BIM for Project Managers

How project managers can utilize BIM in construction projects

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

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ABSTRACT

The Swedish construction industry has long been criticized for being inefficient. It has been claimed that 80 percent of all content within the construction process is the same for all projects and there are therefore huge opportunities for improvements. The project manager is essential for the successful delivery of construction projects. The purpose of this master thesis is to analyze how BIM (Building Information Modelling) can be utilized by project managers. It is also examined how the project manager's role and the relationships to other stakeholders are affected when BIM is employed in construction projects.

In total, twelve separate interviews were conducted, whereof six were with project managers and six with BIM experts. It was concluded that project managers generally have little knowledge concerning BIM, which makes it hard for them to see its applications. The study revealed that BIM can help project managers in the task of delivering successful projects. Through BIM a better basis for decisions is provided in comparison with traditional projects. In addition, the benefits of better communication and quality are granted. The communication benefit is valuable for creating mutual understanding regarding goals, and moreover the quality benefits allows for better control of the project. Many of the interviewees wished for more utilization of linking the building information model to time, which would provide increased control in the construction phase. Many of the benefits with BIM do not apply to the project manager directly, but contributes to the project as a whole, with better profit margins and making delivering a successful project more likely. The fundamental challenge regarding the implementation of BIM is the personal opinion. Pilot projects are essential for changing the personal opinion, as all interviewees who had personal experience of working with BIM had a good impression and wanted to continue working with it. The project managers' role will remain the same in BIM projects as in traditional projects. However, the project manager might be required to learn some new skills related to working with BIM. The project managers' relationships to other stakeholders are required to move towards more partnering-like relationships for effective implementation of BIM.

Key words: BIM, Building Information Modelling, project manager, project management, construction industry

BIM för Projektledare
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SAMMANFATTNING

Den svenska byggbranschen har länge kritiserats för att vara ineffektivt. Det har hävdats att 80 procent av allt innehåll inom bygg-processer är detsamma för alla projekt och det finns därför stora möjligheter till förbättringar. Projektledaren är avgörande för en framgångsrik leverans av byggprojekt. Syftet med examensarbetet är att analysera hur BIM kan användas av projektledare. Därutöver har det granskats hur projektledarens roll och relationer till de övriga intressenterna inom byggprojekt påverkas när BIM appliceras.

Totalt genomfördes tolv intervjuer, varav sex var med projektledare och sex med BIM-experter. Slutsatsen drogs att projektledarna i allmänhet har liten kunskap om BIM, vilket gör det svårt för dem att se dess nytta. Studien visade att BIM kan hjälpa projektledare i deras uppgift att leverera framgångsrika projekt. Genom BIM erhålls ett bättre underlag för beslut i jämförelse med traditionella projekt. Dessutom erbjuds fördelarna av bättre kommunikation och kvalitet. Kommunikationsfördelen är speciellt värdefull för att skapa ömsesidig förståelse för mål, och kvalitetsfördelen möjliggör bättre kontroll av projektet. Intervjupersonerna såg stor potential i att använda en byggnadsinformationsmodell länkad till tid, vilket skulle ge projektledaren ökad kontroll i byggskedet. Många av fördelarna med BIM kan inte kopplas till projektledaren direkt utan bidrar till projektet som helhet, med bättre vinstmarginaler och ökad sannolikhet att ett lyckat projekt levereras. Den fundamentala utmaningen gällande implementering av BIM är den personliga inställningen för vilken pilotprojekt är viktiga för att påverka. Alla intervjupersoner som hade personlig erfarenhet av att arbeta med BIM hade ett gott intryck och ville fortsätta arbeta med det. Projektledarens roll kommer att vara densamma i BIM-projekt som i traditionella projekt. Det kan dock vara nödvändigt för projektledaren att lära sig om BIM. För effektiv användning av BIM förutsätts att projektledarens relationer till andra aktörer inom projektet bli mer som de inom samarbetsformen partnering.

Nyckelord: BIM, Building Information Modelling, projektledare, projektledning, byggindustrin

Contents

Preface

This master thesis is the final part of the two authors' education at Chalmers University of Technology and the department of Civil and Environmental Engineering in Gothenburg and comprises 30 credits. The thesis has been produced in collaboration with the consultancy firm Ramboll in Gothenburg. The work began in January 2011 and was completed in July 2011.

Thanks to our supervisor Fredrik Öster at Ramboll for the support, and Malin Svedmyr, also at Ramboll, for providing us with many of the interviews. We also greatly appreciate the support and comments from our supervisor at Chalmers Börje Westerdahl. Additionally we thank our dear friend Kevin Dang, who has encouraged us during late nights and early mornings when writing this thesis at Chalmers.

Finally, we would also like to thank all of the interviewees for openly sharing their experiences with us.

Gothenburg, July 2011

Rim Lahdou & David Zetterman

Notations

BBR	Boverkets Byggregler
BIM	Building Information Modelling
BKR	Boverkets Konstruktionsregler
CAD	Computer Aided Design
CMM	Capability Maturity Model
HVAC	Heating, Ventilation, and Air Conditioning
IAI	International Alliance for Interoperability
I-CMM	Interactive Capability Maturity Model
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
NBIMS	National Building Information Modelling Standard
PLM	Product Lifecycle Management
SIS	Swedish Standards Institute
ÄTA	Ändrings och Tilläggs Arbete
2D	Two dimensions: x and y
3D	Three dimensions: x, y and z
4D	A 3D model integrated with a time plan
5D	A 3D model integrated with cost estimation

1 Introduction

In this chapter, the background, purpose, delimitation and disposition of the master thesis will be described. Moreover the consultancy firm Ramboll, which this master thesis is written for, will be presented.

1.1 Background

The productivity in the Swedish construction industry has long been criticized for being inefficient and resource consuming. According to Byggkommittén within the Ministry of Social Affairs, approximately 30 percent of the total cost of production is due to faults in construction and other wastes (Byggkommittén, 2004). This number implies that approximately 50 billion SEK are wasted annually in the Swedish construction industry. A main reason for the low productivity is the diversity among stakeholders. The construction process is fragmented with many stakeholders active in different phases (Lutz & Gabrielsson, 2002).

Although each project is considered unique, Gabrielsson and Lutz claim that 80 percent of all content within the construction process is the same for all projects, and there are therefore huge opportunities for improvement (Lutz & Gabrielsson, 2002).

Recently, there is a tendency for increased interests in Building Information Modelling (BIM) among companies in the Swedish construction industry. The reason for the interest in BIM is the potential for solving some of the problems with low efficiency in the industry and increase productivity (Byggindustrin, 2011). Although BIM has started to become more noticeable in recent years, the concept is not new. Methods resembling what is now called BIM can be dated back as far as the 1970s, although the exact term “Building Information Model” was nonexistent at that time. Terms utilized during the early 1980s were “Building Product Model” in the USA and “Product Information Model” in Europe, and eventually these two terms was conformed into the term Building Information Modelling in the early 1990s (Eastman, et al., 2008).

The project manager is essential for the successful delivery of a construction project and has the overall responsibility for the planning, co-ordination and control of a project from conception to completion. Is it possible that BIM can help project managers to increase productivity in the construction industry? Or is BIM just another new trend that will soon be forgotten?

1.2 Purpose and aim

The purpose of this master thesis is to analyze how BIM can be utilized by project managers. Additionally it will be examined how the project manager's role in construction projects might be affected when BIM is employed.

Aim

- To analyze benefits and challenges with utilizing BIM for project manager in construction projects.
- To determine the project managers role in BIM projects.
- To evaluate how the project managers' relationship to the other involved stakeholders is affected when BIM is implemented in construction projects.

1.3 Delimitation

In this master thesis the project manager is presumed to be a representative of the client, as the case is with the project managers from the consultancy firm Ramboll, which this master thesis is written for.

Additionally, the focus is on larger projects were the project manager and planning manager are considered separate roles. This indicates that the project manager is active from initiation to closure of the project.

This master thesis is focused on the Swedish construction industry. Only relatively new information about BIM is considered, from year 2006 and onwards, as the development concerning BIM is constantly progressing.

1.4 Disposition

This master thesis consists of eight chapters, which creates a comprehensible knowledge base for how project managers can utilize BIM as well as how their role and relationships to other stakeholders might change.

Chapter 2 – Method
The purpose of this chapter is to describe the method which has been utilized during the process of producing this master thesis. In addition, it is accounted for how the collection and analysis of data was performed.

Chapter 3 – BIM
This chapter introduces BIM and how it is defined in this master thesis. Furthermore technical aspects of BIM and how its use can be classified in maturity levels, is described.

Chapter 4 – Construction Project Management
The purpose of this chapter is to give an overview of project management within the construction industry, as well as the project manager's role and responsibilities. Moreover, the cooperation form partnering is depicted.

Chapter 5 – Results
The findings from the interviews are presented in this chapter and form a reference point for the subsequent analysis. The results are naturally organized into five topics, which were the basis of the interview questions.

Chapter 6 – Discussion
In this chapter the results of the interviews are analyzed and relevant discussions are brought up and correlated to what has been described in theory.

Chapter 7 – Conclusions
The purpose with this chapter is to state the most important conclusions of this study. The conclusions correspond to the purpose of this master thesis and bring up subjects relevant to the aims.

1.5 Ramboll

Ramboll is a technical consultancy company which specializes in infrastructure and construction. Ramboll has its strongest presence in Scandinavia, but has worldwide operations with close to 9 000 employees in 23 countries. The company is owned by the Ramboll foundation based in Denmark (Ramböll, 2011).

Ramboll Sweden has approximately 1 400 employees with its head office located in Stockholm. Ramboll Sweden is made up by three divisions and one subsidiary: The divisions Technology & Design, Project Management, and Energy, and the subsidiary Ramboll Natura. Ramboll Sweden offer services within the following areas: construction, infrastructure, industrial processes, energy, water and environment, telecommunications, management and IT. See figure 1 for an overview of Rambolls organizational structure (Ramböll, 2011).

Ramboll's goal is to maintain long-term profitability based on stable and steady development. With a common work method and comprehensive skills to manage technological aspects in construction projects (Ramböll, 2011).

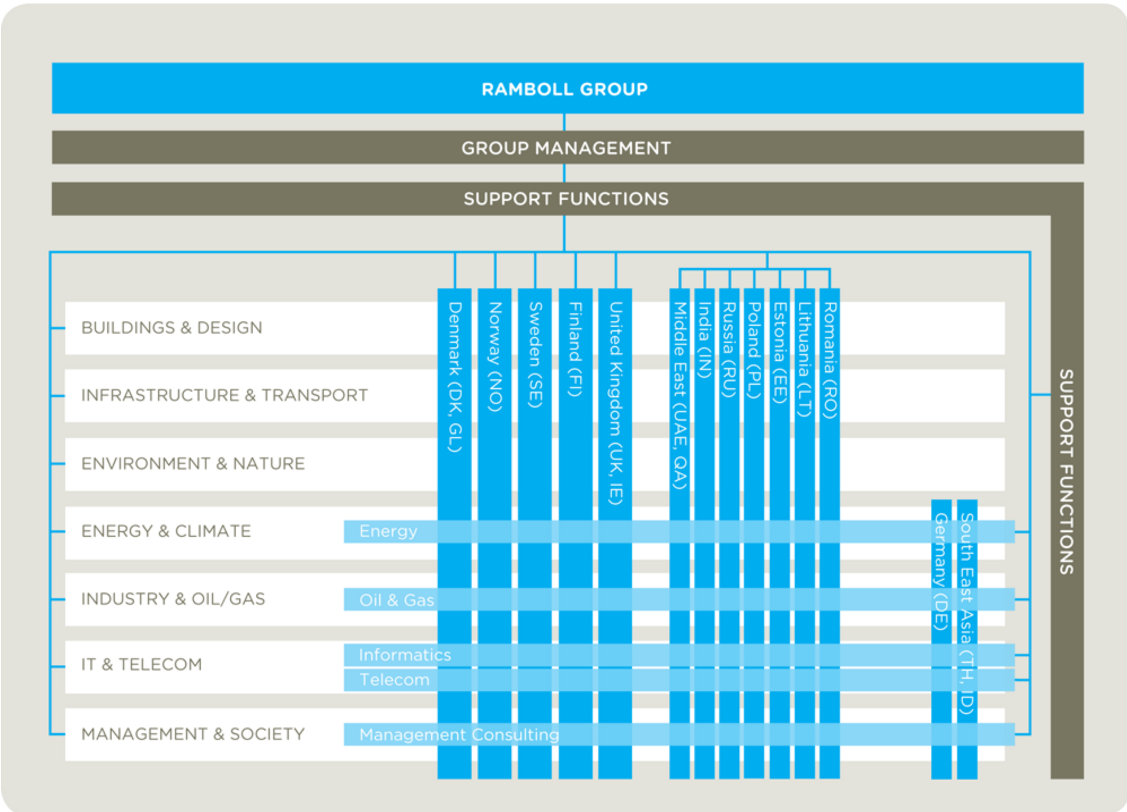


Figure 1: Ramboll's organisation chart (Ramboll, 2011)

1.6 Definitions

Disciplines

When referring to the different disciplines it implies the actors which operate in the design phase and are active in producing construction documents, such as the architect, structural-, electrical- and HVAC-engineer.

The building information model

The building information model refers to the combined model where the models from the different disciplines have been merged. According to the BIM handbook the building information model is characterised by the following features:

- *"**Building components** that are represented with intelligent digital representations (objects) that 'know' what they are, and can be associated with computable graphic and data attributes and parametric rules.*
- ***Components that include data that describe how they behave,** as needed for analyses and work processes, e.g., takeoff, specification, and energy analysis.*
- ***Consistent and non-redundant data** such that changes to component data are represented in all views of that component.*
- ***Coordinated data** such that all views of a model are represented in a coordinated way (Eastman, et al., 2008, p. 13)".*

Traditional projects

Traditional projects are considered projects were 2D-CAD is employed or alternatively 3D-CAD but without a coordinated building information model. Thereby traditional projects implies projects that are on level 0 or bellow in the BIM levels described in chapter 3.3: BIM levels.

Stakeholders

The stakeholders are considered to be the client, project manager, architect, discipline leaders, contractors and subcontractors.

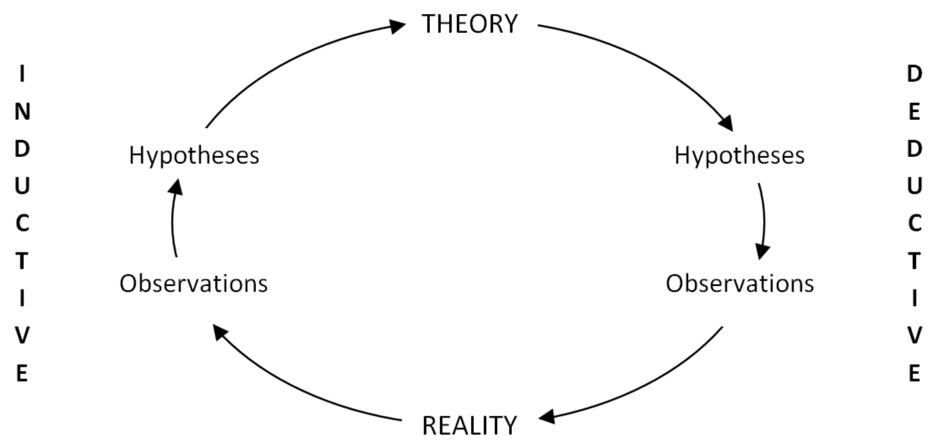
2 Method

This chapter accounts for the method which has been employed in this master thesis. Moreover, it is depicted how the collection and analyzes of data was conducted.

2.1 Deductive & inductive

There are two main approaches for reasoning, deductive and inductive. The deductive approach is based on already existing hypotheses which are tested in order to through logic reasoning confirm their accuracy (Research Methods Knowledge Base, 2006).

The investigation in this master thesis has been carried out using an inductive approach. An inductive approach implies that data is collected without beforehand formulating hypotheses. Based on the purpose of the master thesis, data is collected, analyzed and compared to established theory regarding concerned topics. For further clarification of the two approaches, see figure 2 (Research Methods Knowledge Base, 2006).



Figur 2: Deductive and inductive approach (Eriksson & Wiedersheim-Paul, 1997).

2.2 Quantitative & qualitative

A quantitative study is well suited for an approach in which there are already established properties or hypotheses. These hypotheses are tested on a large sample size in order to determine the degree to which the hypotheses are fulfilled (Holme & Solvang, 1997).

The purpose with qualitative interviews is to identify and explore insufficiently known properties. The idea is to discover something which cannot be established in advance and acquire a deeper understanding of a subject. In a qualitative study a large amount of information is collected from a small sample size (Holme & Solvang, 1997). Considering the purpose and aim of this master thesis and as the availability of interviewees has been limited, a qualitative method was selected.

Execution

In this master thesis, semi-structured interviews were employed. A set of interview topics with sub-questions were prepared in advance. Four trial interviews were held in order to improve the quality of the interview and implement adjustments. The interview framework was approved by both tutor and supervisor.

The same interview framework was utilized with both project managers and BIM experts. The main interview topics were discussed in successive order during the interviews, while the employment of sub questions varied. Moreover, additional questions not present in the framework could occasionally be added.

During the interviews both interviewers transcribed while asking questions by turns. The semi-structured interview form allowed for well-organized comparison between answers, while it at the same time provided room for flexibility. See appendix 1 for the interview framework.

In total twelve separate interviews were conducted. Six of the interviews were with persons with a project managing role and the other six with persons that worked with implementing BIM in different companies. However, it is not revealed which answer any specific interviewee gave, with the motive that the anonymity would allow the interviewees to express themselves more freely.

2.3 Literature review

Literature reviews are based on secondary sources which are available as common knowledge and consequently do not present any original ideas. Litterateur reviews are aimed toward bringing the reader up to date with current literature (Höst, et al., 2006)

A literature review was performed in order to attain a comprehensible understanding of the main subjects relevant to this master thesis, project management and BIM, but also to attain knowledge of interview methodology and ideas of how to structure the thesis.

2.4 Validity and reliability

The value of a study is based on its validity and reliability. The validity indicates whether what is investigated corresponds to the purpose of a study (Kvale & Brinkmann, 2009). In order to ensure a high degree of validity, the interview questions were formulated with the purpose of the thesis in mind. Furthermore, only interviewees with relevant knowledge in project management and BIM were selected.

The reliability signifies how trustworthy the outcome of the study is. A study with high reliability should reproduce the same outcome if executed for a second time, regardless of whom the interviewers and the interviewees are. To achieve a high degree of reliability can be problematic in qualitative studies and depends on the ability of the interviewer. If a second interviewer participates in the interview, the reliability of a qualitative study can be verified (Kvale & Brinkmann, 2009).

With the intent of ensuring the validity of the study, both interviewers transcribed answer during the face-to-face interviews, and conversations from phone interviews as well as several of the face-to-face interviews were recorded. Furthermore, the material from each interview was analyzed directly after the interview session.

3 BIM

The purpose of this chapter is to introduce the reader to BIM and how it is viewed in this master thesis. Furthermore, technical aspects of BIM and how the maturity regarding its use can be classified, is described.

3.1 Introduction to BIM

The BIM Handbook (2008) describes BIM as a computer aided modelling technology for managing and generating building information, with the related processes of producing, communicating, and analysing building information models.

Building information models are object oriented, which means that building components contain information describing what they represent. The building components can be attached with parametric data that describes its attributes for use in functions such as analyzes and work processes. Changes of data in one view of the model results in updates in all views associated with the model in a consistent and coordinated way.

There is no definite definition of BIM; rather there are many ways of interpreting what BIM is. In this master thesis, BIM is viewed according to the following definition from the National Building Information Modelling Standards:

> *"… a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder* (NBIMS, 2007, p. 21)*."*

According to Jernigan (2008), there are many common misinterpretations concerning BIM and that a way to get an understanding of BIM is to understand what it is not. One of the biggest misconceptions regarding BIM is that it consists of a single model or database. This is not really the case as BIM on the contrary is constituted by multiple linked models and databases.

It is important to keep in mind that BIM cannot replace people. BIM reduces repetitive and mundane work tasks and ease the processing of information, but it is still people who gather and put information into the model. Another common confusion is that there are no errors in BIM, but as a result of the human factor incorrect data is sometimes added and errors occur as a result. However, data is inserted only once which makes the risk for errors less likely.

3.2 Technical aspects of BIM

This chapter describes specific BIM functions, which are connected to common features that are provided within the BIM levels in Ramboll's internal BIM strategy (see chapter 3.3: BIM levels).

Clash controls

By clash controls, the building information models of different disciplines are brought together and checked for geometrical design inconsistencies. Points where the models of different disciplines overlap each other when brought together are detected and can then be corrected. Moreover, visual errors which can lead to poor esthetical quality can be discovered and corrected (Eastman, et al., 2008).

Analyzes

Energy analyzes can be performed by linking a building information model to tools which analyzes the isolating ability of a building and measures energy usage for heating and cooling during peak periods. Energy analyzes enable production of buildings that consume less energy during its lifecycle (Eastman, et al., 2008).

Other examples of analyzes which can be performed with the help of BIM are light and acoustics analyzes.

Time estimation (4D)

With time estimation, often also called 4D, the objects in a building information model are linked to the time plan. The linkage to time plan makes it possible to graphically visualize the projects schedule and users can simulate the building site and construction at any point in time. This type of simulation provides considerable insight and allows for early detection of planning errors. Instead of realizing planning mistakes later on in the construction phase, and having to resolve problems on site which can be very costly, mistakes can be eliminated already in the design phase (Eastman, et al., 2008).

Moreover, time estimation can be utilized to optimise the logistical aspects. Various alternative solutions of conducting the construction can be simulated and weighted against each other to find the most beneficial solution (Eastman, et al., 2008).

Cost estimation (5D)

With cost estimation, often also called 5D, the objects in a 3D design can be connected with price lists for different materials. The price lists are mainly based on volume cost of materials, but can also include labour and equipment costs for more detailed cost estimates. This enables accurate cost estimation at any point in the design phase and creates understanding regarding financial implications of design decisions. Materials and construction solutions can therefore be evaluated from an economical perspective (Eastman, et al., 2008).

3.3 BIM levels

NBIMS has developed a capability maturity model (CMM) to define the maturity of models, and to enable users to evaluate their practices and processes based on a broad spectrum of technical functionalities. The objective with the CMM is to provide actors within the construction industry with a tool for determining their level of maturity in an individual building information model by comparing it against a set of criteria. Moreover, the CMM can be used to set goals for achieving greater maturity in future project activities, by progressing towards more advanced features in the CMM (NBIMS, 2007).

The CMM is a matrix, on the x-axis there are 11 areas of interests, such as data richness, life-cycle views, and roles or disciplines. The y-axis comprises 10 levels of maturity, with 10 being the highest level of maturity. See figure 3 for a detailed view of the CMM (NBIMS, 2007).

Tabular BIM Capability Maturity Model 5/30/2006

Maturity Level	A Data Richness	B Life-cycle Views	C Roles Or Disciplines	ITIL Maturity Assessment	D Business process	F Timeliness/ Response	E Delivery Method	H Graphical Information	I Spatial Capability	J Information Accuracy	K Interoperability / IFC Support
1	Basic Core Data	No Complete Project Phase	No Single Role Fully Supported	No ITIL Implementation	Separate Processes Not	Most Response Info manually re-	Single Point Access No IA	Primarily Text - No Technical Graphics	Not Spatially Located	No Ground Truth	No Interoperability
2	Expanded Data Set	Planning & Design	Only One Role Supported	Initiation	Few Bus Processes Collect Info	Most Response Info manually re-	Single Point Access w/ Limited IA	2D Non-Intelligent As Designed	Basic Spatial Location	Initial Ground Truth	Forced Interoperability
3	Enhanced Data Set	Add Construction/ Supply	Two Roles Partially Supported	Limited Awareness	Some Bus Process Collect Info	Data Calls Not In BIM But Most Other Data Is	Network Access w/ Basic IA	NCS 2D Non-Intelligent As Designed	Spatially Located	Limited Ground Truth - Int Spaces	Limited Interoperability
4	Data Plus Some Information	Includes Construction/ Supply	Two Roles Fully Supported	Full Awareness	Most Bus Processes Collect Info	Limited Response Info Available In	Network Access w/ Full IA	NCS 2D Intelligent As Designed	Located w/ Limited Info Sharing	Full Ground Truth - Int Spaces	Limited Info Transfers Between COTS
5	Data Plus Expanded Information	Includes Constr/Supply & Fabrication	Partial Plan, Design&Constr Supported	Limited Control	All Business Process(BP) Collect Info	Most Response Info Available In	Limited Web Enabled Services	NCS 2D Intelligent As-Builts	Spatially located w/Metadata	Limited Ground Truth - Int & Ext	Most Info Transfers Between COTS
6	Data w/Limited Authoritative Information	Add Limited Operations & Warranty	Plan, Design & Construction Supported	Full Control	Few BP Collect & Maintain Info	All Response Info Available In BIM	Full Web Enabled Services	NCS 2D Intelligent And Current	Spatially located w/Full Info Share	Full Ground Truth - Int And Ext	Full Info Transfers Between COTS
7	Data w/ Mostly Authoritative Information	Includes Operations & Warranty	Partial Ops & Sustainment Supported	Limited Integration	Some BP Collect & Maintain Info	All Response Info From BIM & Timely	Full Web Enabled Services	3D - Intelligent Graphics	Part of a limited GIS	Limited Comp Areas & Ground	Limited Info Uses IFC's For Interoperability
8	Completely Authoritative Information	Add Financial	Operations & Sustainment Supported	Full Integration	All BP Collect & Maintain Info	Limited Real Time Access From BIM	Web Enabled Services - Secure	3D - Current And Intelligent	Part of a more complete GIS	Full Computed Areas &	Expanded Info Uses IFC's For Interoperability
9	Limited Knowledge Management	Full Facility Life-cycle Collection	All Facility Life-Cycle Roles Supported	Limited Optimization	Some BP Collect&Main t In Real Time	Full Real Time Access From BIM	Netcentric SOA Based CAC	4D - Add Time	Integrated into a complete GIS	Comp GT w/Limited Metrics	Most Info Uses IFC's For Interoperability
10	Full Knowledge Management	Supports External Efforts	Internal and External Roles Supported	Full Optimization	All BP Collect&Main t In Real Time	Real Time Access w/ Live Feeds	Netcentric SOA Role Based CAC	nD - Time & Cost	Integrated into GIS w/ Full Info Flow	Computed Ground Truth w/Full	All Info Uses IFC's For Interoperability

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Figur 3: The CMM matrix (NBIMS, 2007, p 75).

Organisations often develop their own methods for measuring BIM maturity. The following material regarding BIM levels was developed for the internal BIM strategy in Ramboll and is not intended for marketing purposes. Rather the purpose is to provide a basis for internal and external communication to ensure that communication is based on the same reference point (BIM strategi, 2011).

The maturity regarding utilization of BIM in Ramboll is described by levels ranging from 0 to 3, where 0 is the lowest and 3 is the highest level of progression. What parts of BIM which are included in each BIM level is specified. This enables task managers to always have a next maturity level, including more parts of BIM to progress towards. For example, services as BIM coordination could be provided to a client in order to reach level 1 (BIM strategi, 2011).

Level 0 – Usage of BIM softwares

At level 0, 3D is utilized in the design phase. But there is no coordinated connection to the models of other disciplines or requirements regarding documentation of information exchange (BIM strategi, 2011).

Many of the 3D softwares which are employed in the day-to-day work have functions that could be classified as BIM. However, these functions are not utilized at the present time and there is unexploited potential which could be benefited from (BIM strategi, 2011).

Level 1 – 3D coordination

Stage 1 in the BIM maturity levels implies a well functioning coordination between different disciplines. As the building information models of different disciplines are interconnected, clash controls can be performed (BIM strategi, 2011).

An example of an additional service that can be provided at this level is identification and organization of information flows within the project, which is a prerequisite for creating a common understanding regarding goals in the project (BIM strategi, 2011).

Level 2 – Analyzes, time and cost estimation

At level 2 in BIM maturity, level 1 and one or several additional BIM services which require input from more than one discipline are provided. Examples of services which can be provided at level 2 are energy analyzes and more elementary variants of time and cost estimation (BIM strategi, 2011).

Level 3 – Integrated model

In order to operate at level 3, more advance models are required. Services from both level 1 and 2 are provided with a highly integrated model between the different disciplines (BIM strategi, 2011).

Examples of services which can be provided at level 3 are more advanced time and cost estimation, programmed with a parametric design, as well as maintenance models which is fully integrated with the client’s management and maintenance systems (BIM strategi, 2011).

The idea is that level 3 should represent the cutting edge of BIM technology, not impossible, but certainly unusual to reach. The content of level 3 should be periodically updated as the technological development progresses (BIM strategi, 2011).

3.4 IFC

IFC (Industry Foundation Classes) is an open-data format developed by BuildingSMART, formerly known as the International Alliance for Interoperability (IAI). IFC is a neutral and independent file format that does not belong to any particular software vendor. The IFC is also independent of any vendor's software development plans. The goal with IFC is to facilitate the information exchange between different programs developed by different software companies (buildingSMART, 2011).

4 Construction project management

The purpose of this chapter is to give the reader an overview of project management within the construction industry. A brief introduction of the topic is presented, followed by the construction process and the project manager's roles and responsibilities. The chapter ends with a description of the cooperation form partnering.

4.1 Introduction to project management

A project is an undertaking to achieve a unique goal within a time period that has an explicit beginning and end. Projects are temporary organizations were the project team is made up by stakeholders from different organizations. These stakeholders work together during the duration of the project and separate on project completion Considerations in the early phases of a project generally have a major impact on successive phases, which makes planning important (NE, 2011).

Project management can be applied for effective delivery of projects. According to the Project Management Institute, project management can be defined as "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" (PMBOOK Guide, 2004).

4.2 The construction project process

The construction project process can be organized into four sequential phases: initiation, design, construction and closure phase (NE, 2011), see figure 3. Descriptions of these phases can be seen in the subchapters below.

Figure 4: The four sequential phases: initiation, design, construction and closure phase.

Initiation phase

A construction project develops and initiates through emerged needs of appropriate premises for certain types of activities. Once the needs and requirements are established and the financial aspects settled, the client appoints a project manager to plan and manage the project together with the client. The client is the one making the important decisions concerning for instance the appearance, standard, quality and environmental requirements of the building by approving or declining suggestions by the project manager (Nordstrand, 2008).

Before initiating a construction project it is necessary to perform a pre-study to determine whether to go forth with the project or not. A pre-study includes an investigation and analysis of prerequisites for the possible construction project, such as topography and geotechnical characteristics of the site. The study also includes specifying the need of premises as well as evaluating financial consequences of the project. The project team that perform the pre-study should know what activities will take place in the premises to get an idea of the need for space, and once a gross area is calculated, cost assessments can be made. The project team should consist of the client, persons with technical skills, and economical skills as well as representatives from the end-users (Nordstrand, 2008).

When the pre-study is finished and the client has decided to go forth with the construction project, a more detailed investigation must be carried out. The client's needs and requests are specified and more accurate cost calculations and proposals of the design outlines are performed (Nordstrand, 2008).

Completion of the initiation phase results in a program which contains an overview of all performed investigations. The program includes a project description, where the vision of the project is established; an activity description, where the use of the building is specified; a premises program, where space requirements of the premises are evaluated; and a technical program, where requirements of lightning, energy and acoustics etcetera are established. The program can also contain a site investigation and geotechnical study, outline drawings, environmental program, quality program, time plan and spreadsheet program, and so forth. Further on the program can be a basis for the procurement of the contractor, architect competition and for the design phase as a whole (Nordstrand, 2008).

Design phase

During the course of the design phase, a construction that meets the client's needs and requirements is compiled according to the program produced in the initiation phase. The building is presented in construction documents that contain drawings, descriptions, specification, lists, geotechnical report, time plan, technical calculations, and colour presentations etcetera, which will be the basis for the contractor constructing the building (Nordstrand, 2008).

Besides the project manager, the design team mainly consists of the architect as well as structural-, HVAC- and electrical designers. In large projects, a planning manager can be appointed by the project manager to plan and coordinate the design work. These stakeholders should have a close relationship and a good communication during the entire design process in order to avoid clashes between construction and installation components (Nordstrand, 2008).

The design work is continuously customized in order to fulfil requirements according to for instance the project's environmental plan as well as regulations in the BBR (Boverkets Byggregler) and BKR (Boverkets Konstruktionsregler). The design phase is performed step by step and is divided into three phases; 1) the schematic design phase, where the building is shaped in general terms and draft drawings are produced, 2) the design development phase, where load bearing structural and installation systems are established and design development documents are produced, and 3) the construction documents phase, where detailed design of the building is achieved and construction documents are produced (Nordstrand, 2008).

The construction documents should convey information between the participants within the construction project process. In order to avoid misunderstandings, common document guidelines, like for instance “Bygghandlingar-90”, are published by the SIS (the Swedish Standards Institute). These documents should contain all information needed to construct a building according to the client’s requirements and needs. The contractor should also be able to perform cost estimations in relation to the tendering process by having these documents as a basis (Nordstrand, 2008).

When the construction documents are completed the project manager should check the time plan of the project and recalculate the budget. In some cases the project manager also has to produce operating and maintenance instructions for the future managing and maintenance of the building, which will be delivered to the client in relation with the closing phase (Nordstrand, 2008).

Construction phase

The contractor is the main stakeholder in the construction phase and is responsible for acquiring and managing resources, as well as preparing and carrying out the construction in order to fulfil the requirements of the client (Nordstrand, 2008).

Before initiating the construction work, the contractor must plan and organize the production of the building. This is important for efficient execution in the construction phase, which means fulfilling requirements regarding schedule, budget and quality of the project. These plans, together with the project budget, should ensure control over the execution in the construction phase (Nordstrand, 2008).

To be able to execute the construction work according to established plans, the contractor must acquire both human and material resources such as subcontractors, material and machines. In order to minimize costs, appropriate resources should be obtained in the right amount, delivered on time and to the correct location on the construction site. The construction process should be constantly supervised to create a secure work environment. Re-planning during the construction phase is common due to unexpected events and risks (Nordstrand, 2008).

The agreements between the contractor and client are regulated through general provisions AB 04 and ABT 06. It is important for both parties to be familiar with regulations and their application to avoid time-consuming and costly negotiations concerning legal issues (Nordstrand, 2008).

Closure phase

In the closure phase, all project processes are finalized once the final inspection is approved and the warranty period begins. The completed project attains a formal acceptance and can be handed over to the client (Nordstrand, 2008).

Parties involved in the handover process are the construction and installation contractors, the quality manager and in some cases also representatives of the client, designers, supplier and specific inspectors. Activities such as inspections and development of quality documents which must be performed to achieve formal acceptance, are specified in the construction documents and in current legislation. A final inspection is executed to determine if the building fulfil all requirements or if there are errors that must be corrected. In order to minimize the number of errors in the final inspection, the contractor and the client can decide to perform several inspections during the construction phase. By having these inspections, errors can be detected and adjusted at an early stage (Nordstrand, 2008).

All documentations from the inspections are submitted to the building committee, which on approval will write a confirmation that states that the client has fulfilled its commitments. If the building committee has any remarks, it will be decided if the building is approved for use before or after adjustments are implemented (Nordstrand, 2008).

After project completion, representatives from involved parties might gather for a seminar with the purpose of analyzing and discussing what can be learned for future projects. This is a common approach in projects where the cooperation form partnering is employed. For a depiction of partnering see chapter 4.4: Partnering (Nordstrand, 2008).

4.3 The project manager

The project manager has the overall responsibility of a project from conception to completion, and is essential for its successful delivery. In this master thesis, the project manager is seen as a representative of the client, and as a separate role from the planning manager.

Successful project – definition

From a project manager’s point of view, a project is considered successful if the project has been delivered:

- according to its specifications
- within budget and time
- to the satisfaction of the client, end-users and investors
- with the help of a satisfied project team (Antvik & Sjöholm, 2005).

Responsibilities

Some of the main responsibilities that a project manager must fulfil for the successful delivery of a project are the following:

- **Define goals and scope**: The project manager must comprehend the client’s goals with the project and communicate them to the project team. Based on the goals, project scope is defined by evaluating which deliverables should be included or excluded. The project manager should clarify to the client which actions are taken to meet the goals (TenStep, 2010a).

- **Manage human resources:** The project manager is responsible for establishing the project team by acquiring personnel with the necessary competence to complete project activities (TenStep, 2010b).

- **Manage communication:** The project manager is responsible for providing and receiving information during the project process. The project manager should also communicate with the client, team members, and other relevant involved parties regarding project progress and status (TenStep, 2010c).
- **Manage risk**: Risk refers to circumstances that would have a negative impact on project performance if they occurred. The ambition is to identify and avoid risks. It is however impossible to foresee all risks. When problems occur the project manager is responsible for taking corrective action and to get the project back on track (TenStep, 2010d).
- **Manage schedule and budget:** The project manager is responsible for delivering a project on time and within budget. The project schedule and budget are estimated based on the currently available information and should be continuously updated. These two components are key deliverables as they are criteria for project success and are generally closely connected; if the project is behind schedule it will usually also be over budget (TenStep, 2010e).

Roles

The project manager takes on multiple roles in projects. Some of the most central are described below.

Chairman
During the course of the project, numerous meetings, such as a kick-off meeting, planning meetings, follow-up meetings and a closing meeting will take place. The project manager functions as chairman at these meetings and oversees that the meetings are conducted in an organized and orderly manner. The project manager could if necessary entrust this role to an assistant project manager (Mygård, 2009).

In small projects where there are few members in the project team, all members usually participate in the meetings, while the members of large projects often meet in various group constellations (Mygård, 2009).

The project manager must ensure that the project is thoroughly documented during the project process, which means writing protocols of meeting proceedings to facilitate the planning, tracking and reporting of the project (Mygård, 2009).

Team leader
Once the project team is established, the project manager will function as a team leader in the temporary project organization. This implies leading one or several teams to function well and create an enjoyable work environment (Mygård, 2009).

As a team leader the project manager is in charge of delegating obligations, authority and work tasks to members of the project team in order to complete project activities (Mygård, 2009).

Trouble shooter
It is the project manager's role to function as a trouble shooter in the event of conflicts and disputes among members of the project team. This implicates functioning as an intermediary between the disputing parties, finding out what caused the problem and how a solution can be achieved (Mygård, 2009).

It is favourable if the project manager can get involved parties to view a dispute as a common problem with a mutual solution (Mygård, 2009).

Representative
The project manager acts as a representative of the project in various situations. As a representative, the project manager acts in the interest of another party through delegated authority. In the communication process between the project team and the client, the project manager functions as a representative for both parties (Mygård, 2009). In this role it is important to separate own opinions from those as a representative (Mygård, 2009).

4.4 Partnering

The way construction projects are commonly executed have long been criticised for the lack of cooperation between stakeholders. Stakeholders often have narrow areas of responsibility and they often prioritize to profit individually instead of maximizing the value of the project as a whole (Nordstrand, 2008).

Partnering is a cooperation form which addresses these problems; it focuses on close relationships between stakeholders with mutual trust and openness. Emphasises is on best value rather than lowest cost (Nordstrand, 2008).

The ambition with partnering is to maximise the efficiency of each participating stakeholders' resources. This can be achieved by teamwork and by involving stakeholders at an early stage so that potential problems can be identified and addressed early on, instead of being detected on a later stage in the project process (Nordstrand, 2008).

The client appoints stakeholders who are considered reliable and cooperation is initiated at an early stage. After the project team has established mutual goals, time plan and budget are decided, responsibilities are delegate and agreed upon. Eventual profits from lowered costs in the project are shared by the involved stakeholders. In the closure phase, project performance and experiences are evaluated (Nordstrand, 2008).

5 Results from interviews

In this chapter the results of the interviews are presented. The chapter is structured with five subheadings which reflect the topics that were discussed during the interviews. The statements consist of subjective summarizations of the interviewees' answers. In total twelve interviews were conducted: six with project managers and six with BIM experts.

5.1 Interviewees BIM definitions

During the course of the interviews it became evident that some of the project managers had little knowledge about BIM and its implementations. Naturally, the BIM experts were more specific in their BIM definitions in comparison to the project managers.

A common theme concerning the interviewee's definitions of BIM was that BIM was commonly perceived as having a lot to do with information management and communication between different stakeholders. Moreover, many of the interviewees emphasised that BIM is more than just a model, and that it could be seen as a process of managing information; "Building Information Management" rather than "Building Information Modelling".

Beside the common theme of seeing BIM as something having a lot to do with communication and information management, the interviewees' BIM definitions were expressed in somewhat different ways. It was pointed out by the interviewees that there is no unified definition of BIM within the construction industry. Organizations create their own definitions of BIM, customized by the particular way they work with and relate to BIM.

5.2 Definition of project management

The interviewee's definitions of project management quickly lead into descriptions of the project manager and this person's role in construction projects. The project manager was often described as "the spider in the web", which has the overall responsibility of delivering a project and ensuring that the requirements of the client are fulfilled. Depending on the specific project, the project manager could also be assigned with the economic responsibility of a project.

For consultancy firms, the project manager is seen as a representative of the client and can operate in all phases from initiation to closure of the project. As Ramboll is a consultancy firm, the project manager is presumed to be a representative of the client in this master thesis. Additionally, the focus is on larger projects were the project manager and planning manager are considered separate roles.

The perception of in which phases the project manager operate varied between the interviewees. Contractors could perceive the site manager, which operates in the construction phase, as a project manager. While the planning manager, who operates in the design phase, is another type of project manager.

In smaller projects, the planning manager and the project manager is often the same person. Whereas, in larger project the planning manager is usually a separate role that is added because the project manager has to focus on coordinating the project on a larger scale and often does not have time to get too involved in the design phase.

5.3 Benefits with BIM

According to the interviewees, BIM can provide a number of benefits for project managers in construction projects. The benefits which were pointed out as the most significant ones were better communication and quality.

Communication benefits

The communication process between stakeholders involved in a construction project can improve noticeably with the help of BIM. A fundamental reason for this is that it is much easier to relate to a 3D model of a building rather than by 2D drawings, where the observer first has to analyze the drawings, and then has to create a mental image of what the structure would look like in 3D. It is virtually impossible to include everything that can be shown in 3D trough 2D drawings. For example, it could be difficult to understand the drawings of a HVAC engineer when a lot of overlapping pipes are depicted in 2D; this could be made much easier to understand if a 3D building information model were available.

BIM also allows for much less costly and time consuming production of building visualisations. In traditional projects, building visualisations have to be produced from scratch, whereas when BIM is employed most of the material for visualisations can be taken from already created models.

An important point claimed by the interviewees was that the project manager can communicate more efficiently with the client regarding goals and requirements concerning a building when there is a 3D model available.

The building information model would function as a single source of information in construction projects, which would provide easy access to information for all stakeholders. If for instance the project manager wants to know which classification a certain door has, this information can easily be obtain from the building information model instead of having to contact the fire safety engineer.

Quality benefits

As mentioned above, BIM provides a better depiction of reality. This makes it much easier to understand and see the consequences of decisions that are made. For instance the visual effects of different facade materials as brick and compo can be seen. The result is that a better basis for decisions is offered through BIM in comparison with traditional projects.

A main reason that higher quality can be achieved when BIM is utilized is that information only needs to be entered once in BIM projects in comparison with traditional projects. For instance, the quantifying of material demand can be computed several times by different stakeholders in traditional projects, with the motivation that stakeholders do not trust the computations done by others than themselves. When data is computed only once, it is more likely that existing errors are identified and there is also less risk that errors slip in as a result of the human factor. Moreover, less time will be wasted on repetitive work. For instance, when modification and supplementary work (ÄTA) is performed, it is only necessary to implement changes one time, and all drawings linked to the model will be updated, instead of manually updating a set of separate drawings.

Another benefit is the ability to perform clash controls in the design phase. Here the models of different disciplines are merged into a single model and points where the structures clashes, are detected. These points can then be corrected, in order to avoid problems that would otherwise occur in the construction phase. The interviews claimed that approximately nearly all clashes that they would normally receive would be avoided by performing clash controls.

When using BIM, it facilitates for the project manager to control a project so that it follows the time plan during the design phase. During planning meetings, stakeholders such as the architect and electrical engineer reports to the project manager what they have accomplished in their work-tasks. In BIM projects, the project manager will know exactly what each stakeholder has accomplished until each meeting, as they will upload the latest version of their models where everything can be clearly seen. In traditional projects, there is more room for uncertainty regarding what have actually been accomplished, as stakeholders tend to hold on to their drawings as long as possible, until finished.

With BIM, there is a 3D model available which increases the access to different kinds of analyzes of for instance energy, light and acoustics. In traditional projects, a model has to be produced from scratch in order to perform an analysis of this type. In comparison, only the data necessary to run an analysis has to be added to the building information model in BIM projects, for instance the isolating ability of different materials in order to perform an energy analysis. For this reason, the time and cost to perform analyzes is much less, and as a result more analyzes are often performed which increases the quality.

Many of the interviewees wished for more implementation of linking the building information model to time and believed that this would allow for more effective planning of the construction phase. The time linkage can be used to visually simulate different scenarios and in which order different parts of the construction could be built. The advantages and disadvantages of the different alternatives of conducting the construction can be weighed against each other in order to come up with an optimal solution. This enables early detection of planning errors, instead of realizing the planning mistakes later on when construction is already underway, which can be very costly. Moreover, the logistics could be planned more efficiently, when certain materials should arrive and where the best locations are to place cranes on the construction site. The time linkage to a 3D-model could also be used by the site manager to see how the time plan is followed, as well as to communicate building plans for the construction to subordinates, for instance by what point of time a certain wall should be raised.

The building information model can also be connected to price lists for the different materials that are used. This enables cost estimation where materials and construction solutions can be evaluated from an economical perspective. Cost estimation can be helpful when discussing different alternatives with the client from an economical viewpoint; it can for example be determined what the client can obtain from a certain amount of invested money.

5.4 Challenges with BIM

According to the interviewees, the greatest challenge concerning implementing more utilization of BIM in the construction project process is the personal opinion towards BIM. It is very hard to get somebody motivated to implement a change if they do not understand what the change is good for.

Many of the interviewees stressed the importance of pilot projects where BIM is utilized. Through pilot projects, the benefits with BIM can be experienced. All interviewees who had personal experience of working with BIM, had a good impression of it and wanted to continue working with BIM because of the benefits it provided.

A big challenge according to the interviewees is the lack of cohesion among stakeholders in the industry. Some companies focus on production and operate in the construction phase. Architectural and consultancy firms operate in the design phase, and there are also many small enterprises which do not have the economy to invest in new technology. These dispersed stakeholders make it difficult to work towards a common goal and introduce new ways of working.

Another challenge pointed out by the interviewees was that the Swedish construction industry generally is on a beginner level concerning the implementation of BIM. This can make it hard to find stakeholders that have the required competence to participate in BIM projects.

The interviewees claimed that the implementation of BIM is not always as easy as software developers suggest. A usual problem is getting different file formats to function properly when creating a combined building information model. This could for example relate to the computation of material volumes. When data is taken from the original building information models a certain value is attained, and when data is taken after the models have been converted into the IFC file format, a dissimilar value can be generated.

Another issue brought up during the interviews was the legal status regarding the combined building information model which does not have any legal validity, and can just be applied as a complement in the project process. It is only 2D drawings plotted from the discipline specific models that have any legal validity.

A further challenge is to choose an appropriate level of detail for the building information model, so that money and time is not wasted on compilation of unnecessary information. It is for instance often necessary to choose if the information needed for certain analysis should be added in advance, as there is often not enough time to add this information in retrospect as the project progresses.

5.5 Changed role and relationships

According to the interviewees, the project manager's role would remain the same in BIM projects as in traditional projects. BIM is just a tool that can aid the project manager in the project process. If any changes occur, this would not apply to the actual role, but rather to the skills of the project manager, who might be required to learn about BIM.

A new stakeholder that has emerged in BIM projects is the BIM coordinator, who functions as a support for the project manager and is responsible for technical issues regarding BIM.

The interviewees suggested that the relationships among involved stakeholders are required to move towards more partnering-like relationships for effective implementation of BIM. Stakeholders would be involved earlier in the project process to provide insights concerning their particular competence. There were interviewees who had participated in BIM projects, in which the contractor had come with suggestions of construction alternatives that lead to money and time being saved in the construction phase. The open attitude between the stakeholders would also create a more enjoyable working environment.

6 Analysis & discussion

In this chapter, relevant discussions will be brought up and linked to theory. The chapter is structured in the same way as chapter 5, with five subheadings which reflect the topics that were discussed during the interviews.

6.1 Definition of BIM

The results indicated that there are differences in the way BIM is perceived by both different individuals and organizations within the Swedish construction industry. This is confirmed by Jongeling (2008), who claims that there is confusion regarding what BIM is, and what BIM is not. This could lead to misunderstandings concerning expectations from different stakeholders involved in construction projects where BIM is utilized. Moreover, BIM is a very wide concept with many features, such as clash controls, analyzes, time estimation and so forth. It is therefore important to be precise when talking about BIM, for instance when specifying requirements regarding BIM in the tender request documents. This is important for avoiding misunderstandings and ensuring that stakeholders can deliver what has been requested concerning BIM.

It comes naturally that different organizations and people create their own definitions of BIM, accommodated to the particular way they work with BIM. For this reason it might be difficult to come up with a common definition of BIM for the entire construction industry.

6.2 Definition of project management

According to Haughey (2011a), the project manager has the overall responsibility for delivering a successful project. This validates the results of this study, in which the interviewees clarified the importance of the project manager for the successful completion of construction projects.

There were small variations in the interviewees' descriptions of the project manager's role. The role clearly implicated to act as the "spider in the web", with overall responsibility for delivering a successful project, and to ensure that the requirements of the customer are fulfilled. The interviewees' descriptions of the project manager's role correlated to a large extent to what were described as the goals of the project manager suggested by (Antvik & Sjöholm, 2005), see chapter 4.3.1: Successful project – definition.

6.3 Benefits with BIM

One of the aims of this master thesis is to identify advantages of utilizing BIM for project managers. As previously mentioned, the project managers' main task is to deliver successful projects, and the results showed that BIM can help the project manager in this task.

The results of the study showed that the communication benefits which BIM provides is particularly valuable for project managers. It was pointed out that the increased ability to communicate provided through BIM can be a substantial help creating mutual understanding between the project manager and the client. The project manager has a key role regarding maintaining communication with stakeholders. One of the hardest parts is to create mutual understand with the client. As one of the interviewed project managers said:

> *"The hardest part in the role as a project manager is to understand what the client wants to achieve and to describe for the client what he will get"*

The finding that the communication benefit that BIM provides is valuable for project managers corresponds to what was described in theory. Mygård (2009) claims that the client's goals with a project are often hard to interpret, and according to Tensteps (2010c) and Mygård (2009) communication is crucial for creating understanding regarding a client's goals with a project.

The quality benefits which BIM provides are most valuable for project managers concerning keeping control of a project; according to Haughey (2011b), the project manager is responsible for keeping control of a project from project initiation to closure. When a building information model is utilized in the design phase, project progression can be clearly seen when the disciplines' models are uploaded. This allows the project manager to estimate project schedule and budget more accurately in comparison with traditional projects, where the disciplines often want to hold on to their drawings as long as possible until finished.

The results showed that many of the interviewed project managers saw big potential improvements from linking the building information model to time. This would provide the project manager with better control coming from more precise time estimates and better planning of the construction phase. The ability to plan the execution of the construction phase would be a significant benefit for the contractor, and would lead to improved performance in the project as a whole. The BIM Project Execution Planning Guide (2009) states that time estimation provides better understanding of construction plans.

Cost estimation can provide better control of the economical aspects of a project, and optimize the value a client can obtain from investments. According to the BIM Project Execution Planning Guide (2009), cost estimation can be applied to avoid cost overruns as well as to explore different design options within the client's budget. According to the interviewed project managers, the biggest gains of cost estimation would be for the contractor, reducing costs in the construction phase.

Many of the benefits that BIM provide do not apply to the project manager directly, but to other stakeholders involved in a construction project. When stakeholders perform better in their individual tasks, this will indirectly affect the project manager positively. When the project as a whole performs better, it is more likely that the project will be successful and there will be better profit margins for all stakeholders, including the project manager. Jongeling (2008) claims that there are substantial cost savings in BIM projects, in comparison to projects where 2D-CAD is utilized; a lower end estimation of the savings are 4 percent of the building costs, the net cost savings for the architect and technical consultants is between 0 and 20 percent, and for the contractor 4 percent.

6.4 Challenges with BIM

As the results showed, the greatest challenge concerning implementing more utilization of BIM is the personal opinion. In order to be motivated to implement a change one must understand what the change is good for. Bengtson (2010) suggests that it is the attitude towards BIM that is the greatest challenge and has to become better in order to develop the utilization of BIM.

> "*Why should you change if you can complete a work task completely fine the way you have always done it*? -one of the interviewed project managers

Project managers are often very skilled and have great knowledge about the construction industry. However, since they are often older, they are used working with 2D drawings and information on paper and do not have the same experience with computers as younger colleagues. Moreover, project managers have to be very authorial in their role in order to effectively run construction projects, and if given the wrong tools they can feel that they lose control. There are older project managers who are very enthusiastic concerning BIM, but there are also those who believe that BIM is only some new nonsense.

There has to be proof that BIM is useful in order to motivate those who have doubts concerning the usefulness of BIM. Many of the interviewees stressed the importance of pilot projects where BIM is utilized. Through pilot projects, the benefits with BIM can be experienced. All interviewees who had personal experience of working with BIM, had a good impression of it and wanted to continue working with BIM because of the benefits it provided. According to the BIM Project Execution Planning Guide (2009) and Thorell (2010), practical studies in pilot projects, where the economical benefits of BIM are proven, are necessary to bring the utilization of BIM further.

Another challenge with implementing BIM is the difficulty to find stakeholders with the competence to participate in BIM projects. The results indicated that the level of knowledge regarding BIM in the Swedish construction industry generally is low, and the lack of cohesion among stakeholders makes it difficult to improve the knowledge level. Many of the interviewees pointed out that the utilization of BIM goes hand in hand with a new method that allows more partnering-like relationships between stakeholders. These collaborative relationships can create more cohesion between stakeholders, thus making it easier to work together towards a common goal of implementing BIM.

Many of the interviewees talked about the initial expenses associated with education and acquiring the hardware and software necessary for transitioning from traditional projects to a work method where BIM can be employed in construction projects. However, the BIM experts pointed out that this is not a real challenge but should rather be viewed as an investment, which would pay off in the long run.

The results also showed that there can be problems with the implementation of BIM, for example loss of information when files are converted to another format. Khöler (2008) validates that there exist problems with the implementation of BIM, especially with transfer of data between software.

Another issue is the legal status regarding the combined building information model, which is just a tool in the project process and does not have any legal validity. It is only 2D drawings plotted from the discipline-specific models that have any legal validity. This can create confusion when trying to determine who is responsible if something goes wrong, following decisions that have been based on information from the building information model. Lindström & Jongeling (2010) state that there are a lot of legal questions regarding responsibility, copyrights, access rights and ownership connected to the utilization of BIM.

Something that should be kept in mind when starting projects where BIM is utilized, is the level of detail which is used. It is important to only include the information which is necessary, so that time is not wasted on unnecessary tasks with compilation of information. It is also important not to exclude important information; a calibration has to be done regarding what information should be included.

6.5 Changed role and relationships

The results of the interviews indicated that the project manager's role will remain the same in BIM projects as in traditional projects. The project manager might however be required to learn new skills related to working with BIM. This finding is confirmed by Smith & Tardif (2009), who claims that the roles and responsibilities of individual stakeholders are not likely to fundamentally change when BIM is implemented.

The transition to BIM does not have to be complicated for the project manager and other stakeholders. In order to make the transition more natural, the interviewees suggested that the implementation of BIM should be done incrementally. Small parts of BIM should gradually be implemented and when experience has been gained in these parts, additional parts of BIM can be added in the next project. Bengtsson (2010) validates this suggestion by proposing that BIM should be implemented step by step for a smooth implementation process.

A new role that has emerged with the introduction of BIM is the BIM coordinator, who is responsible for the technical aspects of BIM, for instance merging the models of different disciplines into a single building information model. The project manager is not required to have advance knowledge in the different software used in BIM projects, but should rather have general knowledge of BIM and its implementations. As one of the interviewed project managers said:

> "*If you as a project manager do not want to focus on the technical aspect of BIM, but let the BIM-coordinator focus on that, then BIM will simplify things a great deal*."

Smith & Tardif (2009) suggests that the nature of the relationships will change and become more collaborative with the implementation of BIM. Regarding the project managers' relationships to other stakeholders within BIM projects, the interviewees made clear that these relationships are required to become more partnering-like between the stakeholders for effective project delivery. The partnering relationships aimed towards more long term and close relationships could resolve some of the challenges with dispersed stakeholders. Stakeholders can then come together and work towards a common goal of implementing BIM.

Many of the interviewees claimed that BIM project with its partnering-like relationships along with less mistakes and fewer conflicts, results in a more friendly working environment. According to Antivik & Sjöholm (2005), one of the project goals is to complete the project with the help of a satisfied project team. A friendly work environment could contribute to fulfilling this goal.

7 Conclusions

The purpose with this chapter is to state the most important conclusions of this study. The conclusions will correlate to the purpose of the master thesis and bring up subjects relevant to the aims. Furthermore, suggestions for further research will be proposed.

Project managers generally have little knowledge about BIM, which makes it hard for them to see implementations and benefits of BIM in construction project.

The study showed that BIM can help the project manager in the task of delivering a successful project. The project manager must make decisions in the project process. With BIM, a better depiction of reality is provided, which makes it easier to understand and see the consequences of these decisions. Therefore a better basis for decisions is offered through BIM in comparison with traditional projects and the project manager can do a better job. BIM also provides the benefits of better communication and quality for project managers. The communication benefit allows the project manager to communicate with involved stakeholders more effectively, which is important for creating a mutual understanding regarding goals of the project, and thereby fulfil the needs of the client to a higher degree. The quality benefits that BIM provides are most valuable for project managers concerning maintaining control of a project. The project manager can clearly see the progression in the building information model during the design phase, giving the project manager a better basis for assessing the schedule and budget more accurately. Thus better control over the project is acquired. The interviewed project managers saw potential improvements coming from linking the building information model to time, which would lead to increased control in the construction phase. Many of the benefits with BIM do not apply to the project manager directly, but contributes to the project as a whole. Since the project will go smoother, the benefits indirectly affect the project manager positively in delivering a successful project. When the project as a whole performs better, the project is more likely to be successful and there will be better profit margins for all stakeholders, including the project manager.

Challenges that were pointed out were the risk of adding unnecessary information that would lead to waste of time and money, legal issues concerning the legal validity of the model, technical problems with the implementation of BIM, as well as the lack of cohesion in the industry. However, the fundamental challenge regarding the implementation of BIM is the personal opinion towards it. People must see how they can benefit personally in order to be motivated to change. Pilot projects are essential for changing the personal opinion and bring the utilization of BIM further. Stakeholders need a chance to experience the benefits that BIM provide firsthand in order to embrace it. The interviewees who had personal experience of working with BIM, had a good impression of it and wanted to continue working with BIM because of the benefits it provided.

The project managers' role will remain the same in BIM projects as in traditional projects. However, the project manager might be required to learn some new skills related to working with BIM. Regarding the project managers' relationships to other stakeholders within BIM projects, the interviewees made clear that these relationships are required to become more like those in the cooperation form partnering for effective implementation of BIM.

Suggestions for further research

Several interesting subjects were encountered during the process of producing this master thesis. These have however not been within the scope and purpose of this study and are therefore suggested as subjects for further research. Subjects that require further investigation are for example:

- How BIM will affect the project process, e.g. big rooms, integrated. project delivery (IPD), product lifecycle management (PLM).
- How organizational culture affects the ability to implement new ways of working.
- The legal aspects concerning BIM.
- How an organization can balance between continuous development and standardization.

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8.4 Other

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Seminar
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Appendix 1: Interview framework

Kontext

- Vi presenterar oss.
- Berättar vad examensarbetet handlar om (syfte/mål).
- Frågar respondenten om det är ok att vi spelar in intervjun (vid behov av inspelning).
- Förklarar att intervjun är anonym.
- Några frågor?

Inledande frågor

- Namn
- Ålder
- Utbildning
- Yrkesbakgrund

Intervjufrågor

1. Hur skulle du definiera BIM?

    a. Hur har du fått din kunskap BIM?
    b. Hur väl känner du till BIM? 1-5 där 1 är inte alls och 5 är väldigt insatt

2. Hur skulle du beskriva/definiera projektledning?

    a. Kan du beskriva projektledares arbetsuppgifter/roll i byggprojekt?
    b. Din erfarenhet gällande projektledning? Hur många års erfarenhet har du?
    c. Vilka verktyg använder projektledare i sitt arbete när inte BIM används?

3. Vilka fördelar kan BIM bidra med för en projektledare inom byggsektorn?

    a. Vilka av projektledarens arbetsuppgifter skulle kunna datoriseras mer?
    b. Hur kan förbättringen ske?
    c. Vilken del av projektprocessen kan förbättras och bli mer effektiv?

4. Vilka hinder finns det från en projektledares perspektiv för användning av BIM i byggprojekt?

    a. Finns det hinder baserade på personlig inställning?
    b. Hur mogen är din orginisation/byggindustrin i Sverige för en övergång till BIM inom projektledningsprocessen?

5. Hur kan projektledarrollen komma att ändras i byggprojekt där BIM används i jämförelse med det “traditionella” arbetssättet?

    a. Tror du att projektledarens relation till övriga involverade parter (beställare, arkitekt, entreprenör och underentreprenörer) kommer att förändras?
    b. Om man specificerar sig mer till relationen mellan projektledaren och beställare/arkitekt/entreprenör/underentreprenörer, hur kan relationen komma att påverkas?