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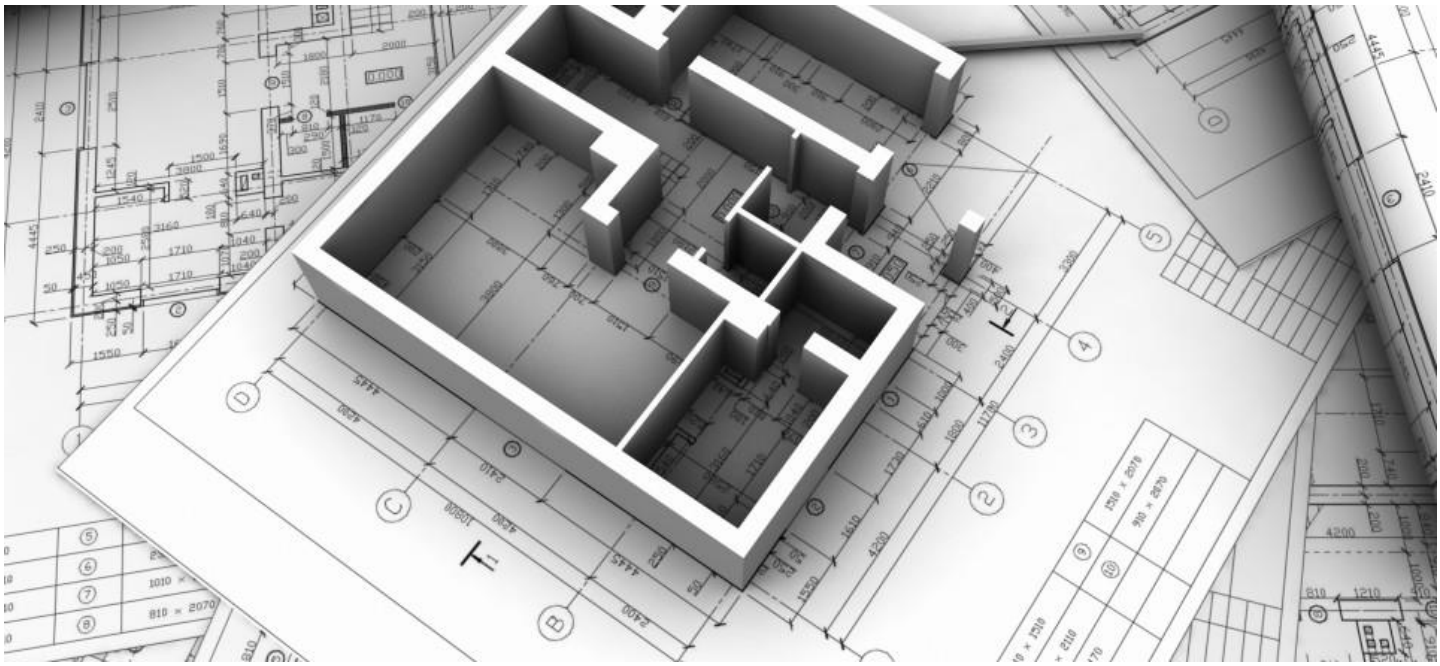

Digitalization of Facilities Management

The Slow Development of Space Management

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

SIMON TREVIK
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Department of Civil and Environmental Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Master's Thesis BOMX02-17-35
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ABSTRACT

The Facilities Management (FM) industry has to deal with a lot of information concerning facilities. This information needs to be handled, available and stored in a easy way for the facility manager to use. Previously this was done in an analog manner, but now digitalization of FM is an ongoing process. Building Information Modelling (BIM) could be a major part of this digitalization. New methods to perform FM services through digital tools such as BIM, are on the rise in the construction industry. These tools are however seldom used, even if the development of BIM in the field of FM is growing. One aspect of FM that may be improved with digital tools is Space Management (SM), which has the potential of reducing costs of both space and personnel. The aim of this thesis is to investigate how digitalization, especially BIM, can be used to support SM. This is done through mapping how facility managers utilize BIM for the purpose of SM today and to analyze how it can be improved.

Through an abductive research approach a literature study and a qualitative empirical investigation were performed. The literature study served to compile knowledge for the thesis regarding FM, SM, BIM and associated methods and tools semi-structured interviews with facility managers as well as BIM- and FM-consultants were performed, to gather empirical information regarding how large property owners in the Gothenburg region perform SM. The literature study demonstrated the importance and benefits of efficient SM. Highlighted benefits include, decreased facility costs, improve business performance, keeping track of information that enables better decision-making concerning future business planning. Several reviewed authors mean that BIM has the potential to improve SM by, storage of information concerning spaces in one place, provide up to date information and graphics, up to date space utilization, and allows FM staff to make decisions that are well informed both visually and technically. BIM implementation is however costly for adopters since it involves new working methods, new software and knowledge about it.

The study showed that higher profits were the most important issue among the property owners and one way to achieve this is to make sure that facilities are being fully utilized and spaces don't stand empty or are forgotten. The facility manager's own knowledge of the facilities is important, not many digital tools are used more than technical drawings, in the form of PDF-files. Some of the interviewed companies do however work with BIM models for their newly constructed facilities, but not for existing ones. There are differing views concerning BIM among facility managers, some do not find it beneficial enough to implement, while others see potential

benefits, and wish for digital development in this direction. Even though some of the interviewed facility managers does not want to implement BIM, small steps towards digitalization have been seen among all property owners.

In conclusion, the commercial property owners in Gothenburg do not perform SM with BIM tools. The facility manager's knowledge and technical drawings is the information material that is used. Some of the interviewed managers do however want to use BIM more, while others do not. Digitalization is something many of them believe will increase. Even though the expression BIM may be used less because of prejudice among professionals, digitalization will most likely develop the work of SM and enable new working methods. Professionals interviewed for this thesis were more positive and optimistic towards digitalization than BIM.

Key words: Building Information Modelling, BIM, Space Management (SM), Facility Management (FM), digitalization, property owners and property management.

Digitalisering av Fastighetsförvaltning
Den långsamma utveckling av Space Management

Examensarbete inom mastersprogrammet Design and Construction Project Management

SIMON TREVIK
TOBIAS NILSSON
Institutionen för bygg- och miljöteknik
Avdelningen för Construction Management
Chalmers tekniska högskola

SAMMANFATTNING

Fastighetsförvaltnings industrin måste hela tiden hantera mycket information om sina fastigheter. Denna information måste hanteras, vara tillgänglig och lagras på ett sätt som gör det lättare för fastighetsförvaltaren att komma åt och använda. Tidigare gjordes det på ett analogt sätt, även om digitalisering av fastighetsförvaltning just nu är en pågående process. Byggnadsinformationsmodellering (BIM) kan vara en viktig del av denna digitalisering. Nya metoder för att utföra fastighetsförvaltnings tjänster via digitala verktyg som BIM, är på väg in i byggbranschen. Dessa verktyg används sällan för fastighetsförvaltning, även om utvecklingen av BIM inom det området växer. En aspekt inom fastighetsförvaltning som kan förbättras med digitala verktyg är Space Management (SM), vilket har potential att minska kostnader för både lokaler och personal. Syftet med denna avhandling är att undersöka hur digitalisering, särskilt BIM, kan användas för att förbättra SM. Samtidigt ska den undersöka hur fastighetsförvaltare utnyttjar BIM idag med syfte att förbättra och effektivisera SM.

Genom en abduktiv forskningsinriktning utfördes en litteraturstudie och en kvalitativ empirisk undersökning. Litteraturstudien fungerade för att sammanställa information för avhandlingen om fastighetsförvaltning, SM, BIM och tillhörande metoder och verktyg. Halvstrukturerade intervjuer med fastighetsförvaltare samt BIM- och FM-konsulter utfördes för att samla empirisk information om hur SM utförs av stora fastighetsägare i Göteborgsregionen. Litteraturstudien visade betydelsen och fördelarna med effektiv SM. Betonade fördelar omfattar minskade fastighetskostnader, förbättrad affärsutveckling, hålla reda på information som möjliggör bättre beslutsfattande när det gäller framtida affärsplaner. Flera granskade vetenskapliga texter menar att BIM har potential att förbättra SM genom att lagra information om utrymmen på ett ställe, ge aktuell information och grafik, aktuellt lokalutnyttjande och gör att fastighetsförvaltare kan fatta beslut som är välinformerade både visuellt och tekniskt. Implementering av BIM är dock dyrt eftersom det innebär nya arbetsmetoder, ny programvara och kunskap om dessa program.

Studien visade att högre vinster var den viktigaste aspekten bland fastighetsägarna och ett sätt att uppnå detta är att se till att alla ytor utnyttjas effektivt. Fastighetsförvaltarens egen kunskap om anläggningarna är viktig, inte särskilt många digitala verktyg används förutom ritningar, i form av PDF-filer. Några av de intervjuade företagen arbetar emellertid med BIM-modeller för sina nybyggda

anläggningar, men inte för befintliga. Det finns olika åsikter om BIM bland fastighetsförvaltare, vissa tycker inte att det är fördelaktigt att implementera, medan andra ser potentiella fördelar och önskar mer digital utveckling i den riktningen. Även om några av de intervjuade fastighetsförvaltarna inte vill implementera BIM så har små steg mot digitalisering tagits av samtliga fastighetsägare.

Sammanfattningsvis utför inte kommersiella fastighetsägare i Göteborg SM med BIM-verktyg. Fastighetsförvaltarens kunskaps- och tekniska ritningar är den informationsdatabas som används. Några av de intervjuade förvaltarna vill dock använda BIM mer, medan andra inte gör det. Digitalisering är dock något som de intervjuade tror kommer att öka. Digitaliseringen kommer att ta ytterligare steg i branschen, men uttrycket BIM kan dock användas mindre på grund av fördomar bland yrkesverksamma. Studien har visat att de yrkesverksamma som intervjuats för denna avhandling har varit mer positiva och optimistiska gentemot digitalisering i jämförelse med BIM.

Nyckelord: Building Information Modelling, (BIM): Space Management (SM), fastighetsförvaltning, digitalisering, fastighetsägare, fastighets service.

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Preface

This thesis is the final piece of our master programme, Design and Construction Project Management. Through the work required we have gathered a lot of knowledge about the facility business and its methods and actors. The authors have produced this work in close collaboration and would therefore like to aim a thank you to each other. However we did have help along the way, our supervisors, Ylva Berner, consultant at WSP and Christian Koch, Professor at Chalmers University of Technology, have provided invaluable consultation throughout the process.

We would also like to thank all the interviewees the participated in the work with this thesis for their time and competence.

Additional thanks goes to our opponents Axel and Sophia for helping us see our work from a different perspective.

Gothenburg, May 2017
Simon Trevik
Tobias Nilsson

Abbreviations & phrases

Abbreviations

AEC	-	Architecture, engineering and construction
BIM	-	Building Information Modelling
CAD	-	Computer aided design
CAFM	-	Computer aided facility management
COBie	-	Construction operations building information exchange
FM	-	Facility management
ICT	-	Information communication technology
IFC	-	Industrial foundation classes
O&M	-	Operations and maintenance
SBM	-	Statsbyggs manual for bygningsinformasjonsmodellering. Norwegian manual for BIM.
SM	-	Space management
SQM	-	Square meter

Phrases:

Facility manager	-	The person responsible for a property's operation, maintenance, space management and lease contracts.
Property owner	-	The owner of a facility and proprietor of the facility management tasks.
Technical drawings	-	Drawings concerning the facility such as floor plans, detail drawings and blueprints.
Efficient SM	-	Space management performed in a manner that reduce costs for space and personnel by keeping good track of spaces and associated information along with having good space utilization.
Churn	-	Refers to the reorganization and changes required in a facility in order to meet new business demands related to personnel.

1 Introduction

Space management (SM) refers to the process of keeping track of information concerning a facilities tenants, utilization, use and areas. By performing SM, higher facility or space utilization and better productivity of facility users can be achieved. At the front of the digitalization in the construction and facility industry Building Information Modelling (BIM) is found and could be the main tool for this process. BIM is a tool that is described as *"a digital system that works as a tool that contains and helps manage a building's information from construction through its operational life time to demolition".* This tool can perform SM and Facility Management (FM) tasks digitally. It can help the facility managers to keep track of all information concerning a facility's spaces and utilization.

1.1 Background

The construction and FM industry have to deal with a lot of information concerning facilities and spaces. This information, depending of what type of information it is, needs to be handled, available and stored in some way. Previously this has mainly been done in an analog manner but new modern digital methods have surfaced and today they are implemented to improve this process. BIM is such a digital tool containing a lot of information and it is growing in use for project planning, designing, constructing along with FM. Some potential benefits of implementing BIM and an efficient information transfer for FM and operations are reduced costs, improved performance and well-functioning integrated systems for facilities operational phase. The vast majority of a facility's life cycle costs can be connect to the operational phase and not the actual construction (Becerik-Gerber et al., 2012). Despite this, BIM development has had a great focus on the initial phases of the facilities life cycle, e.g. design, plan, and construction (Rui & Raja, 2014). However in recent years research in the field of FM through BIM has grown (Volk, et al., 2013). There are organizations worldwide, found through literature research, offering BIM enhanced FM services with facility owners and managers performing FM work with assistance of BIM. However none of the interviewed companies for this thesis, found in the Gothenburg region, offer BIM enhanced FM services. One aspect within FM is Space Management (SM), which has the potential of reducing both costs of space and personnel (May & Madritsch, 2009). Efficient SM entails keeping good track of spaces and associated information along with having good space utilization. This thesis will investigate the usage of BIM for the purpose of SM today and how it can be improved, be made more effective and available for different stakeholders.

1.2 Purpose

The purpose of this thesis is to investigate how BIM can be used to aid SM. The thesis will use qualitative research methods in order to provide knowledge of how BIM is used in the area of SM and identify where improvements can be made. This thesis will investigate these issues by looking at literature concerning the field of FM with BIM tools as aid. Additional inquiries regarding how facility managers perform SM today will be made, with the aim to get insight in how BIM could improve these processes.

1.3 Research questions

The thesis aims to answer the following research questions;

- Do commercial property owners in Gothenburg manage their spaces efficiently?
- Which information is necessary in order to keep track of all spaces for a facility?
- Can BIM or digitalization make Space Management more efficient?

1.4 Contribution of the thesis

The contributions of this thesis is an investigation and a literature study where information is compiled regarding FM, BIM, SM within FM and how SM and FM tasks can be enhanced with the help from BIM. Furthermore a qualitative mapping of how SM is performed among five major property owners in the Gothenburg region. From this empirical work, a few issues are noted as well as the possibilities for BIM remedy them.

1.5 Delimitations

This thesis will highlight and discuss how SM can be enhanced with the help of BIM models. This will be examined through a literature study with international literature within the field. Furthermore this thesis will investigate how large property owners and FM companies active in the Gothenburg region, Sweden, work with BIM and SM. The examined facility types are commercial, such as offices and retail buildings. Questions will be raised concerning how these companies work with SM, digital tools as well as what they think about future tools and usage of such tools.

2 Methodology

In order to gather information for this thesis a literature study was performed with the support from books and articles concerning Facility Management (FM) and Building Information Modelling (BIM). A literature study was done in order to gain knowledge in the field of BIM, FM, and Space Management (SM) as well as BIM and SM as a combined topic. Alongside this, consultations were held with our supervisors at Chalmers University of Technology and WSP as well as with a peer review group throughout the process.

Interviews were conducted with people from different companies working within the area of BIM, as well as with FM, and SM. Literature regarding methodology was reviewed in order to find suitable interview methods and guidance in how information should be gathered and reported in the thesis. This thesis aims at performing qualitative research.

2.1 Research design

For this thesis an abductive reasoning was chosen, this entails that the authors studied literature in order to acquire an understanding of case participants' worldview and situations, see Chapter 2.1.3. Interviews were performed with what was deemed from literature and supervisors to be appropriate interviewees. Information received from interviews was compiled and compared with existing theory in order to come to a conclusion. This way of working with case or interviews and theory back and forth or simultaneously is referred to as an iterative process or abduction (Bryman, 2012).

According to Bryman (2012), inductive theory is a qualitative method that is suitable when trying to conclude a theory. A qualitative method relies heavily on the understanding of the phenomena through an examination of the participants view on the matter. This suits the thesis' goal to provide reasons for BIM usage and what type of information is necessary for people working within the area of FM. As observations and information from interviews were used to answer the research questions the approach can most accurately be described as inductive (Bryman, 2012). However to gain a general understanding of the issue, the literature study was performed prior as well as throughout the interviewing process. Given the unstructured nature of the interviews parallel literature study was required as new information was gathered from the interviewees. This information gave rise to new search words and terms further deepening the theoretical research. This indicated an abductive approach.

2.2 Ethical considerations

All interviews that were performed were arranged with the full consent of the interviewee. If the interviewee did not want to have the interview recorded for one reason or another, the interview was not recorded. To ensure the anonymity of all the participants person and company names are replaced with pseudonyms. When it comes to choice of interviewees the people that were contacted were either recommended by supervisors or other people asked to participate in the study.

Additional considerations in the choice of interviewee were that the work title was, according to the authors, applicable to the topic of the thesis.

In regards to ethical considerations with the topic of SM, there are a few to consider. Firstly there is the issue of any type of efficiency improvements where any given person with help of technological or other advancements could do more work. This will ultimately lead to either expansion, redistribution of duties or cutting down on staff. Another aspect is measuring facility usage with aims of making a facility more effective, this could be for example measuring how much a toilet is being used, tracking personnel, heat cameras etc. These kinds of measurements might reach a point where the people being monitored will feel their personal integrity being compromised.

2.3 Literature study

In order to gather information for the thesis literature study was done in the form of books, reports and articles concerning FM, SM and BIM. The literature study was done firstly in order to gain knowledge in the field of BIM, FM separately as well as SM. Secondly, literature related to BIM and SM was studied as a combined topic. Alongside this, consultation was held with our supervisor at Chalmers and WSP as well as with a peer-review group throughout the process. These consultations were an aid in order to find relevant literature.

As mentioned by Flick (2009) the literature study should include the following parts.

- Theoretical literature about the topic of the study.
- Methodological literature, where the studied area is how to do research and how to use these research methods.
- Literature about earlier research within the topic (empirical literature).
- Compare and contextualize both theoretical and empirical literature.

For this thesis methodological literature were studied before the theoretical literature study commenced.

Search words that have been used when performing the literature study have been: FM, building information modelling, building information model, SM, spatial management, area management, workspace management, as well as the abbreviations FM, SM and BIM for building information modelling/model. Additionally the Swedish translations of theses expressions have been used to find information within Swedish organizations and academic works. Chalmers Summon and Google Scholar were used to gather the majority of literature on theory and cases of BIM and SM. Chalmers summon is a search engine provided by Chalmers University of Technology gives results of academic articles and scientific books related to the topic. Google Scholar provides somewhat broader results, making source criticism more important. To complement these academic works some information was collected from BIM Alliance, studentarbeten.chalmers.se as well as from company webpages. The theoretical framework is based on a literature review and divided into three main parts BIM, SM and how they affect each other.

2.4 Interviews

In order to gain insight into the practical execution of SM for private commercial property owners interviews with a few of the bigger property owners in Gothenburg were requested by the authors. This thesis is based on empirical data collected through these interviews along with theoretical information from academic publications. Interviews, together with a literature study will be the tools to provide qualitative information.

The interviews were recorded, if the interviewee agreed to it, thereafter transcribed verbatim to make sure that no information got missing. Both authors participated in the interviews by asking questions, this was done to make sure that every issue was addressed. If the interview was not recorded both authors took notes and asked questions. Interviews were performed with a semi-structured approach, this allows the interviewers to combine open-ended questions with clear predefined questions (Wilson, 2014). The variation of questions resulted in an interview approach with a mix of a structured and an unstructured type of questions. This is an approach considered applicable for an abductive approach (Bryman, 2012). The authors found this way of conducting interviews as the best way to gather information since all interviews were to be done in a systematic and similar way, along with possibilities for additional exploration if new topics appear. The authors have some experience from interviewing situations, mostly from previously written bachelor thesis. According to Wilson (2014) semi-structured interviews are preferable to use when there is knowledge about the subject, but further more in-depth information is requested. Since most of the literature study was done before the interviews the authors had knowledge about the subject. Semi-structured interviews should be used when the goal is to *"gather information about tasks, task flow, and work artifacts such as job aids, best practices documents, equipment…"* (Wilson, 2014, p. 25). This cohered with the aim of this thesis, which is to answer the following questions:

- Do commercial property owners in Gothenburg manage their spaces efficiently?
- Which information is necessary in order to keep track of all spaces for a facility?
- Can BIM or digitalization make the business of Space Management more efficient?

Strengths and weaknesses according to Wilson (2014) about this approach are mentioned below.

Strengths:

- Reveal unknown issues.
- Illustrate more complex issues through clarification and probes.
- Gives the interviewers the possibility for broad comparisons across the different interviews.
- This approach provides a mechanism for redirecting conversations that deviate from the issue at hand.
- Additionally, the semi-structured interview approach require less training than unstructured interviews.

Weaknesses:

- Time consuming to analyze results.

- Consistency among interviewers is important not to make the the comparisons difficult.
- Some training and experience are required in order for the interviews to run smoothly.

As the research took place in Sweden the interviews were held in Swedish to allow interviewees to express themselves as freely and unhindered as possible. The goal was to ask the same questions to all interviewees, however for the first interview the questions were rearranged to better suit that company. The first interview was with a company that expressed themselves as experts in BIM, or BIM consultants, and not a property owner, this is why the questions were rearranged. For all other companies the questions were arranged in the same way. All interviews were held in person, this was done in order to conduct an interview that gave room for good discussion and without eventual disturbances because of technical issues such as phone interviews etc. To keep the anonymousness of the interviewees they were not mentioned by their real name and the company names were also kept anonymous throughout this thesis.

2.4.1 Selection of interviewees

Interviews were conducted with people from different property owning companies working with FM. The companies chosen for the interviews were decided in collaboration with the authors and the supervisors. One of the supervisors is a Full Professor at Chalmers with knowledge within the field of facility management and BIM. The other supervisor that gave advice for interviewees is a professional, working as a consultant within the construction industry. Additional considerations were taken to whether the company is active in the Gothenburg region, worked with commercial facilities, and companies that were large in the region. The companies were chosen from a list of the largest property owners in Sweden, and with consideration of their presence in Gothenburg.

The people that participated in the interviews were professionals that the authors thought worked with tasks related to SM and BIM. Along with the first contact with professionals a short project description and a definition of SM were sent. This was done in order for the person in question to decide if he/she saw themselves as suitable to take part in an interview. This resulted in more contact and an interview, no answer, a decline to participate, or an answer that we should talk to someone else within that company. A total of eight people accepted and were interviewed, alone or with colleagues. Four of the people that were contacted declined to participate, five asked the authors to contact someone else within the company without a result of an answer, and eight did not reply at all. Eight interviews were conducted with a total of 14 professionals, eight who worked at facility management companies, one at a BIM consultant company and four at a FM management company. Six interviews were conducted with the facility managers, one with the BIM consultant and one group interview with all FM consultants.

2.5 Information handling

Information was processed and compiled using shared online storage, where articles and related notes were stored together. Additionally texts produced by the authors were available for review and further contribution. Time plan and week plans were

managed in the same manner and kept updated throughout the process with the help of a daily journal. The journal and time plan served to keep track both of the planned progress and the actual progress. All interviews were transcribed, thereafter the data was sorted, translated if needed and divided into different themes. This was a help when handling information received from all of the interviewees.

2.6 Epistemological considerations

Bryman and Bell (2011) mentions the importance of considering if any knowledge gathered for the thesis is regarded as acceptable or not in the discipline. This needed to be considered when collecting information for the empirical part of this thesis. Since the conducted interviews were held with companies active in a small region in Sweden no generalization of the whole country can be given. Further research should continue studying the same issues with the aim of creating a more general picture of how private real estate companies work with SM and BIM throughout Sweden. This thesis focus on the Gothenburg region and private real estate companies working in the region and aims at describing their view of, and how they work with, SM and BIM. However since most studied literature was written in other countries and by authors around the world this only gave the authors of this thesis general information about how SM and BIM is used, its potential, and to some extent how it has been implemented. In order to make sure that the information gathered was acceptable as a knowledge base, known and well reputed journals were used and a lot of information that was used was agreed upon by more than one researcher.

The focus when gathering information from our interviewees was to systematically arrange interviews in similar ways e.g. face to face meeting, the same questionnaire along with room for spontaneous questions that come to mind. This gave room for discussion and for the interviewee to speak freely and unhindered. The goal of this thesis is not to generalize BIM usage and SM issues in Sweden, but rather give a view of how large property owners work with BIM for SM purposes in the Gothenburg region. The view that this gives is, as mentioned by Bryman and Bell (2011), a specific view of the researcher's version of the reality, in the Gothenburg region, and this version cannot be regarded as definitive for Sweden as a whole, or BIM usage and SM in general. This is something to have in mind when reading this thesis. However it could be shown that by doing more research in the area our picture could be confirmed as valid for the whole industry in Sweden.

The authors of this thesis was somewhat biased when it comes to see the benefits of BIM. Mostly since the literature study concerning BIM started before the interviewing process commenced and questions were written with the knowledge of benefits related to SM and BIM. This thesis will contribute to research in the area of BIM and SM in a Swedish context, it will form a base about how the usage looks in the Gothenburg region among property owners today. Additionally provide insight into why and how BIM could be used for SM, as well as indicating which information will be of importance for SM to enable efficient SM through BIM.

2.7 Analysis and discussion setup

The choice of literature was discussed with the supervisor from Chalmers. The supervisor gave recommendations of some authors and papers that could facilitate

knowledge for the thesis. However most of the literature was found by the authors' own literature search.

The discussion is based on the authors' thoughts and comparisons of theory and empirical information gathered throughout this thesis. Some notes, ideas, and thoughts have been brought up by the supervisors of this thesis and discussed further by the authors. The supervisors were however not included in the discussion itself. The discussion was done in this way in order to provide a broad base of ideas and thoughts to discuss. The authors also thought that this would result in an interesting discussion and a discussion that resulted in rewarding conclusions.

2.8 Work contribution

This thesis is the result of close collaboration of the authors. Nearly all work has been performed side by side with reflecting discussions about each part in order to reach a common understand of the topic. Each section has been an iterative process where the authors have had an equal chance to influence the outcome. Both authors participated in all the interviews and were equally active during the contact, interview and transcription processes.

2.9 Summary of methodology

After studying literature regarding methodology an abductive research approach was chosen and a qualitative study was applied for this thesis. The literature study is based on international literature consisting of academic papers and reports, books and other reports related to BIM, FM and SM. Consultation regarding choice literature was discussed with the supervisors for this thesis. The interviews were conducted with facility managers, consultants and property owners. In the thesis all interviewees are anonymous and almost all interviews were recorded and later transcribed in order to gather as much information as possible. All interviewees are active in the Gothenburg region and the thesis is limited to this area.

3 Theory

Below follows the theoretical part. First the theory about Facility Management (FM) is presented, in this part the life cycle approach is also discussed. This is followed by a section explaining BIM and the benefits BIM can provide. Following the section about BIM is a part about standard concerning digital tools. Later Space Management (SM) is presented, what it is and how it can be performed and how it has been performed. The last section brings up literature regarding SM, FM and BIM and how these work together.

3.1 Facilities management

FM refers to the profession involving multiple disciplines, which aim to ensure functionality and performance of the built environment, through integration of people, processes and technology. Functionality for the user of a building is provided by facility operation & maintenance (O&M), maintenance is done in order to prevent, correct or predict issues that may arise in a facility (Shalabi & Turkan, 2017). Other areas within FM are SM, renovation along with internal services such as, reception, cleaning, booking systems etc. This is done to make sure that the core business is productive, safe and pleasant for the users, which enables efficient execution of organizational operations. A facility manager is either someone from the organization that owns the building or a person hired by the owner to perform FM tasks. The facility manager serves to ensure functional and profitable operation of the buildings in their organization's portfolio, with the budget as main control mechanism (Aziz et al., 2016).

Atkin & Brooks (2015) argues that FM covers more than the above mentioned areas such as financial management, organizational management, innovation and change management, as well as human resources management. The areas mentioned above, O&M, SM etc. can be included into something that Atkin & Brooks (2015) call real estate management. Additional competencies that the facility manager preferably should possess, that were mentioned above are explained here:

- *"Financial management include: accounting, finance, purchasing and supply aspects.*
- *Organizational management includes: organizational structure, behavior, processes and systems.*
- *Innovation and change management include: processes, technology, ICT and information management.*
- *Human resources management include: motivation, leadership, employment law, health, safety and security"* (Atkin & Brooks, 2015 p.17).

These different areas combined are what, according to Atkin & Brooks (2015) makes a successful facility manager. A successful facility manager enables opportunities for an organization to enhance capability and quality of service for organizations and tenants. Additionally, identification of risks and clarification between service provider and organization, maintaining a building's performance along with proper documentation and contracts are part of FM tasks. In contrast unsuccessful FM can result in problems obtaining new tenants, retaining current ones, not being able to maintain the performance of a facility as well as poor relationship between tenants, service providers and the FM (Atkin & Brooks, 2015). The management of a facility

is required all through a building's life cycle, which means the tasks of a facility manager end when the building is demolished. Figure 1 below, describes the life cycle of a building. All costs throughout a facility's life cycle results in a term called life cycle costs, which refers to all costs of everything a facility requires to fulfill its purpose, e.g. construction, O&M, refurbishments etc. The costs that appear in the operational phase are the largest cost that the building will require, more than the cost of first constructing the facility (Parsanezhad, 2015; Becerik-Gerber et al., 2012; Nical & Wodynski 2016; Aziz et al., 2016; Ilter & Ergen, 2015, Rui & Raja, 2014). Research shows that the costs of facilities' operational phase are about three times higher than the costs of constructing a building (Kassem, et al., 2014). This indicates the importance of facility management as well as creating a qualitative building from the beginning. The cost distribution through the facility life cycle indicates that a lot of money can be saved with an improved operational phase.

Figure 1. The life cycle of a construction product (Saint-Gobain, 2017).

In recent years the importance of considering environmental and sustainability issues have grown, facility managers now need to take the carbon footprint of facilities into account when performing their tasks. A facility is going to be used for many years, which make it important for tenants to know about the facility's carbon footprint and sustainability since the pressure to reduce energy consumption will probably increase (Atkin & Brooks, 2015). Long term views and a life cycle way of thinking is important for an organization to be aware of its energy usage and obligations and liabilities for future demands of carbon footprints. Facility managers are responsible for maintaining and keeping facilities' energy consumption levels low. Also facility managers need to be aware of the energy consumption and being able to inform tenants about it. Performing FM task with the help from BIM has gained interest in recent years, especially in the UK since the governmental BIM (see Chapter 3.2) initiative informed that FM is an important part of BIM and the project life cycle (Ilter & Ergen, 2015). BIM tools can help facility managers in their work with environmental, sustainability and energy consumption issues. BIM achieve this by providing tools that help analyze impact of sunshine, analyze running costs, energy waste, what if scenarios and sensitivity analyzes (Oduyemi, et al., 2017), and

calculate electric energy and water consumption (Wang et al., 2013). Utilization of BIM in FM enables life cycle data management (Ilter & Ergen, 2015).

3.2 Building information modelling (BIM)

BIM is a common working method today and it has been used in order to make design and construction phases more effective for some time now. There is a need to expand BIM even more, especially in the FM phase (Rui & Raja, 2014). BIM can aid FM tasks and increase performance of FM by streamlining closeout, maintenance of warranty and service information, energy and SM, visualization, planning and performing maintenance, emergency management, and deconstruction. In order to enable utilization of BIM in these areas all information needs to be integrated with other information systems at use, e.g. FM information systems (Ilter & Ergen, 2015). Other application areas for BIM in FM is as stated by Becerik-Gerber et al., (2012) locating building components, facilitating real time data access, creating digital assets, personnel training and development, and planning and feasibility studies for non-capital construction.

3.2.1 Explanation of BIM

Building Information Modelling refers to a digital working method concerned with planning structures and buildings along with relevant information virtually. BIM allows project participants to design, change, analyze and sequence a project's characteristics in a digital environment (Hardin & McCool, 2015). Building Information Modelling (BIM) is a common phrase used in the construction industry today. BIM has a number of different definitions and meanings for different companies throughout the industry. BIM is defined by BuildingSMART (2016) as: *"a digital representation of physical and functional characteristics of a facility. A building information model is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition."* BIM is defined by Volk et al., (2013, p.110) as: *"A tool to manage building information over the whole life cycle, it is adequate to support data of maintenance and the construction process."* Further, Golabchi et al., (2013, p.3) mean that: *"BIM is a value creating processes that involves the generation, management and exchange of knowledge of a facility forming a reliable basis for decision making throughout its life cycle from the conceptual, design and construction phases, through its operational life and subsequent closure."*

This shows the variance throughout the industry, which in turn results in a variance of utilization of BIM. The usage and utilization differences means that BIM is used both as a model with information about the whole building and is generally used only to realize the building, but also used by some as a tool for life cycle management during a facility's operational phase until demolition. The shape of BIM can however vary throughout the life cycle, initially it might just be a graphical model, which during realization of the building is filled with information. This information is then used during the operational phase and the graphical aspect is now of less value. As can be seen all definitions mentioned above refer to BIM as something that can be used throughout the life cycle of facilities, however Volk et al., (2013) and BuildingSMART (2013) indicate that BIM is more of a product or tool to be used during construction and operation. While Golabchi et al., (2013) argues that BIM is

more of a continuous process. As this thesis is partly based on interviews with people that had more, less or no information about BIM the authors needed to inform the interviewees about the expression BIM and its definition. The authors created a definition with help from above stated scientific definitions to provide interviewees with a similar picture of what BIM is and what the author mean that BIM is. This resulted in this definition:

> *"BIM is a digital system that works as a tool that contains and helps manage a building's information from construction through its operational life time to demolition. The BIM model is a tool that needs continuous updating."*

3.2.2 The potential of BIM

BIM's potential has been recognized for a number of years and it is mentioned in a book by Eastman et al., (2011) that BIM has large potential of developing the Architecture, Engineering and, Construction (AEC) industry. Eastman et al., (2011) means that BIM is a new approach to design, construction and FM, in which digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format. In a book by Eastman et al., (2011) the difference in working with BIM is highlighted stating that BIM can be used both for realizing the building but also with a life cycle approach. BIM models contain a vast amount of information, which provides a rich source for facility managers to gather required information. BIM according to Shalabi & Turkan (2017, p.11): *"is sought to enhance current FM practices by improving interoperability, visualization, and fragmented data challenges."* Interoperability between BIM technologies and FM technologies is an issue that needs to be improved in order to be efficient (Kassem, et al., 2014; Shalabi & Turkan, 2017; Ilter & Ergen, 2015; Rui & Raja, 2014). In a life cycle approach the BIM model is used for FM as well as for realizing the building. This corresponds with the definitions mentioned above. However, as mentioned by Kassem, et al., (2014) there is a lack of contractual and legal framework to follow when implementing BIM in general, and for BIM in FM in particular, his creates a significant area of challenges. Standards for BIM usage are created to avoid problems with these issues (Kassem, et al., 2014).

Levels of BIM utilization differ, there is one process that is commonly used in both approaches. That is BIM's ability to detect clashes in-, and between models in the planning phase of a project (Eastman et al., 2011). Clash detection is an important tool when merging models from different disciplines to make sure that the building described in the technical drawings is buildable. However, commonly when working with clash detections, they do not ordinarily detect accessibility issues (Rui & Raja, 2014). Accessibility issues are problems related to access of certain components and installations during construction and maintenance. Issues like clash detection can be resolved more quickly in BIM systems because of cloud based models that can be shared, visualized, estimated, and resolved without time consuming paper transactions (Eastman et al., 2011). This indicates that BIM is a great tool for digitized information exchange, as mentioned by Oduyemi et al., (2017). Cloud based computing is used by many companies working with BIM. Cloud computing means that all disciplines work on models stored online and available for all involved stakeholders (Hardin & McCool, 2015). The benefits of this way of working are that the model is always

updated, different disciplines do not have to physically be at the same location and *"real-time clash detection"* is possible. Despite working with cloud computing, it is mentioned in an article by Oduyemi et al., (2017 p.32) that: *"the technology to collaborate on models has not yet delivered the industry requirements for BIM collaboration… in the full lifecycle of AEC projects."* This indicates that more development in these areas is required. It is of great importance to differentiate a BIM model from a 3D model. A 3D model is commonly used for visualization and possesses no intelligence at object level. While a BIM model contains intelligent objects, e.g. a wall, contain geometry information, material characteristics, quantities, etc. Modification of objects in BIM adjusts according to the whole model (Eastman et al., 2011).

3.2.3 Level of BIM maturity

The use of BIM can be divided into levels of utilization or as mentioned by mentioned by Bew & Richards (2008) levels of maturity, this is illustrated in Figure 2. These levels of maturity describe how extensive the BIM use is, what purpose it has and how the use of BIM will be in a specific project. When the utilization of digital tools changes, then the level of detail change. For example level 1 requires 2D technical drawings and 3D models or 3D visualization with low level of detail. In comparison to Level 3 that require high level of detail to perform tasks as life cycle management and FM. Level 3 also indicates that the BIM will be used for the whole life cycle of a facility, which entails that the model needs to be worked with continuously. This also means that models and objects have information tied to them, e.g. what it is, specifications and characteristics. When working with BIM at Level 3, the model is integrated and this is when BIM can be fully utilized. In comparison with Level 3 BIM, which can be seen as a 100% integrated BIM model, Level 0 stands for 0% integrated BIM. Level 0 means drawings, lines and text on technical drawings etc. All technical drawings have no information tied to them except for text written on those plans. Additionally 0% BIM means no link between drawings and other information material tied to a project (Eastman et al., 2011).

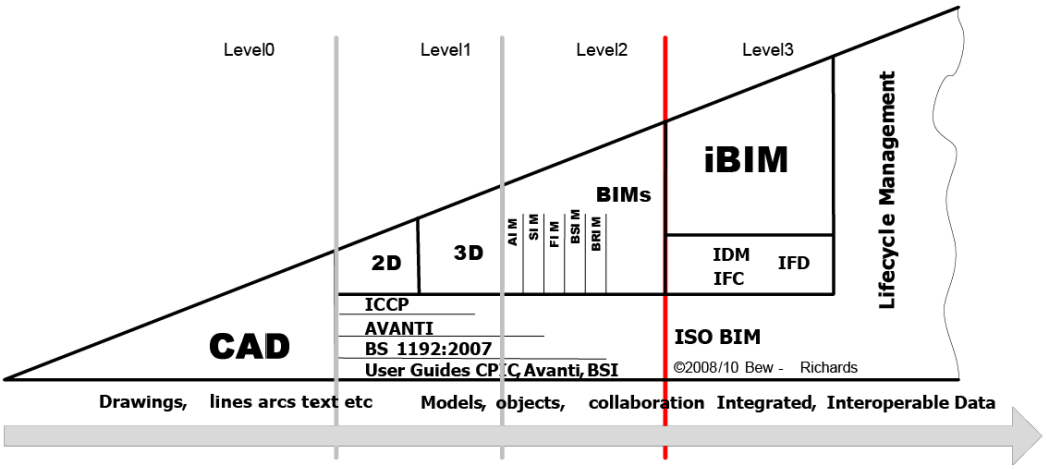

Figure 2. BIM Maturity Diagram, shows the different levels of BIM implementation and what they represent (Bew & Richards, 2008).

BIM is as mentioned before a phrase commonly used today, it is however seen as something that is new in the area of FM (Rui & Raja, 2014). When faced with

discontinuous and new innovations, customers fall into five broad categories along an axis of risk-aversion, see Figure 3 below. The first users of a new innovation are called the innovators followed by the early adopters, early or late majority and lastly laggards. This is usually how the adoption of new innovations look (Everett, 1962). The same thing goes with BIM, as a new innovation it has to go through these steps for each level of BIM maturity, see Figure 2 above. To speed up and enabling the implementation of BIM classification standards are a possible tool.

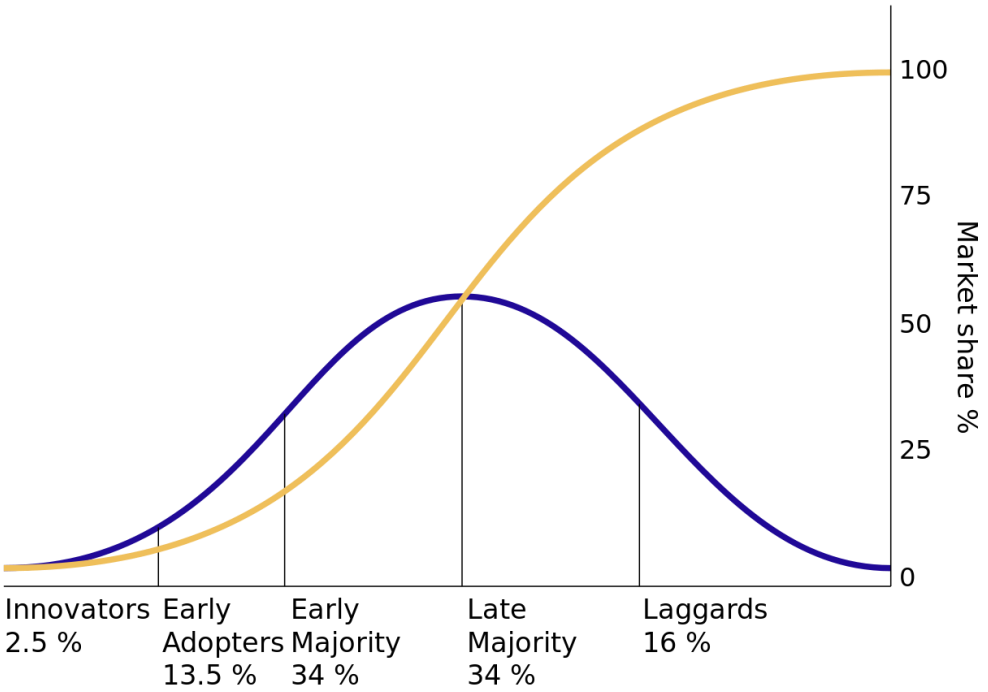

Figure 3. Diffusion of Innovations (Everett, 1962).

3.2.4 Swedish standards

When it comes to Swedish classification standards there is none that is demanded by authorities to use for public funded projects. There is an organization called Svensk Byggtjänst that have created a classification system called BSAB 96, which aims at sorting information in a similar way throughout the construction industry. Additionally, Svensk Byggtjänst work for similar BIM-usage throughout the Swedish construction industry, through code systems and coding language for BIM. With coding language means file formats such as IFC used for all BIM files. Svensk Byggtjänst is owned by different construction and property sector organizations throughout Sweden. The work that Svensk Byggtjänst does on the questions regarding BIM can be seen as a standard, but there is no requirement from anywhere to use it, except from specific owners that require it (Svensk Byggtjänst, 2013).

However there is a communication standard for facility management issues at use in Sweden today, it is called fastAPI or fi2, (Jönsson & Johansson, 2014). Fi2 is a standard concerning information exchange between FM systems and other systems, this standard decides the format that information should have in order of be compatible with other systems different than one's own (Jönsson & Johansson, 2014). This system is a standard that enables CAD-systems, technical systems, economy, and

administration to communicate and transfer information between each other. Systems like fi2 makes it easier to share information using cloud based solutions (Jönsson & Johansson, 2014).

The development of BSAB 96 was based on ISO12006-2, which is the standard for development of standards in the construction sector. This standard got revised in 2015 adapt to digital modelling. Hence an update of the Swedish standard was required (Svensk Byggtjänst, 2016).

3.2.5 CoClass

Right now a new standard for categorizing buildings and its components, areas, locations and uses is being introduced in Sweden. The standard developed with the help of ISO16006-2:2015. It is called CoClass (or BSAB 2.0) and aims to reduce miscommunication within the construction business, the standard can and should be used through the whole life cycle of any construction and is developed to be compatible with BIM software and work methods (Svensk Byggtjänst, 2016). According to a survey done by Svensk Byggtjänst in 2014 the estimated cost of miscommunication within the construction industry in Sweden alone rises to sixty billion SEK a year. CoClass is stated to support digital development and BIM by common classifications making the process of creating an information model easier. It also makes information transfers easier if all involved parties use the standard. The aim is that CoClass should be used in all software and databases in the industry throughout the whole process, by all actors, from planning to demolition of any built environment. When creating or working with a model the user should not have to look through a classification database, the classification should rather be incorporated automatically, which is something the software developers will have to ensure in order for CoClass to reach its full potential when it comes to BIM compatibility (Svensk Byggtjänst, 2016).

ISO16006-2:2015 has its base in the fact that operations have demands on the spaces it is performed in. With CoClass all spaces should be coded with appropriate classification depending on the form, function, user activity, equipment or combinations of these. (Svensk Byggtjänst, 2016). The benefits with using CoClass for builders and property managers are stated by Svensk Byggtjänst (2016) as:

- Structured information that is delivered in the same way in all projects regardless of actor ease the process of listing requirements
- Serves as basis for maintenance planning, follow-ups and analysis.
- Control of included materials, products and components
- Creates a database of experience that can be used for future projects
- Fewer disputes
- Effective handling of assets (Asset management)

Around the world there are standards for the usage and utilization of BIM in the construction industry, standards which aim at providing guidelines for usage as well as contractual and legal frameworks. Similar standards have been implemented in the UK and Norway for public funded projects, they are called COBie and SBM respectively. The benefits of the COBie- and SBM-standards can be seen in the industry today and research show that there is a need of development and

standardization of BIM in order to provide coverage of all user requirements and information flows throughout a project's whole life cycle (Oduyemi, et al., 2017).

3.3 Space management

The focal point of the thesis is Space Management (SM), its role within Facility Management (FM) as well as examining the possibilities of using BIM to enhance the process. Here, firstly SM will be investigated and later on SM within FM and lastly theory regarding SM through BIM will be compiled. Some of the aspects explained in this chapter are of varying relevance depending whether SM is viewed from a user's and owner's perspective, although in practice this depends on the involvement from the owner in the tenant's organization.

3.3.1 Exploring space management

In comparison to FM, SM focuses on managing space rather than building elements or inventory. Assets within a facility all occupy a location, it is important to consider in their management. By definition space incorporates the concept of location and is generally the first facility asset to be graphically documented, and thus provides means to graphically locating other physical assets, equipment, furnishings, people etc. This graphic documentation serve as means of allocating cost of space, equipment, furniture etc. between the tenants or internally for charge-back systems (Teicholz, 2001). Space is a major tangible and valuable asset for a company that owns it. In order to utilize or value the space, detailed knowledge about its size, location, use and contents is important (Kensek, 2015). Through space planning, facility managers aim at creating as efficient spaces as possible. This is done through rearranging, planning, performing tenant improvements and more. It is all about optimizing leasable spaces for current and/or future operation (Steiner, 2006). SM is needed when any changes for the property or organization are planned or required. SM is described by the FM software developer Archibus (2017) as: *"Evaluate and plan space usage to maximize efficiency and decrease total occupancy costs."* While Hassanain (2010) defines SM as: *"Space management is concerned with providing the delivery of space services and the management of the completed space plan. In practice, office space in many organizations may be provided in absence of considering work environment settings, space planning methodologies, technology, innovative and creative ways of operating at the workplace."*

According to Hassanain (2010) changes occur for two reasons. Firstly, because of technological changes and innovations, globalization and other space re-configurations with the aim of enhancing productivity. The second reason is more connected to improvement in flexibility, capability to change the workplace, develop a different culture in the workplace and enhance communication patterns. Haron (2000) points out that the main goal with SM is to maintain the facility in a state of equilibrium. This means a situation where available space is appropriately located, well utilized along with making sure spaces are adequate, and suitable for tenants. Good space management and design will, according to Steiner (2006 p.20): *"stem from business trends that influence work-style, such as knowledge-sharing, collaborative work, a flattened hierarchy, employee churn, increased mobility and technology innovations and tools."* Herein lays one of the main difficulties with SM, to maintain an appropriate balance between supply and demand of space as

organizations change. There is also a great deal of marketing involved in SM, the facility manager need to have a close eye on the market and be aware of current trends and how the conjectures are moving to be able to plan the SM accordingly (Haron, 2000; Steiner, 2006). This is done by comparing rent levels and other facilities in the area and through researching the current demand, the information is then used to plan changes and set rent levels, but also as arguments when negotiating with the intended tenants. The owner is the number one stakeholder in SM, he/she is the proprietor of the issue, however often there is someone else that is appointed to do the job for the owner. Facility managers, technicians, development managers, technical managers, economical manager and tenants can all be part of the space planning and management. SM is however very important for both the owner and tenant. To ensure that costs are covered by the rents, utilization is a key aspect in SM (Haron, 2000), as well as maintaining the property value, which is directly connected to keeping the property attractive for leasing as well as sale. Weight is also put on getting the right tenants, the majority of the time long-term tenants are preferable (Steiner, 2006). According to Teicholz (2001) there are three main goals that SM aims to improve. Those three goals are described below.

- **Goal 1, Increasing Productivity of Facilities**

There are several variables in a facility's productivity or business performance. In office buildings staff density is often used, area per person. This measurement is a common benchmark, and tempts minimization of workstation in order to maximize staff numbers per area. However to aggressive workstation minimization could result in lower staff performance, and since salary costs are much higher than facility costs this could be an expensive endeavor. What is rather sought after is an optimal workstation size, which maximizes performance at an optimal occupancy cost. Major concerns here are attaining full utilization of space and equipment. SM systems are aimed at providing information, which assists management avoiding excessive capacity and reaching complete utilization of the facility (Teicholz, 2001).

- **Goal 2, Minimizing Facilities Costs**

Ratios like staff density, square meter occupied etc. compared with revenue per ratio can be used to analyze space use. This can be compared with other companies or benchmarks within the relevant field of business (Teicholz, 2001). Facilities can be built in certain ways to make them more efficient and the physical boundaries of the facility limits the ultimate efficiency. Every building regardless of its design does however have an optimal level of maintenance (Teicholz, 2001). Additionally there is the opportunity to optimize flow of energy in the form of light and heat. The need for energy in the facility will vary with space and time, and the flow can be modulated accordingly to ensure minimal energy expenditure (Teicholz, 2001).

- **Goal 3. Providing an Information Foundation for Strategic Planning**

In addition SM systems can provide useful information regarding the current state of the facility concerning facility resources and utilization, which will help in deciding where and how the facility should look in the future. Information regarding facilities resources and utilization can be gathered physically through surveying the facilities, examining technical drawings or an up to date BIM model or asset system can provide reports concerning these issues. The latter being the cheapest and quickest, however a combination of the approaches is generally applied Teicholz (2001).

3.3.2 Defining space management

In order to inform interviewees about the meaning of SM the following definition was made based on the theory presented about SM. This definition will be provided to the interviewees before or simultaneously as the interview occurs.

"Space management refers to the management of an organization's physical space inventory and handling of tenants and information about their organization, staffing and physical space requirements. The goal with performing space management is using a facility's space more efficiently, understand space usage, keeping track of the space, occupancy and facility information, identifying utility rates and plan changes in accordance with current and future operations."

"There are several ways to perform the practice of space management, the simplest being pen, paper and a floor layout with occupancy information and/or a spreadsheet containing details of occupancy and resource usage of spaces. The more modern way of working with space management is by using space management software to help manage a facility's spaces. Software like these makes the information more available, accessible and allows for space planning. Space management software gives the facility manager additional capabilities to work more efficiently with spaces."

This definition will be the definition of SM that will be used all throughout the following parts of this thesis. As the interviews were held in Swedish a translation of the definition was made and can be found in Appendix A, along with all questions both in English and Swedish in Appendix B.

3.3.3 The space manager's role

Space manager is generally not a specific role within an organization, however different organizations have different staff responsible for the management of space. Therefore the title space manager will be used here referring to whoever is responsible for SM within any organization. SM is a strategic way of working. The space manager steers and plans the space allocated for business purposes, its efficiency and type of usage. FM-, and SM systems provide top management useful information for strategic planning, benefits of having accurate information about facilities are most significant at the top level of an organization. Thus top management should support the implementation of such systems, which can be directly beneficial to the FM-staff but also have impact on the whole company (Teicholz, 2001).

Accurate information enables good decision making throughout an organization, a SM system can act as a key role as an information source. Since the information in these systems can be useful for different stakeholders there should be a good interface which allows for filtering appropriate information for each user (Teicholz, 2001). For some companies however the space manager's role is to manage all spaces within the facility, not only the space allocated for business purposes. Effective SM will help improve business productivity and support the business along with space utilization (McGregor & Then, 1999). According to Steiner (2006) property costs is the second highest cost, after salaries, for many organizations. SM has hence become an important tool to reduce costs in organizations. Adjustable spaces are required in order to accommodate expansion, growth or decline. SM is a tool that helps achieving

adjustable and efficient spaces (Hassanain, 2010). In contrast to Hassanain (2010), who writes about reducing facility costs, Heynes (2007) states that since salaries are the highest cost for many companies it highlights the importance SM has in promoting productivity and finding ways for employees to perform in the best possible way, e.g. by arranging the workplace in a certain way. Since this thesis is limited to commercial properties, *productivity* could be changed to *better business performance* as this mean better quality and creativity rather that quantity (Haynes, 2007).

3.3.4 Space management tools

Traditionally space planning was done with pen and paper and later with various CAD tools. SM and the importance of utilizing space in the best way arose when Taylor (1856-1915) invented the *Taylorism*. The Taylorism revolutionized the manufacturing industry with his application of scientific methods to the organization of production. Taylorism was followed by Fordism that was more about maximum economies of scale, standardization and mass production (McGregor & Then, 1999). Taylor's ideas were so influential that they dominated a lot of the design of working environments for the majority of the last century (Pitt & Bennet, 2008). Buildings referred to as office buildings first occurred during the Victorian age (1837-1901). Since then the occupation has evolved very much, especially after 1950's with the introduction of personal computers and a lot of following technological developments (McGregor & Then, 1999). Thus began the space planning of the workspace for offices.

Today SM can be done with the help from modern IT tools that can assist FM staff with these activities. This is usually referred to as Computer Aided Facilities Management (CAFM) or Computer Integrated Facilities Management (CIFM). The software in this category range from simple space planning tools to full-fledged FM programs containing every aspect a facility manager requires doing their job (Elmualim & Pelumi-Johnson, 2009; Booty, et al., 2009). Additionally systems called Computerized Maintenance Management Systems (CMMS) help with dealing with maintenance planning, assessment, improvement and execution (Shalabi & Turkan, 2017). CMMS however lacks user-friendly interface and compatibility with other FM systems (Kumar, et al., 2014). Many FM systems are only compatible with their own software and hardware (Wang et al., 2013), which is problematic from a compatibility point of view. A FM program can e.g. help a facility manager in the daily tasks by reporting a fault or malfunctions in a facility automatically. However these issues needs to be reported to maintenance personnel who then needs to locate, inspect and gather maintenance information about that particular element (Shalabi & Turkan, 2017). A FM program combined with BIM tools can help with locating as-built elements and equipment along with providing all information needed about that element. Without a BIM-enabled FM system when equipment breaks down maintenance crews spend a lot of time locating the error and checking original technical drawings to get information in how to resolve the issue (Wang et al., 2013).

In regards to SM Booty et al., (2009) mentions design, costs and inventory, recharge, moves and changes as well as visualization of space usage as important components to have available in the CAFM software. Additionally if the system can place assets

and list them and have data categorized by space ID, floor or building etc. is of importance. Further the system should be able to contain contract information regarding the building or equipment and the manager should be able to create zones for different tasks, e.g. cleaning, in order to enable optimization of such tasks (Elmualim & Pelumi-Johnson, 2009; Booty, et al., 2009). One important aspect of any new piece of software is whether it is compatible with existing systems and how easy it is to populate the system with the required information. Re-entering data is time consuming and costly (Booty, et al., 2009). To handle all FM related information there are numerous software to choose from, below follows an example of one such software, called Archibus. Archibus was studied to gain insight into the possibilities of what modern tools provide, note that the claims are mainly from the manufacturer themselves. An example of a CAFM system introduced to incorporate BIM data into FM is Archibus (Shalabi & Turkan, 2017). Archibus is one of the leading FM software in the world. This software can provide solutions for e.g. real estate portfolio management, move management, environmental and risk management, building operations, and SM. One of the goals with using Archibus is that organizations can use one single, comprehensive, integrated solution to make informed strategic decisions about their facilities that optimize income and return on investment, along with lower asset life cycle costs (Archibus, 2017). The benefits with using this software according to the manufacturer include, improving space efficiency, lowering overall occupancy costs, allocating space usage, generating building performance reports along with accurate space planning information by linking facilities and infrastructure drawings.

3.3.5 Methods of space management

Size of organization can be a determining factor when deciding which approach to SM to have. Small companies with no or few departments, low churn rates and no plans of reorganizations acquisitions or mergers, an expensive system is not justifiable. The value the systems provide must exceed the cost of acquiring and maintaining the system. On the other end of the spectrum large organization with the opposite plans and conditions could according to Teicholz (2001) easily justify a fully automated graphic FM-system. Teicholz (2001) points out the need of keeping any system up to date and mentions that the cost of keeping it so is one of the most underestimated costs, however the costs of not having updated information can potentially be much greater. Failing to keep reality and system in synchronization can render the information provided by the system useless.

SM is used for determining and managing all leasable areas, including common areas for an organization. Common areas and the possibilities that these give can, if used wisely, help attain and retain staff. SM helps to achieve more efficient capture of areas within a facility, volume capture, calculation of occupancy rate, costs per area unit (cost/sqr.ft., cost/sqm) (BIM Alliance, 2014). Occupancy costs are calculated by dividing the usable area with number of workstations. The cost per square meter times the area of each workstation gives the cost per workstation. This means that the higher number of workstations in an area, the better the space utilization (Finch, 2011). Once the cost/sqm is determined the organization can be used to compare various options and select the one that is most economically viable and fits its requirements (Hassanain, 2010).

Many organizations lease office space in order to avoid tying up capital in buildings, and rather focus their capital on production related assets e.g. equipment and inventories. The leasing of space can inherit a significant expense, one which can be minimized by effective SM. Teicholz (2001) continues to mention that the working environment which is influenced by the SM can have great effects on the productivity of the staff. Staff often represents the most significant of an organization's expenses. Hence work environment should be a central concern for any facility manager (Teicholz, 2001).

Changes originating from SM are often hard to measure or quantify as they are often introduced in order to improve productivity or operating efficiency. These sought after improvements are incredibly hard to measure. Teicholz (2001, Chapter 21.1.5) gives these examples, "*how will the productivity of staff change with a 10% change in their workstation sizes? What about a 20% increase in lighting levels or another air-change or two per hour?*" Further he claims, return on investment for these and similar changes are often impossible to measure. However the investments and expenses for the changes are of course measurable (Teicholz, 2001). In periods of financial bad times a lot of surplus space appears, than the tenants either have to reduce headcount or find other smaller facility options. "Cost of churn" is a growing expense for companies in modern times. Churn refers to the reorganization and changes required in a facility in order to meet new business demands, and have become a critical FM focus (Teicholz, 2001). Churn is an expression that is used by many to describe personnel related changes within organizations. Multi-year planning is important in order to deal with both growth and contraction (Finch, 2011). With information from above mentioned uses, decisions about rearrangements of a workplace should be changed, new hiring customers, refurbishments, new construction, liquidation, or other changes (BIM Alliance, 2014). Additionally the space planner needs to be aware of and be able to announce conditions generated by equipment in a certain area, e.g. noise, air quality, gases, heat, moisture and fire hazards, to the tenants (Hassanain, 2010). This information is important to ensure the quality of spaces for the tenants. It is also wanted by investors that, according to Reed & Halvitigala (2015), Heating, ventilation and air conditioning (HVAC), electrical-, lighting-, and water supply systems are designed in a flexible way in order to accommodate additional space use intensification.

To perform SM and FM, several authors stress the importance to make data available (Volk et al., 2013; Kassem et al., 2014). Teicholz (2001) stresses the importance of only storing required data in one place and notes that data stored in several places causes two major issues. Firstly it requires redundant updating which increases the costs associated with updating. Secondly there is high risk of it being out of sync where only one data location is updated, this causes uncertainty of which data is correct and reconciliation costs. To resolve this issue a primary location of the system data should be chosen and only appropriate staff given access to change it. Also here the issue of different data standards is mentioned as a hindrance in terms of compatibility when gathering all data in one location from existing systems or databases. If compatibility is achieved systems can draw data from each other that enables an organization to only store data in one place and other systems requiring the same date can draw it from the primary data source. Additionally the stakeholders of the data should be identified as well as by which means the data should be kept up to date. Teicholz (2001) states that data should be updated by those who are most

capable and knowledgeable in order to efficiently execute the task but also that those that are most impacted by the data in question should have the responsibility of keeping it current. Kassem et al., (2014) agrees with that there is a lack of established processes for updating BIM models with information and that this results in uncertainty for the facility manager. This is one of the biggest challenges for BIM in FM applications (Kassem, et al., 2014).

It is of great importance for the property owners to understand the operations taking place within the facility. This understanding is required in order to classify or adjust space and to perform departmental allocations. Nical & Wodynski, (2016) mean that the BIM enables space planners to use its coordination and visualization abilities to standardize change processes, space analysis and for forecasting space requirements. The importance of BIM is stated to be indisputable (Nical & Wodynski, 2016). Teicholz, (2001) emphasizes the need for a flexible FM system that can provide information filters and custom reports. These systems do however often require specific user training and ability to export reports to more familiar analytical tools such as Excel should be considered. The ability to produce reports and export data to common office tools gives the FM staff good opportunities to communicate their needs to others (Teicholz, 2001).

3.3.6 The workplace

Steiner (2006, p. 9) means that: *"The physical workplace is one of the top three factors employees take into account when deciding to accept or leave a job"*. This means that the space planning is of importance in order to attain and retain the right personnel, and the effect it has on employee productivity. According to the survey performed by Steiner (2006) about what people look for in a workplace, the following issues are of importance, to have access to a clean and orderly workplace, a workplace that looks good and appealing, that is well-lit and bright workplace, furniture and equipment that is new, privacy and quiet spaces, good air quality and easy access to people and equipment. The area of dissatisfaction mentioned in this survey was lack of privacy, too low or high temperature, noise, bad air quality. All of the above mentioned issues related to the workplace have to do with space-, and FM, along with the building itself.

Traditionally the relationship between user and space was managed in a simple manner where each person was allocated a certain floor space. However the nature and pattern of office work has changed dramatically over time. With help of the advances of technology work can easily be performed almost anywhere. Old ways of SM are in some ways rendered obsolete, and the factor of time has been introduced in the space planning process. Where space allocation is done differently depending on how much time individuals or departments are predicted to actually be in the office. Modern ways of working affects the type, amount and location of space needed for certain workers (Ilozor & Ilozor, 2006). Good space planning includes configuration of the workplace dependent on the type of work-style, employee churn, knowledge sharing, technologies, job type, tools etc. Spaces are arranged to fit the specific way of working. When it comes to offices there are a number of ways to arrange the workplace. Though, the most prominent workspace setting today is open plan attributes. An open plan layout can be described as an office space without dividing walls (Ilozor & Ilozor, 2006). Today many larger tenants have been downsizing their

space requirements based on these types of modern, open plan settings with unassigned workplaces and adoption of technology in order to enhance flexible work practices (Reed & Halvitigala, 2015), where more people can work with less required space. Other arrangements are, as mentioned by Duffy & Powell (1997), hive, cell, den and club. The different arrangements are illustrated in Figure 4.

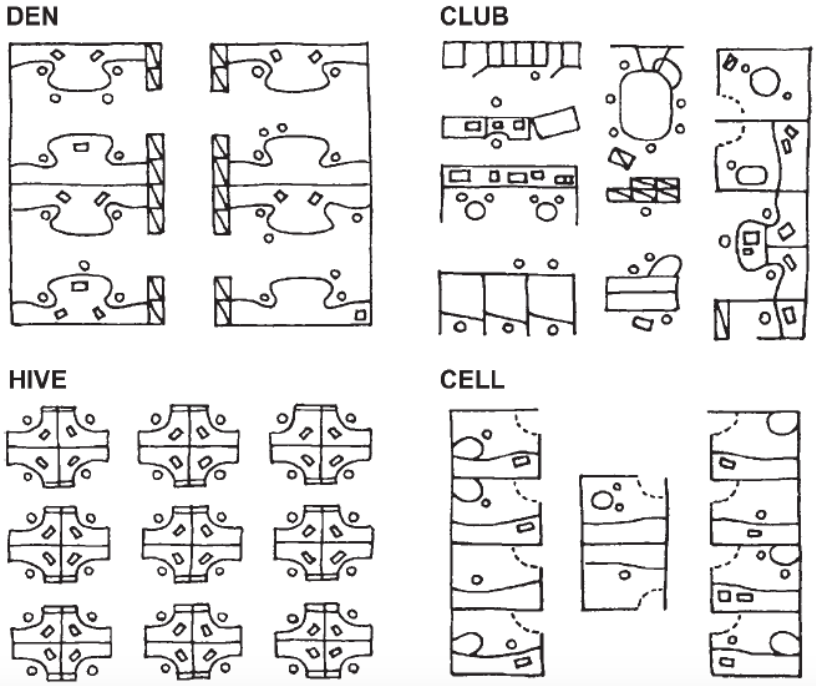

Figure 4, Illustrations of different arrangements of an office (Duffy & Powell, 1997).

The den arrangement is aimed at improving group processes and interaction increase. Club is more oriented towards transactional knowledge, interaction increase. When it comes to the hive arrangement it is aimed at more individual processes. Cell is an even more individual oriented arrangement aimed for concentrated study, autonomy increase. Companies often use mixes of the arrangements within the company to fit different tasks. Additionally the choice of workplace configuration may differ depending on the intended corporate culture (Steiner, 2006). The open-plan layout, mentioned above, aims at increasing knowledge sharing and interaction, similarly to the club arrangement. Older buildings however are seen by open-plan advocate space managers, as bad for their portfolio value, since these buildings have smaller floor plates which results in smaller open areas. Modern office buildings are often built with larger open areas, where floor plate depths range between 15 to 20 meters. Buildings with even larger floor plates often result in issues related to lighting and ventilation (Reed & Halvitigala, 2015).

Pitt & Bennett (2008) investigated a case study where open-plan workspaces were applied and worked well. The various approaches they worked with in order to achieve this was hot-desking, touchdown areas, bookable private offices, group collaborative workspaces, break out workspaces. Hot desking means shared desks to promote efficiency. Touchdown area is an area with unassigned workspaces, which allows employees to sit anywhere and access information more quickly. Bookable offices are places that are unassigned and used s individual workspaces to provide privacy. Break out workspaces are tables, sofas and chairs arranged in more relaxed

atmospheres that allow spontaneous and informal collaborative work. As can be seen by this example and mentioned by Steiner (2006) most companies use a mix of arrangements, which means that an open-plan workspace includes somewhat different arrangements. All of which are used in order to promote better business performance.

3.4 Compiling the concepts SM, FM and BIM

This section compiles theory in the areas of SM and FM, SM and BIM along with the owner's role related to these topics.

3.4.1 Space management and facilities management

SM as well as FM can be performed more effective and efficient with the use of BIM as a primary tool for information handling. In Cotts et al.'s (2010) Facility Management Handbook space is referred to as the frontier of FM and that within these physical dimensions is where the manager exercises his or her duties. Hence the success of the FM is partially measured within the planning, forecasting, allocation and management of spaces. Booty et al., (2009) also hints at the importance of SM by claiming that it is the most conspicuous of a FM's functions. Further they highlight the vitality of well-functioning SM in order for the workspace to operate at its optimum and that an efficient, safe and comfortable workplace contributes to this. One of the core matters of space planning is the effect of layouts on communications and productivity, effective SM ensures this as well as optimizes the utilization of spaces and assets (Steiner, 2006 Booty, et al., 2009). In a survey done by Becerik-Gerber et al., (2012) FM professionals were asked which their organization's functional responsibilities were, *space management* was the third most common answer after *maintenance and repair* while *energy management* was first on the list.

3.4.2 Space management and BIM

Spatial BIM is a term mentioned by Kensek (2015), with focus on the management of spaces rather than building elements or inventory, and as such an expression of SM through BIM. The required information for SM is relatively easy to insert into a BIM-model and to access once the model is populated with information. The model can be used for audits of space utilization, changes in space design and space utilization management. The 3D model itself is of limited value for SM, however with the added feature of attached database allows for easier space identification using data fortified walkthroughs, this can contribute to greater efficiency by considering e.g. furniture placement. Kensek (2015) states that during a facility's operational life the greatest function the BIM-model provides is the space utilization. Additionally it is mentioned that spatial BIM can be used to avoid conflicts in operation during changes in facilities through its up to date information and graphics, as well as streamlining traffic of people and equipment within the facility (Kensek, 2015).

In regards to the decision making process about space use, BIM allows FM staff to make decisions that are well informed both visually and technically. FM personnel can identify spaces and its uses as well as its components and attain information about its possible functions through BIM (Kensek, 2015), since BIM is seen as the solution for sharing information and data among multiple systems, especially systems that handle SM-, FM- and O&M-phases (Shalabi & Turkan, 2017; Becerik-Gerber., et al.,

2012). In 2016, Gheisari & Irizarry performed a survey regarding facility managers work days and habits when it comes to tasks, mobility, and platform use etc., the survey showed that 75% of the companies involved did not use BIM. Additionally it showed that respondents rated their own BIM capabilities as 2.36 on a scale from 1-4, where 1 was none and 4, excellent. Further the respondents were asked to rate the applicability of BIM in regards to certain areas, here *Locating building components, 3D visualization* and *Space management* where listen as the top three possible applications, with a score of 3.13-3.37 on a scale from 1-5. Challenges related to the implementation of BIM in FM were also rated, here *Start-up/initial costs, Administrative costs* and *Lack of BIM models of the facility* where the top three. Also issues related to knowledge of BIM and how to use it were given high scores (Gheisari & Irizarry, 2016).

Hagan (2014) argues for the advantages of spatial BIM by stating that it has the capability to carry more measurements and attributes of space as well as being digital. Additionally Hagan (2014) mentions the growing complexity and evolvement of measurement standards calls for a digital rather than manual analog approach to space measurement. The life cycle of a facility is a complex process with vast amounts of information being stored, compiled, created, transmitted and processed. Spatial BIM is mentioned to be able to provide order and a solid base of information that follows the facility through its life cycle. The advantage that BIM brings when it comes to information handling is its storing possibilities and accessibility of information. SM through BIM is said to be: *"a potentially dramatic improvement for the benefit of the entire facility life cycle and a myriad of building types and works across the scale from global to room contents. It remains a frontier yet to be fully explored and its potential to be fully realized"* (Hagan, 2014, p. 291). Hagan (2014) also mentions the lack of adopters of spatial BIM and that is still quite undeveloped as a specific concept of BIM.

From the providers of modern FM services and developers of BIM-software similar advantages are mentioned. Here it is claimed that BIM can improve SM by quick and visual illustration of where space can be used more efficiently and help make it so. Change processes are improved through scenario planning and space configuration, also here conflict that arises from changes to requirements or purposes of space can be identified (Archibus 2017; youBIM 2015; Autodesk 2013). Facility BIM software is a great tool to get an image of the distribution of areas in a facility. BIM can enable the space planning process in being performed quicker and with less workload. The way this process is done in a more efficient way is that facility-BIM gives answers to if a space is suitable for a certain tenant. In order to do these types of analyzes the software needs to have the possibility to search for area specifics and specifics about the strains that the area is dimensioned for, e.g. when it comes to ventilation, heating, cooling, electricity etc. In order to be able to perform prognosis about alternative areas and to create scenarios in distribution of areas and configuration of operation areas, a software support system for SM is needed. This type of support can be achieved with a BIM-software (BIM Alliance, 2014).

3.4.3 The role of the owner

Which information is required, needs to be decided by the owner based on their needs. Further it is mentioned that the information needs to be thorough, systematic and

specific to the needs of the occupant's requirements (Kensek, 2015). This indicated that the model design needs to be done through collaboration between the owner and the occupants, which is also supported by Pitt & Bennet, (2008), Hassanain, (2010) and Reed & Halvitigala (2015). The owner's role is more important if no standards are in use. Because then the owner needs to specify the exact BIM requirements, decide Level of Detail (Hardin & McCool, 2015). A standard can partly do this for the owner (Svensk Byggtjänst, 2013). For example if the owner requires a BIM model with a certain standard the deliverer knows what to deliver. Without the standard, the deliverer knows not what is expected without specific requirements from the owner.

3.5 Shortcomings of reviewed studies

No research specifying the information needed in order to operate FM through BIM was found, rather what and how it can be done,. Additionally no distinction between information needed in order to perform FM or SM with BIM compared to performing these services in another way have been found. The lack of distinction may be because all information about the facility is needed in one way or another. This is interesting since theory often bring up the importance of well-structured, available, updated information as well as sustained information flow (Nical & Wodynski, 2016) and the benefits this gives. The indication of what information is needed in order to perform FM and SM through BIM can be gained when going back and studying what information is included in the BIM model. The information in the BIM model is information that aids the performance of FM and SM. This shows the width and amounts of information available and needed to achieve expected tasks. Though the indication that is given by many researchers is again the availability of information BIM gives a project (Nical & Wodynski, 2016; Kensek, 2015; Svensk Byggtjänst, 2013). Then again if all information is more or less used the availability, structure of information etc. provide the enhancement of a project's performance.

3.6 Summary of theoretical framework

SM entails keeping track of spaces and related assets and information, with the goals of reducing facility costs as well as increasing profits and user productivity. Productivity and culture of the user can be greatly impacted by the workplace layout, this is where the most monetary benefits of SM are said to be found. Benefits of efficient SM include decreased facility costs, improved business performance, keeping track of information that enables better decision making concerning future business planning. BIM is a digital tool that helps manage a building's information throughout a building's life cycle. The use of BIM changes throughout the life cycle, in the projection phase it is used in one way, in the construction phase in another and in the management phase a third way. BIM can make the work with SM easier by, storing all information concerning spaces in one place. Further BIM can provide up to date information and graphics, up to date space utilization, and allows FM staff to make decisions that are well informed both visually and technically. Costs of keeping information up to date may be large, however the costs of not having updated information can be much greater. BIM implementation is costly for adopters, which may be a contributor to lack of adoption within the industry. A study, from 2016, shows that only 25% of facility managers use BIM in their operations. The owner is the one deciding whether and how BIM should be used for a certain facility. If the owner does not require a BIM model, generally a BIM model will not be created. No

research specifying the information needed in order to operate FM through BIM was found, rather what and how it can be done

4 Empirical part

The following parts are based on answers from the interviews that have been arranged to form the basis for results and discussion for this thesis. The interviewees will firstly be presented with current work tasks, background along with a short presentation of the organization the interviewee works for. Both the name of the person interviewed and the company in question will be kept anonymous.

4.1 Interviewees

The interviewees represent seven companies located in Gothenburg, Sweden. At any point in the rest of the thesis they will be referred to by pseudonyms. Below a list of the names along with a short description are presented. For a more extensive description of the companies see Appendix C. The property owning companies were chosen due to the fact that they are among the biggest property companies in Sweden and the consultants are leading in their respective fields.

Table 1. A short description of the interviewed organizations and their pseudonyms that will be used throughout the thesis.

Company names	Profile	Number of interviewees	Number of interviews
BIMex	BIM consultant, performs consultant services related to BIM	1	1
Magnum Co	Property owner, leases, develops and manages commercial spaces	2	1
Calippo Llc	Property owner, leases, develops and manages commercial spaces	2	2
Solero Ltd	Property owner, leases and manages commercial spaces and apartments	1	1
Iglo Inc	Property owner, leases and manages commercial spaces and apartments	1	1
Cornetto Ltd	Property owner, leases and manages commercial spaces and apartments	2	1
ConsultEx	Consultant in the fields of facilities, spaces, community building and more	4	1

4.2 Interview compilation

Here follows a compilation and summary of all performed interviews. The interviews for this research have been performed in the Gothenburg region with a variety of companies working with Facilities Management (FM) or as consultants. Gathered information from the interviews, along with the literature study, form the basis for the conclusions drawn in the thesis. How the interviews have been performed is described in the method section, Chapter 2.4 - 2.5.

4.2.1 Questionnaire

Prior to the interviews a document with a short project description, a definition of Space Management (SM) and Building Information Modelling (BIM) were provided to the interviewees, see appendix A. The questions that were asked can be found in appendix B.

4.2.2 Facilities management

When interviewing representatives from the property owners it quickly became apparent that from the five companies' perspective the most important question is how they can make as much money as possible from any given property. Some say it outright some are more subtle, this is however mentioned to be achieved through customer satisfaction and long term tenants. Calippo Llc expressed a desired symbiosis between them and their tenants where they explained that if the tenants business is good, their business is good. Customer satisfaction comes from the property owner's ability to remedy any faults that appear with the facility but also through customization of the space in question. The five property owners say that in order for the tenants operations to function properly they will have certain demands on the space they are renting, any changes are developed with the help of consultants, architects. Only minor changes are planned entirely by the property owners themselves. One manager, from Iglo Inc, mentioned that the competence could be stored in-house however this could lead to competition between the managers and prioritizing for the in-house architect would be difficult and might cause conflicts. The same manager also notes that the ability to accommodate the changes themselves could strengthen the relationship with the tenants. It is mentioned by Magnum Co, Iglo Inc and Cornetto Ltd that an architect's competence is required in order to ensure all modifications meet current building regulations.

The five property owners mention that higher profits are said to be achieved by finding and converting spaces into more profit generating types e.g. converting storage to office, common areas to stores etc. Connected to this they imply that facility knowledge is of great importance, and that physical presence is essential in order to know the facility through and through. This indicated knowledge might be stored somewhere, but is however largely stored in the managers heads. This is mentioned out right to be the case when it comes to technical management from five of the facility managers interviewed. However Iglo Inc and Magnum Co identify this as an issue that should be solved. The manager from Iglo Inc also mentioned that with current trends the facility managers have too much to handle to be able to keep track of everything and need efficient ways to store and access the information. In contrast another manager, from Solero Ltd, means that if they cannot keep track of everything

then the manager is responsible for too many facilities and will not be able to perform their duties and should be responsible for less. This manager could be described as somewhat conservative and mentioned that he prefers to have their files in analog folders etc.

Two of the interviewed organizations, Calippo Llc and Cornetto Ltd, mention another important factor in increasing profits, namely reducing time between tenants, this is time the space generates no income. To tackle this they mention that any modifications to the space should start as soon as the previous tenants are out of the building. This might seem obvious, however all except one (Calippo Llc) of the interviewed facility managers say they do not perform any modification without first finding a new tenant, they say that each tenant's needs are too specific for them to do the customization. One of the respondents did however mention a desire to be able to modify prior to finding a tenant in order to make the space more attractive, this was Iglo Inc. Additionally both of the managers, from Calippo Llc, said that they since a few years back started doing modifications prior to finding new tenants which had decreased their time between tenants significantly.

Although the BIM consultant from BIMex had limited knowledge of property and FM, he predicted a future where this facility knowledge will not be sustainable and proper documentation would be essential. Further BIM was stated to be a possible way of achieving this documentation, and that in the future consultants would be used to larger extent when it comes to general service and maintenance of a building. This way they would not need to know the buildings through and through because the information would be easily accessible and sufficient for them to perform the job they are assigned (BIMex). He continues with his predictions about future facility management. He means that more and more companies will move towards more slimmed organizations, meaning more outsourcing of actual maintenance work. This means less knowledge about the actual buildings. Then an implemented BIM model with VR technology can be used. One master technician can sit on all information at the office connected via skype and the technician that got called in for this particular job get the information is his device. Everything the owner then need is BIM models of the buildings and consultants that do all the actual work. Though the interviewee finishes this with saying that he is now far ahead in the future, and this may never happen. In a sense Cornetto Ltd already worked like this, they had consultant technicians responsible for e.g. ventilation, electrical works in their properties, see Chapter *4.2.3.1. Facilities managers view of BIM*. These technicians, or house consultants, however were described as having as good facility knowledge as the other managers described that their own technicians had since the same consultant or consultant company would be responsible for a certain house for a long period of time (Cornetto Ltd).

4.2.3 BIM

12 out of the 13 interviewees have heard about the term BIM and had an idea of what BIM is. None of the interviewed companies work with BIM on any larger extent even if small steps are taken towards digitalization.

4.2.3.1 Facilities managers view of BIM

When it comes to their view regarding BIM's potential to improve their ways of working there were different views of this topic. Statements about BIM ranged from, unnecessary, excessive, hard and expensive to implement. To opinions that mean that BIM would absolutely improve the ways of working and that implementation would not be a major issue. However, it was shown that property owning companies see BIM benefits mainly as tools to improve marketing, promote sales of facilities, and visualize a building for potential buyers, (Magnum Co, Calippo Llc, Solero Ltd and Cornetto Ltd). Solero Ltd thinks for example that 3D is unnecessary except for doing presentations of a project, marketing purposes and to inform and gain construction permits. It was mentioned in the interview that you always get the best understanding about a facility by visiting it in person not through a 3D model. Additionally the interviewee was of the opinion that the responsible manager of a facility would not benefit from BIM as an information management tool, because the responsible facility manager has knowledge of his/her facilities. To the question if such a system is vulnerable in case of the responsible manager decides to leave his/her duties. The reply was that it might be vulnerable but that the information is easily accessible via paper documentation in binders or in the database.

Magnum Co is of the opinion that IT-, and technological tools will come more and more as part of the digitalization in society today. This company is in the early stages of trying out visual models and VR technology which the interviewees think is good and will increase in use in the next coming years. However all these new tools will never replace the importance of the personal presence and personal relationship with tenants. Magnum Co does think that BIM will probably enhance their way of working and information handling about facilities in a way not known by the interviewees.

Even though working with BIM and 3D visualization is new for Calippo Llc they have recognized benefits working with it, and are positive towards BIM implementation. The use of 3D representation is mentioned by Calippo Llc to be of specifically good use if potential clients are situated far away. However they have only applied BIM and 3D visualization tools for newly constructed buildings. One example of how Calippo Llc have used this is in a new construction project where one can attend a showing of a house that would be finished in 2020, where you can enter the terrace, and walk around in the building and so forth. This was only made for marketing reasons. The BIM model or the 3D visualization model for these reasons is made by different consultants, none of the interviewed companies possess the competencies to build a BIM model or 3D visualization model themselves. The interviewee is also of the opinion that digital tools will be a part of the property owner's everyday work more and more. Calippo Llc, the largest of the interviewed companies mentioned that they work with BIM for larger new construction projects. They also state that it is very costly for them, but that BIM and 3D visualization is a good selling argument. The cost is the reason why BIM models and 3D visualization models of older buildings are not something they do. The opinion of the interviewee from Iglo Inc was clear: *"I believe that BIM could really improve facility management tasks"* Iglo Inc does not however work with BIM but the interviewee have seen and heard about benefits from other sources, he also recognizes that the digitalization will affect the way FM tasks are performed. Furthermore he does not think that implementing BIM would be a big issue for the industry. The interviewee from Iglo Inc means that the opinion of BIM is different from person to person even

within a company. This results in that different facility managers work in somewhat different ways with the help from different tools. He also mentions that this may be problematic for BIM implementation, that some people in the industry thinks that it is not needed and unnecessary.

Another problem with implementing BIM, as mentioned by Cornetto Ltd, is that in order to make BIM profitable it has to be used for large volumes, larger than the facilities they possess today. This is why Cornetto Ltd will implement BIM first when they start their production of commercial real estate. Otherwise the opinion was that they have benefits from visualizing facilities from a selling point of view. An interesting statement was that Cornetto Ltd does not want help with "knowing their facilities", that is something the facility manager should know. This is something that is a part of the company philosophy about knowing their product. One reason why 3D visualization is performed, is according to Cornetto Ltd because people cannot read floor plans and technical drawings properly. In contrast Solero Ltd means that their clients are professionals and floor plans provide them with sufficient information.

Furthermore when it comes to ventilation and electrical works Cornetto Ltd spoke in detail about how they work with these issues in their facilities with new ventilation installations. The person responsible for the ventilation in a specific facility is a so called "house consultant" working for a consultancy firm specialized in the area of ventilation. This person works with online tools to steer and receive alarms about everything that happens with the ventilation. This online tool can measure incoming and outgoing temperatures in a room, ventilation force, receive alarms if something breaks down, etc. All this can be governed and followed in real-time from a mobile device. This consultant has great knowledge about the specific facility and this consultancy firm solves all issues with the ventilation installations. This can be seen as one step towards digitalization and towards BIM and how organizations may look like in the future, where the knowledge about the digital model lies with consultants.

4.2.3.2 The consultants view of BIM

Apart from our interviews with people from the FM/property owner side we arranged two additional interviews, one with a BIM consultant (BIMex) and the other with FM consultants (ConsultEx). Both these parties mention that there are benefits to be gained from implementing BIM for FM and SM. The BIM consultant means that you can save the most money in the FM phase rather than in the planning, and construction phases. The FM consultant continues and mentioned that BIM can be used to e.g. analyze electricity, ventilation, and other needs that are required in a certain facility at a certain time. Another benefit of BIM is to make sure that facility managers always can keep track of technical drawings but also to know how areas are used such as gross floor area, usable floor area. Such information is hard for facility managers to get keep track of today. Both of these consultants agree that BIM is mostly used in the construction and projection phases today and it is not used for FM because of the lack of demand of BIM models from owners.
Furthermore they both agree that BIM will be used more and more, and that the industry will move towards more digitalization. The BIM consultant stated that: *"BIM is a name for the digitalization of the construction industry, as every other industry is being digitized".* This can then be interpreted as BIM and digitalization being the same phenomenon. The statement is additionally a clear sign that BIM will be used

more, this is something that the interviewees at ConsultEx and Cornetto Ltd were certain of. This means that the industry will be more digitized. The clear sign in this case is as mentioned by the BIM consultant, that the whole society is getting more and more digitized and the construction industry is no exception. He continues and means that only your fantasy is the limit to how much help you can get out of a BIM model, and standards are needed to speed up the process of implementation of such tools.

4.2.3.3 Digital tools today for existing buildings

The five property organizations interviewed have floor plans and technical drawings available on various online databases, further explained below. Magnum Co has a type of online file structure where they keep information about a facility e.g. 2D floor plans, 2D technical drawings and information about technical specifics such as ventilation forces. Each department within the company has their own structure. This information needs no specific software in order to utilize. The file structure is available from mobile devices and can in cooperation with architects or consultants be used by them. When it comes to Calippo Llc they have something similar, a digital system where all buildings are represented with some kind of 2D floor plan, and/or technical drawings. For some facilities Calippo Llc have inserted color markings into floor plans showing tenant boundaries. In the fourth interview with Solero Ltd a different view was presented where the interviewee preferred to have all information in binders even though the same information such as floor plans, drawings, and specifications of the facilities were available at an online database.

In the interview with Iglo Inc the interviewee mentioned that they collect technical drawings straight from the municipality's archive. These drawings are building permit drawings, which means that changes may have been made since, making them inaccurate. After collecting the drawings they store the drawings in their own file structure, from here they can perform any necessary changes and update the model making it accurate. Their file structure is online based and all necessary information about the facilities is stored there. Cornetto Ltd have technical drawings and floor plans on an online database available for all employees as well. As mentioned before, their work with new ventilation systems are quite extensive and definitely a digital tool. These online accessible floor plans and technical drawings were used and updated more by some than others both within each company and compared to each other.

4.2.4 Standards

As mentioned by BIMex, BIM is just a name of the digitalization that is happening and will continue happening in the construction industry. This means that BIM may be implemented eventually. However it is argued by BIMex that standards are needed in order to make the implementation of BIM work, as well as making the implementation phase quicker and similar throughout the industry. Standards resulting in the same, use of software, naming standards and that the way BIM is used and utilized are the same. Most importantly that the file format of information is the same for contractor, facility managers, architects and other consultants. This is argued by BIMex to be of great importance for the industry to implement BIM in an efficient and beneficial way. Iglo Inc is a company that agrees to the statement made by BIMex that standards would be beneficial for BIM implementation. It may however be

problematic with a standard since companies work in different ways today. This is something that BIMex agrees to but means that you can still work differently even if you follow the same standard. However the interviewee from Iglo Inc thinks implementation will not be a problem for the industry and means that many companies often do not have problems adapting. The answer to the digitalization and BIM issue for it to be implemented, as mentioned by ConsultEx, is to show that it is profitable, or for developers to demand BIM models from the contractors and architects for their projects.

4.2.5 Space management

Iglo Inc explains that they through the help of facility knowledge and floor plans try to make buildings more effective in terms of rentable spaces, both by changing and creating new spaces. Calippo Llc states that for some of their facilities they have floor plans where all rented spaces are drawn out, which helps them determine how changes could be made as well as allows them to keep good track of their tenants' spaces. Calippo Llc also mentions that by working a lot with their spaces they have found the importance of keeping track of every square meter. This has been done by drawing tenants rented spaces into floor plans to get an overview of the space use and which areas are vacant. So far mainly larger investments and refurbishments where there has been a lack of knowledge concerning space usage have been drawn up like this. The indicator of the importance of keeping track of every square meter is that it has become profitable for them. They also emphasize not forgetting about less attractive spaces such as storage and explains that one unit might not generate much income but they stack up it is very important to have knowledge about those spaces. Magnum Co's and Solero Ltd's way of keeping track of who rents what is through contract appendix where the rented space is marked on a floor plan, this is done individually to each contract on no compilation of the spaces is made. They however state that they have a good idea of the correlation and keep a good overview in their heads, in the following sentence Magnum Co highlight the vulnerability in this way of working if someone is home sick or changes jobs. To counter this Magnum Co work in teams where the team members have some insight into each other's facilities, they also mention that it takes quite a while to attain their level of facility knowledge making it challenging for someone new to perform their tasks.

Calippo Llc explain that they have managed to achieve good flexibility in their spaces by using room dividers that are not walls, but rather seating with high backs or screens. Further Calippo Llc state that they have been able to reduce their vacancy time by creating standard office spaces that they modify prior to finding a tenant, and mentions that their ability to do this stems from experience with customer modifications which has given them a good idea of what their tenants want. They mention that modifications without tenant input are more general and work better over time, which then leads to fewer modifications throughout the lifespan of the facility. Tenants who rent these spaces get to put their touch on the space with smaller modifications such as furniture and lighting but walls and rooms are already decided. Calippo Llc notes that some spaces are however modified with tenant input, and explains that any modifications are dependent on type and contract length, longer contract length enables more modification, although modifications that are considered more general can be extensive and still accompanied with shorter contract lengths. Further it is mentioned that any modifications involving room changes or creation are

accompanied with modifications to ventilation as well as electrics. Also Cornetto Ltd notes that flexibility can be achieved through smart furniture and technical equipment that can be moved easily, and that the traditional teardown and rebuild for each new tenant is not economically sustainable. Furthermore when Calippo Llc perform changes in their facilities, refurbishments or other changes, they work with different consultants such as consultants for electrical works, fire safety, ventilation, architects and decorators. ConsultEx share their view of SM and mention that it is a broad topic involving "*space, equipment, furnishing, everything really.*" They continue to explain an important part of it is how the space can help the tenant in their operations.

When analyzing a space in terms of SM they perform measurements of attendance and space saturation and mention that these are some important and easy key figures when performing SM. Further analysis can be made in regards to tenant staff duties, who need to interact with whom, and how should they sit with this network in mind etc. Further ConsultEx explain that they form with space resource planning and include a lot of aspects of FM, they look at whole portfolios, which they break down into groups depending on use or location or other suitable categories. What they are trying to figure out are current operation and facility capacity now and 10 years forward and make a plan of how the organization and the space could be adapted in order to enhance its performance.

Calippo Llc mentions a way they work with SM is by upgrading the ventilation system in order for the facility to serve more people. While Magnum Co explain that the ventilation system often works as a limit when it comes to how many people they can sit in a certain space or facility. Along with that they often get requests of increasing the population in a rented space but cannot accommodate the requests due to limits of the ventilation. Also Cornetto Ltd mention that it is often installations that limit the capacity of any given space, however the key figure they work with is 10 square meter per person in an office, they continue to mention that five years ago 15 was the norm. A reason for the decrease for these key figures are that the need for office space has decreased a lot in recent years, mostly because of mobility of devices, thin computer screens and laptops, meaning that no big desks are needed anymore. Another reason for this is that large multinational companies have other demands than traditionally in Sweden according to Cornetto Ltd. Additionally Cornetto Ltd explain that when planning their facilities they try to estimate the absolute maximum amount of people that could be there physically and use this figure when dimensioning the ventilation, this way they aim to make sure they are able to accommodate requests of rising occupancy in their facilities. Cornetto Ltd mentioned that the biggest challenges when managing spaces is the installations since there are no quick fixes if the systems do not meet the requirements of the tenants. Solero Ltd explain that they try to make their properties more efficient by combining common spaces with local spaces, this way the common space generates rent income as well. Further the knowledge of the tenants' organization is highlighted as important.

Further Magnum Co explain that they get input from their tenants from tenant meetings once or twice a year, where the tenant gets to deliver any requests they have in terms of changes to the space or facility. In regards to space requirements from tenants Cornetto Ltd mentions that new key figures are used to express demands, which the property managers need to be aware of and able to adapt to. Cornetto Ltd highlight the importance of ensuring that the users of a space are pleased and mention

that any dissatisfaction end up at their table, even flaws that the tenant was aware of when first renting the space. Further Cornetto Ltd notes the importance of listening to the tenants and understanding their goals and space needs, which they state is closely related to the type of personnel they want to attract. Calippo Llc works a lot with tenant satisfaction as well. An interesting example of how one of their tenants wanted to utilize their spaces more was to change the use of their space after office hours into a call center. Then two divisions from the same company can use the same space at different times of the day. This is also an effective way of utilizing spaces as well as establishes tenant satisfaction. The BIM consultant notes that when working with property managers the importance of having knowledge of areas has become clear. Additionally he mentions the fact that many organizations have poor awareness of their spaces and that they use old systems to store them and often they are not correct. Updating these systems is stated to be time consuming.

4.2.5.1 Goals and benefits of space management

When discussing the goals of SM the five property managers talked about minimizing vacancy as a high priority, as well as converting low income types of spaces into higher income ones. ConsultEx however mentioned creating a space that enhances the tenants operations and explained that their role when it comes to SM is often in between the tenants and the property owner, while the property managers firstly look to the owners incentives. Calippo Llc explained that when managing space from their perspective they usually have the whole building or portfolio in mind, but when considering SM for a certain space, the tenants are the ones who have the most to gain from it. Calippo Llc and Iglo Inc stated that the goal is to use a building to the furthest extent possible, Calippo Llc continued explaining that a property simplified is worth the sum of its future profits, and higher profits come from increasing amount of rented spaces or lowering operational costs of the property. Also Magnum Co and Iglo Inc mentioned the benefits of increased property value if more rentable spaces are available in the facility.

Solero Ltd expressed doubts if making a tenant's rented space more effective have any monetary benefits for the property owner and mean that any customizations mainly benefit the tenant. In regards to who can have the most benefit of performing SM, ConsultEx have different opinions, one state that the tenant is the one who has the most to benefit from it. While another meant that it is most crucial and beneficial for the party with the least money, the one who needs to increase their profits or decrease their costs, if they are not in either of those situations they do not care. Further ConsultEx explained that they often work for municipalities and government organizations, which require an overview perspective where both user and owner need to be considered equally since in many of these cases they are the same. Additionally it is noted by ConsultEx that the benefits from a tenant’s perspective should be focused on increasing user effectiveness and productivity rather than operational costs, however it is stated that this is often not the case, most likely due to the difficulty in measuring productivity or determining the reasons for its increase. They meant that if you can manage to increase the productivity operational cost of the space that the employee occupies are negligible. Further it is discussed that performance can be harmed by little things such as difficult equipment, untidy spaces, or temperature, which are all parameters related to SM.

4.2.5.2 Trends in space management

Recent trends within the field of SM is, as mentioned by Cornetto Ltd, that companies intend to locate themselves in areas where large, innovative and new companies establish themselves. This is called clustering, making specific areas close to these companies attractive for other companies to establish operation. An example of this is when a large Swedish games developer established an office at an unusual place in Stockholm and all of a sudden many companies, both national and international, wanted to establish offices nearby. Another trend today is that an office or a facility is no longer four walls, floors and ceiling. It is space that shall support the organization's development attract new employees, as mentioned by Cornetto Ltd. This is something that ConsultEx agrees with and means that many companies have recognized that the workplace in itself is a competitive mean to attract competent personnel. A final trend as brought up by ConsultEx is the importance of the space usage for a company's image. That the company's offices look, feel and work in the same way, wherever in the world the office is located. Additionally the company image should mirror itself in the spaces used by the company.

4.2.6 Space management and BIM

As mentioned above both the BIM- and the FM consultant can see clear benefits with BIM when it comes to SM and FM. This part presents the views that the facility managers have when it comes to BIM for SM.

It is mentioned by ConsultEx that BIM can help the company in question with analysis of energy consumption for a facility. This makes it possible for the facility owner to take preventive actions to reduce energy usage faster than with analog measures. According to the interviewees from, Calippo Llc, Iglo Inc and ConsultEx buildings that are environmentally sustainable are gaining popularity among tenants. Calippo Llc means that most large tenants demand environmentally friendly buildings for their spaces. This indicates that making a building more energy efficient is positive for the facility owner. Another thing as mentioned by Calippo Llc is that digital tools can measure presence of people and in that way calculate usage and utilization of a facility. Calippo Llc performed this kind of presence measurement over a period of one year. The result was astonishing, showing that the utilization and presence at the company's workplaces was only 37%. This analysis provided them with insight, and the interviewee mentioned that this is a tool to use when deciding how close together and how many workplaces fit to a certain space.

In one of the larger companies, Calippo Llc, that was interviewed it was stated that for some of their facilities where they had lack of knowledge about tenant's, usable areas, and they felt like they were not aware of the use of the areas in the facility. What they did then was to update all technical drawings and floor plans and made color markings of all areas occupied by different tenants. In this way they could analyze all areas and keep track of every single square meter. This has according to our interviewee at Calippo Llc given great result providing them with more leasable areas, better tenant service, and provided them with spaces they did not know were unutilized. This was discussed with other interviewees as well, where BIMex, Magnum Co, Calippo Llc, Iglo Inc and ConsultEx could agree upon that this could be profitable while Solero Ltd and Cornetto Ltd saw this way of analyzing areas as more

or less unnecessary and excessive with the argument that, it is always easier and less costly to visit the facility and do analyzes like these in person.

4.3 Summary of the empirical part

The interviews were conducted with seven different companies and with thirteen people. They worked as consultants or property owners. Higher profits are important among the property owners, to achieve this all areas are aimed at being utilized. To achieve this, the facility manager's own knowledge of the facilities are important, not many digital tools are used more that technical drawings. Their views of BIM differ, from unnecessary and hard to implement to necessary and not hard to implement. Some of the companies mentioned to have found positive effects of keeping track of all spaces.

Calippo Llc and Cornetto Ltd work with BIM models for their new constructed facilities. Iglo Inc is alone in thinking BIM would not be problematic to implement and it would improve FM and SM for property owners. Others are unsure concerning BIM, though Solero thinks BIM is unnecessary. Recent trends in SM is clustering. Calippo have had positive effects of applying color markings, marking tenants and their organizational boundaries.

5 Discussion

Issues that will be brought up in this section are issues that the authors thought were interesting and problematic for the interviewed companies. The issues will be discussed and compared to the studied literature.

5.1 Differences in definitions

When it comes to Building Information Modelling (BIM) it is shown in the literature that BIM have no common definition used by all. If one look at the definition by BuildingSMART (2016) where BIM is written about as a model, other explanations vary, some view it as a process: "*BIM is a value creating process … of a facility"* (Golabchi, et al., 2013). *"a digital representation of the building process"* (Eastman et al., 2011). This indicates an ongoing phenomena, and not a completed work, Golabchi et al.'s definition talk of a facility indicating its whole life cycle while Eastman et al.'s focus on the building process. Others view it as a tool to enhance other processes and not as a process in itself: *"BIM is sought to enhance current FM practices by improving interoperability, visualization, and fragmented data challenges"* (Shalabi & Turkan, 2017). *"BIM is a tool to manage building information"* (Volk et al., 2013).

These different explanations of BIM could be argued to be confusing, however we would rather argue that it shows the broad spectrum of what BIM can be. The definition is dependent on the problem at hand and what the intended use is for a given project. The authors believe BIM can be used for many things and the limit to what BIM can be used for is not really defined. This means that it is used by many for different reasons. Additionally the definitions are dependent on the usage of BIM in specific researched areas. It was recognized by the authors that several of the interviewees saw BIM as a 3D model and not much more, even if the theory means that BIM is more than just a 3D model. This is why we thought that we, for this thesis, needed our own definition about what BIM was.

The definitions of Space Management (SM) are often quite simple or absent in the texts reviewed for this thesis. This could be due to belief that the term is self-explanatory, which at least for the authors of this thesis and the organizations interviewed it is not. Generally SM is mentioned and then the texts go straight into explaining the different aspects of it without first explaining the concept as a whole. This is not surprising though, it is a complex practice which might mean different things to different stakeholders. Archibus (2017) describe their product as being able to: "*Evaluate and plan space usage to maximize efficiency and decrease total occupancy costs"* which is a concise statement and goes straight to the goals of SM and is aimed towards the user of the space. This is not surprising considering they aim to sell products that help their clients perform SM. It leaves the means out of their description this however leaves the interpreter wondering or drawing their own conclusions about what SM is. In contrast Kensek's (2015) Steiner's (2006) explanation of SM are from an owner point of view, however they still incorporate the tenant's use of the space as a parameter of SM. Steiner (2006) mentions SM being all about optimizing leasable space for current and future operations, which entails high tenant influence of the process however it points out the property owner as the proprietor of the task. Similarly Kensek (2015) state that a space is a valuable asset for the owner and in order to utilize it efficiently detailed knowledge of its use is

important, which in extension requires knowledge of the tenant's organization. Additionally Kensek (2015) mentions knowledge about size, location and components as important when performing SM. These shorter explanations compiled give insight into the goals of SM as well as which parameters need to be considered. However to gain insight into the methods of SM the literature needs to be studied more extensively. If the methods would have been described briefly along with the goals in the literature a much better picture of SM could be created for the readers more easily.

The authors, of this thesis, put together a definition that was defined with the help from literature about SM along with other definitions of SM, see Appendix A. It was thought to be of importance in order for interviewees to understand the thesis' purpose and for the authors to receive better and more qualitative interview answers. If we compare our own definition of SM to the goals of SM mentioned by Teicholz (2001), the definition does not bring up productivity, which is the first goal according to Teicholz (2001). Instead the definition say using a facility's space more efficiently which can be interpreted as the same thing. Then it is more up to the tenant to decide what area usage promotes the highest productivity. The second goal according to Teicholz (2001) is minimizing costs for the facilities. This is not mentioned explicitly in our definition but rather efficient management, which in extension entails monetary savings. In retrospect it may have given a larger effect for our interviewees if we would have mentioned costs savings in the definition as well. As presented by the interviewees, high emphasis lies on saving or earning money within the property industry. Finally the third goal of SM mentioned by Teicholz (2001) was: *"Providing past, current and future information base for strategic and business planning"*. This is argued by the authors to be the same as stated in the definition *"...plan changes in accordance with current and future operations"*.

As can be seen by this comparison the definition does not exactly agree with Teicholz (2001) but they are similar in many ways. This indicates a variance of how SM is used by different stakeholders. The second part of the SM definition is more how it can be done, it was added to give the interviewees a view of how it can be done and give them insight in how we, the authors, thought it was done.

5.2 Views of BIM and its implementation

Implementation of BIM is an issue that has been brought up both in literature and interviews where the views of problems associated with implementation differ. Some of the interviewed professionals look upon BIM implementation as inevitable (Iglo Inc and BIMex), problematic (Solero Ltd), unproblematic (Iglo Inc), very expensive (Cornetto Ltd), not very expensive (Iglo Inc) etc. One of the interviewees even see BIM as unnecessary, this was Solero Ltd. We think this has a lot to do with that people in the industry and professionals working with FM do not understand what BIM really is, that it is more than a virtual model, that it is more than just information on a computer. For example none of the interviewed companies worked with BIM at level 3, see Figure 2, even if they used a variety of digital tools. Gheisari & Irizarry (2016) issued a survey regarding how and if facility managers worked with BIM, showing that only 25% of the companies involved did use BIM. Since it is not used by many it may be harder to gain knowledge of how to use it. Another thing brought up by Magnum Co was the importance of personal connection with customers for the sake of customer satisfaction. Magnum Co means that implementing BIM may result

in less customer satisfaction and their perception of service. This is something that has not been brought up in any of the reviewed literature.

Even if views differ concerning BIM, the interviewees mentioned that they work with some kind of online database for information, technical drawings and contract storage. This can be seen as cloud based computing which is, as mentioned by Harding & McCool, used by many companies working with BIM. This could be an indication that the interviewed companies are moving towards BIM and a more digitized industry. We, the authors of this thesis, who have studied the topic of BIM in more detail, may be a bit biased when it comes to BIM implementation as we are positive to it. It is however interesting that the views differ so much. Even though we think that BIM will be implemented in a larger scale as a part of digitalization of the industry, something BIMex agrees with. There are however obstacles to overcome in order for it to be successful. Here follows issues that have been brought up in literature and interviews, costs of implementation, user friendliness, lack of contractual and legal framework to follow when implementing BIM (Kassem et al., 2014; BIMex,) interoperability of software, change attitudes of those who are against this type of changes. The reviewed papers that brought up operability and user friendliness issues were Kassem, et al., 2014; Shalabi & Turkan, 2017; Ilter & Ergen, 2015; Rui & Raja, 2014. Also BIMex mentioned this as a major issue to be solved in order to attract more adopters. Another issue is lack of contractual and legal framework for the implementation of BIM in general, and for BIM for FM in particular, is another significant challenge (Kassem, et al., 2014).

The authors of this thesis believe, after what have been seen and heard from the interviews, that it is hard to change something that already work. Work in the sense that facility management and property owning companies are making money and are doing well. The question can be raised concerning why would they invest in new IT tools if they earn money as it is? We came across some contradictions in our interviews concerning digital tools, for example when it comes to finding empty spaces and unused spaces in a facility. Some of our interviewees (Cornetto Ltd, Magnum Co, Solero Ltd) found that it is both easier and faster to visit the facility and walk through and do the analyzes in person rather than with the help from digital tools or BIM tools. This raises questions whether their drawings are faulty or that their information systems are. Furthermore Magnum Co, Solero Ltd and Cornetto Ltd are satisfied with the situation as it is today and doubted that any software could perform these types of analyzes. However it is thought by us that information systems connected to a model would be able to perform analyzes like these. Again lack of knowledge of BIM for SM may play a role for attitudes against it.

Something that is brought up in literature and by our interview with BIMex is that software needs to have the possibility to search for space specifics and details about key figures which the space is dimensioned for, e.g. ventilation, heating, cooling, electricity etc. In order to be able to perform prognosis about alternative areas and to create scenarios in distribution of areas and configuration of operation areas, a software support system for SM is needed. This type of support can be achieved with a BIM-software (BIM Alliance, 2014).

The empirical research done for this thesis reflects what Hagan's (2014) statement that BIM for SM lack adopters, he further states that is underdeveloped which might

be the cause of the low level of adoption. Further when asked about the potential of BIM in their work, Magnum Co, Calippo Llc, Cornetto Ltd, imply it would mainly have illustrative marketing value. This can be connected to Gheisari & Irizarry's (2016) study about BIM use for FM where 3D visualization was ranked high, though in this study locating building components and space management were also ranked about equally on the uses of BIM for FM. While BIMex and ConsultEx pointed out all of these uses, these are the BIM and FM consultants respectively which could explain their different point of view. However Iglo Inc wished for technical developments like BIM and said he definitely thought it could bring improvements to facility managers but was unsure in which ways. Iglo Inc's representative was the only one of the property managers who was overall positive to the incorporation of BIM in their work, while the other expressed doubts or questions of the need for it.

5.3 The literature

One issue that was clear early in the literature study was that many of the reviewed authors' works did not differentiate the differences between user and facility managers' point of view of SM. A lot of the studied literature comes from international journals and books written by authors outside of Sweden, which did not give us a view of how the industry BIM in Sweden works with BIM today. Some literature however came from Swedish sources e.g. information concerning CoClass and Swedish standards. Interestingly it is often noted throughout the literature that SM with the aid of BIM can result in financial benefits, however it fails to note how and to what extent. There is a lack of financial data regarding the extent money may be earned or saved. It may then be hard to connect certain savings to SM, other than reduced costs due to less space use. This is something agreed upon by Reed & Halvitigala (2015) who mention this in a paper concerning workplaces: *"The findings also highlight the lack of availability of reliable financial data on costs and benefits of developing more flexible and adaptable buildings"*. Along with cost savings etc. there are always costs of rearranging a workplace or performing SM in a facility. This is something that, like savings, are not really brought up in literature or brought up with lack of reliable data. The same thing goes for drawbacks of certain decisions connected to SM. For example the drawbacks of implementing open plan settings for an office. There are often mentions of the benefits but seldom of the drawbacks of such settings. Drawbacks of open plan settings were discussed in the interview with Cornetto Ltd. The representatives from Cornetto Ltd brought this up because they have seen people quit their job because of changes like this, mostly because of dissatisfaction with the work climate.

5.4 Incentives and practice of Space Management

When reviewing the literature facility costs were stated to be the second highest cost after salaries (Steiner, 2006; Hassanain, 2010; Haynes, 2007). Both Steiner (2006) and Hassanain (2010) claim this, however they continue to highlight the importance of lowering the facility costs, and no comparative figures are given in regards to the ratio of these two costs. Haynes (2007) claims the same thing but rather than targeting the facility costs, it is suggested that the goal of SM is to target the personnel costs. Haynes (2007) means that slightly increased personnel productivity will outweigh significant changes in costs for rented spaces. Although still lacking any comparative numbers between the costs it is hard to determine the reason of differentiating focus

points in the texts. Haynes (2007) priorities are also reflected in Teicholz's (2001) goals of SM where the first goal is pointed out to be foremost to increase the productivity of the staff who occupy the facility, he does however in his second goal bring up reduction of operation and ownership costs. If salary costs are higher than the facility costs, the focus of SM for an organization should arguably be to increase the productivity of the staff and reducing the facility costs are in comparison a futile endeavor. Much like ConsultEx suggested in their interview, where they went as far as suggesting that if a staff members' productivity can be increased it does not matter how much space he/she needs if that is the reason for the increase in productivity. This is most likely the situation in Sweden where personnel costs are considered high. If the situation however would have been reversed and facility costs where the highest cost, it would justify the priority given to facility costs by Steiner (2006) and Hassanain (2010).

It should be noted that this is with monetary gains in mind, if social and environmental sustainability is considered maybe Steiner's and Hassanain's views would still be made priority even in a situation where staff costs are by far the highest. Teicholz's (2001) description of the second goal of SM suggests that in order to justify investments in any FM systems the gains have to be put into figures. This also gives understanding to the focus of reducing facility costs rather than productivity which is harder to prove prior to a new system implementation or other changes. Additionally the cause of higher productivity was stated by ConsultEx to be hard to determine. Hard to determine but still important for the tenants, Calippo Llc mentioned that for some of their spaces, mostly for retail, they apply reacting rents. This means that the tenant pay different rents depending on how well their business is doing. This can be seen as one way of measuring the performance of tenants. The importance in order to improve performance in these cases is according to Calippo Llc to have a great mix of stores, tenants and other spaces that attract people. The fact that higher productivity is hard to determine also reflects well what Iglo Inc mentioned in their interview in regards to when and how the ways of working with property management could develop and show benefits of those developments. It was then discussed that in order for the facility owners to develop in their working methods, e.g. digitalization, the monetary gains need to be shown otherwise development will be limited. This was something that Calippo Llc agreed with.
If reviewing the gains from an owner's perspective it might be difficult to justify Teicholz's (2001) and Heynes' (2009) idea of increasing productivity of the tenants. However like Calippo Llc explained they like to think of them working in a sort of symbiosis with their tenants, and if the tenants do well it is also beneficial for the property owner. This goes hand in hand with what the interviewed property managers all mentioned about their goals of keeping long term tenants. Although it should be noted that this was not considered their main concern in regards to SM but rather to ensure as high utilization as possible of the buildings, to make sure they generate as much income as possible, and second in line with Steiner's (2006) and Hassanain's (2010) views to reduce the costs of the facility and in that way increase the profits.

Throughout the interviews Magnum Co, Solero Ltd, Iglo Inc and Cornetto Ltd all explained their ways of working with SM as having great knowledge of their facilities or visiting the property in order to evaluate any possible changes in its space usage. They also explained that they store their information about the facilities on servers in a "folder structure." Calippo Llc did the same but had developed user friendly

software which the folder structure was accessed via. This also could handle the showing of floorplans. For some properties the tenants spaces where drawn out on these floorplans, this was as close to the theory about SM we got during our empirical work. In contrast the theory suggests that information handling could be improved by accessing it via BIM (Kensek, 2015; Hagan, 2014). Further this facility knowledge the managers from companies Magnum Co, Solero Ltd, Iglo Inc and Cornetto Ltd stated to have was put in question when they explained that they had discovered quite large unutilized spaces within their facilities. Cornetto Ltd mentioned they found a packet of butter in the space which had expired 5 years earlier in a room which was about 40 square meters. If they do not keep track a space as large as 40 square meters, how are they dealing with all the small spaces of a facility? Once spaces are identified BIM could provide visual and technical assistance to the managers determining what to do with the space (Kensek, 2015).

5.5 Space modifications

Facilities can be built in certain ways to make them more efficient and the physical boundaries of the facility limits the ultimate efficiency. Elevators, staircases and external walls for example could be much too expensive to change. Every building regardless of its design does however have an optimal level of maintenance (Teicholz, 2001). This means that maintenance is unavoidable and something that always have to be considered when constructing a building. It is mentioned that: *"Most of maintenance problems are not attributed to construction problems but are due to design defects. If the facility manager's involvement can be brought into design phase, major repairs and alterations in the lifespan of the facility will be reduced"* (Rui & Raja, 2014).

Accessibility of applications, pipes, etc. are easy to hide by smart design, but may be pointed out by a facility manager. If the facility management is involved more in the design phase and gather knowledge about design software they may later be able to change their technical drawings without having to get help from architects or consultants. Because those who are knowledgeable about these pieces of software today are architects and consultants but those who are affected by them are facility managers and tenants. Kassem (2014) argues that there is a lack of established processes for updating BIM models with information and that this results in uncertainty for facility managers. If this changes and property owning companies possess the knowledge it may be more effective, and if facility managers performs the changes themselves there will be less uncertainty. BIMex gave an interesting example of consultants that may be needed for a FM company that use fully implemented BIM systems to change a lamp: *"Who should have the knowledge in changing and updating BIM models? Is both an architect and electrical engineer needed in order to change a lamp, and get the update etc. right?"* This was a view about the future and from his imagination and somewhat of a joke. But this may be where it ends up if the facility management does not gain knowledge about digital tools and how they can use them. This can however be linked to the house consultant that Cornetto Ltd uses for ventilation and electrical works, where all knowledge about their ventilation systems lies outside of their own organization. It should however be considered if this way of arranging responsibility could amount to risks.

However, as shown by interviews digital models and technical drawings are updated by architects or consultants. Teicholz (2001) means that: those who are most capable and knowledgeable in order to efficiently execute the task but also that those that are most impacted by the data in question should have the responsibility of keeping it current, in other words the facility manager.

5.6 The workplace

It is mentioned both in literature (Kassem et al., 2014; Reed & Halvitigala, 2015) and in interviews that the workplace has evolved a lot in recent years and will continue in doing so. Recent changes that occur especially in the office world is open plan settings with unassigned workspaces. Changes often occur because of modern ways of working (Kassem, et al., 2014; Reed & Halvitigala, 2015), new ways of working, and that new tools are implemented (Calippo Llc, Cornetto Ltd) affects the amount and type of spaces needed. Because of these types of changes many tenants have been downsizing their space requirements, it is however important to consider that the physical workplace is a large factor to attract personnel (Steiner, 2006; Cornetto Ltd). According to Cornetto Ltd it is hard to attain the right personnel and competence today, which means that to have an attractive workplace, is of importance. An interesting thing that Cornetto Ltd brought up was that some people do not like to work in open plan layouts because it is described by tenants as stressful, hard to concentrate etc. this may of course be the case, the authors also think that people want to have their own space or more of a comfort zone which assigned workplaces may contribute with. We also think that this is a generational issue that the younger generation will have fewer problems with open plan layouts while older people who experienced having their own offices may have a harder time accepting open plan layouts. According to a presence measurement that Calippo Llc did which showed that the presence at a company's workplaces was only 37%. This means that the workplaces in themselves are not used for most of the day. This results in less people at the office and in turn reason for a company to adopt unassigned workplaces for more efficient space utilization.

It is further discussed with Cornetto Ltd how the workplaces may evolve in the future. Cornetto Ltd means that it will be more common in the future that you work from home or that you start working when you leave your home and log onto skype (or similar), not when you arrive at your desk. These offered workstyles aim at increasing efficiency and attraction of competent and fitting personnel. We, the authors, think that this will be a mean of competition when attaining personnel, the same thing goes for flexible workspaces and an office where you want to be. A place where you hang out more than work, socialize with colleagues etc. We think that this will increase popularity for many companies in the future. It is mentioned by Cornetto Ltd that many software and programming companies work a lot with offices that are not just for working. Offices like these are requested by tenants they have in Gothenburg and Stockholm. Furthermore they mention Google as a great example of this, meaning that Google is a great example of how one can use one's workplace as something more than just to perform the actual work.

5.7 Standards

To this date no national standards related to BIM usage and utilization in Sweden are implemented. However there is a communication standard for facility management issues at use in Sweden today, it is called fastAPI or fi2, (Jönsson & Johansson, 2014). These do not have much to do with BIM on the other hand, but are rather naming and file format standards enabling use by several actors regardless of their system. This is problematic for the future evolvement of the industry according to the BIMex interviewee. However there is a standard related to BIM in Sweden, which is not adopted by the majority. The BIM related standard is, according to what we have seen and read, in the innovation phase, see diffusion of innovation diagram Figure 3. This standard is called CoClass and is, as mentioned earlier, developed to be compatible with BIM software and BIM work methods (Svensk Byggtjänst, 2016) similarly to COBie and Statsbyggs manual for bygningsinformasjonsmodellering (SBM). As benefits of COBie and SBM can be seen in the industry today (Oduyemi, et al., 2017) we believe both that the BIMex representative is right when the interviewee talks about the importance of implementing standards in the industry in Sweden to accelerate the adoption of BIM and digitalization. Which the authors believe may make the industry more efficient and make it possible for the industry to be more sustainable, cooperative, and effective. This is something that needs to be studied further in order to see these benefits for Swedish projects and to confirm the benefits seen in literature from other countries.

The problem that comes with setting a standard is as mentioned by BIMex that the digital world is changing all the time, and it is very important to use some kind of open source standard that can be adapted and used in for example 50 years from now. Note that BIMex will be used as a short for the interviewee from BIMex. Kassem, et al., (2014) mentions the same issue that differing life span of technologies and buildings suggests that there is a requirement for open source standards, which makes it easier to aid and maintain usability of models. In the end it falls on the owner to state what is required for a building in the project brief, if it is a BIM model or something else. When it comes to maintenance and life cycle issues requirements for a BIM model it should be stated in the agreements with a facility management company to make sure that the BIM model is updated and maintained throughout the project life cycle. It is not up to the entrepreneur or the facility management companies to create the BIM model themselves if they do not see it as profitable for their own company.

5.8 Is BIM the answer we need?

When studying literature regarding BIM, its software benefits and capabilities it is convincing that BIM is a great solution in order to make FM and SM more effective. However it has been shown from our study, that the interviewed property owners, and FM companies active in the Gothenburg region does not use these kinds of digital tools in their everyday work. While not using BIM they are managing many facilities and buildings and manage to gain profit. This raises the question whether BIM tools are needed or if they are, as mentioned by Solero Ltd, excessive and unnecessary. Evidently companies see benefits of digital visualization and so forth, but maybe this is all of the digital tools that will be used by facility managers. The indication that BIM will not be implemented in a larger scale in the interviewed

companies is given by Magnum Co, Solero Ltd and Cornetto Ltd, who do not think BIM will improve their way of working substantially. The question remains, is BIM the best solution the make FM and SM more efficient. Maybe more evidence of the benefits are needed for facility managers to implement BIM, even if much benefits can be seen in research today. When the interviewees from property owning or FM companies mention that they have heard about BIM etc. they often view BIM only as a 3D model. Since BIM is more than a 3D model and that people's view of something is hard to change it may be better just to use the word digitalization and scrap the expression BIM. Start talking more about digitalization than BIM. More people may then be more open to develop ways of working. It may also be easier to see and adopt small digital changes that lead towards digitalization than to adopt BIM.

5.9 Summary

Facility managers' space knowledge is believed to be better than it is. Throughout the interviews the facility managers highlight facility knowledge as an important factor in enabling them to do their job. Some do mention that this knowledge is hard to come by and that it would take a new employee quite some time to achieve this level of knowledge. Their supposed extensive facility knowledge is contradicted by examples of unused and even unknown spaces within their facilities. Further the BIM- and FM-consultants confirm this by sharing experiences where facility managers' knowledge is lacking. They gave examples of clients who had poor utilization of their spaces and even unused spaces. Connected to this issue is the poor documentation mentioned by most of the interviewees, here especially older facilities lack documentation, and again everything depends on the facility manager to either know or retrieve the information. One SM related issue noted by some of the interviewees is the vacancy time between tenants. Here one of the facility managers have managed to reduce vacancy times by offering pre-designed spaces with limited tenant modification.

These issues could be handled with the help of BIM, however the facility managers mainly only see the visualization as a benefit. Additionally, there is the cost of implementing BIM and other useful software as well as educating staff to use that software. One interviewee mentions that the monetary gains need to be shown in order to this development to truly gain traction. Additionally all but one of the interviewed facility managers, do not think that BIM would improve their work. This could be due to misconceptions regarding what BIM is, reluctance to change or the fact that implementing BIM is believed to be a very big step.

6 The authors´ word

By doing this thesis we have first of all learnt a lot about SM, FM, and BIM. Throughout the work with this thesis we have practiced our skills in interview situations, planning, being critical to literature and interviewees, and understanding that BIM may not be the answer to every problem in the construction industry. Additionally, we have experienced conservative people in the industry whom our supervisors warned us about, however also the eccentric visionary who only sees possibilities and the contrast is interesting and thought provoking. Furthermore, we have experienced the issue and time consuming process of getting into contact with the right people, receiving answers, and arranging interviews. Also the interview process has been a lecture in itself, open-ended questions sometimes result in a two word answer and sometimes a 20 minute monolog where the two word answer can be as informative as the monolog.

We have learnt that an abductive approach can be somewhat frustrating if new issues and topics appear, after conducting interviews, which we wanted to include in the study. This becomes problematic since the interview questions were already decided upon. The same thing goes for finding topics in our interviews that we wanted to investigate more in literature. The findings of this thesis can lay ground to new research topics. When it comes to concepts used in this thesis we think that we have used the right concepts to study and learn more about. However in the interview process it may have been better not to use the term BIM since many of the interviewees did not really know what BIM was, or they had an own view of what they thought BIM was often just a 3D model. Instead something like, digital tools or digitalization should have been used to achieve a more accurate result in their answers.

The topic of this thesis has been relevant to the master's programme. Both of the authors study, Design and Construction Project Management. It has been relevant in a way that it is applicable to many of the courses taken throughout the master's programme e.g. real estate finance and economics, design management (use of BIM software), managing organizations, knowledge and learning in project organizations. We strongly believe that the topic of this thesis have been highly relevant to our studies. The insight we have gotten in the FM industry may be of use in the future. The interest and knowledge of digitalization, knowledge about how an office works may all be useful for us in the future as professionals.

7 Conclusion

The thesis sought to answer the following:

- Do commercial property owners in Gothenburg manage their spaces efficiently?
- Which information is necessary in order to keep track of all spaces for a facility?
- Can BIM or digitalization make the business of Space Management more efficient?

Below we answer these research questions. A couple of additional, however related, issues regarding Space Management (SM) was identified during the empirical work and will also be dealt with.

The commercial property owners in Gothenburg perform SM mainly by visiting the facility in person while doing analyzes such as what state the facility and its installations are. Through these visits the facility manager gets facility knowledge, insight into the operation at the facility and the space use. The interviewee working as a BIM consultant mentioned that all of these types of analysis can be done digitally with BIM. And that updated information about a facility should help many facility managers in decision-making processes. The information that is necessary in order to perform SM is mostly the facility manager's own knowledge about the facility and its surroundings. Some of the interviewed companies use floor plans and drawings to help analyzing a facility's spaces. The reason all companies do not use floor plans and other drawings are because they are faulty. Faulty drawings often depend on the lack of updating being done. The facility managers also have to gain knowledge about tenants' organization and what the facility will be used for. After gaining knowledge about tenants, another analysis of current performance of installations such as electrics, ventilation is done. This is done in one way or another, in order to determine if they need to be modified something done in general according to all interviewees.

Sometimes visualization tools are used to show potential tenants how an unmodified space may look like after actual modifications in order to attract more interest about the facility. The interviewees see the beneficial use of BIM as visualization purposes of future projects. For a few of them BIM is also used to visualize refurbishments and modifications, mainly done for marketing reasons and to attract more tenants. Cornetto Ltd mentioned that they use digital ventilation systems in facilities where new ventilation is installed. Regarding the interviewed facility managers' attitude towards BIM, this could be due to lack of knowledge of what BIM is and how to work with it more than with just visualization. Additionally, any monetary gains have not been shown to them, which could be the driving force to implement BIM. However it should be noted that a lot of studies show gains of implementing BIM. Another issue related to the somewhat negative view of BIM is the costs implementation may include. It is clear that there are costs related to the implementation of BIM as any new ways of working is. These costs were mentioned by many of the interviewees to be the one of the main reason for not implementing BIM.

7.1 Poor documentation and operability

The interviewees either mentioned or indicated lack of documentation in older facilities. BIM can be used to draw up the facilities and attach relevant information would be a solution, it is hard to say if this is the best solution in the long run. Initially this would be expensive however according to the studies in the literature there is money to be saved in operations. An alternative is drawing up the facility and documenting its content without BIM which would be cheaper. Extensive case studies of the two alternatives would need to be made in order to determine which one is the better option, and even then it would probably depend from organization to organization.

As mentioned by Iglo Inc even if they were to receive a BIM file now their current software would not be compatible and able to handle it, which entails a lot of technical upgrading or change for the organization in question. Further the company BIMex as well as Teicholz (2001) mention that the user friendliness is key, right now these software require too much effort of the user to get a accustomed to. This is further strengthened by Magnum Co, Solero Ltd and Cornetto Ltd, who mention that they have the possibility to use new technical tools such as 3D models, or other types of models, however they choose to work with their simpler 2D technical drawings because it is easier.

7.2 Vacancy time between tenants

Time between tenants is an issue that was brought up in the empirical part of the thesis however in the theory this issue was not encountered. This time spaces generate no income and is a concern related to SM, which could benefit from using BIM through illustrative marketing and easy analysis of the space use modifications could start as soon as the previous tenant is moved out. However Calippo Llc's way of dealing with this issue was to reduce or eliminate tenant modifications by not giving their tenants the possibility to change the space. This of course requires well thought through space design that appeals to many possible users.

7.3 The future of BIM

We believe that BIM can make SM work more efficient because facility managers' space knowledge is believed to be better than it actually is. BIM will make SM more efficient through information handling. BIM and digitalization will further develop and be applied for more reasons than the area of visualization solutions for projects, which is it used for today. SM was firstly performed with pen and paper later with CAD tools and 2D drawings. Today those tools and personal knowledge of the space are the tools applied today. While the development of new digital tools are developed that can perform FM and SM tasks, according to BIMex. The reason why these are not used is an issue that has risen throughout working with this thesis and is believed to be, the lack of shown gains within the industry, adoption issues, and the issues of change. Another reason may be that the property owners are doing well and the need for new ways of working are not necessary for them to make a profit. We do however think that digitization will change the industry, even if it may take a longer time than if a decision regarding BIM implementation would be taken. The question is if such a solid industry with long-term goals and investments are up for making a change as long as they are doing well. A possibility is that digitalization will take further steps within SM when

the tenants or enough facility managers require it. With the generation shift more knowledge regarding these tools will be introduced in the business which might speed up the process.

Cornetto Ltd mentioned that they work with house consultants. This means consultants who are responsible for a certain field for a certain facility, e.g. ventilation. BIMex see a future where in this way of working may be applied in a larger scale. That all FM and SM work can be outsourced via online solutions where the BIM model is made available for the consultant with the solution to a problem. This may mean the organizations like the ones interviewed, in a centralized way will decrease in size and their roles will be very different. Decrease in size regarding personnel, not in terms of number of facilities. This is a future that according to the authors is realistic and that some companies will start working this way more and more. Cornetto Ltd has taken one step, and will probably move more in this direction.

7.4 Further research

Several of the reviewed publications on the topic of BIM and FM, note benefits with BIM in FM (Aziz et al., 2016, Becerik-Gerber et al., 2012, Azhar et al., 2012, Nical & Wodynski, 2016, Kensek, 2015, Turk Z, 2015, Parsanezhad & Dimyadi, 2014, Volk et al., 2013). Becerik-Gerber et al., (2012), Kensek, (2015) and Parsanezhad & Dimyadi's, (2014) work examine particular cases and how certain organizations work with BIM connected to FM. Of the investigated papers only Azhar et al., (2012), Hagan (2014) and Kensek, (2015) note that benefits could be gained from using BIM for SM. However they do not go into great detail regarding how it is or should be done. Further, not many articles specifically dealing only with BIM and SM have been found. This is an area that should be investigated further and case studies within SM and BIM should be studied more.

Several of the reviewed works mention potential monetary profits or savings as a result from efficient SM. There are little to no concrete numbers in the reviewed literature. Even though we realize this is a hard investigation to make, and any numbers will be rough estimations especially when considering work performance, this is still a very interesting area to study further. This paper is limited to commercial properties, a similar study could be done with other types of facilities or from a user perspective. As noted from one of the interviewees if the facility managers do not see great need for BIM, maybe the requirement has to come from the tenants. The users could possibly see other uses for BIM for SM, or other fields. Further research should be done on a larger scale, e.g. on a national level with a much larger interview base to provide a picture of the usage all over Sweden. A quantitative study with a survey covering all major property owners in Sweden, where this thesis can form a base for the questionnaire could be a way of doing that.

Additionally a study covering the effects of the concept of working with "house consultants" should be done to evaluate the possible benefits or downsides. Further how it affects the property owner's organization could be investigated. Right now the investigated organization are all low on the scale of BIM-maturity, a study investigating the next steps to take for the organizations could provide guidelines for them to develop their operations. Connected to this a study more focusing on change management among property owners and facility management companies, especially covering IT-solutions and tools could provide necessary management steps along the way.

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Appendix A

Explanation space management for interviewees
In order to inform interviewees of our view of space management the following definition was made based on the theory presented about space management. This definition will be served to the interviewees before or simultaneously as when the interview occurs.

Space management refers to the management of an organization's physical space inventory and handling of tenants and information about their organization, staffing and physical space requirements. The goal with performing space management is using a facility's space more efficiently, understand space usage, keeping track of the space, occupancy and facility information, identifying utility rates and plan changes in accordance with current and future operations.

There are several ways to perform the practice of space management, the simplest being pen, paper and a floor layout with occupancy information and/or a spreadsheet containing details of occupancy and resource usage of spaces. The more modern way of working with space management is by using space management software to help manage a facility's spaces. Software like these makes the information more available, accessible and allows for space planning. Space management software gives the facility manager additional capabilities to work more efficiently with spaces.

As the interviews were held in Swedish a translation of the definition was made and provided to the interviewees before interviews were conducted.

Space management innebär förvaltning och hantering av fastighetsbestånd och hyresgäster, samt att skaffa ingående kännedom om hyresgästernas organisation/bemanning och fysiska utrymmesbehov. Space management har som målsättning att använda fastigheters ytor mer effektivt, förstå hyresgästernas nyttjande av lokalytor, hålla reda på utrymmes, beläggnings och anläggningsinformation, identifiera nyttjandegrad samt planera förändringar för befintliga och framtida verksamheter.

Det finns flera sätt att uträtta space management, de enklaste med hjälp av penna, papper och en planskiss med beläggningsinformation och/eller ett kalkylark med data angående beläggning och resursåtgång för utrymmen. Modernare arbetssätt nyttjar space management programvaror för att hjälpa förvaltaren med hantering av byggnaden. Sådana programvaror tillgängliggör information lättare och till fler personer som gör det möjligt att planera av ytor. Dessa programvaror ger fastighetsförvaltaren fler möjligheter att arbeta effektivt med en fastighets ytor.

Appendix B

Here follows the interview questionnaire in English and Swedish. The Swedish version is the one used in all interviewees.

Introduction
We are writing a master thesis on the topic of BIM and Facilities Management (FM). Our subject-matter within FM is Space Management (SM). The aim is to investigate and analyze how companies use BIM as a primary tool for performing space management.
With space management we mean: "*management of an organization's physical space inventory and handling of tenants and information about their organization, staffing and physical space requirements. The goal with performing space management is using a facility's space more efficiently, understand space usage, keeping track of the space, occupancy and facility information, identifying utility rates and plan changes in accordance with current and future operations."*
Additionally, we investigate SM from the facility owner's point of view.
When we say BIM we mean "*digital models of a facility, containing information about the building, its contained parts, components, appliances and characteristics as well as their locations and related documentation etc*."

Background of interviewee:
- What Education do you have?
- Have you had any previous positions?
- Current Role in your company?
- What are your Work duties in the current role you have now?

Questions
First we would just want to take note to how you would say that you use BIM, in your company.

Are you working actively with your BIM models?
- Are they updated after changes in a building?
- Do you have any general specifics about the level of detail in your models?

Now we will continue asking about Space Management both how you work with it specifically but also how it is done with BIM.

What is the organization's goal with space management?
- How do you work with space management towards customers/tenants?

How does your company work with space management in order meet those goals?
- What are the technologies and tools being employed?
- How do you use BIM or other Facility Management software?
- How does BIM or FM software give value to the tasks?

How does the process usually look like when determining a facility's spaces and opportunities for tenants?
- What are the technologies and tools being employed?
- Approaches?

- Does the workplace meet the immediate and long-term business strategies, operating procedures and work processes that the tenant has? How is this controlled?

Do you have any personal idea about how facility management and space management in particular could be improved with the help from BIM?

- Does your company have any ideas how to improve the processes?

When using BIM, what does the communication patterns look like for the people who perform SM?

When BIM was implemented did it require be major work-style changes, resulting in a lot of re-training programmes?

- Does it require a lot of training for newly hired staff?

In other words, over the next five or ten years, will the workplace stand the test of time?

- Will you still use BIM?

Swedish questionnaire

This version mirrors the way interviews were arranged.

Introduktion

Vi skriver vårt Examensarbete med inriktning på BIM och fastighetsförvaltning. Vår inriktning inom fastighetsförvaltning är space management. Syftet är att analysera hur företag använder BIM som primärt verktyg för att möjliggöra space management.

När vi skriver space management menar vi: "*förvaltning och hantering av fastighetsbestånd och hyresgäster, samt att skaffa ingående kännedom om hyresgästernas organisation/bemanning och fysiska utrymmesbehov. Space management har som målsättning att använda fastigheters ytor mer effektivt, förstå hyresgästernas nyttjande av lokalytor, hålla reda på utrymmes, beläggnings och anläggningsinformation, identifiera nyttjandegrad samt planera förändringar för befintliga och framtida verksamheter."*

En notering är att vi undersöker space management från fastighetsägarens synpunkt, inte hyresgästens.

Med BIM-modell menar vi: "*en digital modell av byggnaden, innehållande information om byggnaden i sig, dess ingående delar, komponenter, apparater och egenskaper såväl som dess placering och relevant dokumentation etc."*

Intervju objektets bakgrund

- Vad har du för utbildning?
- Vilka tidigare erfarenheter och jobb har du haft?
- Nuvarande roll inom det företag du arbetar?
- Vilka är dina arbetsuppgifter i den roll du har just nu?
- Vad har du för erfarenheter utav att arbeta med BIM? Arbetat med det?

Frågor

Först tänkte vi fråga om space management i stort och vilka nyttor man har av det, men även vilka verktyg som ni använder er utav.

Hur arbetar ni med space management?

- Vad är målen med det? t.ex. Utnyttjandegrad
- För vem gör man det? t.ex. Hyresgästens krav, maximera inkomst.

Hur ser processen ut när ni analyserar en byggnads möjligheter för uthyrning och nyttjande?

- Vilka tillvägagångssätt använder man sig utav?

Vilken information är viktig för att ni ska kunna uträtta arbetet?

- Hur levereras/ hur får ni tag på den information som behövs?
- Hur hanteras den?

Vem utför space management?

- Vem har huvudansvaret?

Hur påverkas kontraktsförhandlingar av space management?

- T.ex enklare att förhandla upp priser, förhandla ner lokalstorlek.

Vilka skulle du säga är det största/viktigaste nyttorna Space management kan tillhandahålla?

- För kunden?
- För ditt företag?
- Långsiktigt ägande gentemot fastighetsutveckling och mer kortsiktigt ägande, olika mål?
- Hur mäter man nyttorna?

Vilka teknologiska verktyg använder ni er utav när ni planerar ytor etc.?

- Hur hanteras dessa programvaror?
- Hur används de, vilken nytta tillför de?

Nu vill vi fortsätta fråga om space management, i relation till-, samt hur det kan utföras tillsammans med, BIM.

Arbetar ni aktivt med era BIM modeller?

- Om och när uppdateras modellerna, vem ansvarar för att hålla den uppdaterad? Finns det några rutiner för dessa grejer?
- Har ni några speciella specifikationer på vilken detaljnivå ni använder för era modeller?
- Vilken nytta utgör BIM och/eller andra fastighetsförvaltnings programvaror för ert arbete?
- Vilken information behöver ni för att kunna arbeta med yt-förvaltning i BIM?
- Hur kan BIM förbättra förvaltningen av ytor?

Hur ser kommunikationsmönster ut för dem som arbetar med SM via BIM?
Hur har processen att implementera BIM gått till?

- Svårigheter, utbildning av personal, ändringar i arbetssätt etc.?

Hur kommer arbetssättet se ut om 5-10 år?

- Är BIM här för att stanna?

Alternativa frågor för dem som inte jobbar med BIM
Hur arbetar ni med byggnadsmodeller och ritningar?

- Om och när uppdateras modeller/ritningar/system?
- Har ni några speciella specifikationer på vilken detaljnivå ni använder för era modeller?
- Tror du BIM skulle kan förbättra förvaltningen av ytor?

Hur skulle processen se ut om arbetssättet skulle förändras tror du?
Finns det svårigheter med att implementera nya arbetssätt och programvaror?

- Svårigheter, utbildning av personal, ändringar i arbetssätt etc.?

Hur kommer arbetssättet se ut om 5-10 år tror du?

Tilläggsfrågor
Om tid finns och möjlighet ges ställs även dessa frågor.
Vad lägger ni mest tid på, till exempel en vanlig arbetsvecka?
Har ni uppmätt nyttor om ni använt space management?
Finns det några etiska dilemman man ställs inför när man utför space management?
Finns det hållbarhetsfrågor som övervägs och spelar roll för val av hyresgäst eller beslutsgrundande för något annat problem?

- Krav på nyttjandegrad på offentliga byggnader i Norge och Danmark, hur ställer ni er till det?

Skillnader mellan BIM och andra metoder. Mer en iakttagelse för oss.

Appendix C

BIMex was the first company that was interviewed. BIMex distinguish themselves as Building Information Modelling (BIM) experts or BIM consultants. They possess great knowledge in the area of BIM and BIM software. The person that were interviewed here, Paul, work as an operations manager. Paul had limited knowledge in the area of Space Management (SM) but great knowledge about BIM, though he did understand the concept of SM and could see the benefits that BIM can give.
Paul has a bachelor's degree in civil engineering along with architecture studies. His first job was at an architecture firm where he worked as a project coordinator for 3 years. He has now been working at BIMex for 2 years. Paul's daily tasks are BIM coordination and supporting architects and designers in the projection phase.

The second interview was conducted with Mark and Phil at Magnum Co. Magnum Co is a growing property owner, who first and foremost owns and manages commercial real estate. In Magnum Co people are working in smaller teams conducted of 3-4 people. These teams have responsibility over a number of facilities, both financial as well as caretaking and customer service responsibility. Mark neither Phil have a specific education in the area of facility management, they have *"worked themselves to success"*.
They were not familiar with the expression SM, though after an explanation they understood the concept. They knew somewhat what BIM was but they mentioned that they did not work with BIM.

The third interview was conducted with Calippo Llc, which is one of the largest commercial property owner in Sweden. We can call the interviewee Carla, she is responsible for one of the two business areas within the company. Her works tasks consist of financial management in the customer side and facility management. Another part of Calippo Llc works with technical management and caretaking.
Carla has an MSc degree in civil engineering with an orientation in construction and real estate & economics. After her studies she worked as a consultant as a representative for tenants in relation to property owner. Then she started working as a facility manager for a real estate company, which later merged with Calippo Llc where she works today.
Carla was familiar with both the term SM as well as BIM. Calippo Llc works with BIM mostly for larger, newly constructed properties while they work with Space Management in all properties.

Interview number four was conducted with Solero Ltd that works a lot with commercial real estate, mostly shopping malls. The interviewee was a man in his 60s, let us call him John. He works as a central manager and has been at Solero Ltd for ten years. John has no education from university or similar but has taken some economical courses. Previous experience in the real estate industry is that he worked as a facility manager for some years before starting at Solero Ltd. John was not familiar with either the term SM or BIM.

The fifth interview was conducted with Ollie from Iglo Inc. Ollie has a *Degree of Master of Science in Business and Economics*. His life in real estate started when he studied at University where he worked part time as a facility manager for a department community house. Iglo Inc owns and manages mostly commercial real

estate. When the interview took place, he worked as a facility manager at Iglo Inc. Ollie was familiar with the term BIM and had heard about SM but not familiar with it in any detail.

Interview number six was done with two people from Cornetto Ltd called Adam and Emma. Cornetto Ltd owns and manages commercial real estate as well as housing facilities. Adam has a bachelor's degree in business development and has been working at Cornetto Ltd since is 12 years. He works with tenant issues such as contract handling and negotiations with tenants. Adam was familiar with BIM but not so much about SM.
Emma has a Msc degree in civil engineering and has been working at Cornetto Ltd for seven years. Previous work experience has been 18 years at two different real estate companies followed by 5 years as a project manager consultant. Emma had good knowledge in both BIM and SM, however mostly about BIM.

The seventh interview was arranged with another employee at Calippo Llc. However this person, called Peter, had another position in the company compared to Carla. Peter was a technical facility manager. He was familiar with BIM but not really with the term SM, he had however heard about SM before.

The eighth interview was conducted with ConsultEx, this company is a Facility Management (FM) consultant. There were four people from this company that was interviewed, they did know what BIM was and they had heard the term SM.