CHALMERS

iBIM – integrated Building Information Modeling

An Integrated BIM Team in the Design Phase

Master of Science Thesis in the Master's Programme International Project Management

JEMI GABRO

Department of Civil and Environmental Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
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ABSTRACT

To optimize BIM design projects' outcome, team integration is essential. Unfortunately, scholars focus on the new technology and do not recognize the importance of putting effective collaboration before even introducing the new technology. Hence, the objective of this research is to generate an awareness of team integration and suggest more efficient ways of working. The research is done by a comparative research, containing two firms from two different markets to support the findings. The findings are collected through qualitative semi-structured interviews and assist to clarify the issue in focus. The research shows how the procurement route has major effects on the team integration. However, it seems that some circumstances are not always allowing which route to choose, such as when the government requires having an open bidding for the construction project. The contractor can therefore not be included in the early stages of the project lifecycle, resulting in a scope environment where team integration is less possible. Furthermore, the research findings also present the importance of a co-location, in other words a physical place where the team can work closely together and to include all actors counting the owner, which often is forgotten to be part of the team itself.

Key words:

AEC: Architect, engineering and construction industry

BIM: Building Information Modeling

BD: Design and Build

DBB: Design, Bid and Build

MPA: Multi-Party Agreement

IPD: Integrated Project Delivery

XC: Extreme Collaboration

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I want to take the opportunity and thank both companies and all participants that donated from their valuable time and supported me with my research. I especially want to thank the Swedish company who structured and supported me with an office at their company. More particularly I want to show my greetings to my supervisor at the firm who took me under his wings and also all the colleagues sitting at the firm. I hope there will be a chance in the future where we have the opportunity to work with each other again. Furthermore, I do want to thank my supervisor at the universities, who helped me find articles connected to the subject and guided me along the way. This dissertation would not have been possible without their guidance.

Yours Sincerely

Jemi Gabro

Contents

Preface

The Architect, engineering and construction industry (AEC industry) has frequently shown that the construction industry is ineffective (Owen et al., 2010). The prime cost of today's construction projects is not because of costs of raw material or cost of labor, but the inefficient ways projects are managed (Thomsen et al., 2010). New techniques and methods to reduce the cost and time while at the same time increase the productivity and quality is crucial for AEC industry to develop. BIM is such a technology who supports team integration, which is the subject of this dissertation. This research will look at the importance of team integration when working with BIM and how it can be managed. The dissertation will first present previous research on the subject, when later on move to the result findings. The findings are collected through a comparative research done at two different companies and markets. The focus will be on the effects that the procurement route, the team, culture, communication and decision have on the team integration, when working with projects executed with BIM.

The study is carried out from January 2014 to June 2014 the work is within construction carried out at the Department of Civil and Environmental Engineering, Chalmers University of Technology, Sweden; and Northumbria University, Newcastle.

Gothenburg August 2014

Jemi Gabro

1 Introduction

The introduction chapter will start by presenting the background and context of the research, giving an overview of the relevance of this study to the wider market. From there the chapter will move on to the aim and the objectives of the research, followed up by introducing the question in focus. Furthermore, an introduction will be presented on how the research was done and finally the structure of the dissertation.

1.1 Background and Context

The Architect, engineering and construction industry (AEC industry) are currently based and evaluated on the iron triangle Time, Cost and Quality. Previous result studies have frequently shown that the construction industry is ineffective (Owen et al., 2010). It is commonly known that around 40-50 percent of the projects are running behind schedule Also, the prime cost of today's construction projects is not because of costs of raw material or cost of labor, but the inefficient ways projects are managed (Thomsen et al., 2010). Hence, the industry has frequently suggested new techniques and methods to reduce the cost and time while at the same time increase the productivity and quality. The industrialization of the construction sector started a number of years ago and according to various researchers Building Information Modeling (BIM) offers such potentials that these objectives are achievable (Babič, et al., 2010; Arayici, et al., 2011). Some even say that BIM is this generation's game changer (Parrott & Bomba, 2010).

Various numbers of researches has been done within the area of BIM. It is shown that facilities emerging from projects using BIM are more sustainable and increase the productivity than non-BIM projects (Khosrowshahi & Arayici, 2012; Bernstein & Pittman, 2004). It is not a secret that the largest contractor and consultant companies are fully aware of the benefits and advancements when implementing BIM. The world leading countries that have completed and documented BIM pilot projects in the construction sector are Finland, Sweden, Norway, Germany, France, Singapore and Australia (Khosrowshahi & Arayici, 2012).

Researchers discuss various subjects within the BIM methodology, which consists of three areas that are integrating and overlapping with each other. These areas are Technology, Policy and Processes (Succar Sher & Williams, 2013). Process is the subject closest to management and the issues addressed in this paper and it is recognized as one of most the important parts of BIM (Arayici, et al., 2011; Bernstein & Pittman, 2004). Executing BIM effectively demands major changes in the way construction business works; at almost all levels within the building process (Arayici, et al., 2011, Owen et al., 2010). It is a new way of thinking that essentially makes it a new and more powerful way of planning. The paper will address the issues within the frame of the design phase affecting the work process of the BIM Team. The BIM team is in this paper referred to the design team who are going to construct the BIM model. Therefore, clear guidelines which outline effective work process of the project team could benefit the whole industry.

The construction design phase is a complex phase with many stages which affects various multi-disciplinary stakeholders. Moreover, the design phase is only becoming more and more complicated, because of the increased specialized staffs, technologies and tools (Bosch-Sijtsema & Henriksson, 2014). Hence, studies have to be made to

further understand the current situations of the construction design phase. Moreover, from the beginning of this decade there has been ongoing discussion within the construction industry in relation to collaborative and integrated approaches to the design and construction projects. BIM has the potential to analyze and process huge amounts of inputs to resolve issues that usually are not discovered until the facility is being constructed. The new possibilities BIM provides are encouraging, however there is still a need to be rational regarding collaborative manners, which BIM embraces (Parrott & Bomba, 2010). Dossick, and Neff (2011) claim in an article that individuals and scholars do not recognize the importance of putting effective collaboration before even being able to introducing the new technology. There are only a few studies that look into how the design team can be integrated or improved and there is still much work to be done there.

Moreover, it is extremely difficult to implement something's if the current market is not ready to tackle the issue. Thus, this paper introduces alternatives to the current way of working, where a higher integration can be organized within the BIM project team in the design phase, referring to the Swedish market. There is unquestionably a substantial project scope to be improved, to deliver value for clients and other stakeholders, but also to reduce cost and lead time for delivering a facility (Owen et al., 2010)

Finally, it is known by researchers that depending on which procurement route is chosen for the project, the affect will differ on the BIM team and either increase or decrees the chance of working integrated (Thomsen et al, 2010). However, it is not always as easy as researchers suggest, since there are countries that have demands on which procurement has to be chosen. Hence, this report will bring up the issues of choosing different procurement routes and which one is more suitable to choose when working with BIM.

1.2 Research Aim and Objectives

The aim of this study is that by a comparison of the Design phase in a construction project, within two of Scandinavians largest Engineering and Design Consultancy firms, find improvements to the process of how to work with the BIM methodology in the Design Phase and Swedish market.

The objectives of this study are to reflect around (i) the existing conditions of how the Design process is structured in a project that uses BIM, (ii) the existing conditions of how the Project teams work with BIM in the Design phase and (iii) what procurement routes are chosen by the client (iiii) and suggest a more efficient approach for the Project teams to implement the BIM methodology that is mature enough for the current Swedish market to handle.

1.3 Research Question

Literature frequently mentions that working in an integrated environment in the design phase has its major benefits on BIM projects, such as cost savings on the following phases, the facility itself, and in the operation (Prins & Owen, 2010). But then again the market might not even be mature enough to implement an optimized level of integration. Hence, the research question in focus will be:

"How can the BIM project team work in the design phase to improve and develop a higher level of integration in the Swedish market?"

Sub questions have been developed that would support to answer the research question, these are

- What procurement route should be chosen that could support integration in BIM projects?
- How should the BIM project team work together?
- How can a collaborative environment be upheld?

It is believed that by answering these questions a higher level of integration can occur within the Swedish project teams.

1.4 Scope and Limitations

As mentioned in the previous chapter the BIM methodology consists of three areas which are integrating and overlapping with each other, these areas are Technology, Policy and Processes, Figure 1 (Succar, 2009). The research scope will strictly be within the framework of comparing processes for executing BIM in the Design Phase.

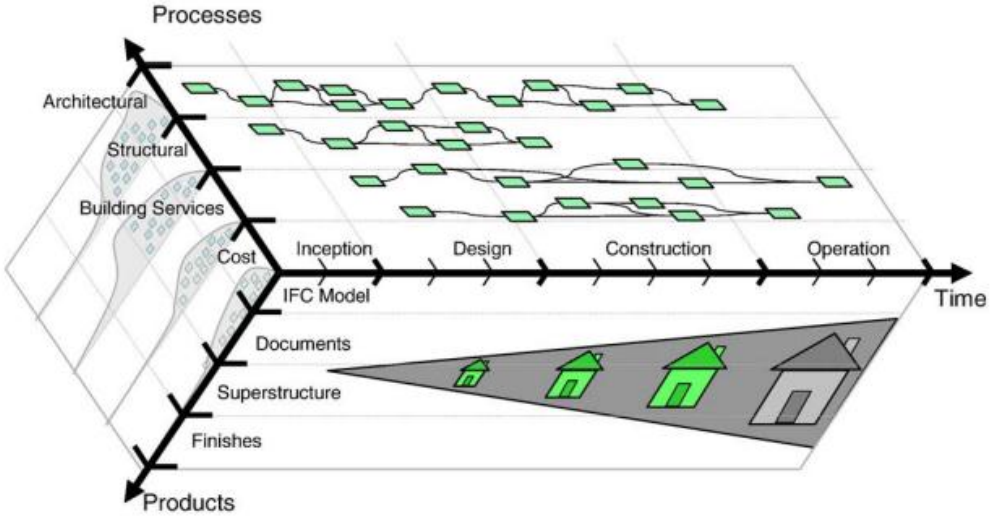


Figure 1*: Diagram of the elements in a united approach to project management (Succar, 2009)*

The report will only emphasize on construction projects with a focus on buildings. Furthermore, when it comes to the area of processes the focus will be on the process at meso-level that is to say a focus on the Design Team (Moum, 2009). Soccar et al. published an article in 2012 where it was mentioned that processes within BIM concern areas such as of Resources; Activities and Workflows; Leadership and Management. These subjects are motivating and guiding this research. Other areas such as products and service; tools and marketing will not be discussed in this paper. Hence, looking back on the objectives the research will lift up what procurement route is suitable for an integrated BIM project that the Swedish market is mature to

incorporate, how the team should be structured and when disciplines should be incorporated in the team, how they should communicate and be managed, and last but not least how an integrated work environment can be uphold.

1.5 Research Case and Organization

This research will be a comparison study between two of Scandinavians largest Engineering and Design Consultancy firms, one based in Norway and the other one in Sweden. The study will be upheld to help support the Swedish market to increase the integration of the BIM project team in the Design phase. The researcher will be located in the Swedish firm, but also travel to the Norwegian company. The research strategy will emerge with help of an epistemological approach. Where the focus is on theory of knowledge and the emphasis is on how reality is perceived and how the methods are assessed by the participants (Bryman, 2012). The data conducted will emerge through involving literature followed up by close examinations of current manuals, guides and other reports, provided by the firms. However the main data collections are trough qualitative interviews.

Company S (Sweden) has for some time now been working with an investment in BIM. They are a multi-disciplinary consultancy firm that covers a global geographical range and offering services from initial surveys and analysis, to planning, design and management. Moreover, Company S is one of the main shareholders of Company N (Norway).

Company N is one of the leading engineering and design consultancy firms in Scandinavia, but also work on a global scale, offering the same services as Company S. Company N has for some time developed a methodology for executing BIM Projects which consists of manuals, templates and utilities. Company S has seen the value of Company N's material and decided to develop their own methodology based on Company N's material. Thus, the choice of the firms for this research.

1.6 Dissertation Structure

Understandably the focus is going to be on the integration of the BIM project team when working in the design phase. Hence, this is going to be a red thread throughout the whole dissertation. However, along the red thread will be sub elements such as how meetings are structured, culture, procurement routs and decision making, which have an effect on the project teams' way of working.

The dissertation is structured in such a way that before each main chapter there will be a small introduction giving the reader an insight of what will come next. The structure is as following: Chapter one covers the introduction of the dissertation. Chapter two will then present precious literature conserving the subject and explaining what is meant by some fundamentals. Chapter three will then be presenting the results conducted from the research and after that a discussion chapter is conducted. Discussing the findings and linking it to the literature review. Finally, the last chapter presents the conclusions made from the study and recommendations for future researches.

2 Literature Review

The literature review chapter gives the reader the current understanding of the issue in focus and what kind of research has been made in this area. The first subchapter will spread some light on what the design phase is, the different stages in the design phase and also why it is difficult to manage. The next chapter will then present three commonly used procurement routes that occur in the Swedish construction market and also how and if they support team integration. The chapter after that will focus on the cultures and way of working, giving an insight on integrated project delivery and extreme collaboration. Furthermore, Subchapter 2.5 will then introduce the issue of communication and how meetings are managed. After that is a subchapter about decision making, giving an understanding of the decision making process and the final chapter eventually emphasis on BIM as a method!

2.1 Design Phase

The Design Phase is one of the major phases in a Project Lifecycle and as Maylor (2010, p 130) states *"If you fail to plan, you plan to fail"*. The Construction design phase addresses key issues such as planning and modeling the project, estimating costs and resources, conflict resolution and justification. It is in this phase that models are constructed to illustrate *how* the needs will be developed to become reality. It is essential that this is done in the most optimal way possible to minimize risks. Questions such as - How will it be done? Who will be involved in each part? When can the project start and be finished? - have to be answered (Maylor, 2010).

The design Phase is seen as a difficult process that continuously rises in complexity because of its increased specialized expertise. Up to date there is an enormous increase in variety of firms that contribute to the design phase. This creates a domino effect, which generates a design process where frequent exchange and modification of information and knowledge emerges. Actors affected by the design are clients, architects, contractor, structural engineers, and heating, ventilation and air condition. Hence, it is important to uphold an environment for successful collaboration within the frames of the design phase (Bosch-Sijtsema & Henriksson, 2014). It is a challenging environment to handle where even the most skilled project teams fail to manage the complex process to provide the accurate information at the right time, and correct quality to the participants of the construction team (Moum, 2009).

The design and construction sectors are currently based and evaluated on the iron triangle Time, Cost and Quality. Previous result studies have frequently shown that the design and construction industry is ineffective (Owen et al., 2010). It is commonly understood throughout the construction industries that between 40-50 percent of the projects are currently running behind schedule. Also, the prime cost of today's construction projects is not because of costs from raw material or cost of labor, but the inefficient ways projects are managed (Thomsen et al., 2010).

2.2 Procurement Route

What procurement route to choose for a construction project is one of the most important decisions clients have to make. Depending on the complexity of the project, risks, price, flexibility to make changes, the client's consultants, and more, the route

will differ. This paper will present three commonly used delivery routes that occur in the construction sector; Design-Bid-Build; Design-Build, and Muli-Party Agreement (Thomsen et al, 2010) and according to a Swedish firm (Used for this research) take place in the Swedish construction market.

Depending on which procurement route is chosen the influence will differ on the BIM project team. It is safe to claim that there is an increased choice of the Design-Build (DB) procurement model in comparison to the other procurement models (Anumba & Evboumwan, 1997).

2.2.1 Design-Bid-Build

The DBB procurement route is common in many countries such as Singapore, the United Kingdome and United States of America. In this traditional procurement method the owner has a separate contract with the designer and the contractor, Figure 2 (Ling et al. 2004). One reason why the route is still popular is because the owner gets the benefit of an open competition, where the design phase is followed by a separate bid and construction phase. Some governments have required a construction industry where a fair "open bidding" has to emerge, which makes it impossible to bring in constructers in the early phase, since this would affect the open bid fairness (IPD Guide©, 2007).

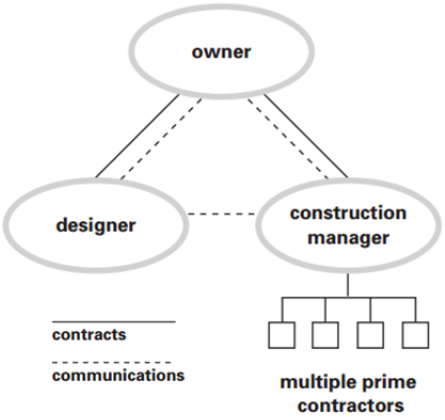


Figure 2*: Contracts and communication in a DBB procurement route (IPD Guide©, 2007).*

In the DBB procurement route the owner first signs a contract with the designer, who is responsible for developing the project requirements and from there develops a design for the facility. The design is then put out for bid where the owner selects a constructor for the project and who then moves on to the actual construction. The project design in a DBB has usually very little, if any, input from the actors who are essentially going to construct the facility, which means that construction and coordination issues are not exposed and determined until the facility really is being built. This particular delivery model only allows very few opportunities for participants to work in an integrated environment (IPD Guide©, 2007).

2.2.2 Design-Build

In the DB delivery model the owner enters a contract with a single entity (Figure 3) who has the reasonability to deliver both the design and construction activities. This route is often chosen because by combining the design and construction the risk and management shifts to a single entity. This allows the team to manage the project more easily, reduce risks and improve the forecast of cost changes. Furthermore, the owner has a heavily integrated role in the early design phase, which reduces along the process. The Design-Builder accepts the owner's desires and takes over the control from thereon. In this procurement model the success are usually measured by the time and cost savings compared to the maximum budget. Hence, the owner has to be clear with the requirements of the desired quality and accept quality compromises through quantity, graphical or presentation of the design criteria. Moreover, the delivery model may therefore take different routes, such as (IPD Guide©, 2007):

- picking only the qualifications
- choosing the best value provided by the owner, or
- selection driven by price

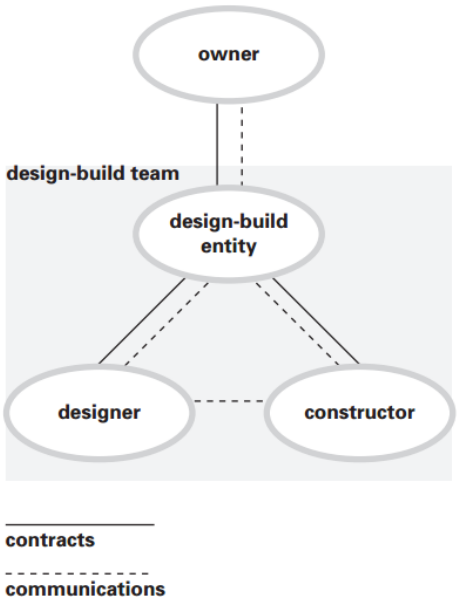


Figure 3*: Contracts and communication in a DB procurement route (IPD Guide©, 2007).*

The Design-Build delivery model is very much suited for a high level of integration, because of the many routes that are available, especially between the design and construction team members. More importantly, the contractor has the opportunity to get involved in the early stages and influence the design. Also, the members of the team are usually self-chosen and have probably worked together previously, which generates many benefits. Finally, an important member if the Design-build team is the owner, who can require whatever level of participation he/she desires (IPD Guide©, 2007).

2.2.3 Multi-Party Agreement

Multi-Party Agreement (MPA) is when the key project participants are boned under one contract that defines their responsibilities, roles, obligations and rights. MPA are working as a temporary virtual and formal organization to deliver a specific project (Figure 4). Hence, the agreement is depended on trust since the individual success is bound the overall project achievement. Moreover, the team needs to work closely together to achieve the team goals. Such a tight integration is excellent to improve the team performance, by increasing flexibility, generating creativity and improving the decision making process. Thus, MPA is well suited for complex and uncertain projects where the process is custom-made to support the team setting in focus (IPD Guide©, 2007).

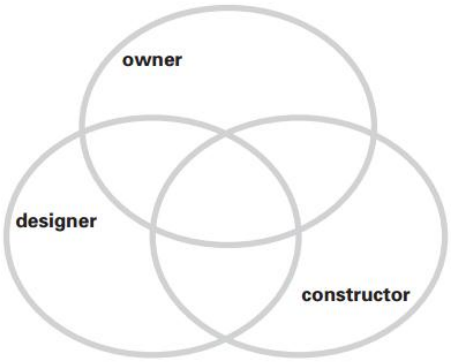


Figure 4: *Contracts and communication in a MPA procurement route (IPD Guide©, 2007).*

MPA entails during the planning an instance team building determination and cautious negotiation, which usually is very costly particularly if the team has little previous experience of MPA agreement. However, in lager projects this cost is easily beneficial and in smaller project this cost can be reduced by using team members that have previously worked together (IPD Guide©, 2007).

2.3 Cultures and Ways of Working

Several articles have been published which state that BIM is a new way of thinking that essentially makes it a new and more powerful way of planning (Khosrowshahi, 2012). Authors claim that working with BIM demands major changes in the way construction business works, at almost all levels within the building process (Arayici et al., 2011; Prins & Owen, 2010), also the role definitions will have its impact (Moum, 2009). Previous research shows that it is beneficial to work integrated between actors to create an optimal environment for exchange of knowledge and information, enhance innovation, and minimize structural risk, process inefficiencies and generating value throughout the project. (Prins & Owen, 2010; Bosch-Sijtsema & Henriksson, 2014). Hence, it is not a surprise that various articles are published in a combination with Integrated Project Delivery (IPD) and extreme collaboration (XC) (Prins & Owen, 2010; Owen et al., 2010; Parott & Bomba, 2010; Garcia et al., 2004).

2.3.1 Integrated Project Delivery

IPD means different things to different people, however it can be seen as a framework that involves designers, owners, and contractors to work together in all phases of the project. IPD has its base in a new way of thinking around the design and construction process, Figure 5. However, in some aspects it can be seen as a highly improved and advanced DB approach. IPD is centered on forming a motivational alliance, where the parties are agreeing to work integrated as one unit. In other words the contract strives to motivate the parties to put their individual interests aligned with the project interests. The parties are bound to the project risks or benefits together, where participants divide the savings or losses, depending on the project outcome (Parrot & Bomba, 2010). Various researchers have stated that risky and demanding projects can be improved by joint risk management (Lehdenperä, 2011). Also, in IPD the relationship, within the alliance, is based on ideologies of trust, respect, equity, honesty, no dispute and blame. The aligned interest encourages the participants to work together to find solutions as problems rise, instead of save their own skin and point fingers, which is the case in current delivery models (Parrot & Bomba, 2010).

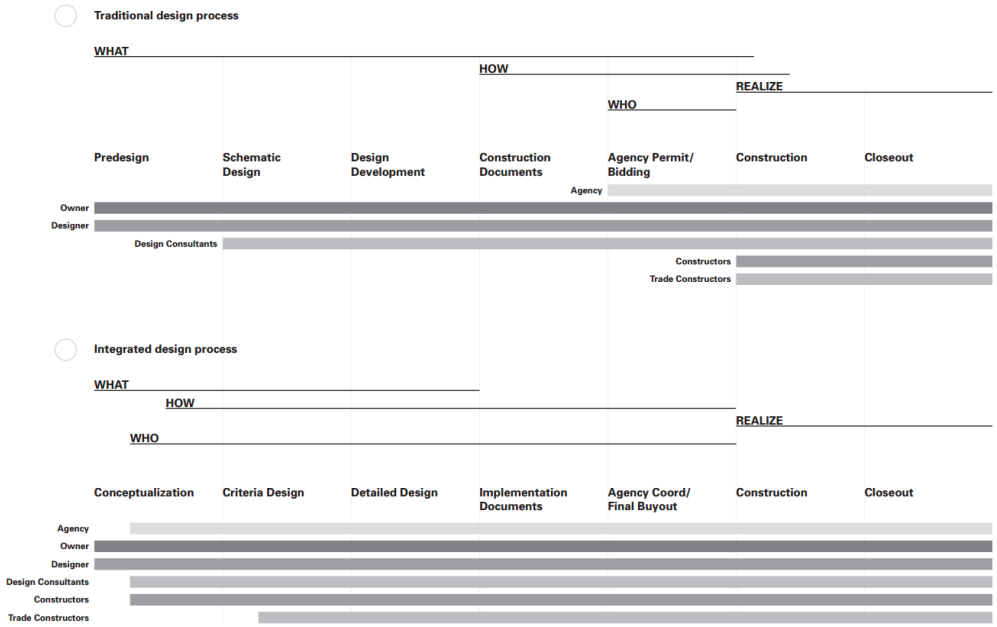


Figure 5: *Design and construction process in a traditional and IPD project (IPD Guide©, 2007).*

2.3.2 Extreme Collaboration

Currently the fully developed level of integration is to a large extent hindered by shortfalls in the aspects of process, people and technologies (Prins & Owen, 2010). Hence, the full benefits and efficacy is still a couple of years in the future (Moum, 2009). However, much focus in the later years has been to help supporting the project cross-functional teams managing new developed tools and techniques, when working with BIM Projects. Extreme collaboration and modified workspaces for cross-functional teams are such support elements (Fischer et al. 2002; Fruchter et al., 2007; Garcia et al., 2004). XC entails to bring together multi-functional design team participants, to collaborate in an environment where shared visualization, information, meetings and decisions area uphold (Garcia et al., 2004). It is shown that this way of

working can enrich the information flow, sharing knowledge, innovation and decision-making process, between different players (Fischer et al, 2002; Bosch-Sijtsema & Henriksson, 2014). Garcia et al. (2004) even states that the goal of XC is to produce and document a project clarification for a specific project that usually takes 6-12 months, down to a single week.

However it is not always that easy to create an XC environment. There are numerous of elements that affect the extreme collaboration. Previous studies have shown different elements that have an impact on communications and managing the construction design process, such as what actors are involved in the project, when they get involved, the contract form, the market culture, the tools that are used, and much more. All these are all components that have a direct influence on the outcome of XC (Bosch-Sijtsema & Henriksson, 2014, Lahdenperä, 2011). Nevertheless, due to the time and the scope of this research the focus will only be on the structure of the project team, managing the team and process by decision-making to improve the collaborative work process.

2.4 The Team

Working in an IPD that is built upon BIM has a significant effect on the project lifecycle and demands changes on all stages from the design, supply chain, construction to the commissioning, operation, reformation and decommissioning. The key lays in the culture and the firms participants of the project team (Prins & Owen, 2010). Examples of changes are a new team approach, support for innovation, strong cross links across boundaries, united decision making, commitment, new contracting forms, transparency and risk management. These changes are favorable for allowing an integrated workflow, by letting intelligent information systems, common models, people with specific expertise, management and leadership work together (Owen et al., 2010).

Previous case studies show that there is a possibility to work integrated by bringing in contractors in individual projects or where a temporary joint venture is created (Owen et al., 2010). Nevertheless, it is also mentioned that working integrated is quite rare and even more uncommon is to integrate the supply chain, although it is understood that these approaches offer benefits in time, financials and quality. What instead tends to happen is that individuals work isolated in absence of an overall or complete correct knowledge (Owen et al., 2010).

Integrated Project Teams have at least one thing in common; they try to involve construction managers and some of the key trade contractors, together with the owner and designer, in the early design phase. Hence, the contract manager and trade contractor are based on the qualification and not the price. Bringing the key players together has numerous benefits. A closer and more fruitful relationship between the parties can emerge with a common understanding and insight into the other participant's work, with a new culture and where the design will shift forward (Figure 5). The contactor continuously has the ability to give input on the cost, constructability and value, giving the designers to take more accurate decisions with less severe negative setbacks. This gives the contractor some psychological ownership and the capability to impact the design (Thomsen et al., 2010).

Because of the many challenges and massive information the multidisciplinary design team encounters in, a BIM design phase a new role has to emerge in the team,

someone that supports the knowledge exchange both within and beyond the design team. Such a team member who support the information flow and simplifies knowledge exchange across boundaries can be referred to as "boundary spanners" or "coordinators" (Bosch-Sijtsema & Henriksson, 2014). It is shown that coordinators create an efficient form of communication which is meant to be more collaborative and increase the effectiveness of both the team and organization. Who actually should take the responsibility as coordinator differs from organization and projects; however project managers are fitted to tackle the responsibility since they have to obtain politicians, involve stakeholders, gather information and ideas, and also manage the team (Bosch-Sijtsema & Henriksson, 2014).

2.5 Communication

It is clear that face-to-face meetings are the most effective way to communicate and reduce misunderstandings and misconceptions. However, face-to-face meetings have their restrains and do not necessarily mean XC. Creating the right environment by using the correct technology and involving different actors is crucial to improve the quality, reduce risks and rework (Garcia et al., 2004). Some teams manage to create such an environment, by physically co-locating the members of the construction and design team, where the multidisciplinary participants have the opportunity to discuss issues affecting all aspects of the product, organization and process. The development of the product affects the thinking of the designer around related activities (process) and workforce that carries out the task (organization) (Garcia et al., 2004). This kind of integrated environment is sometimes called BIG Room or iRoom (Thomsen et al., 2010; Fischer et al., 2002)

The idea of the Big Room is to let people to see themselves as one team when they tackle the project together, making friends and solving problems by communicating data visually (Thomsen et al., 2010). However, unfortunately the variety of data from different sources usually ends up on paper that are put up on the walls or spread out on tables. Data that are included are; schedules, spreadsheets, contractual documents, CAD drawings, PERT sheets, work activities and much more. All these papers are strongly connected and are offering different views of the project. Well organized decision making obligates a close analyze of the connections between these views. However, sheets do not even support the managers to find the same information across different papers (Fischer et al., 2002).

New technology has been developed to help move out of the sheet walls to electronic live walls to increase the efficiency. It makes it possible to actively view different angels, highlight and compare components across different foundations. Also, making it more flexible to create, change and try different design and construction settings to compare different "what if" situations (Fischer et al., 2002). It is structured in such a way that with three large whiteboards displays monitor the project from three different angels supporting the multidisciplinary team to review the project, plan the operation and make decisions. It entails graphical modeling, analyses, mathematical simulations, connected worksheets, network support and a BIM model (Garcia et al., 2004). This effectively increases the possibility to view a variety of information at the same time and simply make changes during the meeting. Giving the project team the option to control if the product will reach its specifications, predict possible risks and also learn from effective and none effective cases (Garcia et al., 2004; Fischer et al., 2002).

2.6 Decisions Making

As mentioned in the previous chapter team members tend to work individually isolated in absence of an overall or complete correct knowledge. Hence, decisions are frequently made through a few specific individuals or even totally separately, without the remaining participants. This creates an environment where the design team has a hard time to collaborate efficiently, which intend to create an culture where intellect, coordination and agility either gets corrupted or lost (Owen et al., 2010; Bosch-Sijtsema & Henriksson, 2014). Other previous research such as the one Lahdenperä (2011) states that multidimensional projects do not deal with problems, but messes, where problems are components of the wider mess. Hence, the decision makers cannot solve each of the components individually, without affecting the others, since no mess can be fragmented into problems that are independent from each other.

Moreover, in a traditional design process approach the designers tend to have regular meetings to review the different activities, where the designer usually has performed the activities in an isolated environment. The amount of information exchange between the meetings are usually very limited and not shared between all actors. In contrast to XC and iRoom the involved participants become involved in a much deeper level where the technology supports the communication among the team members, and also where unified decisions can be made and immediately are adapted to the BIM model. This might enrich the participants understanding of the project scope, influence the decisions and also minimize the schedule overrun (Garcia et al., 2004; Fischer et al., 2002).

2.7 BIM

"BIM can be summarized by project information that is digital, spatial, measurable, comprehensive, accessible, and durable. Instead of a beam being represented by a static line, in a fully realized BIM environment that beam would be represented by an intelligent digital object which might contain (when you click on it) the beam's sizing, connections, structural forces acting upon it, when it is scheduled for fabrication, its delivery schedule and cost" (Parrott & Bomba, 2010 p.1).

BIM modernizes the two-dimensional drawings into a three-dimensional model, which creates an opportunity to improve the drawings, information and process both through quicker response and discreet coordination. Comparable, to the computer added conscripting software in the 1970s, BIM is most probably going to be a game changer (Parrott & Bomba, 2010). It is seen as the current generation of architecture engineering, and construction (AEC) industries most promising developments (Azhar, 2011). BIM has the potential to revolutionize the current practice by having a major impact on the processes in a construction project (Owen et al., 2010). With the support of the BIM technology an exact simulated information model can be constructed, which could be used for planning, designing, constructing and operating the facility. It is meant to support and simulate the scope of a construction project, so that AEC, client and other stakeholders can visualize the potential design, construction, operation issues. However, according Prins and Owen (2010) project managers face difficult challenges when implementing BIM into a project, since is there no operations, guidelines or tools for selecting different BIM-qualified options for communication, analyses and coordination to improve and maximize the benefits and costs. Prins and Owen (2010) state there has been educations and guidelines for

designers to create models and for owners to understand the benefits, but unfortunately project managers have been forgotten along the way.

Moreover, even though the new technologies have the ability to effectively reorganize the structure of the organization and even though the industry understands the opportunities that arise with BIM. Dossick, and Neff (2011) claim in an article that individuals and scholars do not recognize the importance of putting effective collaboration before even being able to introducing the new technology.

A BIM maturity model has been developed by the UK department of Business Innovation and Skills, where the model defines levels from 0 to 3, Figure 6. The majority of countries are still at level 1, while the best in the area have reached a level 2 (Porwal and Hewage, 2013).

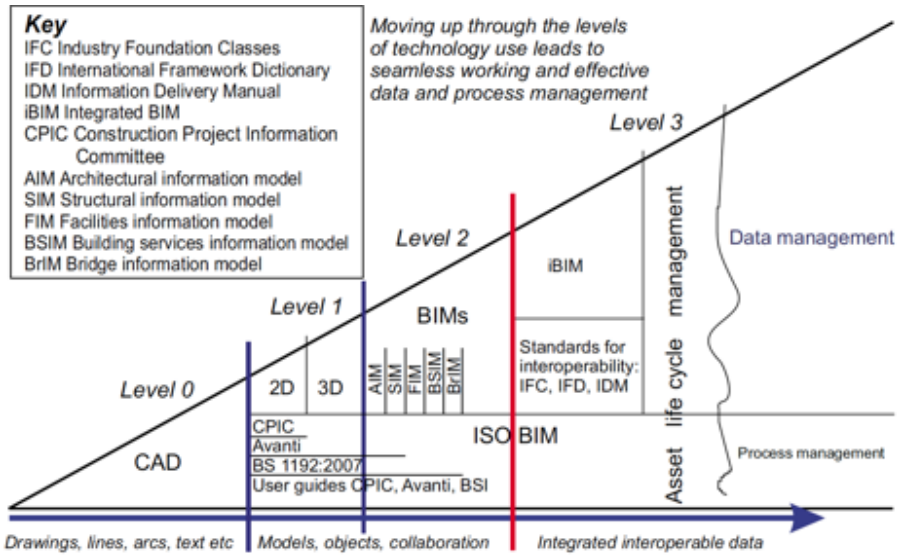


Figure 6*: BIM maturity model, adapted from Business Innovation and Skills (Succar, Sher & Williams, 2013)*

BIM structures a new era of working within the AEC industry, an era where the technology encourages stakeholder and process integration (Azhar, 2011; Prins & Owen, 2010). It can for instance be used to inspire discussions around the organizational plan, work flow, process and clarity to generate a positive culture (Dossick, & Neff, 2011). It is viewed as a virtual process that covers all elements, disciplines, and systems of a building, within a single model. Making it possible for all members to integrate and allocate more exact information than in a traditional process. Alongside the process richer detailed objects can be crated, renewed, and adjusted to confirm a more exact model. More importantly, BIM not only uses an intelligent 3D-dimensional model, but has a significant effect on the workflow and process delivery. Hence, it is important to mention that BIM not only is a software, but also a process (Azhar, 2011). Researchers even describe BIM as an actually primary component of a shift towards XC and IPD, by entwining organization, people, and systems to work in a collaborative process and thereby optimize the workflow and reduce waste (Azhar, 2011, Parrott and Bomba, 2010).

Unfortunately even if the BIM concept has been wide spread, it is currently only used in addition to the computer design and forced to adapt to the current unchanged process (Owen et al., 2010; Prins & Owen 2010). The full potential of BIM will only

be ensured when procedures are renewed, skilled professionals and workers are educated and retrained, to collaboratively work in a BIM environment with integrated processes (Prins & Owen, 2010). There is still much to learn and the construction sector has a major opportunity to pick up knowledge from other industries such as the automotive manufacturing sector. In the manufacturing sector the firms have managed to structure a scope were suppliers, designers and workers are cooperating in the design and produce a product according to the demands of the client (Prins & Owen, 2010).

As mentioned the type of BIM that considers the whole life cycle from design, construction, operation, to repairs, re-use, rebuild and demolition does not yet exit. However, there have actually been a few examples worldwide that have incorporated a high degree of BIM. Such projects are much sustainable and think in a long-term perspective, which both look backwards and forwards in every phase along the process. For instance in the design phase, the focus is not only to perform the delivery, but on the whole performance of the lifecycle of the facility producing data and meta-information. The BIM methodology offers a movement towards integrated procurement routs and eliminates the DBB procurement path. It supports to resolve the issues designers face today and effectively work towards ideally efficient whole lifecycle integration (Prins & Owen, 2010). In other words an integration which supports knowledge management, processes, technologies and ideologies such as supply change optimization.

3 Research Methodology

There are many different ways to tackle the research conducted and depending on which way to take will affect the results of the study. Hence, careful considerations regarding the research approach, research strategy, research design and data collection has to be done. This chapter will help the reader to understand how the study was conducted, which should be in the readers mind along the dissertation.

3.1 Research Approach

Bryman (2012) mentions that there are many different ways of doing social research. Social research is referred to questions concerning social scientific grounds, such as human geography, social policy, sociology, politics or criminology. Such research is motivated by wanting to change and develop the society. Firstly, an understanding has to emerge of what theory it is talked about, but more importantly is whether the data is collected to test theories or to build theories. There are two common theory approaches; **Deductive theory,** where the research is guided by the theory; and **Inductive theory, where** the theory emerges from the research conducted (Bryman, 2012).

In this particular case it is hard to categorise the research approach specifically to either of the mentioned. When starting the research it was clear what subject should be evaluated however there was no clear theory conducted from the start. On the other hand previous literature about the subject was assessed to help understanding the issue in focus. Therefore, a more suitable research approach was chosen, called Explorative Research. The research took a more inductive approach to gather data, which then jumped back to the literature to help mature the research. Hence, the research was helped by an iterative strategy, which involves moving back and forth between data and theory (Bryman, 2012).Therefore, the research as a whole had a broad focus, but this is not an excuse for lack of definition. Quite the contrary, clear objectives had to be defined.

3.2 Research Strategy

3.2.1 Epistemological Consideration

Epistemological considerations address questions of what is or should be accepted information in a particular discipline. That is to say depending on what zone in the social world that is studied, different approaches is more suitable for the study (Bryman, 2012).

The study is done at the actual location of the company in Sweden, which will support the researcher to get a deeper understanding of the situation at the firm and how they actually are working around the subject in focus. However, due to the fact that humans are self-interpreting and social research cannot be studied in same way as natural science. Hence, in this case an interpretivist strategy is most likely to affect the results of this research.

3.2.2 Ontological Consideration

Ontological considerations are looking at the question whether the social entities are or should be objective, or whether they are or should be considered as constructions build up from the perceptions and activities of the participants. Hence, choosing the right strategy is critical to the way how the data is going to be collected (Bryman, 2012). The research issue is focusing on *How can the BIM project team work in the design phase to improve and develop a higher level of integration*, therefore a dialog has to emerge by the participants and the researcher. Thus, it is hard to connect it to the objectivism rather than that the knowledge is built up from the perception of the participants. Hence, a *Constructionist* strategy is conducted, since the data is going to be collect from interviews and the participants' perceptions of the issue in focus. Constructionism says that social entities should be seen as a social structures built up from the opinions and acts of social members and not totally constrained by for example organisation or culture, which is the view of an objectivist (Bryman, 2012).

3.2.3 Quantitative or Qualitative Research

When choosing strategy for the study it is helpful to distinguish between a qualitative or quantitative research. A quantitative research advocates for a strategy that stresses quantification when it comes to data collection and analyzing the data collected. Furthermore, quantitative research supporters a deductive approach, has combined actions and standards of natural science, and also entails the view of objective reality (Bryman, 2012).

In the contrast, a qualitative research underlines words rather than numbers when it comes to data collection and analysing the data collected. Qualitative research usually has a more inductive approach, stresses that participants interpret their own social word and also expresses constructionism where the reality around participants continuously changes, since it is build up by the individuals' perceptions (Bryman, 2012). Hence, going back to the strategy mentioned in the previous chapters and the subject in focus a qualitative strategy is most suitable for this research.

3.3 Research Design

In this study two firms, one that is based in Sweden and the other one based in Norway, will be evaluated on how the project team is working in the design phase in a BIM construction project. Two cases are going to be evaluated and compared, to support answering the research question. Bryman (2012) suggests when the study is meant to observe two or more issues where the socio-cultural aspects differ; such as organizations, traditions, value or language; a *comparative study* is appropriate. The aim of such a study could be to seek a clarification for resemblances and differences, or also to get a greater understanding of the social reality in different national settings.

However, it is important to not forget there are also some flaws with a comparative study. For instance writers argue that the researcher might pay less consideration to the specific context and more on comparing the two cases. Furthermore, a comparison study means that the researcher has to put an amorous time to create a respectable staring point, while writers mean that it might be more beneficial to have a more wide starting point in some studies. Nevertheless, a major benefit with a comparing two or more cases it that the research has an improved and solid base to stand on examine if

theory will hold or not. These are aspects kept in mind when the study was done (Bryman, 2012).

3.3.1 Reliability and Validity Vs Trustworthiness

Qualitative researches has in a similar way as quantitative research embraced the terms validity and reliability for having criteria's to evaluate research. However, some writers suggest an alternative to qualitative Reliability and Validity called trustworthiness. Trustworthiness is made up of four criteria, which are comparable to the quantitative reliability and validity (Bryman, 2012).

Credibility: How believable are the findings? (Equivalent to internal validity). Because there are various possible versions of characteristic of social truths, it is the credibility that determines its acceptability to others. A triangulation was adapted in this research to make sure of the credibility of the research, meaning that more than one technique or source of data was used in this study. In this study seven participants were interviewed for collecting the data, which will be mentioned in the next chapter. Moreover, manuals, other sources and visualization of the locations ware provided by the company.

Transferability: Do the findings apply to other contexts? (equivalent to external validity). Because qualitative research entails intensive study of groups of individuals, the findings tend to be unique and significant to the social world that is being studied. Hence, the dissertation is presenting a rich amount of details of the culture, organization and case to make it more transferable.

Dependability: Are the findings likely to apply at other times? (equivalent to reliability) This research has a time schedule of maximum 6 months and data collected is done from participants who currently working on a project, therefore the data collected is up to date and relevant.

Confirmability: Has the researcher allowed for his/her values to intrude to a high degree? (equivalent to objectivity). Firstly, it is vital to mention that it is impossible to be objective in qualitative research. However, the research is done with an open mind and acted on good faith. The research is based on a closed investigated literature review, which was researched by the researcher himself and also articles suggested by different external sources, such as the researcher's supervisor and university tutors.

3.4 Data Collection

To achieve answering the question in focus, an understanding of the existing processes and involving literature research was essential. Also, the researcher was sitting at the actual location of the Swedish Company to grasp an understanding of the existing culture, which was followed by trips to the Norwegian firm to support create an image of the existing conditions. Furthermore, close examinations of current manuals, guides other reports were used as central data collections and to support structuring the qualitative interviews. However, the interviews were the main data for the findings.

The collection of data was assembled through semi-structured interviews. Semi-structured interviews are optional to use if the interviewer only has one chance to interview someone. The semi-structured interviewers help to deliver a trustworthy and

equivalent qualitative data (Cohen & Crabtree, 2006). Hence, an interview question form was designed with key questions. The questions were divided into three categories, which will be mentioned further down. The interview questions were not sent in beforehand, since the researcher wanted all participants to have the same kind of starting point. The questions ask were open-ended questions with sub questions to help the author collect the data needed.

3.5 Respondents

Choosing the right participant has a significant effect on the trustworthiness on the research conducted. Totally seven persons have been participating in the qualitative interviews, whereof two persons were female while the rest were men. One of the females was forking for Company S and one was working for Company N. Four interviews were conducted at the Swedish company while three were conducted in Norway. Furthermore, the respondents who were chosen are all project managers, who are responsible to deliver a BIM model to the client. Every individual has and still are implementing BIM in their construction projects. With help of the companies' senior managers, project managers where evaluated and chosen to support the research.

3.6 Interviews

The interviews were conducted both in Swedish and in Norwegian making sure that the participants have understood the question asked. Furthermore, the interviews were structured in a semi-structured fashion. Semi-structured interviews have the ability to clarify how the participant is viewing the world around him, which is crucial for the interviewer to understand. (Bryman & Bell, 2007). The researcher had a list of questions on topics that had to be covered as a guide. However, the interviews were not following the exact outline of the list. Also questions that were not included in the guide were asked along the way, since the interviewer picked up things along the interview. Nevertheless, all questions in the list were answered by all interviewees.

The interviewees were contacted in beforehand and informed about the topics that were going to be discussed during the interview session. However, even though the questions were prepared in advance and divided into categories, they were not handed out in beforehand. The purpose was to inform the participants about the topic in focus, for preparation purposes, but with a minimal possibility to manipulate the answers to the questions and also to make sure that all individuals have the same starting point. When handing out the questions there is a possibility that some have read the questions in focus and some would not.

3.6.1 Interviews Structure

As mentioned above the interviews were semi-structured. The questions were open-ended and divided into categories. The questions were structured with both main questions and sub-questions. The main questions were asked specifically to every participant, however not necessarily in the same order. When the question was asked the participant had the opportunity to talk freely around the question. If some

questions were not fully answered, sub-questions were asked to support the participants to provide the research data needed for the study.

The first category was about team formation and team building. This section involved questions such as how the team is formed, who is involved in the team, and how an integrated environment could be upheld. Furthermore, this section also looked at when the different actors got involved in the project. The idea of this section was to clarify the when and who is involved in the actual project team and also the environment around the team. Moving forth to the second category that was focusing on the manner of communication. This section asked questions around how the actors are communicating with each other, what tools are used and also how often the actors actually meet face-to-face. Moreover, questions were also asked about how the project meetings are structured and also if the team is sitting at a co-location or at different places. The general indication of this section is to help spared some light on how the team is working together and how the communication is moving along. The third and final section was focusing on the decision making process. Who are deciding on what, how is the decision making process, but also who decides on what comes next. To understand the work process a clarification had to emerge on how the decisions are made in the project team.

3.7 Data Analysis

To find a track along the data collected is not an easy matter, however with support of previous literature a five step process has been taken place to analyse the data collected (Taylor-Powell & Renner, 2003). Important to mention is that the process was moving back and forth between the five steps.

***Getting to know the data*:** Was done by recording the interviews and then several times listen to the recordings that had been made. However, there was one person at Company S who was not comfortable to have the interview recorded. Hence, his request had to be respected, instead notes were made in writings. All the taped interviews were written down on paper before moving forward to the next step.

Focusing the analysis: Was made by identifying few open-ended questions, which were written down to support the researcher getting the answers needed from the analysis. These questions change along the way but were always in mind when re-listening to the recordings. Focusing the analysis depends on the evaluation of the data and how the results are going to be used (Taylor-Powell & Renner, 2003). In this case the researcher wanted to look at how the individuals answered to certain topics, which can be identified by looking at the headings of the result section in this dissertation. Focusing the analysis helped identifying reliabilities and differences regarding the different topics.

***Categorize the information*:** The core in qualitative research is to identify the themes or patterns and then establish them into clear categories, which might be an intense task, however this helps bringing meaning to the data collected (Taylor-Powell & Renner, 2003). The categories were made by list topics in advance and from there search for data that matches these themes. This strategy can be called "present categories" (Taylor-Powell & Renner, 2003). Also the themes supported too proved a direction for what to look for in the data.

Find links and patterns both within and among categories: When arranging the data into categorise both connections and differences started to emerge (Taylor-Powell & Renner, 2003). Relationships were discovered where two themes constantly emerged together in the data, which will be presented in the result section. These connections are important to discover since they help explaining the cause of why certain happenings take place. Furthermore, the similarities and differences between the individual's responses within categories were captured. To do this the data was partnered into particular themes. This was done by cutting and sorting statements made by the participants.

Interpretation: Last step vas to interpret the data by giving meaning to the analysis (Taylor-Powell & Renner, 2003).

4 The Cases

Two companies in particular ware evaluated. Company S, which is based in Sweden, has for some time now been working with an investment in BIM. Company S has a wide range of services, which covers all aspect of project delivery, from initial surveys and analysis, to design, to planning and management. The firm covers a geographical area of 35 countries has over 300 offices and 15.000 employees worldwide.

In Sweden Company S are active in many different industries and market sectors, with a staff of 2.500 employees. They are a multi-disciplinary consultancy firm that covers a wider geographical rang in Sweden. Nevertheless, Company S has a large focus on the concept of Design, from the Design of a product to the Design process of a project. Several internal writings and reports have been produced, market analysis has been made, and also their own development is in progress. Moreover, four main focus areas have been identified from the company's perspective regarding BIM - communication, marketing, tools and processes - for further development, in the coming years.

Company N is based in Norway and is one of the leading engineering and design consultancy firms in Scandinavia. Company N, has over 1 350 employees that covers a wide range of different disciplines and work in over 100 different countries. Company N has for some time developed a methodology for executing BIM Projects which consists of manuals, templates and utilities, such as planning, status management, process maps, checklists, etc. documents.

To get a wider understanding it is crucial to mention that the BIM execution methodology for Company S is based on the methodology that Company N has constructed. Company S owns 25 % of Company N. Hence, they had and still have the opportunity to get important inside information from Company N. The Swedish company liked the concept on how the Norwegian firm is executing their BIM projects and has therefore decided on using Company N's execution plan to structure their own. However, it has been over two years since they have sheared the information between each other and much has happened since then.

One factor worth mentioning is that Company N has structured one detailed execution plan for each different discipline. In other words one specific execution plan that states what and when activities has to be done for construction, one for electro, one for the ground, and one for plumbing. In the Swedish firm on the other hand there is only one single execution plan overlooking all disciplines. That is to say one manual for all declines to follow.

5 Findings and Analysis

As mentioned in the previous chapters the data was collected through qualitative interviews. In this chapter the findings will be presented in a close connection and structured as the previous literature review chapter. Firstly, a description of the current design phase will be demonstrated of the two firms, in order to help the reader to get an understanding of the current state of the process. After that is a subchapter about the procurement and its effects on the team and then is there a subchapter about the team itself. Furthermore, an understanding of the culture and way of working will be presented and the last two subchapters will be about the meetings and the decision making processes.

Also, it is important to mention that not all the data collected is going to be presented in this rapport, because of the time and scope issue. There was a large amount of data collected and the most relevant, linked to this research question, is going to be shown.

5.1 Design Process

Both companies have the same base when it comes to the execution plan. The idea is to have the execution plan as a base for all projects to support the disciples for understanding their role in the project and the ongoing process throughout the design phase. The BIM execution plan is partly a tool to help managing, control and communicate the BIM-models status, and partly a tool for project and time planning. The method is also supposed to be used for feasibility studies for the management level and structured in such a way that it can be implemented regardless delivery model. Also, it is meant to affect the work flow in such a way that of the architect, owner and technical disciplines work in a more close and narrow line alongside the project (Appendix 1), which is structured the same in both companies.

Appendix 1, illustrates the method of implementation. The horizontal part is a timeline tailored to the project. Project leaders are timing the project by placing the model's Quality Levels. The Quality levels and schedule determines the object controls, which items are covered by each level and what points in the checklist that has to be checked.

The responsibility lies on the project leader to time the project start and end of each phase and levels of quality, to ensure efficient execution of the various assignment activities within the timeframe specified by the client. One important element to mention is that it is usually one person who is assigned to structure the activities along the time plan. In the time plan a named member of staff is assigned to each activity. The time and resource schedule is supposed to give a good overview of the assignment process so that it becomes a useful tool for all those involved. After coordinating with the project manager, the assignment manager approves the plan.

The aim is to ensure that the necessary understandings and that the right decisions are done, which according to the BIM methodology should be done with the client, the users and between the various project planning disciplines along the different phases of the project. This method is also to ensure that the achieved product forms a complete foundation for further planning.

The design clash controls, that detect the clashes, are directly made in the BIM model. There are also phase descriptions, process descriptions and check lists for the objects

that have to be implemented in the model. Each object in the model is supposed to be status and colors coded to show all actors in what status the object has and thereby give a more detailed understanding between the different participants. Unfortunately, the status coding is still fully developed and has just been implemented. Hence, there are still no documentations on how this is working in reality.

Nevertheless, the project manager who has been assigned by the head of department puts together an assignment team with the right pool of expertise and formal qualifications for the BIM project. Responsibility and authority always go hand-in-hand, so that the person who is responsible for a particular task also has the authority to implement it. The responsibilities and authority for a number of key assignment functions are described in the "corporate system". Other, more specific functions may need to be described for each individual assignment. It is here Company N differs from Company S. Company N has chosen to do a separate detailed plan for each discipline that provides the individual with exact activities regardless project. While the Swedish company has an overlooking single manual for all disciplines combined.

5.2 Procurement Route

Both Company S and N are following a traditional delivery model. Where an external architect usually is the first participant getting involved in the project by being contacted by the owner. Together they are defining the project and doing some early designs of the facility. If the first drawings are done in a 2D or 3D environment and if project manager is involved at this stage depends totally on the qualification of the architectural firm and the owner's demands. At this point the first issues have already been raised. Project Managers have even expressed their concerns, one manager in Sweden said:

Company S - "It is frustrating that we often have to redo the design work of the architect. They only think in their own terms."

However, even though both follow a traditional approach there is a difference between the delivery models between the two markets. The Norwegian government has required a construction industry where a fair "open bidding" has to emerge, to make it possible for all contractors to have a chance to get involved in the projects. However, this makes it impossible to bring in contractors in the early phases. Hence, the firms are obligated to have a Design-Bid-Build delivery model. This is not an issue for the construction industry in Sweden, since the owners have the opportunity to choose what kind of delivery model they would like to.

In the interviews the Norwegian participants were asked if they would like to have the contractor involved in the earlier phases and how they know the information the contractor needs are incorporated in the model, participants answered:

Company N -"It would make cost and time estimations easier. We are estimating according to previous experience. However, there is nothing we can do about it right now."

Company N - "It would be favorable to bring the contractor in early."

The same question was asked at Company S and the response was the same as in the Norwegian firm. However, even though it was understood by the Swedish participants that the contractor should be involved as early as possible. It was mentioned that the most common delivery model is the Design-Bid-Build.

Company S - "The Contractor always comes in after 10 years. In the most common way of working he is not involved until the Biding."

5.3 The Team

Which participants are included in the different teams, differs from project to project, but there are some actors that were always re-mentioned throughout the interviews. These actors are the architect, project manager, fire engineers, construction engineers, plumbing, electrical engineers and acoustics. Even though all these are not always included in the very beginning the research shows that these have to be included at some point.

Company N - "Architect, landscape architect, Project Managers and all technical advisors – constructors, plumbing, electro, fire, Building physics, energy, welders, logistics and acoustics are involved in the project team".

Company S - "We have the Architect, construction, pluming, and electronics involved in the planning staged. Also, once we move to into system stage, the fire and acoustic also got involved and once we reach the detailed stage the contractor will also get involved."

The research also showed that an important actor who usually is not involved in the design team and the maturity of times forgotten to be mention is the owner himself. Throughout the interviews only two participants actually mentioned that they try to incorporate the owner in the team and both are participants from the Norwegian company.

Company N - "We always strive to have a project place for at least the Architect, Project Manager and Owner to sit together."

Company N - "At this point the client is involved in all the design meetings, since he is his own Design Project Manager and responsible for the architect"

Furthermore, the research also shows even though the actors are mentioned it does not mean they are working in an XC environment, which will be presented in the next chapter.

5.4 Culture and Ways of Working

Company S and N have both mentioned in their execution plan that a project location is crucial, for all actors in the project to gather a greater understanding of the wider project and between each other. It is also mentioned in the company's manuals that this helps to solve problems before they come to light during a coordination meeting as well as speeding up the process as a whole. Moreover, is a temporary place not possible an alternative solution is suggested for the project manages, which is that the discipline should have frequent collaborative meetings days. Because, of the statements that have been made questions have been asked to the participants wondering if any project locations have been uphold in the projects they have worked with. All three research participants in Norway were sitting at a colocation, where they were trying to incorporate all project disciplines.

Company N - "If the owner does not offer such a place then our firm tries to generate such an environment. However, it is better if the owner requires and provides this;

otherwise there is a possibility that the owner and architects would not be involved since we do not have any architects at the company"

Company N - "In my project all actors sit together, we are up to five companies who are sitting in the same open space, except the owner who is sitting in the same building, but in a different room"

Another participant from Norway also mentioned that they are actually working with an XC environment where all the participants who are sitting at the place have the opportunity to connect to a server and work with the model in a live environment. In other words they all work in one model at the same time. The participants also mentioned that there are both pros and cons with this kind of work culture. For instance it is hard for the plumbing engineer to put out pipes if the architect is moving around the design. Hence, it is easier for the plumbing engineer to work in a permanent stable model. However, that said the project manager sees the XC benefits are greater than issues that occur, in form of time and cost savings.

In Sweden on the other hand XC is not the case, even though it is stated in the manuals and guidelines of the firm. The Swedish company still follows the traditional way of working where the different disciplines usually sit in separate rooms or even separate locations, isolated from each other. Not one of the four research participants was sitting at a co-location in their current projects.

Company S - "We are not sitting together! I do not know how much it would help the project to sit together, but I have a project that is coming up where we are going to try to sit integrated, at least once or twice a week. We will see how this will go"

Company S - "We are sitting in different locations. The actual project team sits at a project location, the main project manager sits at our firm and the architect has his own location. There are also other discipline managers and consultants that sit in their offices in Uppsala (another city)".

5.5 Meetings

In the execution plan are also some simple guidelines for constructing meetings. There is one specific guideline that says that the times, conditions and place for coordinating meetings, should be specified in the project plan. Also that project leader should actively pursue project meetings based on the latest common BIM model and also there is a statement of what tools the rooms should be equipped with. However, what different kind of meetings there should be how they should work, how often and how long the meetings should be are not specified. Hence, questions were asked to get understanding of the how the different companies have structured the meetings.

First of all it is important to mention that none of the project managers interviewed is working in an iRoom environment. Nevertheless, the research showed that there are usually a higher level of project meetings and a lower level. At a higher level usually the owner's project manager, external actors, economics and authorities discuss elements such as contractual issues. These kinds of meetings are usually structured as a normal meeting and appear regularly once a month with duration of 2 hours. The model is usually not shown and discussed in these meetings. The lower level meetings are more technical and focus on issues regarding the model such as the geometrics. The clash controls and other preparations are done the day before so that the collisions

and other issues can be discussed during the technical meeting. The clash controls are usually done and documented by the BIM coordinator.

In the technical meetings the architect, the technical disciplines (both experts and leaders) and the coordinator are sitting together and go through the issues of the model. These kinds of meetings differ from project to project in length however five out of seven interviews stated that typical time was around two hours. One participant said the standard time for their meetings ware three hours and the last participant stated their meetings last for half a day. Finally, it is also stated that these meetings are usually once a week. On these meetings the technical disciplines have the opportunity to talk to each other and work in a more integrated environment by resolving issues that affect each other. However, the owner is usually not involved in these meetings.

The two meetings mentioned above are the most common meetings and mentioned by all the participants. However, there are other kinds of meetings that are included in some of the projects. Especially, in Company N:

Company N - "We have meetings for quality control that can take a full day where we go through the whole model. We also have meetings with the client once a week to have a more formal meeting to decide on issues that for example are affecting the end user. The project is a library connected to the university, so we have regular meetings with the end users to get their requested input, which we then present for the client"

The Project manager who was mentioned in the previous chapter that worked in an XC has meetings almost every day of the week. On Mondays there is a small meeting to check with all the discipline managers, on Wednesday mornings there is a design meeting with all the technical discipline leaders, authorities and other external stakeholders, where they discuss key aspects affecting the model and other elements. After the lunch the technical discipline leaders and the coordinator meet up again to resolve all the issues troubling the model. From there specific needs might emerge for the specific disciplines. Hence, they have another meeting the day after to move into even deeper details. These are the consistent meetings that accrue weekly.

When a question was asked to a Swedish participant about integrating all actors in the meetings and to work in an integrated environment, where all discipline participate. The response was:

Company *S - "there is no point in integrating all actors in the meeting. It is not productive and it costs too much."*

However, later on in the interview the participant also stated that to reach maximum benefits of working with BIM is by having a MPA contract where the different participants are involved early.

5.6 Decision Making Process

The projects are organized in a linear structure, where there are different levels of leaders. The higher up the structure the more authority the person has to make decisions. Higher issues that affect the contracts and authorities are usually the owner who decides on. Other issues' affecting the boundaries between the disciplines is the higher level of project managers´ responsibilities to resolve. At a lower level there are discipline managers who have the responsibilities to resolve issues within their own discipline. Even though it is a liner project structure and the different managers have

the capacity to take action within their authority a question was asked on how they actually are deciding on an issue.

Questions concerning the model and that stretches over boundaries are usually decided on during the technical design meetings. Usually there is one person who has the accountability to take that decision. However, it is pointed out that there needs to be a certain amount of information to make it possible for the manager to base his decision on. Furthermore, it is not uncommon that the decisions are made in a group where some participants are seen as key actors and others as support functions. In these cases it is usually the once that have the most amount of volume in the model who are seen as the key actors and take the decisions.

Company N - "The Project Manager, the architect and the construction manager, who are seen as the higher level of leaders and are the ones who decide on solutions together."

Nevertheless, many decisions are also done in between these meetings which are usually done by contacting their closest supervisor. Hence, a lot of decisions are done in isolation from the other parties at least until the next meeting.

6 Discussion

This research has helped to paint a picture of how the current Swedish and Norwegian market looks like. It has also helped to spread some light on the issue in focus, but on the other hand also resulted in more questions around the subject. Previous literature states that choosing the procurement route has a significant effect on the projects process and outcome (Thomsen et al., 2010). It is suggested that when working with BIM a DBB procurement route is not an effective choice, even though it is the most common route chosen in some countries (IPD Guide©, 2007; Anumba & Evboumwan, 1997). A better route to choose would be DB or MPA where the contractor has the opportunity to get involved early in the process and have an impact on the design project. However, it is not always as easy as presented in previous literature. Hurdles such as in Norway where the government has decided on DBB makes it impossible for companies to follow the suggestions of previous literature. Hence, the possibility to work more integrated in different context is hindered by the procurement contract, but also other aspects as the way of working in particular countries, as well as the company's strategy in terms of cost, time, quality, etc. has its impact on the team integration.

Nevertheless, to reach a level 3 BIM, the importance of having an integrated team is crucial. There are always some suggestions that can increase the XC a bit more. Unfortunately, some markets have not quite understood that it is more cost and time efficient to work integrated as literature suggest (Thomsen et al., 2010). It is not like the Swedish company does not have the place or the knowledge for working in an XC environment. However the organizations have to be clearer on this issue, demanding and providing more detailed guidelines to support the project manager creating an environment where XC is possible.

There are many aspects that are very much alike in the two firms, but also much that sets them apart. Previous literature has various times stated that there are too little guides to support the project managers when working with BIM (Prins and Owen, 2010). These case studies advocate for these statement. Looking at the BIM execution plan it is understood that Company N has dug deeper into the subject then Company S and structured separate execution plans for each discipline, where guidelines for what and when objects have to be delivered. This way every discipline will generate a healthier understanding for the outline of the process, making it easier to discuss the "right" issues at the right time. While Company S has one overlooking guide for all disciplines that is not strait forward.

Nevertheless, just because the BIM execution plan is more detailed does not mean the right integrated environment is organized. There are some statements in the BIM execution plan that point out that an integrated environment should be uphold. However, there were no guidelines for the project managers how this should be done; the same statement can be said regarding theoretical research. As mentioned in the literature review it seems that the project managers are forgotten when it comes to how to work around BIM (Prins & Owen, 2010).

The main question in this report is *How can the BIM project team work in the design phase to improve and develop a higher level of integration?* The first and most interesting point to mention is the project delivery situation. It is interesting to see that the Swedish market does not have any demands on what kind of delivery model the project should have, in comparison to the Norwegian market. Since, the Norwegian government is demanding a competitive market where all construction firms have a

fair chance to win and build a construction project. This is understandable; however it makes it impossible to fully work integrated in the design phase. Previous research showed that a DB or partnering delivery model is much more suitable for BIM team to reach a higher level of integration than a DBB (IPD Guide©, 2007). Hence, it is in accordance to this research, a better possibility for the Company S to work integrated in comparison to the Norwegian company.

All participants in the research see the benefits of implementing the contractor as early as possible to structure a BIM model that is more accurate and adapted to the contractor's demands. It is also mentioned by the Norwegian participants that if they would have a choice they would bring in the contractor into the design phase early. Unfortunately, even though the Swedish market has a better starting point to work in an integrated environment, they have not managed to do it in the same extend as in Norway. It becomes clear that not only the procurement approach and governmental and market have the main impact on the team integration, also the working culture and mindset to work in a more integrated way are important factors, as was the case for the Norwegian Company.

Another interesting point worth to emphasize on is that the Norwegian company always tries to work in a project place environment where they have ambition to incorporate all necessary discipline to work under one roof. It is even stated by them that if the owner does not supply such a place then the company itself is conducting the habitation that is needed. However, it was favorable if the client is requiring this, to ensure discipline participation. The interesting point is here is that even though they manage to uphold a co-location the owner is often not included in the team. In the Swedish market a co-location seems to occurs even less. However, research has pointed to the importance of co-location in construction. Previous research has shown that bringing together multi-functional design team participants, to collaborate in an environment where shared visualization, information, meetings and decisions area uphold can enrich the information flow, sharing knowledge, innovation and decision-making process, between different players (Garcia et al., 2004; Fischer et al, 2002; Bosch-Sijtsema & Henriksson, 2014). It is shown that this way of working has a significantly effect on reducing the time duration of the delivery (Garcia et al., 2004).

When looking at the Norwegian market they have been able to understand this and actually work in an XC environment where participants such as architect, landscape architect, project managers, constructors, plumbing, electricity, fire, building physics, energy, welders, logistics and acoustics, get involved early and help create a model that is as accurate as possible. One Project manager even took it one step further and created a server for the project members who sit at the location to work live in the model. Moreover, since they sit in one single room with an open environment they have the opportunity talk face-to-face with each other and resolve issues at high speed by taking fast decisions. Yet, the owner is usually not included in the team even though previous literature suggest that the owner should be heavily integrated in the project to ensure fast decisions and project success (IPD Guide©, 2007).

On the other side of the border another interesting point was discovered, which is that the Swedish markets actually are involving the same participants as the Norwegian market pretty early in the process. However, it appears they are working from different locations. According to Garcia et al. (20049 and Fischer et al. (2002), by working from different locations, great amount of information and time savings is getting lost. In other words, just because the right actors are involved in the project does not mean that a XC environment is conducted.

As mentioned in the literature review the most effective way of communicating is through face-to face interaction, but it is also stated that this does not mean XC (Garcia et al., 2004). It is crucial to have the technology and managed correctly to be able to integrate a variety of actors. Various researchers suggest an iRoom environment to help support team integration (Thomsen et al., 2010; Fischer et al., 2002). Unfortunately the meetings in the case studies show they do not differ markedly compared to the regular projects, except from one particular meeting, the technical design meeting.

The technical design meeting is one specific meeting type that differs from the regular projects, since the technical supervisors, architects and project manager actually are working in the model itself, to solve the clashes that have been detected by the coordinated clash control, which usually is done before the meetings. The length of such a meeting can differ, however the most common length was around two hours. For the project team who actually sit in an open environment at a project place it is understandable that a two hour meetings is enough, since they have the opportunity to still work with each other after the meeting. However, this becomes more difficult for those project teams who only have the possibility to meet each other during the meetings and then travel back to their own offices to work isolated.

Furthermore, it seems that even though they have meetings in an iRoom environment the data end up on papers placed upon the walls or spread out on tables, as forecasted by Fischer et al. (2002). Technology presented by Fischer et al. (2002) would help increasing the efficiency by move out of the sheet walls to electronic live walls. Even though, it is not a must to have this kind of technology previous studies have shown that all charts, documents and the model itself is very much entwined. Such technology might enrich the workflow, decreases the loss of information and also supports the decision making process (Fisher et al., 2002)

The decision making process seems to be the same regardless construction company or market and as predicted in the literature review decisions are frequently made through a few specific individuals or even totally separately, without the remaining participants (Owen et al., 2010). The once that usually have the authority to take significant decisions are leaders or managers at different levels depending on the magnitude of the problem. Many times the disciplines involved do not get involved in the decisions, which both has its pros and cons. Fast decisions can be done in this way, however if the "wrong" manager with the "wrong" capabilities makes a decision it can be devastating for the entire project. On the other hand all decisions done together in a group meeting are not efficient either if every individual sit in different locations. Many firms feel that it is too costly and time inefficient to have more integrated meetings, because there are few measurements available that show the instantly cost benefits. Hence, it is understandable that projects that are structured in an isolated environment have to make fast decisions pretty much individually. Nevertheless, this is not an excuse for why projects fail. In an open environment where all the necessary actors are integrated in one location a united decision would be very effective. As mentioned by Ladhdenperä (2011 p. 61) "Multidimensional projects do not deal with problems, but messes, where problems are components of the wider mess". Hence, being able to work in a live model and having meetings almost every day of the week to make decisions seems to have a positive effect on the wider project.

7 Conclusion

Now that there is a picture of how the different markets look like, conclusions can be made for how to improve and implement a higher integration of the project team. The first and most important suggestion is to implement the contractor as early as possible, regardless market. Unfortunately, it is impossible to include the contractor if a DBB delivery model is forced on the construction business by the government. Nevertheless, the countries where the owner has the opportunity to choose the procurement route the DBB delivery model should be reduced significantly, if not totally excluded. The DB or MDA delivery model is a much more suitable for a BIM project, if the goal is to use BIM more than just a visualization tool and to reach a higher project value, integration, risk reduction and information flow. However, the author would recommend to take it a step further and work in an IPD delivery model where the full potential and a BIM can emerge according to previous research (Porwal and Hewage, 2013). However, it is believed that the Swedish market is still not ready for an IPD model yet. Thus, this is a recommendation for the future.

The research has also discovered that the project place is crucial for organizing a XC environment. Regardless if the owner demands and provides such a location or not; the architect, coordinator, contractor, all technical discipline (plumbing, electronics, fire, acoustics, constructor); are all discipline that have been mentioned by the research participants and that have to be involved in the design phase. Hence, the project manager has to take on the responsibility to arrange such a co-location and integrate the different actors early in the design phase.

Moreover, clear guidelines for what the participants have to do at what particular point is also an important part in an XC environment. However, much is focused on the technical aspects and as mentioned over and over again the Project Managers seems to be forgotten. There has to be clear guidelines for how the project managers should work in an integrated environment. Hence, it is understandable why project managers still implement traditional meetings. The research has shown that even though BIM is implemented in the project the length of the meetings is still the same. For the project team who actually sit in an open environment at a co-location a two hour meeting seems to be enough, since they have the opportunity to still work with each other after the meeting. However, if that is not the case two hours does not advocate for a XC Team.

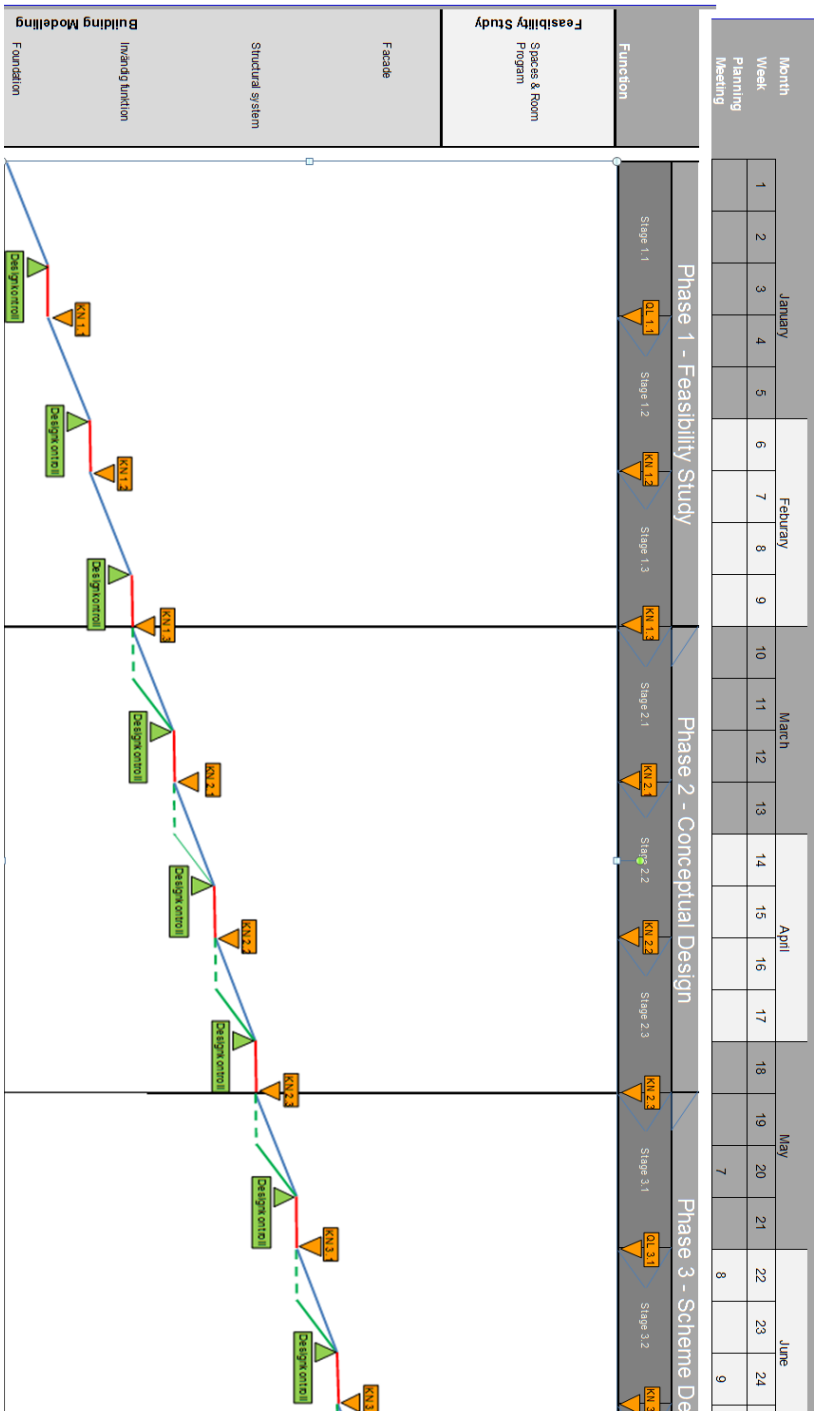
Finally, looking into the decision making process, it seems that different levels of authority for taking decisions has to emerge. Nevertheless, the decisions are made on the information provided and often during the meetings. Hence, in an XC environment the information might have a richer content to help the authorized member to make the decision. Also, between the meetings a possibility is to make collaborative fast decision, since the actors are integrated under one roof. This seems to be difficult and ineffective in a traditional isolated approach. Therefore, having fast and isolated decisions made are not uncommon.

This study has helped understand that there is a gap between the literature and the actual market regarding the issue of implementing an extreme collaborative environment. However, it has also demonstrated that there is a possibility to actually increase the integration between actors in the current market. It may not be the full potential of XC teams, but smaller changes can be made with just a change of mindset. To fully integrate a XC environment and reach an even higher integration further studies have to be made. One area is the issue of developing a supportive

guide for project managers to follow when working in a XC environment. Moreover, it is also essential to conduct a research on how the contract agreements should be upheld between the actors. Finally, this research touched upon the areas of iRoom and IPD. It seems that the market however, has not been mature enough to implement these features. Therefore, supporting research in these particular areas is a must to help the market reach Level 3 BIM.

Appendix 1

Workflow of the Architect and constructor



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