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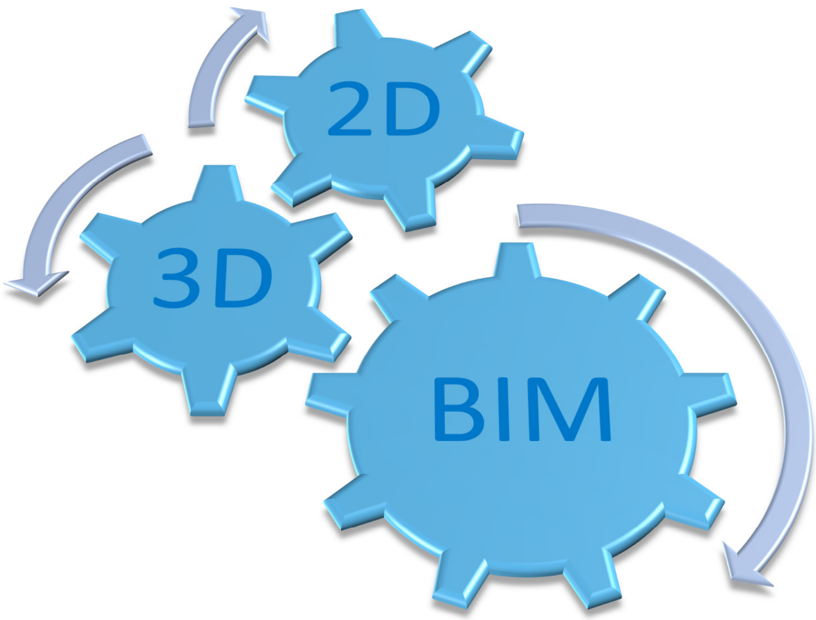


# BIM in the production phase

## Views, opinions and expectations from the construction industry

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

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ABSTRACT

Designing and building large structures is a complex process which involves the creation and processing of vast amounts of information that has to be managed and communicated to various stakeholders. One attempt to do this within the construction industry, to gather information about its products and transform from analogue to digital construction, has been labelled BIM. In the design phase of a project, designers can assign detail product information about objects which then is merged into a 3D-model. This model is perceived as a starting point for BIM and a further conception is that it also should pose as a database of project information. So far, the design phase has been given the most attention in the matter of development, but after this stage usage quickly decreases. Therefore this thesis focuses on an organisation that is on the verge of implementing BIM in the production phase. This study investigates a larger construction company, a major actor within the Swedish market, and it is based on a case study where the roles of interest are those of supervisor and BIM-coordinator. The aim is to present areas in which an organisation ought to engage from a supervisor's point of view and map out expectations on BIM from the production phase. Findings include that when introducing BIM, education and 'proof' in the form of hard facts, i.e. profit, is required and additionally the studied organisation's own view of BIM needs to be communicated. Further areas of significant interest to supervisors are presented, for example software licences, however these should not be regarded as generally applicable for BIM in the construction industry. Rather, these might be seen as guidelines and indications to other companies while they ought to be considered important areas of interest for the studied organisation.

Key words: BIM, Information Management, Information Resource Management, Information Logistics, production

BIM i produktionsfasen
Visioner, åsikter och förväntningar från byggsektorn
Examensarbete inom Design and Construction Project Management
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SAMMANFATTNING

Att rita och producera stora och avancerade byggnationer är en komplex process som kräver både skapande och hantering av enorma mängder av information som måste kontrolleras och styras till ett antal intressenter. Byggindustrin har på senare tid försökt att ta efter bil- och flygplansindustrin och fånga all produktinformation på samma ställe, och resultatet kallas BIM. Konceptet som sådant utgår ifrån att projektörer tilldelar olika komponenter digital information och dessa blir sedan sammansatta till en 3D-modell. Denna modell ses som grunden för BIM användning och tanken är också att den skall fungera som en databas som information kan hämtas ifrån. Som det ser ut idag används BIM främst i projekteringen av ett projekt men efter denna fas minskar användandet snabbt. Detta examensarbete fokuserar därför på en organisation som är på väg att introducera BIM i produktionsfasen. Denna studie riktar sig mot ett större byggbolag, som anses vara en ledande aktör på den svenska marknaden, och resultaten hämtas från en fallstudie där de intressanta rollerna är arbetsledare och BIM-koordinatorer. Målet är att presentera områden inom vilka organisationen i fråga bör satsa på enligt arbetsledare samt att kartlägga förväntningar på BIM från produktionsfasen. Resultaten innefattar bland annat att när BIM introduceras krävs utbildning och konkreta siffror som visar på vinst. Vidare områden som arbetsledare finner intressanta presenteras, till exempel mjukvarulicenser, dock bör dessa inte ses som generellt applicerbara för byggbranschen i sin helhet. De kan ses som riktlinjer och indikationer för andra företag men bör anses högst relevanta utvecklingsområden för den studerade organisationen.

Nyckelord: BIM, Information, Informationsstyrning, produktionsfasen

# Contents

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Thank you!

Göteborg May 2012

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# List of abbreviations

BIM – Building Information Management

BIM – Building Information Model

BIM – Building Information Modelling

CAD – Computer Aided Design

IL – Information Logistics

IM – Information Management

IRM – Information Resource Management

PSD – Plan for Site Disposition

# English – Swedish dictionary

As-built – Relationshandling

Construction documents – Bygghandlingar

Design phase – Projekteringsfasen

Designer – Projektkör

Facilities Management phase – Drift och underhållsfasen

Plan for Site Disposition – Arbetsplatsdisposition

Production phase – Produktionsfasen

Subcontractor – Underentreprenör

Supervisor – Arbetsledare

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# 1 Introduction

Data can be defined as raw facts or figures, yet to be analysed by someone, while information is a collection or set of specific data put into a context (Boddy *et al.*, 2005). In the construction industry projects are built upon these fundamentals and pose as essentials for organisational progress. Jagersma (2011) recently noted that large organisations harbour huge amounts of information, but few exploit this effectively. Prior to this, Goedert and Meadati (2008) held that one way to control loads of information and make sure of its accuracy is by adopting information management systems, although in the case of the construction industry this is not working satisfactory.

The process of developing new and efficient systems to gather as well as manage information results in different outcomes and Watson (2011) argued that development based on, and aided by, information technologies will play an important role in this process. Information is increasingly being managed digitally and within the construction industry, the attempt to follow the aircraft and automotive industries in their transition from analogue to digital construction, has been labelled BIM (NIBS, 2012).

The founding ideas of BIM were anticipated during research in the late 1970's (Howard and Björk, 2007), and in the following decade software developers emerged and begun releasing CAD tools (Eastman *et al.*, 2011; Zyskowski, 2008). Over time, development advanced from CAD into 3D-drawings and eventually 3D-models and information databases emerged (Barlish and Sullivan, 2012). In the design phase of a construction project, designers assign detailed product information about objects which then is merged into a 3D-model. This model is perceived as a starting point for BIM and a further conception is that it also should pose as a database of information (Eastman *et al.*, 2011). The collection of information on a building gathered in one place is believed to enable a better view of a product and increased productivity (Azhar *et al.*, 2007) and recently Singh *et al.* (2011) held that BIM also enables improved collaboration and communication between project stakeholders.

The origins of BIM might have been vaguely formed and discussed decades ago but it is not until recently that these ideas are starting to be realised. Thus far development of BIM has progressed in an ad hoc manner with no real industry consensus (Azhar *et al.*, 2008), but it is recognised that the focus area for BIM development has been that of the design phase (Bentley Systems Inc., 2012). In contrast, BIM in the production phase has received much less attention and as a result, usage quickly decreases (Goedert and Meadati, 2008). With the above in mind, this particular thesis focuses on the introduction of BIM in an organisation and the expectations on the concept, such as it is perceived by a set of predefined roles connected to the production phase.

## 1.1 Aim

This thesis targets information needs and demands from individuals in the production phase when an organisation finds itself in the early stages of BIM implementation. The aim is to present areas in which an organisation ought to engage from a supervisor's point of view and map out expectations on BIM in the production phase. In order to do this, two research questions must be investigated.

### 1.1.1 Research questions

1. What are the expectations on BIM from production phase supervisors?
2. What kind of information is required regarding BIM when introducing it at a construction site?

### 1.1.2 Research objectives

To answer the research questions, four objectives have to be obtained.

1. Investigate different views and opinions of BIM in the construction industry.
2. Examine applicable literature related to the subject of information regarding its management and distribution.
3. Review literature from academic sources regarding various aspects and perceptions of BIM.
4. Perform a practical evaluation of existing problems related to the flow of information in projects using BIM.

## 1.2 Scope

This study investigates the housing division in a large construction company on the verge of engaging in the field of BIM. Focus in the thesis is on the production phase where the role of interest is that of construction supervisor. To verify or question expressed views from the production phase, a role connected to the design phase is also to be studied, namely that of a BIM-coordinator. Furthermore, the phase of facilities management is excluded because of BIMs limited usage in production.

The development of new standards or technologies will not be included, neither will there be an extensive discussion regarding the use of different software. Rather, this thesis aims to present indications of areas in which the studied organisation ought to engage when fully introducing BIM in the production phase.

The importance of how to practically perform the implementation of BIM is recognised by the authors, but it is considered wide enough to be a research topic of its own. Since focus for this thesis is on information and needs surrounding BIM, implementation will not be discussed more than briefly.

## 1.3 Structure of thesis

To enable readers to quickly locate areas of interest, this section briefly describes each chapter and their contents.

Chapters Two and Three contain the theoretical framework that presents studied literature within the two main areas of interest. The aim is to provide a basic understanding of information and its importance to BIM as well as introduce and clarify the concept as such.

Chapter Four briefly describes a number of different methods that could be used when undertaking research in this particular area. The method of choice is explained further to create an understanding of why it was chosen as well as give the reader the possibility to weigh results presented in the thesis.

Chapter Five introduces the studied organisation used in the practical evaluation. The main part of the chapter presents the organisation's official views and intensions with BIM.

Chapter Six present findings from the case study performed within the chosen organisation. The presented results regard the areas of chapters Two and Three while other findings are excluded.

Chapter Seven is the discussion where findings from the case study, with reflections and opinions from the authors are compared and evaluated in support or contradiction to reviewed literature.

Chapter Eight presents conclusions from the study. The research questions are answered and relevant topics that were encountered during the case study are evaluated and concluded. The thesis ends with questions for further research.

# 2 Information utilisation

This chapter introduces the subject of information: what it is, why it is important and how organisations should make use of it. It presents theoretical areas which could be seen as foundations for BIM and why information is an important part of the concept.

## 2.1 Definition of information

In literature, data is described as recorded things, events, activities and transactions including characteristics such as values, numbers and digits (Body *et. al*, 2005). In Boddy and Paton (1998), it was described and exemplified as raw and as of yet unanalysed facts, figures or events. All these facts may or may not have a meaning to a person; it all depends on the situation at hand. Boddy *et al.* (2005) then went on to describe information as a collection or set of data that has a meaning to someone; it might be important because of its usefulness in a given context or simply be of significant interest for any reason. The result of using interpreted data as information ends up in someone gaining knowledge. The difference between the two is that while information belongs to the things being described, knowledge is a 'property of people' (*ibid.*). In order to acquire knowledge from information it should be of high value; meaning it is reliable, well timed without flaws or errors, accurate and relevant for the one receiving it (Boddy and Paton, 1998).

The IT revolution and increasingly interconnected industries has brought vast increases in information volumes, making organisations work under something akin to an information overload (Jagersma, 2011). As an example, a solution to a problem might already exist within an organisation, but it becomes lost in the disorder of information within a system (Strömfelt, 1990). Information is not only an issue to solve through technological innovations; people have to start managing information rather than regarding it as something of a technological issue (*ibid*). Furthermore, Best (2010) argued that information is manageable if it is created for a reason to make a contribution to organisational purposes and that the connection between information and reaching a defined purpose is either observable or measurable. By doing this efficiently enough, organisations end up getting more efficient internal processes and better integration with their surroundings (Boddy *et al.*, 2005).

## 2.2 Information Resource Management

The Information Resource Management (IRM) approach implies that an organisation should be able to control necessary resources to assure that the need of information is satisfied across the entire organisation (Bryce, 2007). In addition, IRM targets the overall use of information in an organisation (King and Kraemer, 1988), and makes it possible for a central storage of information, regardless of the context in which to use it (Bryce, 2007).

Information should not be ignored as a critical asset to an organisation (Reponen, 1993; King and Kraemer, 1988), and it could be argued that it should be managed as a resource equal to land, money and labour (Eaton and Bawden, 1991). Best (2010) argued that there has been an increase of titles such as 'Information Resource Manager' and 'Information Coordinator' and Trauth (1989) argued for a 'Chief Information Officer' in the upper regions of the organisational hierarchy.

However, since the value of information depends on context and the reason for its use, it is hard to agree whether it is beneficial to collect and store all information available (King and Kraemer, 1988), and it might be argued that IRM is more about management of data (Mutch, 1996). Altogether, either organisations view information as a resource like any other, such as labour, or simply declares that there is an awareness of the importance of information (Eaton and Bawden, 1991).

## 2.3 Information Logistics

With the great amount of information available today, it might be difficult to find exactly that one piece of information which is searched for (Sandkuhl, 2008), and as databases for information grows within organisations it is getting even harder (Jagersma, 2011). An easy and simplified way to describe Information Logistics (IL) is to compare it to the theory of 'just-in-time' material deliveries. The idea is to provide only relevant information that a user needs at a given time and location (Vegetti *et al.*, 2007; Heuwinkel *et al.*, 2003; Oulton, 1990). Sandkuhl (2008) later added that delivery of information with the right quality is an important attribute to the concept.

To be able to realise IL, it is important to organise information in ways that enable individuals to access the right information (Badii and Sharif, 2003), which in turn demands that an individual knows what information is needed for a specific task (Sandkuhl, 2008). Retrieval of relevant information is vital when making decisions or solving problems (*ibid*), and by using IL techniques an organisation could allocate and synchronise information to improve its quality towards customers (Jagersma, 2011).

It is easy to claim that the right information should be provided. However, since individual requirements vary and change over time, it is problematic to determine what those are between different users (Sandkuhl, 2008). There is additionally a need to determine in which context particular information should be used and to question if information is relevant in that specific situation, which could only be done by a person familiar with the area of utilisation (Oulton, 1990 and Strömfelt, 1990). This requires the person distributing information to be familiar with the status of the receiver. Additionally, there is a risk that the information needed does not exist within the organisation, and if it does, the user might still not be able to access it (Sandkuhl, 2008).

## 2.4 Information Management

Designing and building large structures is a complex process that involves the creation and processing of huge amounts of information, which has to be governed and communicated to various stakeholders (Collinge *et al.*, 2009). The subject of information management could simplified be described as managing a structured database of information vital to an organisation (Reponen, 1993). Further definitions are:

> *"The economic, efficient and effective coordination of the production, control, storage, retrieval and dissemination of information from external and internal sources, in order to improve the performance of the organisation."* (Best, 2010)

> *"The management of the processes and systems that create, acquire, store, distribute, and use information … A good information management program in an organization will manage the full lifecycle of information ranging from creation to use."* (Detlor, 2010)

Detlor (2010) also separated the organisational information management from the personal ditto. Information management at the organisational level includes the whole lifecycle of various processes ranging all the way from initial idea to the delivery of a product as well as maintenance. The personal perspective is narrower; personal information management is more about day-to-day usage and it is work-specific and does not place an organisation's needs in top priority (*ibid*).

From the sections above it is clear that a key challenge for organisations is to channel information to locations in need of it. By doing this, it is possible to avoid overloading a work site with unnecessary information or data. However, this is easier said than done when needs constantly change throughout projects, which in turn might argue for an organisation collecting information and structuring and storing it similar to a library for its members to use over time. One way to do this might be by combining Information Management, Information Logistics and Information Resource Management; provide a database with relevant information that stakeholders can access and retrieve when needed. In the construction industry this could possibly be done through BIM.

# 3 BIM

This chapter contains a brief introduction and historical overview of BIM and how different segments within the construction industry define the concept. Positive and negative aspects of BIM as presented in the literature are outlined and finally summarised in a table at the end.

## 3.1 History and basic features of the concept

The fundamental ideas of BIM were anticipated during research in the late 1970's and started to grow in the mid 1980's as a result of the Standard for the Exchange of Product [model] Data (STEP), which aimed at solving issues related to the transmitting of data throughout several industries (Howard and Björk, 2007). During this period and several years thereafter computer software developers emerged and begun releasing CAD tools (Eastman *et al.*, 2011; Zyskowski, 2008). The technological development advanced from being paper based into computers aided design and digital 2D drawings. From this, software was continuously developed and as a result 3D drawings started to emerge and later posed as a foundation for 3D-models and information databases (Barlish and Sullivan, 2012).

BIM is to a great extent based on these 3D-models which are created during the design phase where designers add parts and put them together to shape a building in a virtual environment. Eastman *et al*. (2011) held that BIM transfers construction from drawings and spread-sheets into a process of collaborative and coordinated efforts between its actors and enables the capturing of information. Prior to this it was explained that:

> "*BIM represents real world elements such as walls, doors, and windows as three-dimensional (3D) objects. In addition to geometry details, other information can be attached to these objects including manufactures, fire rating, schedule, and cost estimates*." (Goedert and Meadati, 2008)

The steady development of increasingly sophisticated software, that enables construction companies to put ever more detailed information into digital representations, has served as a source for radical ideas. Some actors within the industry see BIM as a solution to numerous challenges and obstacles encountered in construction projects. Below is a quotation, presented as a utopian ideal that illustrates some of these ideas:

> "*…build a single data-rich model containing architectural, MEP and structural elements and all the drawings will be produced automatically – plans, sections, the quantities, the renderings, the costings and even perhaps the energy certification*". (Day, 2011)

Notwithstanding the seemingly overwhelming potential of BIM it is still currently in the early stages of development, and there are many different views and opinions throughout the industry of what it really is.

## 3.2 The ambiguous nature of BIM

Today the development of BIM is uncertain and the concept is currently in a situation best compared to a 'trial and error phase'. It continues to develop according to different specific needs (Azhar *et al.*, 2007), and how BIM is defined and what it means varies between professionals in the industry (Sebastian, 2011; Sing *et al.*, 2011). Some see the acronym BIM as standing for Building Information Model (or Modelling), while others refer to it as Building Information Management. There are also those that prefer not to use the label BIM at all; contractors on the Swedish market have instead begun talking about Virtual Construction or Virtual Design and Construction (Köhler, 2011a). In a survey performed on 440 people working in the Swedish construction industry the answers regarding the meaning of BIM varied from "*what is BIM?*" to "*BIM is the future, and the future is already here*" (Hindersson, 2011a).

The variety of abbreviations and translations indicates some uncertainties and an ambiguousness of the concept. BIM is not only about creating 3D-models, nor is it a database with a bundle of information. These opinions are not essentially wrong, rather BIM is a combination of both, and more (WSP Group Sweden, 2010). To clarify the situation somewhat, the sections below will present views and opinions about BIM as it is presented in literature.

## 3.3 Arguments for BIM

The larger and more complex a project gets, the more extensive the demand for information. In construction, this information has historically been channelled and communicated through 2D-drawings and volumes of documents on bookshelves and databases. A major driver for implementing BIM is the possibility to collect and distribute information from one single place, for all actors to access whenever they want. BIM is in this context seen as an information database from which to extract and use vital material at any time (Sebastian, 2011), and this could additionally be provided in a format that fits various stakeholders (Goedert and Meadati, 2008). For example, Davis (2007) proposed that the reutilisation, rather than the recreation, of information would not only reduce waste but also raise the quality level of a building. Such arguments have further been supported by amongst others Azhar (2011) who also discussed the importance of reusing information and added that BIM is the way to do this efficiently.

Some of the above arguments are based on the assumption that when shaping the idea of a building and creating its model, it is possible to assign detail information to selected objects. Depending on the quality and quantity of details that are put into a model, BIM enables the possibility to extract accurate estimates of material from within (Azhar *et al.*, 2007). In addition, when information is changed within a model, the alteration is updated throughout the system (Watson, 2011), which makes it possible for designers to continuously change and add features. Eastman *et al.*, (2011), held that project participants can respond to changes made by designers and clients in real time. Information about alterations can be channelled through a model and then be reviewed as well as analysed by affected actors.

Using a 3D-model as starting point, the concept is commonly portrayed as having the potential to enable better communication between the phases of design and production (Olatunji, 2011; Watson, 2011; Azhar *et al.*, 2008), and the development is seen to have brought advantages such as increased coordination of work and decreased costs (Digital Drafting Systems, 2012). In addition, Singh *et al.* (2011) stated that BIM provides a basis for better interaction and collaboration between stakeholders. An argument showing that collaborative efforts could prove profitable was given by Cannistraro (2010), who claimed that such initiatives might save as much as 20% of project finances.

BIM is seen to be profitable throughout the whole lifecycle of a project. When looking at the design phase, WSP Group (2012) claimed that gains have been recognised in the form of reduced alterations and rework caused by information losses, which in turn has generated increased savings in projects. This is to a large extent due to clash controls when designers revise and control their information, avoiding contradicting drawings and possible collisions, thus making sure that contract documents are accurate. Moreover, case studies have shown that investments in BIM can be profitable for an organisation in terms of Return on Investment (ROI), as shown by Azhar (2011) and Azhar *et al.* (2008).

Turning to the production phase, BIM is seen as a way of increasing quality, control over schedule and monitoring of costs (Digital Drafting Systems, 2012). Another advantage, as expressed by Jongeling *et al.* (2011) as well as Gu and London (2010), is the possibility to use BIM in the phase of facilities management. This argument was further supported by Watson (2011) who suggested that 3D-models have an extended use past the construction phase with the explanation that changes are diffused throughout a model which gives facilities management accurate documentation.

Further benefits recognised in the pro-BIM literature are the possibilities for four-dimensional planning which enables the establishment of a more comprehensive visualisation of project progress (Azhar *et al.*, 2008). A potential result is a better utilisation of land available as well as more effective deliveries of materials. Cost is often referred to as the fifth dimension in BIM, but according to WSP Group and Kairo's Future (2010) the concept could include so much more, and potentially evolve into a stage of nD-modelling. The opportunity to add information and link this to a model makes for vast possibilities:

> *"BIM will contribute to a higher degree of prefabrication, greater flexibility and variety in building methods and types, fewer documents, far fewer errors, less waste, and higher productivity. Building projects will perform better, thanks to better analyses and exploration of alternatives, fewer claims, and fewer budget and schedule overruns."* (Eastman *et al.*, 2011)

## 3.4 Challenges with BIM

Flipping the coin and looking at some challenges to the concept, there are aspects that need consideration. Perhaps the most fundamental of these is the notion of that there is something embedded in the construction industry that creates resistance when changing people's way of working, in turn affecting new ideas such as BIM. New solutions to old problems fail when people in the generally conservative construction industry prefer to do things 'the way they have always done it' (Hammond, 2008). WSP Group Sweden (2010) portrayed this as a lack of will and interest. Hindersson (2011b) argued that there is a shortage of knowledge about the concept among employees working in BIM projects. This statement is echoed by Eastman *et al.* (2011) who held that what really makes it problematic is lack of training and motivation of personnel. Employees have low BIM-education and their views do not necessarily align with those declared by an organisation, which in combination with a shortage of experience and on-site knowledge creates something akin to a bottleneck situation (*ibid*). Singh *et al.* (2011) also explained the situation as something of a 'status-quo loop' where people lack appropriate knowledge and subject awareness, which makes them reject the notion of adopting new BIM-based collaboration, with the result that BIM-knowledge is kept low. Many of these arguments can be characterised by an overriding assumption that if only the people involved received sufficient training they would surely see the light and fall into line, and start using BIM.

An additional explanation to the 'conservatism' is institutionalised practices. For example, Gu and London (2010) claim that 2D drawings are still considered trade praxis when it comes to sharing and distributing information. This is one of the reasons for a delay in the acceptance of 3D-models. Paper drawings are legally binding construction documents while information within a 3D-model is not (Köhler, 2011b). Indeed, there are a number of legal issues still to be resolved (e.g. Ferguson, 2009; Azhar *et al.*, 2008; Post, 2008; Azhar *et al.*, 2007). As an example it is hard to establish who actually owns a 3D-model when several actors modify different components contained therein. These parts are owned by their creators, while the model itself could be owned by the client (Azhar *et al.*, 2007). Additionally, by using one model into which several participants add or change information over time, it might be questioned who should be held responsible if something goes wrong (McAdam, 2010).

It is obvious that a number of stakeholders have an opinion in legal issues and therefore Azhar *et al.* (2007) discussed the issue of who should be developing BIM and how added costs are to be distributed over industry stakeholders. Day (2011) extended the discussion in an analysis where contractual structures not sufficiently reflected risk/reward arrangements. It was additionally claimed that before being able to reap the benefits of BIM, firms have had to go through several non-profitable projects in the process. In other words the concept does not always create solutions to existing problems; instead it might create new issues that need to be solved. An example of a problematic situation using BIM is discussed by Day (2011) and Eastman *et al.* (2011), who argued that there is a difference between the architectural model and the model used for construction. The explanation for this was that geometries contained in both models might be the same, but relevant information varies.

An issue for not only an individual organisation, but also the industry as a whole, is that of software compatibility. National and international competition laws make it difficult to dictate the use of one common platform. A standard could provide a foundation from which to plan a building, using standardised items and processes that are agreed upon by united industry actors and governments. Some software developers create BIM technologies only compatible with a few others or just their own, causing problems for aligned development when contenders have separate agendas for how to improve the business and its standards (Köhler, 2011c; Gu and London, 2010; WSP Group and Kairo's Future, 2010).

The ideas of a standard were formed with the STEP initiative and later on developed when Industry Foundation Classes (IFC) emerged and there are currently more initiatives to create some kind of standardised procedures, but none of these are neither widely used in practice nor accepted by the industry (Howard and Björk, 2008). This could prove dangerous since information in general is becoming more and more digitalised and one ought to remember that information should be accessible not just today and tomorrow, but also in the future, which could be difficult with varying formats (WSP Group and Kairo's Future, 2010).

Even though the idea of BIM holds a lot of promise, the industry is still far behind the ideals that have been around since the '1970s (Howard and Björk, 2007). In addition, Goedert and Meadati (2008) proclaimed that BIM is frequent in the design phase but usage drops rapidly in the later stages of construction. Azhar *et al.* (2008) held firm that BIM adoption is slow in uptake and argued that there is no consensus within the industry of how to practically perform this implementation. Notably, Post (2008) reported from an interview with leading industry professionals that it is still close to ten years before the design discipline will be fully shifted to BIM.

## 3.5 Where is BIM heading?

Clearly there are both appealing aspects of BIM as well as challenging obstacles still to be solved. The table below groups and gathers key subjects from both sides.

*Table 1: Summary of positive aspects and challenges with BIM.*

| Positive aspects | Challenges |
|---|---|
| • Increased collaboration between actors within the industry<br>• Making communication of information easier between stakeholders<br>• Accurate construction documents from the design phase<br>• Visualisation of a project in a virtual environment before construction<br>• Accurate information throughout a project lifecycle, including design-production-facilities management<br>• Capturing of multiple dimensions beyond the standard 3D-model | • Complicating legal issues regarding documents and ownership between stakeholders<br>• Difficulties deciding responsibilities among participants<br>• The ability to trust information in 3D-models is lacking<br>• There is a low level of education within the industry as a whole<br>• Bad compatibility between different software<br>• Various degrees of maturity and no aligned development of BIM |

Howard and Björk (2007) claimed that the initial struggles with BIM might be difficult, but necessary for the concept to evolve and Eastman *et al.* (2011) as well as Suerman (2009) held that organisations have to change their processes to adapt to this development. BIM is by many seen as the next big thing within the construction industry although today it is not adapted to the way the industry previously has, or presently is, working (Day, 2011). Opinions are also divided on the impact that BIM has and could have on the industry. Some authors, e.g. Singh *et al.* (2011), proclaim that BIM has the potential to fundamentally change how construction is documented and performed. Others, such as for example Watson (2011), are more moderate in their views and argue that it is currently more of a foundation for development and a base for future attempts to create digital as-builts. It is not possible to state in which direction BIM progresses or if some kind of new concept will appear and become dominant, but IT-based aid will certainly be a part of the future in the construction industry.

# 4 Methodology and research design

Research can be conducted in many different ways, and in order to achieve aims and objectives of a thesis, a number of different approaches can be used. The main method used in this research is a case study. The steps taken in the research and thus forming the research design are:

- Pre study: With the aim to create basic knowledge about the opinions of BIM existing in the construction industry, a pre-study was performed. It consisted of a few unofficial interviews with academic researchers together with a short review of trade magazines. The results are incorporated in the literature review chapters, thus fulfilling research objective one.
- Literature review: Bryman (2008) explained the aims of a literature review to be several: the gathering of information about what is already known in a certain field to avoid doing unnecessary work, what theories are further applicable to a given subject and also the possibility of finding further research topics or questions related to the one at hand. In performing a literature review researchers can work to avoid the risk of being accused of plagiarism and this type of study is important to be able to analyse findings from for example case studies (*ibid*). Through this review, research objectives two and three were obtained.
- A *case study* is used when there is a need to observe a phenomenon in its natural settings and be able to understand current situation (Eisenhardt, 1989). This type of qualitative research is used to extract large volumes of in-depth information from a small number of sources, commonly through interviews (Cavaye, 1996). Therefore a case study was conducted in order to observe the subject of information as well as BIM in projects.

## 4.1 The chosen method for practical evaluation – a case study

The aim of a case study is to get an understanding of the dynamics present within a certain setting (Eisenhardt, 1989) as well as contribute to knowledge by connecting theory possible to generalise with findings from the study performed (Cavaye, 1996).

Gillham (2000) explained that when starting a case study a broad focus area should be defined and the aim to be achieved should not be too narrow. One or several research questions should be investigated with the intent to find raw data from different sources; the more sources that are used, the deeper and more extensive findings can be made. These questions can be changed or increased in numbers during an investigation with the argument that a wider set of questions are needed to be able to fulfil the purpose of the research. The unanalysed data should then be put into a context and analysed within this, which then forms a part of the foundation for realising the research aim (*ibid*).

Benbasat *et al.* (1987) made a distinction between a case study and other types of research and held that that prior knowledge in a subject does not have to be of a high level. A typical feature for case studies is that it could be seen as a combination of for example interviews and observations (Eisenhardt, 1989), and the investigated units can be a person, a group or an entire organisation (Benbasat *et al.*, 1987). Cavaye (1996) stated that positive features of a case study are, among others, that one can study a topic in its natural context and observe various aspects of a phenomenon without them being previously defined. However, a constraint is that one should not try to generalise findings from a case study to an entire population and although patterns might be observed in findings, one cannot always determine their origins (*ibid*). Finally, it is important to evaluate findings from studied objects and critically regard these; why or why not the answers given are in line with the research questions (Gillham, 2000).

## 4.2 Case study design

An initial understanding of the topic area and the articulation of issues of interest was formed incrementally during the pre-study and literature review. This in turn served to form the basis of the case study design highlighting the kind of information sought after. A series of questions were created that were then merged into a draft interview template. An initial interview to rule out irrelevant questions was performed before forming the final template. When used in the case study it was divided into four parts: three consisted of open questions while the fourth part contained statements for interviewees to either confirm or contradict. The interviews had duration of at least one hour and were semi-structured with one person leading and taking small notes while the second focused on writing. Directly after the interviews all notes were summarised as findings in a document and sent to the interviewees for them to revise and approve of. Those neglecting to approve or disagree within a given time were treated as having given a silent approval, unless they had expressed a wish for an extended time period.

All interviewees worked within the same organisation, as further presented in Chapter 5, as either *supervisor* or *BIM-coordinator*. In all, seven supervisors and four BIM-coordinators were interviewed. To avoid the risk of result biases due to local conditions the projects visited were spread over separate regions in Sweden and altogether a total of six different housing projects were visited during a time period of four days in March 2012.

The supervisors were interviewed in order to collect and analyse impressions of BIM in the production phase such as they perceive it today. All interviewees referred to as supervisors throughout this thesis were either currently or previously employed as such within the studied organisation. Responsibilities of the role include, among other things, to control and make sure that construction progresses according to time plan. Further areas are management of labourers, deliveries of material and otherwise making sure that personnel have all necessities for construction. Standard operations are information distribution and communication, measuring amounts of material and site planning. The supervisor serves as the connection between upper site management and labourers.

The BIM-coordinators were all currently employed for that purpose, but with varying degrees of involvement in the production phase. They were interviewed in order to verify and clarify answers from supervisors and to gather aspects and input from the design phase. When starting a new project a design manager and a BIM-coordinator set a target vision, a BIM plan, and then it is decided to which extent BIM will be used. This decision depends on the knowledge and commitment by the people involved as well as demands expressed by clients. The role is mainly about managing different designers, producing viewable 3D-models and making sure they contain correct information. When a complete model is produced a BIM-coordinator performs clash controls together with involved designers, controlling that nothing clash and otherwise making sure that problems are dealt with. Additionally, a BIM-coordinator produces digital viewpoints for employees in the production phase to observe in a DWG-viewer.

# 5 Case prerequisites

In the following chapter the case study organisation is first introduced and attention is then turned to how the organisation officially interprets BIM. Information within subchapters is gathered from researching the company's internal documents. Some clarifications were given by employees at the department for technical support when needed.

## 5.1 The chosen organisation

The case study organisation, from now on referred to as 'CC', is one of the largest construction companies active in Sweden and it is widely considered to be one of the leaders in the markets in which it is active. The organisational structure of CC could be compared to a matrix organisation with different divisions, focusing on for example housing and infrastructure, supported by departments such as Human Resources and process support. A majority of the organisational divisions have regional offices, with additional local offices that focus on projects in specific areas of Sweden.

## 5.2 CC's view of BIM

There has been a steady development within CC towards a more BIM-oriented practice since 2007. Some market competitors have chosen to quickly acquire new technologies while CC has placed main focus on developing its processes. The aim is to create a long term advantage against rival actors due to a solid theoretical foundation and thoroughly evaluated processes. CC has an expressed view from the senior executive team to substantially increase BIM engagement in construction projects, and since 2011, the organisation has introduced a new policy on the housing department that all turnkey contracts exceeding SEK 50 million shall use BIM. A special unit within the technology department is coordinating BIM development and initiatives throughout the Swedish market.

In CC's view BIM means Building Information Management with the argument that information as the primary word in B-I-M, the organisation works actively with this and tries to find ways to manage it in the best way possible. The aim is to use specific information not only in the design phase but also throughout a project to completion and beyond, although when this thesis was written, BIM in the production phase was just about to be implemented.

To be able to control the above, and align development within the organisation, CC has focused on two basic features internally considered to be foundations for BIM:

- The 3D-model is regarded as a basic requirement upon which further features are dependant. It is meant to enable planners and production teams to see the same things and ease visual communication.

- Clash controls are based on the 3D-models with the aim to detect manufacturing errors, clashes and the optimising of available solutions. This is primarily to save money in the design phase and deliver accurate contractual documents to use for production as well as maintenance.

There are additional options available for clients to choose as add-ons in projects where BIM is to be implemented. Add-ons are chosen after the counselling of a BIM-coordinator and as of spring 2012 these consisted of following:

- Four-dimensional time and production planning is based on the merging of 3D-model and time plan. A model is created in which to observe the construction progress through the different stages and the added benefit is the ability to simulate different solutions and scenarios before taking important decisions.
- BIM on the construction site refers to the use of tablet-PCs to enable employees to better visualise and monitor that projects progress accordingly. Advantages from this option are a deeper understanding about on-going activities and the possibility for employees to perform mobile follow-ups.
- Material estimations from within 3D-models are considered to save time and to increase control over quantities. The assumption is that information assigned to a particular component makes it possible to automatically extract amounts of required material.
- Safety planning makes it possible to visualise and simulate risks involved in a project and enables early interventions to reduce risks which results in safe construction sites.

CC are also investigating other technologies still in the pilot stages, these include lifecycle cost visualisations, improved collision controls and information summaries for the continuous management of a completed project. Additionally, in the near future CC aims to widen the BIM concept with the introduction of model based purchasing, deliveries and quality assurance.

Gains from BIM implementation is recognised to be both fewer misunderstandings and work related accidents as well as a decrease in failed projects due to multiple disciplines being able to discuss and visualise project stages together. The involvement of a BIM-coordinator with knowledge about tools and technologies is seen as important to support implementation and future development within CC. The organisation is aware that there are further efforts needed for full BIM implementation and aims to establish a broader use of its basic BIM features and further develop the add-ons available.

# 6 Case study findings

This chapter covers findings from interviews performed during the practical evaluation. They are divided into three categories: ‘Information utilisation’, ‘Expectations and demands put on BIM’ and ‘Collaboration and development areas’. The first category presents the management of information on a construction site as it is currently performed while the second regards recognised needs and preconditions for BIM. Finally, the third part contains development areas for the studied organisation and the collaboration between the phases of design and production.

## 6.1 Information utilisation

Opinions related to the reviewed literature on the subject of information and connections to the situation of the supervisor are presented below. The aim is to provide a description of management of information on site as it is currently performed. The opinions referred to derive solely from employees currently working as supervisors.

### 6.1.1 Planning of resources and deliveries

The planning and allocation of resources is primarily performed by a supervisor although larger issues of concern are decided upon together with team leaders, labourers and in some cases subcontractors. Decisions made in a project are commonly published on whiteboards for stakeholders to review when needed. This current practise is satisfactory for all supervisors in the case study. However, a problem was identified regarding the work with updating multiple whiteboards accurately.

> *“The planning is done incrementally on whiteboards with narrower timescale in each step down to the level of detail showing actual location of labourers on site. There is always a risk of information not being transferred when going from one timescale to another.”* (Supervisor Three)

To clarify, information is not entirely lost; rather it is neglected or forgotten when relocating it from different boards. Notable is that the site office referred to in the above quote is separated from the labourers’ site cabins and so, accordingly, are the whiteboards containing the information.

In addition, the planning of important deliveries and milestones, such as framework and concrete for casting, is performed well ahead since the activities are time consuming and crucial for the overall production pace. These activities are considered vital and set milestones are in general performed as planned. However, as stated by Supervisor Two, for some reason it is difficult to plan smaller deliveries far ahead. The method of choice with whiteboards is, in its simplicity, useful in both situations.

Apart from the whiteboard, a PSD can be used to gain an overview of a construction site and enable planning under changing conditions and further identified areas of use are safety planning and site introductions. In addition, there is the possibility to plan both mobile and stationary cranes and their radiuses as well as the use of available storage areas throughout the construction site and prepare for upcoming deliveries.

If volumes of material do not cover actual need, supervisors have to order extra to reach required amounts to avoid the risk of delays to time plan. Large quantities of material are usually estimated beforehand, but supervisors have the responsibility to evaluate these and make sure that they are accurate, and the shared opinion is that they all too often have to recalculate these amounts. Furthermore, standard practice for this procedure has been to use either a view-only license of AutoCAD or paper drawings and scalar rulers, which has been questioned by the majority of supervisors in the study.

### 6.1.2 Information management in practice

Information is distributed from site office to employees by oral and written communication and morning meetings are generally held each day to review daily work and immediate concerns. These are backed up with larger, more thorough meetings once a week to cover larger issues such as logistics and planning for the overall construction as well as project progress. Additionally, information is transferred onto whiteboards in the site cabins as a way to ensure that it is available to concerned employees.

> *"Information is important, though not as important as a resource. It is possible to nurture a resource; personnel can be treated in ways to either increase or decrease its attitude, motivation and commitment. In that sense it (a resource) is alive while information is dead."* (Supervisor One)

The above quote is an example of a general opinion among supervisors on how to view information. They recognise that information is important to their role, although physical attributes that can be found on site, such as labour, quantifiable volumes and money, are more important. In connection to these discussions, the opinion that it all depends on what the information is used for, and in which context often surfaced.

### 6.1.3 Modifications and distribution of drawings

Modifications on site which deviate from drawings are common, although according to supervisors, this is seen as something that belongs to the industry. A common problem is that information regarding small alterations to components of a building is not communicated or changed in drawings, but it is considered trade praxis.

> *"There are constantly issues that cannot be performed which have to be altered and solved differently from what the drawing says. This is of course as long as the nature of the actual solution is not interfering with specified demands for function and quality of the component."* (Supervisor Two)

In a worst case scenario designers need to be advised of necessary modifications and changes have to be visible on updated drawings. Normally though, required changes are decided upon during weekly meetings and notifications are collected to use for the creation of as-builts. Noteworthy is that the conditions of construction documents in the projects visited in this case study determined the degree to which these alterations occurred.

Project drawings are commonly delivered to supervisors electronically through a database connected to involved designers. When new drawings are published or changes are made to existing drawings, memos are sent to concerned supervisors. It is then for each supervisor to retrieve updated information from the database. In general, supervisors have been optimistic to the use of this database with the argument of having all information collected in one place. Although, some frustration has been evident about the lack of communication regarding modifications to drawings; the information that *something* has been altered is there but not the actual change.

## 6.2 Expectations and demands put on BIM

This section begins by showing various definitions of BIM as described by interviewees. It further presents findings related to the requirements that could be recognised as prerequisites for BIM on site. The subchapters are presented independently without internal priority.

### 6.2.1 Definition of BIM

All of the interviewees were given the chance to define BIM in their own words. Quotations below are from those who gave a definition, however not everyone chose to do so.

> *"A model where everything in a building is specified and contains information. It is possible to choose a wall and see what it contains in detail. Electricity, HVAC, all installations are included."* (Supervisor One)

> *"BIM is a place which one could enter, like a database, and retrieve precisely the information one is looking for. There is a 3D picture to spin."* (Supervisor Three)

> *"BIM is to use information in one way or another from the 3D-model, use the fact that it is stored digitally. It is a way of working and a mind-set rather than a tool."* (Supervisor Four)

*"An intelligent drawing or model with more than just visual information. One can ask a question to the system and get an answer. BIM makes it possible to filter lists with properties like cost and weight and visualise collisions."* (BIM-Coordinator Three)

*"Exciting. A supportive function or a planning tool to make it easier for production and distribute a lot of information, a way to increase effectiveness."* (BIM-Coordinator Four)

### 6.2.2 A need for BIM introduction

Supervisor Three commented that there is a lack of information concerning BIM and according to Supervisor Two, most labourers have no idea what BIM means or even that something like it exists. This was a common reflection among supervisors regarding the level of knowledge about BIM outside site office. Labourers are more focused on doing their job and get it done as quickly and smoothly as possible, regardless if it is achieved through something referred to as BIM. However, there are segments of labourers more interested than others who are curious and open-minded to the introduction of BIM but the notion of the concept as such has often been acquired from outside CC.

*"An interesting question is why the board takes a decision to engage in BIM in projects without any information as to why and what it is reaches projects throughout the organisation."* (Supervisor Seven)

The absence of information about BIM is evident. Time is a scarce commodity on site and although personnel are aware that proper information on BIM exists within the intranet of CC, there is no time or practicable opportunity to read these documents. The prevailing opinion amongst supervisors is that there is a need for time to be reserved for BIM information and training of employees. BIM-Coordinator Two supported this and additionally held that it is not necessary for people to embrace the whole idea that is BIM, but it would be beneficial with a common basic view.

### 6.2.3 BIM education among employees

The general opinion is that for BIM to become accepted, employees on site need education about what it is and how to work with it. BIM has to become a natural part of everyday activities on site to generate an interest among employees of engaging further in the concept.

*"Let the BIM-coordinator visit construction sites and show practical examples of BIM utilisation and make employees interested and want to discover benefits ... Without education, the issue might be raised of how to make BIM successful when knowledge and understanding is a key to development."* (BIM-Coordinator Two)

> *"In connection with education let employees try for themselves instead of watching when a BIM-coordinator navigates or otherwise uses a model."* (BIM-Coordinator Four)

Thus far the issue of integration of BIM on site has to some extent been solved by a BIM-coordinator visiting construction sites. The role is mainly bound to the main office, working simultaneously with development and information distribution to several projects at once. At present, there is no defined level of how much knowledge a supervisor should possess and BIM-education for employees on site is expressed by supervisors as a way to even out the level of knowledge between the phases of design and production.

> *"There should be a possibility for education to make a supervisor able to navigate and use a model on the same conditions as a BIM-coordinator. Today a supervisor needs five minutes to do something which takes thirty seconds for someone with the proper education and experience."* (Supervisor One)

Supervisor Three argued that today the level of knowledge on site varies which requires a person on site who knows the whole system and pointed out that this person, with extended education and experience, does not have to be a whole new role. In line with the above, BIM-Coordinators have expressed the belief that given time, the role of BIM coordinator will most likely be decimated or even redundant if site employees in general and supervisors in specific can manage BIM on their own. BIM-Coordinator One estimated that within five to ten years the role of the BIM-Coordinator will be replaced by someone working on site who is sufficiently experienced in BIM.

### 6.2.4 The importance of user friendliness

If BIM is introduced as something which is either hard to grasp or difficult to use, a majority of the supervisors have difficulty seeing its successful implementation. This has been a returning finding throughout the whole case study, commented and confirmed in different ways by all interviewees. The top arguments regard two main areas. First, it should be possible to find correct information in a simple way and secondly it should be possible to find this information fast. Further arguments have been related the level of complexity of the system; keep it as simple as possible.

### 6.2.5 Concretise the usage of BIM

Factual profit gained through BIM is of vital importance and it has to be evident through raw data related to production in which areas advantages could be achieved. An example of how to do this was given by Supervisor Six, who suggested that other divisions within CC should be allowed to show how their projects profited from BIM.

> *"A problem when introducing BIM is the lack of hands-on numbers regarding investments in new technology. It is important to make people ask whether it is profitable rather than how much it costs."* (Supervisor Seven)

An attempt to actually concretise BIM has been encountered in the case study, where the traditional way to acquire bills of quantities is to be compared with producing the same through BIM.

## 6.3 Collaboration and development areas

The first part of this section deals with perceived issues of interaction between the phases of design and production. The final part presents thoughts and opinions as they were expressed during interviews regarding areas of development within CC. Comments are based on employees' personal experiences from current or recent projects and a reader should be aware that some subjects regarding development might already exist in pilot projects of development within the organisation.

### 6.3.1 Perceived issues of collaboration

A majority of the participants in the case study acknowledged a difference between what BIM is and how it is utilised between design and production. Opinions have surfaced that since the phases of design and production are focusing on different things, perhaps there should be two versions of BIM. Supervisor Four and BIM-Coordinator One both recognised that the phases should connect better instead of having solely the design phase engaging in BIM and when construction commence, usage is limited.

Supervisor Six claimed that employees involved throughout the phases of design and production lack knowledge and experience about the other; often with the result of long decision routes for limited gains. In accordance with this, a majority of interviewees recognised the importance of collaboration between design departments and site offices and argued the need for the design department to adopt the perspective of the production phase.

> *"In order to accept BIM in the next project, first thing to do should be to give us what we need and not what the provider think we need, thus making it more bottom-up."* (Supervisor Two)

> *"Information must be governed and packed in the right way to adapt it for production. The main office needs to adopt the mind-set of production instead of the other way around."* (BIM-Coordinator Three)

BIM is seen to provide a holistic view of the project and allows for various aspects to be taken into consideration. Supervisor Two claimed that although there is an understanding for this approach, BIM in production is of better use in the form of details and Supervisor One added that information should be channelled to fit the individual needs of the recipient.

> *"To ease the development of BIM within the organisation, the question "how do you want it" should be asked and that is where money should be spent."* (Supervisor Three)

Supervisors have been united in the opinion that CC should make them contribute to the development of their role and it was evident in all interviews that in order for successful implementation, the organisation has to ask employees in the production phase what they want and need out of BIM.

### 6.3.2 An issue for development

Supervisors currently have software in the form of a DWG-viewer on site. With this supervisors can open viewpoints extracted from a 3D-model but the program only allows for simple operations and manoeuvres. When using this software it is not possible to use any other information than what is provided in the viewpoints. BIM-Coordinator Three explained that employees often highlight problematic areas when navigating a model. Reaching those areas is possible when a BIM-coordinator is present on site as they have access to full software licenses. However, viewpoints are limited to a predefined set of information, and the user cannot access anything which is not included from the provider, which makes spontaneous problem solving difficult.

> *"Licenses and education would mean that supervisors can do more things on their own without having to contact the main office as much."* (BIM-Coordinator Three)

> *"Improvements such as full license AutoCAD and Revit are necessary in order to get better and more accurate measures and to be able to print whole recipes of required materials. If employees on site would get the proper education for this software, measuring could be done so much smoother."* (Supervisor Two)

Supervisors have held that by being provided with licenses CC can enable them to work more independently without having to rely on a BIM-coordinator for accurate viewpoints. This would enable employees on site to extract accurate information needed for specific situations from a 3D-model.

### 6.3.3 Further areas of development

Four supervisors expressed a high degree of individual reflections regarding internal development for the organisation, which is why this subchapter contains detailed notes from their interviews. There might be repeated statements concerning similar subjects, although these are presented in order to not withhold any opinions. The sub-chapter is concluded by Table 2 which summarises key development issues identified in the interviews.

**Supervisor One**

In general, it is hard to force people within the industry into using BIM on site and it would be a good idea to start in small scale with enthusiasts eager to try new things then take development further in small steps through an iterative process and evaluate the results. BIM will diffuse better throughout the organisation if employees start sharing positive experiences. For CC to be able to implement it more forcefully, BIM has to be developed to a certain standard.

More specifically, it would be handy with a PSD that contains 3D volumes in order to optimise storage possibilities at a narrow construction site. The ability to connect the PSD with a project time plan would enable supervisors to extract target visions of how a site should look at a given project stage. It should be possible to regard the 3D-model as a construction document which is legally binding and a model should be valid as a drawing with the ability to extract accurate values.

**Supervisor Two**

The communication between designers and the construction site has to be increased since they are not always aware of current project situation. Some parts of the project might be ahead of schedule while others are behind and the implication then is that changes are demanded to something which is already physically built. BIM has to be trustworthy, meaning that all information contained needs to be accurate and not contradict other sources of information. In a project when subcontractors gathered to review the model, it was evident that drawings possessed by subcontractors were not synchronised with the project model, which ended in the cancelation of the BIM initiative.

When it comes to planning of resources, it would be beneficial with a function that allows for a simple overview of current strain on different areas throughout the construction site. It would be great with a tool to manoeuvre different workforces in detail to get a picture of which areas are empty or under full occupation. Moreover, to get a booklet of 30 detailed views from the 3D-model would be a great complement, and examples are: beam connections, window-wall connections and roof details.

**Supervisor Three**

BIM creates problems when one has to cross-check certain areas known to be problematic. An example of this is when a given volume within the model can hold another volume strictly theoretically although in reality one has to take safety margins into consideration; software lacks for critical analysis.

It is desirable with a feature that enables the possibility to divide the project into different stages connected to time plan and from these it should be possible to extract recipes containing information of what material is required on site at a future stage. Furthermore, the time plan should be updated with current project progress and a tool to link budget and time plan to enable a comparison between how much is calculated and how much is actually spent.

**Supervisor Four**

The option to choose from different 'standard packages' is good, although some of the functions do no not generate any profit worth mention and might therefore be removed. Currently the navigation of the 3D-model is prevented by the slow start-up of the software which could provide a barrier for implementation.

A point for development to the PSD is to provide the ability to visualise the production pace compared to time plan and its set milestones. It would also be desirable with a 'drag-and-drop' function of volumes in 3D as well as the connecting of time plan, resources and the 3D-model in a way that enables them to work together. Since a borrowed licence is available on site, solutions for better planning and visualising could easily be performed, although when using a 3D-model, it is a pitfall that the 2D drawings are legal documents while it is the 3D-model one wants to build according to.

*Table 2: Summary of further development areas.*

| PSD | Time Plan | 3D-model |
|---|---|---|
| • Containing 3D-volumes<br>• Ability to extract target visions from project time plan<br>• Synchronised digitally with time plan and set milestones<br>• Drag and drop funtions | • Synchronised with actual project progress<br>• Linked to budget<br>• Possibility to extract recipies of material | • Legally binding<br>• Allowing planning and tracking whereabouts of labourers<br>• Containing folders with construction parts and details in 3D |

# 7 Discussion

This chapter evaluates the three main areas set out in the case study findings. The initial discussion covers the daily management of information performed by supervisors and its connections to the reviewed literature presented in Chapter Two. The two subsequent discussions are divided similarly to the subchapters of the case study findings and it is connected to the academic review presented in Chapter Three.

## 7.1 Information utilisation

If one was to use the definitions of information management by Best (2010) and Detlor (2010), it could be argued that supervisors work actively with the management of information at the construction site. A supervisor distributes information on site via whiteboards and uses this to communicate with labourers. It works as a detailed time plan with upcoming activities to be performed on specific dates and in addition it can be used for delivery plans. The reason for its success and continued use seems to be the simple way it is managed and controlled.

Information is seen as a central complement for supervisors to be able to efficiently control their actual resources such as material, personnel and time. On the other hand, in accordance with Eaton and Bawden (1991), the information managed is not seen as crucial an asset as other resources within a project and the opinion is shared among supervisors that information is something to value but not to the extent of classifying it as a resource. However, as recognised by Sandkuhl (2008), without the right information communicated to a supervisor, the tasks at hand become much harder to solve as earlier exemplified with updates to drawings without references.

When arguing that information is delivered to a construction site in accordance with IL theory, it is crucial that this information is precisely what is needed. For example files in the DWG-viewer provided by a BIM-coordinator have to be exactly the viewpoints relevant for the tasks at hand. In line with Sandkuhl (2008) and Oulton (1990), this requires that the individual sending information knows what is significant to the receiver. Additionally Strömfelt (1990) argued for the importance of an information provider's knowledge and its acquaintance with the area of utilisation. However, as argued by the interviewed supervisors and exemplified in the case study findings, this is not always the case.

Sandkuhl (2008) further held that to determine what is the right information at the right time is one thing to claim in theory, and another to perform in practise, since individual needs differ from one another and also changes over time. When arguing for a role such as BIM-coordinator and those presented by Best (2010) and Trauth (1989), the preconditions mentioned above needs to be taken into consideration. Interviewees acknowledged the need for someone able to take this type of responsibility, but also stated that in the production phase this does not have to be someone specifically employed for that purpose. They see a possibility where current responsibilities of a BIM-coordinator are transmitted to the description of a supervisor, the main argument being that people employed in production possess the necessary experience, hypothetically enabling them to be their own providers of information; thus removing any intermediaries.

## 7.2 Expectations and demands put on BIM

Considering various descriptions existing in theory, numerous abbreviations and the different definitions provided through the practical evaluation, there is certainly an ambiguity about determining the meaning and content of BIM. The confusion within the construction industry as a whole is described in for example Sebastian (2011) and Singh *et al.* (2011), and the findings from the case study confirm these views within CC. There is an expressed wish for information regarding what BIM is and how it should be utilised according to CC's point of view and as stated by BIM-Coordinator Two, there is a need for some kind of basic view throughout the organisation. Contrary to Hammond's (2008) statement about conservatism in the industry, no such opinions regarding BIM have been observed. However there is some frustration and scepticism focused on how and in what way CC has chosen to supply information. It is difficult to foresee how long motivation and curiosity will be sustained without information about BIM is communicated.

Eastman *et al.* (2011), Hindersson (2011b), Singh *et al.* (2011) and WSP Group Sweden (2010) all claimed that the will and motivation to work with BIM among employees is lacking as well as the level of education and knowledge. Regarding the first subject, the interest in the concept and curiosity in new technologies easing workloads was high among all the employees interviewed, thus contradicting theory concerning the lack of motivation. On the issue of education, it is obvious that knowledge about BIM varies although it is important to remember that the studied organisation is still fairly new to BIM. Today, a BIM-coordinator has experience largely due to the fact that BIM is developed to a higher degree in the design phase where employees have daily contact with the subject. The supervisors showed a common understanding of the basic features of BIM, although this knowledge has often been gained because of curiosity rather than from studies of available information from the internal information network.

When information about BIM reaches the construction site it has to be evident within which areas gains could be achieved. As expressed by supervisors and BIM-coordinators; direct profit has to be shown in order for BIM to get acceptance on site. In CC, a project where an attempt to measure differences between old methods and BIM is currently in progress, however the results of the experiment will not be available within the timeframe of the thesis.

## 7.3 Collaboration and development areas

The possibility for BIM to increase the integration between stakeholders in the phases of design and construction has been discussed to a large extent (e.g. Olatunji, 2011; Singh *et al.,* 2011; Watson, 2011 and Azhar *el al.*, 2007). However, cross-organisational collaboration was questioned by interviewees in the case study, who on the contrary recognised an existence of a gap between the phases. As declared by Supervisor Two, it is perceived that utilisation of BIM differs whether one is employed in design or production and Supervisor One argued for the more specific needs within production; both supervisors in line with the arguments from Day (2011). Furthermore, in order to fulfil the words of Goedert and Meadati (2008) regarding the format of information, and bridging the mentioned gap, there has to be an awareness of what different stakeholders want and what their needs are during different stages of a project.

A possible explanation to the gap could be found in Detlor (2010), who differentiated between goals of an organisation and an individual. In comparison with a construction project, the design phase contains more of a holistic approach and information should be valid throughout product life-cycle. On the other hand, a supervisor in the production phase is more focused on specific requirements for the tasks at hand and personal needs. As evident in several interviews, supervisors are aware of the possibilities with BIM, although they also recognise the need for CC to properly investigate what their requirements really are, and how the organisation could help them in their situation.

The most reappearing requirement expressed from supervisors is for CC to provide tools for information retrieval performed on site. Reconnecting to the discussion about ‘Information utilisation’, this could enable supervisors to personally extract information for decision making instead of ordering it externally from the site office. A majority of interviewees questioned current methods and argued that a solution to this is for licenses to be introduced on site. Additional subjects for development, as suggested by employees in the studied organisation, are presented in chapter 6.3.3, but these areas should not be regarded as generally applicable for BIM in the construction industry. Rather, referring to the arguments by Cavaye (1996), these might be seen as guidelines and indications to other companies while they ought to be considered important areas of interest for the studied organisation.

# 8 Conclusions

The first part below sets out to answer the research questions while the second contains concluding remarks, presented chronically and based on the three subchapters of the discussions in Chapter 7. Finally, concluding this thesis is a set of questions for further research.

## 8.1 Answering the research questions

All research methods are prone to limitations and the case study approach is no exception (as previously discussed in the method statement). In recognition of these limitations we have refrained from all attempts at achieving statistical representation or generalising the findings to broadly. However, the case study organisation is widely considered to be a leading player on the market and is currently implementing BIM in the construction phase. As such the case allows for analytical generalisation and for lessons to be learnt across contexts (Eisenhardt, 1989). In terms of the data collected we have tried to minimise the effect of impression management techniques (see Leiringer and Cardellino, 2008) in the interviews by first and foremost presenting the collected data as opinions/perceptions and also by as far as possible confirming key statements in other interviews or through observations. With these issues in mind we offer the following conclusions and recommendations.

*RQ1: What are the expectations on BIM from the production phase supervisors?*

An expectation from the production phase is that BIM should be narrowed and scaled down to details. The vision from supervisors as we perceive it is that instead of a construction site being provided with just one single model containing all information about the project, they should be supplied with models that contain information which is relevant for their areas of responsibility. However, from what we have found, this is due to the lack of education and licences. Had supervisors possessed software and received education to utilise these, they would have known much more about the possibilities to customise a model. As a consequence, the expectation about a "narrowed and scaled down BIM" would probably not have been observed.

Supervisors do not need BIM to revolutionise their way of working; currently they need simplicity and changes in small steps that allow them to free up time. Evidently, in order for supervisors to gradually accept and integrate BIM in their current processes, they want the opportunity to personally contribute to development. All interviewees have to various degrees been 'BIM-positive' and seen the potential within the concept, thus the will to express views about how CC should be developing BIM. It seems obvious that supervisors should be given the chance to help development. In our opinion, the reason for this is self-preservation as employees do not want to be exposed to changes that they are not comfortable with.

*RQ2: What kind of information is required regarding BIM when introducing it to a construction site?*

**The importance of communicating information**: In our opinion all interviewees have had a basic understanding of what BIM is and what its basic features are. However, it is evident from the case study that there was no common source of information from within CC that contributed to this. In our view, supervisors indicate some frustration about the lack of information and arguments for BIM engagement. The information currently available is not being used. To be able to aggressively launch BIM there has to be a common understanding about the concept throughout the organisation, including labourers. Thus there is a need to communicate information from the intranet to construction sites in a better way than current praxis. Not only does it have to be reformatted, but also clarified: for example, the aim and the reason in deciding on a policy to use BIM in projects exceeding a predefined limit.

**BIM needs to be concretised**: BIM is in reviewed literature presented in somewhat fuzzy numbers and in our opinion rather utopian and unrelated to activities in production. Interviewees have further confirmed the lack of examples that shows direct profit from BIM within CC. It was expressed that BIM should become more concretised through an increased amount of experiments. These should present parameters that are measurable and easy for employees in the production phase to grasp. Thereby it should be easier for the implementing organisation to argue for and motivate BIM initiatives. There will always be some employees that are more pervious to development and convinced of technological gains. These should be encouraged and given resources to produce positive results from using BIM. Within CC, this is, in our opinion, currently seen as an expense with limited benefits, something which is quite undesirable for an organisation.

**Supervisors need relevant education**: Based on the reviewed challenges with BIM, and further revealed in the case study, employees need education about BIM. Make supervisors understand the approach and views about the concept and guide them in their use of BIM. From what was gathered it is our suggestion that education is provided to those supervisors that are currently working, or supposed to be working, with BIM. In our opinion, for the implementing organisation to create a foundation for BIM in the production phase, supervisors should receive education to the extent where they will be able to manage 3D-models on their own with the same speed and capacity as the equivalent to a BIM-coordinator. A further advantage with BIM education might be that supervisors could be able to pass on information and generate interest among the rest of site employees. This is most likely a result linked to the absence of information; as interviewees know little about the subject BIM they identify the need to be educated.

**Licenses ought to be introduced on site:** Based on expressed demands and as exemplified in the case study, with additional support from reviewed theory on IL, software licenses should be introduced on construction sites. Instead of only being able to access information available in a single viewpoint delivered to a project, supervisors would have the possibility to use information which is otherwise excluded. We hold that licences enable supervisors to manage information in a 3D-model on their own, allowing for spontaneous problem solving without a need for intermediaries that send accurate information. This gains further weight when considering that supervisors and BIM-coordinators themselves recognise that a manager of information on site does not have to be a new role but someone already present.

## 8.2 Concluding remarks

Whiteboards in site cabins are of vital importance to supervisors and if an organisation aims to replace these, implementation of BIM will be difficult; the sole reason for its prevailing over digital alternatives is its simplicity. Regardless of how supervisors' classify information, a project cannot continue without the *right* information being provided. If providers of information work focused toward construction sites they could educate supervisors in BIM while simultaneously acquiring knowledge of their tasks. This would start an on-going process where the sender gains understanding and insight about needs of the recipient, which would result in increased quality and relevance of information.

Moreover, a lack of information how an organisation views BIM and the absence of education could potentially create a difficult situation: if the impression of BIM is formed from outside of the organisation, there is a risk that when communicating information regarding its opinions about BIM and its significance, these could mismatch. This could then pose as a basis for confusion and perhaps even resistance because of a reluctance to change initial personal impressions.

Finally, the argument that goals for an organisation are holistic while specific for its individuals is confirmed by interviewees in the case study and it is in our opinion a difference between the needs of organisational and individual levels. As BIM in the design phase is much further ahead than in production the result is a gap from not approaching one another with a common language. The integration and implementation of BIM in the production phase will be slowed down if an organisation does not heed the requirements from its employees.

## 8.3 Further research

It is obvious that people deciding on budgets do not want to invest in technologies or systems that are not yet proven to be profitable. During the case study a comment surfaced that the reason for slow implementation of BIM in the production phase is that no site manager wants to make investments unless gains are shown. Might a solution be to subsidise BIM in the beginning of projects to get the implementation going, without providing proof in the form of concretised numbers? Possible research questions could then be to investigate:

- Is it profitable for an organisation to subsidise projects as a first step in its BIM initiative?
- Could measurements of BIM engagement be performed during the subsidisation of a project in order to investigate possible profit?

A role such as that of a BIM-coordinator is regarded to be important for successful implementation of BIM throughout the various phases of construction. From the case study performed in this thesis interviewees indicated on various directions of progress for this role. However, it is quite hard to determine the optimal route of development of the role within different organisations and also how this development corresponds to goals of a company. Therefore, research questions could be formulated as follows:

- What should be included in the tasks of a BIM-coordinator considering the goals of an organisation?
- Should the role of a BIM-coordinator exist within an organisation?
- If not, which and how should tasks should be delegated to other roles within an organisation?

## Final words

Eastman *et al.* (2011) mentioned that in order to reach success in BIM adoption an organisation has to implement major changes through practically all levels. With the knowledge and experience we have gathered during this period we would like to wish CC best of luck in the times ahead. It is our hope that this thesis will be of help in the process of change and we would like to send a sincere Thank You to the employees of CC for all the help, guidance and time spent to aid us in our work.

- June 2012, Olsson and Arvidsson

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