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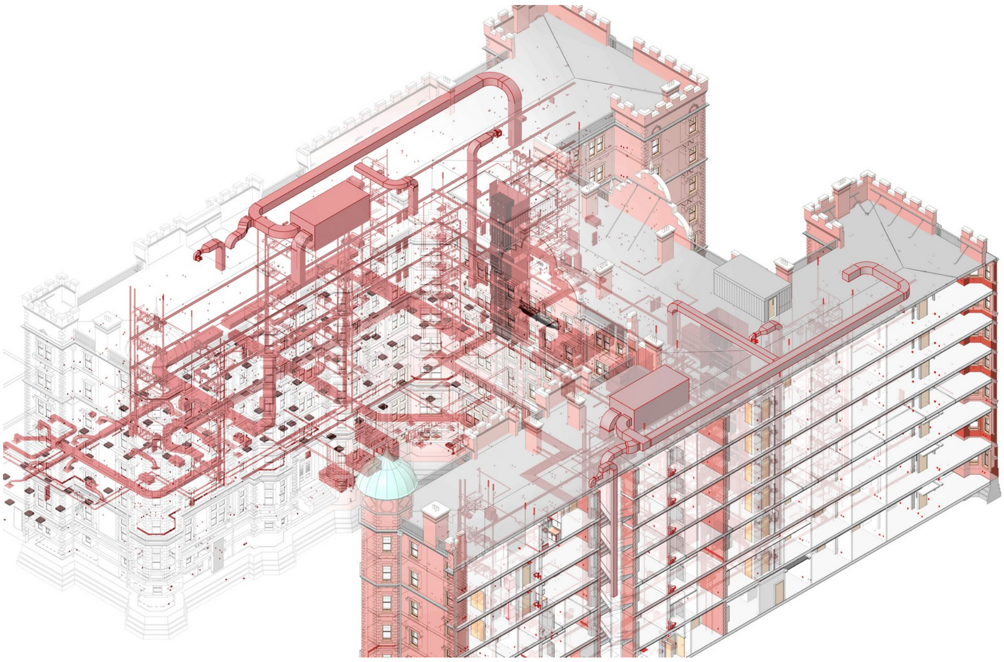

BIM in Facility Management

An assessment case study

Master of Science Thesis in the Master's Programme Design and Construction Project Management

GUSTAV ERIKSSON

Department of Civil and Environmental Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY

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Examensarbete / Institutionen för bygg- och miljöteknik,
Chalmers tekniska högskola 2014:

Department of Civil and Environmental Engineering
Division of Construction Management
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

Cover:
A BIM model created by Miller Dyer Spears (2014)

Department of Civil and Environmental Engineering Göteborg, Sweden 2014

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ABSTRACT

A building is an enduring asset and the facility management phase is by far the longest during its life cycle. Thereof, the practice cannot succumb to all short-term trends, but requires long-term techniques and working methods, suitable to buildings of varying age and condition. One of the main problems facing the practice today involves the information handling. The information-handling problem manifests itself in various ways and results in unstructured building data, which considerably complicates the situation for its users. Building Information Modelling (BIM) offers a new approach to work with building information during the buildings whole life cycle.

This report is a case study and the methodology used is strictly of qualitative nature. A comprehensive literature review in combination with empirical data collection in the form of interviews has provided the basis for the research.

The study examines a facility management organization's current practice of information handling, first to get an understanding of the magnitude of the problem, but mainly to identify the major problematic activities where BIM potentially could offer a solution. This assessment should be seen as an early step in a more comprehensive implementation process, and ought to be used as guidance in future BIM implementation efforts. In addition, the study shows how potential barriers, of cultural and technical nature, must to be taken into consideration when implementing BIM in a facility management organization.

The result of the study is based on 10 interviews conducted with representative employees in a facility management organization, in various positions. It becomes evident that the case company suffer because of deficient information handling. The time spent on searching for relevant building information not only leads to inferior productivity but also deteriorate the tenant service. The highlighted problem areas in the case company turns out to be a good match to BIM application areas in facility management, and which should be seen as a confirmation of BIM's potential in the context. The cultural climate in the case company should not constitute a problem to implementation of BIM, as long as the potential benefits are made clear. Nevertheless, the company should have a strategy to prevent user resistance, especially directed toward older employees. It is shown that that the employees believe BIM would offer great values in their daily work, especially in areas such as "Improved productivity" and "Enhanced communication". Somebody even think that BIM would change the facility management practice fundamentally.

BIM i fastighetsförvaltning
En utvärderande fallstudie
Examensarbete inom Design and Construction Project Management
GUSTAV ERIKSSON
Institutionen för bygg- och miljöteknik
Avdelningen för Byggledning
Chalmers tekniska högskola

SAMMANFATTNING

En byggnad är en bestående tillgång och förvaltningsfasen är den absolut längsta under dess livscykel. Därav kan inte det vedertagna bruket ge vika för kortsiktiga trender, utan kräver långsiktiga tekniker och arbetsmetoder, lämpliga för byggnader av varierande ålder och skick. Ett av de största problemen i förvaltningen idag innefattar informationshanteringen. Problemet tar sig i utryck på olika sätt och leder till ostrukturerad byggnadsdata, vilket avsevärt komplicerar situationen för användarna. Building Information Modeling (BIM) erbjuder ett nytt angreppssätt att arbeta med information under byggnadens hela livscykel.

Denna rapport är en fallstudie och den metod som använts är strikt av kvalitativ natur. En omfattande litteraturstudie i kombination med empirisk datainsamling i form av intervjuer har legat till grund för forskningen.

Studien undersöker en förvaltningsorganisations nuvarande praxis rörande informationshanteringen, delvis för att få en uppfattning om omfattningen av problemet, men främst för att identifiera de största problemområdena där BIM skulle kunna erbjuda en lösning. Denna bedömning bör ses som ett tidigt steg i en mer omfattande implementeringsprocess, och bör användas som vägledning i framtida BIM satsning. Dessutom visar studien hur potentiella hinder, av kulturell och teknisk natur, måste tas i beaktande vid införandet av BIM i en förvaltningsorganisation.

Resultatet av studien är baserad på 10 intervjuer med representativa anställda, i olika positioner, i en förvaltningsorganisation. Det blir uppenbart att företaget lider av bristande informationshantering. Den tid som spenderas på sökande efter relevant byggnadsinformation leder inte bara till sämre produktivitet utan också försämrad hyresgäst service. De belysta problemområdena i företaget visar sig matcha bra med de tillämpningsområden BIM erbjuder förvaltningen, och bör ses som en bekräftelse över BIM's potential i sammanhanget. Det kulturella klimatet i företaget bör inte utgöra något problem för införandet av BIM, så länge som de potentiella fördelarna tydligt lyfts fram. Trots detta bör företaget ha en strategi för att förebygga användarmotstånd, speciellt riktad mot de äldre anställda. Det visar sig också att de anställda tror att BIM skulle ge stora värden i det dagliga arbetet, i synnerhet inom områden som "Förbättrad produktivitet" och "Förbättrad kommunikation". Några tror till och med att BIM skulle förändra förvaltningsfasen fundamentalt.

Contents

Preface

This Master of Science thesis is the final project in my postgraduate studies at the Department of Civil and Environmental Engineering at Chalmers University of Technology. It has been carried out at the municipal housing company Bostads AB Poseidon in Gothenburg Sweden during the spring of 2014. The study can be seen as a part of the company's effort of evaluating BIM as a viable aid to handle building information in the facility management phase. All interviews have been carried out at the interviewee's respective offices.

I would like to thank everyone who has been involved, for their much-appreciated help throughout the project. Special thanks go to my university supervisor, Mattias Roupé and my Poseidon supervisor, Catherigne Gerle for all your guidance and support. I would also like to thank Johnny Ulf and Karolina Sandqvist at Poseidon who have been involved during the project and contributed with important input. Last but not least I would like to thank all employees at Poseidon that I have been in contact with and interviewed. Without all of you aforementioned, this project had not been possible to carry out, thank you!

Göteborg, May 2014

/Gustav Eriksson

Chapter 1 Introduction

1.1 Background and problem description

The facility management phase is the last, but by far the longest, phase in a building's life cycle (Nordstrand, 2000). The development in recent decades, along with changing business trend, technological advancement and shifting preferences among employees and customers, has led to that the practice faces challenges of various nature (Teicholz, 2001). One of the greatest problem is considered to be the information handling (Hardin, 2011). This problem often starts already at project completion and handover of building documentation, and is usually exacerbated later in the facility management phase due to insufficient routines. The information-handling problem is considered to take much time from the important preventive work, which results in resource waste, reduced employee productivity and impaired tenant service.

Building Information Modeling, or BIM, is considered by many, both researchers and professionals, to offer a solution to the problematic information handling within facility management (Hardin, 2011, Eastman et al., 2008). Even though the greatest influences of BIM has been seen in the in the design and construction phase, owners have in recent years begun to see the potential benefits even in the buildings later stages (Becerik-Gerber et al., 2011). BIM offers the possibility to streamline the information handling during a building's life cycle and thereby also improve the building information quality in the facility management phase (Nordstrand, 2000).

BIM offers many benefits and have numerous application areas within facility management, however, all organization are different and requires a unique approach for BIM implementation (Smith and Tardif, 2012). It is therefore important before just plunging into a comprehensive implementation process, to evaluate the organization in question in order to identify unique characteristics, appropriate application areas and required building data.

To manage a successful BIM implementation, a number of barriers ought to be taken into consideration. According to Eastman et al. (2008), there are risks associated with any changes to work processes. User resistance to change is considered a key factor when it comes to implementation of information systems, and that if not taken seriously, could lead to underutilization of the new system (Jiang et al., 2000, Kim and Kankanhalli, 2009). This underlines the need to have a well thought out implementation strategy, not just focused on technology, but just as much on people.

1.2 Purpose

The purpose of this study is to assess a facility management current practice in order to identity appropriate BIM application areas and relevant information need. This evaluation is intended to guide the case company in its further BIM efforts.

1.3 Objectives

The objective is to give an overall depiction of how the current information handling practice is perceived, and then in more detail describe how particularly problematic activities are performed in conjunction with the desirable situation.

1.4 Research question

How can the case company benefit from BIM in the facility management phase?

Sub questions:

1. What is the current situation regarding the information handling?
2. What is the desired situation regarding the information handling?
3. What should the company consider when implementing BIM?

1.5 Limitations

One of the reports main objective has been to assess the company's current practice. The practice involves a large number of processes and activities, all perceived somewhat differently by the company's many professionals. Consequently, a limitation has been taken where suitable employees has been selected, in consultation with company representative, for interviews to reflect the current situation best possible.

1.6 Disposition

The report begins with the theoretical framework of which the study is based. This section starts with defining facility management that is the context where the study takes place. Then follows a review of the concept of BIM, its application areas, the implementation process and barriers. Thereafter, the methodology chapter is presented, where it is described how the study is conducted and the methods used to obtain the results that will answer the posed questions. The methodology is then followed by a short description of the case company Bostads AB Poseidon focusing on their current practice of information handling. The findings chapter presents the findings from the interviews. First, the employees general perception of the current situation regarding the information handling is presented followed by a more detailed description of single activities. Finally, the employee's perception of the cultural climate is examined. The analysis and discussion chapter examines the correlations between the introduced theory and findings, on which recommendations made to the company is based upon. The study concludes with some summarizing conclusion where the reports main points are presented.

Chapter 2 Theoretical Framework

This chapter consist of two main sections. The first part, Section 2.1 begins with an introduction to the building life cycle, which is the context where this study is meant to be fitted. Further, the facility management phase, where the focus of this report will be, is outlined and described in more detail. The second part, Section 2.2 presents a review of Building Information Modeling, its application areas the implementation process and barriers, and which accordingly to research, offers a fundamental change to the facility management practice.

2.1 The building life cycle

The life of a building is initiated by a clients which to fulfil a need (Nordstrand, 2000). The following process can then, somewhat simplified, be described consisting of three phases: The design phase, the production phase and the facility management phase. The design phase involves decisions concerning the building's construction and design, and also how the embodiment will be carried out. This phase results in complete construction documents in terms of drawings and descriptions. The production phase is where the actual construction of the building takes place by means of the documentation from the former stage. This phase is commonly executed by a contracting company in collaboration with subcontractors. With the completion of the building begins the facility management phase, which by far is the longest in a buildings lifetime, often 15 to 25 times longer than the other phases (Cotts et al., 2010). The facility management phase involves operation and maintenance and is intended to uphold the function of the building. As subject of investigation in this report, the facility management phase is further described in Section 2.1.1. Atkin et al. (2008) illustrate a building's various phases in accordance with Figure 2.1.

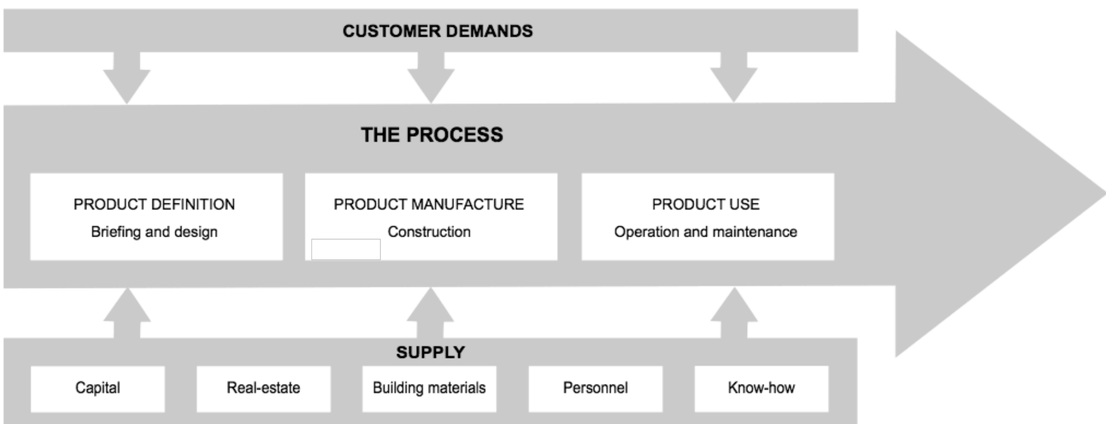

Figure 2.1: The three major phases in the building life cycle, according to Atkin et al. (2008).

2.1.1 The facility management phase

As mentioned in the previous paragraph, facility management is by far the longest phase in a building's lifetime. During this phase, the building is affected by a constant process of change, both when it comes to physical wearing down and user needs and preferences (Nordstrand, 2000). Facility management involves strategic management and governance of the resources and services necessary for a building to function as it suppose to.

2.1.1.1 Concept and definition

Since facility management, or FM, is relatively new as a recognized discipline, there is no uniform understanding of the concept (Kincaid, 1994). Kincaid (1994) argues that the discipline emerged as a result of the integration of property management, property operations and maintenance and office administration. Teicholz (2001) explains FM as a multidisciplinary or trans disciplinary profession based on theories on and principles of engineering, architecture, design, accounting, finance, management and behavioural science. According to the author, the practice has adopted the extensive body of knowledge of the aforementioned to create a new set of theories and practices. The Facility Management Institute (FMI), an organization founded in the late 70's, helped establish the new profession of FM and gave birth to International Facility Management Association (IFMA), the world's largest and most widely recognized international association for FM professionals (IFMA, 2014a). FMI developed a three-element model to contextualize and illustrate the underlying model for FM as a profession (Teicholz, 2001). Figure 2.2, of three interlocking circles, shows the correlation between employees, work processes, and workplaces and how FM plays a crucial role in integrating them into a coherent, productive, holistic system. The meaning of the FM concept in this report refers to the definition stated by IFMA (2014b):

"A profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology."

Figure 2.2: The underlying model for FM, developed by FMI (Teicholz, 2001).

2.1.1.2 The facility management practice

According to Nordstrand (2000) the traditional FM practice distinguishes between technical- and administrative functions. The administrative part handles the financial operations such as rental management, procurement and accounting. By technical management means the operation and maintenance of the property. The differences between operation and maintenance often proves to be quite unclear leading to confusion and misunderstandings (Sääf and Alvebro, 2008). Anyhow, Nordstrand (2000) defines and describes the two terms as follows:

Operation - "Operation is measures with the intent to sustain the functionality of a building." The operation includes all the services required to ensure the building performs as intended. Facility operations typically includes the day-to-day operations of the facility such as media supply waste management, janitorial services and remedial of minor faults. The building operation is mainly based on the operating manuals (or operation and maintenance instructions) handed over to the property owner at project completion.

Maintenance - "Maintenance is measures that preserve the building's original value and function." In Sweden, all property owners are responsible for their property and required by the Planning and Building Act (PBL) to care for them properly. The Construction Act (BVL) further discloses how the building's technical features should be maintained. The maintenance can be broken down into remedial- (more urgent) and planned maintenance as shown in Figure 2.3. To the remedial maintenance belong unforeseen events affecting the building, often of an urgent nature, since it may interfere with the daily operations. Planned maintenance is planned measures to prevent faults from occurring. The planned maintenance can then in turn be broken down into long term planned- and operating close maintenance, where a limit of two years separating them. Finally, operating close maintenance can be divided into periodic maintenance, intended for recurrent maintenance, and condition-based maintenance, where the status on the specific object determine if maintenance efforts is necessary.

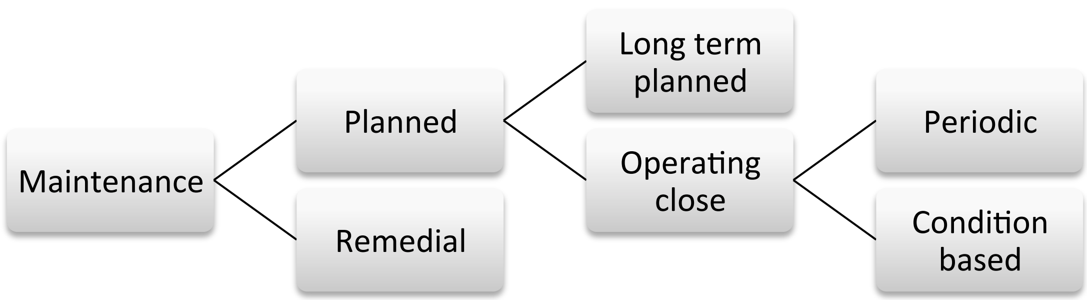

Figure 2.3: Various maintenance concepts and their relationships, according to Nordstrand (2000).

2.1.1.3 Facility management in the public sector

Cotts et al. (2010) and (Teicholz, 2001) discuss how the conditions for the FM practice differ dependent on where it is performed, and especially the disparities between public- and private FM. Public FM organizations usually have tight limited resources to work with in an culture overwhelmingly shaped by bureaucracy. Many decisions must be discussed and approved by assorted involved and comply with a multitude of regulations and standards. Government procurement policies are something typically distinguished for public organization and often constitutes a challenge. The vast amount of regulations and guidelines is intended to ensure fairness to all in the procurement and acquisition of products and services. Although, this process does not always result in the best or most sensible choice based on business criteria. The lowest bidder is not necessary the one providing the most complete or highest quality solution. Hence, the governing procurement process may result in higher cost of ownership, operation, or maintenance over the life of the product or service. Although, public sector FM has its advantages over the private sector. They often deal with large, complex projects and issues in an effective manner. They are often more stable, better organized, and have clearly written procedures, making the job of managing the process more effective.

2.1.1.4 Facility management in Sweden

The FM in Sweden has changed considerably during the 20^{th} century (Högberg and Högberg, 2000). Due to the housing shortage in the 30's, public housing companies owned by municipalities were established. Despite the increase in housing construction, the problem persisted, and a comprehensive project that came to be called "The million homes program" was launched and carried out during the 60's and 70's. The subsidized construction led to lower prioritized FM. In the latter part of the 20^{th} century, the companies realized that a larger property portfolio also required a better-organized administration of the buildings, and a more modern approach to the FM was adopted. The companies began a more active work to keep the maintenance costs down, by installing more effective systems and consult external specialized personnel.

2.1.1.5 Facility management challenges

There are plenty of research literature covering challenges in the FM industry. According to Teicholz (2001), there is a business trend towards flatter organizational structures resulting in increased demand and responsibility on FM employees. Cotts et al. (2010) bring up how FM advocates the concepts of cost-effectiveness, productivity, improvement, efficiency and employee quality of life, but how these concepts often seem to be in conflict with each other. Teicholz (2001) state that the FM practice is characterized by its reactive approach, and that the lack of proactive management, or management that is based on planning, anticipation and dealing with issues before they become problems, leads to inefficient use of resources. The author also brings up the connection between customer knowledge and customer requirements and means that increased sophistication among customer leads to an increased demand in quality of the services required, and thereby a need for continuous improvement in service and process delivery.

Perhaps one of the most frequently discussed challenges in FM literature concerns the information handling. The greatest problem in FM according to Hardin (2011) is the huge amount of documentation owners are left to deal with after project completion. The delivery of information usually includes detailed information about the building and belonging equipment, such as materials used, manufacturers, warranties, operation and maintenance instructions etc. William East et al. (2012) explain a worst case scenario where boxes filled with unsorted building information is handed over to owners. The often highly unstructured information handling during the handover process usually continues even later in the facility management phase, which results in an unwieldy information basis that hampers the operational personals daily work.

According to Hardin (2011), the current practice implies inefficient use of resources, and the severe localized information leads to time consuming search processes, time that is deprived from the essential preventive maintenance. An increasingly discussed solution to the information handling problem within FM is “Building Information Modeling” (Eastman et al., 2008).

2.2 Building Information Modeling

Alongside the rapid development of computer technology during recent decades, software used for supporting the building process has also evolved (Wikforsss, 2003). Building Information Modeling, or BIM, is considered by many, both researchers and professionals, to offer a solution to many of the currently perceived problems within the building industry, and not the least the FM phase. (Hardin, 2011, Eastman et al., 2008). This section begins with explaining the concept and definition of BIM, Section 2.2.1. The following part covers BIM in FM including application areas, the implementation process and potential barriers, Section 2.2.2.

2.2.1 Concept and definition

The 3D-modeling emerged in the 70’s from early computer-aided design (CAD) efforts in several industries (Volk et al., 2014). While many industries developed more sophisticated techniques, the construction sector confined for quite some time to the traditional 2D design. But the situation was to change. Jetty Laiserin is by many considered as the founder of the term or acronym BIM (Smith and Tardif, 2012). It was during a meeting, in the early 21th century, of building industry strategists where he suggested the term “Building Information Modeling,” or BIM, as the best way to describe “the next generation of design software”. He would soon thereafter, publish the LaiserinLetter, what may have been the first widely published article on the topic.

What characterizes BIM, and distinguishes it from a mere 3D-model, is the object-based structure (Smith and Tardif, 2012). A traditional 3D digital model of a building is a wire-frame consisting of vectors (3D lines) and simple geometric shapes such as cylinders, arcs, and cones. A BIM model is composed of “intelligent objects”, with the characteristics of their real-world counterparts of actual buildings components, such as doors, windows and walls. This implies that for example a window “knows” that it can exist only in a wall, and a wall “understands” that one of its essential attributes is thickness. Objects may have geometric or non-geometric attributes with functional, semantic or topologic information. In addition to building element properties, a BIM model may hold information regarding spatial relationships, quantities, cost estimates, material inventories and project schedule (Azhar, 2011).

In the early history of BIM, it was mainly of benefit to architects and engineers in the design phase and in areas such as clash detection, visualization and quantification (Volk et al., 2014). Anyhow, the development has led to an increased number of application areas including energy analysis, structural analysis, scheduling, progress tracking, jobsite safety etc. Recent trends indicate a shift and increased focus on the later stages of the buildings life cycle including maintenance, refurbishment, deconstruction and end-of-life considerations. A possible application area of BIM is to simulate the construction process in a virtual environment and demonstrate the entire building life cycle, to facilitate in the design-, construction- and FM phase

(Azhar, 2011). Figure 2.4 illustrates a BIM model in different phases during a buildings life cycle.

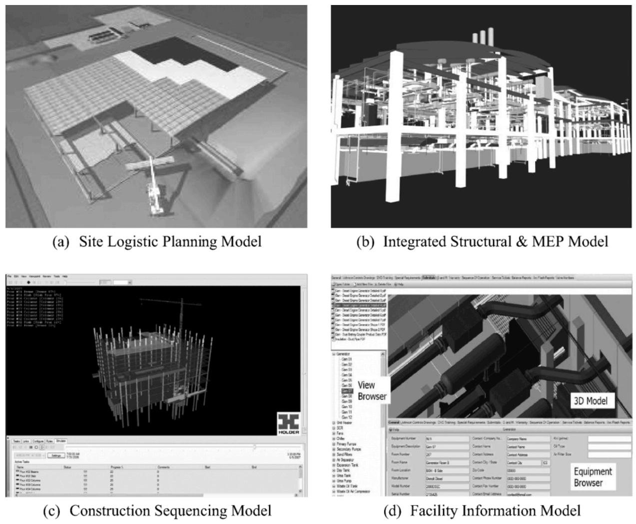

Figure 2.4: BIM models in different phases during a buildings life cycle (Azhar, 2011). MEP = mechanical, electrical, and plumbing.

A common understanding of BIM is a model acting as a single electronic data repository, containing all of the available information about a building, direct accessible to any party who might need to query, add to or remove information from the model at any time in the life cycle of the building (Smith and Tardif, 2012). Through interoperability between software's the involved parties shares data through common information exchange protocol, according to Figure 2.5. Latham (1994) state in his report that 80% of construction administration processes could be saved with single-entry, web-enabled, shared databases and that a 30% productivity increase could be achieved from the development and uptake of data integration across the building and construction industry.

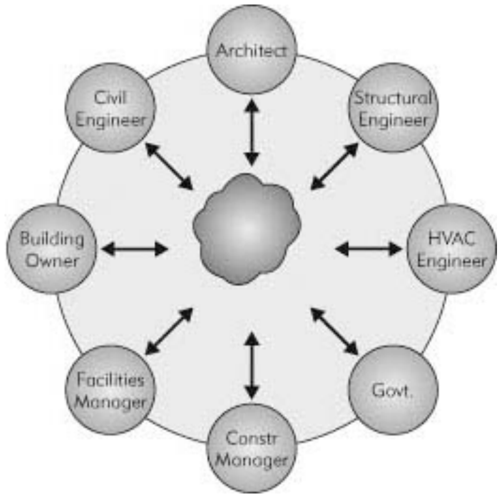

Figure 2.5: BIM interoperability according to Smith and Tardif (2012).

Defining BIM seems to be a task of ambiguity due to the broad nature of the concept and many possible declarations. Researchers has devoted a lot of time in their pursuit of finding the precise meaning of the term (Smith and Tardif, 2012). According to (Barlish and Sullivan, 2012) entire studies have been dedicated for the search of a consistent definition. They have noticed how the concept is differently interpreted dependent on the discipline, how architects focus on the design perspective, contractors on the technical aspects etc. Other definitions however, highlights the holistic nature of BIM, and emphasizes not only on the software but also on the processes (Bryde et al., 2013). The split perception of BIM often stems from the meaning of the letter "M" (Smith and Tardif, 2012). "M" may either refer to "model" or "modeling". According to BIM Alliance Sweden (2014), "Building Information Model" refers to the model, or models, which constitutes a digital object based representation of a building or facility, while "Building Information Modeling" refers to a working method, i.e. the process of creating and using one or more building information models in the building or construction process. For the purposes of this paper, the definition of BIM, credited to American National Institute of Building Sciences (2007) will be used:

"A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward. A basic premise of BIM is collaboration by different stakeholders at different phases of the lifecycle of a facility to insert, extract, update, or modify information in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability."

2.2.2 BIM in facility management

As stated in the previous paragraph, the greatest influence of BIM has been seen in the in the design and construction phase while the adaption in the FM phase has fallen behind (Teicholz, 2012). Regardless of the substantial cost the operation and maintenance phase constitute there has been a distinct focus on the initial construction costs of projects (Becerik-Gerber et al., 2011). Although in recent years, owners and facility managers have begun to realize the potential value of BIM, and a growing interest has progressed (Becerik-Gerber et al., 2011). According to Computer Integrated Construction Research Program (2013), the expansion of BIM usage is largely driven by owners. The authors to the report argue that, "Begin with the end in mind", is a prerequisite for successful BIM usage and thereby highlights the need for owners to understand and communicate their goals for implementing BIM throughout the lifecycle of the building. Latham (1994) state in his report that 10- to 30% of facility engineers time is spent on information searching. According to Eastman et al. (2008), BIM offers the owner benefits by streamlining the delivery of building information, leading to a more efficient and reliable delivery process that reduces time and cost during the entire life cycle.

2.2.2.1 Fields of application

The development of BIM has led to an incredible number of different application areas, not the least in the FM phase (Becerik-Gerber et al., 2011). The following comprehensive summary is based upon Becerik-Gerber et al. (2011) case study in which they discuss current and potential fields of application of BIM in FM. In the following clause, most of the categories begin with a problem description followed by the benefits made possible by the use of BIM.

Locating building components

Locating building components such as equipment and materials is a repetitive and time- and labour consuming task for FM personnel. Conventionally, on-site facility managers rely on paper-based blueprints or on their intuition to form an impression of the situation. A problem with this practice is for example in emergency situations or when new personnel unknown to the site are in need of information. FM personnel could use BIM features such as view, search, filter and highlight, to navigate into a virtual model and guide themselves to target components and display relevant data. The taking out of the guesswork could reduce the maintenance cost significantly.

Facilitating real-time data access

FM personnel's daily practice usually involves a lot of handling of building information, stored in multiple databases the user must toggle between to locate required data. BIM could provide a unified data access point in which the data, along with the knowledge gained during maintenance and operation of the building, could constitute a knowledge management database. In reality it would mean that FM personnel could choose a target object and from it pull the data needed. The efficient access to information would not only reduce the time and labour needed for retrieving it but also avoid unconsidered decisions in the absence of information.

Visualization and marketing

The lack of building visualization tools becomes evident in many different situations in the facility management phase. A three dimensional BIM model with the ability to integrate material texture, light sources, landscaping etc. implies a completely different representation of the space to facility managers, for example during design and construction of renovations and remodels. Improved visualization could also serve as improved decision support in terms of what-if analyses, assessment of construction methods, evacuation planning etc. The possibilities of BIM are not the least obvious from a marketing perspective, where visualization of interior spaces and furniture would have a great influence on the rental process.

Checking maintainability

Accumulated BIM data from different buildings could be useful in maintainability studies where focus is on desired performance at various stages of a buildings life cycle, for example:
Accessibility: Examining possibilities of physical inspection capacity for equipment such as fire protection systems, clear and rapid visual identification of relevant parts and sufficiently large access openings to permit removal and replacement of components.
Sustainability of materials: Avoidance of damaging materials, identification of

associated defects and assessment of material performance such as durability and clean ability.
Preventive maintenance: Selection of components from a safety perspective, virtual inspection of properly installed and protected components that might need to be easily accessed for repair.

Creating and updating digital assets

Usually when a project is handed over to the client, a manual, lengthy and error-prone process of transferring information to the facility management systems begins. It is of critical importance that the imported data is structured with a proper terminology so it can be efficiently used and managed by the organization. By the use of BIM and involvement of the client's requirements in early project phases, it is possible to capture, digitalize, and transfer the necessary data in more efficient manner. The process could be automated and free of manual manipulation if the information from different disciplines stored in the BIM model were accurate and consistent.

Space management

In addition to more effective space utilization, space management also increases the productivity of the people working in those spaces. Space management involves forecasting requirements, assigning spaces and streamlining the moving process. These activities request information such as space numbers, descriptions, boundaries, areas, volume, intended use, and actual status. Traditionally, CAD drawings are used to gather this information, a method where deficiencies occur, such as inconsistent naming conventions and laborious attribute updates. A BIM model could offer the possibility to visualize and host space attributes. Such a feature would facilitate identifying underutilized spaces, forecast space requirements, simplify space analysis, manage the move process, and compare actual with planned space utilization. The information accessible in the model have many application areas such as accurate identification of spaces various purposes, see and track assets through multiple moves over time insurance purposes or dispute resolution etc.

Planning and feasibility studies for noncapital construction

A building is constantly affected by a change process, derived from weather, customer preferences etc., which leads to the necessity of renovating, remodelling or even sometimes demolishing. A BIM model could assist in the planning, designing, analysing, and simulation of these activities. Modulations with a high level of details could be used for presentation of exterior and interior visual characteristics, estimation of quantities of required building materials, identification of equipment etc. Also, extracted historical data of the building, such as materials, labour and cost of designing and constructing could be used when planning the forthcoming work, in decision making and in scheduling.

Emergency management

In the case of an emergency it is of critical importance that the necessary information, typically of spatial nature, is easily accessible through a logical structure. A BIM model and a graphical interface would enable identification of potential emergency problems and hidden relationships between evacuation routing position and environmental risks. The model could also be of assisting use by identifying hydrants, electrical panels, hazardous materials, and floor plans of the building to aid, for instance, the fireman in their work. A BIM model could also serve as a tool where emergencies are simulated and evaluated in the development of response plans.

Controlling and monitoring energy

Traditionally, energy management systems are used for controlling and monitoring a building's media consumption. These are usually separate systems resulting in lack of interconnectivity and isolation of equipment and components from the other building features. The graphical interface of a BIM model and the linkage to building sensors, metering and sub metering information could provide real-time monitoring and automated control. What if scenarios with different energy system configurations could be simulated in order to examine energy saving measures. BIM could facilitate energy consumption control by for example turning off the lights remotely in unoccupied rooms. Also, historical energy usage data could be used for prediction of consumption behaviour, energy-related budgeting and support of conservation activities.

Personnel training and development

When new personnel are introduced to an organization, when new buildings are acquired or when existing buildings are changed, situations occur where new information must me coped with. The traditional routine means training is handled through presentations, site visits, hand-by-hand demonstration, and self-study. This method is time-consuming and is based on a great confidence in the trainer. With BIM, trainees would be allowed to enter into a visual model where the visual representation of the building along with individual walk around and investigation of building spaces, components equipment etc. would constitute the teaching. The BIM model could not only help the trainees in their understanding of future assignments, but also be used in the assessment of their skills.

2.2.3 BIM implementation

That BIM offer potential benefits within FM has been made clear in the previous part. Although, how an organization shall behave to implement BIM and assimilates the benefits is a widely discussed topic. Smith and Tardif (2012) stress the importance of understanding BIM as part of a comprehensive business strategy, and not just a technical solution, and mean that many business processes and workflows need to be changed. Eastman et al. (2008) put much of the responsibility on the owner and emphasise on leadership and involvement as a critical success factor for BIM implementation. Several approaches are suggested such as reviewing and developing BIM guidelines, building internal leadership and knowledge, selecting service

providers with BIM project experience and know-how, educating the network of service providers and changing contractual requirements (Eastman et al., 2008). Arayici et al. (2011) advocate a socio-technical view of the BIM implementation process, which takes into consideration not only the technology but also the sociocultural environment. Further, Arayici et al. (2011) argue that the implementation is better suited as a bottom up approach rather than top down approach in order to engage people in the adoption and to diminish any potential resistance to change.

Recently, two comprehensive reports concerning BIM implementation within FM have been published. The organizations behind these reports are considered to have much influence in the BIM development (internationally respective nationally) and it is reasonable to assume that these publications will have a great impact on the future BIM implementation efforts. One of the reports is a guide derived from a buildingSMART alliance project, “BIM for Owners”. The other one is a governmental report produced by five Swedish public property developers, “BIM in the State”. What especially unifies the two following BIM implementation processes is the importance they attach to the early implementation stages. They advocate that enough resources must be dedicated to the implementation planning and that each organization is unique and thus requiring a distinctive approach. They propose an assessment of the current situation, descriptions of reality cases and activities, in order to identify BIM application areas, and the task is suggested to be performed through the involvement of operational personnel. They also have in common, that after the organizational assessment, they suggest that key performance indicators and maturity levels are established, to guide future BIM implementation efforts. The implementation process suggested in these reports will be examined more in detail in order to map how BIM optimally can be implemented in an FM organization.

2.2.3.1 BIM for Owners

According to Computer Integrated Construction Research Program (2013) the BIM implementation process is a three-step procedure containing Strategic Planning, Implementation Planning and Procurement Planning. Due to the limitations and focus of this report, further emphasis will be placed only on the Strategic Planning part.

The purpose of the Strategic Planning process is to establish BIM objectives and set the direction to focus future implementation efforts. The authors stress the importance to understand organizations uniqueness and thereby there different needs for approach. Before initiating the Strategic Planning, the guide advises that a main responsible for the BIM implementation should be appointed, involvement from top-level management should be confirmed and that adequate resources should have been assigned for the planning process. Thereafter, the following process can be separated into three primary steps: Assessment, Alignment, and Advancement, according to Figure 2.6.

Figure 2.6: The Strategic Planning procedure, according to Computer Integrated Construction Research Program (2013).

- *Assessment* - The purpose of the Assessment is to identify possible application areas of BIM by evaluating the organizational current practice. The collection of relevant information to perform the status evaluation can be carried out in several ways. The guide suggests organizational wide surveys, document analysis, process observations, and workflow analysis. Although, one method is considered more efficient than the others: Conducting interviews with the operating unit's personnel who are directly involved with the performance of the organization. The guide includes proposed interview questions, related to duties of the organizational unit, information they manage, process of managing information, some of the challenges associated with the process, etc. When the status evaluation is completed, the Assessment procedure continue by identifying key performance indicators to be able to determine which aspects of the organization require improvement to control behaviour towards the intended goal. The guide also suggests that these performance measures could be used to benchmark one organizations performance to another.
- *Alignment* - The Alignment process is designed to establish a desired level of maturity for the organization. Here it is important to set measurable and achievable target levels and also consider the inherent capabilities of an organization such as experience and knowledge. BIM objectives, goals and uses are determined and help provide a direction for the organization.
- *Advancement* - The last step in the Strategic Planning is called Advancement. To develop an Advancement strategy is motivated due to the fact that the implementation process depends on many different factors, such as goals and objectives, BIM experience, organization size etc. The Advancement planning helps the organization to track the implementation progress and also to avoid the risk of escalating costs and misdirected time and resources.

2.2.3.2 BIM in the State

In Sweden, five larger public property developers have come together to foster a unified approach in their work with BIM (BIM i Staten, 2014a). They have developed a model suggesting how BIM is to be implemented in an FM organization. Figure 2.7 illustrates the process, which results in a specified requirements definition regarding scope, content and execution of building information along with an implementation plan.

Figure 2.7: BIM implementation process, according to BIM i Staten (2014a).

Due to the reports limitation, the focus here will be set on the first step in the model, “Identify BIM-benefit”. The benefit aspect has a pivotal role in the implementation strategy. It raises the seemingly obvious goal that the introduction and use of BIM should create value and that these values should be measurable. BIM i Staten (2014a) sees it as business processes have information requirements that can be met in various ways. It is “how” you work that is in focus when the BIM benefit aspect is discussed. They define a “BIM-benefit” as: “The improvement which comprises the difference between a current state and a future state.” The following activates are proposed to be performed early in organizations adoption to BIM.

Clarify the benefit - This task seeks to describe reality cases to identify the improvement BIM potentially could have. Operational personnel are involved to get an as realistic description as possible.

Describe the current state – This undertaking establishes a description of situations and activities in order to create an understanding of the current ways of working. The description could for example contain information regarding the initiation of a work task, the following process including detailed steps, actors involved and the end result.

Describe the future state - A future scenario of the work processes is described based upon information available via an updated object-based information model. Thereafter, key ratios are formulated in which the expected improvement could be measured against. An assessment of benefit and cost is carried out, based on estimation of expected results in terms of the defined ratios, to determine on continued work on testing and initiation of a pilot project.

2.2.3.3 BIM maturity levels

The status of BIM implementation can be described through four maturity levels, illustrated in Figure 2.8 (BIM i Staten, 2014b). The five public property developers, mention in the previous paragraph, have made the assessment that the Swedish industry is located between level one and two when it comes to information handling within projects, and on level zero to one for the information handling within FM. That indicates how much BIM benefits that are left to exploit in the FM industry. The different levels have the following characteristics:

- *Level 0* - Computers are used to produce CAD-drawings and building documentation that act as information carriers. The information concerning the building is commonly found in physical format such as binders and paper drawings.
- *Level 1* - The structure of the information allows some interaction on a file-basis, for example can drawings from different disciplines be compared. 2D- and 3D-models are used and in the FM are drawings and documents digitally stored. The databases containing the information have no interaction with the FM system.
- *Level 2* - The 3D-model has developed to an object-based model. The objects hold information about attributes and relations, which enables integration between different information systems. For the facility manager this means that all building related information could be reached through the objects in the model.
- *Level 3* - A future scenario based on a lifecycle perspective and builds upon a uniform information model and standardized structures. The information is stored in open databases, which are linked together via web services. The facility manager will be able to set criteria and search for building related information and facility data.

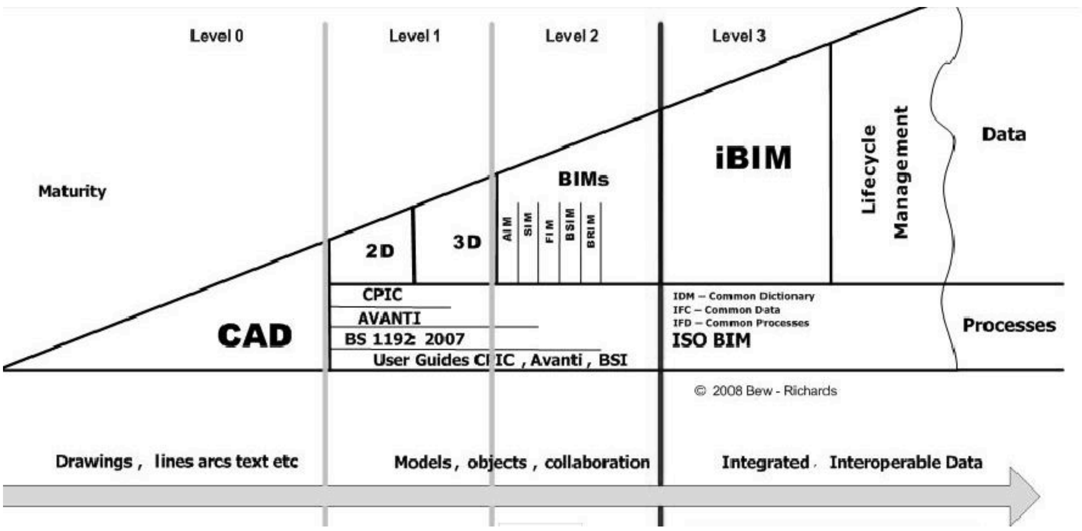

Figure 2.8: Maturity levels for BIM implementation, according to BIM i Staten (2014b).

2.2.4 Barriers to BIM implementation

As has been made clear, the introduction of BIM in an organization offers many potential opportunities and advantages. Although, to manage a successful BIM implementation, a number of barriers ought to be taken into consideration. According to Eastman et al. (2008), there are risks associated with any changes to work processes. The barriers to BIM implementation are often divided into two categories, process- or technological barriers and organizational barriers (Becerik-Gerber et al., 2011, Eastman et al., 2008). Becerik-Gerber et al. (2011) have compiled a list of barriers to BIM implementation within FM.

Process- or technological barriers

• Unclear roles and responsibilities for loading data into the model or databases and maintaining the model

• Diversity in BIM and FM software tools, and interoperability issues

• Lack of effective collaboration between project stakeholders for modeling and model utilization

• Necessity yet difficulty in software vendor's involvement, including fragmentation among different vendors, competition, and lack of common interests

Organizational barriers

• Cultural barriers toward adopting new technology

• Organization-wide resistance: need for investment in infrastructure, training, and new software tools

• Undefined fee structures for additional scope

• Lack of sufficient legal framework for integrating owners' view in design and construction

• Lack of real-world cases and proof of positive return of investment

Understanding the factors that contribute to the success of systems development and implementation is of great importance (Jiang et al., 2000). Due to the reports limitation, two of the above mentioned barriers will be examined in more detail, the cultural- and interoperability barriers. These two factors are brought up in practically all literature covering BIM in FM and are considered to be the most relevant in this particular study.

2.2.4.1 Cultural barrier

User resistance to change is closely related to the cultural barrier, and considered a key factor when it comes to implementation of information systems (Jiang et al., 2000, Kim and Kankanhalli, 2009). User resistance has been given several definitions and theoretical explanations in literature. Markus (1983) explains user resistance in terms of the interaction between system characteristics and the social context of its use. Marakas and Hornik (1996) mean that user resistance occurs as a reaction to threats associated with the new system. According to many researchers, resistance can be viewed from a people-, system- or interaction perspective dependent on the outcome observed (Jiang et al., 2000). The people-oriented theory propose that the resistance is generated by factors internal to users as individuals or groups, such as age, gender, background and value and belief systems. The system-oriented theory suggest that the resistance derives from factors inherent in the design of the system or the technology being used, such as user interface and other systems characteristics. The Interaction theory perspective emphasises on the interaction between people and system factors and argues that neither the system nor the people characteristics themselves are the causes of resistance but instead the users perceived values and social content gain or loss before/after system implementation. User resistance will in this report refer to the by Kim and Kankanhalli (2009) somewhat simplified definition, "Opposition of a user to change". Jiang et al. (2000) have compiled a list of the reasons employees resist new technology:

- Change in job content
- Loss of status
- Interpersonal relationship altered
- Loss of power
- Change in decision-making approach
- Uncertainty/unfamiliarity/misinformation
- Job insecurity

The strategies researchers have come up with to promote system acceptance can be classified into two categories: participative- and directive strategies. Participative strategies, as it sounds, implies a more active role for the employees whereas directive strategies are those imposed by management. Jiang et al. (2000) have further put together a comprehensive list of strategies to mitigate user resistance. The following list is limited to the strategies relevant for this particular study.

- Involve employees in development of new systems to encourage a feeling of ownership
- Open lines of communication between employees and management
- Provide employees with information regarding system changes to preserve ownership
- Pace conversion to allow readjustment period to new system
- Reward ideas that will improve throughput to encourage usage
- Document standards so new procedures are easy to learn and reference
- Clearly establish in advance the demarcations of authority that will exist following changeover to clarify role definitions
- Show sympathy and be receptive to complaints following conversion to maintain user contact and trust
- Conduct orientation sessions to prepare for change
- Give job counselling to help users adjust
- Retrain employees to be effective users of the new system

2.2.4.2 Interoperability barrier

One of the main barriers to BIM implementation concerns interoperability. During a buildings life cycle there are many participants involved, resulting in numerous different interactions, which stresses the requirement of the interoperability dimension (Grilo and Jardim-Goncalves, 2010). Grilo and Jardim-Goncalves (2010) define interoperability as: "The ability of two or more systems or components to exchange information and to use the information that has been exchanged". They argue that true interoperability is achieved only when each participating application's internal data structure, can communicate and exchange information with a universal open data model, and hence with each other. Bazjanac (2008) state that one single software application can not be used to manipulate all data in a BIM model but the main purpose of software interoperability is a problem free data exchange or sharing among multiple software applications engaged in an industry process.

As a part of Industrial Alliance for Interoperability's (IAI) mission of enabling software interoperability and provide a universal basis for process improvement and information sharing in the AEC/FM[1] industry, they developed the International Foundation Classes (IFC), an open standard model. The IFC model defines building objects which can contain numerous properties such as geometry, materials, finishes, product name, costs, etc., as well as relationships to and data inheritances from other objects. Although IFC is has led the interoperability development forward, the model does not provide a sufficient condition for true interoperability (Sacks et al., 2010). BIM software application is used for numerous different purposes, leading to individually customized data representations suited to their own functional needs. Currently, the software vendors need to determine appropriate mapping between the internal representations of their application and IFC entities and attributes when preparing export routines to IFC files. Thereafter, the receiver must translate the information into another system. The practice has led to an unreliable and unpredictable exchange process. Regardless of the extensive efforts to achieve interoperability within the AEC/FM industry, seamless interoperability does not exist and the problem remains (Grilo and Jardim-Goncalves, 2010). Although, a relatively new concept has entered the construction sector discussions: COBie.

2.2.4.2.1 COBie

Construction Operations Building Information Exchange, or COBie, is a relatively new concept within the construction industry, but as a result of increased attention among researchers and practitioners, it starts getting ever-wider recognition (East, 2007). The current practice of building information handling constitutes a problem, as mentioned in Section 2.1.1.5, and a substantial cause to this problem has to with interoperability. According to East et al. (2009) today there is no way to provide facility operators with non-proprietary, interoperable versions of the data they need. The Industry Foundation Classes (IFC), was developed as a partly solution to the data interoperability problem and provides a shared framework for the exchange of facility information (East, 2007). The COBie project, based on the IFC, was initiated in the end of 2006 in order to solve the interoperability problem once for all (William East et al., 2012). COBie specification is explained by East et al. (2009) as: "COBie identifies content of information delivery required by specific project team members during design, construction, and commissioning". COBie facilitates and enhances the information handover between construction and operation, according to Figure 2.9, and eliminates the need for post-hoc as-built data capture (East, 2007).

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[1] Architecture/Engineering/Construction and Facility Management

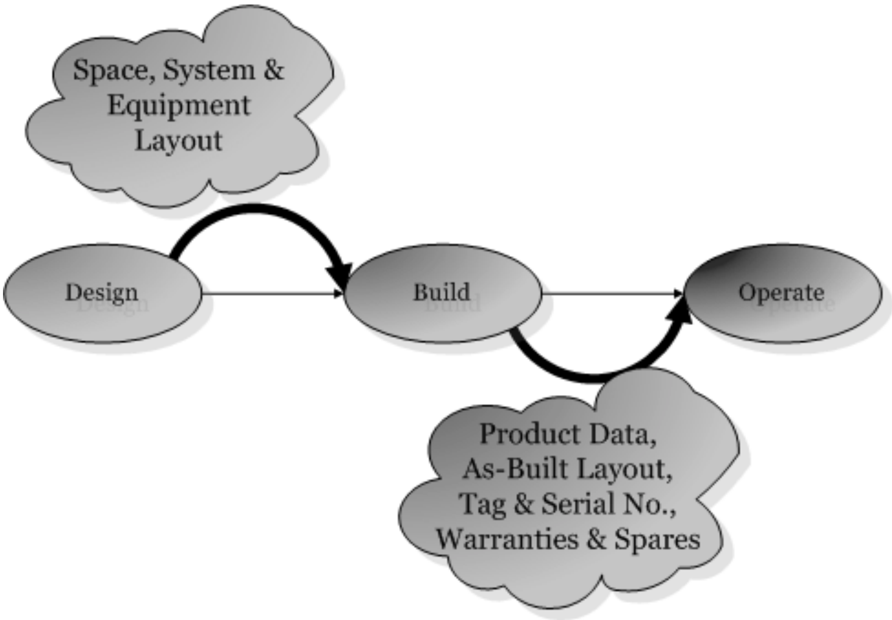

Figure 2.9: The idea behind COBie, according to East (2007).

- The COBie data extracted during a project is stored in spread sheets (East et al., 2009). When these spread sheets are completed, links to BIM object models are maintained by the references found in the individual sheet. The exchange of COBie information occurs at a predetermined time and format but leaves it to the actor in question to decide upon method used for the task. Although, the specification is designed in such a manner that motivates the actors involved to capture the building information as it is created during the project life cycle. At project completion the commissioning agent is given the option to enter maintenance plans and system instructions in the COBie spread sheet format, which then is imported to the facility managers systems. The information exchanges are divided into the following deliveries, see also Table 2.1.

- *As-designed model* - The first information exchange is between the designer or owner and the contractor. The information delivery includes object information such as floors, spaces, zones, equipment and systems. Information regarding space functions and fixed/movable assets are also identified.
- *Pre-built model* - The pre-built model is the first COBie deliverable supplied by the contractor and occurs at 70% fiscal completion of the project. The model includes the majority of manufacturer and related information provided as part of a submittal approval process.
- *Occupancy model* - This exchange between the owner and contractor takes place at 90% completion and includes the list of values and other tagged items along with system operations and maintenance instructions.
- *As-built model* - The model contains 100% building information and is provided as part of the contract closeout documents.

Table 2.1: Summary of COBie deliverables, developed from East et al. (2009).

Model	Contents
As-Designed	Room, Equipment types/list
Pre-Built	Manufacturer data, Warranty, Parts
Occupancy	Tagged items, Commissioning data
As-Built	Updated data

Chapter 3 Methodology

3.1 Research approach

The study method employed in this report is strictly of qualitative nature. The interest for qualitative studies has increased significantly in recent decades (Merriam, 2002). According to Chamberlain (2009) parts of the human system are not amenable to quantitative measurement and qualitative research methods has developed as consequence of that. Compared to quantitative methods, the approach is relatively unstructured and the initial research question is of more general character. Qualitative studies are based on a research strategy where the emphasis is on words rather then quantification regarding collection and analyse of data (Bryman and Nilsson, 2011). Merriam (2002) stresses that the fundamental idea behind this research method is that meaning is socially constructed by individuals in interaction with their world. The world, or reality, is not fixed, single, agreed upon, or measurable phenomenon as adopted in quantitative research, but consists of multiple constructions and interpretations of reality which constantly changing. A qualitative research seeks to understand those interpretations at a particular point in time and in a particular context. According to Chamberlain (2009), a qualitative research have several unique aspects: It is important for the researcher not to exercise any experimental controls on the phenomenon being studied. To include the context as part of the phenomenon, the survey is carried out in in a naturalistic setting. Also, the participants, at sufficient number to obtain rich data, are carefully selected and willing to discuss and explore a phenomenon.

The aim of this thesis corresponds well to what Merriam (2002) stipulates since it tries to make sense of how people perceive the information handling within the company today to assess the potential value of BIM. However, the information handling are not only for people to interpret, which is why, this thesis applies a combination of interviews and documents- and literatures review. According to the case study definition of Yin (2009) this report counts as a case study due to its 5 months duration in a real-life context and the limitation of staying within one single company.

3.2 Literature review and theoretical framework

A literature review is an account of the literature relevant to a particular field or topic (Bryman and Nilsson, 2011). The purpose of the review is to assemble knowledge of the theoretical framework and to develop an argument around the significance of the research. The literature review is divided into two sections. The first part addresses FM and covers the current practice and challenges. The second part deals with BIM and involves application areas, implementation and barriers.

3.3 Empirical data collection

The empirical data was, with the exception of a few internal documents, exclusively obtained through interviews. Interviews are likely the most used method in qualitative research, much due to its flexible nature (Bryman and Nilsson, 2011). According to Steinar (1996) the qualitative research interview seeks to describe the meanings of central themes in the life world of the subjects and understand the meaning of what the interviewees say. McNamara (1999) argue that interviews are particularly useful for getting the story behind a participant's experiences. There are basically three types of interviews: Structured, unstructured, and semi-structured, which can be placed along a continuum (Longhurst, 2003). Structured interviews use a list of predetermined and standardized question asked in the same way and order. Unstructured interviews have little guidance from the questions but are more directed by the informant, and include for example oral histories. Between these two, semi-structured interviews are found. Semi-structured interviews are reasonable informal or conversational in nature. These have some degree of predetermined order but are also flexible and allows for an open response in the participants own words. What also characterizes a semi-structured interview is the tendency for the interviewer to ask follow-up questions on answers considered important (Bryman and Bell, 2011). According to Steinar (1996) the interview process can be divided into five different phases:

1. A preparatory phase where the interview is planned according to time, place and format, which include inform the interviewee.
2. The initial contact that involves creating a good first impression.
3. The orientation phase where the purpose and proceedings of the interview and the research are being explained.
4. The substantive phase is the part where the interview takes its course. It is this portion, which mainly is analyzed.
5. Final phase is partly social, but may advantageously contain a brief summary of the interview.

In this study, 10 semi-structured interviews, in accordance with the process described above, have been held with company employees. Interviewees in different roles were, in consultation with the company supervisor, carefully chosen. The most important factor in the selection process was the interviewee's participation in the building information handling. Thereof, due to the landlords and property engineers significant roles in the matter, three from each respective discipline have been interviewed in order to get an as broad understanding as possible. A comprehensive description of the interviewees is found in Section 4.2.1. The interviews were held in Swedish at the landlord offices, the district offices and at the company headquarter. They were recorded and transcribed in order not to lose any valuable material and facilitate the questioning. A full review of the interview question material can be found in Appendix A.

Chapter 4 Case company

4.1 Bostads AB Poseidon

Bostads AB Poseidon, from now on referred to as "Poseidon", is one of the largest housing companies in Gothenburg with more than 26000 apartments and about 50000 tenants (Bostads AB Poseidon, 2014a). As a municipally owned company, their mission is to provide a wide variety of attractive and affordable homes, but also to strengthen and develop the areas in which they operate. Poseidon's property portfolio ranges from unique centenary buildings to modern it-integrated buildings. "Together we create green homes where people want to live and work." So reads the company's motto, which is reflected in their way to manage and develop the neighbourhoods.

4.2 Organization

Poseidon is a highly decentralized organization with only three hierarchical levels: VD, district manager and landlord (Bostads AB Poseidon, 2014b). The purpose of this structure is for decisions to be made as close to the tenants as possible, and thus increase the residences influence. The company consists of a line organization in combination with a business supporting organization, according to Figure 4.1. The business supportive function is in turn organized in two levels, centrally and locally. The central functions are tasked to support the districts and district managers whilst the local functions focuses their attention to one district to support the landlords. All of the company buildings and apartments are internally divided into 80 landlord areas, which in turn are divided into eight districts. For a more extensive review of company roles, areas and districts, see Section 4.2.1.

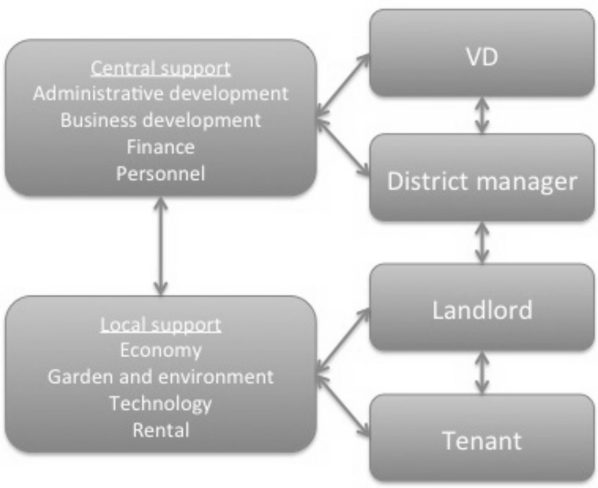

Figure 4.1: Organizational structure, developed by Bostads AB Poseidon (2014b).

4.2.1 Roles, working areas and interviewees

This section is a comprehensive description, based on the interviews, of the roles, working areas and selected interviewees, and serves to provide the reader with an understanding of responsibilities and unique characteristics. The different roles demand different information. The areas and districts differ in size, dispersion, age, condition etc., and consequently have different needs when it comes to operation and maintenance. Also, the particular individuals in question have different preferences dependent on age, experience, interest etc. These factors together contribute to a diverse view of the current and desirable situation. The areas, districts and some of the roles will be fitted with a letter for the sake of structure and clarity. Landlord A operates in Area A, Property engineer A operates within District A and so on.

The Landlord role

The landlords are working close to the tenants in the residential areas and are responsible for the maintenance and service of the buildings. They are the tenants contact person in all questions concerning their accommodation, and responsible for the tenants and administration within their own area. The landlord shall see to that the building functions are maintained and that they have a proper development. Typical tasks may involve handling of fault reports, relocation of tenants, communication with contractors etc. One of the landlords compares his function to an hourglass. Tenants or colleagues provide notifications of occurred problems, which the landlord forwards to appropriate discipline, often contractors, whom solves the problem. Somewhat simplified, the landlord's responsibility concerns the building interior, such as apartments, stairwells, laundries and storage rooms. The roles work tasks and practises depend on the individual but also on area specific characteristics.

Area A

Area A consists of about 600 apartments spread over a number of buildings in close proximity to each other. The buildings were built in the end of the 50's and beginning of the 60's but were subject to a comprehensive renovation project completed in 2003. The area today consists of relatively uniform low houses.

Landlord A

Landlord A is 27 years old. Before she started to work for the company, two years ago, she studied at the property academy and did her practice at Poseidon. Landlord A has a position of trust, where she supports other colleagues in their work with the property system.

Area B

Area B is a fairly compact area consisting of about 650 apartments divided on a dozen buildings. The area is newly built with building ages ranging from 2004 to 2013, containing relatively uniform equipment. It means that many of the buildings equipment has valid guarantee, which implies that supplier perform much of the necessary services.

Landlord B

Landlord B is 48 years old and has previous experience as painter, but has worked for the company 25 years now and as landlord since 1996. Landlord B has a position of trust, where he supports other colleagues in their work with the property system.

Area C

Area C consists of 650 apartments in buildings from the end of the 60's and beginning of the 70's. The area is compact which makes it possible to move across it in just a couple of minutes. The area is part of the million homes program and is characterized by relatively high unemployment.

Landlord C

Landlord C is 27 years old and has worked as landlord for Poseidon since 2012 and for another company since 2008. Landlord C has a degree from the real estate academy.

The Property Engineer role

The property engineer role is a support function on district level, intended to assist the landlords in questions concerning the buildings operation and maintenance. The property engineer is responsible for the maintenance money and should allocate them properly in the district to ensure the value and development of the properties. While the landlord's interest lies with the buildings internal, the property engineers focuses on the buildings external. They are responsible for initiation, planning and execution of maintenance and development projects, often involving measures concerning the building envelope, technical systems, media handling, energy consumption etc. The property engineer is also responsible for building maintenance plans, which are established in communication with the landlords in the district. The work tasks can be divided into planned maintenance and daily maintenance. Planned maintenance is carried out in accordance with a maintenance plan and may involve comprehensive building envelope measures. The daily maintenance is of more remedial character associated with the buildings operation. As for the landlords, the property engineers work tasks and practises depend on the individuals and specific district in question.

District A

District A is the company's third largest district containing just over 3700 apartments, spread over a relatively large area. The building age range, with the oldest building from 1912 and the newest from 2013, makes the district unique. The district contains so called "Landshövdingehus" built in tree with simple installations, as well as more modern buildings with more complex installation systems. The big difference in age implies substantial differences when it comes to the buildings requirements and maintenance need. What also characterise District A is the mix of residential and premises. The premises in the district contain a grocery store, health centre, dental etc.

Property Engineer A (PE A)

PE A is 50 years old and has worked for the company in three years. Previously, he worked for a housing entrepreneur for almost 30 years and has a lot of experience when it comes to buildings.

District B

District B is one of the smaller districts in the company, with a relatively compact building population with close to 2000 apartments. The district was built in the 70's and despite the diminutive size, it is among the largest million homes program district in Sweden. As many buildings developed at that time, they are not particular energy efficient and the building envelopes suffer from leakage problems. Partly because of that, the district has become subject for extensive renovations, including major and minor apartment renovations, strain renovation, building envelope measures etc. Due to tenants involvement in the projects and different preferences the district has developed, from a very uniform environment to a more diversified setting, both when it comes to the buildings exterior and interior, rent levels and people inhabiting the area.

Property Engineer B (PE B)

PE B is 43 years old and has been working for the company for two and a half year. Previously he worked as a technical administrator for the company.

District C

District C extends over a wide area and contains about 4000 apartments and is similar to District A when it comes to the building population. With the oldest buildings from the 30's and the newest from the 90's, it contains pre million homes program buildings, million homes program buildings and more modern buildings. Most of the buildings have a simple construction with natural ventilation systems. The district is currently subject for an extensive project, a development of 11 new environmental buildings/waste rooms that is in line with the company's environmental effort.

Property Engineer C (PE C)

PE C is 38 years old and has been working for the company for eight years. The time before Poseidon, he worked as property engineer at a hospital.

The Lessor role

The lessor is a local support function and responsible for the rental of apartments, and thereby the company's rental income. The lessor shall ensure that the rental process runs as efficiently as possible and in accordance with the applicable rules.

Lessor

The lessor is 50 years old and has been working in the company since 1982, first as cleaner, later as landlord, remodelling hostess etc., until she started as lessor in 1993.

The Controller – IT Systems role

The controller – IT systems is part of the company's central support function, and involved in the system development to reduce buildings consumption. The role implies the responsibility to maintain the system used to monitor the buildings technical systems. The controller – IT systems shall ensure that the communication between the technical equipment is functioning and that relevant values, more actively used by other colleagues, appears in the software.

Controller – IT Systems (ITC)

The ITC is 39 years old and have worked for the company as "Controller – IT system" since 2011. Earlier, she worked with similar systems but at a supplier as an operation and support manager.

The Garden Controller role

The garden controller belongs to the company's central support function and has two primary responsibilities: Development of outside environments and handling of waste issues. When it comes to the outside environment, the garden controller is responsible for the establishment of management plans and staffing, and acts as a consulting support to the districts. The garden controller is working closely with the environmental hosts. An environmental host is stationed in most of the areas and posses expertise in questions regarding outdoor environment and environmental issues. Except the responsibility for the existing two million square meter surface outside environment, the garden controller is also involved in the design of outside environments in new and reconstruction, where he supports the project leader in garden issues.

Garden Controller (GC)

The GC is 57 years old and has been working for the company as garden controller since 2008. Before that, he worked for a contractor for many years.

The Procurer role

The procurer is a central support function responsible for the procurement of the company requested services. Requested services may concern cleaning, painting, plumbing etc., and thus the role involves a lot of communication with contractors and suppliers. The procurer works with different kinds of contracts depending on situation, where framework agreement is used in the more everyday work, and unique inquiry specification are produced prior to larger projects with a budget exceeding 100000 SEK.

Procurer

The procurer is 42 years old and has been working for the company for about 25 years. Within the company she has held various roles such as economist, marketer, administrator etc.

4.3 Sources of building information

Poseidon uses a variety of systems, both of digital as well as of physical character, to handle the building information. This section discloses the most comprehensive system in use, and also the most relevant for this report, to provide the reader with an understanding of current practice and references made in the findings chapter. The descriptions of the systems are a compilation of information captured during the interviews.

Property system

The main system used by Poseidon, introduced 2011, is the property system FAST^2, a platform independent software for storage of property information. FAST^2 mainly provides the user with overall information regarding the tenants and apartments, but also include features such as maintenance, work orders and service requests, inspections, rental administration etc. The system offers different features dependent on user: Tenants can report faults, landlords can request contractors and contractors can accept job requests and get information regarding the issue at hand. By means of mobile and web-based units, operators and contractors can perform apartment inspections and report work orders without being bound to the physical office. To ensure the quality and facilitate the updating process of information, Poseidon has chosen to limit the amount of information integrated in the system. Due to interoperability issues, the company's IT-manager must today manually enter building data into the system. Therefore, the level of detail of information extends to selected unit types and the most recent action. The user interface is non-visual text-based, but the system is linked to the property archive where building- and apartment drawings are found. The overall object structure in the system is illustrated in Figure 4.2

Figure 4.2: The structure of the property system FAST[2], developed by Ulf (2013).

Property archive

The property archive is a system used for digital storage of building information. It contains operation and maintenance instructions and other additional building documentation. In the company's effort to archive a uniform information handling, a routine have been established, which means that all building information in physical form should be scanned and integrated in the property archive. The project network is an internet-based part of the property archive and used for information exchange by all parties involved in Poseidon projects. Information passing through the network is drawings and descriptions, schedules, meeting minutes and other relevant documents. Whilst the property archive is more static in its information handling, the project network is more of a dynamic system where documents are changing during the entire project. When a project is completed, the new and updated documents replace the matching ones in the property archive.

Physical archives

Much of the company's building information is even, or only, stored in physical archives, especially the one deriving from older buildings. Old documentation is not uncommon consisting of hand-drawn unclear drawings. The physical archives take many forms, everything from archive rooms to shelves in employee's offices or RTU[2] rooms. The information is usually sorted in binders with inconsistent labelling and exists in several versions.

Maintenance maps

The maintenance maps is maps over the buildings outside environment, containing surface types, plantings, trees etc. For example, all the trees on the company's land have been inventoried and hold information about sort, size and condition. Relevant information from the built documentation is used to produce the maintenance maps, which are established primary to facilitate the work for the garden controller and environmental hosts. Maintenance maps exists for all company areas and are mostly found in digital format in a separate system.

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[2] Remote Terminal Unit or Remote Telemetry Unit, a microprocessor controlled electronic device.

Energy system

The company's energy unit uses several systems where the FTE-portal is one of them. FTE stands for "future technologies and energy" and is an operational tool used to monitor the buildings technical systems. The data, which may relate to temperature, airflows etc., is received from sensors placed in the buildings. The system illustrates real-time information and status of the technical equipment, and alarms if the actual value differ too much from the set point. Another system used by the energy unit is Analyzer 3. Analyzer 3 is more of an analysis tool and provides information about the buildings energy and water usage.

Others

Poseidon data, a web-based system developed by the company, has many different application areas but is primary used as a reporting tool. The company's hired on call service, active on evenings and weekends when the landlord are unscheduled, uses the system to report occurred problems. Poseidon data also contains statistic on fault reports, waste data etc. SundaHus is another, relatively new, system, used especially in new construction or major reconstruction and renovation projects, to ensure that environmentally hazardous material is avoided.

4.4 Pilot project

Poseidon have initiated, and are currently in the middle of, a BIM pilot project, which is intended to increase the efficiency in projects, improve the internal understanding of BIM and also provide a basis for a strategy in forthcoming ventures (Bostads Poseidon AB, 2014). The project is a five storeys residential building containing 53 apartments. Prior to the project, Poseidon developed a manual, as a complement to their regular documentation guidelines, to control the work with the CAD/BIM-related information (Skanska, 2013). Poseidon did, in cooperation with the contractor Skanska, select a number of application areas where BIM were to be implemented:

- Intelligent 3D design
- Clash detection
- Quantity estimation
- Models at the workplace
- Facility management
- Visualization

Visualization was an important application area for the pilot project. Appropriate spaces, such as representative apartments and a restaurant section, were chosen for detailed modelling and visualization and resulted in a number of interior and exterior images. The requirement on the level of detail was rather high and included objects such as luminaires, fixtures and material with accurate appearances, sizes and locations. For Poseidon to benefit from BIM even after the project completion, they developed a list of information requirements for the FM phase:

- BOA, LOA and Atemp
- Object (apartment, premises, laundry)
- Object type (2rok, 3rok)
- Object number (land register reference, apartment number)
- Apartment spaces (kitchen, living room, bathroom etc.)
- Apartment items (windows, linoleum floor, cabinet doors etc.)

Chapter 5 Findings

This chapter presents the findings from the interviews, which constitutes the empirical data for this study. The chapter serves to provide an overview of the current practice and information handling within the company today. Based on the implementation processes suggested by Computer Integrated Construction Research Program (2013) and BIM i Staten (2014a), the interviews was structured in order to assess and map existing work methods to identify potential application areas for BIM. The first section presents the employees general perception regarding the information handling. It is followed by a comprehensive part covering the more problematic activities in detail. This part concludes with a summary of the requested building data, see Table 5.1. The subsequent paragraph presents the interviewees believed value of BIM. The final part presents finding regarding the company's cultural climate. For the sake of clarity and structure, the sections are broken down and presented by occupational role.

5.1 The information handling today

5.1.1 Landlords

That the current information handling has deficiencies becomes clear during the interviews with the landlords. A recurrent opinion concerned the vast amount of time spent searching for information in the many different storage locations, digital, physical or even so on site. According to the landlords, inconsistent and poor information handling have lead to impaired quality of the available building information, especially in older buildings, and resulted in decreased efficiency in their work. The interviewees believe different working methods are one source to the inadequate information handling and explain how some are more digital-oriented when it comes to handling building information. They mainly use the available systems to gather and update relevant data. Others have a more traditional craftsmen approach and prefer site visits and physical documents. Different working methods, allows flexibility for individual decisions and results in different way to handle and update the building information. The landlords have notice that the absence of clear requirements for working methods, over time, results in unstructured and unreliable data. Another problem, according to the landlords, concerns the newer employees dependency on more experienced colleagues or contractors. Due to the lack of better storage locations, much of the building information is stored within experienced personnel. The landlords bring up their concern regarding the matter. When employees retire or quit, or if contractors are replaced, much valuable information are lost. One of the landlords explains the company as traditional with faithful employees, many who have worked for them in many years, and knows the properties by heart. She brings up a potential future problem, with a changed work climate with increase employee turnover, where it becomes more difficult to have the personnel as information carrier. The landlords have noticed an improvement lately, when it comes to the information handling. The relatively new property system has facilitated their work through clear presentation of building information, simple updating process and mobile units. They all state the importance of an easy to use system and confirm the development is in the right direction. Landlord A describes FM as old fashioned and stresses the importance of development. According to the landlords, the time spent on information handling, see Figure 5.1, is dependent on experience and area characteristics. Landlord A explains how she as a new landlord spent a significant part of her day searching for and learnt to find relevant building information. Landlord B says he spend up to 50% of his time gathering building information when he worked in an older area with a diverse building population. The landlords find the building information they use in their everyday work, relatively reliable, especially the one inserted after the introduction of FAST^2. Landlord A says that one source to inaccuracies is when the tenants themselves make changes in the apartment and the landlord fails to notice it at an inspection. The interviewed landlords do not se the current updating process as a time consuming activity. They explain how the current property system contains a limited amount of information, and how the information, with only a few commands, automatically updates when it is maintained. Although, Landlord A explains how some colleagues do not feel confident using the property system and its functions. Landlord B sees the updating process as a part of the task that has been conducted. He says that it is important to understand ones own responsibility and that data updating favour on selves in the long run. Landlord C believes it is largely due to FAST^2 allowing for mobile and easy updates. The landlords do not see any problem with additional information in use of maintenance, as long as the maintenance of it still is based on a few simple commands. According to Landlord A, a system requiring manual entries of data would not work. She says that a new system must be perceived as easier to use than the previous one. According to Landlord B, as long as the extra time spent on maintaining the data is saved elsewhere, is fine. Landlord C states the importance that additional information must not mean more time spent at the office. The landlords describe how the role over time has developed to a more administrative profession with fewer touches of physical involvement.

5.1.2 Property Engineers

All three interviewed property engineers agreed that the information handling today is time consuming and has considerable potential for improvement. According to them, the biggest problem derives from the structuring of the building information. The information is stored in many different locations and versions, which make it difficult to find, if it exists at all. PE A explains how the physical archives, where for example operational and maintenance documents are found, is very inconsistent when it comes to structure and labelling. PE B means that without clear directives or a framework for how to handle information it is difficult both to find existing and sort new information. He compares it to "inventing the wheel" almost every day and resembles the situation as "running around and put out fires". PE B believes the problem partially derives from the deficient process of handover of documents to the FM phase after project closure. He says it lacks clear structure and follows up, resulting in inconsistent handling of it and hampers the use of it in the future. The property engineers bring up the downside of the company's application of many different systems. Even though they provide a variety of functions, it becomes difficult to keep track on where the information is found and goes, and who is responsible for it. The property engineers explain that their job is based on collecting, structuring, presenting, and storing building information, and consequently, much of their time is spent on information handling. Although, they all agree that the process could be much more effective. Their estimated time spent on information handling is illustrated in Figure 5.1. PE C explains, that despite years of experience within the company, the information handling takes up an unnecessarily large portion of the daily work. The property engineers describe the building information complete and reliable in the beginning of the buildings FM phase, but over time, due to poor maintenance of the information, it becomes obsolete. PE C explains how the lack of a clear framework for information updating leads to own assessments whether some information really needs updating. The property engineers describe the data updating routine as containing of many steps, such as printing, scanning, mailing, manual administration etc., resulting in a fragile and time consuming activity process. They do not see any problem with additional information integrated in the company systems, as long as the benefits from it out ways the downside of extra time spent on administration. Although, they points out the importance's of a user-friendly system with clear directives regarding the responsibility over the information.

5.1.3 Lessor, Controller – IT Systems, Garden Controller, Procurer

The lessor, ITC, GC and procurer believe that there is much to improve when it comes to the current information handling. According to the GC, most relevant building information exists in the company today, but is stored inconsistently, in many locations and versions, which makes it difficult to manage. He wishes he had more time for involvement in new construction projects but the maintenance of existing building population requires a lot of resources. The GC explains how FM is a broad area consisting of a diversity in personnel, all with different skills. According to him, the use of two-dimensional documentation is a major barrier in much of the communication because many involved parties are not accustomed to interpret drawings. He estimates that about 90% of the company employees have some difficulties understanding them, resulting in deficient communication and misunderstandings. He says that many of his colleagues today uses software like Google Maps instead of internal documentation to form on opinion in current issues. The estimated time spent on information handling is illustrated in Figure 5.1. The perception of the reliability of the current building information differs. According to GC, the updating process of data is insufficient resulting in unreliable information. He says many consider themselves fully knowledgeable of the area and ignores to update changes in the systems. According to GC, revisions of maintenance maps are a resource demanding activity. He explains how changes in the outdoor environment are mailed to the one responsible for the drawings, which then manually implement the changes on the documentation. The procurer agrees that older building information is rather unreliable but how the data updating has improved significantly in recent years.

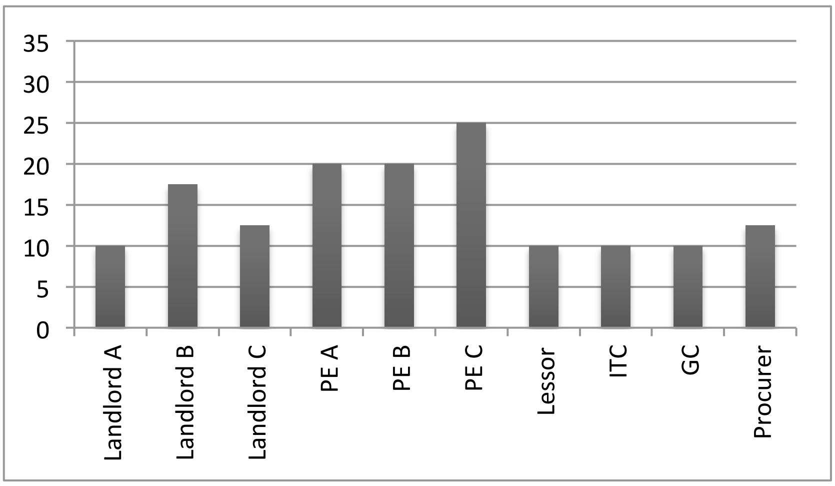


Figure 5.1: Estimated time spent on information handling in percent of total working time.

5.2 Problem areas

In this section, the interviewees describe the most problematic activities when it comes to the information handling. It begins with a summary of the requested building data, see Table 5.1, followed by a comprehensive description of each of the activities, sorted by profession.

Table 5.1: Summary of the interviewees requested building data.

Activities/Data	Landlord A	Landlord B	Landlord C	PE A	PE B	PE C	Lessor	ITC	GC	Procurer
Technical installations										
Routing[3]/3D-model	✓	✓	✓	✓	✓	✓				✓
Previous measures		✓	✓	✓	✓	✓				✓
Manufacturer & model (aggregate, pump etc.)				✓	✓	✓				✓
Capacity				✓	✓	✓				✓
Adjustment protocols					✓	✓				
Stem valves					✓					
Power switches					✓					
Flow						✓				
Set points						✓				
Setup						✓				
Area management										
Apartment areas	✓									
Public areas										✓
Colour codes										
Public areas			✓							
Article handling										
Major kitchen and bathroom equipment	✓	✓	✓							
Lock system										
Key-ID	✓		✓							
Cylinder-ID	✓		✓							
"Flex"-information[4]	✓		✓							
Luminaire										
Model		✓								
Effect		✓								
Amounts			✓							
Age			✓							
Visualization/Communication										
3D-model		✓		✓			✓		✓	
Lights and views analysis							✓			
Building envelope										
Amounts/areas/measurements				✓						
Previous measures				✓						
Constituent materials				✓						
Technical systems										
Location switches								✓		
Location sensors								✓		
Location main centrals								✓		
Outdoor environment										
Routing technical installations									✓	
Previous measures technical installations									✓	
Areas									✓	
Use									✓	

[3] Routing refers to the physical arrangement of plumbing, technical installations etc.
[4] Flex-information refers to how many times the lock have been changed.

5.2.1 Landlords

Installations and structure

Current situation/Problem description

The property engineers commonly deal with problems and questions concerning building installations and structure, although the landlords are faced with issues, of varying extent and complexity, related to them. Landlord A explains how the lack of comprehensible building information makes it difficult to answer even the simplest questions, deriving from tenants, colleagues or contractors, concerning these. She feels that questions of at least more basic character, such as routing of installation systems and main load bearing elements, should be possible to be answered on a landlord level. Today, the necessary information can be found in the property archive, but according to Landlord A, many employees lack the competence to interpret the drawings. She explains how many have learnt to work around this problem, resulting in wasted time, poor tenant service and deficient communication with others. Landlord C concur that the information about building installations is deficient. He believes the existing documentation often is unreliable resulting in uncertainties, especially regarding routings. Landlord C explains the difficulty, when a problem has occurred, to establish the source to the issue and thereby uncertainty in which discipline to contact. Contractors (or sometimes subcontractors to them) are instead given the responsibility to collect the necessary building information, a recourse demanding activity according to Landlord C. Much information lies with experienced entrepreneurs, but they are replaced from time to time, resulting in a fragile system. Landlord C also brings up the problem of missing information on previous measures on the building installations. The documentation today is sporadic and its structure depends on the people involved. He illustrates the problem by bringing up an example regarding a sewage leakage: Landlord C found out, after a time consuming search process, that the documentation and drawings were too unclear to be used. Instead, the contractor had to use a probe and a camera to establish the routing, an expensive arrangement. Another example is about a leakage under a floor which resulted in an almost 100000 SEK expensive measure due to uncertainty of the routing. Instead of a small accurate drill-hole, the entire floor had to be broken up.

Desirable situation and data

Landlord A calls for clearer illustration, like a 3D-model, of the building installations and structure to be able to answer at least questions of a more basic character. It would save her and her colleague's time and improve tenant satisfaction and communication with others. Landlord C requests easy accessible information about the routing of building installations and previous measures performed. According to him, it would not only improve the landlords understanding of an arising problem, but also improve the communication and information transferred to involved contractors.

Area management

Current situation/Problem description

Area management is a part of the landlord's daily work. It becomes relevant when repainting apartments, in carpet lying etc., but even if the landlords are involved in these activities, it is usually contractors performing them. Today, the company uses a procurement model based on unit prices. It means the cost is independent of the area and the contractors themselves are responsible for area estimation and quantification of material. Barrier painting is however an exception, where the cost is based on square metre. Barrier painting is an extra “paint” layer typically used when an apartment is nicotine damaged. According to Landlord A, there is a problem concerning apartment repainting performed by tenants. She explains how tenants are sent to the paint shop, which has been provided with drawings of the apartment by the landlord. The paint store personnel uses their experience to estimate the necessary quantity of paint handed out to the tenant. Without precise measurements, too much or too little paint is often handed out, resulting in an extra visit at the paint store for the tenant or a waste of resources for the company. Landlord A also brings up barrier painting as a current problem. According to her barrier painting is a relatively common measure performed in approximately three out of ten painting orders and the lack of area information makes it more difficult to plan and budget for prospective measures and also to follow up and verify contractor costs.

Desirable situation and data

Landlord A believes that information concerning apartment areas (walls, floor and roof) would be applicable in several situations. Besides facilitation to plan and control barrier painting work, area information could be valuable in the communication with contractors and paint supplier. Providing them with accurate measurements would likely increase customer satisfaction and decrease resource waste. Landlord A believes good knowledge about the buildings is reflected in the service to the resident. She also brings up the value of area information in an eventual future maintenance model that has been discussed. The current one is based on the maintenance need, where the landlord together with the tenant decides whether measures will be taken or not. The one that have been discussed implies that the tenant can decide upon maintenance in exchange for an increase in rent. In this model apartment areas would probably be more relevant with costs associated with the size of spaces.

Touch-up painting public areas

Current situation/Problem description

Building public areas often differ from each other when it comes to their appearance, especially the chosen colour theme. Unlike apartments, public areas, and particularly stairwells, can be subjects to touch-up painting, for example if it has been exposed to vandalism. Landlord C explains the problematic when a smaller surface in a public area is the subject for repainting, but no information about the current colour is available. The landlords may take a chance on the actual colour but then risk having to redo it. Another solution is to repaint the entire space. According to Landlord C, these activities are time consuming and leads to a waste of resources. He explains how he has developed his own archive to keep track on the colour codes in the different public areas to facilitate his work.

Desirable situation and data

Landlord C means that easy accessible information about public area (walls, floor, roof, doors and joinery) colour codes would save him time in his daily work and reduce the resource waste. He also think the information could also be valuable to contractors hired for repaint job.

Article handling

Current situation/Problem description

A lot of the landlord's daily work involves handling of apartment equipment, such as white goods or bathroom facilities, referred to as articles. When problem concerning these arises an apartment visit by the landlord is often required, in order to gather relevant information about the equipment in question and to assess who is suitable to perform the measure needed. Landlord A explains the problem to keep track on apartment equipment when the buildings gets older. The procurement form implies no consistency in contractors and suppliers, resulting in an increased diversity in equipment. She explains how she is running around between apartments, equipped with pen and paper, to gather the relevant information. She says that sometimes, necessary details are missing in work orders to contractors and the landlord or the contractor is obliged to do an extra apartment visit. This is, according to Landlord A, not just a time consuming activity for her, but also frustrating for the tenants. She does not see it as a daily problem today, due to the buildings condition in her area, but has noticed an increase, and believes it probably will be in a couple of years. Landlord B and C confirm the problem with article handling. All three interviewed landlords says that much of the building information is found with experienced colleagues and contractors, which makes new employees very dependent on them. According to them, when employees quits or contractors are replaced, a lot of valuable knowledge of the buildings, apartments and equipment is lost. They see the unstructured way to transfer and store knowledge as a significant problem

Desirable situation and data

The landlords call for easy accessible information about the apartment articles. The requested information concerns manufacturer, article-ID, dimensions, effects and previous measures on larger apartment equipment such as refrigerator, freezer, stove, oven, faucet, WC, wash basin, bathtub etc., They believe it would facilitate the communication and collaboration with the contractors through more accurate information in the work orders. They also believe that many apartment visits could be avoided, resulting in time saved for the landlords (which instead could be used for preventive measures) and improved tenant service. The tenants would appreciate to avoid schedule for repeated apartment visits. According to Landlord B, tenants expect to have problems solved quick and easy. Although, Landlord C says that it is a big part of his job to keep tenants satisfied and he says many of the tenants, especially elderly, new residents, unemployed and immigrants, appreciate and value visits from the landlord, and he means that the greatest value rather is the time saved on administration and communication with contractors. According to landlord B and C, apartment visits can never be completely avoided and is sometimes a prerequisite to gather correct and accurate information. Instead of have the employees as carriers of much information, the model could be used to structure and store the information consistent.

Lock system

Current situation/Problem description

The company uses a lock system in their properties based on lock cylinders with associated keys. That is useful when changing lock, allowing for just a key change up to three times, instead of a more expensive cylinder replacement. A lock schedule, digital and/or physical exists to keep track on current cylinders, keys and where they go. In case of a lock change, the landlord contacts the locksmith, provides him with relevant lock information and is equipped with new lock equipment. According to Landlord A, the lock schedules are obsolete, and due to deficient maintaining, unusable. That often makes the process of identifying the current key-ID's cumbersome. She says that the current lock information might be stored at the locksmith, but the locksmith may change and are therefore not a reliable source. The key-ID is engraved on the key and can also be retrieved by contacting the tenants. Although, landlord A explains the difficulty, especially for elder, to communicate the information over the phone and how it often leads to misunderstandings. Usually, a meeting with the tenant is therefore necessary. Landlord A explains it as frequently recurring problems, resulting in lot of wasted time, both for her and tenants. Landlord A and C believes that the lack of visual aid hampers their work concerning the lock system. Even with key-ID in their possessions, inadequate or even missing drawings over the buildings, especially public spaces, makes it hard to trace where some of the keys leads. Landlord C explains how he occasionally walks around in the building to match keys to spaces. This leads to a situation with unutilized spaces and a lot of wasted time.

Desirable situation data

Landlord A requests detailed information about the lock system and means that it would not just save her a lot of time searching for information, but also improve the tenant service. Landlord A and C want to have the lock system information integrated with clear building drawings to facilitate the matching of keys to public areas. Landlord C explains how it would simplify his daily work and save him time spent on site visits and also the value it would imply to new inexperienced employees.

Lightning and luminaire

Current situation/Problem description

The landlords are responsible for building equipment including maintenance of lamps and luminaire. The normal procedure, when a light source is in need of maintenance, involves a site visit in order to obtain necessary information such as luminaire type and effect. Thereafter, the landlord heads back to the office to get appropriate supplies and then go back to the light source to perform the replacement. Landlord B explains the diversity in equipment type. One residential area contains more than 1500 light sources with varying luminaire and over 40 different types of bulbs and fluorescent lamps. According to him, it takes time to get well known to the area, and a lot of time is spent on site gathering information. The relevant information can be stored within experienced colleagues or contracted electricians, otherwise site visits becomes necessary. Landlord C brings up the problem with lightning and luminaire, but means that information about luminaries and effects are irrelevant, due to the equipment homogeneity in his area. Although, he points out the problem when it comes to larger orders of luminaire change. Due to lack of relevant information about luminaire and lamp amounts, he has to do site-visits in about 45 basements equipped with pen and paper, in order to establish an inventory. He explains, that even though one buildings inventory can be applied in other similar buildings, there are still many unique spaces that must be inventoried.

Desirable situation and data

Landlord B means that relevant information about lamps and luminaries, a mouse click away, would imply a significant decrease in time spent on information gathering site visits. He believes that one site visit per issue often could be avoided. Landlord C calls for information about the amounts and status/age of lamps and luminaire and state that it could save the landlords a lot of time, especially in larger equipment replacement projects. He also brings up the value of age information with the increasing use of LED lights. Unlike traditional lamps, LED lights have a decreasing effect resulting in gradually lost function. Planned changes of them will be necessary and age information can be used to easy calculate their status and remaining life.

Communication/Visualization

Current situation/Problem description

Newly constructed buildings imply lots of warranty issues. That means that the suppliers themselves are responsible for problems occurring to equipment and installations, and the landlord role can be seen as more passive, compared to in older properties. Suppliers and contractors, in need for information, therefore become frequent visitors to the buildings. According to Landlord B there is a time-consuming activity to guide these parties, not as familiar to the buildings as the landlords, to the location of arisen problems. Drawings are sometimes used in communication purpose, but misunderstandings occur easily, often resulting in a need to meet up with them and follow them to the exact location. Landlord B explains how he in his daily work, experience the value of having a three dimensional model. When one of the companies newer residential areas was complete and transferred to the FM phase, Landlord B managed to get access to and retain a three dimensional presentation model used in the production process. The model allows for the user to get an overview of the building exterior, obtain floor- and apartment plans and visual details about apartment equipment. Landlord B considers the current property system together with the model as a powerful tool when it comes to gather and communication building information.

Desirable situation and data

Landlord B calls for a 3D-model to facilitate the communication of building information to contractors and also colleagues, and thus, lead to fewer misunderstandings and reduce resource waste. He thinks, that a similar model that he have the privilege to use in his everyday work, should exist for all the companies building.

5.2.2 Property Engineers

Planned maintenance - Building envelope measures

Current situation/Problem description

When it comes to planned maintenance, with energy savings as a common objective, measurers concerning the building envelope, including roof, wall construction, façade and windows becomes relevant. A planned maintenance project is usually preceded by an inventory of the building status, to for example determine facade condition or confirm roof material. The demands are the same for older buildings causing an equal need for relevant and accurate information about them. Most of the company's buildings have at some point been inventoried and raw data, such as amounts of windows, roofs and facades areas and previous maintenance measures was stored in a previous property system. PE A explains the difficulty to see the maintenance need and plan the maintenance without the necessary information about the buildings. The process of gather relevant building information is somewhat facilitated through the raw data from the old system. PE A says it provides him with a reasonable perception of the building status and allows him to do rougher estimation of planned maintenance activities. Although, the information is not maintained and over time it becomes more obsolete and unreliable. Due to deficient information about the building envelope, much time is spent on reviewing drawings and documentation or on site visits. Doubts concerning the wall construction may lead to the need to drill a hole through the wall to decide upon its constituent materials. PE A explains that the problem with deficient building information always occurs in larger projects involving the building envelope, which is carried out about three times a year in his district. PE C does not find the planned maintenance and building envelope measures problematic due to the long interval between actions taken. More comprehensive building envelope measures are carried in about 30 to 50 years cycles, and there between, not much is happening. PE C believes that easy accessible information about the building envelope of course could be useful in some situations, but according to him, counting windows, calculate façade or roof areas etc., is not a resource intensive activity. PE C compares residential buildings, which he means are relatively uncomplicated, to more complex facilities like a hospital. He says that with some experience its relatively easy to form an understanding about the residential buildings structure and installations, even without accurate documentation. The pipes and installations are often found where you think they are.

Desirable situation and data

PE A calls for easy accessible information regarding the building envelope including roof, walls, windows and elevators. The requested information concerns amounts/areas/measurements, previous measures and constituent materials. He says that the site visits still often would be necessary; it would provide him with a quick overview of the buildings status and facilitate the directing of maintenance. It is not the details but the overall picture he strives after. Accurate raw data on windows, façade and roof are valuable information when budgeting time and costs for upcoming projects. Information about previous measures taken would be useful to avoid maintenance on recently already maintained object, for example a part of a brick façade. Material information would provide a good basis for estimation of products life span. For example, wooden windows wear out sooner than aluminium windows. Wall construction information would be very useful when analysing buildings energy consumption.

Planned maintenance – Larger project

Current situation/Problem description

Larger planned maintenance project, like renovations or reconstructions, implies an extensive information need in the design and planning phase. Today, consultants perform much of the information collection, but with assistance from the property engineers. According to PE B, the most commonly sought after information concerns the building installations, which the consultants spend a lot of time searching for in the digital or physical archives. He says that the relevant information exists somewhere but is hard to find, and they may need to get out on site, to the actual building or sometimes the “The City Planning Office”, to acquire it. The information gathering takes a lot of time, and thus, cost a lot of money.

Desirable situation and data

PE B requests easy accessible information about Technical installations such as routing, manufacturer (aggregate, pump etc.), model, capacity, stem valves, and adjustment protocols. According to PE B, site visits are always useful and maybe necessary, to form a satisfactory understanding of the buildings current status, but state that time and money could be saved in planned maintenance projects, by providing consultants with relevant information. He sees the unpredictability as the nature of FM but believes that easy accessible relevant building information would allow for a better understanding of the buildings, letting employees stay one step ahead, and increased preventive work. PE B adds that increased knowledge of the buildings you are working with would make work more enjoyable.

Daily maintenance - Premises adaption

Current situation/Problem description

The property engineer's daily maintenance is often associated with the company's premises. The future of the premises is relatively uncertain, due to the nature of changing operation and diversity of tenant, and is therefore often subjects for reconstruction. According to PE A, questions concerning premises adaption occurs on a daily basis and involves premises changes and development and building installation capacity. PE A brings up an example where a restaurant may want to expand their kitchen and wonder about the ventilation capacity. The information is either gathered through time consuming searching in operation and maintenance instructions or by hiring expensive consultants, which on site performs relevant investigations.

Desirable situation and data

PE A calls for easy accessible information about the building installations together with a three-dimensional user interface. Technology rooms, installation central and RTU contains a lot of information that would be especially valuable to have easy access to. It would not only provide the tenants with quick answer to their questions, but also improve the property engineers understanding of the premises, facilitate the communication and avoid misunderstandings.

Daily maintenance - Installations

Current situation/Problem description

The property engineers are in their daily maintenance often faced with questions concerning the building installations. Often do they derive from a landlord, maybe accompanied by a consultant, who is in need of building drawings and documentations. It may relate to a pipe leakage, electricity problem, problem with an expansion vessel or temperature anomalies in apartments. It can also be questions concerning the mandatory ventilation inspection (OVK), performed, by certified inspectors, at predetermined intervals depending on type of building. PE B explains a time consuming and frustration search process that often follows questions concerning building installations. The problem, according to him, is the variety of information storage locations. If the relevant data is not found in the digital property archive, it may be found in any of the binders, kept on his office or perhaps with the buildings RTU. Information about older buildings is often not found at all and much of the documentation consists of copies of already unclear drawings, making them unusable. PE C explains how the first step in apartment related problems, typically related to ventilation or heating, involves an overall inspection performed by the landlord. If the problem still prevails after the inspection, the property engineer usually get engages and begins the search for relevant information such as adjustment protocols, valve information etc. According to him, the inconsistent handling of building information is a source to the problem. He explains how new documentation is just added to current documentation instead of exchanged, quickly leading to an almost unmanageable amount of information. According to PE C, the same thing applies to the information gathering concerning the OVK. He explains the activity of collecting relevant information from the buildings operation and maintenance instructions to the contractor performing the OVK, as very time consuming. The physical binder may be lent out to someone or disappeared.

Desirable situation and data

PE B and PE C requests easy accessible information about the building installations. Such as routing, manufacturer (aggregate, pump etc.), model, capacity, stem valves, adjustment protocols, power switches, flow, set points and setups. PE B believes that a virtual interface would facilitate the communication of building information and shortens the time for the information search process. It would also be of great value especially to new employees to quickly form an opinion of the buildings. Easy accessible information could also motivate the landlords to solve upcoming problems themselves.

Energy declaration

Current situation/Problem description

When a new building is complete, an energy declaration shall be established. Normally, the property engineer is responsible for gathering the relevant information, which then is forwarded to consultants responsible for creating the declaration. An energy declaration is established only once, but according to PE A, it is nevertheless a very time consuming activity involving a lot of information handling. PE A, says that the consultants sometimes are given the responsibility even for the preparation of information, which cost a lot of money.

Desirable situation and data

PE A means that easy accessible information about a buildings technical system such as routing, manufacturer (aggregate, pump etc.), model, capacity, age would facilitate the preparation of energy declarations and result in saved time and money.

5.2.3 Lessor, Controller – IT Systems, Garden Controller, Procurer

The leasing process

Current situation/Problem description

When apartments become vacant for rental the company publish them on the web. The information available for the applicant, uploaded by the lessor, derives from the property system and contains raw facts like address, floor, number of rooms, rent etc., together with attached drawings to allow for an increased understanding for the interested. The Lessor explains how unclear information and uncertainties about the apartments results in numerous applicants. Many of them have trouble with interpreting and forming an understanding based on the drawings, and the lessor has to spend a lot of time answering their questions. During apartment visits it becomes clear, that many of the applicants have the wrong idea of the apartment, often regarding the lights or the floor plan. For example, she explains how the four room apartments are believed to consist of 3 bedrooms when they actually just have two bedrooms. She means that this problem leads to a lot of wasted time for all involved parties in the leasing process. The selection process takes longer time due to the involvement of "wrong" applicants, the landlords and current tenants have to perform unnecessary number of apartment views and the lessor get more administrative work. The Lessor also brings up a problem associated with newly built apartments. In older/existing apartments is it possible for the interested to visit it and form an opinion. Due to economic reasons, newly built apartments shall often be leased before completion, which poses a problem in the promotion of it. The only basis for the lessor in the communication with interested is drawings and oral description. She says that the deficient information base makes it feel unprofessional and can easy lead to misunderstandings.

Desirable situation and data

The Lessor wishes to provide future tenant with a more holistic view of the apartment, building and neighbourhood during the rental process. She requests a 3D-model including apartments, balcony/patio, surrounding area and the possibility for lights and views analysis. She thinks a virtual model could be of great support in the marketing process of an apartment, resulting in more accurate understanding of the object by the applicants, leading to a more effective leasing process. She says that apartment visits are necessary and often inevitable, but sorting out the true interested could save a lot of time. She also state the value of a virtual model in the promotion process of new buildings, where it would not just facilitate her work, but also be appreciated by future tenants. At last, the lessor brings up a potential future value of a virtual model, where the demand and supply relation were different, and the model would be valuable from a competitive perspective.

Technical system equipment

Current situation/Problem description

The technical system equipment is components used to provide the systems, primarily used by the company's energy unit, with relevant information. The information is mainly used to monitor and ensure that the buildings energy systems are working properly. The equipment, which may be a switch or a temperature sensor, are usually located at suitable places on site such as close to the RTU, in the electrical room or at the building façades. The ITC explains how failure on the technical system equipment often calls for a site visit but how information about the equipment placement is inadequate or non-existent, leading to a problem to communicate relevant information to the landlord performing the measure. Despite the fact that the equipment usually are found at expected locations or that experienced landlords are well familiar with the buildings, the ITC see this as a significant, time consuming (especially for new employees) and frequent occurring problem.

Desirable situation and data

The ITC calls for easy accessible information regarding the placement of technical system equipment's, such as switches, sensors, central for lock-system placement etc. She says that accurate location information would facilitate the communication with landlords, and especially new employees, significantly, resulting in time saved and less system downtime. The ITC points out that much of the equipment is remained unchanged during many years and therefore requires minimal data maintenance effort.

Outdoor environment – Technical installations

Current situation/Problem description

Not only the buildings, but also the building surroundings can be subject for comprehensive information handling. According to the GC, drainage problems are relatively common to building surroundings, and where a need for information about technical installations, especially routing, arises. He explains the difficulty to find relevant drawings and documentation over the outdoor environment areas, even for more modern buildings. The lack of information might even result in a need to get out on site and dig, to gather relevant data. Usually, older areas with poor drainage are subjects for such measures. According to the GC, deficient information leading to excavation of building surrounding happens two to three times a year and is a very time- and cost consuming activity.

Desirable situation and data

The GC calls for easy accessible information about routing and previous measures on building installations such as storm water conduits, spill lines, wastewater pipes, rinsing well and electric lines below ground in the outside environment. He believes it would facilitate a quick understanding of encountered problems, resulting in improved communication between parties involved and a more resource effective solutions. He says that information about previous measures also would be valuable in the assessment of reasonable measures.

Outdoor environment – Visualization

Current situation/Problem description

In new construction projects, the GC is responsible for exanimating plans over the buildings surrounding area. The task involves reviews of a variety of documents, to ensure an as effective as possible future maintenance, where the GC is engaged in decisions regarding surface choice, tree placements, hedges selection etc. The GC explains the difficulty, despite his experience and skills in interpreting drawings, to form the necessary understanding over the planned area, using two-dimensional information-intensive drawings. He says that land elevation in particular can lead to misinterpretations and future problems. According to him, the process of examining planned areas takes a lot of time and misunderstandings are not unusual.

Desirable situation data

The GC calls for clearer illustration of the documentation in new construction projects, in the form of a 3D-model of the outside environment. He believes it would facilitate the understanding of the building surrounding, resulting in less misunderstandings and a more effective evaluation.

Outdoor environment - Resource planning

Current situation/Problem description

Area information is essential for those working in the company's outdoor environment. Except that the contractor cost is based on area, a districts maintenance, and thus resource need, depends heavily on its surface types and sizes. For example, large lawns require much maintenance during the summer season. The GC explains how area quantities exists in the company today, but how it over time, becomes increasingly unreliable, due to poor maintenance. He believes the poor maintenance is due to poor computer skills among the personnel and incomprehension about the purpose of the data updating process. According to GC, the increased deteriorating information results in poorer information basis to contractors and increased imbalance in workload among employees in the outdoor environment.

Desirable situation and data

The GC calls for easy accessible information regarding the outside environment areas use and size. He believes it would imply a great value to him in his work to plan and coordinate the resources. The information could be used in the communication with contractors and to accurately forecast the maintenance, dependent on district and season.

Procurement- Technical installations

Current situation/Problem description

Larger reconstruction and renovation project is preceded by a procurement of relevant services, performed by the company's procurers. Before the procurement process can begin, necessary building information must be collected for contractors to base their cost proposals on. The procurer is involved with the preparation of these requirements specification. According to the Procurer, a lot of the relevant information for the specification concerns the building installations, information often bothersome to obtain. She explains how the search process involves reviewing of out-dated, unreliable documents and drawings and how the uncertainty not uncommon is to great and thereby results in the need to hire consultants to perform the information gathering. According to the Procurer, this is a resource wasting, almost weekly occurring problem.

Desirable situation and data

The Procurer calls for easy accessible information about the buildings technical installations such as routing, manufacturer and model (aggregate, pump etc.) and capacity. She believes it would facilitate the information collection significantly, prior to the procurement in reconstruction and renovation projects. She also thinks that complete and equivalent building information to the contractors would make their offers more accurate and easier to compare.

Procurement – Area management

Current situation/Problem description

When a building is subject for a reconstruction- or renovation project, the procurer often encounter questions concerning building public areas. The area information is relevant for contractors to estimate their costs for future services such as painting and cleaning. The Procurer explains how contractors today may use drawings to measure and calculate building areas, but how they usually prefer site visits to obtain additional information such as current condition. According to the Procurer, the lack of building area information leads to less accurate and more scattered cost estimates from contractors.

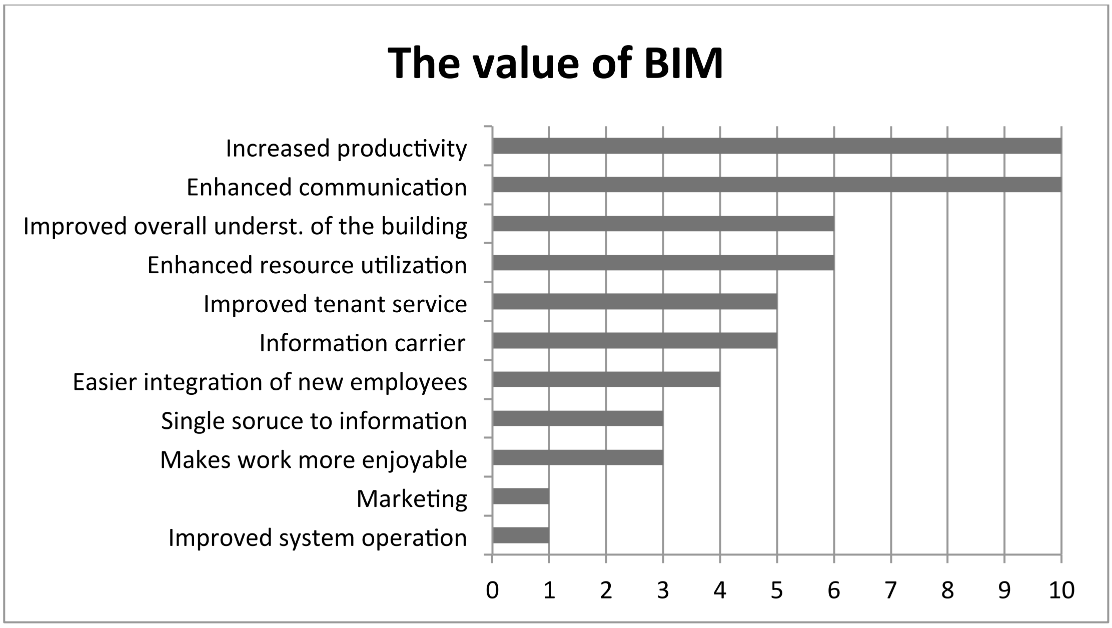
Desirable situation and data

The Procurer calls for easy accessible information regarding the buildings public areas (walls, floors, roofs), and believes it would result in an improved communication with the contractors leading to more accurate cost estimations and resulting in a more efficient procurement process.

5.3 The value of BIM

The interviewees were asked where they thought BIM, explained according to the definition in Section 2.2.1, would imply the greatest value in their work. Just like everyone agreed on the current problem concerning information handling, they all believed that BIM would be of great value to them. PE B and PE C even stated that it probably could change the property engineer role fundamentally. Table 5.2 presents the interviewees believed greatest values of BIM.

Table 5.2: The interviewees believed value of BIM. Since 10 interviews were conducted, 10 are the maximum value.



5.4 Organizational culture

To assess the receptiveness of BIM implementation in the company, the interviewees were asked questions concerning the organizational culture. The landlords consider the receptiveness of new techniques and working practices as very mixed and highly dependent on employee's age and interest. The company has a relatively high average age and they believe older employees constitute a greater resistance to change. Landlord B appreciate that 70% are positive to change, 15% doubtful to change and 15% are against it. According to him, due to different working practices, there will always be those whom will resist changes, especially changes of digital character. He explains how the transition from paper-based to more digitalized FM, many years ago, was opposed. Later it turned out that the biggest opponent were the one most satisfied with the new system. The landlords are worried that a lot of system changes recently in the company may constitute a barrier for the introduction of further changes. Although, the advantage, according to Landlord C, is that it exist an organization for system education and employees are used to it. Landlord A also refers to previous system changes and points out a lack in support of implementation. Even though the quality in the training was satisfactory she explains that the no mandatory sessions and arrangement of intensive training in a short time without any significant follow up, has lead to insecurity for many employees using the full potential of the system.

Although, the landlords think that new technique is welcomed, as long as the responsible clearly communicate the benefits, proper training is provided and employees together take joint responsibility and help each other during the implementation.

None of the property engineers believe that the introduction of a new system would encounter serious resistance as long as the implementation is well conducted. PE A explains how many employees see the information handling as such a great problem and are willing to make an effort to achieve change. He refers to the transition to the current property system and believes the training and support was handled really well from all involved parties. According to PE C, many of the property engineers are relatively young with computer experience that probably would facilitate a change process. He can see that the organization retains employees who hate digital information handling, those who loves it and everything in between. He says, that as long the benefits of new technique is made clear, and it is not just perceived as another system, it will be received with acceptance and positivity.

The Lessor experience, that recent system changes may constitute a problem to additional new technique or working practises. She says it is important that employees feel safe and secure in the system they work with. The GC estimate that 50% of the employees are positive in case of new technique introduction. He says that many of the environmental hosts are unfamiliar with computers, and sees it as partly a generation issue. The Lessor, ITC, GC and procurer all state the importance of an easy to use system and the clarifying of benefits in the introduction of new techniques.

Chapter 6 Analysis and Discussion

The information handling today

The findings from the interviews show that the employees find the current information handling problematic. The nature of the problem seems to consist in an inconsistent way of handle building information, with start already in the handover process, resulting in employee's decreased productivity and little preventive work. The current situation within the company corresponds well with Teicholz (2001) perception. As mentioned in Section 2.1.1.5, he argues that the FM practice is characterized by its reactive approach, and that the lack of proactive management leads to inefficient use of resources. The situation can also be compared with Hardin (2011) and William East et al. (2012) explanations over FM challenges, covered in Section 2.1.1.5. According to them, the information handling is one of the greatest challenges within FM, and they argue that poor information handling results in poor resource utilization. The observed problem can furthermore be analysed by means of the three-element model developed by FMI. As described in Section 2.1.1.1, the model illustrate the fundamental idea behind FM and the integration of employees, work processes, and workplaces (Teicholz, 2001). The findings indicate a shortage in the correlation between these elements, and especially between the employees and work processes. The interviewees estimated time spent on information handling corresponds well with Latham (1994) finding that 10- to 30% of facility engineers time is wasted on information searching. It is therefore reasonable to assume that there is great potential for productivity improvement within the organization. During most of the interviews, it only took the first question to get the interviewees committed and it became evident that they had strong opinions and a lot of thoughts about the information handling. This can be seen as a confirmation of the company's demonstrated concern regarding the issue. Not just have they noticed the problem but also taken a step in the right direction when they have expressed their interest for BIM, a suitable solution for integration of employees and work processes. It is suggested that the company really takes the information-handling problem seriously and continue their pursuit for improvement.

Problem areas

The main purpose of the interviews was to map the company's current practice regarding the building information handling to find potential application areas of BIM. As a consequence, the interviewees were asked to describe problematic activities and also how they would prefer the situation. The desired situations, specified by the interviewees, correlates well with the current and potential application areas of BIM in FM described by Becerik-Gerber et al. (2011), see Table 6.1.

Table 6.1: Interviewees brought up problem areas vs. BIM application areas.

Problem areas	**Matching BIM application areas**
Installations and structure	Locating building components
Area management	Space management
Touch-up painting public areas	Locating building components
Article handling	Locating building components, Personnel training and development
Lock system	Locating building components
Lightning and luminaire	Locating building components
Communication/Visualization	Visualization and marketing
Planned maintenance - Building envelope measures	Planning and feasibility studies for noncapital construction
Planned maintenance – Larger project	Planning and feasibility studies for noncapital construction
Daily maintenance - Premises adaption	Planning and feasibility studies for noncapital construction
Daily maintenance - Installations	Planning and feasibility studies for noncapital construction, Personnel training and development
Energy declaration	Locating building components
The leasing process	Visualization and marketing
Technical system equipment	Controlling and monitoring energy, Personnel training and development
Outdoor environment – Technical installations	Locating building components
Outdoor environment – Visualization	Visualization and marketing
Outdoor environment - Resource planning	Space management
Procurement- Technical installations	Locating building components
Procurement - Areas	Space management

This matching proves that BIM is a viable alternative solution to the problematic information handling in FM. Even the BIM application areas described by Becerik-Gerber et al. (2011) not brought up and directly matched to problem areas in Table 6.1 seems to offer value to the company. For example, During the interviews, it becomes clear that one of the major problems in the information handling concerns the many storage sources of data. "Facilitating real-time data access" is a BIM application area that provides a unified data access point in which the data, along with the knowledge gained during maintenance and operation of facilities, can constitute a knowledge management database. The problem concerning the inadequate project hand over process is also brought up during the interviews. The submitted information is transferred into the property system by manual entering's by the company's it-manager. A BIM application area described as "Creating and updating digital assets" makes it possible to capture, digitalize, and transfer the necessary data in more efficient manner.

The theoretical research regarding BIM coupled with the experienced problem concerning building information handling in the company, highlights BIM potential value. Almost all problems described by the interviews can be matched to the theoretical BIM application areas. A possible explanation to why some areas were more distinctive than others, for example "Locating building components" contra "Checking maintainability", has to with the selection of interviewees. None of the interviewees can be considered top-level management, which probably are more engaged in issues associated with "Checking maintainability"- functions. Given how well BIM application areas matches the currently perceived problem regarding the building information handling within the company today, it is suggested that the company continues their endeavour to implement BIM.

To focus on current practice to identify potential BIM application areas could pose a problem. The interviewee's answer regarding the desirable situation is still based on a fundamental working practice. For example, the interest for area information in the procurement stage was relatively low because the procurement was based on unit pricing instead of space size. Also, much building information was considered irrelevant because external contractors were responsible for its collection and thereby that information had no direct value for the FM-personnel. The company should therefore be aware of the potential of additional values of BIM in FM. In their BIM implementation effort it is suggested that they dare to think outside the box and not just consider smaller scale changes, but even those of more fundamental character. In further BIM studies, the company could focus on the suppliers and contractors and take into account their interests to achieve a broader and even more productive.

Area characteristics

The findings from the interviews indicate that the area/district characteristics had a considerable impact on the interviewees' perception of current and desirable situation. Site visits in areas with smaller distances were considered less cumbersome. More recently built areas were considered consisting of uniform buildings and equipment making them more manageable. Even the residents in the areas influenced the interviewees perception of the situation. Tenants in areas further away from the city center, and particularly in "The million homes program", understand, to greater extent, apartment visits as good tenant service, unlike many others who consider them annoying. Due to the potential of BIM to decrease site- and apartment-visits, it is therefore suggested that the company do not improve their productivity at the expense of tenant satisfaction. Requested building data will depend on area characteristics and it ought to be in the case company's interest to first meet the need independent of area.

Diversity in systems

BIM as a single source to building information was a subject discussed, if not explicitly, implicitly, during all the interviews. Much of the currently perceived problem has to do with the unstructured way of handle building information and many of the interviewees became attracted to the idea of a single source to information. The desire for a single electronic data repository for building information fits well with the explanation of future BIM use, where building data is contained in a single model and where all parties involved in a buildings life cycle exchange information through a single information exchange standard (Smith and Tardif, 2012). Many discussions during the interviews revolved around the many systems in use by the company. Even though there was an understanding, and even in some cases appreciation, for the many systems and functions, one could clearly distinguish an irritation among many employees. Because of the already strained work climate, they seemed to perceive additional features only as something bothersome to acquaint them with. However, it should be seen as a something positive that the company are flexible and open for new solutions. Although, the company is suggested to see BIM as a possibility to integrate functions and systems to a more holistic solution, and thereby, still offer diversity in features, but in a more understandable and manageable way.

BIM implementation

This study has mainly focus on the early stages of BIM implementation. Based on the implementation strategies, covered in Section 2.2.3, an assessment of the organization have been carried out in order to identify potential BIM application areas. The assessment has resulted in areas and data, which should be seen as guidance for the future. In the company's further implementation efforts they are suggested to follow a similar procedure proposed in the two reports mentioned in Section 2.2.3. The next step should be to identify key performance indicators in which the expected improvement could be measured against. Subsequently, an assessment of benefit and cost, based on estimation of expected results should be conducted to determine on continued work on testing and initiation in pilot projects. The company is also suggested to use the advantages of being a public organization in their BIM implementation efforts. As Cotts et al. (2010) and (Teicholz, 2001) state in Section 2.1.1.3, public sector FM are organized and often deal with large, complex projects and issues in an effective manner.

Pilot project

With reference to the above suggested implementation process, the company can be considered have jumping ahead, since they already are in the middle of a BIM pilot project. In this project the company have in cooperation with the contractor selected a number of application areas and the owners have imposed requirements on information content indented for the FM phase. Many of the application areas and data correlate with the desirable information revealed during the interviews, such as visualization, areas and apartment items. The company can therefore be considered having a decent understanding of the prevailing situation and moving in the right direction regarding BIM application areas. However, as Eastman et al. (2008) put it, clear data requirements from the owner are a requisite for successful BIM implementation. This study has resulted in concrete data requested by operational personnel, which should be used as guidance in the preparation of requirement specifications. It is suggested that the company combine their experience from the pilot project and the result from this study in their further BIM efforts.

COBie

Even if the focus in this study not have been of technical nature, it is difficult to exclude the interoperability problem when discussing BIM. The BIM interoperability problem exists in all building phases, but becomes particularly clear for the owner at project completion when building information is to be handed over. COBie, a relatively new concept, identifies content of information delivery required by specific project team members during design, construction, and commissioning, and have been developed to facilitate and enhance the information handover process. As shown in Section 2.2.4.2.1, COBie deliverables corresponds very well data required by the interviewees, summarized in Table 5.1. Since COBie is such a new concept, and the yet scarce proliferation, it is probably difficult that today initiate partnership based on COBie deliverables. It is however suggested, that the company understand the possibilities COBie may offer in the future, and that they keep themselves updated on its progress.

The value of BIM

The findings highlights the areas in which the interviewees' believed BIM would provide most value. "Increased productivity" proved to be the most mentioned benefit. That opinion is also amplified by the interviewees' estimation of time spent on information searching, which turned out to vary between 10- to 25%. This finding correlates well with the argumentation held by Latham (1994), see 2.2.1. He argues that 10- to 30% of facility workers time is spent on information searching and that a 30% productivity increase could be achieved through BIM. It is suggested that the company see this findings as confirmation on the current problematic handling of building information, but also the suitability of BIM as an applicable solution. Other application areas highly valued had much to do with the visual functions of BIM. The interviewees discussed a lot about increased communication and facilitated understanding through a 3D-typeface. The reason for the relatively large focus on visual functions enabled by BIM may have several explanations. First of all, the structure of the interviews did not allow for very much time to introduce the concept of BIM to the interviewee. It could be so that the 3D-functions are the ones easiest comprehensible and thus occupies much of the interviews understanding of the concept. Another explanation of the 3D-focus could be the near extreme absence of it within the company today. They have many systems in use but few with any visual characteristics. However, it is suggested that the company embrace the relatively general perception among the employees that a more visual interface would be preferred.

Organizational culture

The findings from the interviews indicate a relatively unanimous opinion regarding the receptiveness of new technique and working methods. The receptiveness is believed dependent on several aspects, but where age and interest are considered to be the main factors. The company culture and behaviour can be linked to Kim and Kankanhalli (2009) theory on "User resistance to change", see Section 2.2.4.1. The people-oriented theory proposes that resistance is generated by factors internal to users such as age, gender, background and value and belief systems. The resistance in the company also seems to fit under "The change in job content-" category listed by Jiang et al. (2000). The most suitable strategy for the company to employ should be of participative nature where the employees have a more active role. To cope with this user resistance it is suggested that the company evaluates those strategies listed by Jiang et al. (2000) and embrace those considered appropriate to the organization. For example: "Retrain employees to be effective users of the new system", could be an appropriate strategy to motivate senior staff.

Chapter 7 Conclusion

This study has proved that employees in the case company perceive the information handling problematic. The problem often begins already at project completion with an unstructured information handover process, and is aggravated during the FM phase due to inconsistent information management. Most of the requested information exists within the company but are stored in many different systems and location, which makes it difficult to manage. One consequence of the problem is found to be the difficulties for new recruits to familiarize themselves with their duties, which has a large impact on their productivity but perhaps more importantly, their ability to provide good service to the tenants. The insufficient information handling has in the long run led to inadequate quality of available data, especially in older buildings, and thereby reduced productivity for the operational personnel. The appreciated time spent on searching for building information in the case company is found to vary between 10- to 25%. This implies, that through improved data integration made possible through BIM there is a great potential for increase productivity within the company.

The perception of the information handling has been shown to depend largely on employee experience and area characteristics. Older areas generally consist of a more diverse building population, with various building equipment, apartment interior etc. They have for a long time been exposed to more or less deficient information handling, which have lead to unreliable building data found in the systems. This in turn places greater demands on employee experience and consequently complicates the integration of new employees. Even though experience proves to have a large impact on the information handling, employees with many years of practise still consider it as unnecessary time consuming.

The many different information storage location used by the case company, is found to be an important source to the information handling problem. Despite all the functions made possible, many find it difficult to work against so many sources. The problem to locate where the information is found and goes, and who is responsible for its, outweigh the benefits. BIM, described as a model acting as a single electronic data repository, should therefore be considered as a viable solution to the problem.

One significant source to the information-handling problem has proved to be the different working methods applied in the case company. The mixed application of a digital approach and a more traditional craftsmen approach has led to different understandings and opinions of how the building information is to be handled, and thus, resulted in unstructured and unreliable building data.

Another reason for the problematic information handling has proves to be the building data updating process. The lack of a clear framework has lead to own employees assessments regarding the updating process and hence lead to inconsistency. The data updating process also turns out to consist of many different steps with, which makes the process time-consuming, more exposed to errors have a deterrent effect on the updating process. This is also a typical problem, where BIM, with it features such as single-entry updates, offers a suitable solution

Despite the perceived information-handling problem, the case company employees have experience an improvement lately. This improvement consists largely of the systems, tools and features where user friendliness, simplicity and clarity have been prioritized. Systems which the employees find easy to learn, easy to work with and facilitates their daily duties. The introduction of the relatively new property system is seen as a step in the right direction. FAST[2] advocates simplicity, through automatic updates, mobile devices etc. have resulted in building data perceived more reliable and an updating process perceived less bothersome. Even additional information integrated in the company systems are considered okay as long as it is coupled with user friendliness. Also here, the potential for BIM, with visual- and easy to handle typeface, becomes clear.

This study has highlighted organizational activities in which the information handling is considered particularly problematic. The current situations have been compared to desirable situations and thereby revealed BIM application areas, As shown in the Analysis and Discussion Chapter, see Chapter 6, the activities in question correlates well with BIM application areas within FM brought up in the theoretical framework, and thus proves its suitability as a solution, at least partly, to the information handling problem. The more detail building data ought to be used, together with the experienced obtained through the pilot project, as a guidance in the company's preparation of building data requirement in future projects. The study has also shown how COBie deliverables correspond fairly well with the case company required building data, but due to its so far scarce proliferation, the company is only suggested to keep updated on the development. The employees are convinced that BIM could offer a great value to them, maybe even change the practice fundamentally. The greatest believed value of BIM proved to be "Increased productivity" and Enhanced communication".

The receptiveness of BIM in the case company would most likely vary. The older employees have in general a more traditional approach in their work and would therefore oppose changes of digital character more than others. The study have made clear the importance of older employees when it comes to experience and knowledge retention, and it is therefore of particular importance for the company to have their trust before substantial changes are made. A lot of system changes recently may constitute a barrier for the introduction of further changes and it is therefore of great significance that the company clearly communicate the benefits of change. Since the case company's cultural barriers can be likened to "The people-oriented theory" or "The change in job content-" category, both presented in Section 2.2.4.1, the company are suggested to embrace strategies against user-resistance, particularly directed against older employees.

Chapter 8 References

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Appendix A – Interview Questions

Rollen

1. Kan du beskriva din roll och dina ansvarsområden?
2. Hur länge har du arbetat för företaget?
3. Vad har du tidigare för erfarenhet?
4. Vad karakteriserar det område/distrikt du arbetar inom?

Informationshantering

1. Hur uppfattar du att hanteringen av byggnadsinformation fungerar idag?
2. För vilka aktiviteter/arbetsuppgifter innebär hanteringen av byggnadsinformation störst problem?
    a. Hur ofta utförs aktiviteten/arbetsuppgiften?
    b. Hur resurskrävande är aktiviteten/arbetsuppgiften?
3. Hur mycket av din totala arbetstid uppskattar du läggs på hantering/sökande av byggnadsinformation?
4. Hur fungerar ajourhållningen av byggnads information idag?
    a. *Är informationen tillförlitlig?*
    b. *Är det en resurskrävande aktivitet?*
    c. *Hade det fungerat med ytterligare ajourhållningskrävande information?*

BIM

1. Vad skulle en uppdaterad, användbar och lättåtkomlig fastighetsinformationsmodell fylld med relevant information för den aktuella situationen vara värd?

Kultur

1. Hur ser företagskulturen ut när det kommer till villighet att ta till sig ny teknik och/eller arbetssätt?