

CHALMERS



Identification of information needs

A prerequisite for using BIM as an information system

Master of Science Thesis

JOEL SPÅNGBY

Department of Civil and Environmental Engineering

Division of Construction Management

CHALMERS UNIVERSITY OF TECHNOLOGY

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Preface

This Master of Science thesis is the final project for me, Joel Spångby, in my postgraduate studies at the Department of Civil and Environmental Engineering at Chalmers University of Technology. It has been carried out at NCC Construction in Jönköping during the spring of 2013.

I would like to thank everyone who has been involved, for their much appreciated help throughout the project. Special thanks go to my NCC supervisor, Edvin Alnervik, for all your guidance and support. I would also like to thank my supervisor from the university, Mattias Roupé, for help with academic issues and important feedback. Also, all my love to the most beautiful wife, my wife, Malin, who has put up with waiting for me during long days and almost by herself taking care of our daughter, but always encouraged me to complete my studies as well as possible. Last but not least I would like to thank all employees at NCC that I have been in contact with and interviewed, for their patience with my tenacious questioning but of course also for many laughs shared.

Gothenburg, May 2013

/Joel Spångby

A handwritten signature in black ink, reading "Joel Spångby". The signature is written in a cursive style with a small circle above the 'o' in "Spångby".

Abstract

Supervisors and site managers in construction companies work daily with a variety of systems to manage the information and documentation that needs to be available for production work to be managed as planned. According to Granroth (2011) has the data used to produce this documentation often already been developed in earlier phases of a project life cycle. Working with multiple systems and repetition, like acquiring information again and again, can be a sign of so-called secondary needs. According to Modig and Åhlström (2012) a prerequisite to prevent continued pursuit of the secondary needs is to focus on what really is the primary need.

This study clarifies the present approach to information management in the production stage and what in the process that works as providers of information and adapters. In addition, the study shows how the information needs for site managers and supervisors presents itself, both on a general level and more in detail.

The results of the study are based on 15 interviews conducted with supervisors and site managers at five different sites of different characters within the same construction company in Jönköping. Besides these, discussions made with other professional functions in the organization have taken place and a review of the systems and the documentation to be produced during the production phase. The primary needs identified for management personnel involved in production is that information should be obtained in time, be available, be clear and simple to use and that the system itself should be user-friendly. It has also been shown that there is a desire for a continued unified approach as it ensures an approach rooted in the company. More specifically, it is primarily found a need for simplified information acquisition for input in templates, in general, information management for processors or adapters of information needs to be simplified. One suggestion would be automated information retrieval, as the completed document study shows that it should be possible through the use of BIM and VDC technology, especially with database focused mindset. It is also desirable to have fewer or even a single system to manage information.

Sammanfattning

Arbetsledare och platschefer på byggföretag arbetar dagligen med ett flertal system för att hantera den information och den dokumentation som behöver finnas tillgänglig för att produktionsarbetet ska fortgå som tänkt. Enligt Granroth (2011) har informationen som används för att producera denna dokumentation ofta redan tagits fram i tidigare faser av ett projekts livscykel. Att arbeta med flera system och repetition av typen att ta fram information gång på gång kan vara ett tecken på att så kallade sekundära behov existerar. Enligt Modig and Åhlström (2012) är en förutsättning för att motverka fortsatt uppfyllande av sekundära behov att fokusera på vad som verkligen är det primära behovet.

Denna studie tydliggör det nuvarande arbetssättet för informationshantering i produktionsskedet och vad i processen som fungerar som försörjare av information respektive förädlare. Utöver detta visar studien en bild av hur informationsbehovet för tjänstemän ser ut, både på en generell nivå och detaljerad.

Resultatet i studien grundar sig på intervjuer som utförts med arbetsledare och platschefer på 5 olika arbetsplatser av olika karaktär inom ett och samma byggföretag i Jönköping. Förutom dessa har samtal genomförts med andra yrkesfunktioner i organisationen och en genomgång gjorts av de system och den dokumentation som ska produceras. De primära behov som identifierats för personal som arbetar med produktionsstyrning är att information ska fås i tid, vara tillgänglig, vara enkel och tydlig att använda och att själva systemet bör vara användarvänligt. Det har också visat sig att det finns en önskan om ett fortsatt enhetligt arbetssätt, eftersom det garanterar ett arbetssätt förankrat inom företaget. Mer i detalj, är det främst informationssökning för att fylla de mallar eller i allmänhet förädlare av information som behöver förenklas. Förslagsvis skulle informationshämtning kunna automatiseras, något som den genomförda dokumentstudien pekar på borde vara möjligt genom användande av BIM och VDC teknologi, speciellt med ett tankesätt där en databas är en del av lösningen. Det är också önskvärt med färre eller till och med ett enda system för att hantera information.

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Chapter 1

Introduction

1.1 Background and problem definition

Site managers and supervisors in the construction business do daily work with several different supporting tools and systems producing time schedules, calculations, logbooks, quantifications, control documents and work preparations (Persson, 2012). Much of the information used to produce these documents is already developed in earlier stages of the building process which if it anyway shall be repeated is unnecessary (Granroth, 2011). Both this repetition and the presence of several systems handling information can according to the lean concept, as described by Modig and Åhlström (2012), be seen as a sign of existing secondary needs in terms of information management.

Within lean production is an activity value or non-value adding for the customer. The non-value adding time is divided into one part needed in order to carry out the work as it is done at present and some that are pure waste and can be removed immediately. If the non-value adding activities are eliminated, resources can be freed up to develop operations further (Blücher and Öjmertz, 2007). A concept which lean can be seen as a solution to is the problem of secondary needs. These needs have to be fulfilled even though they are non-value adding and emerge due to many restarts, many flow units and long throughput time. Secondary needs often arise as a consequence of failure of not satisfying primary needs since additional work are created. Primary needs is to say needs for executing value adding activities. Meeting secondary needs are often experienced as being value adding, even though they in reality never would have been necessary if the primary need would have been met from the beginning. To be able to mitigate creation of secondary needs focusing on primary needs can be seen as a prerequisite (Modig and Åhlström, 2012).

Parallel to existing information systems and supporting tools, current trends point in the direction of a more extended usage of Building information models/modeling, BIM, and Virtual Design in Construction, VDC, throughout the building process (Granroth, 2011). This is also the case at the construction company NCC¹, which have been working as a case company during this study. In agreement with NCC, a need for knowledge about the primary information needs for site managers and supervisors in the production phase was identified. With the overall aim to provide knowledge for aligning development of BIM with existing concepts and working methods, have the "information needs" been studied.

The concept "information needs" is interpreted in this report based on the article "On user studies and information needs" written by Wilson (1981), where the basic need of information and what demands on information that is required for executing a specific task or activity is what define the meaning of the term. This does only include needs that can be fulfilled through meeting the demands made on the information itself. However, as Kebede (2002) stress that "information needs" are constantly changing depending on changes in technology providing it, has in addition the information seeking behavior as defined by Wilson (1981) consistently been taken into consideration.

¹NCC Construction Sverige AB

1.2 Purpose

The purpose is to support a future reduction of duplicated activities and rationalization of activities performed during the building process at NCC, by providing an identification of the information needs of site management staff in the production phase.

1.3 Objectives

The objective is to give a reliable description of the information needs of primarily the production function, as well as demands on information from the previous functions. The description should serve to make the information needs visible for future information system development.

1.4 Research questions

1. What is the current practice for information acquisition and which are the different information providers and information adapters?
2. What are the needs in terms of managing and using information for supervisors and site managers in the production phase?

1.5 Limitations

The report is primarily focused on the functions at NCC as a construction company in the production phase. Consequently, a limitation has been taken assuming the design phase to be finished and therefore not included in the study. However, the study should be able to show demands on information, delivered from the design phase, which depending on procurement procedure could be an in house operation. The definition of what is contained in the production phase has been decided depend upon the activities primarily performed by site managers and supervisors.

1.6 Disposition

The report begins with the theoretical framework of which the study is based. This section deals with defining the production phase which primarily is the context where the study take place. Then it brings up the concepts of information and data, as well as information needs and information systems. Last, research about VDC and BIM are presented.

Thereafter, there is a chapter on methodology where it is described how the study is conducted and the methods used to obtain the results that will answer the posed questions.

The methodology is then followed by a short description of the case company NCC focusing on their information systems and contemporary VDC usage.

The results chapter presents the interview results that have been developed based on the implementation of the previous chapter. This part concludes with a summarizing analysis of the current state proposed to form the basis for further information system development.

The discussion chapter discusses the analyzed results, which is evaluated based on the reports purpose, objectives and issues. Finally, some concluding remarks, main key points and a few recommendations for future studies is presented.

Chapter 2

Theoretical framework

This chapter consist of three major sections. The first part, section 2.1, present the basic conditions of the building process which is the context where this study are meant to be fitted. The main focus has according to the limitations of this report been the premises for staff in the production phase. In the second part, section 2.2, is theory about information and data brought up with the main purpose to define how the concept of "information needs" is used through out this report. Research about information systems which up until recent years have been the main tools for information management is also reviewed in this part. The third part, section 2.3, present a review of Building information model/modeling and Virtual design in construction research which accordingly to reserach have been stated as the main future information system in the construction industry.

2.1 The building process

One of the most simplified models describing the building process is dividing it into three major phases which are the program, design and production phase. The purpose of the *program* phase is to first investigate if there primarily are economical, but also social, cultural or environmental reasons for starting a building project. Secondly, to develop an overall program describing prerequisites and technical and other demands that shall be fulfilled during the process. The *design* phase define what the finished construction work shall look like, be constructed and detailed. The final step is the *production* phase where the actual building is taking place. The production phase are in the normal case mainly executed by a contracting company in collaboration with subcontractors (Nordstrand and Révai, 2011). As subject of investigation in this report, the production phase is further described in section 2.1.1.

Another way of describing the process is as presented by Atkin et al. (2008), figure 2.1. Here the dimension of product use has been added together with visualization of the overall project driver, customer demands. Different kinds of supply are also mentioned as inputs to the project, as they are necessary for the process to progress.

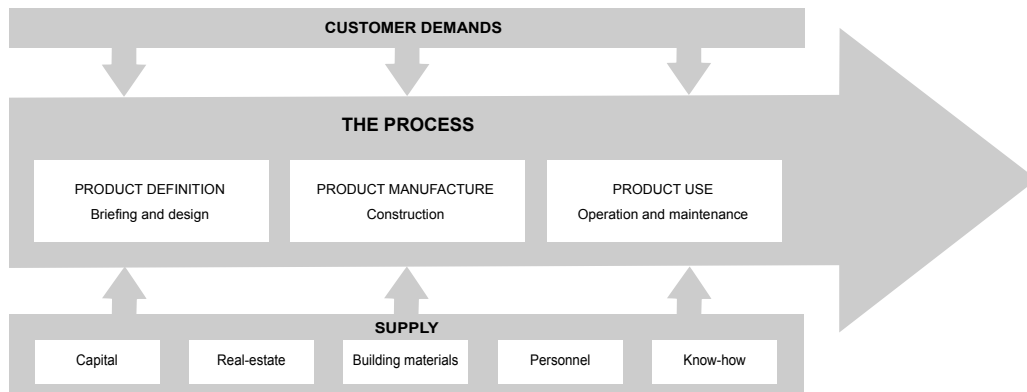


Figure 2.1: The three major phases of the construction process, developed from Atkin et al. (2008).

2.1.1 The production phase

The production phase, as simply shown in figure 2.1, is always incorporating several phases and functions. The structure and working processes can differ depending on the procurement and contract agreements (Nordstrand, 2010). However, the limitation in this report, found in section 1.5, makes the report independent of these differences since all information concerning the production phase anyway have to be taken into consideration and be available. The following functions and tasks are presented in literature as directly related to or being a part of the production phase.

Production planning

Before digging the first sod, the production procedures needs to be planned. With starting point in previously made tender cost calculation, the project time plan, further developed to a production time plan, is being produced. The rank of order is considered as well as the resource requirements and activity tenures, such as which type of lumpers are necessary and for how long (Nordstrand and Révai, 2011). The production planning does also incorporate risk analysis and risk planning, where risks such as working environment issues or project specific condition are considered. Complementary plans are also developed and included, such as machine plan, purchase plan, delivery plan. The production planning can be carried out by the prospective site manager and supervisor with assistance from some sort of construction engineer (Persson, 2012).

Purchasing

This function refer to purchasing as a support function to the production. Material or resources of substantial volume or interest can be bought to a much more effective price when a professional purchaser does the acquisition. The purchaser could for example buy material for several projects at the same time to a lower price taking advantage of the economy of scale. The function can also be concentrated in international purchasing which is a good example of contractors saving a lot of money. The purchasing function is to a great extent involved in producing an overall purchase plan and a delivery plan (Persson, 2012).

Production management

Manage the production phase and the daily production work are mainly performed by a site manager with assistance from supervisors (Alnervik and Jelacic, 2010). The activities of production management can be divided in three main activities, planning, preparation and follow-up which are presented in figure 2.2.

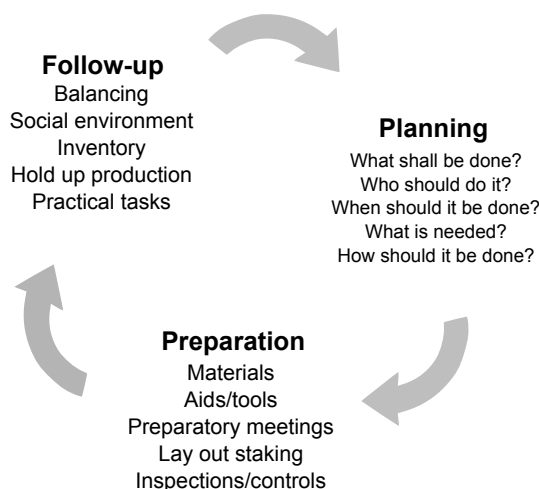


Figure 2.2: The three main activities of production management, developed from Alnervik and Jelacic (2010).

Planning - The way of thinking is that the ongoing planning out on site should answer the questions of what, who, when and how as presented in figure 2.2. Preformed planning procedures should prepare for future operations and solve problems before they arise. With the support of construction documents and the production time plan, more detailed work activities are being planned. Included in this phase are also logistical issues where usually a workplace disposition plan is produced. To summarize, the planning procedure on site originate from the production planning but goes more into details of future activities (Alnervik and Jelacic, 2010; Persson, 2012).

Preparation - The planning procedure is directly followed by a preparatory procedure. This means in detail preparing the activities to be performed by the construction workers. The parts included in the term are preparation of materials, utilities, way of working, laying out staking and inspections. The management shall ensure that the materials necessary for the construction workers to perform a particular operation is available on the worksite (Alnervik and Jelacic, 2010). Work preparation involves detailed planning of operations and building methods (Nordstrand, 2010). During preparatory meetings the parties involved should discuss and conclude the way to carry out the operation together. Another part is to discuss the coordination between different professionals during the operation (Alnervik and Jelacic, 2010; Nordstrand and Révai, 2011).

Follow-up - For the work to proceed as planned, is the management monitoring the proceeding work. The task is to make sure everything is performed in line with drawings, descriptions and agreements (Nordstrand and Révai, 2011). Continuous balancing are performed, mainly against budgets and time plans. In excess of the balancing budgets and building requirements continuous controls of inventory, social environment and working environment are being performed. Documentation supporting the follow-up procedure are control-documentation, daily journals, time-books and forecast documentation, but also previous mentioned time-plans and budgets. Included in the follow-up procedures is also to pick up and deal with additional work and unforeseen changes (Alnervik and Jelacic, 2010; Persson, 2012).

2.2 Information and data

The concept of "information needs" used in this report is a concept of many definitions. The main purpose with this section is to bring order to the meaning of it and how it is being used in this report. First, the terms knowledge, information and data, section 2.2.1, are being clarified to avoid misunderstandings regarding these concepts. Secondly it is explained how the process for a human being gaining information out of data works as well as the connection to underlying cognitive processes, section 2.2.2. After sorting out the meaning of information science terms, a definition of the concept information needs are presented in section 2.2.3. As the study should be seen in the perspective of improving the studied case company section 2.2.4 present the use of information systems in organizations. Ultimately, section 2.2.5 present theoretical data and information categories used in the production phase according to studied literature.

2.2.1 Knowledge, information and data

Data can be defined as discrete, objective facts about an event, such as speed, capacity, height, length or width. In a sense, data can never be wrong since captured data is what it is. When data is contextualized, categorized, calculated, corrected or condensed it becomes information. Information reflects data at one single point, and since data can change, the information can be wrong. Information is meant to change a receivers perception of data or put in another way, perception of facts (Rowley, 2007). However, Frické (2009) is questioning the evolvement from data to information, which sometimes are referred to, and describe that all information do not have to inherent data. For most purposes scientific information such as that the earth are rotating around its axis not inherent any data and is just being informative (Frické, 2009). When comparing, seeing consequences or connections and use it for conversations and evaluation, the information becomes knowledge. Knowledge can be seen as experience and values or when a greater context is added to a message, simply the complete understanding of information. A fully evaluated form of knowledge and the ability to adapt the knowledge to high level problems can also be referred to as wisdom. The meanings of the three concepts knowledge, information and data are occasionally mixed up with misunderstandings as a result, primarily due to the fact that information are interpreted to be a correct reflection of the data which not always is the case, since data can change (Rowley, 2007).

2.2.2 Information visualization

Visualize is by Spence (2007, p. 5) defined as "forming a mental model or mental image of something". Visualization has primarily nothing to do with computers even though they are being used as important tools for creating images and representing data. A computer can although be used to interpret information, but the field of visualization is strictly human. Simply, information visualization can be summarized as helping information to derive from data, by represent and present the represented data in different forms, for example in images, charts, tables or multidimensional models. The information should then be perceived and interpreted in the most satisfactory manner. However, except seeing and interpret the meaning of the information there are also higher-order cognitive processes taking place. It can for instance be evaluation of options, strategy formulation or internal modeling. All highly complex processes are much harder to affect since they are dependent on for example previous experiences of the recipient. Decision making is most often also called a higher cognitive process which introduces the concept of interaction. Interaction is the state when a human and, in modern visualization, a computer are interacting to select the required view of data (Spence, 2007). The simplified process from data to higher order cognitive processes are being displayed in Figure 2.3.

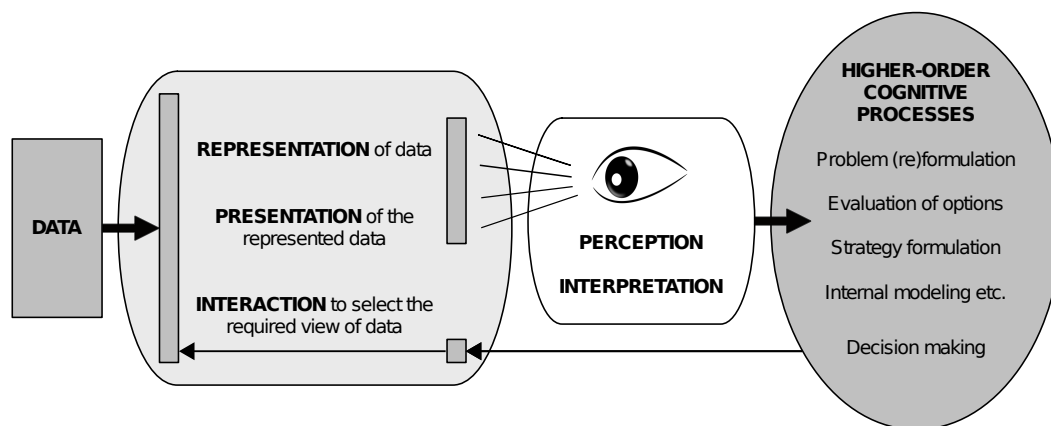


Figure 2.3: Identification of the interaction with data governed by higher order cognitive processes, developed from Spence (2007).

2.2.3 Information needs

Numerous research have been carried out in the field of information science. In his research, Wilson (1981) bring order to the concepts of "user studies" and "information needs". The central questions when it comes to a user's information needs is why the user seeks information, what purpose it will serve and what purpose it will actually put when it is received (Wilson, 1981). The need can also be defined dependent on consciousness which have been presented as four levels by Taylor (1962):

- The actual, but unexpressed, need for information (the visceral need)
- The conscious, within-brain description of the need (the conscious need)
- The formal statement of the question (the formalized need)
- The question as presented to the information system (the compromised need).

Studying information needs can be of considerable importance finding out of in what way an information system should be designed to work more efficient and more effective. It is however necessary to see that it is a difference between demands on information and demands on the informations system, even though they are closely linked (Wilson, 1981).

In step with increasing information system possibilities and information accessibility through computer usage have the information needs been stated as changing (Kebede, 2002). Kebede (2002) further argues

that the basic feature of prevailing needs is the way users set demands on how they require information to be presented and in what way it should be accessible. The user needs are also changing depending on the respective circumstances they are situated in. To make content suitable for users in different contexts must the organizational condition, existing capabilities, hardware, network and available interfaces be taken into account (Kebede, 2002).

One field where information needs for long time have had a central part is within "user studies". The concept have however been debated since a lot of research have been carried out using unclear definitions of the term, consequently giving unclear study results. Wilson (1981) present a model, figure 2.4, to the increase the understanding of the relationship between different concepts used in the field.

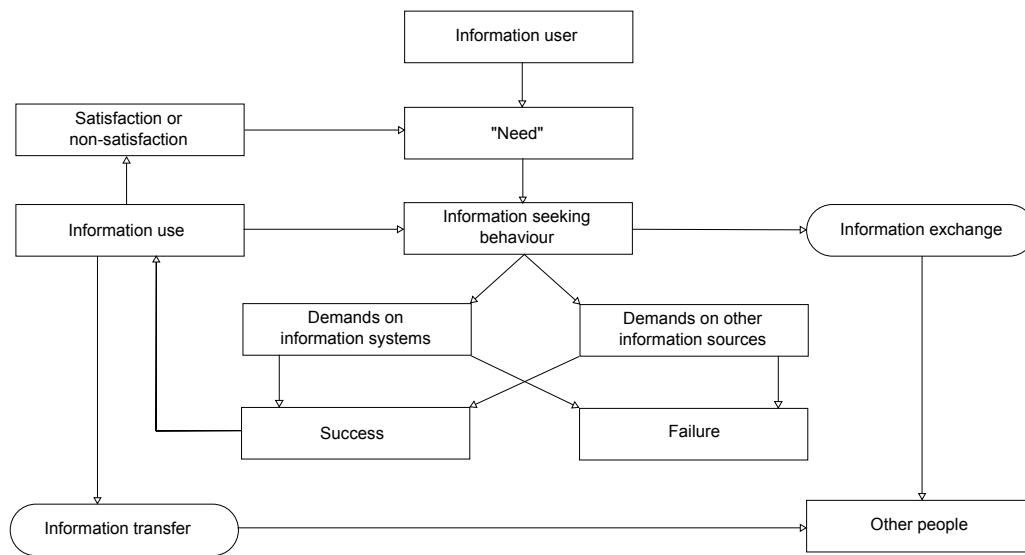


Figure 2.4: A model of information behaviour, developed from ?.

The figure starts with a user who has a need of information of some kind. This need triggers an "information seeking behaviour". This behaviour can take three different paths. The first one can be summarized in setting demands on formal information systems, for example internal computer systems. Demands can also be put on other information sources referring to information functions such as a specialized department. The difference between this path and the next one, information exchange, is the obvious interaction with other people which that one entail. All three paths can either be successful or a failure, in other words the information can be used or not. This is indicated for both demand paths, but of course this is the same also when seeking information from other people. When using the information it can either lead to satisfaction or non-satisfaction, either the need become fulfilled or the information seeking continues. This figure include all types of information, and in reality information from a system and from people most often differ in terms of containing only facts or complemented with opinions. In user studies it is possible to study both the information itself, as well as the distribution of the information containers. The scope should be defined in order to avoid ambiguity (Wilson, 1981).

2.2.4 Information systems

One branch within information science cover the area of information systems, referred to as IS, which is a natural part of almost every organization and under constant development (Mansour and Ghazawneh, 2009). Information systems have historically been an expression for several things, for example management information systems, decision support systems or executive information systems. Thus, as the computer development have accelerated the recent decades, IS has more and more become equated with IT, where concepts such as computer based information systems, CBIS, and Information and communications technology, ICT are common expressions (Rainer and Cegielski, 2012). According to Rainer and Cegielski (2012) does CBIS consist of five basic components:

- *Hardware* which refer to for example monitors that shows the data or information.

- *Software* which is the actual program that makes the hardware work.
- *A database* is a way to sort information and data for easy access of chosen parts.
- *A network* is a way for computers to be connected to each other or the same databases.
- *Procedures* refer to the proposed way of using above mentioned components for acquiring and save information and data.

Different types of systems have been identified serving different parts of organizations. Rainer and Cegielski (2012) have compiled a summary of the most used concepts in different kind of businesses. These are shown below in table 2.1.

Table 2.1: Information system concepts, developed from Rainer and Cegielski (2012)

Type of system	Function
Functional area IS	Supports the activities within specific functional areas
Transaction processing system	Processes transaction data from business events
Enterprise resource planning	Integrates all functional areas of an organization. Softwares use the same database where data only need to be recorded once.
Office automization system	Supports daily work activities of individuals and groups
Management information system	Produces reports summarized from transaction data, usually in one functional area
Decision support system	Provides access to data and analysis tools
Expert system	Mimics human expert in particular area and makes decisions
Executive dashboard	Presents structured, summarized information about aspects of business important to executive
Supply chain management system	Manages flows of products, services, and information among organizations.
Electronic commerce system	Enables transactions among organizations and between organizations and customers.

2.2.5 Data and information used in the production phase

The processes taking place through the production phase of a building project are relying on available information from earlier phases (e.g. Eastman et al., 2008, p. 122). The following bullet list is a summary of theoretical data and information categories used during the production phase found in literature (Eastman et al., 2008; Granroth, 2011; Hardin, 2009; Nordstrand and Révai, 2011; Persson, 2012).

- **Project specific information** - Agreed times, in e.g. final day of completion, meetings, responsibilities, other contractual arrangements.

- **Detailed building information** - For example graphical views in 2D or 3D drawings or models showing the construction entity but also separate elements.
- **Specification information about elements** - Records of type, functionality and quality demands, quantities and bill of quantities.
- **Demands on the building as a system** - In e.g. Structural sustainability, structural loads, maximum expected moments, heating and cooling loads, luminance, energy consumption and demands, but also chronological dependencies.
- **Temporary components needed** - Equipment, formwork, skills, skilled workers, resources and facilities.
- **External factors** - Calculated risks, stakeholders and legislation, for example regarding controls or working environment.
- **Changes and unforeseen events** - Alterations and additions, occurred risks and unforeseen events.

2.3 Introduction to BIM and VDC

As the computer technology rapidly has developed during recent decades, so has also softwares used for supporting the building process (Wikforss et al., 2003, e.g.). The generic term and by researchers announced as the most revolutionary technology is BIM, Building Information Model/Modeling (Bryde et al., 2013; Eastman et al., 2008; Granroth, 2011; Hardin, 2009; Jung and Joo, 2011). Another concept is VDC, Virtual Design in Construction which is a more generic term describing virtual design as a method using BIM (Kunz and Fisher, 2011). This is an inducting section presenting definitions of BIM and the approach used in this report, section 2.3.1, as well as its connection to and usage in VDC. The section also includes the field of application for BIM, section 2.3.2 and summary of research concerning BIM implementation, section 2.3.4.

2.3.1 Definitions

Building Information Model/Modelling, BIM

Defining BIM seems to be a task of ambiguity since it depending on reference has several different meanings. According to Barlish and Sullivan (2012), entire journal articles have been searching for a common viewpoint of the expression. BIM is most often referred to both as a Building Information Model, and with another inflection, as Modeling (Eastman et al., 2008; Granroth, 2011; Hardin, 2009; American National Institute of Building Sciences, 2007). The terms model and modeling can be explained by the definition of BIM both as a software and a process (Eastman et al., 2008). This can also be illustrated by the definition of BIM as formulated by American National Institute of Building Sciences (2007):

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

Here it is stated that BIM is the digital representation of a facility, but at the same time containing a basic premise of stakeholder collaboration creating the model, which furthermore can be identified as a process. Independent of this ambiguity it has been highlighted that it is the holistic way of thinking and working that distinguish the magnitude of implementing BIM (Bryde et al., 2013). However, in the contracting business BIM is often defined prior in terms of its technical aspects working as a model or a documentation tool (Barlish and Sullivan, 2012). In contrast, and for the purposes of this report, the previously quoted definition by American National Institute of Building Sciences (2007) is being used and conformed to throughout this report.

The Building information model/modeling can also be used as an umbrella term which has expanded during the technical development. The acronym BIM is for example including terms such as 3D, with extra dimensions such as time and cost, referred to as 4D and 5D (Eastman et al., 2008).

Virtual design and construction, VDC

The concept of Virtual Design in Construction, VDC, are sometimes used as a synonym for BIM (Hardin, 2009). However, this has been argued not being the complete truth (Kunz and Fisher, 2011). VDC as it is defined by Luth (2011):

”The process of using an accurate and precise 3D model to facilitate visualization, communication, coordination, estimation, simulation, purchasing, fabrication, sequencing, scheduling and site layout”.

According to Kunz and Fisher (2011) can VDC be defined as a method using BIM along with other supporting tools to make the construction process more collaborative and efficient. Kunz and Fisher (2011) present four categories describing how VDC cover the entire construction process:

- *Multi-disciplinary teams* working concurrently and integrated from earlier stages in a project and thorough the process.
- *Virtual models* used for vizualisation and taking advantage information benefits provided by the BIM technology.
- *Project, Organization and Process (POP)* facilitating POP breakdown structures for predicting and manage construction projects.
- *Business metrics and methods* used for measuring performance and manage project processes.

In summary, the purpose and challenge of both VDC and BIM is to increase coordination and integration of different stakeholders throughout the process, as well as using the technology possibilities that has emerged (CRC Construction Innovation, 2009).

2.3.2 Field of application and benefits with BIM

The holistic view of BIM, as stressed by Bryde et al. (2013), can also be found in descriptions regarding possible fields of application during the building process. The BIM model is a object based virtual model that should be in the making throughout the building process and be central regarding collaboration between all stakeholders in a project. During the design and planning phase information can be added, updated or modified in the model. Subsequently, during the production and maintenance phase, the model is working as an information provider, but can also be updated and modified to always give reliable information (Granroth, 2011). Researchers have repeatedly stated several main areas for possible usage of BIM together with associated benefits (Eastman et al., 2008; Granroth, 2011; Hardin, 2009; Hartmann et al., 2008, 2012). A summary according to Hartmann et al. (2008) of application areas in construction management together with associated benefits are presented in Table 2.2 on page 11.

The areas of application in construction management, as identified by Hartmann et al. (2008), spread all over the building process. The benefits can be confirmed as reliable since the results are built upon 26 full scale construction projects with wide distribution in both scale and geographic allocation (Hartmann et al., 2008). Even though benefits have been stated on several areas it is a challenge to gain all benefits in one project. Often the usage of the technology are restricted to one or a few areas (Hartmann et al., 2012). Understanding the utilization of BIM as an information system through the entire lifecycle and using it simultaneously in several areas of construction projects is one of the key issues (Jung and Joo, 2011). Benefits for each discipline, such as customer, project management, architects, constructors, contractors, consultants, suppliers, maintenance and tenants have been stated and categorized by Granroth (2011). To sum up, the overall benefits are for example visualization possibilities of both constructional issues as well as management issues, easy access to information and information transfer possibilities, enhanced coordination and collaboration between disciplines and understanding of what effects and changes have on the totality (Granroth, 2011).

Table 2.2: Summary of application areas and associated benefits for BIM during the building process, developed from Webb et al. (2004) and Hartmann et al. (2008), compiled by Cong (2012).

Project Phases	Areas of BIM application	The benefits with BIM
<i>Conceptualization</i>	Photorealistic renderings/presentations	Serving marketing purposes to seek for financial supports or public involvement
	Virtual design review	Checking or revising specifications to satisfy building codes/standards
<i>Design</i>	Photorealistic renderings/presentations	Virtually presenting building models, construction methods to multifarious stakeholders
	Virtual design review	Communicating complex geometry clearly in meetings ----- Creating a communal medium for joint discussion among different parties
	Cost estimating	Establishing a direct link between 3D and bills of quantities ----- Facilitating changing and updating cost estimation by reducing estimating time and cost, and increasing accuracy
	Analyzing design options	Providing more reliable evaluation of design alternatives by taking all temporal constraints into account ----- Comparing design options with cost constraints to find optimal design solutions
	Analyzing construction operation/process	Establishing a link between 3D and schedules, which allows visualization and analysis of the construction sequences ----- Planning for site layout and required working spaces such as delivery, transportation and storage
	Construction document production	Standardizing building components to reduce assembly time, cost, errors, and to increase accuracy ----- Reducing material orders' lead time
	Bid package preparation	Defining the scope of work clearly for subcontractors to provide better understanding and avoid future conflicts
<i>Construction</i>	Analyzing construction operation	Detecting conflicts in schedules such as time and sequence conflicts ----- Detecting spatial conflicts ----- Detecting design and on-site conflicts ----- Detecting conflicts between subcontractors and among different parties ----- Developing resolutions/alternatives when disruptions occur due to unexpected incidents/changes ----- Maintaining cost control during construction
	Virtual design review	Instructing and training construction teams before engaging in intricate, challenging, or hazardous activities ----- Overcoming language barriers, especially in the context of international projects

2.3.3 Essential benefits for construction companies

As shown in section 2.3.2, benefits have been found for all disciplines within the industry. More narrow, research carried out determining usage and benefits prior to contract companies and on site operation are summarized in this section. Following dot list present these benefits according to selected researchers:

- **Clash and collision control** - Often referred as an obvious advantage by using BIM. Notices and warnings when for example installations interfere with each other (Eastman et al., 2008; CRC Construction Innovation, 2009).
- **Produce drawings and specifications** - From a BIM model it is possible to create any view of the model as a complete drawing, unlimited amount of viewports. Specifications can also be generated (Hardin, 2009; CRC Construction Innovation, 2009).
- **Information management** - Construction projects are relying on that information are available for all project stakeholders. The recent IT-development, mainly referring to BIM, is a step against achieving that goal (Craig and Sommerville, 2006).
- **Production time planning** - Research have shown successful attempts to integrate construction schedules with different databases, such as risk, environmental, construction and sustainable strategies databases. By integrating useful information automated scheduling helping tools can be implemented (Irizarry et al., 2012).
- **Simulation** - By simulating performance of in e.g. HVAC-systems¹ more accurate installation work can save both money and time (Eastman et al., 2008).
- **Data for laying out staking and machine control** - Possibilities to import virtual models into both total stations and machine control instruments have already been developed and recorded as beneficial (Nourbakhsh et al., 2012).
- **Visualization** - Ability to virtually visualize is seen as a clear advantage of BIM, since all stakeholders more easily get an understanding of the project (Granroth, 2011).
- **Controls and monitoring** - The BIM model can be used for balancing the executed work against the timeplan and budget (Granroth, 2011).
- **Relational model/drawings** - The idea is to update the model so that a relational model could be handed over to the user for supporting the maintenance phase (Eastman et al., 2008).
- **Mobile workstations** - For taking full advantage of mobile workstations, such as portable reading devices, BIM technology could be integrated (Nourbakhsh et al., 2012).

2.3.4 BIM implementation

BIM tools as well as VDC working methods have been widely accepted in the construction industry and identified as a part of the solution concerning a more demanding market climate. Mainly due to substantial investment costs and need of competence primarily large companies and consultancy firms have started to implement parts of the technology and a way of thinking in their daily processes (Granroth, 2011). Consequently, implementations of this nature have to change existing organizational structures and methods, which thus lead to several contextual issues that have to be dealt with (Gu and London, 2010; Arayici et al., 2005).

Changing methods and workflows

Gu and London (2010) convey that to get full usage of BIM technology as a working method, the industry have to work more collaborative between disciplines during the building process. A more interactive workflow is needed which will encourage the different stakeholders to work more collaborative and share information. However, Hartmann et al. (2012) describes that the construction business already are full

¹Heating, ventilation and air-conditioning systems.

of functioning construction management methods and shows in studies that it is possible to align BIM functionality with these existing methods. This is not to say that alignment of methods in order to fit the technology is out of order, it is just two possible ways of implementation, a push or a pull strategy (Hartmann et al., 2012).

Issues regarding BIM implementation

In their article, Arayici et al. (2005) stresses the lack of requirements engineering in the development of BIM tools. The term requirement engineering, RE, can be described as an engineering process when developing computer based tools or systems. The method take the activities of discovering, documenting and maintaining requirements of the particular field into consideration (Kotonya and Sommerville, 1996). Because of an unfamiliarity within the construction industry during the development of computer systems and not fully considering requirements engineering, a gap arises between the developers and the users. For accurate implementation and for the ability to create user-oriented systems the requirements engineering process is of high priority. Better requirement capture during the development will lead to better implementation (Arayici et al., 2005). The BIM based tools have to be aligned with and required to work in practical contexts (Hartmann et al., 2012).

Except the lack of requirements engineering preceding BIM implementation, which by the way is a controllable factor, several other groups of more or less uncontrollable issues have been identified by Arayici et al. (e.g. 2005). Below are an assortment of found issues within literature listed according to Arayici et al. (2005) along with connected examples from other literature.

Cultural issues

Such as a non-willingness from staff to adapt to new methods and workflows of pure convenience (Hartmann et al., 2012).

Legal issues

Legal unclarity due to for example complexity of knowing which actor who has the legal right to developed material when using a jointed BIM model (Eastman et al., 2008).

Fragmented nature

The construction industry consist of a lot of actors who understandably tend to primarily look after their own interests, which can affect the big picture negatively (Granroth, 2011).

Procurement

The way projects are procured can affect the interoperability of both systems and organizations due to contractual arrangements in for example joint ventures (Kadefors, 2004).

Contractual issues

It can also be difficult to sort out contractual arrangements due to new IT - based technology, such as for example cloud services (Eastman et al., 2008; Mahalingam et al., 2010).

Technological issues

The main technological issue is the usage of different systems and tools that have to integrate if the full potential of BIM should be utilized (Eastman et al., 2008).

Educational issues

All actors in the industry do not have the same economical abilities to educate staff in new technology (Nordstrand, 2010), technology knowledge which is a prerequisite for a successful BIM implementation (Hartmann et al., 2012) A low level of education will also undermine the trust of the technology and therefore slow down the implementation (Gu and London, 2010).

How to implement BIM tools

As seen in previous section there are several issues that need to be taken into consideration when implementing BIM. Gu and London (2010) have put together four interrelated categories where change occur and that can be used as a framework adapting BIM. First the scope has to be defined along with purpose, relationships and project phases. Doing this in an early stage facilitates to enable a supportive

environment where information can stream freely, which mitigates the implementation. Secondly, work process road maps should be developed for visualization of and creating a seamless integration of BIM in the daily operation. Third, the technical requirements of BIM should be identified. Knowledge of tool compatibility for multidisciplinary model sharing along with possible capabilities is a prerequisite. Fourth, ensure that the skills needed and the capabilities required will be available in a near future, for example due to education, in order to be equipped for BIM adoption (Gu and London, 2010).

In addition to these four suggestions several case studies have been performed examining BIM implementation in a real life context. Several authors presents suggestions and proposals of best practices implementing BIM and virtual tools. Hagan et al. (2009) presents key factors of a successful BIM implementation and argue that they work independent of which actor within the industry that face this type of process. The key factors are cited as follows:

- Adopt BIM in a strategic manner that supports the core mission of the organization.
- Rapidly develop prototype studies of real-world projects, engaging your organization in the research and documenting the results.
- Get high-level management support.
- Foster project-level team and regional champion buy-in.
- Maintain a balance between technology, business and social (cultural) aspects of business transformation.
- Get organizational consensus and realization that BIM, in the end, is not just technology but a transformational approach to the business and mission of the organization. (Hagan et al., 2009)

Seen from a more technical perspective the CIFE (Center for Integrated Facility Engineering) at Stanford University, USA, conducts research in virtual construction in close collaboration with the industry. Implementation of BIM is by CIFE described by the following three phases developed from Kunz and Fisher (2011):

- *Visualization phase* - This includes 3D modeling and 3D visualization, which means that the model used for visual communication and coordination. The model can be used for example in the planning meetings to discuss issues and make a record of the model. From the 3D model can also 2D drawings generated.
- *The integration phase* - The phase where you start to integrate the model with other systems such as cost calculation system, purchasing system, energy analysis, planning or management tools. This postulates clear definitions of what information the model should contain and how it should be structured. Here, one must look at the processes that model should be integrated with.
- *Automation phase* - The third phase requires the process to be as complete that it can be controlled using the model-based information. An example is the machine control using the structures produced directly from a 3D model or automated quantity take-off (Kunz and Fisher, 2011).

2.3.5 Technology interoperability

In terms of visualization, giving possibilities to integrate building information to a model and use the information in management tools such as scheduling, BIM technology has been described and proven to be a functioning alternative (Irizarry et al., 2012). However, a difficulty which is of technical character, is the interoperability between different softwares, actors and already functioning tools and systems used for production management (Grilo and Jardim-Goncalves, 2010). Different softwares have for example had a tradition of using different file formats, where the ability to convert to full compatibility often is absent, partly due to competitive reasons (Wikforss et al., 2003). The main attempt to overcome these complex of problems is the non for profit organization buildingSMART.

To in greater manner enable software interoperability in the AEC/FM² business, the International Alliance for Interoperability, IAI, was established in the mid 1990s. The goal of IAI, which nowadays are

²Architecture/Engineering/Construction and Facilities Management

called buildingSMART, is to create an open common file format that can store and transfer saved data in a BIM, independent of software creator. The format should make it possible to store information about a building through out its lifecycle. The main format is called Industry Foundation Classes, IFC, and is in the making of becoming a full-worthy ISO-standard (buildingSMART, 2013). In Sweden, a partner in the form of an interest group, where most major Swedish actors are members, has been created . This group is the following step of a development program started in 2009. The goal today is for instance to help the construction industry to use the best possible open standards and IT-tools to make it more effective, improve the quality, lower costs and minimize environmental impact. The group, called OpenBIM, should promote a national consensus and praxis, and for the moment they conform with the outline of the IFC standard (OpenBIM, 2013).

The IFC structure can be described as done by Eastman et al. (2008), shown in figure 2.5. The resource layer consist of 26 basic entities which are generic for most construction projects, a few of them are material, geometry, measure and quantity. Combined can the entities define building objects used in the AEC business, for example building elements such as walls, floors, structural elements, service elements, process elements, management elements as well as other generic features. The hierarchical structure of ICF has the purpose of providing the opportunity to create any number of subentities done by subtyping, where the subentity keep the properties of the upper classes. The top domain layer define different extensions for entities of specific usage such as structural elements, fire protection or construction management.

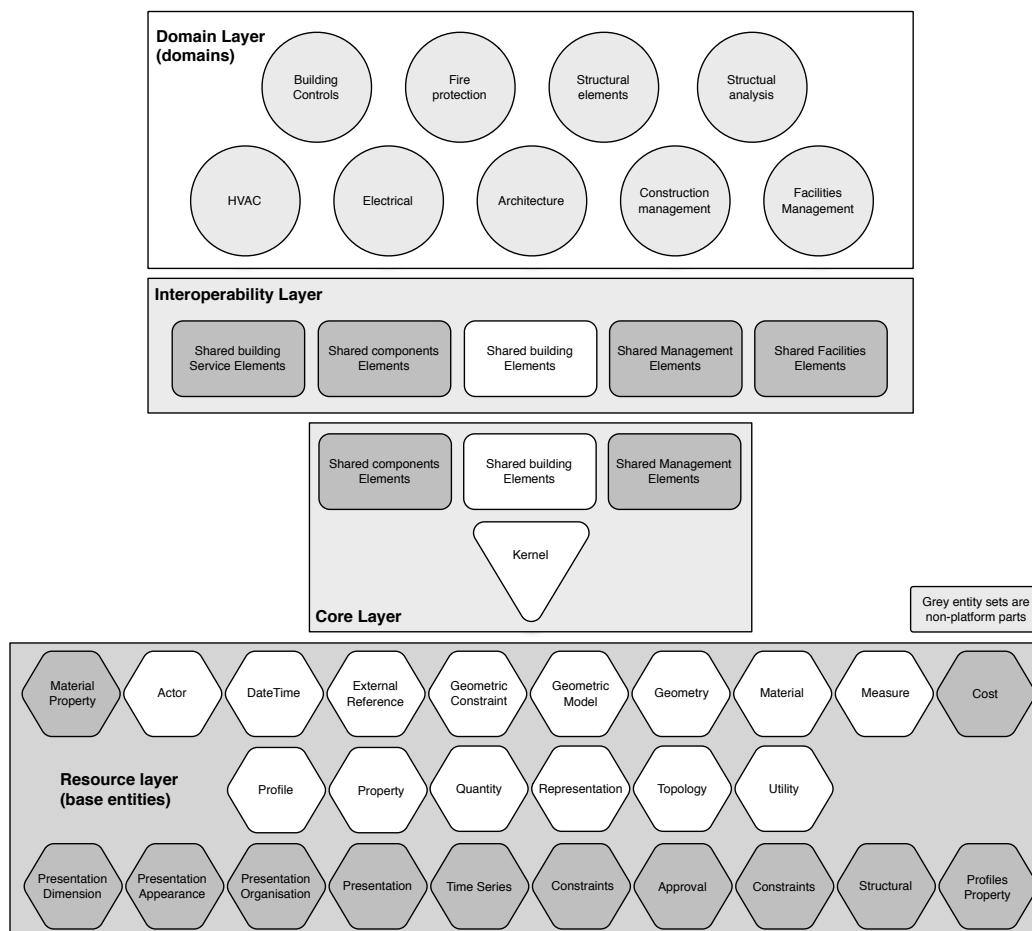


Figure 2.5: The system architecture of IFC subschemas, according to Eastman et al. (2008).

Chapter 3

Methodology

3.1 Research approach

The study method applied in this report is strictly of qualitative nature. As Merriam (2009, p. 14) explains it, the overall aim of qualitative research is to

”Achieve an understanding of how people make sense out of their lives, delineate the process of meaning-making and describe how people interpret what they experience.”

The aim of this thesis corresponds well to what Merriam (2009) stipulates since it tries to make sense of how people interpret and define their information needs and how it is presented in relation to available software aids in their daily working environment. However, the information needs are not only for people to interpret, which is why, direct observations of processes and document reviews had to be performed in addition to interviews.

The study has been carried out in a real-life context during five months time investigating a contemporary phenomenon, which due to Yin (2009) is part of the definition of a case-study. The limitation of staying within one single company also strengthen this notion (Yin, 2009).

3.2 Empirical data collection

The empirical data were obtained by three different sources, documents, direct observations and interviews. They are separately and more detailed described in section 3.2.1, 3.2.2 and 3.2.3 below.

3.2.1 Documents and systems

A thorough review was made of all supporting tools and systems that are being used at the case company. According to the report intention, tools and systems primary connected to the production phase has been emphasized. As a part of the qualitative study the document review as well as direct observation presented below can serve to enhance the interview results and get a more accurate understanding of the daily work Merriam (2009). Thus, this understanding certainly helped to pin down essential interview questions for this study as well as giving important input to the analysis.

3.2.2 Direct observations

Coincidentally with the interview occasions, direct observations were taken primarily focusing on the working environment for the interviewees and their own way of using existing tools and ways of working. Most often the interviewees was substantially showing how they work with supporting tools and information acquiring by executing some sort of minor task made earlier. The observation notes was then considered during the interview analysis.

The document study was first intended to include all documentation available for production management staff through their web based operational system. This was later determined to be a too large task within the framework of this study. Focus was instead changed to only review the documentation where the site management staff, according to the system and interviews, are responsible. These documents are listed in interview question 2, table 5.3. Each document was reviewed and data seen as a prerequisite for execution was noted. This was done for each document and where the information was similar no new category was added and a dot noted in a table.

3.2.3 Interviews

In order to gather the opinions and experiences from people working with the information and functions that the study comprehend, a total of 15 qualitative interviews were conducted. The reason for using interviews was the ability to go in-depth in the research questions presented in the introduction. Thus, the main purpose was to emphasize the experiences and perception of reality working with project information in real life construction projects. According to Yin (2009) do interviews often provide the researcher with comprehensive material that facilitate a total understanding of the context of the field where the study is taking place. The interviews were performed according to the semistructured form as described by Gillham (2008).

The feature of a semistructured interview is that the researcher is using a form consisting of equivalent questions to all persons being interviewed. To secure the interview quality it is necessary that the questions are being thoroughly designed and verified against each target group. During the interview, main points are used for leading the interviewee to cover the areas interesting for the report. Furthermore should each interview occasion last approximately the same amount of time. This form of interviewing also consist of an element less predetermined. The question formulations should be open so that the person interviewed are given the possibility to choose direction of the answer. It is also possible to use exploring questions if it feels like not everything has been said or some things are needed to be clarified (Gillham, 2008). The interviews can be divided in the following phases:

1. A preparatory phase where the interview is planned according to time, place and format which include inform the interviewee.
2. The initial contact that involves creating a good first impression.
3. The orientation phase where the purpose and proceedings of the interview and the research are being explained
4. The substantive phase is the part where the interview takes its course. It is this portion which mainly is analyzed.
5. Final phase is partly social, but may advantageously contain a brief summary of the interview (Gillham, 2008).

The interviews were held in Swedish and a full review of the interview question material can be found in Appendix A. Usually qualitative interviews are being recorded and transcribed, since the researcher most often is very interested in what is being said as well as how it is being said. The transcription also makes it easier to find a statement leading to a citation of the interviewee (Bryman, 2002). In this study all interviews were recorded and transcribed in order not to lose any valuable material. It also made the interview situation easy since it was executed by one person only which could concentrate on the questioning.

3.3 Data analysis

When the empirical data collection was finished the work of interpretation and analysis the found results started.

The qualitative interviews have been interpreted from a hermeneutic perspective. The hermeneutic perspective subsumes that the researcher put oneself in the context of the person being interviewed to

find the exact meaning of what the person actually means (Bryman, 2002). During the result analysis have therefore consideration of for example computer knowledge, working position, project size and support organization been taken.

Chapter 4

Case company

4.1 NCC Construction

Within the nordic region NCC is one of the three largest construction and property development companies and are also represented in several of the european countries (Sveriges Byggindustrier, 2013). NCC are represented in most areas of the building sector, where NCC Construction Sweden is the part of the company that operates their swedish construction activities (NCC, 2013a). NCC was founded in the late 1980s when Nordstjernan AB bought shares in ABV, Armerad Betong och Vägförbättringar, reinforced concrete and road improvements. Nordstjernan already had their own construction company Johnson Construction Company, JCC, integrated which later donated a bit of their name to NCC. In 1988 ABV became a subsidiary of Nordstjernan and at this time, the company had approximately 20 000 employees. Subsequently, a total reorganization was carried out and the name NCC, Nordic Construction Company, was elected. After some share shifts the legally NCC was formed in late 1988 the legally recognized NCC - Group was formed (NCC, 2013b).

4.2 Organisation

With a focus on the Nordic region, NCC is divided into four sections focusing on different business segments, Construction, Roads, Property Development and Housing. The four parts cover the construction market that exists today, building everything from homes and offices to larger facilities and roads (NCC, 2013a). In recent years, NCC has put a lot of time on improving industrial construction, especially with higher quality and lower costs. Much is also property development and sale of commercial properties (NCC, 2013d). In 2012, the NCC Group had 18,000 employees spread over four major regions. South, West, Stockholm / Mälardalen and Northern (NCC, 2013c).

NCC's total turnover in 2012 was 57 billion, of which NCC Construction accounted for 25 billion, an increase compared to previous year. The result for 2012 was historically high where the largest gains came from NCC Construction. In recent years, NCC has according to their annual report improved its ability to achieve the financial targets primarily through the continuous improvements used, where VDC are mentioned as one success factor (NCC, 2012).

4.3 Operational system

The operational system at NCC has been compiled in a computer based process map called their business system. This business system serve to explain the way of working at NCC, how to manage and what support that are available for the ongoing core- and support processes. The support can for example be links to IT-tools together with supporting documentation or template documents supporting a particular activity. The business system is based on the established business plan that NCC:s operational work are based upon (Internal document).

4.4 Information systems at NCC

NCC has in addition to their operational system described in previous section a set of different supporting tools supporting the ongoing processes during the whole project duration. The main tools have been compiled and followed by a short description of the field of applications presented in the following bullet list:

- *Cost estimator and forecaster* - a budgeting program used throughout the process used for tender cost calculation and balancing in the production phase.
- *Planning program* - a program used mainly for producing a overhead time planning in the production phase. Mainly visualized by a gantt-chart.
- *Purchase and delivery portal* - a compilation of supplier products lists with the ability of ordering direct in the portal. Possibilities to produce purchase and delivery plans and checking supplier agreements and manage project purchases.
- *Project portal* - a portal based on the operational system used as example for project coordination, document handling and client communications concerning additions and alterations.
- *Intranet* - A web-based information notice-board and navigation tool for finding information or links concerning the whole organization.
- *Document management tool* - a program used for document management in addition to the project portal with supplementary possibilities to add right of access to different documents to different stakeholders. Developed before the project portal.
- *Invoice handler* - a program used for managing invoices with abilities to attest or send them forward.
- *VDC-tools* - consisting of several software packages used for different types of activities such as managing 3D-files, handling quantity take-off, visualization of workplace outline and visualization of following up procedures (Internal documents).

4.4.1 Current practical VDC usage

NCC promote themselves as a company that wants to be in the front edge when it comes to VDC usage and development. NCC have therefore formed a special group working with such matters. The official standpoint is that VDC should be used "in all projects where we at NCC can effect the project conditions". NCC describe VDC as design and planning executed by means of virtual methods with a process focused management of information (Internal documents). The VDC development strategy performed by NCC are built upon the theories presented by Kunz and Fisher (2011) where the process are divided into three stages. Stage one, visualization, where 3D models are used for communication and collaboration controls. Stage two where the 3D model should be integrated with other information tools such as calculation programs. Stage three where NCC works against automated processes, for example automated quantity take-off.

The interpretation is that NCC currently is in stage one, where visualization and collaboration control within the design phase is where the development is the most advanced. In projects where VDC are being used, NCC sets demands on how the work should be executed, for example what file formats that should be used and what level of detail each model should consist of. This is regulated by a VDC co-ordinator producing a document called CAD-pm. The work are then executed according to this CAD-pm where each model provider focus on delivering a model that can be merged into a collaboration model. This model serves to enable a collaborated review, finding design problems or technical conflicts. The collaboration model are sometimes used for executing analyses and simulations such as energy, heat or fire, but with the main purpose of providing a similar understanding of the project conditions and progress. NCC also tries to integrate the model with the calculation procedures. Thus, quantity take-off in the model by means of a specialized software is more and more being a part of the normal working methods.

Visualization have also been used in the production phase at several reference project throughout the company, where visualization of following up procedures have been most successful. In connection to

this, mobile workstations have started to be implemented. Visualization of the workplace outline is also used broadly where site managers and supervisor perform the actual logistical planning and visualization (Internal documents).

Chapter 5

Results and analysis

This chapter presents the findings of the interviews together with the document and system study used collecting empirical data for this study. The chapter serves to get an overview of the core processes in the production phase as well as the connection to contemporary supporting tools used in the daily processes working with production. A compilation of these are shown in figure 5.1 below. According to the core processes, the interviewees were given the possibility to tell what they wanted to realize and how they experience the way of working today focusing on their information needs. The first part is structured according to the interview questions where each section review the interviewee responses of each question. The findings are interpreted according to the chosen research method, described in section 3. Furthermore, a full copy of the interview questions together with exploring follow-up questions can be found in Appendix A. The findings of the document study are thereafter presented in a table showing which data categories that are needed for site management staff to be able to produce management documents.

The second part can be seen as a summarizing analysis which serves to interpret the interview results in conformance with the found core processes. Influence has also been taken from the document and system review, direct observations during interview situations and coincident study visits at several different construction sites.

Table 5.1: Identified core processes in the production phase together with supporting tools at NCC

Area	Core process	Supporting tool/tools
<i>Economy</i>	Budgeting	Budgeting program MAP
	Balancing	Budgeting program MAP
	Economy administration	MAP and invoice handler Contempus
	Risks and opportunities	Project portal, template documents
<i>Planning</i>	Master time planning	Time planning program PlanCon
	Detailed planning	PlanCon or NCC project planning
	Work preparation	Project portal, template documents
	Working environmental issues	Project portal, template documents
	Logistical planning	Sketchup, Logistic portal
<i>Purchase</i>	Purchase materials	Purchase portal, template documents
	Purchase/rent machines	Purchase portal, template documents
	Procure subcontractors	Purchase portal, template documents
<i>Communication</i>	Meetings	Project portal, Lync, template documents
	Alterations and additional work	Project portal or MAP
<i>Controls</i>	Self-monitoring	Project portal, template documents
	Safety and working environment	Project portal, template documents
<i>Documentation</i>	Logbook	Project portal, PDS, template documents
	Control documents	Project portal, template documents
	Time-record	

5.1 Interview results

5.1.1 Question 1 "Information acquisition"

The question asked was: "How do you get information and understand the basic conditions of a project?" The purpose of this question was to find out if there are a uniformed way of absorbing information and find out where the interviewees lay their focus. The idea was also to get an initial impression of the current working practice and what information providers they use for acquiring information during the project. This was covered by follow up questions.

Below in table 5.2 a summary of mentioned activities for acquisition of information are shown. The activities are listed according to how frequent they were mentioned by the interviewees, where documentation and drawings have the highest rating. Response rate for each activity are shown in figure 5.1. The related commentaries can be seen as explanations based on real quotes made by the interviewees.

Table 5.2: Summary of activities for acquisition of information together with related commentaries.

Activity	Commentary
Documentation	Reading through documentation such as contract and other written documentation connected to the agreed project. These also include prescriptions as AF-parts.
Drawings	Looking through drawings to get an overview of the project. Explained as taking place simultaneously as reading through documentation, sometimes key aspects are highlighted.
Model	When there is an obtainable model it serves in the same way as drawings, but with increased amount of visualization. Currently no additional information benefits due to the interviewees.
Meetings	Meetings serves to get other peoples perceived impressions and discussions are held regarding key aspects. Seen as a formal review of the project information.
External documents	Searching for information on suppliers websites, for example data sheets.
Dialogue with colleagues	Same as meetings but more informal serving to straighten out questions and solve problems.
Dialogue with client	Information from the client is working as a reference that information regarding expected outcome have been correct communicated.
Reference projects	Working as experience feedback. Only a few interviewees did mention active searching for reference projects and experiences.

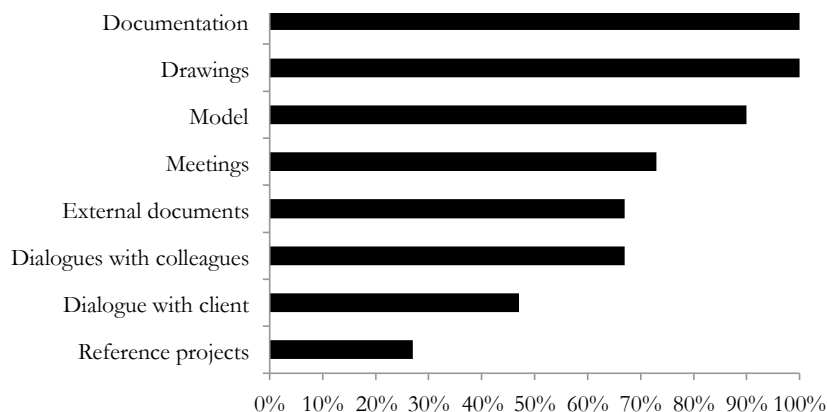


Figure 5.1: Percentage of respondents who mentioned each activity.

All interviewees gave consistent answers of how they learn and get information of a new project, where documents and drawings were the most obvious sources. In the cases where a model was available this was used as a complement to drawings. During discussion four other activities were confirmed as meetings, dialogue with colleagues, dialogues with client and searching for reference projects.

The actual reading most often consist of simultaneously reading through all available documentation, sometimes marking important parts, for example where question arises. All interviewees also stressed that how detailed the reading become to a great deal depends on in what stage of the project you get involved. Early in a project there are most often more time for that kind of activity. The interviewees indicated that there is little specifically set a side time for proper reading through and understand the overall picture before starting the actual production phase. It is interpreted as all the interviewees see it as an advantage to be involved in an as early stage as possible, especially the supervisors which most often not are assigned until the actual on site production starts.

Meetings are used for responsibility checkup and making sure the project follow the companies predetermined working process. Depending on the meeting purpose they are also described as discussion forums. Different peoples opinions and experiences about the project documents are refined working as basis for decisions regarding for example changes and the proceeding work.

External documentation was mentioned as a usual way of acquiring information. The one mainly referred to was collection of data sheets of specific materials or building components. One supervisor thought that it would be interesting with already finished links to available data sheets and information. As he expressed himself while showing the procedure of going in to a supplier website and dedicate several minutes searching for a specific sheet:

"I am pretty shore that I am not the first one in this project collecting information about these piece of ironwork from this website. That feels a bit unnecessary!"

In addition to meetings, colleagues have daily contact about project specific matters. This communication is seen as more informal, not being less important but that often gives a relaxed discussion with a satisfying outcome as result. Several interviewees referred to this kind of communication and information acquisition as being the most important one since it is usually in the daily communication the actual problem-solving take place. When asking about their approach if questions about available information arises it is indicated that the most effective way to straighten them out is through dialogues with colleagues. Most often similar questions or problems have occurred before and consequently is a functioning personal network essential when questions arises.

To get "soft" information, as one interviewee expressed himself, good contact with the client is a must. Soft information was explained as a feeling of how you should behave in relation to for example a client, if there are any unofficial codes to relate to or to learn the clients way of thinking to be able to have successful discussions. It is interpreted as that in general are transparency in moderation and provision of information without delay seen as the recipe for success regarding contact with a client.

The last activity mentioned during the interview sessions was the usage of reference projects. However, only a few persons claimed themselves to have made active search efforts trying to find similar projects. This is thus interpreted being slightly discordant with the reality. The reference projects was by a few explained working as experience feedback, giving for example ideas of design, planning and old documentation working as templates. Even though reference project has not been mentioned as an obvious source to retrieve information, it is clear that these affect both the working methods and the use of supporting tools. For example have a majority of the interviewees used old templates and old project files in order to startup a new project.

5.1.2 Question 2 "Documentation"

The question "What documentation should be produced before and during the production?" was asked in order to identify information adapters that in contrast to previous question are being used to save information and refine information during the production phase. This result also answers why management staff need information.

The found activities or documents have been summarized in table 5.3 below. The commentaries are designed to easily summarize the emphasized interviewee responses. The question also elicited responses about hindrances particularly regarding template documents and supporting tools. These are more thorough reviewed in question 4, in section 5.1.4, thus partly mentioned here as well.

Table 5.3: Summary of activities or documents used for refining information during the production phase together with related commentaries.

Activity/Documentation	Commentary
Production cost calculation	Living document for balancing, including all cost items such as building material, tools and resources. Seen as the most important steering document. Supporting tool: MAP
Production time plan	A time plan built upon the production calculation. Important with correct structured calculation for effective export and conversion to time plan. Supporting tool: PlanCon
Control program, Control documents	The control documents are produced from template documents. Templates can be found in the business system. Filling out templates are described as time-consuming. Template for control program cannot be found.
Working environment plan	This plan is produced from template documents. Can be found in the business system or the project portal. Sometimes the working environment engineer sends out a bundle of security templates.
Workplace information	Same as previous.
Machine plan	Produced from template documents or generated from production calculation. No connection to the actual machines for in e.g. resource control.
Purchase and delivery plan	Can be generated from the Purchase portal, but found not being used in any broader scale. No template document exists which are described as lacking.
Workplace outline, APD	Should be a living document to ease logistics on site. The plan is often produced in 3D, with visualization benefits as result, but occasionally found not being updated in a desirable way. Supporting tool: Sketchup
Work preparations	No uniformed way of working. The available templates are described as working but are not completely satisfying. New support in Project portal.
Risk and opportunity analysis	The analysis should be updated through out the project. This activity could be improved according to interviewees'. New support in Project portal
Environment analysis	Templates are available in the business system.
Logbook	New support for Logbook in the Project portal connected to the production time plan.
Additions and alterations documentation	Documentation and book-keeping. Different ways of documentation and communication. Supporting tool: MAP or Project portal.

When a project starts a list of responsibility distribution are being confirmed, usually on the first building meeting. This distribution emanates from the business system and include the previous shown core processes and responsibility areas that cover the project from start to end. Clearness in this distribution are mentioned as a prerequisite for work not to be duplicated or neglected and the overall impression is that it gives the employees a verification that they are working accordingly to what the company expect. Some site managers reuse this way of delegate and allocate tasks together with supervisors during the production phase which according to them gives the same effect. However, who are being assigned which task can differ from project to project depending on different skills, interest, ability to delegate or amount of available staff.

As a foundation for the production phase, the site manager most often has the responsibility to establish a production cost calculation, which the actual construction activities are based upon. This usually emanates from the tender cost calculation. The interviewees stress the importance for the calculation to be structured in a way so that it easily can be exported and converted into an overall production time plan. In other words, it should be structured according to in what order building components are supposed to be built or at least how they are chronologically connected to each other. Thus, the production cost calculation can be structured in several other ways which aggravate a smooth export. In reality both the calculation and time plan are produced simultaneously and are mutual dependent on each other serving to ensure control over the project economy and the project time plan. One interviewee questioned a procedure allowing a different structure, meaning that if everyone was coordinated a lot of time could be saved. Furthermore, the interviewee stressed that every project does benefit from having an as complete calculation as possible which also would be the basis for a more accurate production time plan.

It is interpreted as the production cost calculation and the project time plan are seen as the two most important information adapters in regards of steering a construction project in the production phase. However, the production time plan is by most of the interviewees mentioned as lacking of update. The impression is that small changes often are neglected and not changed in this level of planning. It is also notable that none of the interviewees mentioned the detailed planning in terms of what documentation they produce during the project. Thus, work preparations was mentioned by most of the interviewees, but is interpreted not being part of the detailed time planning since no connection to other activities were mentioned. This finding are more in detail explored in question 5, section 5.1.5.

5.1.3 Question 3 "Information success factors"

"How do you want information to be presented to you?" The purpose with this question was to identify key success factors for effective information acquisition by the management staff, focusing on their information needs.

The interviewees gave scattered response to what factors that they see as important. To compile this result the answers have been interpreted and sorted in a variety of success factors with related explanations in table 5.4. Response rate for the factors mentioned above are shown in figure 5.2.

Table 5.4: Found success factors with related explanations

Success factor	Explanation
In time	All interviewees gave indications that the most important thing is that information is delivered in time. Especially referring to late building documentation such as construction drawings, which obviously are common.
Quality	Second mentioned were the importance of secured quality. If it is not, it can be followed by unnecessary alterations and large changing costs as result. Consequently also leading to low trust in provided information in general and to the systems. Quality issues mentioned are for example out of date drawings or forgotten communication.
Explicitness	In a way connected to previous mentioned quality issues explicitness is stressed as an obvious success factor in terms of information acquisition. Examples of mentioned problems are for example unclearly written explanatory documents with implied meanings.
Accessibility	Referring to accessibility of documentation, primarily linked information such as explanatory documents linked to drawings or models, such as in e.g. AMA-codes. Unclear descriptions of drawings are identified as a clear hindrance.
Usability	Mainly referred to as user-friendly. Connected to explicitness but interpreted more as how applicable it is in terms of for example visualization and export opportunities.
Standard formats	A standardized way of acquiring information and present information is explained as one way of meeting the needs of previous mentioned success factors, which is why it can be seen as a success factor itself. Template documents and uniformed ways of working were mentioned in positive terms.

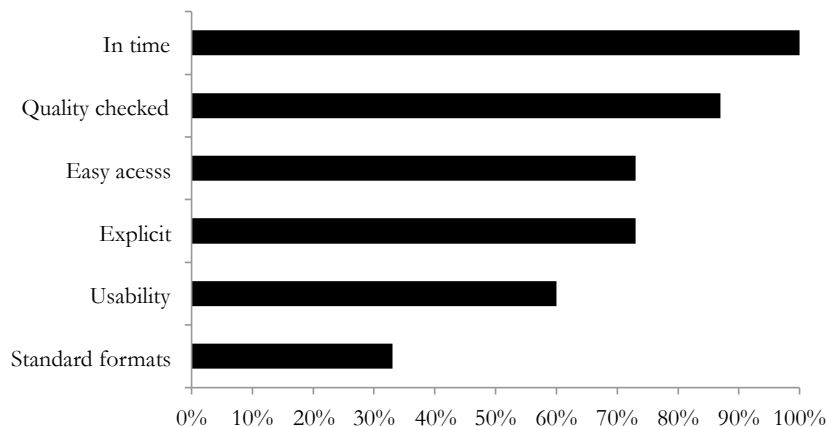


Figure 5.2: Percentage of respondents who mentioned each success factor.

5.1.4 Question 4 "Template documents"

"How do you experience working with template documents?" This question was asked since template documents have been identified as a significant part of the daily work within production, primarily referring to control documentation, work preparation and plans connected to such as working environment and risk- and opportunity analysis.

The general answer given by the interviewees was that the idea of working with templates is good, since they work as checklists and an insurance that you work in uniformity with the company's established processes and working methods. However, in the next instant all interviewees mentioned at least two hindrances each, and after discussion, in some cases also related improvement proposals for different parts of the template management and usage. Apparently is the common denominator the time consumption, which all interviewees felt was the main obstacle. As one interviewed supervisor put it:

"It takes so much time to compile a control document so that when I am finally about to do the reinforcement inspection the workers have already filled in with concrete."

Manual handling

Filling out templates are seen as repetitive work which takes a lot of time since the handling is strictly manual. This means for example templates for control documentation have to be manually modified depending on project. More specific, the actual control points have to be manually committed for each element of the construction that should be controlled. Often, improved templates are being used from project to project in order to ease the process. One proposal is to have discussion groups and to develop more accurate templates for everyone to work with. This has also been done regarding work preparations with positive results. Connected to the manual handling several of the interviewees were frustrated over how to find information for filling out templates. The accessibility as referred to in question 3, previous section, are mentioned as a hindrance referring to the several different locations where you find project information. More links between documentation and more accurate file naming to ease localization are mentioned as improvement proposals. Furthermore, more automatically filled in templates, linked to available documentation and models, are requested.

Missing templates and working methods

Templates can be found for almost every document referred to in the business system at NCC. However, a couple templates are described as missing by the interviewees. These are purchase- and delivery plan and control plan. The purchase and delivery plan are seen as a good tool for keeping track of orders and call-off agreements. When a template not is provided by the company, most often self produced templates float around between management staff. This is not seen as a problem since the experience is that if a template of some kind not should be good, then it simply would not be used. However, one interviewee expressed it like this:

"If using templates is what the company wants us to do, providing them for important documentation is the least they can do. It takes both time and energy chasing working methods."

Discussion about templates a few times led to that opinions about existing working methods came forward. The most obvious opinion among the interviewees is that during the computer development it has become more paper work. Even though much of the documentation and actual producing are executed in a computer this is equated with paper work. The project portal is in this context referred to as a step in the right direction since the actual documentation are more closely linked to the method working with the portal. This is lacking when the idea is to find templates in the business system since as expressed by several interviewees: "It is to many clicks away".

5.1.5 Question 5 "Production management"

The question "How would you describe production management at NCC?" was not a part of the interview sessions in order to find a definition to the concept production management. The purpose was, by using follow-up questions, to get a discussion about the contemporary working methods. How are the working processes managed by means of the different existing supporting tools, seen as information providers, and how should they accurately satisfy production management staff?

A majority of the interviewees mentioned several key words describing production management, for example economic governance, control and communication. Overall was the answers closely connected to the found core processes presented in the beginning of the result chapter. What however stood out and which not have been covered by the other interview questions was activities connected to detailed time planning and coordination of production work. The results of this question have therefore been focused on this finding.

As touched upon in question 2, section 5.1.2, is the detail time planning a subject of ambivalence, there is for example no specific documentation connected to the activity. Some site managers referred to the production time plan as a documentation of the detail planning. Thus is the interpretation that using the same planning tool as for producing the overall time plan is not in general seen as a functioning method, since it becomes hard to overlook and is too time-wasting to work with. Instead, almost consistently among the interviewees is some kind of visual planning method used, where some kind of whiteboard or large time plan is used to visualize the ongoing planning for the construction workers and sub-contractors. How this is practically being executed does differ between work places and between management staff. What however is obvious is that those of the management staff who have been introduced to NCC project planning¹ have been influenced by it even though they have not adapted it to a full scale. All of these interviewees saw clear benefits of broader involvement and collaboration between all parties within the production. However, the main obstacle mentioned against using methods like this is lack of time for implementation and competitiveness with other concepts like using VDC tools. Also, the lack of visualization options of the time plan and documentation problematics were also mentioned as an obstacle. One site manager expressed it like this:

"They want us to use all these different concepts, all I want to do is to produce".

In accordance to this quote the interpretation is that site management staff in general choose to adapt what suits them and leave the rest untried. There are of course also opposites, some site managers and supervisor did not use anything like this at all, instead they referred to themselves as keeping everything in their own minds, and some wants to try everything. This seems to be adaptable to all new concepts or technology.

¹A planning method under implementation by NCC process development group, based upon the ideas of Ballard (2003) involving the one executing the task in the planning procedure, referred to as last planner.

5.1.6 Question 6 "BIM and VDC"

The question "How do you experience or what are your thoughts about working with 3D-models together with associated tools?" was asked in order to collect the general opinions about VDC use today among site management staff. The purpose was not to identify details about software issues, instead more to find possible requests about connections to working methods and non VDC associated tools.

In general is VDC described by the interviewees as the use of 3D-models for visualizing projects in terms of the actual design. The field of application is primarily referred to as use of quantity take-off, coordinating installations and communicating a clearer picture of the project to all stakeholders instead of historically used 2D-drawings. Most of the interviewees have in one way or another been in contact to the concepts of VDC, where the 3D-model is the most obvious tool. It should however be mentioned that only a few of the interviewees recognize themselves as using VDC-technology in their daily work which consequently have been taken into account in the interpretation of their answers.

Quantity take-off have been used by some of the interviewees in earlier stages of projects producing production cost calculations and by a few also out on site preparing material purchase. The impression is that the usability is improving as the software development proceeds. The interviewees stress the importance of ability to control amount of information during quantity take off and the ability to check the calculation afterwards. Since most often a lot of quantity take-off are being executed by site management staff irregular or independent of chosen arrangement from previous phases, does management staff feel the need of free options regarding what quantities that should be measured. Automated quantity take-off is mentioned as a request on future softwares. However, there are still to low trust in such proceedings and checking the used formulas and method is described as a prerequisite. The overall trust in softwares executing automated calculations is low due to several of the interviewees.

The opinions of how 3D-model information should be presented are closely linked to the answers of question 3, section 5.1.3, but with emphasize on the usability instead of time as the most important factor. The interpretation however is not that time is not so important, instead as an expression of experiences of inadequacy of used softwares and models. Going deeper into usability, is the ability to easily use a 3D model for visualization the most obvious request, both on the office but also out on site. A desire of easily access information about a particular building object and additional room declarations are also mentioned as a request. A suggestion of quick links to written documentation directly in the model were mentioned as a proposal, which according to the interviewed supervisor would spare him the time going back to his office and search for the document in his computer.

In terms of using connections between planning, calculation and the 3D-model is the interviewees in general skeptical mainly do to the manual handling, technology problems and consequently time consumption which have been experienced during try-outs. The lack of knowledge are also mentioned as a hindrance. The interpretation of the contemporary standpoint is that VDC-tools are seen as additional tools and not a part of the primarily management tools. It is ascertained by several of the interviewees a uniformed system where you do not manually have to work with linkages and exports is desirable.

5.2 Document study

Partly to see which data that is required to be able to perform an activity, in this case connected to the documents that are produced during the production phase, a document study was carried out. Each document has been analyzed and data used for producing the document has been interpreted and noted. Since emphasis has not been to in detail compare the data usage, has the data been categorized on a level achievable and intelligible within the framework of this study. The level has been chosen as the study went on and while a pattern was recognized. The table shows that the same data to high degree are being used for producing different types of documents, especially data connected to building material. The results are shown in table 5.5 below where each dot represent that the data are being used in the preparation of each selected document. The table does not take into account how the data is used or being accessed, but are compiled based on the data which are important or can be linked to the preparation of each document. The table is used as input to the discussion on the use of BIM and VDC as an information, contained in the discussion chapter, section 6.3.

Table 5.5: Data requirements for producing production documentation, also referred to as adapters.

	Production cost calculation	Production time plan	Control plan and control documents	Working environment plan	Workplace information	Machine plan	Purchase and delivery plan	Workplace outline and logistics	Work preparations	Risk and opportunity analysis	Environmental analysis	Logbook	Additions and alterations
DATA													
Project information													
General contacts				•	•			•			•	•	
Responsibilities				•	•		•	•	•			•	•
Agreed times			•	•	•		•	•	•		•	•	
Personnel resources		•		•	•			•			•		
Documents			•					•			•		
Material													
Building component	•	•	•	•			•	•	•	•	•	•	•
Type	•	•	•	•			•	•	•	•	•		•
Specifications	•	•	•	•			•	•	•	•			•
Performance demands	•	•	•	•				•	•	•			•
Quantity	•	•	•	•			•	•	•	•			•
Risks	•	•	•	•			•	•	•	•	•	•	•
Environmental impact			•	•			•	•	•	•			•
Costs	•												•
Location	•	•	•	•			•	•	•	•	•		•
Work													
Execution method	•	•		•				•	•	•	•	•	•
Unit-time	•	•						•					•
Costs	•								•	•			•
Activities													
Hierarchy	•	•	•	•			•	•	•			•	•
Start		•	•	•			•	•	•			•	•
Finish		•	•	•			•	•	•			•	•
Location		•		•			•	•	•	•	•		•
Dependencies		•	•				•	•	•	•	•	•	•
Machines													
Type	•	•		•			•	•	•	•			•
Specifications	•	•		•			•	•	•	•			•
Risks	•	•	•	•			•	•	•	•	•	•	•
Start				•			•	•	•	•			•
Finish				•			•	•	•	•			•
Costs	•						•	•	•	•			•
Subcontractors													
Specifications		•		•				•	•	•			•
Personnel resources		•		•	•			•	•	•	•		•
Costs	•							•	•				•

5.3 Summarizing analysis

The interviewees generally describe the contemporary way of working as well functioning, referring both to their own projects as well as competitors'. They stress that projects in general most often finish on time, below budget and with a satisfied customers as a result. However, the description, as seen in the interview question reviews, also comes with a conformed view of hindrances that have to be remedied in order for employees to be able to work in a satisfactory way and which would probably also lead to greater project profits (Blücher and Öjmertz, 2007). The most obvious hindrances are that documentation and drawings not are produced in time, that using templates is a time-consuming activity and that there are too many systems for executing different management activities.

The main purpose of this analysis is to summarize the contemporary methods and systems used at NCC today and present the found information needs. In other words, simply and in a clear way answer to the research questions of this report.

The common denominator described in the interviews is that the daily work consist of several different systems or templates supporting different tasks within the field of production management. The following analysis therefore consist of a model, figure 5.3, in order to clarify the contemporary methods. The model includes all providers used for acquisition of information, adapters used for refining of information, a summary of primary data used for producing each document and finally a summary of found needs regarding each adapter. In the model have the providers been separated depending on their way of containing data, were for example a model or documents contain written down information while for example dialogues consist of communicative information with a discursive perspective coupled to it. As shown in the result of interview question one, does the interviewees have a conformed view of where to find information, for example in documentation, in drawings and in the model when such is practically applicable. The purpose of interview question two was then to find out what documentation that are being developed by site management staff and in which way information are processed and used in the production phase, here called adapters. The interpretation is that virtually all of the information retrieved from a provider are used to produce some documentation about the work, such as a schedule, calculation, work preparation or control documents. However, it was revealed that simple operations such as simple work preparation do not always take place, but the process as it is described in the operating system anyway points at that the retrieved data or information usually is processed through a adapter. As it works today, is the transfer of information from providers to adapters completely manual, and usually executed by an ocular review followed by a manual registration of information into a template document or software for further usage managing the production. Of course the ocular review can be performed by means of a digital provider such as for example a model. In general, templates are seen as a good way of verifying that the right working method is being used. There is however a desire that the information should be more easy to access when producing for example templates, or even automated. In terms of production detail planning is some sort of system requested with possibilities to visualize the time plan in different ways using the same in data, the newly introduced project portal does not seem to fulfill that need.

The model also inherent a description of how VDC-tools are being used in the production today, where visualization and quantity take-off are the two major uses. Needs for user friendly systems in terms of VDC has been found as a desire from management staff, where the visualization benefits are seen as the major advantage as well as user friendly quantity take-off.

What should be noted is that each adapter presented in this model does not represent one single system or supporting tool. Several activities can be executed by means of several tools. Collateral can one system inherent several of the adapters. Which one is being used are often decided from project to project, dependent on skill level, experience and convenience. An example could be management of additions and alterations where support can be found both in the calculation program as well as the project portal. For further insight, see table 5.1, which describes what supporting tools that are connected to each core process, instead of the concept of providers and adapters used in this analysis.

In terms of information needs the result have eventuated in precise needs connected to each adapter. In addition, the result also present more general findings. Interview question three provide six success factor categories seen as important by the interviewees when it comes to information needs. Due to the interviewees should information be provided in time, with quality, be explicit, be accessible, be usable and advantageously be in standard formats. These factors can be equated with overall needs on information

where the first three are interpreted to be linked mainly to the needs on the information itself and the last three an expression of needs connected to the information system and therefore to the demands on the system as described by Wilson (1981).

All factors above were described as areas of improvement. Most obvious were that information, such as drawings and descriptions, from previous functions often are delayed with delayed production or risk taking, like producing without construction drawings as result. Within the framework of this study no answer to why this is such a usual problem have been found. Indications have although been registered that it probably is a problem with to ends, where the design function has a positive time-plan and the production function have reasons to start producing as early as possible. To find out the true reasons for this, studies on a more overall and managerial level have to be committed.

Looking at the need of information quality are the interviewees referring to the importance of trust in information. Without trust is the information instead often collected from somewhere else with increased work as result. This is in a way also connected to the factor off explicitness. If information not is explicit, the trust becomes low and the information acquisition time extended. An example could be VDC supported quantity take-off. If the program do not provide trustworthy and explicit quantities, the staff will instead use a manual calculation method.

Instead focusing on those factors concerning the system, are needs for information accessibility and user friendliness identified. Accessibility incorporate an overall need for information to be easy to access and information should be accessible when you need it and where you need it. The system as such should also be user friendly and easy to use. If not, according to the interviewees it will simply be ignored.

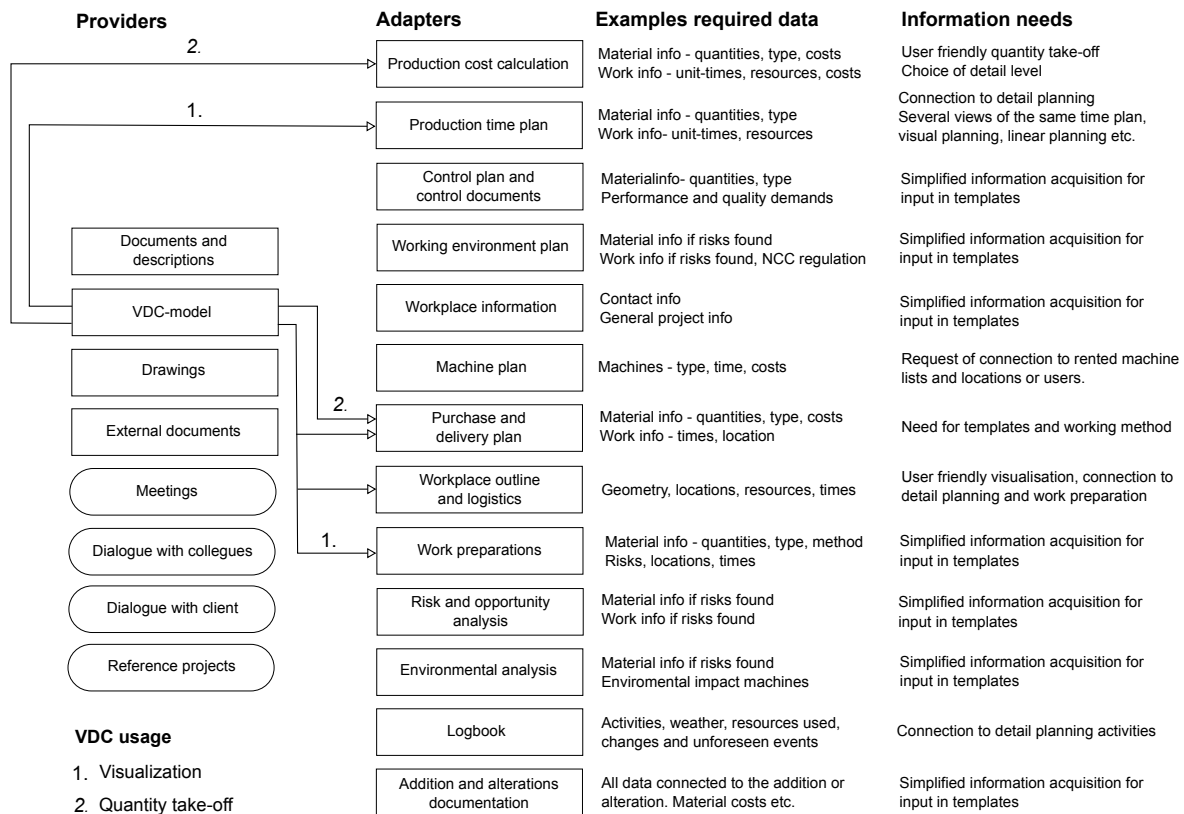


Figure 5.3: Summarizing model of the found results.

Chapter 6

Discussion and conclusion

Have the study objectives, to give a reliable description of the information needs of primarily the production function, as well as demands on information from the previous functions been satisfied by the outcome of this report? Does the description serve to make the information needs visible for future information system development? The purpose of this chapter is to answer these questions by discussing the results based on the reports two research questions, by means of research presented in the theoretical framework. To finish up the discussion part of this chapter is the connection to BIM and VDC brought up. Is it possible for BIM and VDC to be used as a complete information system? Finally, some concluding remarks, main key points and a few recommendations for future studies is presented.

6.1 Current practice for information acquisition

The question "What is the current practice for information acquisition and which are the different information providers and information adapters?" was asked within this study to provide a basic understanding of the working methods and current information systems used at NCC today during the production phase.

The results connected to this research question show which components in the process that can be identified as adapters and providers. Between these it is the information transfer determined mainly as being a manual process. Most often is a template document or a software like a calculation program manually filled with information.

NCC uses, as described previously, several types of tools for working with or as adapters. These tools or softwares can according to how Rainer and Cegielski (2012) defines various information systems exclusively be seen as a system that do not use the benefits of retrieving information from a single database. Information softwares at the moment might instead be seen as a part of a "Functional area information system" where each separate component performs a particular activity without further digital information transfer related to other parts. This include VDC-tools since most often only manual information transmission have been found. The exception is software programs for calculation sheets and schedules where it is possible to export information. Also production of the workplace outline by means of visualization softwares can be mentioned as an exception since the model or digital drawing most often serves as an underlying template file. However, these exceptions do not either share the same database with automatic updates of changed data, which would have been beneficial since data only would have had to be registered once (Rainer and Cegielski, 2012).

NCC invests substantial resources to implement VDC-tools out in production, primarily through various types of visualization operations, for example through visualization of workplace outline and follow-up work. This implementation has been followed by positive responses which is consistent to previous research brought up earlier, for example Granroth (2011). The advantages have by many researchers been identified as improving the quality of results in all phases of the process due to increased collaboration and awareness about project details (Hartmann et al., 2008). However, implementing new technology, independent of industry, has been identified as a task full of difficulties (Eastman et al., 2008), which the interview results also indicates. Difficulties have been identified being connected to the existing methods where the interviewees' standpoint is that there is lack of time for implementing new concepts and that

they do not always see the need for new methods. This is however not a newly emerged problem, and as Hartmann et al. (2012) puts it:

”The challenge is to align building information model tools and construction management methods.”

Perhaps is the perception that there are not enough time for implementation just an expression of issues as described by Arayici et al. (2005), where the staff just are non-willing or where staff just do not know how to use these methods. Another way of seeing it could simply be that new methods does not satisfy the true needs.

In contrast to this reasoning, Cong (2012) among others present the benefits of BIM and VDC mainly referring to how technology can bring new dimensions to the building process with associated tools. Most often mentioned is the visualization benefits of 3D-models, the opportunities of linking information to specific building components and detecting conflicts between different installations and constructions. However, as WSPgroup (2013) express in their list of ten truths about BIM:

”When the system is sufficiently streamlined we can start to focus on using it. Once the basic information infrastructure is in place and we’ve learned to work with it, numerous technologies, in use or in the pipeline, can be brought in.”

In terms of BIM and VDC softwares supporting the production phase, this master thesis have ended up in the hypothesis that in order to ”streamline the system” as expressed by Bryde et al. (2013) above, the information needs of the production management staff have to be identified. Understand the personal benefits and requirements engineering of a new system or methodology, is necessary to seriously take it into heart and start using it (Arayici et al., 2005). One approach for taking complete usage of BIM as an information system could be focusing on making the tools work both as providers and adapters where the model is working as a complete database. Gathering all information in one place could also be seen as a solution to the identified need of information quality, where the existence of ambiguous data would be mitigated.

Since the easiest entry to find the information needs was interpreted to be by asking about current working practice is this research question answered by several of the presented interview question results. The interview results show that the processes used in the production phase are well conformed with the determined general working procedures provided by the operational system at NCC. These working processes are also consistent with the procedures presented by for example Alnervik and Jelacic (2010) in terms of production management and on a more overall level described by Nordstrand and Révai (2011) and Atkin et al. (2008). The interpretation is therefore that NCC is a satisfactory representative of the business as a whole and could be used for generalization to some degree.

6.2 Information needs in the production phase

The question ”What are the needs in terms of managing and using information for supervisors and site managers in the production phase?” can be seen as an attempt of deepened user studies as described by Wilson (1981) in the area of production management. The discussion are mainly built upon the answers found in interview question three to six within the framework of found results in question one and two, as well as the document and system review.

The need for information which the study identified can be divided into a general part, success factors, and a more specific, where the latter is clearly linked to the development of the existing operation. It is especially clear that the information must be available when it should be used, and that the present situation consist of a lot of time searching for information. Often, it is also the same information obtained in the different stages, such as in the work of various adapters, which the executed document study also shows. A concrete example of where the acquisition of information can be very time consuming is according to the interviewees when filling out the templates, such as control documents and work preparations.

Available information is what all the interviewees believe to be the most important need, but also what is considered to be the main deficiency. That documents are not available at the time for construction

is according to this study very common. If not the information is available from previous stages in the process, it is not possible to fill out the required documents for a righteous proceeding. It is also likely that this lack of information leads to so-called secondary needs mentioned in the background to this study, which according to (Modig and Åhlström, 2012) leads to unnecessary work and therefore also unnecessary costs. In order to build a functioning information system must the basic needs be met (Wilson, 1981). However, since this study focused solely on the production stage no reasons for this non-synchronization enshrined.

6.3 BIM and VDC as an information system

In addition to the previously discussed issues, it is in this part, based on the study results, reflected over if and if so how it is possible to use BIM and VDC as an information system. Primarily it is the made document study as an information system that form the basis for these thoughts. The document study shows that the process of producing documentation, adapters, to a great degree inherent the same information that is of importance. Why not let technology provide staff with the information when it is needed instead of forcing them to search for it? As outlined in the theoretical framework is the idea of building models that they should be able to contain all sorts of information about a building project. The entire cycle should be able to be controlled according to research (Eastman et al., 2008). To achieve this, there are several different file formats structured with the ability to include all types of data, such as the IFC format (OpenBIM, 2013). In a simple comparison of the documents study and the type of data which according to Eastman et al. (2008) can be included in a format as IFC show that there hardly is no contradiction. Naturally, IFC is not a perfected format and although the idea is total functionality, there is still lack interoperability (Granroth, 2011). However, the mindset is right, since if the information is assembled with the ability to be updated continuously, could unnecessary time for information seeking be eliminated. The suggestion to NCC is to in the future implementation steps in terms of automatization, as mentioned by Kunz and Fisher (2011), focus on automated information acquisition, for example by auto generated templates such a control documentation. u

6.4 Concluding remarks and recommendations

The study has shown that NCC has a functioning process for production management, but where there is room for improvement in terms of information acquisition. The primary needs identified for production management staff is to get the information in time, it should be easy to obtain, simple and clear to use and the system itself should be user friendly. It has also been shown that there is a desire for a uniform way of working, similar to what is available today, as it ensures a well proposed process anchored within the company. As it is now several concepts are implemented and developed without coordination. More in detail, it is mainly information retrieval for completing the template documents or adapters in general requested, but also fewer or even one single system for managing information. Using a VDC-model a single database is interpreted to be an achievable alternative. It is also noteworthy that within the same company competition exists for selling various concepts to staff where the purpose often is similar, an efficient production work.

Based on this study is the recommendation for NCC to focus development efforts on what information is needed in the processes that are already established and working out in the field. It does not mean that less effort should be in the direction going on today as visualization and quantity takeoff almost only received positive reviews. However VDC should be paired and developed in consultation with other concepts such as NCC project planning or project portal.

6.5 Suggestions for further research

Research should be conducted more in detail focusing on how to make BIM and VDC suitable for production management. Each existing process should be further evaluated in terms of simplify information acquisition by means of technology. A suggestion is in a first step try acquire information from a model for use in templates. For example could a control document be generated depending on building component

information. In a second phase it is reasonable to question the actual use of templates, perhaps could the process be integrated in some kind of software. A production management software.

The presented information or data table, table 5.5, could also be a subject of further studies. One suggestion is to weigh data or information against each other and find time-consuming bottlenecks to be able to optimize future information system development.

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Appendix A

Interview questions

A.1 Interview questions for production (in Swedish)

Site managers and supervisors

Informationshämtning

1. Hur läser du in dig på ett nytt projekt?
 - (a) Informationskanaler?
 - (b) Dokument, ritningar, möten, projektportalen, beskrivningar, lagar
 - (c) Hur får du tag i informationen?
 - (d) Vad är önskvärd mängd information om ett projekt, brukar det finnas?
2. Vilken dokumentation ska du ta fram/ansvarar du för i projektet?
 - (a) Hur går man praktiskt tillväga?
 - (b) Finns det några hjälpmedel att dokumentera?
3. Hur vill du få information presenterad för dig?
 - (a) Text, bilder, punktform, schematiskt, dator, pappersform, ritningar, möten, muntlig förklaring

Hjälpmedel

4. Hur upplever du att arbeta med mallar och mall-dokument?
 - (a) Hur används dessa?
 - (b) Hur inhämtas informationen för att fylla i dem?
 - (c) Egenkontroller, arbetsberedningar, ritningar, möten, projektportalen, beskrivningar, lagar
 - (d) Var sparas informationen för att kunna användas senare?
 - (e) Används den senare?
 - (f) Hur tror du det påverkar resultatet av att arbeta med mallar?
 - (a) Fördelar/nackdelar?

Produktionsplanering

5. Beskriv hur man arbetar med produktionsplanering, och hur man gör en produktionstidplan?
 - (a) Hur arbetar du med arbetsberedningar?
 - i. Malldokument?
 - ii. Hjälpmedel?
 - (b) Hur arbetar du med veckoplanering?
 - i. Malldokument?
 - ii. Hjälpmedel?

Virtual design in construction

6. Har du arbetat i något projekt som använt 3D-modeller och tillhörande verktyg?
 - (a) Tankar kring arbetet?
 - (b) Hur användes modellerna?
 - (c) Kopplingar till andra system? Inköpssystem, kalkylsystem, planeringsverktyg?
 - (d) Vilken information används ur modellerna?
 - (e) Arbetsberedningar, möten, anslagstavla, visualiseringar.
 - (f) Vad fungerar/vad fungerar inte?