CHALMERS
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Enabling Efficient Facility Management Through Integration of BIM

A study of possible benefits and obstacles

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

HANNAH AHRENS
LISA NORRSTRÖM

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Division of Construction Management
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Chalmers tekniska högskola 2017

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

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BIM illustration of the case study Johanneberg Science Park 2 (Tengbom, 2014)

Department of Architecture and Civil Engineering Göteborg, Sweden, 2017

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ABSTRACT

The role of the facility manager has evolved and it now includes handling of various time-consuming activities and inefficient processes. Integration of Building Information Modelling in facility management is an innovative solution to enable more efficient processes by reduction of time-consuming activities. BIM is currently, frequently applied in the design and construction phases in the industry, but integration in facility management is however still uncommon. The *Purpose* of the thesis is therefore to contribute with aspects on how facility management activities can be made more efficient by integration of BIM. The main *objective* is to identify which BIM-parameters and connected application areas would generate the highest value for property and maintenance managers. Further, the aim is to analyse the risks, benefits and challenges regarding BIM implementation. The *Method* of the thesis is a qualitative study including a case study where BIM is currently being integrated. Twelve semi-structured interviews with facility managers at seven different real estate companies in Gothenburg have been performed. The *Result* detects four main, time-consuming activities generally caused by insufficient information handling and usage of too many digital systems. Vague knowledge and limited, or no, experience of working with BIM was also shown among the interviewees which could obstruct a possible implementation. The study *concludes* that BIM could enable more efficient facility management by reducing the number of digital systems used and improving information handling processes. To ensure successful integration of BIM, consideration of facility management should be taken in the design phase and beneficial parameters should simultaneously be implemented in the BIM model. The purpose of sharing information regarding BIM integration is concluded to have been achieved, as the study contributes to the desired movement towards increased knowledge of BIM and possible application areas. Examples of *Further Research* is development of technical solutions for implementation of BIM in facility management, developing standards for BIM implementations and continuing sharing information regarding BIM and its possible benefits.

Key words: Facility management, BIM, Building Information Modelling, Benefits, Innovation, Integration, Efficiency

Att Möjliggöra Effektiv Fastighetsförvaltning Genom Integration av BIM
En studie över möjliga nyttor och hinder

Examensarbete inom mastersprogrammet Design and Construction Project Management

HANNAH AHRENS
LISA NORRSTRÖM
Institutionen för arkitektur och samhällsbyggnadsteknik
Avdelningen för Construction Management
Chalmers tekniska högskola

SAMMANFATTNING

Rollen som fastighetsförvaltare har utvecklats och inkluderar nu fler tidskrävande aktiviteter och ineffektiva processer. Integrering av Building Information Modelling i fastighetsförvaltning är en innovativ lösning för att effektivisera processer genom underlättande av tidskrävande aktiviteter. BIM är idag främst förekommande i design-, och konstruktionsfasen i branschen och att integrera det i förvaltningsfasen är fortfarande ovanligt. *Syftet* med uppsatsen är därmed att bidra med aspekter på hur aktiviteter inom fastighetsförvaltning skulle kunna effektiviseras genom integration av BIM. *Målet* är att identifiera vilka BIM-parametrar och tillhörande applikationsområden som skulle skapa störst värde för fastighetsförvaltare. Vidare är målet även att analysera risker, fördelar och svårigheter med implementering av BIM. Uppsatsens *Metod* är en kvalitativ studie med en case study av ett projekt där BIM nu integreras. Tolv semi-strukturerade intervjuer med fastighetsförvaltare från sju olika fastighetsbolag i Göteborg har genomförts. *Resultatet* visar på huvudsakligen fyra tidskrävande aktiviteter som generellt är resultatet av bristfällig informationshantering och användning av för många digitala system. Bristande kunskap samt begränsad eller obefintlig erfarenhet av BIM är även påvisat bland de intervjuade förvaltarna, vilket kan hindra en möjlig implementering av BIM. Studiens *Slutsats* är att BIM kan möjliggöra mer effektiv fastighetsförvaltning genom att reducera antalet digitala system som används och genom att förbättra processer för informationshantering. För att lyckas med integration av BIM behöver hänsyn till fastighetsförvaltning tas redan i projekteringsfasen och fördelaktiga parametrar bör samtidigt inkluderas i BIM-modellen. Vidare anses även syftet med att sprida information om BIM implementering ha uppnåtts, då studien bidrar till en önskad, ökad kunskap och medvetenheten om BIM och dess möjliga användningsområden i fastighetsförvaltning. Exempel på *Vidare forskning* är utveckling av tekniska lösningar för integration av BIM i fastighetsförvaltning, utveckling av standarder för implementering av BIM, samt att fortsätta sprida information om implementering av BIM.

Nyckelord: Fastighetsförvaltning, BIM, Building Information Modelling, Fördelar, Innovation, Integrering, Effektivitet.

Contents

Preface

This thesis concludes the master program Design and Construction Project Management. The study was conducted at the Department of Architecture and Civil Engineering, Division of Construction Management, at Chalmers University of Technology, in Gothenburg, Sweden. The project was carried out in collaboration with ZynkaBIM AB during the Spring of 2017. The aim of the study was to contribute with underlying information for ZynkaBIM AB to develop a technical solution for implementing selected parameters in the Johanneberg Science Park 2-project.

We would gratefully like to thank everyone who has been involved throughout our research, everyone who in any way have contributed to the outcome of this thesis. We would firstly, sincerely like to thank our supervisor Petra Bosch-Sijtsema at Chalmers University of Technology for her support and guidance, which we have highly appreciated and valued. Secondly, we would like to thank our supervisor at ZynkaBIM AB, Petter Bengtsson, for knowledge and aspects regarding BIM, essential for conducting our research. We further would like to thank all participating facility managers and experts for agreeing to interviews, for contributing with experience and knowledge and for rewarding and interesting meetings.

Also, a sincere thank you, to our opponents, Sara Blomkvist and Rikard Landegren Hagen, for appreciated feedback and sharing of ideas, as well as many laughters throughout this thesis process.

Göteborg 2017

Hannah Ahrens & Lisa Norrström

Acronyms

The following acronyms will occur in the thesis. Knowing the terminology is essential to follow and understand the report.

AEC Industry - Architecture, Engineering and Construction Industry

BIM - Building Information Modelling

FM - Facility Management

HVAC-systems - Heating, Ventilation and Air Conditioning Systems

IoT - Internet of Things

JSP2 - Johanneberg Science Park stage 2

1 Chapter One - Introduction

Chapter one aims to introduce the problem which the thesis highlights and to declare why this topic is being studied. The purpose and goals intended to be achieved are formulated within established limitations and summarised in valid research questions.

1.1 Background and problem description

In any construction project, the post construction phase is the far longest and the phase which contributes the most to the total cost for the project. Despite this, it is traditionally towards the design-, and construction phase where most attention is directed (Kassem et al., 2015). How to minimise costs and improve processes in these phases have received more interest and generated far more research than how to make facility management more efficient. Short term focus and direct savings are generally a greater motivation, than investing in reducing costs in the long run. One cost saving process which has become both more popular and more commonly used in early project stages is Building Information Modelling.

Building Information Modelling (BIM) is an innovative development within the AEC-industry and is currently, most commonly used in the design-, and construction phase (Kubba, 2012). The aim is mainly to facilitate information sharing between involved parties in projects. In BIM, a 3-dimensional model as well as information hub is created, where all data and information regarding the project is stored and accessible. After project completion, large amounts of compiled, valuable information are then often lost as BIM is rarely transferred into the facility management phase today (Becerik-Gerber et al., 2012). Reviewing how, and to what extent this information can be preserved and reused could result in more efficient facility management processes. By planning for operation and maintenance early in projects, transmission and accessibility of beneficial information could be enabled and by that, possibly improve management of buildings. This would lower the costs for maintenance and thereby also the total cost for projects.

Due to an increased interest for BIM, the processes have continuously been developed and more functions and benefits have been discovered with the software (Kubba, 2012). It is potentially beneficial to integrate the model in facility management, but the research on potential application areas is still inadequate. The range of conducted projects is limited and it is still unclear what requirements are necessary, what benefits to gain and what information is essential to make integration of BIM in facility management successful.

1.2 Purpose

The purpose of the master thesis is to contribute with information regarding how facility management can be supported and made more efficient through integration of BIM. It is to underlie and acknowledge future, possible innovation-, and development areas in real estate.

1.3 Objectives

The main objective of the master thesis is to investigate how the role of the facility manager can be eased through usage of BIM. The target will be to identify the BIM-parameters which would generate the highest value, if accessible by facility management. Three key value adding application areas will, based on interviews with active facility managers, be identified and analysed in accordance to relevant theory and expert interviews. The objective will be to acknowledge potential benefits, obstacles and risks of implementing selected parameters in BIM.

1.4 Research questions

The following questions will underlie the research:

1) What are currently the most time-consuming activities in facility management?
2) How can BIM be used to enable efficient facility management?
3) What BIM parameters are essential to enable efficient facility management?
4) What are the benefits, obstacles and risks with integrating BIM in facility management?

The questions will be qualitatively studied in an interview study and validated in the case study of the JSP2-project, conducted by Akademiska Hus in Gothenburg.

1.5 Limitations

The thesis will only analyse facility management in relation to BIM, other subjects or aspects will therefore not be discussed. Efficiency will only be defined and analysed as reduction of time-consuming activities. The thesis will only account for the role of facility managers in private and public companies located in Gothenburg, other roles or companies will not be included. Detailed, daily maintenance work, such as tasks of janitors will not be accounted for, only long term management and maintenance will be discussed. The result of the thesis will solely be validated in a single case study. Furthermore, the theoretical framework is limited to focus on facility management, Building Information Modelling and the interaction between BIM and facility management.

2 Chapter Two – Theoretical Framework

Planning and construction of a building is generally following the process illustrated in Figure 1 (Anker-Jensen, 2008). The planning phase encompasses *Briefing* and *Designing* before the construction is initiated. *Handover* and *Occupation* are the phases where the tenants are becoming involved and are also where facility management is commenced. The aim is then to ensure a maintained facility in a good condition that corresponds with the requirements of the users.

Building Information Modelling is a process which enables information sharing between involved parties in projects. BIM is currently mostly used in the initial phases to design models and for visualisation, however combining BIM and facility management occurs more infrequently. To be able to identify beneficial parameters of combining BIM and facility management, the two different concepts will thus hereby be described.

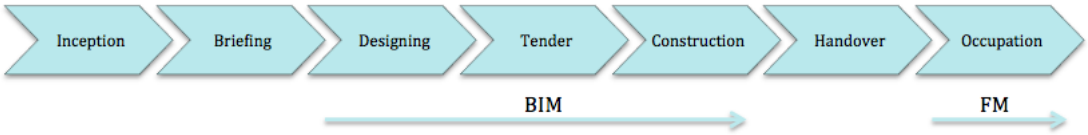

Figure 1. The traditional phases of construction with application of BIM and FM (Inspired by Anker-Jensen, 2009).

2.1 Facility management

Facility management (FM) is the process of supporting the core business of an organisation, including day-to-day operations, planned maintenance and strategic decisions (Alexander, 1996). Facility management aims to enhance the business performance by customisation of spaces and designing buildings in accordance with the requirements of the end users (Atkins and Brooks, 2014). Successful adaptation of space is dependent upon understanding an organisation's core business as well as the non-core functions, including support functions such as human resources etc. Mari and Poggesi (2014) further emphasise the purpose of facility management as being maximisation of available space in order to generate rental incomes. There is often a pressure of simultaneously reducing the operational costs for running the facilities, since this generally accounts for the major share of the annual expenses (Atkins and Brooks, 2014).

The International Facility Management Association, IFMA, (1998) defines facility management as "*a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology"*. The British Institute of Facilities Management (1993) instead defines it as "*the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities."* These definitions, among others, stress the multidisciplinary aspects needed to increase performance and profitability of core businesses. IFMA (1998) further

emphasises the impact of facility management in accordance to the three P's model in Figure 2. The model illustrates the interdisciplinary nature of FM and the level of involvement in the different areas of an organisation. Further, facility management is argued to generate increased cooperation between the factors and is claimed to have emerged through increased focus of the work environment to enhance organisational performance (Anker-Jensen, 2009). An example is where increased workplace design can generate more efficient processes, resulting in reduced costs and added value for people (McGregor and Then, 2003).

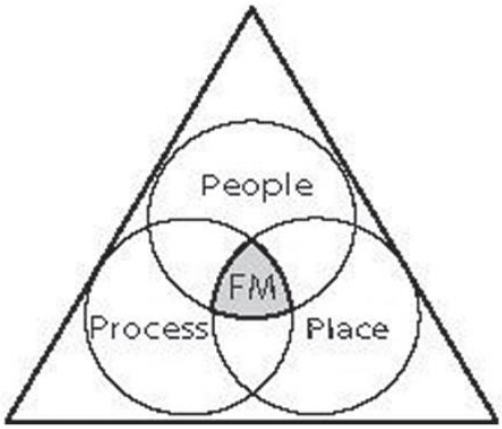

Figure 2. The three P's model, describing the integration of FM in an organisation (IFMA, 1998).

As the three P's model illustrates, facility management is defined as a holistic and integrated approach, where people and processes needs to be coordinated (Atkins and Brooks, 2014). Facility management differentiates from usual operations and maintenance with the objective of adapting the building based on requirements of the end user. Bandur et al. (2016) argues for the importance of valuing buildings as tools to ensure efficient organisational processes. Facility management operations are thereby sometimes called asset management, which encompasses managing space to ensure value for people and processes as well as monitoring running costs of the facilities.

Hard and soft facility management is a general distinction within facility management operations (Meng, 2014). Soft management encompasses the processes of daily support services, such as cleaning and security. Hard facility management instead include maintenance and operational aspects. It also referred to as building related, due to the focus on available space and infrastructure (Anker-Jensen, 2008). Soft facility management is generally a service related aspect with people and organisational focus. Hard and soft facility management is both crucial in order to achieve the strategic objectives of an organisation. Achieving the aim of enhancing organisational performance through facility management can be divided into four possible strategies (Barrett and Baldry, 2003):

1. Integrated strategic facility management: Characterised by close relationships and dialogues between organisation and facility management to develop the operations in accordance with strategic objectives.

2. Proactive strategic facility management: The relationship is based on sharing information that has been developed in parallel processes at organisational and facility management levels.

3. Reactive strategic facility management: Facility management is an independent operation without including the strategy of the organisation.

4. Passive non-strategic facility management: Facility management is only an administrative support function.

The division of different facility management strategies are an attempt to categorise the level of involvement and ways to achieve the mission and vision of tenants. Strategic facility management is generally focused on long term objectives with short term day-to-day operations (Anker-Jensen, 2008). The nature of facility management is today generally characterised as the Reactive approach where actions are taken unplanned. Unscheduled activities are performed and prioritised due to the severeness of the issue, such as water leakage or burglary (Teicholz, 2001). Redirecting the strategy to Proactive facility management with planned maintenance and perception of future, possible errors would enhance utilisation of resources and reduce time spent on handling crises.

2.1.1 The role of the facility manager

To ensure facility management operations being aligned with the strategy of the organisation, there is a need for careful managing (Anker-Jensen, 2009; Meng, 2014). The facility manager has emerged to become the intermediate role of combining the operational activities with the strategic decisions (Meng, 2014). On a daily basis, the responsibilities include managing running costs, contact with users and adapting the buildings in accordance with requested requirements (Anker-Jensen, 2009). The challenge for the facility managers is to fully understand the services needed to enhance organisational performance of the end users. By continuous contact with the tenants, knowledge regarding culture, important organisational processes and support functions needs to be possessed.

Problem solving is also a central proficiency of the facility manager role, where fundamental knowledge of the building systems is crucial (Teicholz, 2001). The role includes having an understanding of all different aspects in the facilities, from drawings to HVAC-systems and lights. Usage of technical solutions, such as various sensors, is a recent development within the real estate industry and more frequently requested by tenants (Cotts et al., 2010). The increased demand of technology, in addition to the constant pressure of reducing running costs, have resulted in the facility management role becoming more complex. Further needs for certifications regarding security and sustainability as well as increased legislations are other influencing aspects and challenges in facility management operations.

2.1.2 Facility management integration in design and construction

The intermediate role of fulfilling the requirements of tenants and simultaneously reducing running costs of facilities is difficult and need careful managing (Anker-Jensen, 2009). To oppose this complexity, Mari and Pogessi (2014) suggest integration of different aspects related to facility management already in the design phase, see Figure 3. According to the authors, planning for facility management

operations early would reduce the operating expenses every year. Even though theory emphasises great opportunities of including facility management earlier in the project life cycle, there are causes why consideration is generally not taken in the construction phase. Earlier consideration is generally more time consuming and linked to high initial costs, which the project owner is often unwilling to invest in. The unwillingness could be a result of the difficulties of motivating the potential savings, which only can be obtained in later phases of the building life cycle. The resistance to implement facility management is also emphasised by Mari and Pogessi (2014) because of the traditional construction processes where the phases are conducted separately and not as an intertwined process.

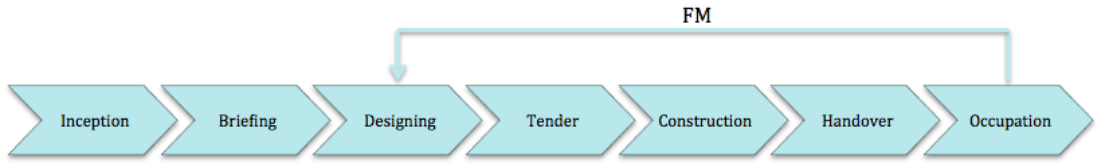

Figure 3. Earlier FM integration (Inspired by Anker-Jensen, 2009).

One suggestion to overcome the barriers for considering facility management in the design phase is by involving facility managers in the design process (Anker-Jensen, 2009). The most emphasized benefit of this solution is the knowledge possessed regarding facility operations, valuable to account for in an early stage to reduce inefficient activities. Allowing a facility manager to review the design brief could result in a building more suitable and adapted to enhance the organisational performance (Anker-Jensen, 2009; Emmitt, 2007). A disadvantage of this solution is although that the facility manager might be viewed as not having the competence needed to influence the planning phase (Anker-Jensen, 2009). Receiving support from the project manager as well as team building activities, such as workshops, are therefore important to ensure successful integration. Emmitt (2007) further emphasizes using computer software to gain experiences from past projects and view important facility aspects to include in the design phase. At completion of construction the owner receives large amount of information, such as warranties, that could benefit from being integrated in software at an earlier phase.

2.2 The BIM concept

Building Information Modelling, or BIM, is today a familiar concept within the construction sector and it being a process with the possibility to facilitate projects and make them run more efficiently is both accepted and proven by the AEC industry (Teicholz, 2015). After BIM being introduced to the industry in the 1990's, the cooperation between involved parties has improved and focus has shifted from every party's own winnings to the overall success of the projects (Hardin and McCool, 2015). Through BIM, it has been made possible to dissolve isolations and increase collaborations between project team members, ease information sharing and thereby decrease waste and budget overruns in projects (Motawa and Almarshad, 2013). Increased use of BIM in the AEC industry, all over the world, indicates that the benefits and possibilities of intelligent virtual modelling are too valuable to ignore

(Kubba, 2012). Kubba (2012) also claims that BIM is the future and companies which do not embrace the method will gradually fall behind the ones that do.

Integrating BIM implies building of a visually and dimensionally correct, virtual 3D-model of a project (Teicholz, 2015). The model also serves as an information hub where all data concerning the project is stored and involved parties can communicate and analyse the design of the building. This makes it possible to make time consuming and costly changes before the actual construction starts (Hardin and McCool, 2015). All necessary data regarding any used object or component is stored within the model and available for every project team member to review (Kubba, 2012). As measurements, geometries and material selections all correspond the actual construction, the model can be used as a complete simulation of the project and information can be handled and adjusted with high precision.

From foremost being used as a visualisation tool, BIM has continuously evolved as more possibilities with the software have been discovered and developed (Kubba, 2012). Today, it has a much wider workflow focus and the possibilities to use the model for solving future problems beforehand is one of the main motives for both implementing it and continuously developing the technology (Hardin and McCool, 2015). A shifted focus has resulted in the industry changing the direction for how to work with the technology, important questions now are "What more can the information be used for?" and "Whom else can benefit from this data?". After merely having used the software during the design and construction phase, it is now being investigated how the information also can be used in post construction phases. According to Ghafferianhoseinia et al. (2016) the collected information could both increase the collaboration and productivity in the industry, improve designs and construction but also improve maintenance work and methods for facility management. As the often very high initial cost for implementing BIM is the deciding factor, Motawa and Almarshad (2013) argue that an integrated knowledge-based BIM system that could monitor post construction phases could justify the investment of implementation better.

2.3 BIM in facility management

As new projects are initiated and carried out, it is rarely the effect on the maintenance and operating costs which are the decisive factors when large decisions are made during design and construction (Kassem et al., 2015). Generally, the project owners focus on minimising the initial and construction costs even though the costs for subsequent operations and maintenance work are the main contributors to the project's total life cycle cost (Becerik-Gerber, 2012). A continued interest in the industry to find ways to save time and money is a major reason for why concepts like BIM are gaining more and more attention in the construction sector (Kassem et al., 2015). Due to the increased interest, several new application areas for the software have been explored and developed, including how it can be used to improve and make facility management more efficient.

The main reason for integrating BIM in facility management is to improve information exchanges between the construction and the operational phase in projects. Improvements which would establish an enhanced foundation for future, potentially comprehensive cost savings. The information that is delivered today is often

inaccurate and incomplete and thereby difficult to manage. It is often fragmented across different systems and formats and usually processed manually which is both inefficient and laborious (Becerik-Gerber et al., 2012). According to Ghaffarianhoseinia et al. (2016), BIM could facilitate information handling by compiling all information concerning physical structure, mechanical and electrical systems, equipment and furniture in the same format, at the same place. The maintenance work can in the model be simulated and thereby the operational processes be optimised. This would consequently enhance space utilisation, future renovations and more precise cost estimations can be provided and thus, save both time and money.

The fact that there are potential benefits and possibilities with using BIM in facility management is commonly agreed upon within the AEC-industry, however it cannot yet be justified (Becerik-Gerber et al., 2012). Research regarding potential application areas for BIM in facility management is still inadequate (Kassem et al., 2015). To be able to measure the efficiency of possible applications for BIM, current facility management functions and processes must be identified and understood (Becerik-Gerber et al., 2012). The number of projects where BIM has been used in facility management is still limited, but expected to increase. Nevertheless, it is still unclear exactly which requirements are necessary, what benefits to gain and how BIM shall be used to make implementation successful and thereby justified.

2.3.1 Potential benefits of integrating BIM in facility management

Potential benefits of integrating BIM in facility management are presented below, the benefits are also linked to possible application areas.

2.3.1.1 Information and data handling

The handover of building documents from AEC to FM is still generally done manually, it is then facility manager's responsibility to digitally transfer the data into used facility management systems (Becerik-Gerber et al., 2012). Manually creating and associating the right data with the right documents is both a time-consuming and error-prone process. In addition, current systems often require the information do be stored and updated at several, different platforms as it is rare for facility management to only use a single platform. Kassem et al. (2014) argues that BIM could facilitate the handover of information and improve the accuracy of the data. Aziz et al. (2016) also states that integration of BIM would enable a paperless environment which would facilitate updating of data in addition to reducing waste, increasing productivity and decreasing costs. As information is delivered from AEC to FM irrelevant and non-accurate documents can also be eliminated.

By integrating BIM in early project stages information could be stored digitally from the beginning and be preserved and transferred to facility management more easily and with higher accuracy (Becerik-Gerber et al., 2012).

Table 1. Application areas associated with Information and data handling

➔ Availability of product and equipment information and data
➔ Execution and reporting concerning corrective servicing and maintenance

➔ Planning of maintenance work
➔ Energy and environmental impact assessments
➔ Space management
➔ Planning and forecasting the rearrangement of spaces
➔ Availability of space information for potential tenants
➔ Visualisation and marketing

2.3.1.2 Tracking of installations, components and associated information

In BIM, it is possible to compile information and data regarding everything that concern a specific building. Information regarding mechanical and electronical systems, piping, installations, equipment and other components which are often invisible in the physical space can be stored and made trackable (Becerik-Gerber et al., 2012). Also, information regarding fabrications, manufactures, special attributes and different types of documents such as warranties, manuals, instructions, certificates and test results can be stored in the model (Becerik-Gerber et al. 2012; Sabol, 2008). This type of information is today often hard and time-consuming to locate as there are rarely any clear process guidelines for how data should be stored in facility management systems. In research conducted by Liu and Issa (2013) it was established that information particularly hard to locate is information regarding spare parts for equipment, specifications and warranties, manuals, safety and HVAC details, work order history and updated drawings.

If components need to be replaced or fixed, the facility managers must today often base their work on paper-drawings, experience, intuition or guessing (Becerik-Gerber et al., 2012). By easing the process of locating components and associated information, costs for repair work and commissioning can be decreased and time for maintenance work can be shortened (Sabol, 2008). Kassem et al. (2014) also argues that to easily access and locate data could increase efficiency of facility management and error reporting processes as faults can be tracked and reported in the model and work orders can be executed faster. It would also facilitate the work if any accidents occur or when new facility management personnel are taking over the responsibility of a building (Sabol, 2008).

Aziz et al., (2016) argues that BIM could enable facility managers to optimise the performance of buildings as the model can be integrated with current control systems for the building. This would allow the facility manager to in real time adjust and control equipment and installations

.

Table 2. Application areas associated with Tracking of installations, components and associated information

➔ Availability of product and equipment information and data
➔ Execution and reporting concerning corrective servicing and maintenance

➔ Planning of maintenance work
Energy and environmental impact assessments
Space management
➔ Planning and forecasting the rearrangement of spaces
➔ Availability of space information for potential tenants
Visualisation and marketing

2.3.1.3 Space management

To compile all information concerning spaces in one place could both ease the work of the facility manager and improve the environment for the tenants staying in the spaces (Becerik-Gerber et al., 2012). Gathering data about tenants, their operations, their location and their specific space requirements would facilitate management processes and enable enhanced service toward the tenants. Documenting space designations, room sizes, volumes and specific attributes could also reduce time spent on locating data and ease the process of finding satisfactory spaces for new tenants.

Furthermore, energy consumption can be monitored and controlled more efficiently due to more extensive, accessible information regarding tenants and various installations (Becerik-Gerber et al., 2012). By tracking energy consumption to specific installations or tenants it is possible to optimise spaces and decrease energy consumption. As spaces are unoccupied, heat can be turned off for example. In addition, it is possible to keep track of historic environmental data and by that in advance predict performances of buildings (Sabol, 2008). This could consequently enable more accurate and tighter planning of budgets as it would be easier to control and monitor costs.

Table 3. Application areas associated with Space management

Availability of product and equipment information and data
Execution and reporting concerning corrective servicing and maintenance
Planning of maintenance work
➔ Energy and environmental impact assessments
➔ Space management
➔ Planning and forecasting the rearrangement of spaces
➔ Availability of space information for potential tenants
Visualisation and marketing

2.3.1.4 History and planning for maintenance

A BIM-model can act as a knowledge base where information and data regarding maintenance and operational work can be stored (Becerik-Gerber et al., 2012). As historic data of maintenance work can be documented in the model, BIM could facilitate future projects and maintenance work (Kassem et al. 2014). Previous mistakes and unsuccessful actions can be analysed and avoided and thereby improve the quality of the work, shorten time and reduce the costs for corrective and refurbishment work. By analysing historic behaviours of buildings and its installations, decisions regarding planned maintenance and repair work can be facilitated and advantageously prioritised (Aziz et al. 2016). This could also improve routine equipment maintenance as components can indicate deficiency and be replaced before breakage.

In addition, by being able to visualise spaces and buildings in 3D, Kassem et al. (2014) argues that this improves the facility manager's ability to solve problems and enhance their ability to make smart decisions.

Table 4. Application areas associated with History and planning for maintenance

Availability of product and equipment information and data
➔ Execution and reporting concerning corrective servicing and maintenance
➔ Planning of maintenance work
Energy and environmental impact assessments
Space management
Planning and forecasting the rearrangement of spaces
Availability of space information for potential tenants
Visualisation and marketing

2.3.1.5 What-if analyses and simulations

BIM could facilitate the process of renovation work, rebuilding or demolition as it is possible to in the model simulate changes in the building (Becerik-Gerber et al., 2012). A visual image of possible changes can be provided before decisions are final and construction starts. In addition, historical data concerning materials, labour and other costs can be stored in the model and used when estimating costs for potential work. Reliable, historical data would make cost estimations more accurate and could thereby also facilitate decision making. In addition, a list of needed materials for the proposed renovation can be extracted from BIM. To in advance analyse a new design through simulations could also make it easier to justify some refurbishments and space adjustments (Sabol, 2008).

As the 3D-model is corresponding to the actual building it is possible to in BIM perform what-if analyses to visualise choices of materials, surfaces, light sources, landscaping etc. (Becerik-Gerber et al., 2012). This could provide a more realistic view over possible refurbishments or changes in the building and would enhance service toward existing tenants. It would also be possible to use models, pictures and animations from BIM in marketing purposes.

In addition to performing what-if analyses for marketing and refurbishment it can also be used for reviewing energy aspects (Becerik-Gerber et al., 2012). By performing what-if analyses in specific spaces or buildings the energy consumption and environmental impacts can be monitored and compared and the most energy efficient scenarios can be found.

Table 5. Application areas associated with What-if analyses and simulations

Availability of product and equipment information and data
Execution and reporting concerning corrective servicing and maintenance
➔ Planning of maintenance work
➔ Energy and environmental impact assessments
Space management
➔ Planning and forecasting the rearrangement of spaces
➔ Availability of space information for potential tenants
➔ Visualisation and marketing

2.3.2 Potential obstacles of integrating BIM in facility management

Even though benefits regarding integration of BIM in facility management has been stated, there are some possible obstacles which needs to be addressed and highlighted, both technology related and organisational challenges. To efficiently and successfully implement BIM in facility management there must be a common interest and understanding throughout the entire organisation (Becerik-Gerber et al., 2012). Resistance to change from the organisations is an obstacle which carefully needs to be addressed. Implementation of BIM would require training, new software tools and new technology which might not be well received in a very rigid industry (Kassem, et al., 2016). A well-established collaboration and communication between AEC, FM, owners, vendors and contractors underlie the success of implementation. In addition, clear distribution of roles and responsibility areas must be established in advance. Hardin and McCool (2015) argues that one of the hardest thing when conducting projects in a virtual environment is to make project team members to integrate each other. If this is properly done, it will significantly improve the result.

The first issue to resolve before implementation is to establish ownership of the model (Kubba, 2012). Establishing who is responsible for coordination, updating and

maintaining the model, who has access and where the liabilities lie are crucial to implement BIM successfully in facility management (Kassem et al., 2016). It is essential that the information available in the model is accurate and correctly updated. A great risk when transferring data in BIM is that alterations made after the design phase have not been updated in the model. The information received by FM is then inaccurate and not coherent with the real-life building. The lack of processes for updating the data and model as the project is commissioned is argued to be one of the main obstacles with using BIM in facility management (Kassem et al., 2014). According to a study conducted by Sabol (2008), the author states that there is a need to introduce new rules and standards for how information should be transmitted from the construction phase to the management phase. For the information to be utilised broadly by facility managers, new frames for data formats, vocabulary and policies must be developed and established. Today, there is a lack of experienced BIM operators in the facility management industry, which make the need for consistency and standardisation important (Kassem et al., 2016). Sabol (2008) argues that BIM is complex and should not be applied by organisations which are not technically mature of which have not the resources to employ BIM specialists who can work with keeping the models accurate and alive.

According to Becerik-Gerber et al. (2012) BIM in facility management still lack proof of being beneficial as there are too few cases to be studied. One obstacle is the clear lack of proof for being a worthy investment. The lack of cases makes the information regarding requirements for implementation limited (Kassem et al., 2016). There is also a lack in demand for BIM in FM by clients, this due to the limited proof of tangible benefits for implementing it. However, Sabol (2008) argues that if the obstacles are addressed and new standards developed, it is only a matter of time before a complete BIM transmission of useful information from AEC to FM is established as standard procedure.

2.4 IoT in facility management

Internet of things (IoT) is presented by Miorandi et al. (2012) as "*the widespread deployment of spatially distributed devices with embedded identification, sensing and/or actuation capabilities."* Devices with internal intelligence connected to a network are placed in a building and are able to share and receive information from the building systems to a facility manager in a remote location (Patel, 2015). The aim is to achieve a two-way communication, where the device sends performance indications and is also able to obtain information regarding corrective actions. The technology behind devices and sensors with ability to measure or adjust the activities has been developed for many years and are due to recent technical innovations now more commonly used in facilities (Gluhak et al., 2015). Example of this application is HVAC-systems and lights that automatically adjusts due to the number of people in the room or building.

The application of IoT in facility management enables facility managers to monitor, measure and predict the performance of different systems, such as status of the HVAC-system in a specific building (Li and Han, 2016). The ability to share performance information through Internet to a remote device of a facility manager could result in more efficient facility management operations, since more accurate corrective or maintenance actions can be performed. According to Patel (2015)

facility management organisations applying IoT have been able to shorten the decision-making processes by making more accurate and insightful assumptions. Thus, these facility managers apply correct actions more frequently on reported errors.

The greatest benefit of using IoT is emphasised as the prediction of the maintenance actions needed, which would reduce the number of unplanned emergency actions for facility managers (Patel, 2015). Although, there are some risks connected to application of IoT in facility management. The indications received from the devices and systems need to be interpreted and managed, which increases the pressure on the facility managers to handle all the information. To digitally apply corrective action to a reported error also demands knowledge of the systems used, which can be an obstacle for those without computer experiences. Implementing IoT in facility management thereby demands systems that are able to translate the information from devices to simplified graphs or diagrams to reduce the risk of misinterpreted indications. If implemented successfully and with proper introduction for the facility managers, usage of IoT can enable increased understanding of repetitive errors in different systems, provide data for energy- and environmental management as well as reduce time-consuming activities (Stackowiak et al., 2015).

3 Chapter Three – Methodology

The methodology chapter aims to describe the research strategy and decisions made affecting the outcome of the thesis. Research design, data collection method and analysis will be presented, combined with ethical aspects applied in the research.

3.1 Research strategy

The chosen research strategy is essential to create a structure and to ensure credibility of the presented results (Gabrielian et al., 2007). A qualitative research strategy is used since the objective is to detect a general perception in the facility management context. Using a qualitative strategy is more beneficial compared to using a quantitative method when the aim is to capture a general understanding of a social context (Saldana, 2011). Since the aim of the thesis is to generate a perception, and not to detect frequencies, the qualitative strategy is advantageous. Significant for the qualitative strategy is knowledge attained from interpreting collected, empirical data through interviews and observations to get a general perception, and collection and analysis of verbal over statistical data (Hammersley, 2013). Another advantage of the strategy is the unstructured approach of collecting empirical data, this to capture the perception and aspects in ordinary settings of the respondents.

Critique of the strategy is the risk of biased research which would affect the credibility of the presented result (Hammersley, 2013). Personal, subjective attributes is argued to potentially influence and possibly interfere with the outcome. The studied area is also chosen based on personal interests of the researchers, which also increases the risk of biased research (Saldana, 2011). According to Hammersley (2013) the influence of subjectivity is not possible to fully eliminate, but essential to consider when performing studies and formulating conclusions. Furthermore, the aspect of making generalisations based on a limited sample group is another critique. The researchers can determine what highlighted aspects to focus on and there is thereby a risk of conclusions being based on generalisations made solely from few respondents.

3.1.1 Research approach

The research was conducted with an inductive approach. The collected empirical data aims to result in a generalisation of the highlighted aspects among observed and interviewed respondents. Elo and Kyngäs (2007) emphasise the characteristic of inductive approach as detecting patterns and relationships through observations. The approach is often used to investigate phenomenon with limited or no prior research (Hammersley, 2013). However, reviewing existing theory is generally done during formulation of research questions. The expressed beneficial aspect of this approach is the possible detection of new areas of knowledge or phenomenon gained through the empirical data collection. The critique although concerns the aspect of generalisations of aspects based on observations of a limited sample group (Elo and Kyngäs, 2007).

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3.2.1 The case study of Johanneberg Science Park 2

The chosen case study is Johanneberg Science Park 2 in Gothenburg, a project initiated by Akademiska Hus in association with Johanneberg Science Park and Chalmers University of Technology (Chalmers, 2017). JSP2 will be a multifunctional office building where innovative collisions between companies, researchers and students can occur. JSP2 is the second stage of the innovation project in the area where the first stage recently was completed by Chalmersfastigheter. The project of JSP2 just initiated the construction phase and is expected to be completed by the summer of 2019 (Chalmers, 2017). The project comprises a building of totally 10,600 sqm divided on six floors and will be located on the south side of Chalmers Campus Johanneberg, see Figure 4.

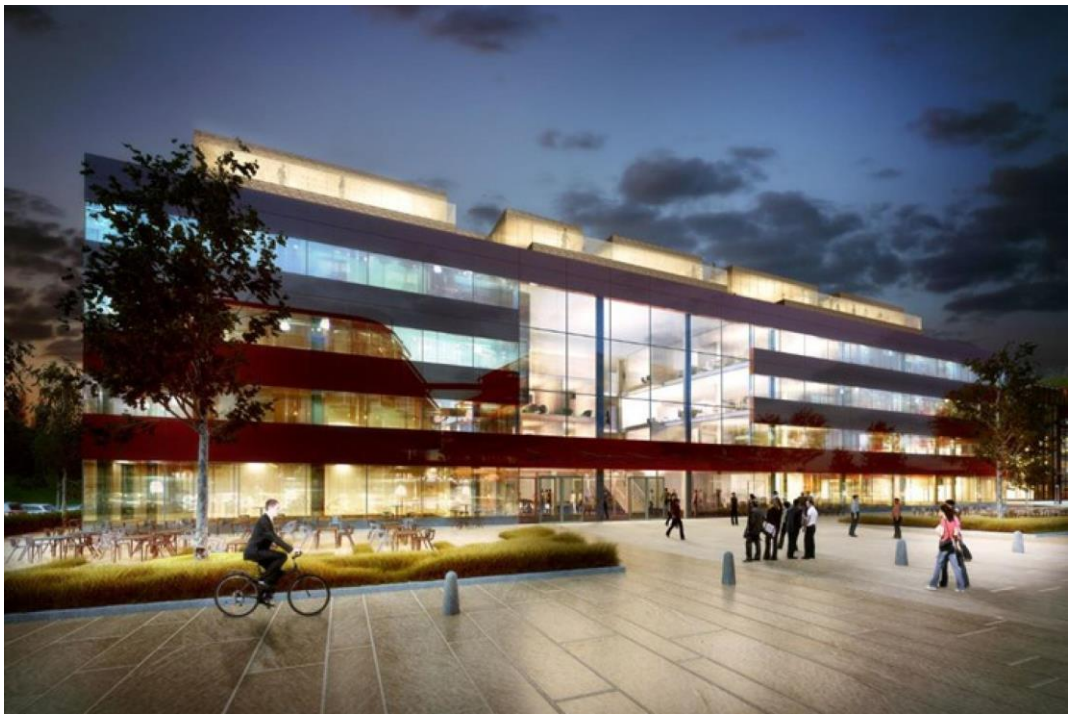


Figure 4. BIM illustration of JSP2 (Tengbom, 2016).

The key word of the project has been innovation and Akademiska Hus have had their own innovation program, not just for the building process, but for how the building is to be used after completion (Akademiska Hus, 2017). The goal has been to in cooperation with suppliers, tenants and partners apply the latest methods, be innovative and deliver more, and to a higher standard than what is required. In combination with creating an innovative building, Akademiska Hus also wants to push the industry to develop and to become more innovative. Akademiska Hus is also in collaboration with ZynkaBIM AB currently developing new solutions for enabling

more efficient facility management by usage of BIM, which will be applied in the JSP2-project (ZynkaBIM AB, 2017).

3.3 Data collection method

Collecting empirical data was made through interviews to obtain in-depth knowledge regarding facility management and BIM aspects. The interview method is generally described as time consuming since it requires finding and collecting empirical data, transcribing, coding and analysing the result (Mason, 2010).

3.3.1 Sample group

The sample group needs to be large enough to ensure a nuanced perspective to detect patterns and enable conclusions (Mason, 2010). The aim is to understand behaviours and demands of facility managers, thus a sample group of 12 facility managers from seven different real estate companies in Gothenburg participated in this study. Northrop and Arsneault (2007) highlight the benefit in sampling a role instead of a specific number of people with the argument that general perceptions can then be detected with a reduced sample size. However, one difficulty, early detected was the different meanings of the role 'facility manager' within the different organisations. A description of the profession of the desired interviewee was therefore crucial to understand the comparative role at another company.

Another challenge with sampling a role was the division of facility management in Sweden, there are generally two different professions, one more responsible for economic management and tenant contact, while the other has a technical and maintenance approach. In this thesis, these are divided as property managers and maintenance managers, respectively. Since the aim of the thesis is to enable efficient facility management, both the different roles were included in the sample group. Out of the 12 interviewed facility managers, five of them where property managers while the remaining seven were maintenance managers. The sample group includes representatives from seven real estate companies, operating in the Gothenburg area from both the public and private sector. Different personal attributes can be detected, a clear difference is in the division of gender, where only two of the interviewees are female. Furthermore, the age span among the representatives is evenly distributed, generating perspectives from both more experienced as well as relatively young facility managers.

3.3.2 Performing interviews

The interviews were conducted between the 7th of February and 11th of April 2017, and were performed face-to-face in Swedish. With all interviewees consent, the meetings were audio-recorded to reduce the risk of losing information and to enable a conversation undisrupted by writing notes. The gathered data was after transcription translated into English. A semi-structured interview method was used where the same questions were asked to every recipient together with optional follow up questions. The fixed questions for all interviewees were important to enable a systematic comparison and analysis between the different interviews. The semi-structure method of the interviews also enabled adaption to the attitudes and interests of the interviewee together with the set structure.

One example of avoidance of biased questions is that the BIM concept was not presented in the initial contact with the interviewees, this to reduce influencing their perspectives. Further, the nature of the questions was unrestricted to enable reasoning and discussions throughout the interviews. Another risk emphasised by Gabrielian et al. (2006) is the interviewees awareness of participation which could affect the answers. To reduce the risk, the unrestricted questions together with semi-structured approach of the interviews resulted in a conversation rather than an interrogation. The interviewees and all the represented real estate companies are also anonymous in the analysis to further avoid the risk; this was informed to the interviewees before the interviews.

To facilitate the identification of application areas for BIM in facility management, research from BIM i Staten (2014) was used during the interviews. BIM i Staten is a preeminent organisation within the field of BIM integration and listed in Table 6 is eight prioritised application areas formulated by them.

Table 6. Prioritised application areas and associated BIM goals (Inspired by BIM i Staten 2014).

Colour code	**Application areas**	**BIM goal**
	Availability of product and equipment information and data	Ease searching for information regarding built in systems, building equipment and materials
	Execution and reporting concerning corrective servicing and maintenance	Shorten the time, and improve the quality of error reporting and compile history of performed corrective work
	Planning of maintenance work	Ease planning of future maintenance work and refurbishment etc.
	Energy and environmental impact assessments	Compile information regarding resource consumption to support energy and environmental decisions
	Space management	Improve handling of space information
	Planning and forecasting the rearrangement of spaces	Enable optimisation of spaces and find alternative solutions for rearrangements
	Availability of space information for potential tenants	Improve accessibility of space information to facilitate information sharing with potential tenants
	Visualisation and marketing	Improve the understanding and dialogue with potential tenants

To enable identification of areas in need of efficient solutions, the list of application areas was shown during the interviews. The interviewees were asked to choose the three areas that would facilitate their daily work the most. if made more efficient. Some of the interviewees choose quickly and with great ease while others had a more difficult time choosing. The aim was also to detect application areas which would facilitate the daily work of the interviewees, regardless of their specific role. Since the sample size was almost equally divided between property and maintenance managers, both roles have been considered.

3.3.3 Transcribing interviews

Since all interviews were audio-recorded, the information gathered in the recording needed to be written down to enable analysis. This process is called transcribing, and was performed after each interview. Saldana (2011) argues the benefits of transcribing the interviews as making a first analysis and generating an insight of the gathered data. The challenge in this case was to translate the interviews to English and still capture the meanings and information originally expressed in Swedish. Recording the interviews and transcribing is demanding in terms of being time-consuming. The benefits obtained by audio-recording the interviews are although worth the time spent on transcribing the recordings. Emphasised benefit is the ability to solely focus on the interviewee and not be concerned by taking notes or remembering information (Saldana, 2011). Since a semi-structured interview method was applied, the recording generated the advantageous ability to concentrate on potential follow up questions on interesting aspects. Hammersley (2013) however expresses the risk of a perception of doubt of being recorded from the interviewees. The risk was accounted for by asking for all the interviewees permission to record prior to the interview. Furthermore, to not violate the given trust, nothing outside the recording was included in the transcriptions or in the thesis.

3.4 Data analysis

The data analysis was made by coding the transcription of the audio-recorded interviews. Coding the transcriptions is a process of classifying and categorising aspects essential to detect patterns and relationships (Saldana, 2011). The aim of the coding was to detect issues relevant to analyse further, which were shown to be *Time consuming activities*, *Digital systems currently used*, *Perception of BIM* and *BIM parameters*. Colour coding was used in the analysis of the gathered data to enable a systematic comparison, where the information in the transcription was coded with a colour based on the expressed issue. According to Elo and Kyngäs (2007) the benefit of categorising information through colour coding is the increased understanding and detection of different aspect of a specific phenomenon. The critique to colour coding is however further expressed by Elo and Kyngäs (2007) as taking information out of context when performing analysis. The result needs to be linked to the collected data and where the authors emphasise usage of citations to capture the context of the presented data. To reduce the opposed challenge and ensuring presentation of trustworthy information, citations are used in the result chapter in Section 4.

The interviews were analysed and in addition compared with input gained from an interview with an expert within BIM implementation. The expert has in-depth knowledge regarding aspects of BIM in facility management and comparing this view with the outcome of the interviews with facility managers generates an interesting

comparison. Since the facility managers have more limited experiences of the issues, the input from the expert generates a validation and detect potential differences in perception within the real estate industry.

3.5 Validation and reliability

When generalisations are made based on findings in a qualitative research the aspects of validation and reliability needs to be reflected upon (Saldana, 2011). Reliability concerns the trustworthiness of the research and where the study should be replicated and generate a consistent result. Reliability is expressed by Saldana (2011) as resulting in similar generalisations and conclusions when replicating the study through receiving the same answers during the same interview context and with the same data analysis. Analysing the empirical data through classification and categorisation as described in Section 3.5 is argued to have increased the reliability of the study. This argument corresponds with the aspect of ensuring credibility by Saldana (2011).

Validation is instead defined as the accuracy of the conclusions made through generalisations (Hammersley, 2013). The size of the sample group is crucial to ensure trustworthy conclusions. The sample group in this research is argued to be large enough to include expressions of differences and thereby nuanced and valid generalisations. The consideration taken to both property and maintenance managers also contributes to the validity, where both roles are analysed to make accurate conclusions. This is however a master thesis and where the knowledge in the field of facility management and BIM can be argued to be somewhat limited. The innovative approach of including the facility managers in the research of possible BIM integration can although be argued contributing to valid outcome, since it has rarely previously been done.

3.6 Ethical consideration

When performing research that involves data collection through interviews, there is a need to consider ethical aspects, including moral and legal codes (Saldana, 2011). According to Wiles (2013) the aspect of anonymity is a central aspect of ethics. As mentioned earlier all audio-recording were approved by the interviewees and nothing said outside the recordings was included in the analysis. According to Wiles (2013) the off record comments could be intriguing to apply in the analysis, but it often result in increased risk of identification for the interviewee. In respect to the respondents and to not violate any ethical aspects the interviewees will not be mentioned by name or pseudonyms, nor will any of the represented companies. The only potential identifying fact about each company and person is whether a highlighted aspect is expressed by a property or maintenance manager, the expert or gained through the case study. The result addresses the outcome of the interviews, but is chosen to reflect general differences or similarities and not detect information that could identify a person or organisation.

Furthermore, participation in the research was voluntary and the aspect of anonymity and exclusion of off-record comments were always emphasised before initiating the interviews.

4 Chapter Four – Results

The following information is collected through performed interviews with facility managers, with the aim to highlight similarities, differences and interesting aspects of discussed topics. The information is presented in a summarised form, beginning with time consuming activities, digital platforms currently used, the perception of BIM and ending with BIM application areas. The findings of the empirical study are validated by input from an expert within the field of BIM implementation.

4.1 Time-consuming activities

One of the questions discussed during the interviews was what most time-consuming activity are included in the role of a facility manager. The interviewees all highlighted more than one time-consuming activity and the following section presents similarities and differences between the respondents.

The most frequently mentioned activity is *administration*, where eight of the twelve interviewees mentions budget monitoring, salaries and time reporting as big parts of their working days. Reading and responding to emails is another major aspect of administration according to the facility managers. As one of the interviewees expresses *"I don't believe that we have very difficult or complicated administration, but to get the economy into it and document everything, it is a lot of work."* The manager further reflects upon the aspect that the creativity of newly employed persons generally tends to decline when the amount of administration is presented. Three of the interviewees argue that an obstacle for efficient administration is the large amount of deficient drawings. Initiating a project with deficient drawings demands more resources to firstly find and update the information, which results in longer time until project completion. Two other interviewees instead emphasise undeveloped and slow systems for information handling. The systems are not adapted to handle the increased complexity in the buildings, which obstruct the administration. The respondents also mention the large amount of different digital systems used as a hinder for efficient administration, since there are difficulties finding and updating the information needed. The interviewed expert emphasises the problem of difficult and deficient processes regarding administration in the real estate industry. Further, using many different digital systems contributes to confusion regarding locating information according to the expert.

Four of the twelve respondents highlight *contact with tenants* as time consuming, especially the travel time for visits. Although, everyone that emphasised this activity also considered it to be rewarding and beneficial for the relationship towards the tenants. As a property manager states, "*Human contact is time consuming and demands logistic to enable meetings, but face-to-face meetings are although the best way to communicate."* Furthermore, of the respondents, both property and maintenance managers consider contact with tenants being time consuming, but also necessary to enable long lasting relationships as well as anticipating future adjustments and potential needs. Contact with tenants also includes documentation of eventual changes and performing negotiations, which is time consuming and where one facility manager especially emphasises the lack of system for handling contracts and agreements. At this particular real estate company the agreements are sent through the regular mail which takes unnecessary long time.

Internal meetings is another activity stressed by four of the interviewed facility managers. The reason for highlighting this activity is according to two of them, the lacking routines in decision-making processes, which causes inefficient meetings and also often require overtime to reach decisions. One respondent says have tried to adapt an efficient meeting routine to reduce the time spent in meetings, with a mixed result. An obstacle is still the large number of meetings and not only the length of the them. Furthermore, the two other interviewees instead express leadership with internal staff meetings as especially time consuming, but at the same time essential to enable teamwork.

Two of the seven interviewed maintenance managers emphasised spending much of their time on *handling emergency activities*, such as various damages. Especially water damages and burglaries are demanding and a frequent problem in some facilities. Furthermore, three facility managers highlight planned maintenance with time consuming pilot studies as critical activities and where deficient drawings are troublesome and causes inefficient processes. One maintenance manager captures the problem with deficient drawings in an example of initiating a plumbing project as *"The drawings are often very scattered and it is difficult to know if the drawings are the latest version or if they've been updated or not."* Since the drawings cannot fully be trusted, the maintenance manager needs to visit the building to ensure the information in the documents being accurate. The result is a very time consuming activity with inefficient and unnecessary long processes to ensure accurate and trustworthy information to enable successful projects. In accordance, the expert also emphasises handling emergency activities to be time and resource demanding. The uncertainty regarding status of a building, difficulties to find information and the trustworthiness of the drawings are expressed reasons for the activity being time-consuming. The expert highlight the complexity as, *"Obtaining information before initiating a maintenance project is very time consuming. We need to know the status of the building. To obtain that information more easily would be beneficial for the industry. The goal is to attain an unbroken information chain that would improve the trustworthiness of the documents."* The unbroken information chain referred to is the possibility to obtain accurate documentation from the construction phase to use as a foundation for facility management activities. Lastly, the issue of many different digital platforms used for handling information is expressed by the expert as the major obstacle for efficient information handling.

4.2 Digital systems currently used

The question regarding what digital systems are used was asked during the interviews to generate knowledge regarding the level of digitalisation at the different real estate companies. All twelve respondents express to be using digital systems daily and where two facility managers mention that their respective companies have converted toward a paperless organisation as a result. Common for all the interviewees was the large amount of different digital platforms used and where every respondent uses more than one system on a daily basis. Although, according to half of the interviewed facility managers there are too many different systems used, which makes searching for information in the systems difficult and time consuming. A property manager express it *as "It is very time consuming that we do not have one single IT-system, much time goes into searching for information, but also to document every procedure*

in all systems when adjusting a facility." The reason for the large amount of systems is explained to be the complexity of the information involved. The information is therefore often divided between platforms, where economy has one system, drawings a second and error reports a third etc.

The motivation for implementing any digital platform has generally been to enable more efficient facility management, but has in some cases resulted in the opposite. One facility manager emphasises difficulties for newly employed, where one person has worked for two years in the organisation and has still problems finding the right information. Experienced facility managers with many years in the same organisation also express having difficulties and prevail a common confusion regarding where to search, find and store information. According to three interviewees, the greatest challenge is therefore keeping the information in the systems updated. Maintaining the systems and the information within is however expressed by the same three facility managers to be essential to achieve successful digitalisation. Notable is that only one organisation expresses successful routines regarding updating drawings digitally. The facility managers at this organisation explain the success factor as *"We have a specific team which works only with updating drawings. […] They work full time with updating and order re-designs and then provide us and the project managers with updated drawings. It requires much, but it works well"*. Having a department solely focusing on updating drawings was unique among the interviewed companies. The other participating organisations instead either procures subcontractors or architectural firms or it is not done at all.

Common for all the responding organisations are the development and implementation of new systems that are currently being performed or have just been finished, with mixed results. According to one interviewee there will always be initial problems related to implementation of new digital platforms and where it is important to account for a transition period between usage of the old and the new systems. Only facility managers from two different companies express a successful implementation and transition towards the new systems. The greatest benefit emphasised by both is the integration of multiple functions in the same platform, which reduces the number of systems used. A property manager explained, *"The idea is that, when you change or update information at one place, that information is distributed automatically to the all other concerned locations regardless of whether you work with facility management or finance etc."*. Another appreciated feature is a more developed and illustrative feedback system towards the tenants regarding error reports. The most emphasised requests and requirements missing in the systems used today are user friendliness, to be able to handle the complex information and to more easily navigate and find the information needed.

The interviewed expert expresses great potential in the digital systems used, but where the possibility of transferring to one single system would enable easier information handling. Further, the expert emphasises the benefit in having mirrored systems, where changing in one system simultaneously makes adjustments in another. This is beneficial until further development of digital systems which could handle all complex information needed and thereby enable more efficient administration.

4.3 Perception of BIM

At the interviews, the question if the interviewees were familiar with the term BIM, prior the interview, and if they had ever come across the concept in their work was asked. Also, the interviewees general opinion of BIM was discussed. The interviewees did not know on beforehand that questions regarding BIM were going to be asked.

The majority of the interviewees did know of BIM as a concept. Six out of twelve has basic knowledge of the BIM and the meaning of it. They have most commonly heard of BIM through education or had in another context seen one or few presentations regarding the subject. The knowledge they have covers BIM being a visualisation tool where information can be stored and retrieved in 3-dimensional models. Three out of twelve have a more extensive knowledge of BIM but have never worked with it themselves. In addition to the knowledge already stated they also know for example that it is possible to handle several layers of information in BIM and some benefits and difficulties with using BIM in projects. These three had come across BIM in projects they had been involved in. The last three interviewees have no prior knowledge of BIM.

Out of the interviewees, the majority have a positive attitude towards BIM, only one interviewee is expressly sceptical toward the whole concept and does not consider BIM to be profitable. This interviewee mentions the sceptical perception is due to being introduced to BIM by someone fairly negative toward the subject. All interviewees do however believe that BIM can, in one or several ways facilitate their daily work and activities. The critiques expressed are that it would take too long to implement and parallel systems would have to be used during the implementation period. Another critique is that it would demand extensive work in the beginning of a project with creating an information base with a very high level of detail. It is considered a risk that the work would be unnecessary and a waste of time as it is not possible to know if and what information is going to be relevant throughout the project. One interviewee says about BIM *"Either you do not use BIM, you can then focus on tracking what you really need, when you need it […] or you can put a lot of work into traceability of things beforehand, even if you'll only need to trace a fraction of it in the future."*

There is also a concern that the facility managers in many cases lacks a technical education and therefore will not be competent enough to use such an advanced system as BIM. This is also discussed in the expert interview. The expert express concerns regarding the facility managers handling and updating information themselves. The interviewee further argues that a support function, working as a link between the information and the facility managers should be used.

Something widely commented on is the importance of keeping the models and information updated and accurate, this is considered a problem today and is thought to still be a problem if using BIM. Several of the interviewees points out that the buildings are getting more and more complex and they believe that BIM is a good method for handling this development. In general, the interviewees are positive toward using BIM in new built projects but are sceptic toward applying it on their

existing stock of buildings as this would be too hard and require way too much work.

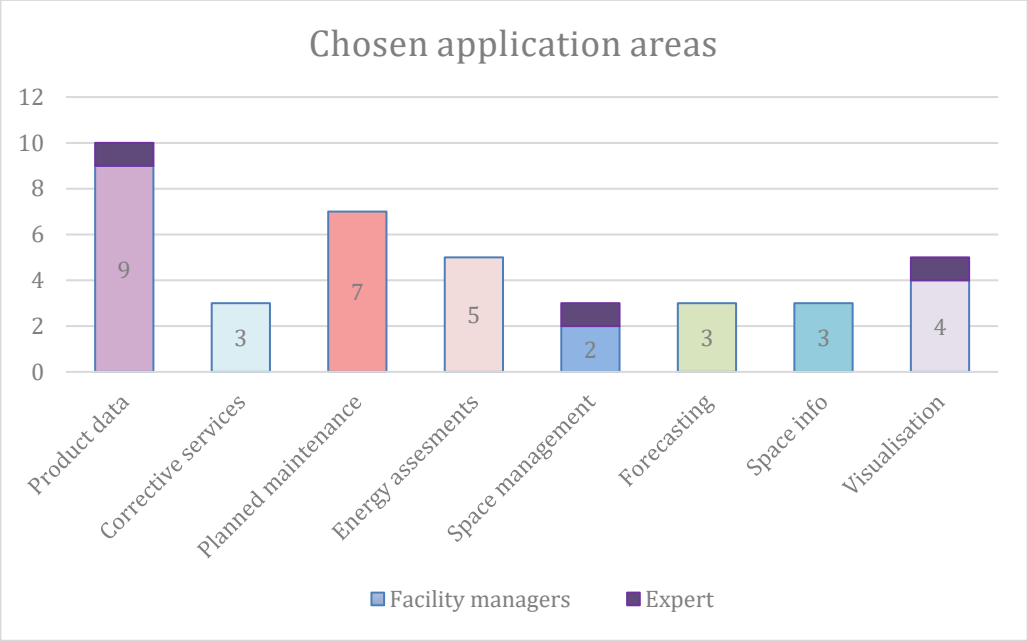
Aspects which are found important among the interviewees if using BIM in facility management is that the organisation is being mature enough in terms of structure, stability and IT-usage. Also, what information that would be available is important. The information available should be evaluated and chosen in accordance with the company and the employees that are going to be using it. It is considered important that the systems are user friendly, and it is therefore essential to have the right amount of data available. Too much information and functions would result in a too complex and difficult system. One interviewee discusses the subject *"If you are going to use a BIM model you must select what information to use. If you have your model with all information there is, you need to screen the model and see, what will we actually use? What do we really need?"* The general opinion among the interviewees is that if a new system is going to be implemented successfully, it must be significantly easier and better than the current systems, otherwise there is a risk of the new system not being used at all.

4.4 BIM application areas

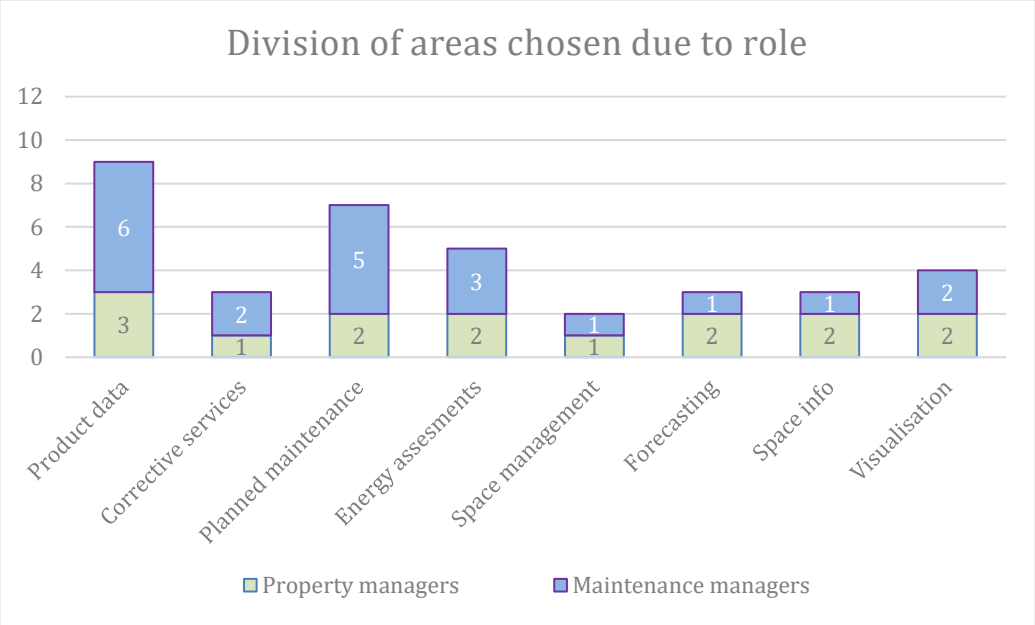
The following application areas for BIM in facility management were listed and presented at the interviews with the facility managers. The list was presented to investigate which daily activities the interviewees find most time-consuming and if these activities can be facilitated with use of BIM. Out of the below listed areas, the interviewees were asked to choose the three areas they found would create the highest value in their daily work, if made more efficient. The distribution of choices among the facility managers are visualised in Table 7 together with the three choices of the expert. In Table 8 the division between how the property and maintenance managers answered can be viewed.

1. Availability of product- and equipment information and data
2. Execution and reporting concerning corrective servicing and maintenance
3. Planning of maintenance work
4. Energy-, and environmental impact assessments
5. Space management
6. Planning and forecasting the rearrangement of spaces
7. Availability of space information for potential tenants
8. Visualisation and marketing

Table 7. Chosen application by facility managers and expert



Tabell 8. Division of application areas chosen due to role



All the areas were chosen at least two times and the majority of the interviewees are generally positive and can see potential in all of the listed options. A few consider some of the areas to not affect them in their daily work at all, while some are affected by all. The maintenance managers tend to chose area number one to four while the choices of the property managers are more evenly distributed. Regardless of choice, the recurrent, overall desired goals are to create a better overview, to save time and decrease repetitive work tasks.

Availability of product- and equipment information and data was chosen most often, nine out of twelve chose this area and it was also validated by the expert to be the most beneficial option. Several interviewees rank this as their number one choice, even though not being asked to rank their choices. This option is motivated by being used daily and that can be used in several ways, for customer service, for trouble shooting and for potential renovation and reconstruction work etc. It is today considered to be difficult to locate the right information in the interviewee's current systems. Often, the data is incomplete or divided between several systems, the information is also often inaccurate as it has not been properly updated. To improve the overview of various installations is considered to be a great benefit. One interviewee exemplifies it by *"Every time I need to measure air flows […] It would be fantastic to have collected information and documents concerning the power it needs, latest measurements etc."* To be able to see when specific equipment was installed, when it was serviced and their unique characteristics would facilitate the work of the interviewees.

Several of the interviewees stresses that mobile product data and information is desirable and to enable easily sharing of information, instructions and manuals with tenants. One of the interviewees explain that they are currently using a mobile facility management system which are not connected to any document handling systems, something that would be desirable.

Planning of maintenance work was chosen by more than half of the interviewees, seven out of twelve chose this benefit. The main reason for choosing this benefit is inadequate overview of properties. Several of the interviewees mentions that they are not at all affected by this activity in their daily work. Two of the interviewees consider their company to be behind concerning this activity. One of them mention that he/she had been surprised over how poor routines there were when he/she first started at the company. The interviewee says *"I was a bit surprised when I started at this company that they didn't have better knowledge of long term planning of maintenance […] We have currently a 2-3-years long perspective. However, we want to get to a point where we can see the entire life cycle, to get a 20-30-years long perspective and then be able to plan maintenance accordingly."* The interviewee continues *"We have a maintenance budget and we perform what is urgent. Earlier years, there hasn't been any time to do more than that, now we have the capacity but we don't have the resources. We spend all the money and then we find a bunch of other stuff that needs to be handled, but we can't as we have already spent all of our resources."* Several of the interviewees mention that a lot of the knowledge a facility manager possesses is based on experience and is not always documented, due to that, it is often lost.

One of the interviewees would appreciate availability of a full life cycle analysis for all the properties. Another one suggests that it would be desirable to instead of replacing equipment regularly, only change it when the need for replacement is indicated by the equipment itself.

Energy-, and environmental impact assessments was chosen by five out of twelve interviewees, and is thereby listed as the third most emphasised area. The reason for choosing this option is mainly a lack of a 100% good system for following up energy existing today, which makes it hard to keep track of where the energy is consumed.

One overall wish is to increase the number of measuring points and by that enable to both distinguish between operational energy and activity-specific energy but also to enable mapping consumption of customers and specific installation. One interviewee says *"If you in BIM can see the equipment and have separate measure points for them, it would be really good. The more I think about it the better is sounds."* One of the interviewees expresses a desire to compile their entire property stock on a property map where energy consumption for each building can be charted, colour coded and compared.

It is also considered beneficial to know exactly where certain materials are located in a building when the building is going to be demolished. Knowing this will also facilitate the work if any material is reclassified as toxic or environmentally hazardous in the future.

Visualisation and marketing was chosen by four out of twelve interviewees. This area is mostly chosen by property managers, but also by one maintenance manager. It was also validated by the expert to be especially beneficial. The main motivation for choosing this option is the sales aspect, to easily and clearly visualise a space or a building for a potential tenant is considered highly beneficial. To enable easier sharing of pictures, drawings and models with tenants is also considered highly beneficial in the interviewees daily work. Several interviewees stresses that there are numerous worn out spaces in need of renovation, this makes it hard for a potential tenant to visualise their operation in that specific space. Some of the interviewees also argues visualisation of spaces in models to be a potential time-saver. One says *"Sometimes you show a customer a certain building and they feel like it doesn't suit their needs or style at all […] If I could have visualised that space in advanced, we could perhaps have excluded that building and we wouldn't have wasted an hour by visiting it."* Two of the interviewees are currently using showrooms in their companies, this with a positive effect. They both believe that visualisation in 3D-models would have a similar effect. The expert argues that there today is a lack of good visualisation tools within the industry, hence a need for systems like BIM.

Execution and reporting concerning corrective servicing and maintenance, Planning and forecasting the rearrangement of spaces and Availability of space information for potential tenants were all chosen three times each. Some of the interviewees considers their current systems for correction services to work well whilst others believe there are great room for improvements in this area. The main reason for choosing this benefit is a desire to increase the level of detail in the reports. This would shorten the time for measures and give the tenants improved customer service and feedback. Another wish is to enable better mapping of report history, both the division of reporting among the tenants but also over specific equipment which has been reported faulty. One interviewee discusses the subject with an example *"For example; we have repaired these windows four times over the past month, maybe they need to be replaced? That's something I would like to be able to see."* Through mapping, clearer indicators of suitable measures can be viewed and faulty equipment replaced in time. One suggestion was to connect error reports to accurate warranties.

Planning and forecasting the rearrangement of spaces does mostly affect the property managers but also some of the maintenance managers. The most desired function is to in BIM perform what-if analyses. The maintenance managers who

chose this benefit wants to be able to simulate changes in the spaces and thereby see changes is airflow etc. The property managers want to perform the analyses in sales purposes. They emphasise a wish to in accordance with the tenants simulate space adjustments to better visualise a clear picture of what to be expected after certain renovation work or other adjustments to the space

Availability of space information for potential tenants was chosen and discussed mostly in accordance with visualisation and marketing and is also motivated in a similar way. A wish to quickly and easily answer questions and share information about certain spaces with potential tenants is considered to be the greatest benefit. The interviewees who chose this area declares a wish for better overview of space information, measurements, characteristics etc., information which today often is inadequate or inaccurate.

Space management was chosen by two out of twelve interviewees and by the expert. One of the interviewees considers this area to be extra important as it is something that he/she handles daily. Especially tracking vacancies and distribution of tenants is something that can be made more efficient. This was also the main argument by the expert for choosing this option. To measure the usage of the buildings and spaces is also considered to be beneficial. One of the interviewees consider his/her company to have an existing, well-functioning system for this and does not see any reason to change from this system.

5 Chapter Five – Case Study of JSP2

The following section reviews reasons, benefits and challenges of integrating BIM in the project of Johanneberg Science Park 2. The information was obtained through an interview with a highly involved actor in the project.

5.1 The reasons, benefits and challenges of integrating BIM in JSP2

The purpose of implementing BIM in the JSP2-project is expressed as a willingness to facilitate the work of the maintenance and operation department at Akademiska Hus. The profession of facility manager is explained to be including administration, such as procurement and orders, and simultaneously perform traditional activities like error handling, damage control and maintenance. Even though the role demands administrative work, technical knowledge is still crucial. According to the interviewee, efficient facility management can only be achieved by having an understanding of the occurred errors and the technical structure. The interviewee sees great potential in integrating BIM in facility management operations and believe the reason for currently not being implemented in the industry is the lack of technical knowledge and support systems to keep the models updated. Another reason emphasised is the market not being mature enough to integrate information handling systems like BIM.

The project has two overall objectives concerning BIM in the construction and facility management phases. Firstly, the goal is to manage the BIM model during the construction period. The ambition is to achieve more efficient construction which would result in a more qualitative end-product to a lower price than traditionally. Since integrating BIM in facility management is an innovation, the second objective is to create an awareness and movement within the industry concerning BIM implementation. The interviewee highlights the innovative decision of having a facility manager participating in design meetings and throughout the construction phase. The importance and reason for the decision is emphasised as *"Facility management and the design collide when there is no consideration for facility management operations in the design phase. […] It might not be intended to be collisions, but there are mistakes made in the design phase when facility managers are not included, and in the end the errors becomes troublesome for the facility managers."* Opportunity to express knowledge regarding maintenance and operations can then be realised and consideration to these aspects be accounted for at an early stage of the project. To ensure knowledge sharing throughout the project, partnering procurement is chosen, where contractors, consultants and the facility manager will work closely together. According to the interviewee there will probably still be errors during the project, but some traditional clashes will be avoided through the chosen form of procurement. Integrating facility management in the design phase is emphasised by the interviewee as beneficial in terms of knowledge sharing, making of more valid decisions and reducing time-consuming errors.

The expressed benefit of using BIM in the JSP2-project is the possibility to establish a shared vision among the involved parties. As the interviewee expresses, *"A picture is worth a thousand words."* and where all involved parties can view the building illustrated in BIM, which generates a shared understanding of what the end-result is attended to be. According to the interviewee, this results in both commonly shared

goals and also higher motivation towards the project, emphasised as *"The benefit of using BIM is that carpenters can see the end result of the planned building on a screen. A house is a mixture of different factors and materials, especially things that you don't see."* In the long-term perspective, the synergy effects of BIM implementation is expressed as increasing the alignment between different professions, where for example, an architect understands the constructor's critical aspects and thereby makes more accurate assumptions. Furthermore, integrating BIM in post construction phases has also economic benefits. The model is generally expensive to produce and initiating usage of BIM in facility management would increase utilisation of the investment. The interviewee also emphasises different "if-factors" as potentially beneficial. Documentation of materials in BIM is one such factor, where it can be very valuable knowing where a particular material is used in case of a future prohibition.

A disadvantage of BIM is expressed as the ability to design with details down to the millimetre, but where the final construction generally contains compromises due to material issues or incorrect presumptions. This generates a difference between the information in the model and the actual end-result. Considerations to tolerance levels where the craftsmen are free to perform and construct within are therefore essential to implement in a BIM model. Revision of the model in accordance with the end-result should then be performed to ensure accurate information before handover to facility management. The importance of updating the model is expressed as "*It is important to validate the information, so that the information is correct. Otherwise you lose faith in the model."* The implementation of BIM is emphasised as another obstacle, which is mainly due to lacking knowledge and technical immature organisations. To enable successful integration the end-users of the BIM model, the facility managers, should be able to participate during the implementation period to emphasise their requirements and wishes. The interviewee also expresses the importance of receiving aspects from people with a negative attitude towards BIM and to review their concerns.
One key aspect highlighted during the interview is the importance of not having overly visionary hopes and be over believing in what they will achieve in this project. In the end, it is about documentation and where it still can be difficult to ensure updated documentation due to limited time. The solution has in this case been to connect the BIM model to their IT-system, which integrates the model to the current digital systems used at Akademiska Hus. The company also has a separate department responsible for updating drawings, essential as a support function to ensure updated models and information within the BIM model. Combining the IT-department and the facility department is one key success factor according to the interviewee, which have resulted in motivation and willingness to work together. As the interviewee concludes, even if they do not reach all the objectives highlighted, the project should still be viewed as an innovation and as starting point of BIM integration for more efficient facility management.

6 Chapter Six – Discussion

The chapter will capture and highlight correlations and differences between the theoretical framework and the empirical data collected through interviews in addition to the JSP2-project. The structure of the chapter will correspond to the result sections where the research questions and how enablement of efficient facility management will be discussed in terms of possibilities and challenges regarding time consuming activities, digital platforms currently used, BIM perception and application areas of BIM.

6.1 Time-consuming activities

When analysing the outcome of the interviews four time-consuming activities affecting the work process of the facility managers were detected. These needs to be reduced or developed to enable more efficient facility management. The finding of the empirical study shows *administration* to be the activity most emphasised as time-consuming. The findings correspond with Coots et al. (2010) where the statement that the role of facility manager needs to handle more amounts of complex information, such as certifications and technical applications, due to current developments and trends in the industry. The interviewee in the JSP2-project also argues that the role needs to handle larger amounts of administration than before. Deficient drawings, undeveloped and to many digital systems are during the empirical study expressed as challenges to enable efficient administration. Furthermore, the second most highlighted activity is *contact with tenants*. Both property and maintenance managers in the study however express benefits of having close contact with the tenants, this to ensure long-term relationships that results in secure rental incomes. Close contact is also argued to be beneficial by Anker-Jensen (2008) where organisational performance of the tenants can be enhanced through adaption of space in accordance with their requirements. The division of hard and soft facility management also captures the service approach of the profession, where both maintenance and organisational objectives need to be fulfilled (Anker-Jensen, 2008). The respondents of the empirical study expresses that contact with tenants become time-consuming due to documentation of changes and agreements, where efficient systems for handling information is missing.

Apart from administration and tenant contact, the facility managers express spending much time in *internal meetings*. Decision-making processes within organisations are causing long meetings which often also results in overtime. As Anker-Jensen (2009) explains, the role of facility manager encompasses managing running of the facilities in combination with ensuring satisfied tenants through adaption of space. The role thereby includes different aspects to handle simultaneously causing much time spent in meetings to coordinate the processes. More efficient information sharing systems would facilitate the daily activities and reduce the number of meetings needed. The aspect of *handling emergency activities* was emphasised by maintenance managers as troublesome and time-consuming. This perception corresponds with the approach emphasised by Teicholz (2001) as a characteristic of reactive facility management. The maintenance activities are then generally unplanned and with purpose of only eliminating damages or other severe issues. Changing facility management strategy to proactive is emphasised as beneficial in the same theory section, since it contains performing planned operations which thereby reduces time spent on emergencies. In

the empirical study the respondents express the opposite, where planned maintenance activities are currently considered time-consuming. The reason is deficient drawings and untrustworthy information, which causes inefficient processes and much time spent on searching for information to initiate maintenance projects.

The issue of handling emergency activities can be reduced by integration of facility management already in the design phase. Mari and Pogessi (2014) express that consideration to maintenance plans in the design phase could reduce time spent on future emergency activities. The obstacle for earlier integration is expressed as the limited design knowledge of the facility manager. Reviewing the findings from JSP2, this complexity was reduced by using partnering procurement with transparent documentation and continuously meetings to ensure mutual involvement. Technical innovations, such as IoT, is another solution that can contribute to reduction of emergency activities. The applications with internal intelligence can both send information and receive corrective actions, resulting in efficient error handling due to eliminating the need for visiting the building. This could be the solution to a successful transition to proactive facility management, since more accurate maintenance plans can be performed and emergency activities reduced. Furthermore, knowledge from past emergencies could also enhance the cooperation and thereby reduce time spent on damages and severe issues. As Patel (2015) highlights, organisations applying IoT-applications have been able to shorten their decision-making processes since information easier can be attained and thereby enable reduced number of time consuming internal meetings to coordinate the processes.

Reviewing the theory, the outcome of the empirical study in combination with validation from experts shows areas of improvement. The commonly shared aspect highlighted is the issue of information handling, where the respondents express difficulties of finding and updating the desired information. Since documentation is a vital activity in the profession of facility manager, developing more efficient system of handling information should be prioritised. Barrett and Baldry (2003) explain the importance of sharing information between the parties as a characteristic of proactive facility management. Better information handling systems can thereby facilitate the desired transition towards this approach. As the managers from the empirical study express, the contact with tenants are rewarding and only becomes time consuming due to the large amount of documentation that is implied with the activity. Relieving and facilitating administration for the property and maintenance managers could enable more time dedicated to contact with tenants and the ability to better anticipate needs and future requirements. A finding from the empirical study and validated by the expert was that many digital systems has been implemented to facilitate information handling processes, but in many cases, instead have resulted in more confusing and time consuming documentation.

6.2 Digital platforms used today

Facility management is, according to Atkins and Brooks (2014), generally characterised as meeting the requirements of tenants and simultaneously reducing running costs of buildings. Enabling satisfied tenants to reasonable expenses need careful managing. Digital platforms are therefore used in order to handle information regarding the facilities, tenants and the building systems. The empirical study shows that all participating organisations use more than one digital system, which cause

inefficient processes and unnecessary time spent on searching for information. The highlighted reason for the many different platforms used is the large amount of information that one single system are unable to handle. According to Coots et al. (2010) the buildings are also becoming more technically complex, which the current digital platforms are unable to handle properly. Ensuring satisfied tenants although encompasses implementation of technical applications that need to be maintained and operated properly. Furthermore, information in the systems is characterised as inaccurate and untrustworthy due to lack of routines regarding updating the documents. Only one represented organisation expresses having well-functioning processes regarding updating information. The digital platforms used is a complex issue where the many different systems results in inefficient processes with reduced information exchange between facility managers and projects.

Lacking functions in the systems currently used are expressed to be, user friendliness, collective information of facilities and easy navigation. A digital system able to handle complex and large amount of information stored in the same format at one single platform is a requirement desired by the respondents of the study. Digital immatureness is although highlighted by Sabol (2008) as an obstacle for implementation of new digital platforms. The many systems currently used by the facility managers can although be viewed as beneficial in terms of the experience of digitalisation gained by the respondents, which could avoid the obstacle of immatureness. The perception from the empirical study is also the general development and implementation of different systems currently made, which can be viewed as a learning to adapt to new digital platforms. In the JSP2-project, the learning period converting to a new platform and a proper introduction to the new system is being emphasised as essential for success. Outcome of JSP2 also reveals the importance of an easy manageable system to ensure efficient information handling.

One obstacle expressed in the empirical study is the issue of keeping the information in the systems updated. The importance of correctly updated documentation corresponds with Kassem et al. (2010) where the importance of accurate information is emphasised. The presumption for enabling trustworthy information is although attaining correct information from the construction phase. However, Becerik-Gerber et al. (2012) express that the information gained from construction is generally inaccurate, causing deficient drawings and documentation. In JSP2 possibilities in revising the drawings after construction completion to account for the differences between the design brief and the performance of construction is expressed as a solution. Revision could ensure more accurate information transfer between the phases and meet the desired outcome of an unbroken chain of documentation emphasised by the expert. Integration of facility management consideration already in the design phase as proposed by Mari and Pogessi (2014) could further facilitate the information exchange between the phases. Shared knowledge by integration can enhance collaboration between involved parties and result in applications for facility management operations in the design phase. Furthermore, the information in the digital systems need to be updated and maintained to ensure accurate and trustworthy information, an issue frequently expressed in the empirical study. As previously stated administration is a time consuming activity for the facility managers. The empirical study and input from the expert generate the beneficial solution of a separate division as a support function to update drawings and information. This would relieve the

facility managers of the pressure and time spent on updating the information as well as be a reassurance of accurate and trustworthy drawings and documentation.

The findings from the empirical study and validation from the expert reveal that the large amount of different digital systems used have resulted in more complicated administration and more time spent on searching for information and making changes. One solution emphasised by the expert is implementation of digital systems that are able to reflect the changes done to other platforms used, to reduce the time spent on updating many different systems. Findings from the empirical study also show this feature to be highly appreciated and also expressed missing in many of the current systems used for information handling. The development of connecting different digital systems is a beneficial development to achieve better information sharing between roles as well as between projects. It can also be viewed as a starting point and contribute to the desired conversion to proactive facility management since reduced time and resources spent on administration instead can be focused on developing the relationships with the tenants.

Another solution is integration of BIM, since it enables a single digital platform, able to handle the large amount of complex information. The integration of BIM can however be difficult since it has not been proven to be profitable in facility management yet (Kassem et al. 2016). The knowledge and perception of BIM among facility managers could therefore become an obstacle and reduce the possibilities of enabling efficient facility management through BIM.

6.3 Perception of BIM

The general perception of BIM is positive among the interviewed facility managers, only one out of twelve is expressly sceptic. All the interviewees do however believe that BIM could facilitate their daily work in one or several ways. Notable is however that some of the concerned organisations are fairly far behind in development and maturity and had potentially not been able to exploit all the potential benefits with BIM. As some of the organisations still work with quite analogue processes, BIM seems like a utopia compared to current processes. This perception is confirmed, as it in the interviews is clear that the knowledge regarding BIM among the facility managers is inadequate. Only three of the interviewees have more extensive knowledge regarding BIM and the meaning of it. Three of the interviewees do not at all know the concept and six have a vague perception of what it entails. It was also discovered that the knowledge possessed was obtained from one or few presentations of the subject. Due to this, there is a great risk of the interviewees having a biased opinion about the subject. This was particularly obvious in the interview with the one participant that expressed scepticism. This interviewee had expressly been presented about BIM by another sceptic and had thereby primarily been informed about pitfalls and disadvantages. In the same way had the other interviewees heard and seen positive presentation about the concept and was therefore more positive towards it. In addition, due to the choice of methodology it is a risk of the interviewers influencing the interviewees with the asked questions. As in this case, three of the interviewees were unaware of BIM and had to be informed about it prior being able to answer the questions, the risk of presenting a biased view is thus impeding. This, in spite of the fact that potential pitfalls and difficulties regarding the subject was discussed during the interviews.

The limited knowledge is a holdback both for the thesis and for the development of BIM in facility management. As the knowledge of BIM is generally low among the facility managers, the understanding of what possible benefits it could generate is deficient. The question regarding possible application areas is leading as the interviewee is asked to choose from a given list. Better previous knowledge regarding BIM processes could possibly enable the facility managers to exemplify areas that would facilitate their work more than the given ones. A chance of there being other, more beneficial application areas is thus impeding. The lacking knowledge does also imply that there is no clear demand for integrating BIM in facility management. As the facility managers do not know themselves what benefits it can provide, there is no need to pressure for change. This could be due to it being rare to consider facility management in early project stages (Kassem et al., 2015). To enable real possibilities for change there must be extensive knowledge and an ambition to improve. The first step toward change, must come from above, but this is rare as the benefits are not yet proven and BIM is still rarely demanded from project owners (Becerik-Gerber et al., 2012). A good antipode example is the case of JSP2, where implementation of BIM in facility management is planned from the beginning of the project. The goal with the project is to enhance the knowledge, spread the word and initiate the work of changing the industry, which is also the objective of this thesis.

Projects like JSP2 are crucial for any change to happen in the industry. The project is already considered to be successful, as the goal of getting the plans approved has been achieved. They have also managed to fulfil the goal of spreading the word about the project within the industry, which will hopefully create a synergy effect for future projects. It will continuously be important to follow up on the project and study the progress after construction completion and facility management initiation. Valuable lessons regarding what information is important, what works, what does not, what requirements are necessary and what benefits are there actually to gain, will be possible and interesting to further investigate. The project will also, hopefully motivate other actors to dare and want to implement BIM in their own projects.

Even though the general perception of BIM is positive, there are some concerns among the interviewees. Especially discussed was the issue of updating models and information. Keeping models updated was in the interviews mentioned to be a current problem by almost all the organisations. This was also considered to still be a problem, even if BIM was implemented. This is also mentioned in theory to be one of the greatest challenges for successfully implementing BIM in facility management (Kubba, 2012). The issue of managing updates efficiently is also discussed in the JSP2-project. Worth mentioning, is that only one organisation argues that their current update processes work well. The same organisation also mentions that they have a specific role in their organisation, which work solely with updating models, information and data. This is also stated by the expert to be a successful approach, and it is how they plan to resolve the issue in JSP2. In addition, Sabol (2008) emphasis that organisations which are not technically mature themselves or which does not have the resources to employ BIM specialist for managing and updating the models should not embrace the method.

Another critique is the risk of performing comprehensive, unnecessary work in the beginning of the project. It is considered to be time-consuming to document

information with a very high level of detail, information which cannot be certain to be needed later in the project. This issue is discussed both by the expert and in the case study of JSP2 as they emphasise the need for beforehand investigate what, and how much information should be available by facility managers. To in advance analyse which parameters should be available would reduce the work and improve the chance of the included information being vital and used in the facility management phase. To eliminate the risk of the work being unnecessary, it is important to choose to implement the information which the facility managers themselves think will be beneficial to their daily work, this is also discussed in the case study. To review beneficial information will also handle the concern which some of the interviewees expressed about the facility managers lacking technical education and thereby, potentially not being competent enough to handle a complex system like BIM. To limit the systems to a few beneficial application areas and focus on high user-friendliness will potentially ease the use of the systems and decrease the complexity. There was a recurrent goal to improve the overview of projects and minimise double working among the facility managers. It was generally in accordance to these goals which the interviewee's perception of BIM was determined as they believed BIM could be a way of achieving their goals. It was also with these goals in mind they choose application areas.

6.4 BIM application areas

As previously stated, all the application areas were chosen at least two times, it was also stated that the majority of the interviewees were generally positive towards all of the areas. This indicates that the presented application areas are valid and accurate. It is further argued that all the listed areas can be facilitated through usage of BIM. The main area, information and data handling are specially argued to facilitate all the listed application areas. Becerik-Gerber et al. (2012) states in this section that BIM can facilitate information handling by digital compilation of data in beginning of projects. This makes the information which is later delivered to FM more accurate and easily manageable for facility managers.

Further, the empirical study indicates some differences between property managers and maintenance managers, as maintenance managers tend to choose application area number one to four and property managers, tend to choose all the areas more evenly. This is hardly surprising as the different roles involve different duties, where the role of maintenance managers are more related to application area number one to four. Nevertheless, all the benefits were chosen by both kind of facility managers which is an indicator of there being some differences regarding what the roles involves within each organisation.

The application area most frequently chosen was by far **Availability of product-, and equipment information and data**, as it was chosen by nine out of twelve facility managers. In addition, this area was also chosen by the expert and stated to be an it-factor in the case study of JSP2.The main reason for this choice was that it is considered to be difficult to locate necessary information and data in currently used systems. This is also mention in regards to being time-consuming and is argued to mainly depend on the information being scattered and divided upon several platforms. This is stated to be a common issue, Becerik-Gerber et al. (2012) states that, the information delivered from AEC to FM is often inaccurate, incomplete and difficult to

manage. It is also often fragmented across different systems and formats. To enable more easy access and location of product data could thus, save time and hence, make facility management more efficient (Kassem et al., 2014). Sabol (2008) also argues in the same section that by easing the process of locating components and associated information, costs for repair work and commissioning can be decreased and time for maintenance work can be shortened.

Easier access and location of product data would reduce the time-consuming activity of *administration* by storing all necessary data concerning specific objects or components at the same platform (Kubba, 2012). Ghaffarianhoseinia et al. (2016) continues to declare that BIM could facilitate information handling by compiling all information concerning physical structure, mechanical and electrical systems, equipment and furniture in the same format, which would reduce the time spent on administration. This does also improve administrative processes as one issue was the large number of different digital systems currently used. In BIM facility managers, would know where and how to store and update information and they would only have to do it once (Becerik-Gerber et al., 2012).

Contact with tenants is stated to be one of the main time-consuming activities for facility managers. By applicating this area, time spent on contact with tenants can be reduced. This activity includes documentation of eventual changes, performing negotiations, also mentioned is the lack of systems for handling contracts and agreement. BIM can handle both various kinds of documents and keep track of maintenance history. By easing the process of locating components and associated information time for maintenance work can be shortened (Sabol, 2008). Kassem et al. (2014) also argues that to easily access and locate data could increase efficiency of facility management and error reporting processes as faults can be tracked and reported in the model and work orders can be executed faster. This would reduce time spent on contact with tenants regarding correction work.

The time-consuming activity *handling of emergency activities* can also be reduced by using BIM. By storing historical data of maintenance in the model, BIM could facilitate future projects and maintenance work (Kassem et al. 2014). This could enable better planning of maintenance and the number of emergencies can be reduced. In addition, Sabol (2008) argues that easier access to data would facilitate the work if any accidents occur.

The fourth time-consuming activity is *internal meetings* where the main issue is stated to be lack of processes for decision making. It is stated that through BIM, it has been made possible to dissolve isolations and increase collaborations between project team members and ease information sharing (Motawa and Almarshad, 2013). By enable information sharing decision processes can be facilitated and make internal meetings more efficient.

As application area number two, **Planning for maintenance work** was chosen. This area was chosen by more than half of the facility managers as seven out of twelve chose this option. The reason for this choice was mentioned to mainly be due to a desire to improve the overview of properties and spaces. As mentioned earlier, facility management is today generally characterised in accordance to the reactive approach where actions are taken unplanned and unscheduled activities are performed due to

the severness of the issues (Teicholz, 2001). By redirecting the facility management strategy to proactive facility management, with planned maintenance and anticipation of possible errors would enhance utilisation of resources and reduce time spent on handling crises. This would facilitate the time-consuming activity *handling emergency activities*. It would also facilitate *contact with tenants* as better planned maintenance would enable preventive maintenance work to be done which would decrease the need for tenants to report errors and unscheduled maintenance work to be needed. It is further mentioned that maintenance managers often need to visit buildings to ensure that drawings and information provided is accurate and correct. To ensure trustworthy information would therefore also reduce the number of visits to spaces and tenants. By analysing historic behaviours of buildings and its installations in BIM, decisions regarding planned maintenance and repair work can be facilitated and advantageously prioritised (Aziz et al. 2016).

The application area is further strongly connected to the time-consuming activity *administration*, this as historic data of maintenance work can be documented in the model and future maintenance work and projects can be facilitated (Kassem et al., 2014). Three of the interviewees argue that an obstacle for efficient administration is the large amount of deficient drawings. Initiating a project with deficient drawings demands more resources to firstly find and update the information, which results in longer time until project initiation and hence project completion. By enabling better planned maintenance would thus also improve and facilitate decision making processes and thereby also reduce the time-consuming activity *internal meetings*.

Choice number three was **Energy-, and environmental impact assessments**, as five out of twelve chose this application area. The reason for choosing this option was mainly a lack of a 100% good system for following up energy, which makes it hard to keep track of where the energy is consumed today. It was also considered beneficial to know exactly what and where certain materials are used, especially in the case of demolitions and when *handling emergency activities*. Becerik-Gerber et al. (2012) argues that this area could be facilitated by BIM as it is possible to perform what-if analyses in specific spaces or buildings, the energy consumption and environmental impacts can be monitored, compared and the most energy efficient scenarios can be found. This would facilitate the time-consuming activities *administration, internal meetings* and *contact with tenants* as energy consumption can be monitored and controlled more efficiently due to more extensive, accessible information regarding tenants and various installations (Becerik-Gerber et al., 2012). By tracking energy consumption to specific installations or tenants it is possible to optimise spaces and decrease energy consumption. In addition, it is possible to keep track of historic environmental data and by that in advance predict performances of buildings (Sabol, 2008). This would improve decision making processes, reduce administrative work and improve service toward tenants. It could also save time for facility managers to avoid some visits to spaces and tenants which is argued to be a great part of the time-consuming activity.

The rest of the application areas were, like the ones mentioned above, chosen in accordance to the general reasons of being time-consuming and lacking of well-functioning processes regarding the activities today. According to Becerik-Gerber et al. (2012) integrating BIM in facility management could enable efficient processes for both maintenance and property managers in terms of information handling. All of the

listed application areas can facilitate the four time-consuming activities if integrated in BIM. As inadequate information handling and to many digital systems used are stated to be the core issues in efficient facility management today, the main goal must be to address these. In this section, it has been presented how specific application areas could make facility management processes more efficient by handling these exact issues. The empirical study, theory and findings in the case study all indicates that there is both a need for, and a willingness to improve the real estate industry, and the potential benefits of using BIM to do so are clear. By implementing BIM and connecting it to sufficient IoT solutions a two-way-communication between building and manager can be achieved (Patel, 2015). It is previously mentioned that IoT can enable facility managers to monitor, measure and predict the performance of different systems in a specific building (Li and Han, 2016). The ability to share performance information through internet to a remote facility manager could result in more efficient facility management operations since more accurate corrective and maintenance actions can be performed and would thus reduce all of the mentioned time-consuming activities. Organisations which apply IoT solutions have been able to shorten decision-making processes by making more accurate and insightful assumptions (Patel, 2015). It enables better precision of maintenance actions needed which would reduce the number of unplanned emergency actions. Finally, Kubba (2012) claims that BIM indeed is the future and organisations which do not embrace the method will gradually fall behind the ones that do. Sabol (2008) also argues that if the obstacles are addressed and new standards developed, it is only a matter of time before a complete BIM transmission of useful information from AEC to FM is established as standard procedure.

7 Chapter Seven – Conclusion

After completed study it can be established that four, eminent, time-consuming activities within facility management can be identified. The activities; *administration, contact with tenants, internal meetings* and *handling emergency activities* are all considered to be facilitated by usage of BIM. The main reason for these activities being time-consuming is due to deficient information handling processes and usage of too many technical systems. BIM is considered to enable collection of several functions on the same platform in addition to facilitating handling of information and data, which would make facility management more efficient. Connected to the eminent, time-consuming activities are the choices of most beneficial application areas, chosen by the interviewed facility managers. The most emphasised areas are **Availability of product-, and equipment information and data, Planning of maintenance work** and **Energy-, and environmental impact assessments**, which are all affected by mentioned time-consuming activities. Implementation of these parameters in the BIM-model is therefore concluded to be a beneficial first step toward fully integration of BIM in facility management.

Found during the research was, to successfully implement BIM in facility management, consideration to FM must be taken early, during planning and the design phase of projects. To account for wishes and requirements from facility management is considered to be essential if implementation is going to be successful. This would both ensure right and valuable information and parameters being implemented but would also facilitate the future usage of BIM for facility managers. Further, what can be concluded is that collected, empirical data is coherent with presented theory, both regarding potential benefits and obstacles. These are also accounted for and validated in the case study of JSP2, which makes continuing to follow the progress of the project important and interesting.

The purpose of the thesis was to contribute with information regarding how facility management can be made more efficient by usage of BIM. It was also to underlie future innovations and development areas within real estate. Both aspects are considered to have been achieved as the thesis indicates several ways in which BIM could make facility management processes more efficient. This justifies several new, further research topics within the subject area, which was the objective of the study. The goal was also to increase the awareness of possible benefits with integrating BIM in facility management. This is also considered to have been achieved, both due to information shared at interviews and to the results published in the written thesis. To actively address facility managers and investigating what they need is considered to have been a successful choice. It was both highly appreciated by the interviewed facility managers to be included and heard and it also results in the outcome to be validated for practice and not only be based on theoretical information.

7.1 Further studies

Further studies should include development of practical solutions for implementation of BIM in facility management. This thesis is merely theoretical and further studies regarding how conducted research can be transformed into practical implementation is thereby necessary. In association to this should statues and standards also be developed and established.

Secondly, chosen application areas should be more thoroughly analysed and evaluated in further studies. The chosen areas are broad and should be refined and defined more accurately prior implementation.

Finally, the project of JSP2 should be continuously studied as there are potential, beneficial lessons to be learn and processes to evaluate. As the project, still has not reached the facility management phase it will be interesting to follow the ongoing process further and evaluate the level of success afterwards.

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