

CHALMERS



BIM implementation and potential benefits for the facility managers

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

MARCUS GÖKSTORP

Department of Civil and Environmental Engineering
Division of Design and construction project management
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012
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ABSTRACT

Building information modelling (BIM) is one of the hotter topics in the construction industry and the ones leading it are the big consultancy companies and the construction contractors. However, the clients, and especially the facility management, are trailing behind. The research has based interviews looked at the facility managers daily tasks and connected this to how BIM can benefit the facility management. Additionally it has looked into different important aspects of the BIM implementation process, in order to find what is needed to realise the potential benefits and discuss how the cases study, Jernhusen, should implement BIM into their organisation. The main potential benefits that a well implemented BIM could lead to are better structured drawings that reflect the actual building and increased efficiency of the communication between Jernhusen and its customers, entrepreneurs, and consultants, through a common BIM model were all the relations are put together. In order to realise the benefits with BIM it is important that the company takes control of the construction process and adjusts it according to the new methods and relations that BIM enables.

Key words: BIM, Facility Management, Implementation, Benefits

BIM implementering och möjliga vinster för fastighetsförvaltarna

Examensarbete inom Design and Construction Project Management

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SAMMANFATTNING

Byggnadsinformationsmodellering (BIM) är ett av de hetare ämnena inom byggindustrin. De som leder utvecklingen framåt är främst de stora konsultbyråerna och byggföretagen. Däremot är fastighetsutvecklare och fastighetsförvaltningen restriktivare vad det gäller BIM. Syftet med rapporten är att visa hur BIM kan underlätta för förvaltningen, samt vad som krävs för att nå dessa förtjänster. Rapporten har framställts genom litteraturstudie och intervjuer främst med förvaltare på Jernhusen. De huvudsakliga vinsterna för förvaltningen med att implementera BIM är bättre strukturerade ritningshantering där modellen hålls uppdaterad mot verkligheten, underlättad kommunikation mellan beställare, byggare, konsult och kund genom en gemensam BIM där samtliga relationshandlingar är i modellen, samt kunna se i modellen vad olika installationer matar. För att förverkliga förtjänsterna med BIM krävs det att Jernhusen tar kontroll över hela projektet från ide till förvaltning och anpassar byggprocessen efter de möjligheter som BIM kan leda till.

Nyckelord: BIM, Fastighetsförvaltning, Implementering, Fördelar

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Preface

This master thesis is interview and literature based, and concerns BIM implementation and potential benefits for the facility management. The research period has been from January to May 2012. It has been carried out at the Division of Construction Management, Chalmers University of Technology, Sweden in collaboration with Jernhusen AB and their business support function Construction & Property Development.

Marcus Gökstorp has been the one carrying out the research and supervision has been given by associate professor Petra Bosch. Extra appreciation goes to Patrik Ahlbin, Michael Dahlgren, Anders Ejdefjord, and Pär Johansson who have been my main contacts at Jernhusen. I would also like to thank all the employees at Jernhusen that took their time for interviews, questions and made me feel welcome, though the research had not been possible without them.

Gothenburg May 2012

Marcus Gökstorp

Notations

Abbreviations

2D – two dimensional (usually width and length)

3D – three dimensional (usually width, length and height)

4D – 3D with an extra dimension (usually time)

AR – Augmented Reality

BIM – Building Information Model / Building Information Modelling

CALS – Computer Aided Acquisition and Logistics Support (Raster image file format)

CAD – Computer Aided Design

DWG – Drawing database (vector) (AutoCAD - Drafix)

HVAC – Heating, Ventilation, and Air-Conditioning

SEK – Swedish Krona (currency)

PDF – Portable Data Format (format used by Adobe Acrobat)

1 Introduction

The construction industry is often being accused as an inefficient and wasteful sector with high production costs, lack of trust, and quality and environmental issues (Granroth, 2011). One of the reasons for this is loss of knowledge in the transfer between the actors. This knowledge loss is an international issue and American research shows that the US industry's failure to adequately transfer information and workflow knowledge costs their sector approximately \$15.8 Billion annually (approximately 100 Billion SEK) (NIBS, 2007). An innovation that has the potential to reduce this waste is Building Information Modelling (BIM) (Granroth, 2011). The abbreviation BIM is ambiguous and could be understood as both a model where the information bound to a building is stored and the processes around the model (NIBS, 2007).

The BIM usage in Sweden is considered to be trailing in comparison with the Nordic neighbours (WSP Group, 2011). But the industry is catching up and especially the architects and other consultants are becoming more familiar with working with BIM (Hallberg and Wessman, 2010). The client companies are still trailing behind considerably in their BIM process, especially when it comes to knowledge about BIM and its potential benefits (Larsson and Nae, 2011). This is reflected in that most clients do not put demands on BIM usage to the other actors. For BIM development this is alarming, because the client sector is given the biggest reliance to push the BIM usage forward, though they have the power to force it upon the other actors as well as they are considered to become the biggest beneficiary of BIM (Linderoth, 2010).

One area that should be interesting for the client is what facility management can get out of BIM and what is needed in order to realise these possible benefits. Today facility management often spends an unnecessary amount of time looking for information in order to fix a problem. This information could be hard to get, hard to use or is not corresponding to the real life situation. In the worst case this means that the facility manager needs to order an investigation to gather the information that has been lost, which leads to extra costs and an unsatisfied customers due to that the problems takes unnecessary long time to sort out.

1.1 Purpose and aim

The purpose is to present how BIM can benefit facility managers and what is needed to reach these benefits.

The aim is to, by summarising theory and present results gathered from interviews and active observation, present aspects needed to successfully implement BIM in a facility management organisation, with the benefits found during the research.

1.1.1 Research questions

The research is structured in order to answer the following questions:

- What are the potential benefits of BIM for facility managers?
- What is needed in order to realise these benefits?
- What aspects are important for implementation of BIM in a facility management organisation?

1.2 Disposition

The report takes its departure by presenting different interpretations of the BIM abbreviation and gives a brief history of BIM in the construction industry. After that it presents the main benefits for projects and facility management with BIM before it moves on to general change theory, with focus on the strategic and organisational aspects that are important during implementation of BIM. Finally the theory section presents some of the change managerial aspects that are highlighted during the implementation process of BIM, here a special focus is placed on the changes in structures and methods that BIM projects will lead to, the specific demands put on managers who want to implement BIM, and current hindrances of BIM implementation today. The aim with these parts is to give a broad basis of aspects needed to keep track of in order to set a basis for BIM implementation. The theory chapter is followed by a method chapter describing how the research has been performed.

A description of the case is then presented where the structure of the company as well as their setting for BIM implementation is presented. Here the organisational structure, other systems used by the company and the setting for BIM implementation are presented. The result chapter is divided into three sections; Information required by the facility management, Non-BIM aspects highlighted by the facility management, and plans regarding the case company's implementation. Due to the fact that the company had limited implementation progress and experience of BIM, there were there limited possibilities to have discussions regarding the implementation theory reflected at the company's BIM progress. The result chapter is followed by the analysis and discussion chapter; here key findings and theory are connected in order to look at how well the implementation theory can be applied at the case. Potential benefits with BIM and a presentation of the aspects needed to be dealt with in order to reach the benefits are also discussed. Finally the report is summarized with a conclusion section where the three research questions are answered.

2 Theory

Because BIM means different things depending on whom and what role the person presenting BIM has, it is important to define; what BIM means. For the implementation it is also important to define the organisational and strategic views that are to be used, and which key characteristics BIM implementation demands. This chapter presents some of the findings found in the literature; the first subchapter introduces BIM and introduces different interpretations of the BIM abbreviation. The second subchapter presents potential benefits with BIM. Section 2.3 is about theory on change and innovation management, and section 2.4 looks at the specifics of BIM implementation.

2.1 BIM introduction

Object oriented CAD has been at the market since Graphisoft released its ArchiCAD in the mid 80's (Sodéus, 2009), however the market and technology has not been ready, and it took more than fifteen years before frequent reports of beneficial BIM implementation appeared (Linderoth, 2010). Now that the industry is starting to catch up with the technology is it mainly the consultants that are the ones with most experience (Hallberg and Wessman, 2010). The client however, is still considerably far behind especially when it comes to knowledge about BIM and its potential benefits for them (Larsson and Nae, 2011).

When you talk to a professional within the construction industry about BIM they often have an idea of what it means, but to get a consistent definition of the abbreviation is actually difficult even from those who have been working with it for a longer period of time (Jongeling, 2008 in Sodéus, 2009), and some that are experts in the area, deliberately keep away from the definitions. One reason for the ambiguity regarding BIM is because people translate the abbreviation differently, and people have different uses and responsibilities during BIM work and adapt the meaning of BIM according to these.

2.1.1 Definition and ambiguity of BIM

BIM could be read as Building Information Model or Building Information Modelling (Granroth, 2011). This might seem like a trivial difference, but it is a major obstacle when it comes to finding a common definition. This issue could be seen in American national institute of building sciences' definition of BIM:

“A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward. ... A basic premise of BIM is collaboration by different stakeholders at different phases of the lifecycle of a facility to insert, extract, update, or modify information in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability.”
NIBS (2007)

In this definition it appears like the second BIM is about the process of creating a model, also know as building information modelling, whilst the three other seems to refer to BIM as the model.

2.1.2 The Meaning of BIM

What is needed in order to be BIM seems heavily individual were a common interpretation of BIM is missing. However the U.S. national institution of building science (NIBS, 2007) has divided the BIM scope into three commonly used categorizations; BIM as a product, BIM as a process, and BIM as a facility life cycle management tool.

- BIM as a product – Building Information Model.
- BIM as a collaborative process – Building Information Modelling.
- BIM as a facility lifecycle management tool – Building Information Modelling.

2.1.2.1 BIM as a product

BIM as a product refers to the actual model as an intelligent digital representation of data about a facility (NIBS, 2007). In order to qualify as intelligent is not just a 3D representation based on objects enough. It also has to include some information or properties beyond the graphical presentation (CRC construction innovation, 2009), and it is primarily this information in BIM that leads to the biggest benefits for the industry (Granroth, 2011). The view of BIM as a product is sometimes called the underdeveloped view of BIM due to that it just considers the model (WSP group, 2011).

2.1.2.2 BIM as a process

The view of BIM as a process considers the process of developing a BIM model (the BIM product) and using it in order to reach project efficiency (WSP group, 2011). At this level of BIM also the social aspects such as; synchronous collaboration, coordinated work practices, and institutional and cultural framework are being dealt with. Most companies that today state that they are working with BIM are looking at this level of BIM and focus on finding processes that enable them to deliver good and profitable projects. The key point from this view is that BIM is a marriage between technology and a set of work processes.

2.1.2.3 BIM as a facility lifecycle management tool

The last and most demanding of these views is BIM as a facility lifecycle management tool. This view sees BIM as management tool, by focusing on a sustainable, verifiable, and repeatable information based environment in order to guarantee well-understood information exchanges, workflows, and procedures, throughout the building lifecycle (NIBS, 2007). Due to this long term perspective is this view extra interesting for client organisations.

2.1.2.4 Interpretation in the report

In this report BIM is mainly seen as a facility lifecycle management tool. However, it is important to recognize that the BIM model and BIM process are steps needed in order to be able to use BIM as a facility lifecycle management tool. This view then means that implementation of BIM should be considered as an innovation where organisational and strategic choices need to be aligned with change decisions (see 2.3 and 2.4). Facilities management implies those who from the client company have the managerial responsibility to make sure that the customers' operations can run smoothly (see 4.2 for a detailed description of each sector).

2.2 Potential Benefits with BIM

The most commonly used and mentioned benefit with BIM is probably the ability to identify clashes during the design phase (clash detection), instead of facing the problems of them at site, which actually is a result from 3D modelling (CRC construction innovation, 2009). However, BIM has more potential benefits than clash detection and the source of these are often the information bounded to the model. At Ch. 2.2.1 will the benefits for the facility management that are found in the literature be presented, while Ch. 2.2.2 presents some of the important benefits that a client organisation also could try to reach according to the literature.

2.2.1 The Benefits for the facility management

The main enabler for most benefits with BIM presented in the theory is the more efficient access, reuse and transfer of information that BIM should enable (Granroth, 2011, & Klein et al., 2012). Following is a list of the most mentioned benefits that the facility managers should be able to realise: (Gustafsson and Mårtensson, 2010, Granroth, 2011, & Klein et al., 2012)

- Better information and guidance for renting and tenant adoption.
- Easier to find building components, which eases the operation and maintenance of the building, through more structured storage of useful documents.
- Lowered operation costs through the ability to monitor and control the energy consumption and HVAC systems.
- Earlier involvement through better understanding and support of planning and pre-study phase. It also gives a better understanding for the effect of changes.

2.2.2 The overall benefits for the company

There are several other benefits with BIM, for a client company that do not directly affect the facility management, but in the choice of BIM usage, need to be taken into consideration. The following is a summary of theoretical benefits found in literature: (CRC construction industry, 2009, Gilligan and Kunz, 2007, Granroth, 2011, Gustafsson and Mårtensson, 2010, Johnson and Laepple, 2003, Kaner et al., 2008, Khanzode et al., 2008, Shen et al., 2012, & WSP group, 2011)

- Better decision basis with more trustworthy calculations and a better understanding between designers and end-users.
- Enable coordination, collaboration and clash detection, between the actors of the design and construction process, through a tighter communication due to a shared model. This enables reduction of the mistakes and increase quality in the design. It also reduces collisions and changes during the construction phase.
- Possibility to get a fast track project delivery, with reduction of duplicated work during design and increased value from the consultants, due to reduction of faults and shorter lead-times.
- Enable easier and earlier simulations and analyses during the design phase, for e.g. energy calculations and life cycle cost calculations etc.
- Ease the simulations during the construction, which enable better construction planning and cash-flow analysis.
- Better documentation in the transaction phase, which simplifies the hand over inspection and reduce the risk for the buyer. The documentation also allows quicker, more efficient, and cleaner demolition.
- Higher project engagement, with more engaged staff and higher engagement from stakeholders that normally not are engaged.

Even though these not directly show up as benefits for the facilities management, will they enable projects with higher quality (Granroth, 2011), that should end up as a benefit for the facility management.

2.3 Management of innovation and change

When faced with the option of implementing a new product, process or service there are several organisational as well as strategic options that need to be aligned. It is these organisational and strategic choices that shape the setting for the implementation. In order to design the implementation of a change into an innovation rather than a mistake the alignment of organisational, strategic, and managerial decisions are the key for a success.

2.3.1 Organisational view

One traditional way to look at change is by Taylor's change initiative, which was built on that change is accomplished through rational plans (Clegg et al., 2009). The view presents innovation as a linear process and can be found in firms that adopt new forms of the so-called 'best practice' (Newell et al., 2009). The plans are developed, implemented and monitored by management (Clegg et al. 2009). And that change programs are put in place to minimize future change. This view considers change as an undesirable interruption of the natural stage of organisation, which according to Taylor should be equilibrium.

Critics to this view argue that the linear model is little more than a feature of retrospective and rationalized descriptions of innovation processes by those involved (Newell et al., 2009).

One of the challenging views is that of processual change which put a strong emphasis on processes and temporality (Clegg et al., 2009). The processual view sees change as a multilinear and multivariable process, where many changes occur simultaneous as the effect of many different variables.

This view was used by Pascale to form his *Innovation and change at the edge of chaos*, which introduce four principles that can frame the innovation process: (Clegg et al., 2009)

Equilibrium equals death – As long as organisations move they retain their balance but as soon as they cease to move, they lose that balance and being unbalanced in the fast-moving corporate world is a recipe for failure.

Self-organisation is important – Management should give up fantasies of control, because instead of acting according to a purposely designed plan, people interact spontaneously and form patterns of collaboration.

Complex tasks need more complex problem-solving processes – All mistakes on the way can be represented retrospectively as learning that in the end will be rewarded in the final successful innovative outcome. This present the idea that failures and mistakes can help the innovators to gain experience that later will be relabelled as wisdom.

Complex organisations can only be disturbed, not directed – In innovation processes, calculations about invested resources and predicted outcome are meaningless because what innovation will produce may simply not be calculated. This is especially true for ground-breaking products or processes where the actual impact is hard to understand (e.g. Post-it notes). Thus, all that can be done is to make sure that the system does not get to close to equilibrium, by experiencing new ideas as opportunities not threats.

2.3.2 Strategic decisions

There are several fundamental choices that need to be addressed when setting the strategy for change (Johnson et al. 2011). The direction chosen in these choices is what will decide how a change will be used in the company, and the final benefits that will be realised through the implementation. Two of these choices are of interest whilst implementing BIM. These are if it should be dealt with as a technological or business model based innovation, and if the company should lead or follow in the development.

One way to reach successful implementation is to rely less on science and technology, but instead involve reorganisation into new combinations of all the elements of a business (Johnson et al., 2011). Here innovators are creating whole new business models by bringing customers, producers and suppliers together in new ways. A business model describes how an organisation manages incomes and costs through the structural arrangement of its activities. How BIM should reflect to this is dependent on which interpretation you use, but WSP group's (2011) 10 Truths about BIM sees this, as "BIM is the marriage of a technology and a set of work processes".

Faced with the option to lead or follow, Johnson et al. (2011) presented five robust advantages that come with being the first-mover, three of these could be realised with being the first-mover of BIM implementation.

Experience curve benefits – The first-mover will be able to get greater expertise than late entrants, who still are relatively unfamiliar with the new product, process or service.

Pre-emption of scarce resources – There is an opportunity for first-movers to get easily access to skilled labour or other scarce resources.

Reputation – By being the first the company might get a reputation of being on the frontline, this is valuable when consumers have limited trust in new companies once a dominant has been established in the market.

But there are examples in history that show that the first-mover advantages are not necessarily overwhelming. Late movers have two principal advantages: (Johnson et al., 2011)

Free-riding – Late movers can imitate technological and other innovation at less expense than originally incurred by pioneers. Research suggests that the cost of imitation is only 65% of the cost of innovation.

Learning – Late movers can observe what worked well and what did not work well for innovators. They may not make so many mistakes and be able to get it right the first time.

2.3.3 Change management

A big portion of the change initiatives fails, even though the organisational and strategic decisions are refined and smart enough to become a success (Clegg et al., 2009). One reason for this could be that the actual implementation was not understood and executed sufficiently, but there are several other aspects, internal and external to the organisation, that can hinder the change implementation. These aspects could be interdependencies of economic, political, social and cultural factors. The management of change are context dependent. Crawford and Nahmias (2010) say that the level of change managerial skills needed for a successful change management depends on the level of supportive culture and leadership, and the degree of behavioural change required. Following is two areas that a manager of change needs to take in consideration.

2.3.3.1 The role of resistance

In the construction industry resistance is often seen as a negative individual attribute. This view is being challenged due to two reasons. The first reason is that the users of the resistance term are often the change agents that try to implement or diffuse a technology. These change agents use the resistance concept in a biased way and often attributes all problems to resistance during the implementation. The second reason is that any response from adopters, “from a smirk or glassy look of inattention to insubordination and sabotage”, can be labelled as resistance. (Hartmann and Fischer, 2009)

Hartmann and Fischer (2009) have a positive view of resistance, and claim that resistance is necessary for individuals to understand, engage with, and use new technologies. Therefore resistance should not be treated as a reaction to change that involves mistrust, but as a rejection of parts of the change based on careful and thoughtful investigations on the aspects of change. In this view resistance can be

considered as a gateway to critical engagement that leads to persuasion of parts of the change and rejection of others (see fig. 2.1).

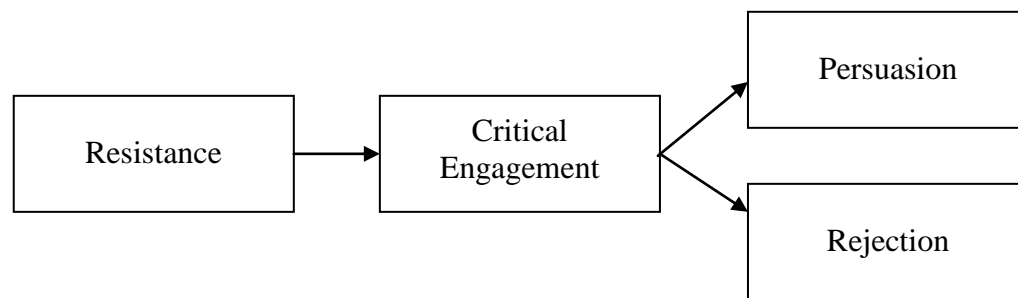


Figure 2.1 Shows how resistance leads to persuasion or rejection of ideas. (Hartmann and Fischer, 2009)

Thus, can resistance be seen as a response that preferably is fostered in order to; increase process awareness, serve as an early warning system about issues and expectations, help to evaluate new processes around a technology, and trigger important and on-going reinvention processes to improve the technology and its related processes during use. (Hartmann and Fischer, 2009)

2.3.3.2 Management fashion

One of the issues of managing innovation is that it is first at the end of the innovation journey that it is possible to evaluate if the new idea led to an innovation, or if it was a mistake. This issue makes it possible for so called management fashions to appear. (Clegg et al., 2009)

Fashions are set by gurus and adopted quickly by consultants and media. These fashions promises simple solutions to complex problems, and often consist of nicely packaged collective beliefs sold through symbolic labels. The power of these fashions comes from symbolic power and seductive rhetoric instead of their actual message.

Fashions create considerable pressure on organisations, because organisations that do not adapt to the latest trends are considered to be inert, reactive, and past-oriented. So one extra aspect that innovation management must consider is to distinguish fashion from true innovation.

2.4 BIM Implementation

BIM is one of those innovations within the construction industry that is given the biggest trust in order to sort the problems that the industry is faced with (Granroth, 2011). But in order to not perceive BIM as a fashion several contextual issues needed to be dealt with. Adoption according to these contextual issues will lead to changes in the organisational level, with new methods and organisational structures, as well as at a business level, to deal with hindrances such as contractual issues (Gu & London, 2010), collaboration issues and the fragmented relay race that construction projects is today (Granroth, 2011).

2.4.1 Changes in methods and structures due to BIM

The BIM model is a tool that allows information about a building to be collected and organised (Granroth, 2011). But to get the maximal value from this tool, and others related to it, there is a need to adapt and change the building process (Arayici et al., 2011, Froese, 2010, & Gu and London, 2010).

2.4.1.1 Changes in methods and workflow

One of the biggest benefits with BIM is that the involved parties become more integrated, allowing coordination and clash detection between consultants (CRC Construction Innovation, 2009), as well as better understanding between designers and end-user (Shen et al., 2012). But the industry has traditionally worked in the form of a relay race, where each actor does its parts and then hands it over to the next in line (Granroth, 2011).

In order to realise the benefits with BIM, the workflow needs to be adjusted into an interactive one where the workflow encourages the actors to collaborate and communicate between disciplines (Gu and London, 2010). In order to get communication and collaboration throughout the project is standard processes and agreed protocols necessary.

2.4.1.2 Training of staff and assignment of responsibilities

A successful BIM process sets new demands on the skills of involved parties (Froese, 2010). Training of these skills should be conducted in order to guarantee that the assignment of responsibilities can be done, so the one with the responsibility knows how to handle the processes around it.

The creation of a BIM model demands more effort in the beginning of the design phase than a traditional CAD drawing (Granroth, 2011). The BIM process is not only about designing and assembly of the shapes of construction parts, as in traditional CAD, but also about assigning information such as colour, weight, cost, manufacturer and heat conduction properties etc. of these (WSP Group, 2011). This extra information sets demands on the process to decide the level of detail included in the models, in order to balance the trade-off between the level of detail and the uses it can provide (Khazode and Fischer, 2008).

2.4.2 Management of BIM implementation

With the several issues and implementation aspects that BIM implementation leads to, it is not strange that several research studies have been done with case studies regarding BIM implementation by the different actors of the construction industry.

2.4.2.1 Effects on the project life cycle

The BIM adaptation leads to changes regarding four interrelated key domains: (Gu and London, 2010)

Defining scope, purposes, roles, relations, and project phases – early decisions are required to enable a supportive business and cultural environment for a streamlined data flow and management.

Developing work process road maps – to guide seamless integration there is a need set guidelines, definitions and descriptions of the work tasks.

Identify technical requirements – identification of knowledge of BIM applications and their capabilities is important. An important aspect is to keep track of the level of interoperability between software in order to get multidisciplinary model sharing.

Customisation of the framework and evaluating skills, knowledge, and capabilities – evaluation and improvement of current skills, knowledge, and capabilities within the organisation is required in order to be equipped for BIM adoption.

2.4.2.2 Managing BIM – Guides on how to implement

There are several case studies on BIM implementation and most of them presents a couple of advices on how to manage the implementation and change process connected to BIM. Following is a selection of some of the advice given from the case studies:

- Get high level management support (Hagan et al., 2009), and make sure that strategic decisions are formulated in order to facilitate the prioritizing process (Jung and Joo, 2011).
- It is important to collectively decide the level of detail, because there is a clear trade-off between the level of detail (costs) and the use it can provide, (Khanzode et al., 2008).
- Maintain a balance between technology, business and social aspects of business transformation (Hagan et al. 2009).
- Engage people in adaptation and ensure that their skills and understanding increase (Arayici et al., 2011).
- Increase acceptance by clarifying the concept regarding responsibilities and discipline-specific models (Moun et al., 2009).
- A possible solution in order to get a tighter collaboration and increased process efficiency is to use a “big room” method, were the consults sits in the same room during the design phase (Khanzode et al., 2008).

2.4.2.3 As-Built models

Even though the model, developed during the design phase, fulfils all the demands that are needed to reach the benefits, there are often changes being made during the construction phase. These changes result in that the model is not corresponding to the final construction. Another phase of the building lifecycle, when the model might deviate from reality, is during minor refurbishment were the changes risks to not end up in the model. In order for facility management to get maximal value from the model they have to develop processes to update the model constantly so that it is as-built throughout the building’s lifecycle. (Gu and London, 2010)

2.4.3 Hinders of BIM implementation

Although the BIM process enables several benefits, for all actors as well as at all phases of construction, there are several issues that need to be addressed or fixed in order to gain a smooth implementation, so that these benefits can be realised. Some of these are quite simple to remove were as others could be considered impossible to even mitigate. Some of the issues can be grouped into the following four categories: (Arayici et al., 2005)

- Legal issues.
- Cultural issues.
- Technological issues.
- Fragmented nature.

These categories do not contain all issues, but they contain several of those who have a major impact on the BIM implementation, following is a brief description of some issues that an organisation needs to address in their effort of BIM implementation.

2.4.3.1 Legal issues

The BIM model is the result of a collaborative process and several actors have been involved in the making of the model, issues has risen when it comes to ownership of the model and especially bound to who is responsible if something in the model is incorrect (Sabo and Zahn, 2008).

The question of who owns the model is an argument between the consults and the client. The consult might want to own the rights to the model in order to protect the information about special solutions as well as be able to reproduce similar solutions to other projects. The client consider ownership of the model important in order to use it as a tool for facility management, be able to reuse parts of the model with another consult, and be able to include it in the handover if the building changes owner.

The responsibility issues is due to that several actors are able to adjust the model and that means revealing unfinished work, this gives uncertainties from the actors regarding the accuracy of the BIM model (WSP Group, 2011 & Gu and London, 2010). This uncertainty can be revealed in that some BIM projects uses BIM in the design phase but before handing over to the constructor, they transform the 3D drawing to 2D (Gu and London, 2010).

2.4.3.2 Cultural issues

The construction industry is known for their conflicts regarding change and mistakes, which often go all the way to court (WSP Group, 2011). This fosters a culture that is heavily influenced by traditions where people like to do things the way they have worked before. This can be seen in that the business often tries to re-implement their traditional manual process with IT support (Arayici et al., 2005), instead of looking at how IT systems can improve their processes.

“Businesses need to identify the practices that belong to the old system and accept that they are not God-given eternal truths, but stem from a certain technological base – one that is evaporating.” (WSP Group, 2011).

2.4.3.3 Technological issues

The most discussed issue when it comes to the technological aspect is the interoperability between the different programs. Another concern were technological issues have risen is regarding security (Gu and London, 2010). The interoperability issue is about that different software manufactures uses their own standards, which are not compatible with each other, this inhibit the actors to use one single program for all their projects. The interoperability issue and lack of standard also hinder efficient use of third party programs, these programs often have trouble in extracting data automatically from the model, thus demanding more manual work and increasing the risk for mistakes.

The security aspect concerns break-in and copyright breaches, and the risk for malicious software reaching the server. The worst case scenario with malicious software would be that the entire model gets erased or that someone goes in and changes parameters in the model so that the drawings handed to the contractor results in a wrongfully constructed building.

2.4.3.4 Fragmented nature

The designers, developers, contractors and construction managers all tend to focus on their area and protect their interests in the building process, giving a fragmented industry (Johnson and Laepple, 2003). Another issue is that the industry consists of many small companies which have trouble to afford the high initial investment needed for training and software purchase that are required to offer BIM services (Kaner et al., 2008).

3 Method

The research could be separated into two categories, literature and interview based research. The literature is mainly from; the two databases Science Direct and Emerald with combination of search words like: BIM, Implementation, Benefits, Facility management, etc., as well as from supervisor recommendation and by following the reference list of read articles.

For the interview a qualitative methodology has been used to gather the information needed to answer the three research questions:

- What are the potential benefits of BIM for facility management?
- What is needed in order to realise these benefits?
- What kinds of aspects are important to implement BIM in a facility management organisation?

The research has mainly been performed at Jernhusen's office in Gothenburg through semi-structured interviews, but as the research was performed onsite some input from active observation were also collected (Bryman, 2009, & Hartmann et al., 2009).

3.1.1 Semi structured interviews and active observation research

In total 22 semi-structured interviews might held, involving a total of 23 employees and three consultants with BIM experiences, between 21st of February and 28th of March. The length of the interviews varied from 20 minutes to 110 minutes, with an average length of about 50 minutes.

In Malmö a group interview was held, the interviewees were a project manager, a technical facility manager, and an economical facility manager. In and around Stockholm thirteen interviews were performed during six days, the interviewees were both technical and economical managers as well as some support functions and external consultants. In Gothenburg eight interviews were held, spread on a wider timespan due to the location of the research. The interviewees in Gothenburg were the head of facility management in region south of business area stations, three technical managers at business area depots, two technical facility managers at business area station, one economical facility manager from stations, and one project manager with history from the facility management and the company from 1979, when it still was a part of SJ (Swedish railway company). All interviewees have been chosen in collaboration with Patrik Ahlbin and Pär Johansson, the two supervisors from Jernhusen. The selection has been done with regard of the interviewees' responsibilities and/or previous experiences.

Due to the low general knowledge of BIM among the interviewees, the information given to them prior to the interviews was very brief, in order to not contaminate the answers. The reason why information was not given out prior to the interviews was a problem described by Larsson and Nae (2011), were the potential use of BIM was reflected to the information they sent out to their interviewees. The lack of knowledge also meant that the goal of the interviews was to find out how the interviewees work, which information they use, and then discuss what information they felt was important. From the answers during the interviews it has been analysed how Jernhusen could benefit from BIM and what is needed to reach the benefits. An example of how an interview question is: What information do you have access to, in

order to make your work as efficient as possible? The goal with that question was to see what kind of information the interviewee had in order to perform its task as efficient as possible and then follow up questions were made regarding the answers, for the standard interview template see attachment 1 (In Swedish).

The reason for semi-structured interviews was to gain the benefits and possibilities of an unstructured method. One benefit is that semi structured interviews keep a certain amount of structure that is needed in order to compare the results and at the same time allows the interviewee to elaborate the areas it feels are more important. (Bryman, 2009)

The research was also performed through active observation at the company's offices for a period of three months. The active observations have enabled a learning of the organisational language and embracement of the information that otherwise is taken for granted in the organisations and thus risk to be missed in a purely interview based study. (Bryman, 2009)

During the literature review limited amount of literature was found on the development process that was aimed towards client companies with facilities management. Most BIM literature today regards the BIM process from project initiation until delivery and thus missing the view of what the facilities managers' needs and requires.

3.1.2 Data analysis

Each interview was taped and complemented with key notes. The recorded interviews and key notes have then been processed in three steps, firstly the results from each interview were compiled into one interview specific document. After that the information was coded and sorted under documents such as; work description, benefits wanted, key aspects, etc. from these documents has then the most relevant information for the research questions been compiled into the result section.

3.1.3 Limitations and decisions made

During the project some limits unfortunately have been necessary to draw. The first and biggest limitation is to concentrate the project to Jernhusen and their three big city offices. The focus on Jernhusen was because it was a wish from their side that the project concerned a wide spread in the company, and the reason why the project focused on the big regions was mainly logistic were it was possible to stay a longer period of time in Gothenburg and Stockholm. One office that would have been extra beneficial to travel to would be the Sundsvall office were expertise about how the company has developed its CAD demands at and the way the railway drawings and models are controlled.

Another aspect that might increased the value of the report might have been if interviewed facility managers were spread to other companies that have gotten further in their BIM approach. The main benefits with this would have been to look at their lessons learned and what they recommend to an organisation that wishes to implement BIM. The reason why this was not done was to be able to get as good spread as possible within the company, so that result can be seen as a representation of the overall opinion of Jernhusen's facility management.

When the project started the aim was to include an economical approach to see the monetary value of BIM. This has unfortunately been left out because of that Jernhusen has not come far enough in there BIM implementation to calculate the biggest costs (tools, education and support) and that figures found around potential savings and incomes were to divergent to give a trustworthy monetary evaluation.

Even though the research was performed with consideration to the fact that the interviewees and the case company had limited BIM knowledge, the lack of knowledge affected the results, especially how they were collected. The balance between how much to tell and not is quite tricky and more value or different results might have been reached if the subjects had experience of working with BIM. An area that was affected by this lack of knowledge was that there was limited possibility to discuss with the interviewees, regarding what is needed in order to realise the potential benefits found.

4 Case Company

Jernhusen is a governmentally owned real estate company that develops, manages and owns property such as stations, maintenance depots, goods and intermodal terminals along the Swedish railway. During the last years the company has grown significantly and now employs around 240 persons. Due to the fast growth they reorganised to today's structure during the end of 2011. The information in this chapter, if other reference is not mentioned, is based on the interviews as well as the company presentation given by the supervisors from the company.

4.1 Organisation

Their new structure consists of the CEO, the five support functions: Communication, Economy, Strategic Development, Human Resources, and Construction & Property Development, and the four business areas: Stations, Depots, Cargo Terminals, and City Projects (see fig. 4.1).

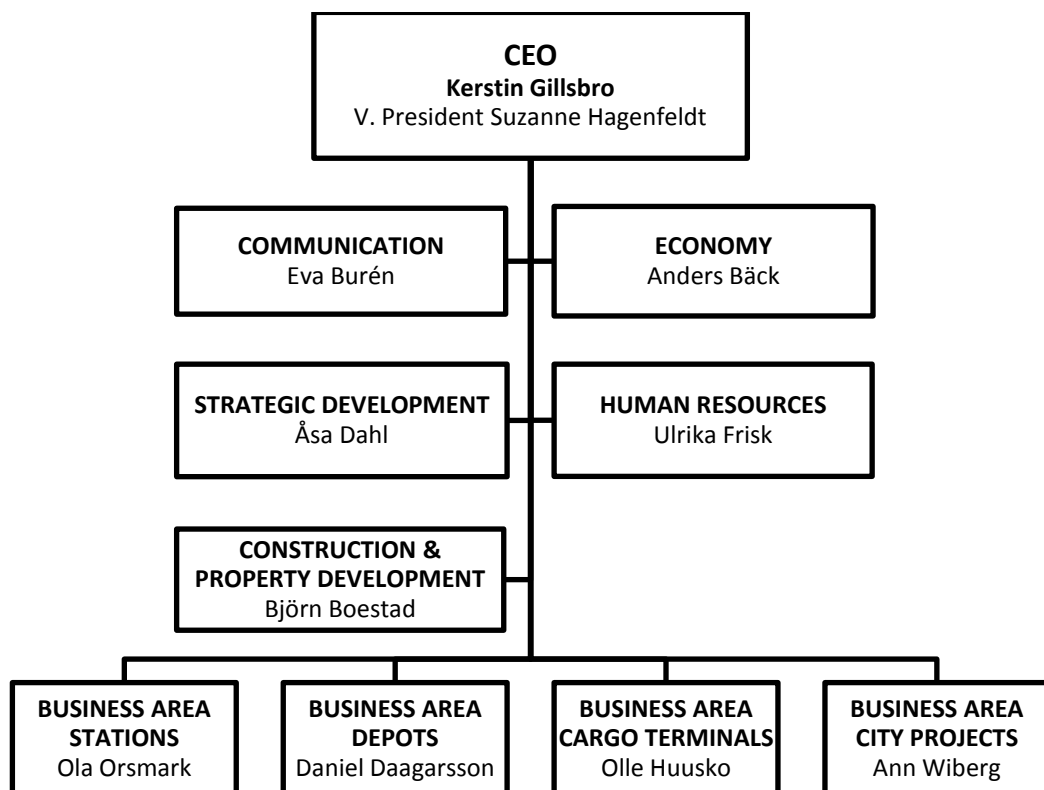


Figure 4.1 Organisation structure of Jernhusen

The business areas could be separated into two categories, in which the three business areas Stations, Depots and Cargo Terminals focus on developing and owning property for a long period of time. The other category consists of City Projects, and their aim is to develop property with the target to sell it within the coming years, one significant difference between city projects and the others are that they do not have facility management on their own, but instead borrow the service from business area stations. These two categories will lead to a different focus when it comes to the value of BIM-models in the facility management, where the first category focuses on how the model should be applied to ease their facility management. Whilst, the other will

focus on what a potential buyer might be interested and pay extra for when it is time to sell it.

This thesis is considering the benefits of using BIM as a life cycle facility management tool and thus considering the benefits of BIM implementation on the facility management with a longer time perspective. Out of the three business areas focusing on long-term owning are Stations and Depots the biggest with around 75 respectively 70 employees and a turnover of 623 MSEK and 372 MSEK, while Goods Terminals has around 15 employees and a turnover of 33 MSEK.

4.1.1.1 Business area Stations

The Business Area Station's task is to create station areas that assist in increasing the commute by taking full responsibility while offering good business for Jernhusen. They are divided into five regions where three of them are the big city regions and the rest of Sweden are split into north and south, the boundary between north and south is by a line from Sodertalje to Karlstad where Region north are responsible for those on the line and to the north. Those that deal with facility management are found at the five regions.

4.1.1.2 Business area Depots

The responsibility of Business Area Depots is to provide maintenance capacity for train operators and maintenance contractors. Due to the enhanced technical difficulties bound to facility management are the internal organisation split into functions and the ones that are mostly affected of BIM and facility management are located within technical management. At depots it is not only the depots that are Jernhusen's responsibility, but also the railway tracks and other functions that are leading into the buildings.

4.1.1.3 Business area Cargo Terminals

Jernhusen owns 13 cargo terminals and the task of the business area is to enable a change of the transportation mode from road to railway. At cargo terminals is one employee responsible for the technical facility management for all 13 facilities.

4.1.1.4 Support function Construction & Property Development

The support function Construction & Property Development are responsible for development projects from that the business area has defined a need, to that a project has been completed and is ready to be handed over to the business areas. Some responsibilities of construction & property development are:

- Coordinate and assign internal and external resources for the design and construction phases.
- Sub-order and sign contract framework agreements with external consults.
- Be a part of the signing of contractors.
- Provide project management resources in the design phase.

- Provide project management resources with a responsibility of the project cost during the construction phase.
- Provide a product within assigned time plan that are aligned with the customers' demands on function and quality.

To be able to fulfil these responsibilities they have organised themselves with four business functions and two support functions. Out of the four business functions are the design and the construction functions, those that will be responsible for the process, from the beginning of the design phase until the handover to the facility managers, and thus have the biggest impact on the design of the BIM process.

The design and construction business functions have split the responsibilities during projects according to fig. 4.2, where the project manager from Design are responsible for the project from initialization phase and hands over to Construction's project manager at the end of the planning phase, Construction are then responsible until the handover.

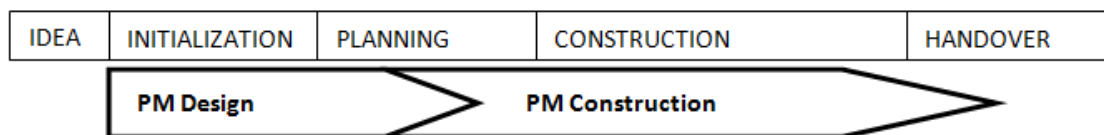


Figure 4.2 Sketch of responsibility during projects.

4.2 Responsibility of facility managers

The facility managers at Jernhusen have a lot of different tasks and responsibilities, varying from maintenance of train tracks to customer care at the stations, where Jernhusen's customers for example at stations are the store owners who are renting the spaces. The personnel taking care of these tasks are firstly divided into their business area and then into either technical facility management or economical facility management. The common goal with both these types of facility managers is to keep the customer happy and enable the customers operations to go on smoothly.

The responsibility of the technical facility management is also different between the business areas. Stations have more of a holistic responsibility where they are responsible for all technical aspects which makes sure that the stations work properly, and thus have split the stations between them. Whilst, at the business area depots have some of the technical facility managers been assigned responsibility for a specific part where they have expertise.

4.2.1 Facility managers at stations

The responsibilities for the technical management could be simplified into: everything that has to do with the technical aspects of the building and property owned by Jernhusen. They are responsible for tenant adaption, refurbishment, governmental demands and surveys, installation projects, emergency maintenance, long-term maintenance, and advisors at major projects, they are also responsible for that the property is clean and look good. The limit when the projects are handed over to the construction and property development is dependent on the complexity of the project

which are decided based on the projects perceived level of; coordination, design, government contacts, and size.

The economical facility management is responsible of capitalizing on the property. They are responsible for customer contracts with economical or legal content, keeping a good relationship with the customers, have a tight communication with the authorities, and finding suitable customers for vacant areas.

4.2.2 Facility management at depots

Most of the facility managers at depots could be considered as specialists. The responsibility is still to make sure that the customers' operations run smoothly, but the challenges are a bit different. The biggest challenge is often the high voltage power line that surrounds all their activities. Another challenge is the tight time schedule of trains, which makes some maintenance work more logistical demanding than it should have been otherwise.

4.2.3 Technical facility management at Cargo terminals

The cargo terminals are often quite simple constructions consisting mainly of a big paved area with tracks going through it, allowing loading and unloading of goods. The most complex buildings are often barracks for the administrative tasks. However at a few of the cargo terminals are storage facilities and some offices placed and thus giving a quite wide variation of the technical facility manager's tasks. At the cargo terminals areas are the most occurring issue damage of the asphalt due to under dimensioned paved areas in relation to the load it has to carry.

4.3 The setting for BIM implementation at Jernhusen

Jernhusen has recently started to demand that all new projects should use 3D modelling in the design phase. But when it come to the information and processes needed for BIM to become a facility lifecycle management tool are they still on the start line in their development.

When looking at BIM and Jernhusen, it is important to look at the setting the company with its different business areas has to deal with. First of all is the Real estate sector often seen as one of the safest investments, were low risk and stabile return on investment are key characteristics (Allansson and Åkersson, 2011). However, it is important to remember that there are big differences between the business areas as well as within the property controlled by the business areas. For example there is significant difference in profitability between Stockholm central station that generates high and stabile income, to the station in Borlänge that barely bears its own costs.

At depots and cargo terminals there are another problem, the land these operates on would often be more profitable if commercial buildings were constructed on it, instead of depots and cargo terminals. However, these buildings are concerned as a part of their governmental mission to enable train traffic in Sweden.

BIM is not the biggest development subject at Jernhusen for the moment, but as the company grows they have been forced to re-structure their way of running projects

and facilitate buildings. This structure has led to the development and use of several systems at Jernhusen (see Ch. 4.4). Another thing to have in mind is that technical facilities management is about fixing diverse problems, which often occurs first several years after a new building is completed.

4.4 Other systems at Jernhusen's facility management

Jernhusen's facility management has implemented several support systems that they use in order to ease and structure their daily tasks. The way Jernhusen plans to work with these systems is by using a common data layer that receives the real estate structure from Fastnet, and then the other support systems have a two-way communication with the data layer in order to extract necessary information for its tasks and put in new information depending on what it is performing. Another potential benefit from the data layer would be that it should simplify and automate the creation of reports of the current situation (see fig. 4.3).

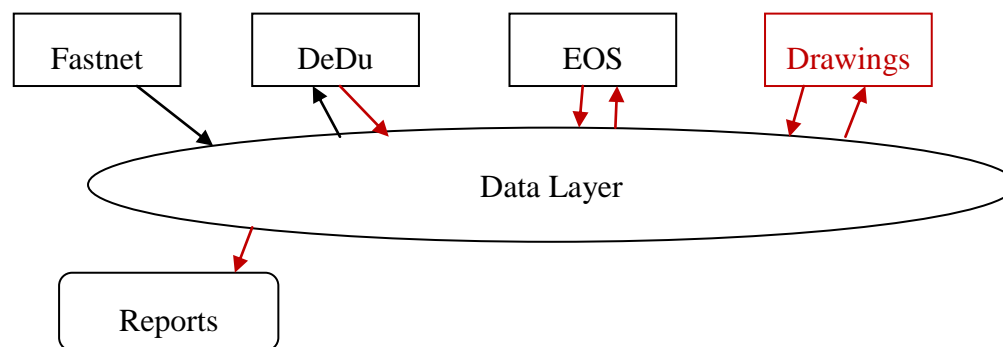


Figure 4.3 Scheme of the systems used by the facility management, red marked means systems or links not realized at the moment (Sahlberg, 2012).

4.4.1 Fastnet

Fastnet is Jernhusen's system used for structuring their properties, houses and tenant contracts. This system could be considered as the structure from which all other system works towards. One problem with this system is the lack of detailed levels that it provides. Today the system only considers giving ID-numbers to buildings and tenant contracts, whilst installations and other details that will be of interesting when it comes to BIM, just get a regular name that are connected to each building and thus becomes unable to track by other systems.

4.4.2 DeDu

Jernhusen has just started pilots were they take back the case management from their operating contractor. In this process they start up their own call centre and the system that connect the call centre, operating contractor and facility management are DeDu. Right now DeDu is getting the property structure from Fastnet, but it does not put back information into the data layer. Information that would be of interest for the moment is what kind of cases that has been dealt with and at which houses.

4.4.3 EOS

EOS is used for financial control and maintenance planning. This system is appreciated as a financial tool, but as a maintenance planning system it is considered quite bad. The problem is that EOS is too heavily focused on yearly basis and presenting final sums, this means that it is hard to know what the sums represent. Another issue is that it is not possible to keep track of future maintenance need, e.g. if the roof of a house needs to be replaced in the coming five years.

4.4.4 Drawings

Right now 2D based CAD drawings are the most technical advanced drawings that are being used by Jernhusen. Their focus with drawing archives for the last years has been to transfer the drawing archive from TRIX to another system. The new system they will use is Hyperdoc, which is sold and maintained by CAD-Q. This transfer makes it troublesome to look at how Jernhusen handle their drawing archive, and for the moment few facility managers actually know what they should do with the drawings they have for the moment. But, there are some lessons to be learned from their 2D drawing archive when it gets time to start archiving BIM models.

Clear updating instructions – Today the company is lacking clear instruction on how to update the drawings and models, this is important in order so that the one responsible for updating knows that it is its task and that the update follows the same structure as Jernhusen wants to work in.

Prioritizing the updating of models/drawings – The task of keeping drawings or models up to date must be given a higher priority so that it will be done when the involved still remember what it is that should be updated. Here it is important that the facility manager gets time to update its drawings/models or that resources are assigned so the facility management can hand it over to a consultant.

At the moment there is no plan to connect the drawings to the data layer. One reason for this is that a vast amount of the drawings at Jernhusen are not digitalized or up to date so that they do not represent the reality. However, there should be several benefits for the facility management if other systems were able to present data on drawings or in models that their tasks will take place.

4.4.5 Data layer

The data layer is basically a vast amount of information that is structured in a specific way. At the data layer is the structure the key aspect, because as long as the information is well structured, with regard to the systems that should use it, the amount of manual input needed to use the same data between different systems will be reduced.

5 Results

This chapter presents the information gained during the interviews. The interviewees were given the possibility to tell what they wanted to realise and what hindrances they perceived for a more efficient facility management. It is important to realise that all facts presented here can not be solved purely by BIM implementation, but this input is needed when looking at the overall picture of BIM implementation with regards of other systems at Jernhusen.

The chapter is structured into different topics found in the data. First description of how the facility managers currently work, second the information required by facility managers, third aspects indicated by facility managers as important for their work in relation to BIM, and finally possible implementation paths for introducing BIM at Jernhusen presented by three BIM expert firms. At this part it is important to keep in mind that this is a representation of the needs they have seen at Jernhusen, which might differ with the picture presented in this report, due to different amount of insight in and approach to Jernhusen.

5.1 Current work practices of facility managers at Jernhusen

The responsibility of the facilities management is quite dependent on if it is technical- or economical facility managers and which business area they are operating in. But, simplified it could be said that the economical facility management is responsible for the income and the technical facility management is responsible for the expenses. This means that the economical facility managers are responsible for tenant contacts and rent negotiations. The technical facilities managers are responsible for the operation and maintenance needed in order to keep their objects functional and allowing the customers operations to run smoothly.

As the demand is to use 3D models at new projects, more of the facilities managers' buildings should be delivered 3D models. However, for the moment the majority of Jernhusen's drawings are in 2D representations in different conditions. The economical facilities management uses the drawings for area management whilst the technical facility management mainly uses it as a planning and communication tool for refurbishment and maintenance.

From the interviews it became clear that the 2D drawings used today are often lacking in accuracy regarding how it is built. This implies that the facility managers sometimes need to be highly flexible, and either obtain the information needed through external consults, or have to make decisions with insufficient information.

5.2 Information requested by the facility managers

The facility managers are responsible for several different areas but with the focus to keep their customers' operations running smoothly to keep them satisfied. In order to fulfil their task and achieve satisfied customer, facility managers had as the most common request accurate and updated drawings (see Ch. 2.4.2.3 As-built models). Another aspect the facility managers emphasized was that the systems being implemented needed to be user-friendly, with a minimization of manual input and

simplicity to sort out the information that they found interesting, without the need to know several different programmes.

5.2.1 Information requested by the technical facility managers

During the interviews a focus area was the information needed to increase the efficiency of the facility managers' tasks. The most mentioned benefit was a common model, where all as-built drawings are connected so it was easy to sort out those drawings that they need, at this common model they also wanted to be able to print layouts of different parts of a building. The interviews also said that a common model could be useful in order to see connections between the different construction sectors (such as; electrical, HVAC, structural etc.). In order to normally find these connections several different drawings are usually needed to be taken into account. Another benefit the interviewees saw was that a common model makes it easier to send the right material to consultancies if they need to calculate potential changes.

Moreover, the interviewees wanted a database solution where they were able to track the meters, with aspect of type, location, value, and where the media, passing the meters, ends up. Additionally they wanted that this database was able to automatically warn if the meters started to show abnormal values, which could indicate a leak. Another feature they wanted was to be able to control the equipment, measured by the meters, remotely.

Additionally, they expressed a wish to have a system that tracks the warranties and warns when they are about to run out, in order to be able to perform warranty inspections before it is too late. Other aspects that they wanted to keep track of were if an installation has broken down several times or if an inspection resulted in any remarks. At this system they expressed a wish to be able to link photographs to the faults so they could be handled properly.

To use the 3D aspect in order to easily find the cross section within the same model was an area that the interviewees could see potential benefits in. One of the managers discussed an example in this respect, where the lack of archived drawings of a cross section at a cable lead to a couple of hours stand still at a construction site, because they had dug through a cable and did not know what went through it.

Several facilities managers saw that by being able to enter a room and clicking around to get necessary information will simplify the communication with the entrepreneurs. They hoped that BIM will enable them to quickly get appropriate information in order to answer eventual follow up questions that often arise before refurbishment or maintenance is to be done.

Another benefit they saw was that an increased digitalization should make them less location bound. Though they instead of searching in a binder would be able to get the necessary information to their computer no matter where the facilities managers are.

5.2.2 Information requested by the economical facility managers

The economical facility managers saw a possibility to easily produce sales material of vacant areas, where the customers logotype, example of furnishing and people moving around in the vacant area, were things that they wanted to show potential customers.

One of them also wanted to be able to bring the model on a tablet (e.g. iPad) during their customer meetings in order to quickly sort out questions and remarks. Some information that they wished to have and be able to show was where the bearing walls were, the ventilation flow in different rooms, the maximal capacity of the ventilation, and how many persons that the room was meant for from the beginning.

5.3 Aspects indicated by the facility managers

During the interviews several aspects were indicated by the interviewees, which will have some impact on either the efficiency of the facility manager or the BIM implementation. Following are some of these indications that should be taken into consideration in the implementation process.

5.3.1 Hindrances for facility management's efficiency

Several aspects were highlighted as hindrances for facility manager's efficiency. Below are some of the non-BIM related hindrances that the facility managers brought up during the interviews.

5.3.1.1 Lack of time

The lack of time was one of the most frequently mentioned issues, and several facility managers said that they had to "put out fires" instead of working with preventative work. This led to that some important tasks got prioritized and other were rushed through, or not done at all.

5.3.1.2 Lack of maintenance planning systems

The technical facility managers lacked a system to keep track of their long-term planning of maintenance. Due to the lack of a common system the facility managers have developed their own systems (often in the form of an Excel sheet) to keep track of the planned maintenance. Two of the interviewed heads of facility management, saw the individual approach to maintenance planning as one of the main issues with switching responsibility of buildings between employees. They also said that the hindrance of switching the responsible facility manager could be considered as an organisational vulnerability.

5.3.1.3 Lack of a system that keeps track of warranties

Another system that the facility managers felt they needed was one that kept track of warranties and notified the facility manager in time to prepare and execute a warranty survey. Such a system is currently not in place.

5.3.1.4 Simple and user-friendly systems

In order for the facility managers to use the systems the interviewees highlighted simplicity and user-friendliness are the key aspects. They pointed out that it has to be easy for them to find the information they are looking for without the need to know

several systems. Key aspects mentioned were a user-friendly interface allowing knowledge in as few systems as possible in order to obtain the information needed.

5.3.1.5 Reduction of decision paths and internal processes

One of the interviewees criticised the bureaucratic characteristics of the company: *“Effective facility management is about short decision paths”* An example presented was that during investments the facility manager had to apply for an investment number before access to money is granted. A preferred solution from the facilities manager would be if they got access to the money as soon as the yearly budget was approved.

5.3.2 BIM related aspects for the facility management

The interviewees also indicated some aspects that can be considered as drawing and BIM related. The main issue mentioned was the lack of as-built drawings due to insufficient updated drawings.

5.3.2.1 Insufficient updated drawings

One of the facility managers mentioned that: *“Every facility managers thinks that it is a dream to have updated drawings”*. However, many of the interviewees mentioned that the drawing material they had was outdated and did not represent how it looked on site. The main reasons why the drawings were not kept up to date was prioritizing of other tasks, lack of routines for drawing updating and for delivery from projects, as well as insufficient resources regarding time and money.

5.3.2.2 Possible resistance

During the interviews mistrust and resistance towards BIM could be noticed, mainly among the older interviewees, were sentences such as *“Fortunately, I will be retired when it (BIM) is implemented in the company”*, and *“It (BIM) sounds great, but...”* were quite frequent during the interviews.

5.3.2.3 BIM knowledge in the organisation

Prior to the interviews as well as during the interviews it was evident that the general knowledge of BIM is low within the organisation. Out of the 23 interviewed from Jernhusen only one of the interviewees had been involved in a project that used some level of BIM. About half of the interviewees had some insight of what BIM was and the rest had as most awareness of BIM prior to the interview.

5.3.2.4 Limited need of information at new buildings

One of the interviewees that were responsible for a two year old building had access to 3D drawings of this building, but stated that at the moment there was limited need for drawings and information on that building. The reason for this was that often just minor adjustments occur whilst the same tenants operate in the building. This was

shown by the same facilities manager who said “*We have not needed to do changes of that magnitude that we needed to hand over such (3D model) material*”.

5.3.3 Other possible BIM benefits for the organisation

The support functions interviewed in Stockholm were transaction, operating under construction and property development, and sustainability operating under the strategic development. Following is a presentation of the potential benefits, for their tasks, that they saw with access to BIM models.

5.3.3.1 Transaction benefits

In the case that a building with BIM is being sold, more information will be available with less effort. Were at the BIM building all documentation should be able to extract digitally and most of it will also be able to collect from one file. Whilst at today’s non-BIM buildings, the documentation of a building is often in several binders at the office or in a storage room in the building. Whether the increased information leads to a higher transaction price depends on the buyer, the complexity of the building and the information given. But the main benefit with BIM for transaction will, according to the interviewee, most likely reduce the time spent to produce sales material and find proper information to answer uncertainties.

5.3.3.2 Sustainability benefits

The benefits from the view of sustainability is that you will be able to easier track where different materials are within a building, so if a certain material turns out to be hazardous it will be quick and easy to see where it is placed in the building and remove it. However, the main benefit, from the sustainable point of view, will most likely be if BIM leads to higher quality buildings, because there are tight connections between the quality and the environmental footprint of buildings.

5.4 Jernhusen’s implementation plans

Jernhusen has started to demand that 3D modelling shall be used at new production. However there are no demands regarding binding information to the model, which is the main step that changes the product from 3D to BIM which can lead to several knock on effects. Regarding BIM implementation at Jernhusen has they not developed an internal plan to set out a fixed strategy in order to deal with these effects and changes, but they have started to discuss with three companies that could be considered as potential partners in the development process. The three companies are:

- Ramboll a major consultancy company.
- Cad-Q a supplier of drawing and model related IT based support solutions.
- Monsén Architecture a local architecture company with BIM expertise.

These companies have quite similar views on that the BIM process of Jernhusen should be based on the needs of the facility management, in order to gain a successful BIM implementation. But they differ when it comes to implementation approaches and thoughts about how to archive drawings and models. Following is a

representation of the different sales pitches regarding Jernhusen's BIM implementation path seen by the companies.

5.4.1.1 Ramboll's view

Ramboll's role at Jernhusen is that they have developed the CAD- specifications and project manual for projects in 3D. Ramboll emphasized that it is important to find a good level and expand from that. Their approach towards BIM implementation is to structure Jernhusen's way of producing and handling information during the projects so there is a unity throughout the company. Once Jernhusen has a structure and is used to work according to the specification and the manual then these two documents can be developed with regards to the information needed by the facility management and what they want to be able to use BIM for.

Ramboll's thoughts about BIM archiving is that there is a need for both dead (non-editable) formats such as .cals or .pdf and living (editable) formats such as .dwg. The plan is to put the dead formats into a passive archive as juridical proof and as a tool to backtrack what has happened over time. This passive archive will be updated only when there has been a major change (e.g. changes in the load bearing construction) and the material that is put in will be the drawings of how it looks after the change. The living file will be put in an active archive, which is meant to be updated according to every little change (e.g. adding a sign for one of the stores) in order to keep it as close to an as-built model as possible.

5.4.1.2 CAD-Q's view

Cad-Q is Jernhusen's provider of the drawing archive service that Jernhusen is on their way to switch to. They see benefits with BIM for all phases of the project process, from concept to facilities management. Their approach towards BIM implementation at Jernhusen is that the facility management should control the project process by setting demands so they are certain that they receive what they want out of every phase of the project. Another important aspect is according to Cad-Q to get the buy-in from the managers in order to make sure that the BIM strategy is followed.

Regarding archiving of BIM, CAD-Q considers the creation and storage of dead files as an unnecessary expense. Their view is that when you archive at CAD-Q you will automatically get the back tracking function due to a check out/in function. This means that when it is time to update a model the facility manager at Jernhusen never will get the true original but only checks out a copy of the model, and each time changes have been made and the model is checked back to CAD-Q, the new model will get a new time stamp and the old one will become a backup that could be used for backtracking.

5.4.1.3 Monsén Architecture's view

Monsén Architecture is an architecture firm with BIM expertise that has been in contact with Jernhusen regarding development of Jernhusen's BIM practices. The firm has a vision that Jernhusen's BIM approach should look towards the manufacturing industry and their process of cloud computing. Cloud computing is

when the information is stored on remote servers, which can be accessed from any place with an internet connection without the need of specific software.

When it comes to the implementation process the company considers an implementation approach according to the following pyramid:

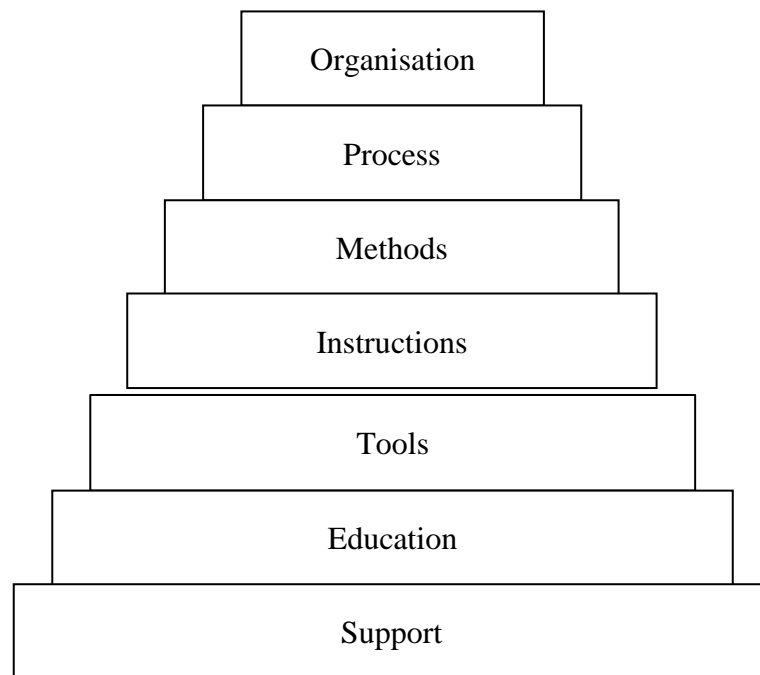


Figure 5.1 Implementation pyramid by Daniel Monsén (2012)

According to Monsén architecture it is important to start in the top of the pyramid by setting an implementation organisation, a person or a group with a high interest of getting BIM into the company. When the organisation is set the focus should be switched to the process, which is, how everything is handled from the idea phase to the end of the facility maintenance. Here it is important that the client organisation has control over the whole chain in order to be able to develop methods in order to increase the efficiency.

The methods consider the work around projects, e.g. quality control of the budget, and make sure that deliveries are according to customers' wishes. The purpose of the method phase is to meet the process. After the method is done, it is time to develop instructions with the purpose to describe the method. Examples of different instructions are the CAD- specification and project manual.

When these internal steps are done it is time to choose the different software and formats to be used throughout the process. This is also known as the tools. After the decision regarding the tools there is most likely a need to educate the involved staff so that they have the knowledge to work with the tools. And finally there can be a need to sign a support deal in order to enable expertise guidance in those cases where it is still needed.

According to Monsén architecture these steps and support from management should lead to a successful implementation. The company also describes that some companies only takes the steps from tools to support and thus end up with tools that are not aligned with their processes and methods.

6 Analysis and discussion

In order to be able to analyse the impact BIM will have on facility management it is important to sort out what kind of BIM that is being discussed. In this chapter will BIM refer to the facility lifecycle management tool view, where the information based environment is the key to well-understood information processes (NIBS, 2007).

6.1 General implementation theory on the case

It is doubtful that Taylor's *change initiative* or Pascale's *innovation and change at the edge of chaos* could be considered as the truth regarding how change occurs. But these extremes are useful in order to look at the different consultancy companies' views of Jernhusen's BIM implementation. Here can the view presented by Monsén architecture be considered as more towards the multivariable view, whilst CAD-Q and Ramboll presents view more related to Taylor's change initiative where, by setting a clear structure, the rest should follow. However, the most important aspects for BIM implementation will be the strategic choices regarding technology or process weighted approach, if the company will lead or follow in the implementation, dealing with the resistance that most likely will arise, and develop the BIM after internal reflection of processes and needs in order to avoid implementation of BIM as a fashion.

6.1.1.1 Strategic choices

BIM could be seen as both a technological and a business model innovation, or perhaps rather a technological innovation allowing and demanding a new business model. This view was shared with the view of the interviewed BIM experts and also explained in WSP group's (2011) 10 Truths about BIM with "*BIM is the marriage of a technology and a set of work processes*".

Jernhusen has not yet set out their path for BIM implementation. However, indications are that they rather will follow than lead the innovation, and the reason for this is probably that there is not much to gain monetary as a client company as the first mover in such an innovation process. The potential advantages that could be realised with being the first mover in an owner setting would be experience curve benefits and an increased reputation. These are in the Jernhusen case not seen as valuable as the savings of free-riding and learning from others. However, it is important to mention that if Jernhusen's BIM innovation journey goes quick and smoothly, could they be considered an early-follower as BIM is still relatively unused within the client side of construction. Another aspect why few client companies lead the BIM innovation might be the considerable stable setting, mentioned by Allansson and Åkersson (2011), that they operate in, which needs no urgency for change towards BIM. The stable setting might also be the reason why client companies in general are trailing behind compared with consultancies and construction contractors when it comes to BIM. Furthermore, another reason for later adoption might be that facility management can not always justify investments in BIM when the profit and pay-off for these investments are low and/or diffuse.

6.1.1.2 Resistance against BIM implementation

Due to the reasons mentioned above, in terms of lack of business value, justification of investments, and general awareness, it becomes clear that, once a decision is made on implementing BIM, the implementation process should be done carefully. The implementers need to be aware that different levels of resistance most likely will occur due to the BIM implementation. This resistance might be a challenge for the implementers, but according to Hartmann and Fischer (2009) should it be positive in order to get employee engagement that increase the possibility that correct ideas get used and less good ideas are rejected. To ease the transformation from resistance to persuasion it can be useful to engage employees' in the adaption, while making sure that their skills and understanding of BIM increases (Arayici et al., 2011), as well as clarify the concept in order to get a mutual understanding regarding responsibilities and discipline specific models, which were recommended by Moun et al. (2009).

6.1.1.3 The risk of BIM as a fashion

If BIM is implemented wrongly, and a company chooses a particular tool first and then develops the whole processes around the BIM tool, or if the implementation strategy is copied from another company's solution, then the implementation might fail and can be seen as a fashion (Clegg et al., 2009). The emphasis in many reports about BIM is that it changes the whole building process and thus makes it to complex for direct reproduction without internal reflection. The three BIM consultants interviewed also emphasised the importance of internal reflection during BIM implementation. In order to avoid fashionable BIM implementation, the risk of implementing a fashion should be kept in mind, and the BIM implementation should be formed after the internal needs and wishes.

6.2 Potential benefits with BIM for facility management

The amount of literature regarding BIM's benefits for facility management is very limited. A comparison between the benefits for facility management presented in literature to those expressed by the facility management of the case, shows that three out of the four most mentioned benefits in the literature were also expressed as a need by the facility managers of the case. These three mentioned benefits are the following:

- Better information and guidance for renting and tenant adaption (Gustafsson and Mårtensson, 2010, Granroth, 2011 & Klein et al., 2012).
- Easier to find building components, which eases the operation and maintenance of the building, through more structured storage of useful documents (Klein et al., 2012).
- Lowered operation costs through the ability to monitor and control the energy consumption and HVAC systems (Granroth, 2011 & Klein et al., 2012).

One benefit discussed in literature, was not discussed by the facility management case study. This benefit discusses the link between BIM and earlier involvement in projects from the facility management. The reason why the other three were mentioned and not the involvement might be that the interviewees had limited experience, and thus look at how the technique might benefit their daily task and not the overall project

process, however when the earlier involvement of facility management in the construction process was discussed, the facilities managers did see this as something positive. However, they perceived that time to be able to attend meetings to give input was the main limitation. The main information requested by the facility management were:

Drawings:

- Collected and structured as-built drawings of each individual building, with the ability to get cross section etc. from one collected model.

Technical issues for maintenance:

- Ability to easily locate meters and follow the flow from these.
- The ability to remotely see the value of meters, get alarms if something is divergent from the norm, and control the installations remotely.
- Keep track of warranties and results from surveys.

Communication:

- Ease communication during customer meetings by being able to bring a model to customer meetings and easily look at things that the customer might want to change, e.g. tear down a wall or change air flows.
- Ease the communication with entrepreneurs by being able to easily find appropriate information and relationships.
- Get showcase material in order to attract new tenants to vacant areas.

These seven requests, presented as the main required benefits, could in all but one case be connected to the four benefits mentioned. Were the collected and structured as-built drawings could be seen as an enabler for the first and second benefit in the literature. Whilst, the two first mentioned requests at technical issues for maintenance can be reflected to the third benefit in the literature. All three benefits in the communication category are needed for the better information for renting and tenant adaptations. The only one, were a connection to the main benefits in the literature could not be found, was to keep track of warranties and results from surveys.

6.3 What is required to reach the benefits

BIM can be understood as a product, a process, and a facility lifecycle management tool. Therefore, it is important for organisations to look at what they want out from BIM and from that sort out at which level BIM is to be used. For a client organisation with facility management functions that wants to use BIM as a facility lifecycle management tool several aspects are connected to the processes and usage of BIM that need to be considered prior to the implementation.

6.3.1 BIM implementation aspects

To implement BIM to gain the benefits that it should enable will mean several changes both intra as well as inter organisational. Collaboration will be one of the keys to success. Another aspect will be an ability to think outside the box, in order to

see what IT enables, as well as keeping a long term perspective to overcome resistance due to lack of evident short term profits for the facilities management. Another aspect of the long term perspective is that the amount of consultancy companies available will be reduced, and a proper risk management must be performed regarding further hindrances of BIM.

6.3.1.1 Collaboration between facility management and project management

Facility management is depended on drawings and models made during the construction of a building. When buildings are constructed with the help of BIM it is important that facility management has been a part of the process development in order to ensure that they receive the type of drawings and models needed for their tasks. Therefore, it is important that the facility managers who are the long term user and that the ones controlling the development of the models, i.e. the project managers, work together.

The BIM process should be developed in order to suit an efficient project, but the demands that control the delivery to facility management must be based on the benefits that the facility management want to realise. The most emergent issue, to sort out through collaboration, is the level of detail that is to be in the BIM model, though there is a clear correlation between the level of detail and design costs, as mentioned by Khanzode et al. (2008). For example, in order to see what a specific meter feeds the connected pipes must be given the attribute that they are fed by that meter. Another area where the demands are important is if an external system/database is to be used with information from the model. The model should be shaped in such a way that at least the external system/database could extract the information automatically.

In order to avoid unnecessary processes collaboration is a key to increase mutual understanding and knowledge about each partner's requests concerning BIM and other processes. This need for collaboration is seldom mentioned in the literature which often is satisfied with presenting the client sector as those who benefit most from BIM and who has the power to demand that projects use it, without further investigations of the true benefits for the clients.

Another potential benefit, that might increase the mutual understanding between project managers and facility managers, is that the model should be easier to interpret than regular drawings, which should make it easier for a new facility manager to understand its building, and thus limit the organisational vulnerability presented by the heads of facilities management. That the model might be easier to interpret can, according to Gilligan and Kunz (2007), also lead to a higher project engagement from employees and stakeholders.

6.3.1.2 Need of collaboration regarding acquired property

One issue, observed during the research, was that acquired property often has been developed according to other demands of documentation than those developed by the purchasing company. This results in drawings or models that are not compatible to the processes and programs used by the purchaser. That in turn leads to that the information attached in the purchase is more or less unavailable for the facility manager and its systems. But it is not only the demands and structure of the information that might be the issue. Because, as Gu and London (2010) presented, if a

different software have been used during development is there a high risk that the model are unreadable by the purchasing company.

If this issue is not taken into consideration might the new facility managers of the acquired property risk being without drawings for their tasks, which will be a major hinder for their efficiency. Solving this issue demands collaboration between the seller and buyer, were the handover of drawing in an agreed format is as obvious as the handover of keys in a property deal.

6.3.1.3 Aligning project processes with IT possibilities

One of the most mentioned differences with BIM in the literature is that the workflow and processes will change. Stopping the relay race and encourage actors to collaborate and communicate between actors were mentioned by Granroth (2011) & Gu and London (2010). An area mentioned by Arayici et al. (2005) is that instead of looking at how IT can support their processes, they should look at how the process could be aligned with IT.

However concerns can be raised regarding to how prepared the different actors need to be in order to work according to revolutionary methods. Especially in the case of facility management awareness and lack of value are perceived concerning BIM. Signs of resistance to change have at several occasions been noticed during the research and the key to get employee buy-in will then be to transform resistance to persuasion of correct parts, through critical engagement by the employees, as presented by Hartmann and Fischer (2009).

6.3.1.4 Long-term perspective

Some of the benefits for the facilities management will be realized first as the building receives a new tenant or goes through a refurbishment. This in combination with the risk of resistance will mean that a certain amount of long-term thinking is preferred when looking at the value of BIM for the facilities management. This might be one of the reasons why, as Hagan (2009) highlighted, the buy-in of top management is needed. Because without their buy-in is there a risk that the top management cancels the implementation process due to lack of early profits or that the facilities managers are not supported by management during the BIM implementation.

6.3.1.5 Effects on surrounding consultants and entrepreneurs

In order to reach the highest possible benefit with BIM there is a need that the whole project chain has appropriate knowledge about BIM with respect to their tasks. E.g. the consultants must have knowledge to not only create a model in BIM, but to also follow the demands set by the client. The entrepreneur should at least be able to read a model and withdraw construction drawings from it, but it would be even better if they were able to work from the model. This will mean that the amount of possible consultants and entrepreneurs tools is reduced, due to the lack of appropriate BIM knowledge.

A risk with this is that knowledge, bound in the persons and processes that have earlier been involved in projects around a building, is lost in the change from 2D CAD to BIM, due to the changes in project management practice and investment costs

that BIM leads to (Kaner et al., 2008). Local knowledge bound to the persons involved might be lost in a particular area or city, because the consultants that the regional office have used often come from small firms that most likely will not be able to afford the investments that BIM requires regarding software and education.

6.3.1.6 Dealing with the hinders

Those hinders that are presented in Ch. 2.4.3 are just some example of hinders that might lead to problems when it comes to BIM implementation. In order to minimize the risk of unsuccessful implementation the risks connected to BIM implementation should be taken into consideration. A suggestion is to do proper risk management of hindrances and look at probability, eventual knock-on effects and from that decides how to act according to each hinder. In some cases they will be able to control the hinder, in other it will be better to accept that it will happen and find a way to live with it. However, it is important to notice that this risk process will demand quite significant work.

6.3.2 As- Built model

It has been found during the research that there are big issues to keep drawings up to date. Developing and maintaining the BIM model as-built will be a key to realise benefits such as, information and guidance for renting and tenant adoption, as well as an aid for better communication. It will be a key issue to keep the model updated so it represents how it is as-built. The need for an updated as-built model was presented by Gu and London (2010) with that there were issues regarding keeping the model updated to the changes from the design phase through the construction until the delivery. If this area of model updating is not receiving any special attention there is a risk that BIM does not change the current problem in the industry of having to work in facility management with drawings that are outdated. According to the facility managers', lack of routines, unclear demands, and time were the biggest reasons why their drawings were not kept up to date and thus should these areas be focused on during BIM implementation.

Another area where an as-built model might give extra value is when the business or project development wants to show a potential customer what it might expect for a certain amount of money. This could be done by showing previous projects with similar functions. The BIM model should then give a better understanding for the customer than what ordinary 2D CAD-drawings are able to provide. The quality of the showcase material can be affected by extended rendering, but just the 3D model should improve the quality of the showcase material compared to 2D drawings.

6.3.3 Technical issues

In order to realise the benefits of BIM implementation there are several technical aspects that need to be sorted out. The most important issue is that the tool must be easy enough to use so the facility managers feel that it is worthwhile to apply it. Because, if the tool is not used it will most likely not give any value. Other key aspects are that the system should be formed according to its purpose and that it is integrated with other programs and systems used by the company. It is interesting to notice that technical issues such as interoperability and security, such as mentioned by

Gu and London (2010), were not discussed by the interviewees', this can be because they haven't met these issues yet or that it is practically the client that will have most power regarding how the BIM process should work.

6.3.3.1 Remote access and control of installations

Some of the facility managers wished to be able to check and control installations remotely. In order to enable the installations must be selected so the feature exists and that the systems used are compatible with the installations. These systems will most likely be a bit more expensive at purchase and perhaps maintenance and thus must it be defended in savings of operations costs. One area to be extra careful at, when designing this system is that the facility managers emphasized that the systems need to be user-friendly so that they do not pay extra for a feature that in the end is too demanding for the facility managers to use.

6.3.3.2 Interlinked and user-friendly programs and systems

According to the interviewees it would be a dream to have the possibility to use only one program for all the facility management tasks, this program does however not exist and several programs are needed. In order to receive value from these programs, they should be interlinked so the user automatically are sent between them, or get the possibility to read and use different programs in one window. An example of programs that work this way is your web browser that allows you to read a .pdf or watch a flash movie without that you, manually, have started the programs needed for this. In order for BIM to be interlinked with the rest of company's systems it is important that the BIM is well structured after what they want out from the other systems.

In order to get economical benefit from the systems that can be developed for facility management a focus should be put on user-friendliness. Important aspects in this area are that the amount of manual input is minimalized, the amount of different programs is kept down, and that all programs are easy to learn and use. Another aspect is that the programs preferably should be able to be run on mobile devices such as tablets or smartphones.

Further it is important to only present the information that is of interest for each professional in order to avoid information overload. A suggestion on a possible way to do this is by implementing filters for each profession that hide information which not are considered important for specific tasks.

6.3.4 Education

According to Froese (2010) it is important that the employees receive training so they have the skills needed for their responsibilities. The level of BIM education needed will be dependent on the usages of BIM and the systems that are to be interlinked. In order to realise some of the benefits the facility management will need some education.

The clearest monetary savings will most likely be due to less changes and additional work during projects. Thus, if facility management is to control a refurbishment

project of a construction that was projected with BIM they should have enough knowledge to use BIM so it decreases the risk for changes and additional work.

The education of facility management might be eased by starting with a pilot and make it possible for the facility managers to get practical training. Because they then will be able to try the model and get a better feeling of what BIM is about. Another positive aspect with a finished model is that lessons learnt from it could be used in development of future BIM processes in order to secure good deliveries and increase the possibility of successful projects.

7 Conclusion

7.1.1 What are the potential benefits with BIM for facility managers?

It will most likely take several years from the completion of a newly produced, BIM based, building before the facility managers are able to realise most of their potential benefits. The reason for this is that few changes occurs during the first couple of years and that most of the drawings and knowledge that BIM has the ability to substitute will still exist. However, after a while should the potential benefits become able to realise, and the key aspects with BIM will then be the collected and structure documentation. That eases information gathering as well as communication with consultants, entrepreneurs, and customers.

Several other benefits for facility management might even be realised without BIM, but the approach towards BIM offers a possibility to highlight issues within the organisation and set out guidelines, allowing these issues to be fixed simpler with BIM than it should have been done without it. The benefits that are not directly for the facility management, such as higher project engagement and earlier simulations, might lead to projects with higher quality, and the increased quality might, in the end, turn out as the main benefit for facility management with BIM.

7.1.2 What is needed in order to realise these benefits?

For facility management at Jernhusen will the deliveries between the different construction phases be the key to realise benefits, and at this aspect it is important that the project management and facility management collaborate, in order to set the process with the level of detail and demands on deliveries according to what they want out of the model. These demands is something that for the moment have not got attached to their CAD- process so this could be considered as an urgent objective for Jernhusen, and can be necessary to improve overall performance no matter if they use 2D/3D- CAD or BIM.

The amount of investments that software, hardware, and education will require depends on the desired use of BIM. E.g. the possible investment for a warranty tracking system must be compared to the costs of missing warranties and difference in time spent on keeping track of them today. Another example is the possibility to monitor and control installations. Were extra investment costs should be compare to savings during operation.

Another key aspect is that the software must be user friendly and if different systems are being used they should be interlinked. The choice of software and how BIM will be used will greatly affect the level of education needed.

7.1.3 How to implement BIM in a Facility management organisation?

The main benefit that most researchers mention is the increased level of communication and collaboration during the projects, but the focus of facility management is to get a model that aids their daily work. However, the way to reach a good facility management model should be quite similar to the way of getting good

projects, what should be needed is a focus on the final deliveries throughout the whole process development.

In order to get good BIM projects is standard processes and agreed protocols a key. Additional, is proper education important, so the involved persons can handle their responsibilities. Another aspect is that the level of detail within a BIM project is almost endless which makes a set level of ambition important to control so everyone has the proper detail and design costs are kept on a reasonable level.

During the setting of processes and protocols there are several issues that need to be kept in mind. The first is to decide who is the owner of the model and is responsible for changes during and after the project, this is extra important though efficient BIM is dependent on simultaneous design on drawings that are still work in progress. The second key issue is to define processes and information structures that overcome the interoperability issue. Security issues is also a key were processes needs to be developed to avoid to much damage if harmful software destroys the model or that copyrighted material are illegally extracted from the project.

Two other issues, that Jernhusen must overcome, are bound to the fragmented nature in construction. For BIM to be truly successful there is a need to change the traditional approach at which everybody looks at their own benefits, to one were the aim is good and profitable projects for all. The second issue is that BIM might disturb the market and knock out smaller actors that are not able to afford the investments bound to it.

Regarding if it is best to use some off the consultancy companies for BIM implementation or if Jernhusen should implement on their own is hard to decide, but it is important that no matter how they decide to proceed they do it with a wide picture, considering benefits they want to realise, hinders, other systems used in the organisation, their project process etc. in order to minimize the risk of harmful sub-optimization.

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INTERTERVIEWS

Berglund Dan, 2012-02-21, Technical facility manager depots, Jernhusen's office Gothenburg, ~40 min.

Björkman Josephine & Nygren Anna, 2012-03-26, Head of Transactions, Business manager transaction, Jernhusen's office Stockholm, ~20 min.

Blomdahl Thomas, 2012-03-16, Technical facility manager depots, Jernhusen's office Hagalund depot, ~30 min.

Bogen Odd, 2012-03-27, IT-manager Ramboll, Ramboll's Office Eskilstuna, ~100min.

Dahlgren Michael, 2012-03-02, Economical manager stations, Jernhusen's office Gothenburg, ~50 min.

Danielsson Jan-Erik, 2012-03-15, Energy and technical coordinator stations, Jernhusen's office Stockholm, ~55 min.

Fagerstedt Johan, 2012-03-16, Technical facility manager stations, Jernhusen's office Stockholm, ~40 min.

Gunnefur Ola, Hultberg Håkan & Tjerngren Joakim, 2012-03-08, Economical facility manager stations Malmö, Project manager, Technical facility manager Malmö, [Group interview], Jernhusen's office Malmö ~110 min.

Hansen Lennart, 2012-03-14, Technical facility management stations/ Project manager drawing archives, Jernhusen's office Stockholm, ~70 min.

Honkonen Richard, 2012-02-23, Head of facility management stations region south, [Phone interview] Gothenburg, ~20 min.

Johansson Klas & Magnusson Annika, 2012-03-14, Head of department of sustainability, operation development, [group interview], Jernhusen's office Stockholm, ~25 min.

Johansson Robert, 2012-02-21, Technical facility manager depots, Jernhusen's office Gothenburg, ~80 min.

Kajbring Anders, 2012-03-26, Economical facility manager stations, Jernhusen's office Stockholm, ~50 min.

Mattson Charlotte, 2012-02-22, Technical facility manager stations, Jernhusen's office Gothenburg, ~50 min.

Moberg Urban, 2012-03-15, Technical facility manager goods, Jernhusen's office Stockholm, ~60 min.

Monsén Daniel, 2012-03-28, CEO Monsén Architecture /Senior BIM advisor [lunch], Mornington hotel Stockholm, ~60 min.

Rydberg Tony, 2012-02-21, Technical facility manager depots, Jernhusen's office Gothenburg, ~30 min.

Sahlberg Håkan, 2012-03-15, Head of technical facility management depots, Jernhusen's office Stockholm, ~70 min.

Sjögren Eddy, 2012-02-29, Technical facility manager stations, Jernhusen's office Gothenburg, ~30 min.

Vestin Cecilia, 2012-03-26, Head of facility management north, Jernhusen's office Stockholm, ~30 min.

Zackrisson Ralf, 2012-02-23, Project manager, Jernhusen's office Gothenburg, ~80 min.

Åstrand Magnus, 2012-03-28, Head of consults, CAD-Q's office Solna, ~70 min.

FIGURES:

2.1: Hartmann, T., Fischer, M., (2009): A process view on end user resistance during construction IT implementations.

4.1: Gökstorp, M., (2012): made for the report.

4.2: Gökstorp, M., (2012): made for the report.

4.3: Sahlberg Håkan, interview 2012-03-15.

5.1: Monsén Daniel, interview 2012-03-28.

Attachment 1

Inledning

Namn?

Titel?

Roll i företaget?

Projekt/ processer som den intervjuade är inblandad i?

Hur stora är dessa projekt (Ungefärlig budget)?

Förvaltning i nuläget

Vilka områden är ditt fokus i förvaltningsskedet?

Vilken information har du att tillgå just nu för att göra ditt arbete så effektivt som möjligt?

Vad ser du som de största hindren för en effektivare förvaltning?

Hur ser du att dessa hinder överkommes om möjligt?

Förvaltning med BIM

Vilken information anser du vara absolut minimum för dig som förvaltare?

Vilken övrig information skulle du behöva för en effektiv förvaltning?

Förvaltning tidigare inblandad i projektering

Det finns önskemål från projekteringssidan att få förvaltningen mer inblandad i de tidigare skedena av projekteringen

När kommer du in i projekten? (förstudie, design o projektering, byggnation, färdigt bygge)

Tror du projekten skulle tjäna på tidigare inblandning från er förvaltare?

Vad skulle krävas för att ni skulle bli inblandade tidigare (från förvaltning samt från projektering)?