation*, human activity is always mediated by a historically developed system of instrumentalities, that is, sets of conceptual, informational and practical tools (Vygotsky, 1978; Engeström, 2007). Since the BIM data is alleged to be integrated into the FM information systems in use, knowledge of the specificity of these systems and of the infrastructure they comprise is needed. In the BIM literature these systems are often defined on an abstract level, as system types such as the Integrated Workplace Management System, the Energy Management System or the Building Automation System. Such a treatment neglects the specificity of the FM information systems in use, the development work done to adapt them to meet local needs and the measures

taken to configure and integrate them into a workable infrastructure (see Figure 1).

In activity theory, internal developmental contradictions of activity drive change in that activity and are regarded as a central motive force of development (Engeström, 2015). Characteristically, they develop between the elements of the activity: subjects, the object of activity, mediating instruments, rules and the division of labour. When a new tool is introduced in an activity, a tension emerges between its use and the prevailing division of labour, social procedures and rules. The whole institutional structure of FM activities (the division of labour, contracts, the system of tools, the expertise of the practitioners) has evolved independently of BIM, which was historically introduced in the construction industry as an instrumentality of design and construction. The BIM literature has discussed this in terms of 'social and institutional obstacles inhibiting the implementation of BIM' (Volk *et al.*, 2014, p. 122). The terms barrier, obstacle and even bottleneck adopt an 'external' viewpoint of introducing BIM into FM activities. This viewpoint is legitimate. However, having a promotional nature (Nelkin, 1994; Van Lente and Rip, 1998) it risks ignoring the realities of the FM practitioners (Miettinen and Paavola, 2014).

Activity theory's idea of internal contradictions looks, instead, at the dynamic forces for implementation inside the FM activities. It underlines the viewpoint of users asking which developmental contradictions or challenges in FM activities would call for the adoption of BIM. Accounts of the barriers of implementing BIM in FM refer to such internal dynamics. The two most important barriers identified in a study by Becerik-Gerber *et al.* (2011, p. 434) are 'unclear and invalidated benefits of BIM in ongoing FM practices' and the 'amount of work that needs to be done to define the specific FM needs for which the model is necessary and how that model may need to be prepared to meet the needs.' We apply the activity theoretical idea of internal developmental contradiction by asking in the interviews whether the FM practitioners find in their work any such major challenges or problems which would call for the implementation of BIM.

The Premises Centre and its information infrastructure

The City of Helsinki is one of the largest real estate owners in Finland. It owns over sixty percent of the land area of Helsinki, equalling a total of 132 square kilometres. The Real Estate Department of the City leases, sells and develops the land areas and buildings owned by the City of Helsinki. The total value of the properties reaches approximately 5.2 billion euros. The Department also takes care of assigning city-owned rental housing, cartography tasks, geographical information services and expert services related to the constructability of soil. The Premises Centre is responsible for the development and maintenance of the city's service facilities and properties. It has approximately 200 permanent employees and is divided into four core units with specialized responsibilities:

1) The *Customerships* unit is responsible for the leasing, selling and buying of premises. 2) The *Investment* unit is responsible project plan preparation, currently including 700 active new build and refurbishment projects. 3) The *Premises* unit is responsible for executing the new build and refurbishment projects and managing the maintenance including property management, annual repair projects, user services, archiving, and property lifecycle expert tasks. 4) The *Administration* unit is responsible for financial administration, data management, customer services and legal matters.

In establishing the Premises Centre in 2005, the information infrastructure of the Premises Centre was developed. It is presented in Figure 1.

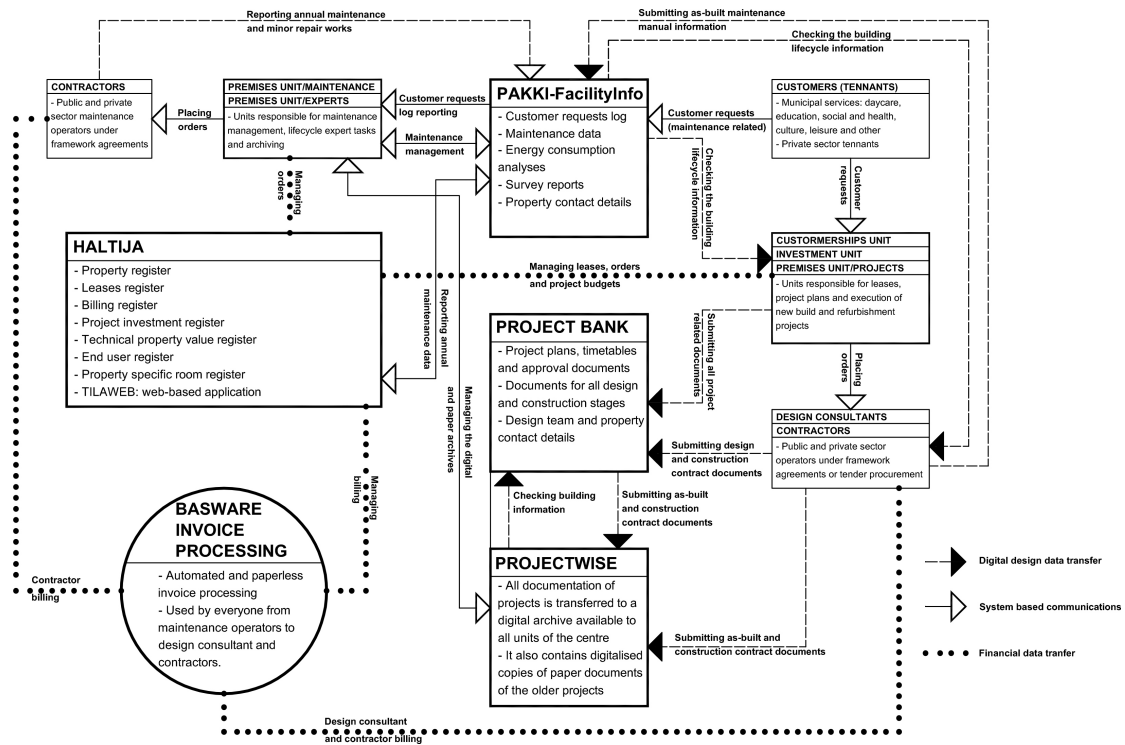


Figure 1. The information infrastructure of the Premises Centre

The Real Estate Assets Management System Haltia (by Miragel Oy) is the main application in the Premises Centre. It provides the maintenance of the property register, the leases register, the lease billing register, the project investment register, the technical property value register, the end user register and the property-specific room register. The user-friendly simplified version of the system, **Tilaweb**, was developed in the Premises Centre.

PAKKI-FacilityInfo (by Buildercom) is a web-based service system for building maintenance, and it is tailored for the Premises Centre. This application monitors and compiles all the data in relation to building-specific maintenance operations, from customer requests to energy consumption analyses and survey reports.

Project Bank (by Buildercom): All the project information (models, drawings, scanned documents, etc.) is saved in principle in the project-specific project bank. After completion, the information is transferred to an archive named **Projectwise** (by Bentley).

BIP – Basware Invoice Processing (by Basware) is an automated invoice processing system used by the City of Helsinki that enables paperless invoicing. All units dealing with procurement, consultants and contractors use this system on a daily basis.

The FM information infrastructure is constantly being developed. Presently, PAKKI-Facility Info and Project Bank are being linked together into a **BEM-Built Environment Management** platform. This makes it possible to view a specific property with all its related past and future projects at one glance.

For the costliest projects, the Premises Centre provides instructions for the use of BIM in the design stage and appoints a specialized BIM coordinator for the project. In the construction stage, the use of BIM is subject to the appointed contractor's abilities. In general, all large Finnish construction companies are experienced in using BIM, but smaller companies are only starting to learn BIM technology. As a result, a fair amount of projects do not utilize BIM after the design stage (at the construction site and in the maintenance).

Data and methods

The main data of the study is comprised of interviews of personnel in each core activity within the Premises Centre (see Table 1). According to the results of the previous group interviews of the research project, only a few employees used BIM in their daily work. Based on previous knowledge of the Centre and with the help of a knowledgeable informant, representatives of each of the core activities were selected as interviewees. To understand the activity of the main groups of the practitioners, we made a distinction between six activities on the basis of their object of work. Although the number of interviewees is small, they represent the main activities within the Premises Centre.

Table 1 The activities of the Premises Centre and the number of interviewees representing these activities (interviewees are referred in the text as Interviewee (I) 1-11 in random order)¹

Activity within the Premises Centre	Object and main content of the work	Number of interviewees
1. Project planning and preparation	Preparing the project plans and budgets for new build and refurbishment projects for the decision making of the city council	2
2. Pre-construction and construction supervision	Coordinating and quality controlling of the detail design, tender and construction stages of the new build and refurbishment projects	3
3. Internal and external renting	Providing premises for city services, preparing rental contracts and defining the level of the rent	1
4. Maintenance	Taking care of minor repairs and maintenance, supervising technical systems	1
5. Archives	Organizing the preservation and availability of all project documents	1
6. System development	Developing the FM and maintenance systems and their integration	3
Total		11

The method of interviewing was open-ended, comprising general themes derived from the theoretical framework and interview themes (Fontana and Frey, 2000). The interview outline included four themes founded on the theoretical framework and previous research: 1) the object and content of the work, 2) the information systems tools and the sources of information they use in their work, 3) the problems, challenges and developmental potentialities that arise in the use of these means, and 4) the possibility of implementing BIM in FM. The three authors of this paper conducted the interviews. The process of interviewing was based on the interaction between the interviewees and

researchers, meaning that an interviewee could also raise the themes (Rapley, 2004). The interviews were transcribed. The method of analysis was 'theoretical' thematic analysis (Braun and Clark, 2008), derived from our theoretical framework and interview themes. The statements of the interviewees concerning the themes were identified and classified into categories.

As a part of the interviews, the interviewees were also asked to demonstrate on their computer display how they use the information systems. In addition, key documents were collected. Among these are, for example, the instructions for the designers and subcontractors for making final images of the maintenance system and the instructions for users of the PAKKI system.

A question is to what extent the findings from the Premises Centre can be generalized. The centre clearly represents a large-scale public owner with a mandate to provide day-care, education, healthcare, a library and services for the elderly. In addition, it has collaborated with another big Finnish real estate owner, Senate Properties, a government-owned enterprise under the Finnish ministry of Finance, which compiled the Common BIM Requirements for Finland (2012). The findings therefore well characterize the situation of public asset owners in European countries, in which the government has not regulated the implementation of BIM.

The FM maintenance activities and the information systems tools they use

This chapter describes in which way the different groups of FM practitioners use FM information systems. First, the uses of the four main FM systems of the Premises Centre (Haltia, PAKKI, Project Bank, BIP) are analyzed. In addition, what other, external information systems and sources they used, and what information tools the practitioners have themselves developed, are told.

1) The *project managers* used all the four systems of the centre: Haltia to chart the number of buildings and projects, and Project Bank to collect all the existing information and design documents of a project. PAKKI was mainly used in

refurbishment projects. In addition, the project managers used several other 'external municipal' information systems.² provides information on previous building permits. *Paikkatietovipunen*³ provides maps, aerial photography, plans and real estate information. *AHJO* is a municipal information management system enabling the project plan to be prepared directly in the system for the City's decision making.

2) The *project supervisors* used Haltia to place orders and monitor the cost development of a project. All of them used BIP for invoice processing. Project Bank was used for storing all design information during a building project. One of the supervisors also used Paikkatietovipunen to search for information on city premises, and the electrical project supervisor used TilaWeb to search for information about previous building refurbishments.

3) The *supervisor of customer services* used Haltia in the calculation of a building's technical value and TilaWeb to carry out quick information searches about premises, PAKKI to search for information about a range of characteristics of a building and Paikkatietovipunen to chart areal plans and the ownership of premises. He had created an Excel list of potential premises for temporary relocation available for tenants during refurbishment projects, and a specific Excel list program for the calculation of rents.

4) The most important tool of the *operations engineer* was PAKKI-facilityInfo. He used it to follow-up of services, communication with maintenance men and the reception of service requests from the users of premises. He also used the location floor plans of PAKKI to locate, for example, water damages. He used Haltia for orders, rental agreements and maintenance responsibility tables, and the Project Bank for monitoring the proceedings of a design process whenever he had time. He considered it, in principle, important to comment on design proposals: 'It is a duty of maintenance to give his views in the design stage, but he rarely has sufficient time for it' (I 7).

5) The main tool of the responsible *archivist* was ProjectWise, in which project information is saved, for instance, for completed new building and refurbishment projects. The designers and contractor were expected to submit

the information directly to ProjectWise, but many of them still used 'old' means such as a CD-Rom. In those cases, the archivist fed the information by hand into ProjectWise. Information needed for building permits can also be retrieved from Facta, a municipal register of Helsinki. The archivist had also created Excel lists to make searches of project documentation more fluent.

6) The *system specialists* are developers of the systems used at the Premises Centre. The development engineer had defined with practitioners 500 standard maintenance measures and standard service packages for different kinds of spaces (day-cares, schools, etc.). These standard packages were used in preparing the maintenance contracts. The IT specialist was engaged in creating links between PAKKI, the Project Bank and Haltia. The main user of Haltia was responsible for the maintenance of the premises register. He removed the information of sold or demolished premises from the active register. He entered the information on purchased and rented premises from other facility owners in the register. He used *Facta* for information searches about building permits, and he retrieved information from *Paikkatietovipunen* and transferred it to Haltia by hand. The IT Specialist has developed the widely used TilaWeb.

In summary, the professionals representing different activities used a variety of functions of the information systems of the Premises Centre in different ways and for different purposes. They have, consequently, different information needs. In addition, the different activities require uses of external information tools. Project managers used widely official municipality information systems. The HVAC project supervisor used an iPad to look at the BIM models and other project information. The maintenance personnel mainly used the functions of the PAKKI system.

Uses, challenges and potentialities of BIM in the Premises Centre

Different groups of practitioners at the Premises Centre had different experience and familiarity on BIM. No one of these groups had a strong familiarity with the BIM use in their own work. Besides their own uses we asked on their

conceptions of challenges and potentialities on BIM. We analysed their account concerning 1) their uses of BIM, 2) what kind of barriers, challenges or worries they mentioned concerning BIM, and 3) what kind of future visions they had on BIM.

The uses of BIM mentioned by the interviewees were grouped into four main categories:

1) *3D laser scanning* is used in bigger refurbishment projects by the Premises Centre. It is not yet actual building information modelling, but it can be used as a basis for making building information models; thus, it was categorized as a part of the discussion on the uses of BIM.

2) *Project managers (pre-construction and construction management) used BIM to control and supervise construction projects.* One of the project managers interviewed had observed that BIM was increasingly being used in design work. He did not modify BIM models himself, but he considered BIM important in checking for clashes between different design disciplines. 'I have seen them used in coordination and planning meetings' (I 5). Other interviewees also explained that BIM is important for the design stage and at the construction site.

3) *The electrical and HVAC supervisors were experimenting with the use of IFC models with iPads.* They were quite satisfied with the trial, even when they had technical problems. They were able to make observations at the construction site without many paper document files and to use BIM models to print screen shots to make notes on them.

4) *BIM model archiving.* The Premises Centre had had a project where they started to archive BIM models of previous projects led by the Premises Centre where BIM had been used. It was not yet clear how and for what purposes these models would be used in the future.

The level of familiarity with BIM was different in different groups of practitioners. Project managers who collaborated with designers regularly saw the use of BIM models in projects even though they were not using BIM themselves. They did not even have any BIM software of their own. System developers knew about BIM although their own work focused on development of FM information infrastructures. The supervisor of customer services made it

clear that he did not have any clear ideas at the moment on the BIM uses in his own work. The maintenance engineer had heard on developmental ideas about BIM in a BIM course but did not see any use of it in his own work. He found important to utilize better the underused functions of the PAKKI FacilityInfo.

Table 2. Barriers, challenges and worries mentioned concerning BIM (with the number of statements related to each)

Barriers to, challenges for and worries about BIM	Number of statements
1. Not clear what extra value BIM provides compared to existing tools or how BIM models are to be used	13
2. Not enough knowledge on BIM or time or resources to acquaint oneself with BIM	10
3. No resources for updating information including the BIM models	7
4. Technical limitations of the BIM tools	7
5. Availability of the BIM viewer software	4
6. The design stage not informed of the needs for maintenance	1
7. 'As built' target buildings/projects in the Premises Centre not prioritized	1

The interviewees were in general favourable to BIM and saw it as a part of the future of maintenance. On the other hand, they often said that they saw no extra benefits from BIM at the moment for their own work, and that they did not know enough on the subject to comment on this (category 1 in Table 2). An IT expert summarized the situation on the linkages of their own work to BIM: 'At the moment quite little, I would say. It interests us, yes perhaps, but it is here still a bit of a distant matter' (I 9).

Several of the interviewees mentioned that they did not know enough about BIM and that they did not have enough time to start learning it (category 2). The development is in the early stages. The maintenance people said that a central problem is how to update any changes to the BIM models (category 3). The model is not useful if information essential for maintenance is not updated. There should be resources and systems for this. 'Then we come across the most difficult issue: with what resources is the BIM model maintained in order to get information out of them also in the future? The traffic back to the models is quite hard' (I 10). A project manager expressed: 'It is the same whether we have the information in a folder or in a BIM model, somebody should update them when changes take place. This is the problem here in the maintenance' (I 7).

Remarks on the technical limitations of BIM (category 4) especially concerned the iPad trial. One interviewee mentioned that it would be nice to add notes to the program used with the iPad (which was not yet technically possible). Slow Internet connections were also causing problems. The Premises Centre had previously had another trial project where the aim had been to develop a maintenance model, but the software had been cumbersome, and its development was not completed. One concern was how to ensure that files are usable in the future (after 15 or 20 years). A related concern was that many BIM models created with different software might mean that the Premises Centre should have a plethora of BIM software programs available.

Three interviewees mentioned that they could not open BIM models themselves because they did not have the viewer software to do so (category 5). This was

not an urgent need, as they said that they were not yet sure for what purposes they would need to use BIM models.

One interviewee who had participated in the development projects on BIM and maintenance commented that those involved in the design stage should be instructed to take into account information needs in maintenance (category 6). The same person also said that there should be trial projects where things were done while taking maintenance needs into account (category 7).

The interviewees were asked about their opinions and visions of the possible future uses of BIM. The opinions were scant and rather abstract. They can be divided into four groups:

1) *BIM models would be updated and easily available* (4 statements). A main concern was that BIM models would provide an as-built model of the building. An additional vision was that the information on any variation and alteration work would be available, for example, for making invoices.

2) *The model should have different levels and be easily used (and updated) by different kinds of users* (3 statements). The interviewees were asked whether a simplified version of BIM models would be needed for different purposes. One of the interviewees had heard of a type of simplified version in a BIM course he had attended. 'Somebody developed there an idea of a lighter BIM model for maintenance in which the equipment and structures are presented at a rough level. When you select one of them, it will look at more detailed information from another program. Something like that would be sensible' (I 7).

3) *The use of visual illustrations and the possibility to locate details with the models*. One interviewee mentioned that it would be nice to demonstrate things from the 3D model in meetings meant for residents. Two people commented on the potential illustrative nature of showing details from the models to contractors. Three persons mentioned the potential to locate details with the BIM models. The IT developer commented more generally, 'Previously, we have only had numerical data somewhere in our Haltia system, so that bit by bit we will change to having places on the map, so that here we have our targets' (I 9).

4) *Suggestions for special applications and specific information needs.* Two interviewees were interested in an application (they had heard of/seen a test version of it) which uses picture recognition technology based on a digital photograph taken at a specific location to find information on the structures and HVAC machines related to that particular place. Various scattered but concrete suggestions gave ideas for potentially useful information from the models, such as surface materials, rainwater outlets within structures, plans for demolition and information on electric motors.

The interviewees were also asked about the linkages of BIM to FM information systems. Many of the interviewees commented that they see BIM to be more and more important in the future, even though they themselves did not know enough about it or its benefits. One interviewee said that BIM models of nationally important buildings (such as Finlandia Hall in Helsinki) and their different phases could be seen as a part of the national cultural heritage.

Discussion: Motives of BIM implementation and FM information infrastructures

Based on the activity theoretical idea of internal developmental contradictions as a driver of change, we asked whether the FM practitioners find in their work any such major challenges or problems which would call for the implementation of BIM. In the interviews, no well-articulated major problems arose which would have demanded implementation. Instead, a major concern was the further development and integration of facility management information systems. In activity theoretical terms, it can be concluded that the contradiction within the FIM activity was not critical enough to call for definite measures to implement BIM. The subjects of that study recognized the potential of BIM as a future technology, but it was difficult for them to specify how BIM could be used in a way that would be useful in their ongoing practice. A governmental decision may be needed to speed up the implementation process.

The FM practitioners interviewed had a limited familiarity of BIM in their own work. That is why they were unable to present well-informed views about the future potentiality of BIM. This however, is an essential part of a problem of the BIM implementation in FM. The provision of more knowledge on BIM is not a sufficient basis for motivating BIM implementation. Our interview results repeated what has been found in the interviews of FM practitioners. The motivation is related to the added value of BIM in relation to the existing FIM information tools (see Table 2) or as Becerik-Gerber summarizes (2012, p. 434) "unclear and invalidated benefits of BIM in ongoing FM practices." The benefits cannot be defined or evaluated from the technical potentialities of BIM, from conceptual frameworks or from visions of future alone. They must be related to existing information systems in use.

The interviewees' ideas on the future needs and development of the information systems included a few specific needs, such as an electronic signature (mentioned by two interviewees), which is not possible with the existing systems. On the other hand, the interviews emphasized the same problems of FM which have been recognized by the literature: the laborious updating of systems and the frequent need to search for information from several systems. The most distinctive problem related to all the basic systems (Haltia, PAKKI, Project Bank) was the difficult and labour-intensive process of updating the systems, which has consequences for the reliability of information. 'If there is updated information in one system, has it been changed in other systems as well?' (I 4).

We have to tap extra work and variations in the orders [into the system]. This here [points at the computer screen], this is, in fact, if I remember it right, is a project budgeted over a million euros, it is over 63 lines [of text]. If we start to tap these in, it will take us forever. (I 5)

The most frequent comments were related to the integration of different systems and the wish to avoid overlapping manual work in the production of data.

It would also be [good] if one adds somewhere some information, for example, new information on renting agreements or areas of the building

or whatever, it would then be changed at the same time in all places that it is seen. (I 4)

The project of the Centre to integrate Haltia, PAKKI and Project Bank into BEM was an attempt to solve this problem. In summary, the interviewees saw realistically that BIM will be used in the future, but many of them did not yet foresee how it was connected to their work. The examples they were able to present were mostly related to specific uses, such as using the tablets in construction sites or utilizing laser scanning in renovation projects. Some foresaw that implementation will be a natural and gradual process that will take place through specific technological developments, increased standardization, a gradually rising number of modelled buildings and the better ICT and modelling competencies of the younger generation of employees.

Conclusions

On the basis of our results and our activity theoretical framework, the perspective for BIM implementation in FM can be characterized in two ways. First, the different groups of the practitioners and secondly from the point of view of the FM infrastructurers. The groups of practitioners are encountering BIM in different ways. The activities most connected to design and construction have also most experiences of the BIM uses. Project supervisors were using the BIM models with an iPad in an experiment. Being involved in project design, project managers were involved in making decisions concerning the uses of BIM, for instance, whether buildings are laser scanned in renovation projects. Without doubt this kind of BIM-related decision making will increase following the ongoing expansion in the implementation of BIM models and tools in design and construction. It can be regarded as a kind of an evolutionary, but only partial process of implementing BIM in FM. It seems, however, that the core FM activities, that is, renting and maintenance are using primarily the FM infrastructure tools, first of all the PAKKI-FacilityInfo. This raises the question of integrating BIM with the existing FM information infrastructures.

At the moment, however, the integration in the Premises Centre is mainly taking place within existing FM information infrastructures already in use (Figure 1). A systems developer implicitly compared the connection of the Project Bank and PAKKI-FacilityInfo to BIM: 'It [our program] is called BEM, to be different from BIM' (I 10). The findings support the view of Anderson *et al.* (2012), according to whom the issue is about distributing BIM data 'across the owner's distributed information technology infrastructure' and to the 'software systems that people are already using'. Different users need different information, and these needs must be embedded in the existing (or developing) information systems in use.

FM and maintenance information systems are an essential part of building information management, with their own functionalities and contents. A partial, stepwise integration based on selective communication between BIM and FM information infrastructures may be the way forward. If this is the case, BIM used over the lifecycle would alternatively be building information *management*, which covers the use of BIM models as well as the development of FM systems. Information created in the design stage is increasingly transferred to constitute a part of FM information infrastructures with FM-BIM systems and other information systems.

Some possible steps towards bringing BIM data into the FM systems used in the Premises Centre were taken up by the interviewees. In PAKKI a location system based on BIM and geolocation information could be integrated into or replace the present location floor plans and impact area plans used by the maintenance men in locating target objects and machineries. This step may become realized when new software technologies developed for that purpose come onto the market. Other subsystems of PAKKI, such as the service request system used by 5 000 persons in the City of Helsinki (including end users, the maintenance personnel of sub-contractors and the Premises Centre's professionals), will remain a central tool of maintenance independently of BIM. In the same way, the standard maintenance packages developed for PAKKI retain their value as a central tool of maintenance contracting, independent of the potential inclusion of BIM information into the system.

In Haltia BIM model data of areas would be useful in preparing the rental contracts. This can be realized without making changes to other parts of Haltia, such as the registers of digital documents. Such steps, however, are likely to be taken as elements of the development and integration of the FM systems exemplified by BEM.

The idea of BIM as a model and a database that can be used during the whole lifecycle of the building is one of the most enduring elements in defining the potentiality of BIM. Since most of the costs during the life cycle (from two thirds to 85%) occur after the construction is completed, the great challenge of BIM is its implementation to FM. Many accounts of the BIM implementation in FM see the process as an extension of BIM models (or data) created during the design to FM. In this paper, we have argued that to have a more realistic view of the implementation two things need to be taken into account. First, different FM activities and group of practitioners have different needs of information. Instead of speaking about FM management in general, the work of these different groups needs to be studied. This constitutes a foundation for incremental implementation of BIM in various FM activities. Second, FM organizations have invested much in FM information systems and created expertise related to them. Therefore, a starting point for BIM implementation is what additional value BIM provides in relation to information systems already in use.

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¹ A limitation in the interview data is that the representatives of assigned city-owned rental housing are not included.

² ARSKA, an archive e-service, contains all of the design plans stored in the archives of the Helsinki City Building Control Department, such as architectural designs and special drawings: <https://asiointi.hel.fi/arska/>.

³ PAIKKATIETOVIPUNEN is the Helsinki City Geographic Information system web service for detailed and accurate information about the Helsinki City region: http://ptp.hel.fi/index_en.html.