CHALMERS
UNIVERSITY OF TECHNOLOGY

A Framework for Standardized Logistic Systems in Housing Projects

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

Fabian Forsman

Department of Architecture and Civil Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Master's Thesis ACEX30-18-49
Gothenburg, Sweden 2018

MASTER'S THESIS ACEX30-18-49

Framework for Standardised Logistic Systems in Housing Projects

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

Fabian Forsman

Department of Architecture and Civil Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2018

A Framework for Standardized Logistic Systems in Housing Projects

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

Fabian Forsman

Examensarbete ACEX30-18-49
Institutionen för Arkitektur- och Samhällsbyggnadsteknik,
Chalmers Tekniska Högskola 2018

Department of Architecture and Civil Engineering
Division of Construction Management
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

Cover:
Kv. Mars in Trollhättan, (https://www.serneke.se/projekt/kvarteret-mars/)

Department of Architecture and Civil Engineering, Göteborg, Sweden, 2018

A Framework for Standardized Logistic Systems in Housing Projects

Master's thesis in the Master's Programme Design and Construction Project Management

Fabian Forsman
Department of Architecture and Civil Engineering
Division of Construction Management
Chalmers University of Technology

ABSTRACT

Production efficiency within the construction industry has been evaluated and criticized the last decade. Supply chain management (SCM) and the logistics of a construction project has been named as on improvement which is necessary for contractors to be able to be competitive and able to handle challenges as decreasing sizes of a site. Several researchers have claimed that the amount of non-value adding work at a construction site is significantly higher than other industries.

The concept of Lean construction (LC), Supply chain planning (SCP) and Change management (CM) is widespread but not always connected and applicable on the construction industry. It exists a lot of research on how a construction project should arrange its logistics and production to achieve efficiency. This thesis aims to bridge the gap between research and practice and to explain how a project organization within the construction industry can implement new tools and techniques which previous research has developed. A qualitative method within SCM and CM was chosen. A literature study was conducted together with interviews of practitioners. The focus of the study was mainly on four topics: SCM, LC, CM and implementation strategies. Within these topics were theories such as Just In Time (JIT) and Location-based Planning (LBP) described.

It has been concluded that to be able to implement an efficient logistical system in a housing project does the design group have to get more involved in the logistical planning of a construction project. Furthermore, is it important for the contractor's site management team to communicate internally to address logistics as a topic during the design phase. Moreover, was in concluded that the site management team could improve the logistical system of a site and production efficiency with already existing tools. Practitioners know most improvements that are recommended by this thesis, but they are not having a systematic approach to handle them. Such a framework was provided from the conclusions of this report.

Key words: Change Management, Supply Chain Management, Supply Chain Planning, Lean Construction, Just In Time, Implementation Strategies

Ramverk för standardiserade logistik system i bostadsprojekt

Examensarbete inom mastersprogrammet Design and Construction Project Management

Fabian Forsman
Institutionen för Arkitektur- och Samhällsbyggnadsteknik
Avdelningen för Construction Management
Chalmers Tekniska Högskola

SAMMANFATTNING

Produktions effektivitet inom byggindustrin har länge varit under utredning och regelbundet blivit kritiserad. Flera olika forskare har hävdat att det icke-värdeskapande arbetet inom industrin är betydlig högre än i andra. I flera av dessa rapporter har logistiken och planering av den blivit omnämnd som en del av lösning. De menar på att detta är ett problem som måste förbättras för att entreprenörer ska kunna vara konkurrenskraftiga och klara av att hantera de snabbt minskade byggarbetsplatserna.

Forskning inom Lean Construction (LC), Supply Chain planning (SCP) och förändringsarbete är etablerad och utspridd men inte alltid kopplad och användbar för byggindustrin. Det existerar redan mycket forskning om hur ett byggprojekt ska bygga upp sin logistik för att öka produktiviteten och effektiviteten. Syften med denna studie är att fylla tomrummet mellan teori och praktik och utreda hur projekt organisationer inom byggbranschen kan implementera nya metoder och tekniker som tidigare forskning utvecklat. För att kunna besvara de ställda forskningsfrågorna har en kvalitativ studie genomförts inom Supply Chain Mangment (SCM) och Förändringsarbete där både en litteratur studie och intervjuer har gjorts. Fokus i rapporten ligger huvudsakligen på fyra ämnen; SCM, LC, Förändringsarbete och implementations strategier. Inom dessa ämnen har teorier som Just in Time (JIT) och Location-based Planning (LBP) blivit behandlade och beskrivits.

De slutsatser som kunde dras av rapporten gällande implementation strategier av logistik system i bostadsprojekt är att projekteringsgruppen måste bli mer involverade i planeringen av logistiken på byggarbetsplatsen. Det är upp till entreprenörens platsorganisation att intern kommunicera med varandra så att viktiga logistiska frågor kan lyftas upp i ett tidigt skede. En annan slutsats är att platsorganisationen kan förbättra logistiken på en byggarbetsplats genom att använda sig av redan befintliga metoder och verktyg. De flesta förbättringsåtgärder som blev framtagna i denna rapport vet redan praktiker om men de har inget systematiskt tillvägagångssätt för att kunna använda sig utav kunskapen. Ett ramverk för ett sådant tillvägagångsätt har blivit framtaget genom denna studie,

Nyckelord: Change Management, Supply Chain Management, Supply Chain Planning, Lean Construction, Just In Time, Implementation Strategies

Contents

Preface

The master's thesis was conducted in the Division of Construction Management at the Department of Architecture and Civil Engineering at Chalmers University of Technology. The thesis was the final part in the M.Sc. program Design and Construction Project Management and consisted of 120 ETCS. It was performed in cooperation with Serneke Construction during the spring term 2018. There are several persons that deserved acknowledgement from contributing to the thesis.

First, would I like to thank my supervisor at Chalmers, Professor Christian Koch for pushing me constantly and being committed to moving the project forward. It has been reassuring to have such an engaged supervisor. I would also like to thank Mr. Oskar Andersson at Serneke Construction for being more than just a contact person. Your input, guidance and enthusiasm have made the study equally challenging as fun and has developed me in several ways. Finally, I would like to thank all the interviewees for your willingness, knowledge and input. The study would not be able to perform without you.

By conducting this project have I gained extensive knowledge regard implementation strategies, the complexness of a construction site and how to execute a project. It was the final step to conclude my education at Chalmers University of Technology and I would like to thank everyone involved.

Göteborg, May 2018

Fabian Forsman

1 Introduction

The inefficiency in the construction industry has been known for a long time; various reports and researchers have identified several major structural failures within the sector, which causes non-value adding work (Thunberg, 2016). One reason for the low productivity is the loosely connected projects, which is the structure of the industry; this causes communication problems that result in i.e. lead times. The majority of a craftsman working day consists of waiting time and indirect work (Josephson and Björkman, 2013); this is a consequence from having communication problems, which are identified as an important factor when trying to improve the productivity. Barbosa et. al (2017) states that the low productivity in the industry is a consequence from a highly regulated market with few incentives to improve. Furthermore, are there some actors at the market that want to improve but mostly they are either too small or the market regulated which makes it hard to change the foundation of the industry. The author posits that construction companies could improve their productivity with 50 - 60% by endorsing innovation, techniques and tools (Barbosa et. al, 2017).

By applying Supply Chain Management (SCM) important low productivity and communication problems can be improved, and this has been known for long (Thunberg, 2016). Various researchers and organizations have presented several solutions with frameworks on how to design the supply chain, yet organizations have not adopted them. By standardizing the supply chain and rebuild the organization to an entity instead of a project based organization would the industry take a step toward efficiency (Thunberg, 2016). As Barbosa et. al (2017) states this could is be done through digitalization and implementation of a new way of viewing construction, to change the perspective from unique projects to a manufacturing perspective where value adding activities and standardization is prioritized.

Since digitalization had its breakthrough and Industry 4.0, business has seen important changes where new tools and techniques have emerged in a high pace. New planning tools and ways of communication have enabled great efficiency improvements, which has lead to development for most industries that have been forced to adopt them. The construction industry is currently lacking behind since implementing systems, which is built on new technologies, merely has been adopted. The industry has historically continually underinvested in IT (Barbosa et. al, 2017). As Jonsson and Holmström (2016) writes that the new tools have made it possible to make an efficient use of SCM and the SCP.

1.1 Background

Lean construction is a philosophy that has been enforced by several researchers and institutes over the years. It has been stated that by applying a lean way of thinking into construction organizations increases the efficiency and time spent on value adding activities (Gao and Low, 2014). Lean is based on the concept on performing the right activity at the right time with the right resources and at the right location (Gao and Low, 2014). Both production and logistic systems have been improved ands achieving better workflows through the supply chain (Gao and Low, 2014). SCB (2018) showed that in the productivity in the construction industry in Sweden have

been stagnating but also that Sweden is one of the countries that spends most time on the design phase in a construction project and therefore is moving its productivity to an earlier stage since more time is put into planning then production instead of solving problems when performing the activity. Barbosa et. al (2017) states that one reason for the stagnation is increased regulation and higher demand on the productivity at site which most companies are not prepared for, therefore is new technology and implementation of lean construction into the SCM crucial.

The foundation of SCP is balancing the demand with the available resources that could be broken down into three concepts; *The process, the organization and the planning* (Jonsson et al., 2013), where the planning is mainly built on new IT tools to be able to support the process of the business and the people who perform it (Jonsson et al., 2013). One of the main factors for a functional SCP framework is trust, and trust is built through transparency. Therefore, new ways of communicating with in the organizations and through the supply network is crucial for the construction industry to evolve (Jonsson et al., 2013).

SCP can be seen as a toolbox for SCM and can differ depending on the philosophy of the management. One of the tools used when managing the supply chain is applying JIT, which is frequently used integrated in the SCP framework to enforce lean construction (Seppänen and Peltokorpi, 2016).

1.2 Objectives

The construction industry faces a great challenge trying to improve the efficiency; one step toward an efficient production is dealing with the logistical problems. Previous research already exists on how the logistic framework should look like and the industry is aware of the problem, therefore the report aim to develop a framework for implementation of standardized logistics system to bridge the gap between theory and practice.

1.3 Research questions

To further specify and clarify the objective of the study it can be divided into the following questions:

- What logistical tools exist and can be used in the design phase?
- What factors should be considered during the procurement of consultants and early contracted subcontractors with consideration to onsite logistics?
- How can logistical improvements efficiently be implemented in project organizations?
- How would a framework at Serneke Construction look like?

1.4 Delimitations

The scope of the report only includes housing projects in an urban area. It will examine the implementation strategy from the contractor's perspective and will focus on the planning of logistic system at the construction site during the design phase. How and when the logistic system should be developed and implemented to achieve maximum efficiency throughout the project will be reviewed.

1.5 Thesis outline

The thesis is divided into six chapters, which is structured to guide the reader through all steps to gain insights on how to interpret the results. The chapters will be presented in the following order and further explained:

Chapter 1 - *Introduction*, presents the context of the industry and the environment in which the study was conducted. Also, it presents background information for the report as well as the studies objective and research questions.

Chapter 2 - *Research Methodology*, describes how the study was conducted and how the necessary information was gathered, both empirical and literature. Also, it presents the approach of the thesis and how information was valuated both ethically and relevancy. It describes the design of the study was determined.

Chapter 3 - *Theoretical Framework*, in this chapter the theory that the analysis is based on is presented. The necessary theory to explain methodologies and strategies that can be applied on targeted organization. The first part of this chapter explains the basic concepts of logistics and SCM and the second presents change management and success factors for implementation.

Chapter 4 - *Empirical findings*, aims to present the gathered data from interviews and observations to be able to interpret and analyze it. The chapter is divided into two parts where the first one aims to present data on the topic logistics and SCM while the other describes data about change management and implementation.

Chapter 5 - *Analysis & Discussion*, in this chapter the analysis done by reviewing both the theoretical framework and the empirical data is presented and discussed. It describes how conclusion was made.

Chapter 6 - *Conclusion*, in the following chapters the conclusions that were made in the previous chapters is presented and how they are connected to the stated objective of the report. Also, how the conclusions answer the study research questions is described.

2 Research Methodology

To be able to answer the research question and achieve the purpose of this study a structural approach was needed. This chapter will highlight what approach that was used and how it was developed. Furthermore will this chapter present the process of designing, searching, gathering, describing and analyzing the information needed to be able to answer the stated objective and research questions. It is divided into four sections which each has a separate perspective, these will describe how the project was conducted and how the different chapters were developed. The sections are; *Research design*, *Literature research*, *Ethical conduct* and *Data collection and analysis*.

2.1 Research design

Continuously throughout the project new theory was reviewed to understand and further develop the observation which was made and therefore the empirical findings and the theoretical framework are complementary to each other which fits into the definition of an adductive study stated by Bryman and Bell (2015). An iterative process is defined by being repetitive, where task are repeatedly conducted to be able to review them and align them with the goal as the process continuous. Since the report was conducted as an iterative process where theory and observations was done simultaneously this approach fits the project better than a deductive or inductive. A deductive process is characterized by having a hypothesis and afterward tries to enforce it by empirical findings while an inductive process is the other way around (Bryman and Bell, 2015). None of these characteristics is suitable for this project since the research questions was challenged and revised during the process, which requires a dynamic theoretical framework that evolves with the raised questions (Bryman and Bell, 2015).

The report mainly builds its empirical data on interviews with practitioners. Therefore emphasis will be put into words rather than numbers and a qualitative approach was chosen (Bryman and Bell, 2015). A qualitative method focuses on understanding the objective and the reasons behind it. It aims to describe the context, which the behavior exists in and by doing so an understanding is developed which is used when interpreting and analyzing the facts to be able to answer the stated research questions. Since the project used several cases to create an understanding on how the targeted organization and its representatives are thinking and behaving when implementing a logistic system, the interviews was performed as semi structured (Bryman and Bell, 2015). A semi-structured way of interviewing has the advantage of making the different cases more comparable than a unstructured interviews but still more flexible than a structured interview. This is suitable when trying to understand the behavior through a quantitative study with selected cases (Bryman and Bell, 2015).

The report was conducted as a multiple case study since the aim of the research is from a holistic perspective within the targeted organization. Therefore is it important to get several different perspectives from different roles within the organization to be able to get a overview of what the problem is and what could solve them. The cases that were selected are chosen in accordance to the delimitation and the interviewees from the cases posse's different roles. Site managers, project leaders and logistic managers were interviewed from the cases. Aside from interviews were observations

and reviews of internal documents taken into consideration when gathering the empirical data.

2.2 Literature research

Before and during the process of examining the selected cases a literature review of existing research was done to provide a theoretical framework and develop an understanding to contextualize the empirical data. The literature was mainly found in scientific papers, books and conference publications. This was done to ensure that the theoretical framework was up to date and that different perspectives were cross-referenced (Bryman and Bell, 2015). Research from all over the world has been reviewed while the applicable case is Swedish, therefore the articles was examined to be able to determine if it is relevant to the Swedish construction industry since it traditionally is local market. The research was mainly found on *Chalmers Library* and its different databases such as S*ummon* and *Scopus*. Complementary research was found on Google Scholar and books/article recommended by interviewees. The main search words used when searching for literature were: *Supply Chain management, Change management, Implementation strategy, Project-based organizations, and Project management*. Some articles have been found through combining these words in various combinations.

As stated in chapter 2.1 *Research Design* the study was performed as an adductive process which means that the theoretical framework was developed through an iterative process where theory was reviewed throughout the whole project (Bryman and Bell, 2015). The process of developing a theoretical base can be divided into three phases were the first one was to develop a broad and general framework while the second one was more specified and the third complementary.

2.3 Ethical conduct

In order to perform the study in an ethical way and especially the empirical investigation the interviewees were informed in advance about the questions. The information was presented for the interviewees a week in advance to ensure that they could prepare and review the questions. Information regarding that the interview was voluntary and that the option to be anonym was also presented. To ensure their anonymity only their current working title will be presented and they got the opportunity to review the summary and contribution to the study before the presentation and publication. Furthermore, the interviewee was asked before the interview if a recording of it could be conducted.

2.4 Data collection and analysis

The empirical data was gathered through semi-structured interviews with representatives from the industry. The representatives were selected based on their current profession and specialization, which could contribute to the study. The interviews were done continuously throughout the project and were compared with the theoretical framework as a iterative process. The interviews were done at the representative's offices and lasted between 45 - 75 minutes. The interviews were recorded and afterward summarized and analyzed. Totally, seven interviews were

conducted with representatives from Serneke Construction. The question, which the interviews were based on, can be seen in appendix A. The Seven interviewees are presented below:

Interview object A is a Logistic Manager. He has an engineering degree in Logistics. Been working at Serneke for approx. 1 year

Interview object B is a Logistic Manager. She poses a construction engineer degree and has worked at Serneke since 2012. She has had several different roles within the industry before she became a Logistic Manager; she started as a Construction Superintendent with special focus on logistics.

Interview object C is a Site Manager. He started as a craftsman and has worked his way through the different production roles such as Leading Craftsmen, Construction Superintendent. He studied at a Higher Vocational Education school before becoming a Site Manager.

Interview object D is a Site Manager. He poses a Construction Engineer degree and started of as a Construction Superintendent. He had this role for 3 years before becoming a Site Manager, which he has been for 3 years.

Interview object E is a Site Manager. He poses a Engineering degree and started as a craftsman. He worked in Norway for 15 years and had several different roles. He has been working as a Site Manager in Sweden for 3 years.

Interview object F is a Project Manager. She poses a Civil Engineering degree and has worked within the industry for 15 years. She worked as a Client for 12 years and afterward a project engineer for 2 years before becoming a Project Manager.

Interview object G is a Project Manager. He poses a Civil Engineering degree and has worked within the industry for 18 years. Has worked as most roles within production, started of as a Construction Superintendent and became a Project Engineer, afterward Site Manager before becoming Project Manager.

Both the empirical data and literature has also been reviewed to be able to determine if it is trustworthy and if it presents the information in an academic/empirical correct manner. By analyzing the authors and their experience but also by controlling the publisher or company did not only do this.

3 Theoretical Framework

This chapter will present the theoretical framework that the analysis is based on. It is divided into two parts. First theory about *Supply Chain Management* will be presented to get a picture on what theories and tools exists, afterward *Change Management* will be presented to describe how organizations can handle innovation, adoption to become competitive. In this chapter *Implementation Strategies* will be presented to describe how theory can be converted into practice and what techniques that can be used to bridge the gap between theory and practice.

3.1 Supply Chain Management

There are several definitions of supply chain and one of them is "*the network of organizations that are involved through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.*" (Christopher, 2011 [Reorganized definition]). A supply chain consists of all actors, which are involved beginning to end. An organization consists of several supply chains where each one is unique, they are however highly dependent of each other. Together they create a network of chains and the process of governing it is called SCM (Liang et. al., 2016). Furthermore, SCM according to CSCMP (Council of Supply Chain Management Professionals, 2013) also includes all logistic activities such as procurement, planning, coordination and sourcing but most importantly do they emphasize on the coordination of the different partners in the value chain i.e. suppliers, speeditors, and any other third-party member (CSCMP, 2013).

SCM is a function that acts both between companies and within them. It takes a holistic perspective where organizations exchange information to share risk and optimize the process. By adopting a systematic SCM approach to an organization results such as lowered costs, collaboration advantages while also an increased client satisfaction can be seen (Thunberg, 2016). The traditional view of a SCM divides it into three levels, this is usually called the hierarchy perspective and the different levels is; *Strategic, Tactical and Operational* (Liang et. al., 2016). Depending on what time horizon the decisions or goal have when managing the supply chain determines whether if it is on a strategic, tactical or operational level (Ramanathan, 2014).

There are several different approaches and theories about how to manage a supply chain and as Liang et al. (2016) writes is the strategic approach to an organization's supply chain highly dependent on what it consists of and how the process is aligned. Therefore, in practice, are the combinations of several concepts the optimal solution for a company while on an organizational level a company should strive for the practice of principles from one theory (Ramanathan and Ramanathan, 2014). Some major theories and logistics approaches are SCP, Lean and Just in time.

3.1.1 Supply Chain Planning

Supply chain planning (SCP) can easily be mistaken for SCM but there is a crucial difference between them, SCM is the principles for collaboration through the supply chain while SCP is the process and framework of a methodology that consist of four parts (Jonsson and Holmström, 2016). The four parts are; *sales and operations planning for coordinating supply and demand in the supply chain*, *network production planning for several plants, planning and control of inventory and replenishment in the supply chain and information sharing and collaboration.* As mentioned in chapter 3.1 the managerial perspective is divided into strategic, tactical and operational depending on the time horizon, this also applies on SCP since it is viewed upon as being a part of the SCM (CSCMP, 2013) where the strategic goals affect the tactical and the tactical the operational (Jonsson and Holmström, 2016). The core of the planning is the process of balancing the demand with the resources available by integrating the included members of the supply chain to create a high-end value for the customer (Thunberg, 2016). To be able to integrate the members of the supply chain does the process have to transparent so each member can access the needed information to be able to perform forecast and demand expectations (Thunberg, 2016).

To be able to set a functioning SCP framework the organization have to implement a culture of efficiency and use the right tools to be able to perform them (Gao and Low, 2014). SCP in the construction industry is usually divided into different phases since a construction project is naturally divided into phases. The different phases that Thunberg (2016) describes are the pre-construction planning process and the on-site planning process. The pre-construction phase is the crucial one since it determines the preconditions for the on-site planning, therefore does it also have a major impact on the economic aspect of the project and hence can it be the difference between success and failure (Mollasalehi et al., 2017).

The pre-construction phase is the period of time when the main contractor identifies the requirements of the project, available resources and the bill of quantity. By reviewing the blueprints, conceptual documents and standard times for performing the work is the contractor able to do a assessment of the time and cost (Thunberg, 2016). By using this information can the contractor start planning the production by creating a master schedule from which the production flow for the subcontractors and supplier are determined. Through this estimation is the contractor able to set which activity is connected with a specific material (Thunberg, 2016). During this process is it important that the design group frequently get input from both suppliers and subcontractors to be able to modify their sourcing plan and time schedule, this can be described as developing a balanced sourcing plan through input from official documents, subcontractors, supplier and can be described through the figure below (Thunberg, 2016):

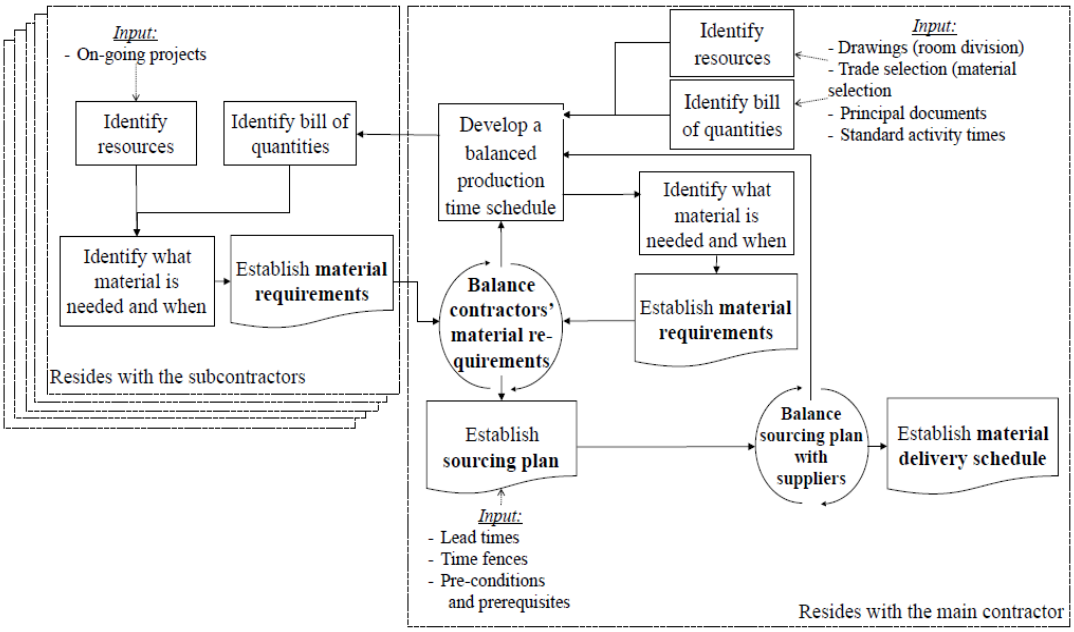

Figure 1: Process map of planning the supply chain in construction (Thunberg, 2016)

During the design/ pre-construction phase is therefore important for the main contractor to engage the involved consultants in how the production will be conducted to be able to steer the design with respect to the production logistics (Kamara et al., 2000). Furthermore, is it important to be able to control the consultants since the impact from the design phase on the production is significant with regard to efficiency, time and money (Mollasalehi et al., 2017) and one way of doing so is by regulating the consultants already in the procurement stage. By writing the contacts in such a way that the main contractor has the tools to be able to control the information flows in the design group.

3.1.2 Lean Construction

Lean construction is a adoption of the traditional Lean production theory developed at Toyota for the manufacturing industry to the construction industry (Gao and Low, 2014). It consists of several principles on how production should be executed but could be defined, as "Lean construction is a way to design production systems to minimize waste of materials, time and effort to generate the maximum possible amount of value." (Koskela et al., 2002). However, the Lean Construction institute defines it as "a management based production approach to project delivery that is particularly useful on complex, uncertain, and quick projects" (LCI.org, 2018). Both these definitions are applicable when discussing Lean on a theoretical level since the essence of them is the same, to reduce waste and maximize the added value. A more applicable view of Lean thinking is to see it as a set of techniques that could be applied to construction to increase the efficiency and added value (Gao and Low, 2014). Lean thinking can be described through different perspectives; *Value, Value stream, Flow, Pull and Perfection* (Gao and Low, 2014). Gao and Low (2014) explains how *Value* is a subjective matter since it only can be determined by the customer but emphasizes on how the service is fulfilling the need of a client and *Value stream* describes how the value is created for the customer, what activities that are non-value adding and how to minimize them. Furthermore do Gao and Low (2014) describe that *Flow* focuses on how an organization should eliminate waste and

unwanted variations in the value stream and how the process is conducted. *Pull* describes how the planning is performed and when activities are triggered meanwhile *Perfection* is the strive for zero errors throughout the process of value creation from the beginning to the end user (Gao and Low, 2014).

According to Song and Liang (2011) in *Lean construction implementation and its implication on sustainability: a contractor's case study* have Lean construction been proven improve planning and construction operations which have lead to development of methodologies as the Last Planner system which is a framework for planning on several levels during a project. The framework consists of the master schedule, look-ahead schedule and the weekly work plan which all are put in place to increase the flow through the project process (Song and Lian, 2011).

The philosophy of Lean consists of several perspectives and one of them is push and pull factors. Push and pull describes in which order activities are triggered in the value chain and how an organization is design to act in production, if it is proactive or reactive (Lai and Cheng, 2009). The terminology of push and pull factor is used commonly when describing SCM in manufacturing and the concepts of Lean and has merely been adopted by the construction industry. A push system can be defined as a system whose activities are triggered by the available resource and the supplier capability to provide them without regard to the customer needs (Lai and Cheng, 2009). It can easily be compared with Material requirement planning which is a system that plans the required amount of material for the next step in the value chain and thus the information travels the same way as the information, which is the core in a Push system (Kalsaas et al., 2015). A Pull system on the other hand is a system where activities are triggered by demand, the information travels from the end customer to the supplier and therefore is it the end customer's needs that determine when and what should be produced (Lai and Cheng, 2009). The principles of Lean such as Just in Time (JIT), master scheduling and Local Based Planning (LBP) are typical systems that fits within the definition of a Pull system (Kalsaas et al., 2015).

3.1.3 Just In Time

JIT is a management approach developed in the 1950s together with Lean, it is a concept whose essence is to deliver the right material at the right time at the right location to minimize all types of waste and enhance the quality (Gao and Low, 2014). JIT philosophy can be seen as a culture driven by structure, innovation and efficiency and is therefore closely connected to scheduling systems. The system is built to increase efficiency by eliminating waste that can be divided into categories: *overproduction, waiting, transportation, processing, stocks, motion* and *defective products* (Akintoye, 1995). According to Josephson and Saukkoriipi (2005) are several of these types of waste a major issue within the construction industry and as Boverket (2012) states is the amount of space that can be omitted to the contractor during construction one of the biggest future issues for the industry.

JIT can be viewed as a business concept that can be implemented in several functions within an organization. To achieve efficient use of JIT does it have to be used through the whole supply chain and as a multi functional philosophy, this is called the total business approach of JIT (Akintoye, 1995).

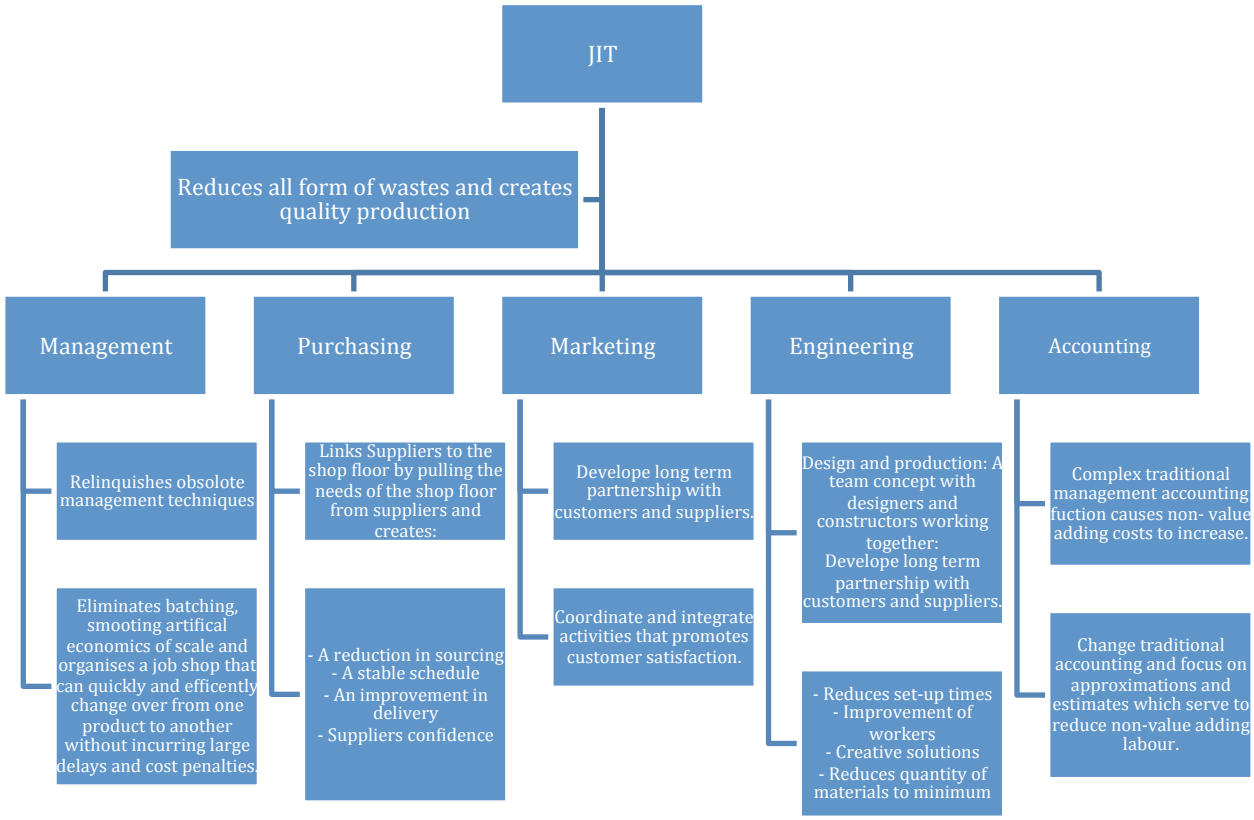

Figure 2: Just In Time through an organization. Based on figure from Akintoye (1995)

To achieve a functional JIT system that works as an efficient Pull system tools acts as support and controls the processes (Song and Lian, 2011). As mentioned earlier it is the foundation to manage a SCP and through LPS, the Last Planner System a framework for how to plan can be found (Gao and Low, 2014). LPS was developed to support the Lean and JIT principles and focuses on optimizing the workflow through the organization (Ballard, 2000). The system is built to systematic execute action planning as close to the activity as possible so that all pre-existing circumstances can be fulfilled before assigning a task to a workforce (Ala-Risku and Kärkkäinen, 2006). The overall philosophy is to use the overall project plan as a framework but to manage the daily activities in a more flexible way; it can be divided into four steps: S*hould, Can, Will* and *Did* (Ballard, 2000). The four steps describe how the activities in the procedure can be categorized where *Should* is the activities that needs to be performed in the near future according to the project plan and the *Can* is if it is possible to do the activities, is the right material at place, have the preclusion activities been done. *Will* describes the activities that should be commenced before the next step of planning and *Did* is the activities that has been completed (Ballard, 2000). Together does these categories create a framework for planning and make the planning more reliable. The LPS can be used both reactive and proactive since it is used to coordinate activities and hence, has to take multiple actions into consideration (Song and Lian, 2011).

The creation of schedules in LPS is also categorized to be able gain both an overview over the project and detailed planning of complex parts in a project. Mainly LPS scheduling is built on the master-, phase-, look ahead- and the weekly work plan (Gao

and Low, 2014) which all take a different time frame into consideration. The master and phase plan is the main project plan which builds on the clients objectives and the contractors time to achieve these, the look ahead plan takes the operations the next time period into consideration, the time period is determined on how long the project is and the weekly work plan describes when activities should be done in the near future in detail (Song and Lian, 2011).

3.1.4 Tools for coordinating logistics

There are several tools that can be used to support the principles of Lean construction, JIT and LBS. By using new tools and techniques to coordinate the precision of the principles can the use and adoption of them spread to create a more efficient construction site (Barbosa et. al., 2017). The SCM of a construction project is closely connected to its production and good logistical planning is fundamental to create a efficient production flow (Said and El-Rayes, 2013). When implementing a system and tools to control it is it important to take into consideration that the consequences of the change becomes larger the earlier it is performed, therefore is it important to take the problems which occur at the site into consideration when designing the project (Kolbusa, 2013).

An example of a tool that can be used to support a logistical system at a construction site is digital scheduling, there are several software's that can enhance the production planning by centralizing all the information (Hautala et. al., 2017). As Barbosa et. al (2017) states that the adoption of existing IT-tools is crucial for the construction industry to evolve, one example of such a software is Myloc which enables the management to plan the material flow through a cloud service and can therefore decrease the amount of transports to the site. The information and created schedule can be presented on a monitor, which automatically updates when the admin makes changes. The monitors are available in the cloud so each part can access it on their own device (Myloc, 2018). By implementing such tools where suppliers, contractors and speeditors can share their information and increase the transparency of the operation enhances the possibility for efficient planning and coordination (Hautala et. al., 2017).

To create a synergy between the supply chain and the production digital scheduling tools can be used as well as other solutions, one of those is consolidation center. Construction consolidation centers (CCC) is a warehouse where operators can store their material until they need it to avoid unnecessary traffic at the site or to deal with material storage (Greger, 2015). The material is repacked in a way that makes the site able to handle it, by doing so is it possible to achieve JIT since the material is on call and the system is design so it can be delivered with short notice (Greger, 2015). This can be used to create a logistical system that practically can perform reliable JIT deliveries. Since reliability is one of the major issues in the construction logistics (Thunberg, 2016) are CCC one way to handle it but to be able to determine whether a construction project should use this type of solution, a substantial evaluation the supply chain and the needs to be done. Therefore is it crucial to determine the supply chain needs early in the design phase in order to be able to coordinate the logistics (Greger, 2015).

3.2 Change Management

The organizational change within a company is crucial for its survival in a high paced industry where new tools and techniques become more advanced. Traditionally has project management and the practitioners mainly had their focus on other topics than managing change but during the decade have companies realized the value in being able to control change (Hornstein, 2015). Change management has been developed through organizational change and can be defined as: *"The process of continually renewing an organization's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers"* (Moran and Brightman, 2001). The need of change management is important since change is constant at all levels within an organization during its lifetime. It has been found that proper management of change in project-based organization is a crucial factor to ensure success (Hornstein, 2015). Furthermore, is it important to educate managers to handle change since effective leadership significantly improve the success rate of projects is a project based organization (Hornstein, 2015). Change management is traditionally described through Kotter's eight processes of change (Gupta, 2011):

1. Establish a sense of urgency for innovation
   In order to succeed with change you need to motivate the people within the organization that there is a need, which needs to be solved.
2. Creating the guidning koalition
   Influence the organization by developing a team of leaders that represent the entire entity to give the change credibility.
3. Developing a vision and strategy
   The vision and strategies should be well formulated, achievable and easy to communicate.
4. Communication of the change vision
   By communicating the vision can you spread it and achieve legitimacy. Also make people understand why it is needed.
5. Empowering employees for broad-based action
   What organizational barriers are there and solve them by engaging the personnel.
6. Generation short-term wins
   By showing short-term achievements the change can get momentum and overcome resistance.
7. Consolidating gains and producing more change
   Keep reminding the organization of the urgency through the whole process and keep showing achievements from it to lower the resistance and motivate people.
8. Anchoring new approaches in the culture
   Implement it in the culture of the organization to make it last over long time, introduce new workers directly and keep education the staff.

Organizations within the construction industry frequently use services from architects, engineers and contractors (AEC) have through history tried to perfect their project performance by standardizing their sourcing and project management (Lines et al., 2015). One way of doing so has been to implement changes in areas such as procurement methods, contracting methods and management of AEC etc. (Lines et al., 2015). To be able to implement new practices in these fields proper change management is required since the construction industry traditionally is conservative

(Barbosa et. al, 2017) and is project based. When implementing AEC changes is concrete change management needed both in the central organization and in the projects where people need to learn the new approaches simultaneously as they phase out traditional processes which has been developed through practice and decade of operations (Lines et al., 2015). Furthermore, is time a important factor to take into consideration when practicing change management on project based organizations since the timing of the change is crucial for its success, most commonly does a change have a chance of succeeding and have a impact on the project if it is implemented in the beginning (Hwang and Low, 2012).

The construction industry is special when it comes to change management (Lines et al., 2015) since its project-based nature where each project can be viewed upon as an organization and therefore, changes need to be implemented in on both a organizational- and project- level to be effective (Gareis, 2010). However there are some factors that are important when planning change within the AEC industry, to be successful on a project level is it; *Project scope*, *size duration* and personnel *hierarchical positions and experience* (Lines et al., 2015). On a organizational level is it manly the approach to implementation that has to be managed, usually *unrealistic expectation* and *underestimation of the time horizon* of change leads to resistance. Another factor that has to be taken into consideration is the *training of members* within the organization and how the *change message is delivered* (Sullivan, 2011).

Difficulties that arise within the construction industry with regard to change is the different types of changes that exists in a project life, as earlier mentioned is change management both needed within the central organization and the project organization. Hence, is two separate systems created which have separate definitions of change (Bröchner and Badenfelt, 2011). The organizational change is mainly the one described above while the project change is changes within the temporary organization. Project changes can for example be to us another tool/material or a change in staffing (Bröchner and Badenfelt, 2011), one of the major changes that occur during a project is with the supplier, when deliveries are unpredictable since delivery methods are outdated (Geraldi et al., 2010). To be able to set an efficient project change management system is it important to be proactive in the planning during the design phase to minimize changes during the project and also write the contracts in a way that makes the contractor able to minimize the changes, for example by adding specialized clauses to the contract (Bröchner and Badenfelt, 2011). As Hwang and Low (2012) states does an effective change management system at site significantly deteriorate the project result.

3.2.1 Changes & Implementation

Changes within in an organization occur frequently and is a part of the development of the entity. When trying to manage the change is it important to understand what type of change it is to be able to determine a suitable implementation strategy (Andersson et al., 2001). There are mainly three types of change, which exists within an organization: *Development Change, Transitional Change* and *Transformational Change* (Andersson et al., 2001). Depending on what induces the change and how the organization around it is affected by it determines which type of change it is.

Development change is the natural change, which occur in a organization when constantly trying to improve already existing processes, it can be described as a linear

change since it happens over time and in a constant pace. This type of change is the easiest to implement in an organization since there are no fundamental and sudden changes, which can be hard to anchor with employees (Andersson et al., 2001). Nevertheless does all types of changes disrupt the safety which the human usually seek so even if there are small changes does top management have to take action to be able to implement them. This can be done through education, training and involvement when developing the solutions to build commitment (Gareis, 2010).

Transitional change is a more complex change then the earlier mentioned Development change since it focuses on changing the entire process to something new rather than improving it. It's usually conducted as projects, which has been initiated by top management (Andersson et al., 2001). The change has a budget, a clear beginning and end with a specific problem to solve which is the traditional way of implementing change. Some examples of transitional change is reorganization, small merges or new tools which don't require a new mentality within the company (Andersson et al., 2001). A problem, which usually occurs when implementing transitional change, is the human behaviors within a corporation. Top management usually see this type of change as a strictly technical since it is conducted as a project which has a budget to manage. Consequences from neglecting this perspective could be major since an organization is built on people and to be successful in a implementation is it crucial to align the human behavior with it (Hutchins and David, 2016). One way of managing Transitional change is to be transparent with what the change is and what impact it will have. In the same way as with Development change is training etc. one way of achieving this, but when performing on a bigger change there need to be a more structured approach (Andersson et al., 2001). An efficient way of doing so is to do a impacts analysis which maps out where the major changes will occur. It also assesses both the human and organizational impacts to be able to reduce the human trauma. Furthermore, does it reveal what processes that can be kept and align the new the desired state and which ones that has to be terminated. A proper impact analysis also highlights the gaps where new processes need to be developed to fit the desired state (Andersson et al., 2001). By conducting an impact analysis in an early stage management can develop a logic and clear plan on how to implement the change and what is actually is required to be changed (Andersson et al., 2001). Another efficient way is to set up a parallel system throughout the transitional change where the new state is implemented and controlled meanwhile the original system is running efficiently (Andersson et al., 2001).

Transformational change is the most complex and unpredictable change since it requires organizations and humans to change their fundamental values and culture. It can be described as a radical shift from an old state to a new one (Andersson et al., 2001). To successfully implement and manage Transformational change time is required since there are several more external factors that contribute to it. Usually this type of change is started with an external "wake-up call" which profoundly traumatizes an organization and the humans within it. To be able to manage this type of change, top managers need to be able to identify the wake-up calls to be able to initiate a change program, which affects the culture, environment, mindset and processes within the organization. These initiatives are usually several different Developments and Transitional changes which are painfully to conduct and therefore takes time and effort (Andersson et al., 2001). Transformational change often occurs in a business sector which forces the organization within it to follow, this can be seen

as society development which is driven by external factor such as innovation and equality (Andersson et al., 2001).

According to Barbosa et. al (2017) is the construction industry currently in need of a Transformational change where new policies and cultures has to be built. The author describes how the industry is currently in a state where techniques, values and methods are highly outdated where its non-adaptive approach has made the industry lack behind (Barbosa et. al, 2017). As earlier described is a Transformational change consisting of several Development and Transitional changes whereas creating a more efficient SCM is one of them. Not only by implementing a more updated approach and framework but also to change the perspective of the people involved in the business (Barbosa et. al, 2017).

3.2.2 Success factors for Implementation in Construction Projects

Its project-based environment defines the construction industry where temporary ventures of entities are created for a specific project. Because of this project members are highly dependent on each other since usually one can't succeed without the other one. Therefore is it crucial to take each project members perspective and timeframe into consideration when trying to implement innovation (Ling et al., 2003). To be able to implement changes in project where several different actors are engaged is it important to know that the initiative organization for an innovation has to get support from the other members. Therefore is it fitting to divide a project into two blocks; *the origin organization* and *Supporting organizations* (Ling et al., 2003). The origin organization (OO) is the initiative organization which is trying to implement innovation and the supporting organizations (SOs) is the project members who is either directly or indirectly affected by the innovation and needs to be supportive to the OO for them to be able to succeed with their implementation (Ling et al., 2003).

There are two major forces that cause organization to implement innovation, these are *Expectancy driven normative force* and *Result driven instrumental force* (Repenning, 2002). To be able to point out why an organization managed to perform a successful implementation is it crucial to understand how these forces correlate and their impact on implementation strategies (Repenning, 2002). The first force is driven by the goal that by adopting innovation the organization will be able to achieve new strategic goals that couldn't be met with the current state of the organization. Therefore, are organization willing to adopt innovation in order to be competitive and for self-fulfillment. The second force, *result driven instrumental force*, is driven during the implementation process where the result from the innovation can be noticed in concrete ways. This makes the organization feel committed and simulated since result from the implementation of innovation can be seen in an explicit way (Repenning, 2002). In construction project-organizations are several organizations involved in innovation therefore a third force must be taken into consideration to be able to successfully manage an implementation. The third force is *Inter-organization interaction force*, which describes the will between organizations to create a long-term relationship, and how organization can be willing to sacrifice short-term profit to be able to ensure further business relationships (Ling et al., 2003). How these forces correlate and drive implementation within a project organization is visualized in figure 3:

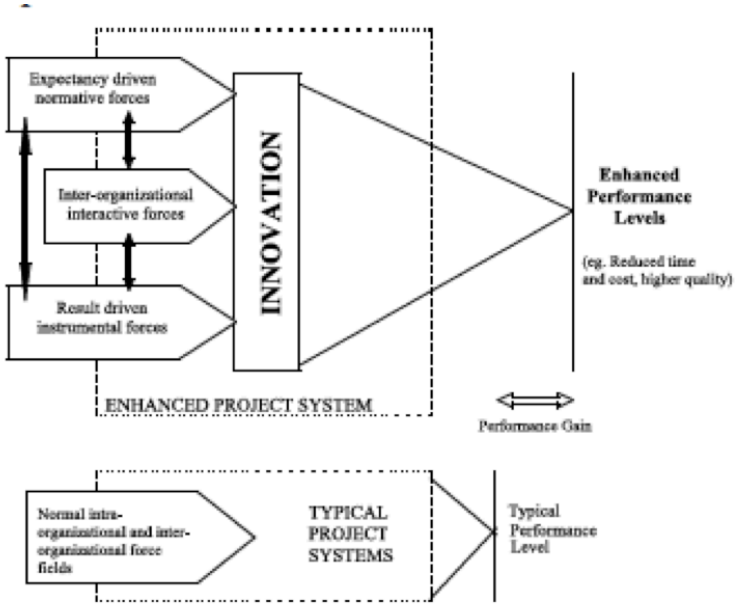

Figure 3: Forces of innovation implementation within a project organization (Repenning, 2002)

Within these forces are there some critical factors, which are important to take into consideration to successfully implement innovation in construction project organizations, these are (Ling et al., 2003):

1. Long-term relationship between the major parties that are involved in the innovation since this increases the motivation alignment and transparency in the project.
2. The motivation alignments in the implementation team are strong forces to ensure success for the innovation.
3. The client should play the role of a strong SO to the main contractor.
4. Important to be able to show short termed results that quickly can be noticed and to manage long term expectations so realistic goals is set.

4 Empirical Findings

In this chapter the information gathered from interviews, observations and by reviewing internal documents at Serneke Construction will be presented. The chapter is divided into two different subsections. *Current state* that will describe how Serneke is working right now with logistics through their projects which is presented as how they do now and what strategies they use to implement their way of working. The second section, *Desired State*, will describe what they would like to improve through the process and which tools they would like to have to be able to do so.

4.1 Current State at Serneke Construction

At Serneke Construction does the production- and SCP significantly varies depending on what kind of project it is and what the preexisting conditions are. However are there some similarities on the overall approach and the detail planning. Where the biggest variations occur is in the bigger processes, which often are regulated by the client, at site that usually is what makes each project unique.

4.1.1 Production Efficiency & Supply Chain Management

When planning the supply chains and the connected network Serneke generally start early in the project phase, already in the design phase does project managers start thinking about the overall situation at site. One project manager stated that the design group does not usually think about the SCP but by trying to create an efficient design for the production the SCP is done implicit. However does both Project Managers state that it is important for design group the get a good overview over the project and take a holistic perspective to get a sense about the billability but more advanced planning in accordance to logistics is not done. When the site managers get involved in projects is the start of proper SCP is started, as the seven interviewees stated is this one of the first thing that the site manager starts with. After studying each projects blueprint and steering document does the site manager create a realistic picture of the conditions at the site, from this does the so called APD-plan which is a blueprint over the site where necessaries such as the establishment, construction electricity etc. are marked out. When constructing this document, the site managers not only take material inflow and outflow into consideration but also safety and environmental regulations. Simultaneously is a time schedule created, in format of a Gant-scheme, this is usually developed together with the project manager to determine in which order to construct the project. As many of the interviewees stated is this one of the most crucial steps when planning the project since the production and hence the logistical system is based from it. In project where the organization consist of a logistics manager is other supportive documents created, both logistical managers that were interviewed stated that they created a “logistics appendix” which is a document that describes the preexisting conditions, the transport rules on site, what Serneke expect from the involved parties to conduct in term of lead times and delivery accuracy. In these project is this document the foundation of the SCP since it is a part of every procurement and makes it possible for the practitioners at site to steer the involved parties since they have a signed document that describes what Sernekes project standard is regarding logistics.

The interviewees where asked what parts of the production which is important for the design group to get done with and which consultants that has the biggest impact on the onsite logistics and the supply chain, their answers are presented in the list below:

- Architect
    - Material selections
- Construction engineer
    - Consultants in charge of the majority of Sernekes own work, control that current dimensions can handle scaffolding and working machines.
- Ventilation
    - Have a big amount of deliveries, which usually are bulking.
- Climate envelope – Walls, windows, doors etc.
- Materials with long lead time
- Use standard measurements on openings i.e. doors, windows
- Increased transparency
    - Blueprints that can be trusted

The next phase in the project is where most of the planning for efficiency is executed, the early production phase when major procurements of suppliers and subcontractors are done. In this step are usually more parties involved from Serneke, both the project- and site manager work close together with either construction superintendents or project engineers as the seven interviewees stated. During this stage is the production planning in focus and therefore the site is closely reviewed, hence is the on-site logistic planned. This is usually not done as an explicit task but rather consequently from planning each activity and how these can be performed efficiently.

As five of the interviewees mentioned are there no clear action plan for how to handle the production planning or the logistics that comes with it, the only cases where there is such a plan are the projects that have logistic managers. What determines how the planning is done is in a clear majority of the projects the experience of the site organization. As all seven interviewees stated does the Site Manager have a crucial role during this stage and traditionally this way of working has been successful since the site organizations have had significant experience. However, does the Site Managers that where interviewed state that their first task during this phase is to revise the time schedule to set a reliable timeframe for the project, this is done by gathering information from suppliers, subcontractors and the client to get lead-times, number of working hours and keystones during the project which the client demands. Afterwards the plan is reviewed together with the whole project organization (Project Manager, Site Manager, Construction Superintendents, Project Engineers) from Serneke.

As mentioned are several major procurements done during this stage and contracts written. Five of the interviewees stated that their main tool for controlling the logistic on and off site is by using clauses in the written contract with the Supplier or Subcontractor. The written contracts are mainly based on previous templates from more senior colleagues which states in what order to prioritize the steering documents which is attached as appendixes. These documents do not regulate the parties to follow any logistic framework other than the attached time schedule. One Project Manager stated that this phenomenon can cause severe problems since the time schedule usually is written in a vague manor to make deadlines more flexible for

Serneke but consequently also for the other part and therefore a situation where no regulation of the other parties can occur and hence, Sernekes main tool is disabled.

Since the SCP was mainly built on experience the interviewees where asked what is important to think about during the planning and design phase to be able to eliminate non-value adding work and getting an efficient supply chain, their answers are presented in the list below:

- APD - plan
    - Where will the bottlenecks occur?
    - Material zones
    - Placement of scaffolding & Elevator
    - In and out transportation
    - Name zones, temporary doors
- Logistic appendix
- Customization choices
    - Are they done?
    - Is there no risk for wrong interpretation?
    - Capability with standard execution?
- Material bills - estimations
- Measurement on opening
    - Capable for material transportation?
    - Are standardized dimensions used?
- "Users moving in" - plan

4.1.2 Just in Time & Synergies

When planning the production as described in the previous chapter did all seven interviewees confirm that each project is striving to achieve JIT production. By adapting the sizes of the material orders to match what actually is consumed on each site to minimize waste. Another stated reason for trying to achieve JIT production was the material storage area, several projects described that one severe problem with the on-site logistics was the material flow and storage. As previously stated does most projects use contacts as their main tool for steering suppliers and subcontractors, and this is the case with JIT production to. By writing contracts, which allow Serneke to split orders and change, the date of delivery the site management team can plan the material flow to be synchronized with the production. Another tool, which are used to synchronize the production, is an analog calendar that showed the next following weeks and the deliveries that was planned within that timeframe except during the first stage of production, when the structural construction is built usually did this. During this period, six interviewees stated that they were lifting the calculated amount of material to each level in the construction as the structural framework was raised. By doing so they could use the crane to lift in heavy and large amount of material to the right place before each level got their celling built and hence, the material was at the right place but not at the right time. But by doing so the projects minimized the transport of the materials at site and avoided inefficient work. Another solution, which was presented by a majority of the interviewees, was to use logistic teams/lifting teams. This was an option that some projects used to some of the larger material deliveries, especially if it consisted of bulky material such as kitchens etc. In these cases, the logistic team was either a part of the initial procurement with suppliers or

an outsourced service by Serneke to lift the materials that arrived at the site to the assigned area.

Moreover, did the interviewees state that they do not believe in the use of traditional consolidation centres since the cost will not be motivated when compared to the benefit, especially if the logistic systems and production planning gets better. However did, several interviewees from all different roles describe how they believe that projects should work close together to be able to use economic of scale for important purchases and that it would be possible since many project have the same client or suppliers. But an important factor that was presented was the need of increased transparency between projects both internally and externally to be able to create efficient synergies and a reliable supply plan. Only two interviewees described that they would like to use more digital means to be able to increase the transparency.

4.1.3 Implementation Strategies & Tools

Since interviews showed that there is limited explicit logistical thinking during the design phase Serneke are not using any methodology or tools for implementing it. Although, the interviews did show that most of the logistical planning is done during the early production phase and therefore is it mainly the site organisation, which develops and implements the system. All seven representatives from the site management teams explained that there is no overall approach to how to make the designed systems work, most interviewees answered that they use communication and a "adopt and improvise" – approach except the cases in which they had separate resources for logistics.

The seven interviewees unanimously stated that there are some documents that need to be set in order to show and visualise the supply plan and production, these are the APD – plan and the time schedule. These are used to visualise the production through the whole project. These documents are crucial since it can be used to show suppliers, subcontractors and craftsmen a holistic view of the project which can be forgotten when the labour is heavy specialised. In the cases that has Logistic Managers an additional logistics appendix was also created and used as the main tool for making the project organisation adapt to the set system. The above-mentioned documents are commonly attached in the contracts and therefore Serneke can force supportive organisations (sub contractors and suppliers) to follow the designed system.

The interviewees answered that the most common tool for implementing changes within the project organisation is communication and their main forum are meetings. These are performed on all levels within the organisation and at a construction project there are several types of meetings. Many of the interviewees stated that logistic is a subtopic, both Site Mangers and Project Managers answered that they rarely thought primarily about the logistics but often as a consequence that had to be dealt with. Other stated that logistic is a standing topic on each meeting since there is always a need to plan for it even if employees don't see it as their main activity. Since there are meeting on every level within the projects is it possible for the Site Management to gather and spread data through these to reach everyone in the organisation.

Another tool that is commonly used according to the interviews is a delivery calendar, which shows the following weeks where each person can put their delivery or bigger

operations on it. This calendar is revised every week and in some projects everyday. The calendar is mainly built on data gathered from all the meetings as previously mentioned. There are some differences in how the different project uses the calendar in meaning of timeframe, review routines and bookings but also appearance. Most commonly the interviewees stated that they are using a analogue calendar where people book slots by writing in it, other stated that they first tried with a digital one but slowly had went over and back to the analogue calendar. This was the case without a Logistic Manager. The projects that had a Logistic Manager used a digital calendar that had the same function but several other ones too, this system is called Myloc.

The last tool, which was presented during the interviews, was to lead by example. Four interviewees stated that to be able to steer subcontractors and suppliers to follow their plan is to always perform accordingly by them selves. Several interviewees stated that this usually was hard since the site management team often doesn't have logistics as their highest priority. As a reaction five of the interviewees felt that the design supply plan and logistic system didn't last trough the project.

4.2 Desired State at Serneke Construction

During the interviews conducted at Serneke Construction the interviewees express potential improvements for the different processes. These are summarized and presented in the following chapter. The suggestions are strictly based on the interviewees experience from their current and previous projects. The ideas are presented to describe how knowledge exchange between the design group and site management team can improve both the situational activities as well as the overall project process.

4.2.1 Production Efficiency & Supply Chain Management

While designing the project six interviewees stated that Serneke would benefit from working closer with the Architects and the Construction Engineers since these are the consultants who has most influence on the work that is performed by Serneke. As two Site Managers expressed, a closer relationship between these three parties result in more efficient solutions, an example of such a result would be the amount of wall types in a project. One Site Mangers expressed that there will always be several different types of walls is a project, but many times the amount could be reduced significantly by minor adjustments. Another senior Site Manger said, "Sometimes the shift of one beam can result in five different wall types, and if you build one wall wrongly, the cost of rework will be significantly bigger then choosing a more expensive beam to minimize the amount of wall types and hence, mitigate the risk of error". Six interviewees stated that they would like to see the Site Manager involved in an earlier stage in the project to increase the awareness of buildability.

When setting up the design process and determine in what order to conduct the activities involved in it does several members from the site management express the necessity in taking decisions regarding material choices. Usually this occurs as a major production disturbance since it is crucial information to be able to plan the production for mainly two reasons mentioned by the site management team. The first one is the lead-time of the materials; several materials have long lead times and therefore must be ordered early in the process. The second reason is the non-value

adding work and rework; since decision regarding material / colours etc. is done late in the process does it often result in major reworks since the original blueprints can't be trusted even if it is classified as "Buildable", hence the previous work becomes non-value adding in addition to the rework. Moreover, did both Site Managers and Project Mangers mention the importance in getting complete and locked customisation list for each apartment for the same reason mentioned as above. The interviewees stated that they would like to see suppliers involved earlier in the process to get practical information, which can be crucial for the production planning or the design of the project. They felt that suppliers often have advanced knowledge about their product and what the precondition for them is. Usually they have necessary information about how complex problems can be solved by either adjusting or a change of material. By involving the suppliers in an earlier stage the design team will get more input about the buildability of their solutions.

Moreover did five interviewees explain that they would like to have more tools for being able to control subcontractors and especially bigger and the highly specialised ones. Sernekes representatives felt that there are some subcontractors that work with highly advanced technology and techniques and therefore become hard to steer. It was suggested that these subcontractors should be procured for both design and execution, by doing so, Serneke can hold these subcontractors fully responsible for the performance and the production of the systems. The subcontractors that were mentioned was:

- Electricity
- Ventilation
- Piping
- Fire sprinkle systems
- Doors and lock system

When asked upon in what order to execute the production design and planning most of the interviewees stated that they felt that the time schedule must be done in an earlier stage. As described is the time schedule first set when the Site Manager gets involved in the process and by then a clear majority of the design has already been done. Instead the interviewees felt that the time schedule should be the first thing that should be done, and by doing so will the design team get a list of activities and in what order to perform them. As many interviewees stated would this increase the time gap between design and production and therefore could proper planning be done. As a Project Manager stated "It feels like we are doing the design in the wrong order, how can we know what to prioritise when we don't know how it will be built?

4.2.2 Just in Time & Synergies

To be able to achieve a logistic system that can perform JIT deliveries in a reliable way five interviewees described the necessity of having accurate bills of quantity. This could be achieved by having a closer relationship with mainly the Architect since their models contains the information and by regulating the contract in such a way that the Architect is forced to present i.e. windows and doors both totally and by level. But as many of the interviewee's states could this only be achieved with greater transparency in the industry, which many felt was a problem in the projects. One solution that was presented by the interviewees was to educate Sernekes employees to be able to understand the Architects software. Another one was to regulate the

consultant's contracts in a way, so they are forced to sit on site for a fixed number of hours per week. During these hours could the site management team ask them questions and problem could be solved directly.

Another solution that was presented was to enhance the relationship with suppliers and set higher demands on them. Six of the interviewees said that Serneke could demand suppliers to deliver more accurately and be obligated to involve their own storage area. This is usually a service which supplier has but it must be asked for and since Serneke has a position of strength when negotiating with suppliers could they demand them to act as consolidation centres for the products that they deliver. Based on the answers from the interviews was this the preferable solution to be able to achieve a JIT delivery system. Furthermore, the interviewees explained that some sort of consolidation centre would soon become a necessity to be able to have a reliable delivery system in an urban area. However, does the cost of one not outweigh the benefit for a single project and therefore would several projects have to share one. Some interviewees described how it could be a service provided by the central organisation and could be sponsored by adding a factor into the overhead costs for each project.

4.2.3 Implementation Strategies & Tools

When asked about implementation strategies and tools all the seven interviewees were unified, they would like to have support from the central organization and a standardized framework for implementing a logistic system in the projects. However, the interviewees also stated that the framework can't be to extensive since it is not within the Serneke philosophy of letting the employees use their own knowledge and operate under freedom.

From the central organization the site management team would like to have an expert within the company that could consult and brainstorm together with the responsible at site. The resource would act in the same way as many companies have with work safety and environment, the so-called KMA division. The resource could help the site management with both designing a system and maintaining it, but not doing it for them. The interviewees described how they would like having a senior colleague that could come out to the site and help them with i.e. placement of material, transport routes and common mistakes so they can be avoided.

The support they would like to have from a standardized framework was described as an easy document, which could be designed as an action list with important lessons learned from previous projects and things to think about when planning the production. It could be simple things that are obvious but easy to forget but also specific advises when doing i.e. procurements. All the information in the action list does not have to be relevant for the specific project so it will be able to customize each system to every separate project. The document could both work as tool for implementation as well as a tool for knowledge management, several interviewees suggested that a central resource could be responsible for gathering data from each project and update the document.

5 Analysis & Discussion

This section aims to interpret the gathered empirical data and compare it with the existing theory presented in the chapter *Theoretical Framework*. The analysis will be divided into three sections; *Production Efficiency & Supply Chain Management* where the design phase and the building of the supply chain will be reviewed. *Just In Time & Synergies* where the performance of the supply chain and the pre-existing condition will be analysed and presented, also how project can work together and results from doing so. *Implementation Strategies & Tools* will focus on how to support the site management team and what tools they need to be able to implement an efficient system.

5.1 Production Efficiency & Supply Chain Management

The empirical findings showed that the design group consisting of Serneke and various consultants does not think about the on site logistic or the supply chain, which causes significant disturbances in the production planning and efficiency. Considering that the design group are the ones setting the conditions for the project is it crucial for them to engage in the logistic planning since the earlier an actor is involved, the more influence they have (Thunberg 2016). For Serneke Construction is it important to inform their Project Manager about their impact on the on-site logistic, also what to think about in order to create a guiding leader which can empower the rest of the design organization and hence, give the change of perspective legitimacy (Gupta, 2011). Since the interviews showed that neither of the Project Managers thought about the production logistic and design of supply chain explicit is it important to set a clear framework to support them, one example of such a framework could be what questions to ask each consultant regarding production efficiency and buildability in order to secure important information and condition which is needed to design a efficient logistical system on site. Furthermore, did the empirical study show that one cause of disturbance is the time between design and production, generally is it to little since there are no clear prioritising order in the design phase which prevents the site management team from being able to develop a balanced source plan (Thunberg, 2016). Simply engaging the Site Manager in an earlier stage to create a time schedule with the Project Manager could with easy means prevent this, this would also increase the input for the consultants regarding buildability, which was another major factor for disturbances. Involving a major supplier to the project to give both Serneke and consultants guidance regarding price and material choices, also what quick fixes that exist which make the production flow increase, could also prevent this. During the interviews was clear how significant role the big suppliers and their contact persons had within the project, so to align them in an earlier stage would be beneficial, they would not necessary have to be a part of the design team but could act as a supportive organisation for the design team. By doing so would Serneke be able to show the design team short-term wins that is one factor in Kottler's 8 steps of implementing change into an organization (Gupta, 2011) and hence create better conditions for spreading the perspective down the organization.

Furthermore, is it important for Serneke to take charge in the design phase and to clearly state what should be done and when. Therefore is it important to provide the Project manager the necessary training, as both the theory and empirical study pointed out is it crucial for a project to have clear guidance and leaders to lean against (Gupta, 2011). Also, the fact that the earlier a change or a system is designed, the higher the

chance of being effective and successful it has shows that the Project Manager must think about consequences in the production and prevent them in an earlier stage (Thunberg, 2016). One way of doing so is could be to assemble the site management team to design a change routine since the project will change over time since they are depending on several external factors. By doing so the site management would be prepared for changes that would increase the production efficiency and minimise the amount of non-value adding work (Andersson et al, 2001). By developing and implementing the change routine would problems regarding customisation be prevented. Several interviewees stated that customisation is a big disturbance in the production logistics and hence the efficiency, therefore is this a crucial step to minimise non-value adding work and flow disturbances. By having a reliable change organisation at the site that would be communicated to the craftsmen could further trust and engagement through the organisation be built which is one of the identified critical success factors for implementation (Gupta, 2011).

Another important factor to be able to design an efficient production system is to increase the transparency between the consultants and Serneke, therefore the contracts must be written in a way that encourage the involved parties to share their information with each other (Barbosa et al, 2017). This could be done by either regulate it directly in the contract i.e. Architect should provide a bill of quantity for windows by level or steer the consultants to having fixed Q&A hours at the actual site during production. A third option to how increased transparency could achieved is to train Serneke employees in the necessary software's to enable an information change between the design team and the Site management team by digital models. Since the consultants will withdraw their information from built models in i.e. CAD, could a solution be to share the CAD-file together with the rest of the blueprints and therefore Serneke would be able to within the information by them selves. However, is it also important for the Project Manager to prioritise an increased transparency and relation with the consultants who have the biggest impact on the work performed by Serneke and for the overall site efficiency. As the empirical study showed are these not only consultants, but also highly specialised subcontractors, these parties need to be engaged in an early stage in the design phase to ensure collaboration through the project lifetime.

As stated in the previous chapter is most of the logistical planning done in the early production phase during which the site management team sets the organisation on the site. Another factor which was identified from the interviews was how much more flexible and efficient the sites which had used a logistical appendix when planning the production was regarding logistics and minimising non-value adding work. As many of the interviewees stated do they feel the need to have something to lean against when handling the logistics during the production and by using the appendix would they have that. Therefore is it highly important for the site management team to create a logistical appendix when assigned to the project and use it as a steering document in the contracts in order to empower the site management team and give them a position of strengths against SOs which was identified as a success factor for implementation (Ling et al., 2003). Furthermore, is it crucial for the site management team to review the time schedule that has been set and critically inform the design team on what material they need and when they need it. By doing so the different teams could work proactive to maximise the time between design and production, which was a problem that was identified. It is also important to align the subcontractors with the stated time

schedule and get input from them regarding production times etc. During this phase of the production is it also highly important to communicate material demand to suppliers and get their input whether they can fulfil it or not.

5.2 Just in Time & Synergies

All seven interviewees stated that they have partly adopted the JIT delivery approach but not fully since the nature of the industry is to complex. This indicates that Serneke already is within a *Development Change (Andersson et al., 2001)*, which can be managed by further train and educate the employees (Gareis, 2010). Many claimed that there are to many external factors to be able to successfully practice JIT. This is however wrong, JIT can be achieved in construction, since practitioners have already adopted the mindset but currently lacking the tools and skill to practice it. As five of the interviewees described when asked upon what they would like to improve to achieve better efficiency, do they describe solutions, which would enable a more precise use of JIT. The knowledge and solutions to practice it does already exist but the bottleneck are tools and skills and also the sense of urgency, which has to be established by the design group in order to successfully adopt it (Gupta, 2011). To achieve JIT deliveries is it important for the site management team to create the necessary condition for it to be possible and one way of doing so is to use the logistics appendix since it regulates how subcontractors and suppliers shall manage their deliveries. Since all involved parties will have signed a contract stating that they will follow the rules form the appendix does the supervisors at site have the tools to steer the different parties. Furthermore, it is crucial to understand that JIT is more than only delivering materials at the right time; it is a part of an approach to enhance efficiency and minimize waste by only having the right resource at the right time (see chapter 3.1.3). By planning the material deliveries accordingly to the production and to plan the production realistic: these are critical tasks, which must be performed by the site management team since it has a major impact on the efficacy at the site. Both to plan the quantity, time and how it is going to be transported at the site must be done, and sometimes does the material have to arrive to the site to be able to use transportations means that simplifies the transportation significantly. One case of such which has to be performed by the site management team is gypsum, isolation and beams. This material has to be ordered long before its going to be used since the possibility to transport it into each apartment by crane when raising the structural construction is more beneficial with regard to waste, efficiency and safety. Generally is it important for the site management team to do proper estimations of quantity and to split them to make the manageable when arriving to the site. Also, to consider using logistics teams which can be in charge of the transportations at site, by doing so would a big amount of non-value adding work be prevented since this is the highest cause of waste at a construction site (Thunberg, 2016).

Another solution for increased production efficiency and waste reducing would be to use consolidation centers to enable the possibly of order large quantities and reduce the amount of material stored at the construction site. Many practitioners believed that the idea is good, but the cost would be greater than the benefit from it but did also state that this will likely be a future need since urbanization is causing the construction area to become smaller while the buildings are getting bigger. However, could this be solved through negotiation with supplier and by demanding the service from them. This could be regulated in the logistics appendix hence would a major

contribution to waste be reduced. This would lead to an increased cost from suppliers but since Serneke is in a situation of power, which is crucial when implementing innovation (Ling et al., 2003), when procuring suppliers could this be regulated as a demand in order for supplier to even be considered. Another way of achieving this service without the full cost would be for projects to combine their forces when doing procurements. If similar projects would work together to achieve synergies would the quantities increase and therefore the will to win the procurement, which would create a situation where Serneke can set higher, demands. Also, would the possibility to work with long-term relations be enhanced since projects would deal with the same supplier over a long time and therefore would the willingness to support each other be increased.

5.3 Implementation Strategies & Tools

As the interviews stated is there no overall approach in Serneke for implementing a logistical system in a project even though employees expresses the need of having one. Hence, would a Transitional Change would be needed since there are no current processes and new ones has to be developed (Andersson et al., 2001). The employees did however also express the philosophy of Serneke, which is to not standardize all processes and therefore give their employees the freedom to use their own knowledge. Hence, is it important to create an overall approach which can fulfil the philosophy but also the need of support which the employees need. The approach, which is used today, is basically only built on the experience of the site management team and specially the Site Manager. Therefore could an approach be to design a document in which experience is put down into words and spread for everyone to use and by going so could each project adopt the "lessons learned" which is relevant to their project. The document could be updated and followed up by a central resource and spread through central systems. Another solution that is crucial for developing an overall approach is to educate the management teams in the importance of having a structured way of working and the consequences that comes from not using one to establish a sense of urgency (Gupta, 2011) and create *Result driven instrumental force* (Repenning, 2002). By having knowledge meetings where logistics and site efficiency could be discussed, as many of the interviewees stated that they would like to have, could this be achieved.

Moreover, the interviews show that the main tool for implementing change is by regulating it in the contracts and hence staying in a situation of power (Ling et al., 2003). They also showed that to be able to do so several documents must be developed and accurately performed. Therefore is it highly important for the Site management team and the Project Manager to develop documents to insert as steering documents in the contracts during the design phase. First of all is it crucial to create a logistical appendix and an attached APD-plan both to be able to use in contracts and to actually reflect over the problems, which can occur. Secondly is it to align all the suppliers and subcontractors with the schedule and to do a formal one and leave no room for interpretation. As a Project Manager stated is it normal to formulate the time schedule in a vague way to not jeopardize Serneke but by being proactive and designing a realistic time schedule with slack included would this not be necessary and therefore would it be easier to steer the involved parties. But since most of this planning is performed based on previous experience Serneke would need to provide the site management team with some support, and this could be performed in the same

way as stated above. By spearing knowledge that already exists within the company. By doing so would Serneke develop their site management team to a strong guiding coalition, which can spread the knowledge on-site (Gupta, 2011). To be able to implement a logistical system would these documents have to be inserted in all procurements that is done and for it to be possible would the documents have to be the first thing that is done by the site management team when assigned to the project. Moreover did the both the interviews and the theory show that communication is the main tool for implementation (Gupta, 2011). It is used to build commitment, get input, and align the involved parties and to spread the change or system. This is manly done by having meetings in Serneke projects, therefore is crucial develop a systematic way of working in these, to analyse which parties that needs to be informed and when. First of all is it necessary for Serneke to set up a routine for a revision of the steering documents with the involved parties when the procurement is done. This have to be done to explain what Serneke expects from them and to get input if they foresee any problems. Furthermore is it important for the site management team to follow up how the system is actually working and to work proactive to secure its use. One way of doing so could be to have logistics as constant point of discussion in all meeting about the production. By doing so would the management be able to show the craftsmen and suppliers the short-term achievements from it and therefore empower the system. Another effect from doing so would be a natural revision of the planning which would give the site management the tools and time to minimise waste and make the production more efficient.

The communication and planning tool, which all the cases used, was a short-term calendar where delivery slot, certain happenings in the production etc. and if the activity needed special resources were booked. This system was in all cases except the ones with logistics manager's analogue to ensure its usage and decrease the cost from buying software license. The principle of the tool is good and it is a clear way to visualise the SCP and making it understandable, therefore is it important for the site management to set one up when arriving to the site. However is it important for the site management team to review it systematically and spread the information to the craftsmen since they are impacted by it. There are several mays to spread the information and the use of the calendar, the easiest solution would be to display it at a location where both craftsmen and the site management team can observe it, another would be to several boards, but this would cause some troubles with updating it since generally they are analogue. Therefore should the site management team consider using a digital system which suppliers, craftsmen can access through their phone or a computer. From the observations of the sites and by the interviews can it be identified that adopting digital tools can solve several problems with the communication of changes, planning of the supply chain. As stated in both the SCP and change management chapter is communication the key for success (Thunberg, 2016 & Gupta, 2011) and here are there several improvements that can be done with small means. One example of such a mean would be to introduce digital meetings, since meeting is the main tools for implementation and planning. Meeting can often be hard to schedule since people are located at different positions and have other working habits, therefore would an introduction of digital meeting significantly simplify this and also decrease the amount of non-value adding work (Barbosa et al, 2017). By doing so could the amount of meetings increase and plans be reviewed in shorter intervals. However, is it important for Serneke to educate their employees in how to perform meetings efficiently and how to develop agendas. The introduction of efficient

meetings that could be held online would increase the flexibility and action oriented mind-set of the industry. There is however a need for physical meeting since trust and personal contact has to be developed in order for a project to be successful, therefore could they not be totally replaced by ICT solutions.

6 Conclusion

Summarizing the theoretical framework, analysis and discussion there are some concluding remarks that have been developed to answer the stated research questions. Moreover, insights on the current state of Serneke and how they should proceed to develop a framework for implementation of logistics systems in housing projects has been developed. A draft that can be used at Serneke is presented in appendix B and C.

How would a framework at Serneke Construction look like?
From the empirical study the conclusion can be made that there is a need for a framework for implementing logistic in construction projects. At Serneke Construction a framework would have to be designed in a way, which makes it easy to understand and use. Generally, people within the organization have a limited amount of time for planning and learning new ways of working. Also, it must be easy to adapt even though there are big resemblance between housing projects each project is unique. Another key factor to ensure the use of the system is to make it easy to follow up and renew. Concluding with the fact that most of the logistical planning is based on previous knowledge within the organization the framework is designed as an action list with important lessons learned in previous projects. The framework shall be updated regularly to improve its relevance and to add new knowledge. By designing it as an action list it will be easy to identify and follow up what improvements that could have been done if the production planning and delivery system fails, and hence, both the site management team can get regular follow ups on their planning ability and the craftsmen can be engaged in the planning and further develop commitment. The framework also includes “do’s” and “don’ts” when procuring suppliers and subcontractors, which can reduce, cost significantly.

The action list is divided into two parts; *the design phase* and *production planning* since there will be different people involved in these stages and to make it easier to navigate the documents, which is crucial to ensure its usage. An example of how such action lists can look like is presented in Appendix B and C.

What logistical tools exist and can be used in the design phase?
The main tool that is used within the company today is standardized documents such as logistics appendix, APD-plan, and the Time Schedule etc. that regulate the conditions on the site. These documents are used when procuring consultants, subcontractors and suppliers and are mainly developed by the Project Manager, Site Manager or Logistic Manager. However, the documents are not always used and developed at the right time and can therefore not be used to its full potential. It is crucial for the contractor to develop these documents to be able to set the conditions of the project already in the design phase since the earlier they are developed the more impact they have. During the design phase the contractor have to evaluate what logistical tools that should be used during the production and insert regulations, which enables them to be efficient. An example of such a tool is digital scheduling’s. As both the theoretical and empirical study showed digital scheduling is an important tool when planning the production and hence, the supply chain. There are several different types of software’s that can be used; one type that was used in two cases in the empirical study and showed positive results is Myloc. However, it is important to evaluate to what extent the tool should be used based on the conditions of the project. Another tool that can be used and must be evaluated during the design phase is

consolidation centers which are used as terminals and storage area. By using centers the planning of deliveries can be more precise and hence, more flexible which avoids non-value adding work. Consequently, both the productivity and the financial outcome from the project can be increased.

What factors should be considered during the procurement of consultants and early contracted subcontractors with consideration to onsite logistics?
When procuring consultants and subcontractors is it important to consider what the conditions of the project are for each consultant and what challenges the specific project induces. To have an idea of how the site management team will look like and what tools they need to be able to execute the project. Since changes in the projects are more expensive than doing it right from the beginning, it is also important to have the right people in the planning. Depending on which consultant or subcontractor that is procured there are different factors to consider during contracting but overall the contractor have to steer the collaboration of the design team and the site management team. It is important to establish a transparency mainly regarding material choices and technical solutions since they have a big impact on the logistics. Moreover, is it important to consider the buildability and how the project is going to proceed, therefore the Contractor should use the schedule to determine how consultants and subcontractors are going to be procured and in what order to design the project to maximize the time between the production- and design phase which, creates the opportunity to revise the planning and hence, create trustworthy blueprints. Furthermore, the Contractor should in general consider regulating some of the consultants to have fixed Q&A time at the site during the production to enable communication channels and efficient solutions.

More specific factors regarding different consultants and subcontractors can be found in appendix C*; Action list for design phase*.

How can logistical improvements efficiently be implemented in project organizations?
To implement logistical solutions within the construction industry would in many cases be to implement change. When doing so in a project organization is it important to have reliable management team that can act with confidence and give the change legitimacy. Therefore it is necessary to educate the site management team and to involve them in the development of the system in order to successfully implement logistical solutions. The site management team is crucial when implementing change in construction projects and hence is it important to make them understand the outcome from using new methods and techniques, how it will simplify and add value to their work. Another important factor for a successful implementation of a logistics system is to establish the right conditions; this is mainly done by enabling time for planning the production. By doing so problems can be identified and therefore prevented. By developing documents, which regulates the conditions on the site, the logistical systems will be ensured to be followed since the site management has something to lean against during the production. The documents are also important because it puts the Contractor in a position of power against all supportive organizations involved in the project, which is a necessary factor when implementing a change internally but have effect on external parties as well. Moreover, it is fundamental to communicate the system and to regular maintain it. By establishing communication routines such as meetings, introductions and information

transparencies commitment and excitements are built within the project organization. Also, by having an open dialogue short term wins can be noticed and therefore give the implementation further legitimacy.

Concluding Remark
As a result from this study a framework for standardized logistic systems and an action plan for how to implement it in each project has been developed. Concluding, the previous mentioned suggestion could be categorized into solutions for two problems, *achieving transparency* and *empowerment of employees*. By resolving these issues Serneke would be able to increase their productivity, improve their knowledge management and hence, achieve better financial output from each project. By implementing the developed system Serneke is taking one step toward performance excellence even though there are more obstacles to conquer.

6.1 Further research

During the research new questions did arise and additional topics, which could be investigated, were developed. The topics could be used to further improve the conclusions conducted in this report and contribute to a more efficient design phase in construction. Some topics that could be analyzed are:

- Analyze cost improvements from using logistical solutions in order to gain examples of good logistical solutions and how they affect the financial performance
- Change management systems for blueprints to develop an efficient system to handle changes is the design
- Analyze the usage of a central consolidation center and the economical effects from it

7 References

Akintoye, A. 1995, "Just-in-Time application and implementation for building material management", Construction Management and Economics, vol. 13, no. 2, pp. 105-113.

Ala-Risku, T. & Kärkkäinen, M. 2006, "Material delivery problems in construction projects: A possible solution", International Journal of Production Economics, vol. 104, no. 1, pp. 19-29.

Anderson, D., Ackerman-Anderson, L.S., Books24x7 (e-book collection), Ebook Central (e-book collection), ebrary, I. & Books24x7, I. 2001;2002;, Beyond change management: advanced strategies for today's transformational leaders, 1. Aufl.;1; edn, Jossey-Bass/Pfeiffer, San Francisco

Ballard, H.G. 2000, The last planner system of production control, ProQuest Dissertations Publishing.

Barbosa, F., Woetzel, J., Mischke, J., Ribeirinho, M. J., Sridhar, M., Parsons, M., Bertram, N. & Brown, S. 2017. Reinventing Construction: A Route To Higher Productivity. www.mckinsey.com.

Boverket. 2012. Vision för Sverige 2025 [Online]. www.Boverket.se: Boverket. Available: http://www.boverket.se/sv/samhallsplanering/sa-planerassverige/sverige-2025/vision-for-sverige-2025/ [Accessed 2018-03-15].

Bröchner, J. & Badenfelt, U. 2011, "Changes and change management in construction and IT projects".

Christopher, M. (2011), Logistics and Supply Chain Management, Prentice Hall - Financial
Times, Edinburgh Gate.

Council of Supply Chain Management Professionals. 2018. CSCMP Supply Chain Management Definitions and Glossary [Online]. www.cscmp.org: CSCMP. Available: https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921 [Accessed 2018-02-14]

Dallasega, P. , Marcher, C. , Marengo, E. , Rauch, E. , Matt, D.T. & Nutt, W. 2016, 'A Decentralized and Pull-Based Control Loop for On-Demand Delivery in Eto Construction Supply Chains' In:, 24th Annual Conference of the International Group for Lean Construction. Boston, USA, 20-22 Jul 2016

Gao, S., Low, S.P., SpringerLink (Online service) & SpringerLink (e-book collection) 2014, Lean Construction Management: The Toyota Way, Springer Singapore, Singapore.

Gareis, R. 2010, "Changes of organizations by projects", International Journal of Project Management, vol. 28, no. 4, pp. 314-327.

Geraldi, J.G., Lee-Kelley, L. & Kutsch, E. 2010, "The Titanic sunk, so what? Project manager response to unexpected events", International Journal of Project Management, vol. 28, no. 6, pp. 547-558.

Greger, L. 2015, "Consolidation Centres in Construction Logistics" in Kogan Page Publishers, , pp. 1-1.

Gupta, P. 2011, "Leading Innovation Change - The Kotter Way", International Journal of Innovation Science, vol. 3, no. 3, pp. 141-150.
Hautala, K., Järvenpää, M. & Pulkkinen, P. 2017, "Digitalization transforms the construction sector throughout asset's life‐cycle from design to operation and maintenance", Stahlbau, vol. 86, no. 4, pp. 340-345.

Hornstein, H.A. 2014;2015;, "The integration of project management and organizational change management is now a necessity", International Journal of Project Management, vol. 33, no. 2, pp. 291.

Hutchins & David 2016, Hoshin Kanri: The Strategic Approach to Continuous Improvement, Routledge Ltd.

Hwang, B. & Low, L.K. 2012, "Construction project change management in Singapore: Status, importance and impact", International Journal of Project Management, vol. 30, no. 7, pp. 817.

J.M. Kamara, C.J. Anumba, N.F.O. Evbuomwan, (2000) "Process model for client requirements processing in construction", Business Process Management Journal,Vol. 6 Issue: 3, pp.251-279

Jonsson, P., Holmström, J., Chalmers University of Technology, Institutionen för teknikens ekonomi och organisation, Supply and Operations Management, Department of Technology Management and Economics, Supply and Operations Management & Chalmers tekniska högskola 2016, "Future of supply chain planning: closing the gaps between practice and promise", International Journal of Physical Distribution & Logistics Management, vol. 46, no. 1, pp. 62-81.

Josephson, P., Saukkoriipi, L. & Sveriges byggindustrier. FoU-Väst 2005, Slöseri i byggprojekt: behov av förändrat synsätt, FoU-Väst, Göteborg.

Kalsaas, B. T., Skaar, J. & Thorstensen, R. T. (2015) Pull vs. Push In Construciton Work Informed by Last Planner. 23rd Annual Conference of the International Group for Lean Construction, 2015 Perth, Australia. International Group for Lean Construction.

Kolbusa, M., SpringerLink (Online service) & SpringerLink (e-book collection) 2013;2014;, Implementation Management: High-Speed Strategy Implementation, 2013th edn, Springer Berlin Heidelberg, Berlin, Heidelberg.

Lai, K., Cheng, T.C.E. & Ebook Central (e-book collection) 2009, Just-in-Time Logistics, Taylor and Francis, Abingdon.

Liang, D. & Song, L. 2011, "Lean construction implementation and its implication on sustainability: a contractor's case study", Canadian Journal of Civil Engineering, vol. 38, no. 3, pp. 350-359

Liang, Z., Chaovalitwongse, W.A., Shi, L. & Taylor Francis (e-book collection) 2016;2015;, Supply chain management and logistics: innovative strategies and practical solutions, 1st edn, CRC Press, Boca Raton, Florida.

Lines, B.C., Sullivan, K.T., Smithwick, J.B. & Mischung, J. 2015, "Overcoming resistance to change in engineering and construction: Change management factors for owner organizations", International Journal of Project Management, vol. 33, no. 5, pp. 1170.

Ling, F.Y.Y., Dulaimi, M.F., Kumaraswamy, M. & Bajracharya, A. 2003, "A Case Study of the Management of Innovation Implementation within a Construction Project Organization", International Journal of Construction Management, vol. 3, no. 2, pp. 79-91.

Mollasalehi, S. , Rathnayake, A. , Aboumoemen, A.A. , Underwood, J. , Fleming, A. , Kulatunga, U. & Coates, P. 2017, 'How BIM-Lean Integration Enhances the Information Management Process in the Construction Design' In:, 25th Annual Conference of the International Group for Lean Construction. Heraklion, Greece, 9-12 Jul 2017. pp 531-538

Moran, J.W. & Brightman, B.K. 2001, "Leading organizational change", Career Development International, vol. 6, no. 2/3, pp. 111.

Myloc. 2018. Myloc Construction. [Online]. www.myloc.se: Myloc. Available: https://myloc.se/sv/construction/ [Accessed 2018-03-30]

Ramanathan, R., Ramanathan, U. & SpringerLink (e-book collection) 2014;2013;, Supply chain strategies, issues and models, 2014;1; edn, Springer, London.

Repenning, N.P. 2002, "A Simulation-Based Approach to Understanding the Dynamics of Innovation Implementation", Organization Science, vol. 13, no. 2, pp. 109-127.

Said, H. & El-Rayes, K. 2013, "Optimal utilization of interior building spaces for material procurement and storage in congested construction sites", Automation in Construction, vol. 31, pp. 292-306.

Sullivan, K.T. 2011, "Quality Management Programs in the Construction Industry: Best Value Compared with Other Methodologies", Journal of Management in Engineering, vol. 27, no. 4, pp. 210-219.

Svensk Byggtjänst. 2016. ”CoClass – Nya generationen BSAB Klassifikation och tillämpning” [Online]. www.static.byggtjanst.se. Available: https://static.byggtjanst.se/coclass/pdf/Slutdokumentation-CoClass-v1.2-20161026.pdf

Thunberg, M., Rudberg, M., Karrbom Gustavsson, T., Fastigheter och byggande, Skolan för arkitektur och samhällsbyggnad (ABE), KTH & Projektkommunikation 2017, "Categorising on-site problems: A supply chain management perspective on construction projects", Construction Innovation, vol. 17, no. 1, pp. 90-111.

Vrijhoef, R. & Koskela, L. 2000, "The four roles of supply chain management in construction", European Journal of Purchasing and Supply Management, vol. 6, no. 3, pp. 169-178

8 Appendix

Appendix A - Preparatory information prior to interviews

Mitt examensarbete handlar om implementations strategier för logistiksystem i bostadsprojekt. Jag jobbar på att ta fram en standardiserad mall på hur platsorganisationen ska gå tillväga för att få ett fungerande logistiksystem på ett snabbt, enkelt och effektivt sätt. Arbetet undersöker även möjligheterna som finns med att använda konsulterna och deras information för att planera logistiken i ett tidigt skede.

Nedan finns det intervjuformulär som intervjufrågorna kommer utgår ifrån:

Presentera lite om dig själv, vad för bakgrund har du och vilken position har du?

Presentera projektet kort, vad är typiskt för just ert projekt?

Sammanfatta hur logistiken ser ut på ert projekt och vad för problem ni har stött på/stöter på.

Hur har planeringen av projektlogistiken sett ut?

Hur ser Ni på projekteringsfasen och de involverade konsulterna med avseende på logistiken, finns det problem som hade kunnat fångas upp i ett tidigare skede? Hur hade projekteringen kunnat hjälpa till att styra produktionslogistiken?

Just-in-time är något som det talas flitigt om, hur anser du att det bör tillämpas? Vad krävs för att det ska fungera?

Hur anser du att supply chain management ska tillämpas i ett byggprojekt? Vilka verktyg använder ni hur kan konsulterna bli mer involverade i denna process?

När du blir tilldelad ett nytt projekt och har ansvaret för logistiken, hur går du tillväga för få ett fungerande system?

Vad för verktyg använder du dig av för att implementera ett logistiksystem? Känner du att systemet anammas av alla och håller genom projektet?

Hade du velat ha centralt stöd i logistikfrågor? Hur skulle du då vilja att detta såg ut och vad hade varit viktigt att inkludera i det?

Appendix B – Action list for design phase at Serneke Construction

PROJEKTERINGSCHECKLISTA	To do	Doing	Done	Ansvarig
Tidplanering	X	X	X	AS
Utvärdera behov av logistikpersonal, internt eller externt?				
Involvera produktionspersonal för att påbörja nedbrytning av tider				
Utvärdera system, hur vill produktionspersonal bygga huset?				
Ordningssätta system, i vilken ordning sker produktion?				
I vilken ordning ska systemen projekteras?				
Sätt deadlines för när inköp ska vara gjorda				
Projektering				
Håll produktionspersonalen informerad under projekteringen				
Skapa en logistikbilaga, baserad på bestämda system				
Ha med logistik som en punkt i protokoll				
Projektera fram klimatskärmen tidigt för att uppnå tätt hus				
Följ upp så att systemen projekteras i den bestämda ordningen				
Utvärdera materialval och föreslå ändringar				
Uppdatera inköpsplan efter eventuella ändringar				
Följ upp så att inköp utförs enligt satta deadlines				
Upphandlingar				
A - Bilägg logistikbilagan i kontrakt				
A - Skriv in mängdindelningar i kontrakt				
A - Utvärdera materialval och prioritera de med lång leveranstid				
A - Få dem att använda standardiserade mått, gör checklista för påverkade system, exempelvis för kök, badrum, väggtyper, dörrar etc				
A - Sätt deltider för detaljer som motsvarar inköpsplanen				
K - Bilägg logistikbilagan i kontrakt				
K - Skriv n mängdindelningar i kontrakt				
K - Utvärdera dimensioner för eventuell logistik på plats för ex. maskiner, liftar etc				
K - Få dem att använda standardiserade mått, gör checklista för påverkade system, exempelvis för spännvidder för bjälklag, väggar, armeringsdimensioner, hältagningar etc				
K - Sätt deltider för detaljer som motsvarar inköpsplanen				
V - Bilägg logistikbilagan i kontrakt				
V - Överväg att handla upp för både projektering och utförande				
V - Utvärdera system ur logistiksynpunkt				
E - Bilägg logistikbilagan i kontrakt				
E - Överväg att handla upp för både projektering och utförande				
E - Utvärdera system ur logistiksynpunkt				
VS - Bilägg logistikbilagan i kontrakt				
VS - Överväg att handla upp för både projektering och utförande				
VS - Utvärdera system ur logistiksynpunkt				
Sprinkler - Bilägg logistikbilagan i kontrakt				
Sprinkler - Överväg att handla upp för både projektering och utförande				
Sprinkler - Utvärdera system ur logistiksynpunkt				
Styr - Bilägg logistikbilagan i kontrakt				
Styr - Överväga att handla upp för både projektering och utförande, med vent?				
Styr - Utvärdera system ur logistiksynpunkt				
Dörrar och lås - Bilägg logistikbilagan i kontrakt				
Dörrar och lås - Överväg att handla upp för både projektering och utförande				
Dörrar och lås - Gör gränsdragningslista om endast utförande ska köpas				
Dörrar och lås - Kontrollera så att dörrar och låssystem är komplatibla				
Logistikpersonal				
Utärdera behov av extern logistikhjälp till produktionsfasen				
Överväg att välja en huvudleverantör för material/partner till projektet				
Konsultera system- och materialval med ev. huvudleverantör eller logistikpartner				
Gör simulationer för projektets utformning under olika skeden för att htta risker				

Appendix C – Action list for production planning at Serneke Construction

PRODUKTIONSCHECKLISTA	To do	Doing	Done	Ansvarig
Tidplanering	X	X	X	AS
Utvärdera tidplanen, stäm kontinuerligt av mot upphandlade UE och leverantörer				
Finns någon luft i tidplanen?				
Har inköpsplanen följts? Uppdatera med kvarstående köp.				
Produktion				
Skapa och dokumentera rutin för att hantera ritningsändringar				
Skapa och dokumentera rutin för kommunikation av ändringar				
Skapa och dokumentera rutin för ändringar av material				
Skapa ooch dokumentera rutin för ordererkännanden och leveransbekräftelser				
Utvärdera logistikbilaga och anpassa organisationen efter den, hur agerar varje projektmedlem?				
Utvärdera resursbehov för hantering av logistik på arbetsplatsen				
Ha logistik som punkt i protokoll för UE-möten, lagbasmöten och samordningsmöten				
Skapa en leveransplan som är anpassad till tidplan och inköpsplan				
Visualisera leveranser så att alla på arbetsplatsen kan se vad som händer under varje vecka				
Gå igenom simulering för byggets problematik i olika skeden av produktionen				
Har mängder köpts från A och K? Annars mängda i ett tidigt skede för inköp och leveransplanering				
Hantera tillval och stäm av med varje UE och leverantör som kan påverkas				
Kontrollera att tillval är komplatibla med grundstandard och varandra				
Utvärdera vilka material som är skrymmande och kräver extra tillsyn, gör checklista				
Utvärdera skräp och container-hantering, skapa bilaga för kontrakt mot UE leverantörer				
APD-plan				
Ha med materialzoner				
Ha med av- och på-lastningszoner för in- och ut-transporter				
Ha ställningar och hissar i åtanke				
Utvärdera placering av kran för åtkomst till materialzoner och av- och på-lastningszoner				
Namnge zoner, öppningar och dörrar efter funktion				
Upphandlingar				
Bilägg logistikbilagan i kontrakt				
Ha med i kontrakt att UE och leverantörer ska boka in leveranser i leveransplanen				
Överväg vilka leveranser som kräver klockslagsleverans				
Ha med viten för uteblivna och felaktiga leveranser i kontrakt				
Överväg att slå ihop eller dela upp leveranser				
Utvärdera metoder för intransporter				
Användning och behov av hissar, när är de körbara?				
UE och leverantörer ska medverka vid logistikmöten				
Skriv kontrakt där material köps och monteras av samma part på ABT-u eller AB-u och inte ABM				