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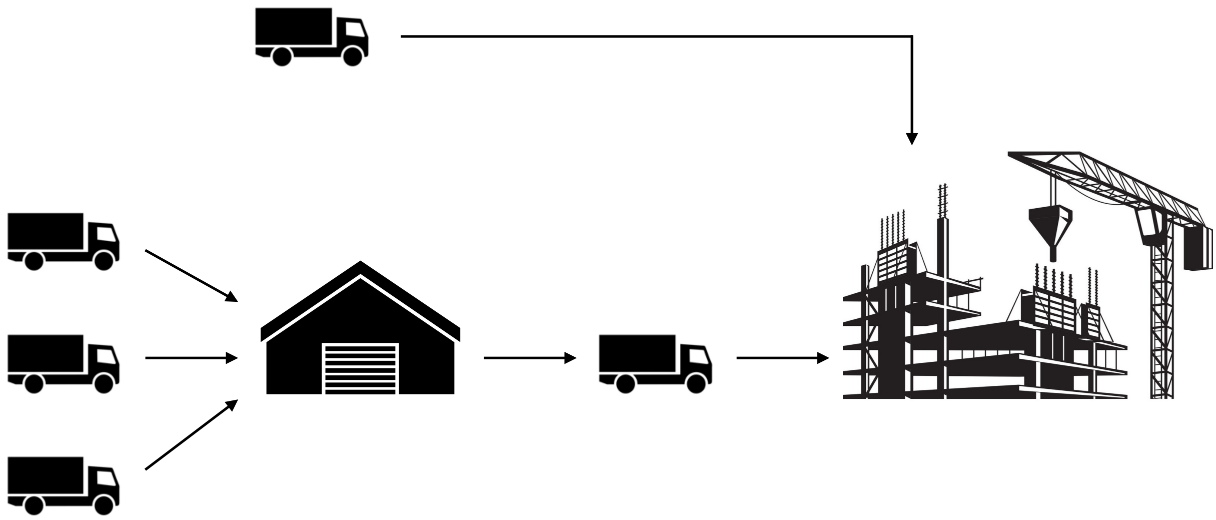

Planning for Construction Logistics

An evaluation and development of a construction logistics plan at Serneke

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

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Abstract

The construction industry in Sweden has a turnover of 639 billion SEK, which corresponds to an increase of 71 % over the last decade. Moreover, Sweden is the fastest urbanising country in all of Europe. Increasing construction within dense cities results in complex processes. Congestion at sites, delayed deliveries and coordination of the supply chain are stated to be some of the main logistics issues in the industry, which suffers from low productivity and efficiency. Therefore, this thesis aims to identify logistical challenges in urban city construction projects for the construction company Serneke and how their logistical processes could be developed to cope with these challenges. Further, the study contributes to the understanding of construction logistics and its importance for Serneke to achieve a successful project outcome. In order to reach results that align with the aim of the thesis, an abductive research method was chosen, comprising a literature review followed by site observations at four of Serneke's projects and interviews with employees at Serneke in different positions. In total, 11 interviews were performed in the study.

The findings from the study show that the processes differ between the projects and the organisation, and the projects have implemented dedicated logistical solutions to a varying extent. Furthermore, the project based nature of the industry seems to lack standardised processes for construction logistics where the logistical responsibility seldom is connected to one person at the site, resulting in un-announced deliveries and a planning that does not correspond with the reality. In order to increase the productivity and efficiency of construction logistics, the contractor has the responsibility of coordinating the activities throughout the project process. A construction logistics plan, is one solution to ensure an efficient logistics process. The plan is a tool for coordinating logistics to overcome the obstacles of congestion on construction sites by addressing how to use e.g. Just in Time, construction consolidation centres, and dedicated planning systems. In addition, standardising a planning and execution process simplifies the transition between projects and the processes it entails. There is still much to improve within construction logistics. Therefore, one suggestion is to investigate key ratios regarding logistics and what economical figures logistics tools could contribute with.

Keywords: construction logistics, consolidation centre, dense cities, construction delivery systems, Just in Time, material handling, logistics planning.

Planering av bygglogistik
En utvärdering och utveckling av logistikbilaga för Serneke

Examensarbete inom masterprogrammet Design and Construction Project Management

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Sammanfattning

I Sverige står byggbranschen för en omsättning 639 miljarder, vilket motsvarar en ökning av 71 % över det senaste årtiondet. Till detta är Sverige det snabbats urbaniserande landet i Europa. Ökad byggnation i täta städer resulterar i komplexa processer. Trängsel på byggarbetsplatser, försenade leveranser och koordination av försörjningskedjan är några exempel på de logistikproblem som industrin ställs inför, en industri som även lider av låg produktivitet och effektivitet. Syftet med detta examensarbete är därför att undersöka hur byggföretaget Serneke hanterar de logistiska utmaningar som de ställs inför när byggprojekt skall genomföras i stadsmiljö och hur deras logistiska processer kan utvecklas för att hantera dessa utmaningar. Vidare bidrar examensarbetet till förståelsen av bygglogistik och dess betydelse för Serneke för att få ett framgångsrikt projekt. För att nå resultat som går i linje med studiens syfte valdes en abduktiv forskningsmetod, vilken innefattar en litteraturstudie följt av platsobservationer på fyra av Sernekes projekt. Till detta genomfördes 11 intervjuer med anställda på Serneke vilka hade olika positioner och ansvar.

Resultaten från studien visar att processerna skiljer sig mellan projekten och företagets huvudorganisation. Projekten har även, i olika utsträckning, implementerat dedikerade logistiklösningar. Dessutom verkar den projektbaserade karaktär som branschen besitter sakna standardiserade processer för bygglogistik där det logistiska ansvaret sällan är kopplat till en person på plats. Detta leder till oannonserade leveranser och en planering som inte stämmer överens med verkligheten. För att öka produktiviteten och effektiviteten av bygglogistik har entreprenören ansvaret av att samordna aktiviteter genom hela byggprojektet. En bygglogistikplan är en lösning för att säkerställa en effektiv logistikprocess. Planen verkar som ett verktyg för att samordna logistiken och för att överkomma problemen med trängsel på byggarbetsplatserna. Detta görs genom att bland annat förklara hur användandet av Just in Time, construction consolidation centers och dedikerade planeringssystem kan användas. Att standardisera en planering- och utförandeprocess förenklar övergången mellan projekt och dess processer. Det finns fortsatt mycket att förbättra medavseende på bygglogistik. Ett förslag för fortsatt forskning är därför att undersöka nyckeltal avseende logistik och vilka ekonomiska följder logistiken kan medföra.

Nyckelord: Bygglogistik, logistikcentra, förtätad stad, leveranssystem, Just in Time, materialhantering, logistikplanering

Contents

Preface

This master's thesis marks the end of our education in Civil Engineering at Chalmers University of Technology. The thesis was conducted at the division of Construction Management at the department of Architecture and Civil Engineering and extends 30 credits. The study was performed from January to June 2018 with a case study that was carried out at the construction department at Serneke in Gothenburg. Several individuals have contributed to the thesis who deservers acknowledgement.

First of all, we would like to express our gratitude to our examiner and supervisor at Chalmers, Viktoria Sundquist. Thank you for your time, your positivity and the feedback you have given us, it has been of high value. Also, the input, ideas and knowledge that we have received over the course of the thesis have challenged us and developed the study. Furthermore, we would also like to express our gratitude toward Serneke and our supervisor Joakim Antonsson along with all the participating interviewees for allocating time and contribute with experience and knowledge, this study would not the possible without you.

During the course of the thesis and the completion of our master's education, we have gained extensive knowledge in construction logistics and its importance within the industry.

Thank you all!

Oskar Andersson & Andreas Nilsson
Gothenburg, June 2018

Notations

CCC	Construction Consolidation Centre
CLP	Construction Logistics Plan
CPM	Critical Path Method
DB	Design Build
DBB	Design Bid Build
JIT	Just in Time

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1 Introduction

The first chapter aims to describe the background of the study together with the aim of the thesis, its delimitations and the thesis outline.

Globally, the construction sector is one of the largest and most influential economies in the world (McKinsey Global Institute, 2017). In addition, the turnover within the Swedish construction industry during the last decade has increased with 71%, resulting in a total turnover of 639 billions SEK, divided between 73 000 companies and 225 000 employees (Sveriges Byggindustrier, 2017). Even though the construction industry is one of the largest economies in the world, it lacks in productivity (McKinsey Global Institute, 2017) and efficiency (Fernández-Solís, 2008). According to McKinsey Global Institute (2017), the construction industry suffers from a lower amount of added value per worker compared to the world economy and the manufacturing industries. Material transportation, employees waiting for material or other processes to be completed and rework are key factors that contribute to the low productivity in the industry (Josephson & Saukkoriipi, 2005). Productivity is also closely related to the ability of managing and eliminating time and material waste throughout the entire supply chain (Josephson & Saukkoriipi, 2005). In addition, Fernández-Solís (2008) describes that the construction industry is also less effective compared to the manufacturing industries. The main reason for this is because of the complexity of producing customised, unique products in a shifting environment due to the characteristics of the site and the shifting project teams. Adaptive on-site changes, complex operations and long lead times are also mentioned as reasons for the lower efficiency. Adapting new technology and emphasising on more innovative processes, such as supply chain management, SCM, and lean construction, together with an improved on-site execution are some of the solutions that could improve the industry (McKinsey Global Institute, 2017). Above all, lean construction emphasis on cutting waste along the supply chain (Josephson & Saukkoriipi, 2005) and the SCM approach promotes an increased transparency along the supply chain which enables a smoother process and a more sophisticated logistics management (McKinsey Global Institute, 2017). However, the construction industry is known for being slow to implement and adapt such an innovative logistical solutions and strategies (Sullivan, Barthorpe, & Robbins, 2010).

Relating to the construction industry's increased turnover on the Swedish market over the last decade, Sweden is the fastest urbanising country in all of Europe (Ljungberg, Sundberg, & Wendle, 2012). The western regions of Sweden are no exception from this trend of creating more coherent cities (Borås Stad, 2017; Göteborgs Stad, 2014; Trollhättans Stad, 2017). According to Sullivan et al. (2010), deficient attention has been given to logistics in the construction industry. Further, it exists four main reasons why one should focus on construction logistics. First, maximise the productivity and efficiency at the construction site; second, maximise the quality of the logistics; third, minimise the negative environmental impact that the construction industry causes; and finally maximise the safety and health on site. As a result of the densification, the society experiences an increased construction in the city areas with the logistical difficulties it entails, resulting in construction logistics being of greater importance than ever before.

When carrying out a construction project in a dense city area with the lack of available space it entails, the processes of construction logistics becomes more complex (Lindholm & Browne, 2015). The transportation, both inbound and outbound the construction area is affected in greater extent and the congestion makes handling and storage of materials more problematic which highlights the importance of having a well-designed material planning system (Sobotka & Czarnigowska, 2005; Sullivan et al., 2010). Sobotka and Czarnigowska (2005) quantify this by advocating that up 70 % of the total project cost are directly related to material costs. Not only focusing on the material aspect of logistics, Josephson and Saukkoriipi (2005) stress the importance of a well-designed supply chain and describe that it is essential throughout the whole construction process, both in an operative manner i.e. at the construction site, but also in supportive functions inside the organisation and the organisation management.

The issues addressing construction logistics in operative and strategic levels in an organisation is in this thesis conducted together with the company Serneke, a Swedish contractor founded in 2002 with approximately 1000 employees (Serneke, 2018e). The thesis is conducted as a single case study, applied on four of Serneke's projects in the western Sweden. The projects are of different characteristics and includes the construction of a shopping mall in Kungälv, new office spaces in Gothenburg, apartments in centre of Trollhättan and a congress centre in Borås. Common for all the projects are that they are all facing logistical difficulties due to the being constructed in dense cities and with limited space. The focus of the thesis lies on logistical solutions at the construction sites and their interfaces. In addition, one of the projects uses a logistical plan while others do not. The plan includes details on how to integrate logistical solutions as well as how the logistical responsibilities are distributed and tailored to fit the project where it is applied.

1.2 Aim and research questions

The aim of this thesis is to identify logistical challenges in urban city construction projects for Serneke and how their logistical processes could be developed to cope with these challenges. To concretise the purpose of the study, the following research questions will be addressed.

1. How are logistics processes, from a strategic and an operational perspective, conducted at Serneke today?
2. Which are the main barriers for an efficient logistics at Serneke and which factors are affecting how construction logistics is conducted?
3. How is Serneke utilising the existing logistics plan today as to contribute to efficient construction logistics?
4. How could Serneke's logistics plan be used and developed in order to address the logistical challenges in urban city construction?

1.3 Delimitations

This thesis addresses logistical challenges from the studied contractor's perspective and how the contractor chooses to work with their logistical processes. The logistical segment in this thesis is limited to transportations to the site and does not focuses on material or waste leaving the site due to e.g. defectiveness. Furthermore, this thesis does not consider clients, suppliers or sub-contractors involved in the investigated projects. Aspects regarding environmental classifications that could affect construction logistics will not be considered. Finally, this thesis is limited to the studied projects and the context in which these projects are conducted and therefore does not provide the reader with a complete overview of the industry or the case company. Nevertheless, results and logistics solutions may be applicable on the construction industry in general and the other projects of the case company in particular.

1.4 Thesis outline

The thesis is divided into six chapters. Underneath are the chapters presented in order and described with their respective content;

Chapter 1 – 'Introduction'

The first chapter aims to give an introduction to the subject, addressing why logistics is important in the construction industry. The case company Serneke is briefly presented together with the investigated projects. Furthermore, the aim of the thesis and its limitations is presented.

Chapter 2 – 'Theoretical Framework'

The second chapter provides research on the subject and strives toward giving the reader a sufficient theoretical background. The theoretical framework will, together with the empirical data collection, form the basis for the analysis.

Chapter 3 – 'Research Methodology'

The third chapter contains the research methodology. The chapter describes which methods that have been used to retrieve empirical data, to conduct the theoretical framework and to perform the interviews. At last, a description of the ethical conduct and trustworthiness has been treated.

Chapter 4 – 'Empirical Findings'

The fourth chapter describes the empirical findings of the four projects in detail. Its purpose is to provide a deepened understanding of the logistics and the logistical issues at each of the projects involved in the study.

Chapter 5 – 'Analysis'

The fifth chapter contains the analysis between the theoretical framework and the collected empirical data. The chapter aims to highlight the importance of the research questions and point at similarities and differences between the theory and the empirical data. In addition, the authors of the thesis will share their thoughts on the subject and the presented findings.

Chapter 6 – 'Conclusion'

The final chapter provides the conclusions to the research questions. It also provides recommendations for Serneke in terms of what need to be done in order to improve logistics together with further areas of research.

2 Theoretical framework

The following chapter provides theory related to how the construction industry have been dealing with logistical issues throughout the history. In addition, concept and innovative solutions that may positively influence the logistics in the industry is also treated. The framework is divided into 6 subsections starting with an *Introduction to the construction logistics* in order to provide the reader with a context to the subject. Both a traditional view of the industry as well as how the industry could be improved and the importance of construction logistics is treated. Furthermore, *Supply chain management* and *Lean construction* is presented as a more modern approach to improve the logistical processes. Moreover, *Logistics tools* used in the industry are presented, followed by a presentation of different *Procurement forms* and how they could affect construction logistics. Finally, a summary of the *Theoretical context* is presented with emphasis on relating the presented concepts and theories to the thesis research questions.

2.1 Introduction to construction logistics

The construction industry is in public defined as a slow and uninventive industry (Persson, Bengtsson, & Gustad, 2010; Vrijhoef & Koskela, 2000). As a result, the process from fundamental idea of a project until the completion contains inefficient supply chains which in turn is connected to high costs. According to Sobotka and Czarnigowska (2005) and Fernández-Solís (2008), the construction industry differs from other industries by the project nature and so does the integrated supply chains which often result in a complex environment. The complexity originates from e.g. the surrounding environment where the construction takes place, the available resources, the level of scientifically knowledge required and the number of activities in need of coordination (Gidado, 1996). In general, the reasons may be arranged in two categories, *Uncertainty* and *Interdependence*. *Uncertainty* deals with components embedded in the nature of the individual task and the environment in which they are performed. *Interdependence,* involves the complexity regarding coordination of activities. In addition, today’s society and its construction clients requests shorter project duration of more complex projects (Koskela, Howell, Ballard, & Tommelein, 2002). The category of *interdependence* advocates that the way of coordinating the sequences should not be standardised. The construction industry is also highly influenced and steered by governmental regulations and decisions (Dubois & Gadde, 2002a).

2.1.1 A traditional view on the construction industry

Constructing a building is inherently considered as an activity carried out on a construction site in form of a project (Cox & Thompson, 1997; Halpin & Riggs, 1992; Shirazi, Langford, & Rowlinson, 1996). In addition, Shirazi et al. (1996) state that construction is mainly about coordinating the area specialists and the tasks at site. However, construction projects are often treated as single entities without clear connection to the parental firm (Engwall, 2003). From this point of view, all projects are considered as unique undertakings and “economies of repetition” are neglected even though one project probably contains activities that may be regarded as repetitive from previous projects. Nevertheless, the success of a project is likely to be more dependent on the experiences of key team members involved in the project than on specific management skills and techniques.

In order to execute a project, the firm's resources need to be managed in a sufficient way (Halpin & Riggs, 1992). Therefore, it exists an embedded hierarchy which deals with different tasks in order to reach a high degree of success within the firm. The hierarchy can be summarised in the following four stages. First, the organisational level responsible for the business structure, management and interaction between head office and the field managers, which projects to submit tenders to and which resources to recruit. Second, the project level addresses the projects purpose and breakdown together with cost and time control. Third, the operational level deals with on-site processes and details of the project performance. Finally, the fourth level considers identification and assignment of isolated work tasks to middle managers. Furthermore, it is stated that the traditional way of deliver a construction project favours the transformation of the building while neglecting both value maximisation and waste elimination (Koskela et al., 2002). Moreover, as an attempt to simplify the complex nature of construction projects, different tools are used to divide the project into smaller, and more manageable pieces (Project Management Institute, 2013). Work breakdown structures and the critical path method, CPM, are both traditional examples of how the projects are divided and arranged in a logical order for execution whereon the main schedule is created. Finally, the activities are assigned to internal capacity or sub-contractors through external contracts (Koskela et al., 2002). Thereafter, site managers use the main schedule and pushes activity start according to the earliest start date. Late changes in the design of the project affect the processes, but to which extent is hard to measure (Dubois & Gadde, 2002a). In addition, capacity in form of equipment is often seen as a project temporary resource that can be purchased or leased in the appropriate time and thereafter returned when it is no longer useful (Paez, Salem, Solomon, & Genaidy, 2005).

The traditional way of addressing planning and execution of a construction project suffers from an imperfect view of the project itself, the activities involved and the general control (Koskela et al., 2002). Furthermore, the use of output measures leaves the project management with little opportunity to affect an escalating situation. The increased complex construction in combination with shorter project duration forces the industry to reconsider and innovate the processes involved when carrying out a project. Even with highly detailed schedules originated from the CPM, coordination of these new projects cannot be assured since a smooth handover of one activity to the next is assumed or neglected. Despite attempts to bring parties closer to each other in terms of business relations, supervisors tend to ensure the own business in favour of others and the risk of sub-optimising is imminent. Focus on improving isolated activities often result in a reduced project performance.

2.1.2 Improving the industry

The constructed society is developing and expanding through different pattern and trends. The ongoing trend in city planning is densification of cities (Mattson, 2015). Along with the densification, the construction industry moves into the city with the logistical problem that it entails. Lack of space, limited transportation routes and closeness to third party are some of the issues in need of solutions (Sullivan et al., 2010). When both transportation possibilities and space becomes limited, the importance of addressing the logistical issues early in the planning process, to avoid disturbances, becomes greater.

The construction industry also differs from other industries through the processes involved, the environment in which it takes place and how the roles of the parties involved may vary from one project to the next Dubois and Gadde (2002a). Sharing a common sense of how things should be executed and what practices that rules, has created a community of practice. These, often unspoken, practices serve as an informational coordination between involved parties in the construction industry. Even though the construction industry differs from other industries, the progression of cutting cost and increasing efficiency has not passed unnoticed. The impact of adopting techniques such as Just in Time, JIT, and strategic partnering relations with suppliers is questioned through the literature. The question addresses whether such techniques could help to improve the efficiency in the construction industry, like in other industries, or if implementing them could result in the opposite due to the complex nature of construction.

Efficiency in the construction industry is today driven by competitive tendering, which advocates the use of standardised products (Dubois & Gadde, 2002a). Customised solutions will not be promoted unless the industry changes the norm of purchasing and external contracting. In addition, this nature of purchasing also forms the basis of relationships between parties in the industry which is regarded as market based and short term. Observing the construction industry from an operative point of view, two features can be highlighted (Dubois & Gadde, 2002a). The first feature is on the individual project in terms of decentralising the decision making, due to local knowledge of the site that top management may lack. The second focus addresses local adjustments due to lack of complete specifications, unpredictable environment and the issue of uniformity. The construction industry has developed a working environment where the use of standardised products is advocated and preferred above standardised processes. However, if the second focus prevails, the project could benefit from having standardised processes.

Several authors claim that the best way of ensuring project success is through letting a powerful project manager steer the project with vague connection to the parental organisation (Engwall, 2003). Therefore, the accepted view of projects being a lonely island in the context of the larger organisation. However, it is advocated that instead of treating each project as a lonely and closed system, all projects of a contractor should be regarded as part of the larger entity (Dubois & Gadde, 2002a; Engwall, 2003). Every contractor dealing with more than one project at the same time needs to coordinate its resources according to the different phases in the projects in order to ensure maximum output (Dubois & Gadde, 2002a). Even though there is a large possibility that efficiency will rise if the same teams and roles are repeated from one project to another (Gidado, 1996), it is not common (Engwall, 2003). Even if the team members might be the same, their roles in the project are likely to have changed. Due to the inconsistency in team composition, the project management technique or approach successful in one project is not necessarily successful in the next (Engwall, 2003). In addition, in order to coordinate the available resources, the contractor needs to embed slack in the planning in order to deal with potential shifts in activity duration. If not, there is risk of transferring knock-on effects from one project onto the next. Since the contractor's projects often are competing for the same human resources, both internal and external, there is a risk that projects may lack resources if the planning is not sufficient.

2.1.3 Construction logistics definitions

Like other phenomenon, there is not one definition of logistics in general and hence there is not one for construction logistics in particular either. However, as the definitions below states, construction logistics entails operations throughout the supply chain. The European committee of Standardisation defines logistic as:

> "Logistic comprises planning, organising and control of flows of goods from their purchase, trough processing to distribution to the end user, in order to fulfil market requirements and by minimal cost and capital engagement" (Sobotka & Czarnigowska, 2005, p.74).

The Chartered Institute of Logistics and Transport in the UK states that logistics is:

> "the process of designing, managing and improving such supply chain which might include purchasing, manufacturing, storing and, of course, transport." (Sullivan et al., 2010, p. 4).

Sobotka and Czarnigowska (2005, p.74) specify construction logistics by adopting the definitions made by Christopher (1992):

> "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 customer".

Furthermore Sobotka and Czarnigowska (2005) advocate that there are two approaches regarding logistics in construction, the traditional approach and the modern approach. The traditional approach states that reducing inventories of resources is the way to improve logistical chains. Meanwhile, the modern approach considers frameworks of supply chain management where coordination between material flow and information flow is important. Logistical concepts may therefore be visualised as both a system of different resources and a way of managing these resources by ensuring the efficiencies of its flows. To summarise, the definition of logistics and logistics management varies but essentially it entails the process of ensuring that a product or service is in the right place; at the right time; in the right quantity; at the right quality; and at the right price (Lundesjö, 2015). However, it is a common view that construction logistics entails several processes within the construction industry and hence, supply chain management, SCM, has been a key concept to consider for the parties in the industry.

2.2 Supply chain management

SCM has become one of the most important aspects to consider to gain competitive advantages on a market (Lee, 2002). In addition, SCM is regarded to be synonymous to logistics management which is about both managing the flow of information and material throughout the entire supply chain (Taylor, 1997). Vrijhoef and Koskela (2000) explain that there are four different roles connected to construction supply chain management. The characteristics of these roles shift depending whether the focus lies on the supply chain, the construction site or on both of them. The first role focuses on reducing time consumption from activities and cutting overall costs on site. The role strives toward ensuring reliable material and human resources at the construction site to avoid disturbances. The relationship between the site and its direct suppliers is the single most important factor in the first role which is primarily adopted by a contractor. The second role does not solely focus on cutting on-site expenses. Addressing the issue one step further, this role also focuses on cutting costs along the entire supply chain which includes cost of transportation, lead-times and inventories etc. The second role is more commonly associated with different suppliers. The third role focuses on transferring on-site activities up-stream the supply chain to avoid interference on site between activities. Historically though, this has been found difficult in the construction industry due to the activity dependency on site. Both contractors and suppliers may initiate the third role. The last role focuses the attention to the integrated management and is trying to emphasise a holistic view on the entire supply chain. Considering the construction site to be a part of the supply chain and not a separate phase in the end of it. In addition, this the fourth role may also be introduced by the clients, contractors and suppliers.

SCM in the construction industry is stated to be diverse from other industries due to its many actors with different organisational characteristics and purposes (Lundesjö, 2015). This makes logistics management coordination more complicated than in other industries. Nevertheless, it makes the SCM more important during construction where flow of material is critical in order to use resources and equipment in an efficient way. The rather complex supply chain in construction may, according to Dubois and Gadde (2002a), be explained as a loose and a tight coupled system. Deliveries can be performed from a warehouse, which often includes smaller orders, or from a factory which often is connected to large order quantities with longer lead times. Thus, the supply chain is loose in the sense that the site production is not directly connected in off-site material production and therefore hard to control or predict. In addition, the supply chain is also a tight coupled system between the activities on site and along the supply chain. The coordination between the loose and the tight system is essential in order to ensure the material needed on site, which otherwise could cause disturbances and affect the production plan.

Robbins and Thomas (2013) explain that even though insufficient amount of resources are focusing on logistics, techniques over best practice for construction logistics has emerged. These methods include checkpoints for sub-contractors and suppliers in order to coordinate JIT-deliveries; off-site construction consolidation centers, CCC; a dedicated logistics team at site that are responsible for all activities connected to logistics and a construction logistics plan, CLP, which is a document that defines the logistics for the specific project. Yet, this is still not a common practise in the industry but instead the logistic management is often confined to the site, with short term planning, and ignores off-site supply chain and resource efficiency (Lundesjö, 2015).

2.2.1 Logistics Manager

The logistics manager is the latest, by the industry, accepted role even if the need of coordinating logistical processes has been ever present (Lundesjö, 2015). Having a well-functioning supply chain in the construction industry, like in many other industries, is crucial for success and with more complex construction in denser cities, the demand for efficient logistics is more important than ever (Brown, 2013). Lundesjö (2015) explains that the client often is aware of the importance of logistics and the impact poor logistical planning can have on the final cost and quality of the project. Furthermore, logistics within the construction industry need to follow the development of new tools and phenomena such as building information modelling, BIM, and IT solutions. In construction projects today, the logistics managers are claimed to have much influence in the project teams and the tasks of a logistics manager stretches from planning to delivery and everything in-between. However, the general task of the logistics manager is to oversee all aspects regarding the logistics supply chain in the project. Furthermore, the logistics managers need to aim their attention to both material, human and equipment movement. The planning includes creating a site layout in order to ensure a secure and efficient location and how people, material and machinery should be moved around the construction site. A well-planned logistics system is also permeated by clear communication throughout the supply chain which includes information about delivery routes and clear marking for suppliers and sub-contractors, the logistics manager is responsible for overlooking the supply chain where controlling and planning daily, weekly and short-term material flows are the main factors. In addition, the logistics manager is in charge of managing the sub-contractors regarding logistics and coordinate the deliveries.

2.3 Lean Construction

Post the Second World War, Toyota found themselves competing with industry giants such as Ford and General Motors for market shares in Japan (Liker, 2004). In contrast to these giants who mass-produced their vehicles, Toyota were forced to maintain flexible around their production line which led to a discovery crucial for the birth of lean production. With short lead times and flexible production lines you can achieve better quality, customer responsiveness, productivity and utilisation of space and equipment. Instead of optimising one process to achieve a low cost per piece, Toyota choose to aim their focus on eliminating material and time waste throughout the entire process and thus create a mind-set of flow in their organisations.

Lean construction emerged as a concept in the mid-90’s and is a result of designing the construction processes and its production systems to the model of lean manufacturing, i.e. to minimise waste of materials, time and effort (Koskela et al., 2002). In addition, focus lies on maximising the value output by utilise the value added by all work processes form idea to construction delivery. Workflow reliability and labour flow are stated to be key determinants of the construction performance. For a lean project delivery system to be effective it must pursuit the three goals of transformation, flow and value adding. Organising and preparation are also key factors in order for the operational activities to be carried out smoothly (Koskela et al., 2002; Paez et al., 2005). In addition, the predetermined goals are stated to be achieved through commitment and two-way communication (Paez et al., 2005). There are two general ideas of what the concepts of lean construction can provide and aid within the construction industry. The first one is regarding the application of lean production method into the construction industry. The second forms a basis of a new mind-set within the industry. Until today, the main focus of implementation has been on creating continuous flow, pull production and continuous improvement.

The construction industry consists out of, and has therefore been focusing on, one-of a kind production which does not have any fixed sequences that can be standardised (Paez et al., 2005). Even though some of the features of traditional practice seems like they could be a part of lean, the processes are often not deep enough in their nature to be considered as a lean process (Koskela et al., 2002). The main difference between lean construction and the traditional view of conducting a construction project is that lean treats all activities as part of something larger and not like isolated activities (Koskela et al., 2002; Paez et al., 2005). By combining the focus of the activity interaction and the task execution, it is stated that lean may create higher performance. In addition, another key difference between the traditional way and lean construction is that the latter considers the relationship between the construction phases and its participants (Koskela et al., 2002). Lean construction advocates that involving all the stages of the constructions life cycle is of importance. The mentality of solely focusing on the own working task and "throwing the result over the wall" for the next workforce to catch and continue the progress, is stated to be a problem in the traditional way. As an example, the project design is often conducted between an architect and the construction client. Seldom do they have an interplay with the contractor or other area specialists which may cause problems in the construction phase. Concerning the matter of putting the own firm in front of the others, traditional construction management has a tendency to freeze the construction design rather quickly. In the short run there is time to spare but there is imminent risk of creating rework since changes made to benefit one area specialist might sub-optimise the work of another. Lean construction advocates that decisions regarding design are made at the last responsible moment. Together with the focus of reducing lead times, time waste, lean construction tries to postpone this point of decision in order to create more time for the design and hence, higher customer value generation. The core differences between lean construction and the traditional delivery approach are presented in Table 2.1.

Table 2.1 – Core differences between conventional construction and Lean construction (Adapted from Koskela et al., 2002)

Lean	**Traditional**
The production system is in focus	Transactions and contracts are in focus
The upstream actors are influenced by the downstream actors in their decision making	Sequential decision making from area specialists whereon the decisions are "thrown over the wall"
Processes and products are designed as a joint effort along the entire supply chain	First the product design is completed, after that the process design begins
Activities are performed as late as possible at the *last responsible moment*	Activities are performed at the first available opportunity
Efforts are made to reduce lead times along the entire supply chain	The linkage between organisations are neglected and instead you take what the market offers you
Learning is a natural element into project, firm and SCM	Learning is not incorporated in the processes, instead it occurs sporadically
Buffers and their location is dimensioned to fill its purpose of reducing the effects of system variability	The involved parties build up large inventories to protect their own interests

Lean construction has adapted tools and techniques from lean manufacturing as well as developed unique ones for the industry itself. Some of the more frequently used tools and techniques of lean construction is presented below.

2.3.1 Push and pull in the construction industry

Conventional planning in the construction industry is connected to a push system where the master schedule controls the deliveries and the production (Kalsaas, Skaar, & Thorstensen, 2015). Furthermore, the CPM and a push system does neither consider the amount of work in process and the state of the system, nor how the different units are coping in the system (Ballard, 2000). Instead, the system releases order according to a dispatch list, i.e. the master schedule. However, with careful planning and control systems, a pull system for production is stated to be more efficient and considers the material needed at the site and the actual production (Kalsaas et al., 2015). The deliveries are, in a pull system, coordinated to when the production is ready for it, where material and deliveries are being triggered from downstream activities. This makes pull system in construction a more flexible way of working and is desirable due to many changes in the master schedule (Seppänen & Peltokorpi, 2016). It is also desirable in order to avoid congestion on site since the system considers the production progress and thus, uncertainty is decreased since accuracy can increase. In order to visualise the need of material and deliveries on site, a Kanban system where notes are used to signal upstream processes in order to increase pull for construction (Kalsaas et al., 2015). In a perfect one-piece flow, inventories do not exist and goods will show up when needed (Liker, 2004). However, this is not applicable in the reality and therefore the next best choice is often referred to as Toyota's Kanban System. Kanban derived as a replenishment system for downstream processes to signal upstream processes when in need of replenishment. Through this system, flow and production of materials are kept in a JIT system and interruptions are expected to be avoided. In construction, the system is based on key concepts such as marketplaces, milk-runs, satellite stores and inventory management systems (Paez et al., 2005). At site, the marketplace is represented by a site warehouse which distributes material and smaller tools. Adapting to the construction industry the fundamental idea is that processes starts with open orders. The sites are thereafter able to pull material from the suppliers up to a predetermined limit. The requested material arrives at the market place and the products are distributed from the store. The store inventory is controlled and replenished through a re-ordering point.

Nevertheless, it is explained that the complexity construction projects faces, makes it important to separate different levels in production when looking at push and pull systems, e.g. the production could be seen as a push system while higher level planning should be considered as a pull system. However, Ballard (2000) claims that increased flexibility is not always a possible solution in the construction industry. Many sub-contractors and suppliers are procured a long time in advance and some materials requires push in production due to long lead times from suppliers. Hence, moving to a production system which solely is based on a pull system would be a complex task.

2.3.2 The Last Planner System

The Last Planner System, LPS, is stated to be the single most important tool of all lean construction tools (Koskela et al., 2002). First presented by Ballard (2000), the LPS addresses the variability within the construction industry. The high level of planning needed to realise a construction is depending on completion of activities. All processes connected to activities will ultimately lead to physical execution of one individual or a group of people. In addition, there will be someone accountable for the execution and hence the production unit control. This responsible group or person is called the *last planner.* The traditional execution does not consider the difference between what should, can, and will be done and pushes activities with the belief of achieving better results. As a consequence, production is often running late which is a result of lack of collaboration between client, contractor, suppliers and sub-contractors in the planning process (Daniel, Pasquire, Dickens, & Ballard, 2017). Fundamental for the LPS is the workflow control which is conducted to ensure the flow of design, supply and installation (Ballard, 2000). It is performed by splitting the main schedule into pieces, often 3-12 weeks, creating a look-ahead schedule that in detail explains the method of execution, check for capacity and determine a backlog of ready work. The LPS is described to create a social process where the actors performing the task should be involved in the planning which increases in detail as the task is due to be performed (Daniel et al., 2017). This would also increase pull for production when decisions are made late in the process and thus minimising the uncertainty.

2.3.3 Challenges of Lean Construction

Achieving a fully lean process is impossible since it would require to provide a unique product to each customer, in zero time, with no waste or storage (Koskela et al., 2002). Nevertheless, there are clearly some positive benefits of creating a “leaner” process. However, to adopt a lean-based project management requires lot of attention and effort. Changes will not only be required by the people involved and their individual approach to construction but also of the embedded culture within the industry. To substitute the current practice, these issues must be considered and solved. Changing procedures and techniques in production and processes are in the context easy, whereas changing mind-sets are considerably tougher. Another problem with implementing lean in the construction industry is that the people active in production focus on single point efforts, with lack of an overall understanding of the lean mind-set (Granja & Picchi, 2004). The techniques used in the construction industry are both techniques directly adapted from e.g. the manufacturing industry as well as ones developed to fit into the context of construction (Gao & Low, 2014). The construction industry, unlike the manufacturing industry, is performing unique projects without a predetermined and standardised task order and hence, the process cannot be standardised (Paez et al., 2005). In addition, the construction industry suffers from not being able to utilise gained experiences due to significant shorter project duration. Nevertheless, the only way to succeed is by trying to be consistent even though the probability of instance positive results is low (Koskela et al., 2002).

Lean construction is still a work in progress, and is likely to be so over a period of time (Koskela et al., 2002). Nevertheless, the approach is better founded within theory than existing ways of construction and even more efficient. Lean is not just another approach to construction, but instead a challenger of the traditional understanding and practice within the industry. Team work, problem-solving and creative thinking are areas of focus regarded as key elements for the success of lean construction. The technical elements of lean construction rely upon the performance of all participants. If the firm lack capable workforce, outcomes of the performance will always be limited.

2.4 Logistical tools

Ensuring that material arrive at the right time and in the right quantities are crucial for the construction project and controlled by the logistics management (Lundesjö, 2015). A sufficient logistics management enables more free space at the site and avoids congestion. In addition, the construction site's resources can be utilised to its maximum. In order to manage the logistical challenges in today's construction, several tools have emerged. The tools explained in this chapter are *Construction logistics plan, Construction site layout, Delivery management systems* and *Construction consolidation centres*.

2.4.1 Construction Logistics Plan

A CLP, is a document to plan and streamline the logistical processes (Lundesjö, 2015). The CLP aims to provide a holistic view of the logistical work in the project and stretches from initiation of the project to commissioning and everything in-between, which is described in Table 2.2. The CLP is explained to benefit a more structured and controlled way of working with construction logistics, which the industry is in great need of. In more detail, the CLP serves as a document that will clarify the constraints of the project regarding logistics and should be produced by the main contractor. The document should provide a holistic view of the relevant logistics in the project and be a communicative tool for the management regarding receiving, storing, distributing materials and managing waste along the entire supply chain. However, the usage of a CLP is known to be rare and logistics coordination is often confined to the site only, overlooking the complete supply chain.

Table 2.2 – Content of a CLP in different project stages (Adapted from Sobotka & Czarnigowska, 2005)

Construction logistic planning system	
1 Initiating	• Preparation of logistical guidelines for the construction site • Strategic planning for the project management
2 Design	• Preparation of logistical guidelines for the design • Preparation of requirements specification • Logistical guidelines for the tender preparation • Quality system of logistical service
3 Planning	• Preparations of schedules and charts of labour and equipment utilisation, sub-contractors work and material consumption • Preparations of a logistics concept of the construction site • Design of the installations on site and how to disassemble these • Preparations of guidelines for lease or purchase of machines • Preparations of selection of suppliers • Assessment of logistical service efficiency and impact on the environment • Preparation of planning and placing orders, scheduling and deliveries • Waste management planning
4 Execution	• Work progress monitoring • Schedules and plans updating • Adjusting orders to current demand for resources, workforce, materials and sub-contractors • Planning and coordinating deliveries, loading, un-loading and warehousing, distributing • Implementing logistic service quality standards • Managing waste
5 Commissioning	• Dismantling of site installation • Managing information flows and documentation

2.4.2 Construction site layout

One step in order to create a mutual understanding of the site and how the space should be utilised is by creating a construction site layout. Further, a visual representation of a project may result in a shorter project duration and one step in this process is a construction site layout (Hammad, Zhang, Al-Hussein, & Cardinal, 2007; Ma, Shen, & Zhang, 2005; Russell, Staub-French, Tran, & Wong, 2009). Historically, even though conducting a site layout is regarded as a standard routine for site managers and project managers, it has been given little attention due to its complexity (Hayes-Roth, Levitt, & Tommelein, 1992a). The complexity originates from the problem of allocating space to objects at the same time as managing the changes during production as a direct cause of the construction schedule. Furthermore, a suitable site layout often deals with paradoxical objectives resulting in that the site management must prioritise the most important factors in each case. For example, reduced traveling time affects the congestion on site. As a result of not fully solve the complexity problem, construction sites suffer from lack of optimisation and miss-out potential improvements and benefits. Dawood and Mallasi (2004) express that workspace interferences could reduce productivity with approximately 40 %. In addition, it is hard to directly link project savings or avoided costs, due to the site disposition, which makes it even harder to advocate the importance of a well-planned site. However, site layout objects, such as temporary facilities, equipment material and access roads, corresponds up to 10 % of the direct costs of a project (Andayesh & Sadeghpour, 2015; Hayes-Roth, Levitt, & Tommelein, 1992b) and according to Handa and Lang (1989), the potential savings of good planning may be between four to eight times the cost of the preplanning. In addition, Hayes-Roth et al. (1992b) state that a well-designed layout do pay off, if the management are given the time needed and are willingly to put the effort down needed to create and manage it.

Due to its complexity the site disposition often suffers from being an isolated problem (Hayes-Roth et al., 1992a), which is dealt with first after construction scheduling, resource allocation and budgeting is performed (Hayes-Roth et al., 1992b). In addition, the site design will, consciously or unconsciously, be affected by the individual responsible for the design due to the person's previous experiences, priorities, involvement in the project and personal relationships within the project. Even though it does not exist a rule of how one should prioritise, Russell et al. (2009) advocate that there are two fundamental ideas for performing a site disposition. Either the labour-oriented buildings are located near the work site which may reducing traveling time for workers or the material-oriented structures are located closest reducing the time of material handling. In addition, Andayesh and Sadeghpour (2015) address the issue one step further and present three approaches to create a representation of the site disposition. *The static site layout planning* does not consider changes that occur over time. Instead the site is represented in a simplified way and it is assumed that all objects exist on the site during the whole construction process. *The phased site layout planning* divides the project into several time intervals and one separate layout is created for each interval. *Dynamic site layout planning* which allocates space to objects for their project lifetime. This means that space can be reassigned to other objects and the approach is stated to address space requirement more realistically. Nevertheless, having a realistic representation of the site is important (Hayes-Roth et al., 1992b). On-site changes will occur during the project and it is important to review the site disposition sketch with regard to changes connected to occupation and site usage (Andayesh & Sadeghpour, 2015). Despite this, the sketched layout is rarely updated as the project proceeds and hence, the document becomes less valuable (Hayes-Roth et al., 1992b).

2.4.3 Delivery management systems

Even though technical systems in today's society are developing rapidly, the construction industry seems to be unwilling to transfer to technological tools and solutions (Hagenbjörk, 2014). Delivery plans are lacking standardisation, structure, efficient communication and digital support. A delivery management system provides a basis for the movement of coming and leaving vehicles to the construction site, and enables the contractor to plan deliveries and be notified when they arrive (Lundesjö, 2015). The system also allows the site management to refuse deliveries that are early or late to the site, which is managed by controlling the resources needed for loading and un-loading material. Furthermore, the system can be used in different ways, from a whiteboard in the site office to spreadsheets or a complete digitalised system. It is also explained that the usage of a whiteboard is the most common feature in today's construction but digital systems are increasing. The use of a whiteboard is stated to be manageable at a smaller construction site where one person is responsible for the deliveries. However, it is also easy to make mistakes and miss out on delivery changes when using this approach. The spreadsheets are a more sophisticated way of working compared to using a whiteboard, but still disposed to operator error and requires management to be updated which also makes them suitable for smaller construction sites. Finally, the digital delivery systems are made for larger and complex construction sites with the benefit of truly being a multi-user system which could be managed from different location. It could also minimise the risk of deliveries getting booked at the same unloading zone and ensure that unloading vehicles and necessary personnel are ready to receive the order. A system like this will also decrease the potential waiting time for the truck driver and ensuring available space for the delivered material. However, the higher cost may make it unnecessarily in some projects where the other methods mentioned would be sufficient.

2.4.4 Construction Consolidation Centre

The construction industry is permeated by many transportations, mainly due to transport of material to and from the construction sites (Lundesjö, 2015). Furthermore, the material is often purchased from different suppliers who deliver on separate vehicles, without mutual coordination and timekeeping which lead to congestion at the construction sites. In addition, many deliveries are also in small quantities, containing a few packages, resulting in an additional number of transportation.

As a way of ensuring precise deliveries and addressing the described challenges, CCC may play a large role in the construction industry (Hamzeh, Tommelein, Ballard, & Kaminsky, 2007; Lundesjö, 2015). The CCC is a buffer storage that is supposed to store material for a limited time period before transportation to the construction site, see Figure 2.1. (Sullivan et al., 2010). When striving for on-time and precise deliveries in order to avoid congestion on site, it is less risky and more easily controllable to use a CCC instead of having each delivery done by the sub-contractors or suppliers themselves (Lange & Schilling, 2015).

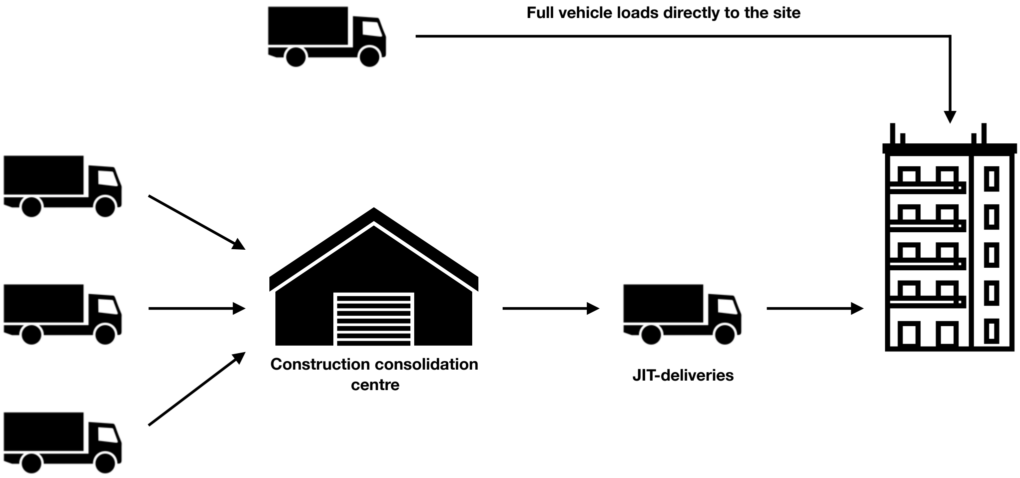

Figure 2.1 – Different delivery procedures to the construction site, when using CCC.

The CCC is multifunctional (Hamzeh et al., 2007). From a storage point of view, it can reduce the supply chain cost by reducing the on-site inventory and the possibility to order larger quantities to a lower price when not being limited to the available space on the construction site. Larger orders can also be separated in the logistics centre and then shipped out to the construction site, which also would be cost efficient. Since a company can use the logistics centre in several projects, the overall safety stock is able to be reduced as all the projects can share the safety stock, which is lowering the total stock. By using it on several projects, milk rounds where one transport serves multiple projects instead of one transport for every order and with CCC as a base of operation is also a possibility (Lundesjö, 2015).

The outgoing supply from the CCC works as a pull system, where the material is ordered from the construction site after which being delivered to the site. Deliveries that normally would come from many different suppliers can be reloaded and repacked and thus more consequent and organised deliveries to the construction site. This view of CCC is also supported by Sullivan et al. (2010) in a study from Heathrow England, who claim that the best use of CCC is in dense cities where it is common with lack of space at the construction sites. Furthermore, it is explained that construction vehicle movements have been reduced by up to 50% by using CCC. In addition, it is pointed out that in reality, when each site works with separate suppliers, the suppliers often shows up an hour early, having to either wait or drive around on nearby roads which has both a negative impact on the available space at site and the environment. As a result of the Heathrow study, where a CCC serves four different construction projects with material, it is explained that cost savings could be made due to faster turn-around times and increased productivity on site. Furthermore, it is stated that delivery precision is often within plus or minus 15 minutes from the appointed slot time when using consolidation centres, comparing with ordinary delivery systems where deliveries often are specified as mornings or afternoons (Lundesjö, 2015).

Nevertheless, the CCC is less used than expected based on their benefits of precise deliveries, storage possibilities, productivity gains and environmental benefits (Lundesjö, 2015). The main cause for this is a highly competitive procurement process resulting in that few are willing to trust that the savings of using a CCC would be fulfilled. This is exemplified in the London case study where a 3000 square metres CCC cost approximately 10 million SEK each year when serving a 4 billion SEK project, but the potential savings from the solution are hard to concretise (Lundesjö, 2015).

2.5 Procurement´s effects on logistics

The chosen form of procurement may affect construction supply chain in one or several ways either through simplified ways of communication between parties, advocated request of enhanced information flow or as a result of long term collaboration (Briscoe, Dainty, Millett, & Neale, 2004). In this section some of the more commonly used forms of procurement and how they may affect the logistical work will be addressed. According to Walker and Lloyd-Walker (2015), there are three fundamental procurement approaches, here referred to as the traditional approach, the planning and control approach and the collaboration and coordination approach.

2.5.1 The traditional approach

In the traditional approach it is common to separate the design phase from the delivery phase (Walker & Lloyd-Walker, 2015) wherefore it is sometimes also called the separate approach. (Masterman, 2001).

One of the most used procurement forms in the world today is the design bid build, DBB (Forbes, Ahmed, & Taylor, 2011; Walker & Lloyd-Walker, 2015). The elementary idea of this procurement form is that the design phase is thorough, detailed and completed at the time of tendering, so that the bidding process can determine the cheapest and/or fastest tendering cost. In addition, the separation is not solely between the design phase and the construction phase (Masterman, 2001). The responsibility in managing the project is also divided between the client, its consultants and the main contractor. Coordinating the clients consultants is almost always done by an architect or an engineer (Mohsini & Davidson, 1992). This coordinator collects, depending on the complexity of the project, additional knowledge from area specialists and take necessary measures in order to create the documents needed to issue a tendering process. On the other hand, the construction phase is coordinated by the main contractor who hires different sub-contractors and creates relations with different suppliers in order to produce the building. Due to this separation between the design team and the constructing team, there are little involvement of one team in the other ones activities (Masterman, 2001).

As a direct result of the high level of detail at the tendering process there is an imminent risk for contract variations even though there is small risk for essential changes in the main project objective (Walker & Lloyd-Walker, 2015). These contract variations may be both time consuming and resource demanding and one of the greatest criticism towards the procurement form is the claim mentality that it urges to i.e. bid low claim high mentality. Lu, Hua, and Zhang (2017) state that one of the reasons for this is the lack of contractual link between the contractor and the designer. Some of the major benefits of using a DBB procurement is the low uncertainty in the documents which in turn enables contractors with the right resources the opportunity to be highly efficient and therefore lowering the overall cost (Walker & Lloyd-Walker, 2015). On the other hand, some major disadvantages mentioned are insufficient design when rallying for a tender and the risk of finding a contractor unable to deliver what is asked by them. According to Forbes et al. (2011), insufficient design and the claims that were mentioned above are some of the largest reasons for delays which, in the long run will be costly.

2.5.2 The planning and control approach

Forms of procurement sorted into this approach have in common that planning and control logic drives the projects (Walker & Lloyd-Walker, 2015). Instead of focusing on collaboration between people and people management, this approach advocates that planning and control systems is of greatest importance.

One of the forms of procurement that Walker and Lloyd-Walker (2015) categorise in this approach is Design and Construct, D&C, or as it is often referred to today Design Build, DB (Beard, Duncan, Loulakis, & Wundram, 2001). Unlike the traditional approach were design and construction are divided on two separate teams, design and delivery elements are integrated with the holistic responsibility with one entity alone, not seldom the main contractor (Beard et al., 2001; Koskela et al., 2002; Sacks, 2013; Walker & Lloyd-Walker, 2015). As a matter of fact, DB derived as an attempt from project owners to transfer the responsibility, and hence also risk, for cost, quality etc. on to this single entity (Beard et al., 2001). DB enables for a faster process than the traditional approach (Beard et al., 2001; Forbes et al., 2011; Sacks, 2013; Walker & Lloyd-Walker, 2015). Some reasons argued for are less complex ways of communication, earlier start of the project due to design being carried out during the construction phase (Forbes et al., 2011) and the fact that the overall supply chain is more integrated in the process (Walker & Lloyd-Walker, 2015). In addition, DB is stated to give a higher customer satisfaction than the traditional process (Forbes et al., 2011; Sacks, 2013)

Another procurement process in this approach is the Integrated Supply Chain Management (Walker & Lloyd-Walker, 2015). This fairly new form of procurement has gained a lot of interest during the last couple of years and focuses on how to use the supply chain to create as much value as possible. While still advocating for competition one step of ISCM is to reduce the number of sub-contractors and suppliers used by the contractor to only a core consisting of only a few members who all strives to really add value to the final product. The idea is that with a smaller group of stakeholders in the project, the possibility for commitment, strong bonds and trust between them is larger. This way of procurement has its origin in the automotive industries and some of the focus lies on JIT deliveries. Even though JIT may improve the efficiency for the main contractor, it is likely that such an approach might omit opportunities that collaboration does not oversees.

2.5.3 The collaboration and coordination approach

Partnering may be seen as a philosophy to be applied to other forms of procurement rather than a form of procurement itself (Walker & Lloyd-Walker, 2015). The concept of partnering and its impact on the construction industry is widely discussed and is seen as both the cure for an otherwise unhealthy industry as well as a trendy term for common sense (Nyström, 2005). In a frequently changing environment, flexibility and response time has become highly valued features which companies can use as competitive advantages (Thompson & Sanders, 1998). These commodities could thrive and be more easily managed through partnering. One goal of partnering is continuous development (Kadefors et al., 2004; Nyström, 2005). Regular follow-up meetings, evaluations etc. are important features of a well-functioning partnering. With the reasoning above, the authors of this thesis choose to include the concept of partnering it in this chapter, mainly due to the increasing interest from the industry the last couple of year

One definition of partnering is given by the Construction Industry Institute (2018), where partnering is stated to be:

> "A long-term commitment between two or more organizations as in an alliance or it may be applied to a shorter period of time such as the duration of a project. The purpose of partnering is to achieve specific business objectives by maximising the effectiveness of each participant's resources".

In addition to the mentioned definition of partnering above, several other authors determine that an important corner-stone in this form of procurement is trust (Crane, Sanders, Felder, Thompson, & Thompson, 1997; Kadefors et al., 2004; Thompson & Sanders, 1998).

Within the concept of partnering there are mainly two sub-branches of partnering: strategic and project partnering (Cheng, Li, Love, & Irani, 2004; Nyström, 2005; Walker & Lloyd-Walker, 2015). Strategic partnering is often applied between two parties of an supply chain over a longer time period than just single project (Walker & Lloyd-Walker, 2015). The fundamental intention of this approach is continuous improvement. Through a deeper understanding for the other parties there is a possibility to customise the working process and hence improve from one project to the next. Strategic partnering is considered to be process-oriented (Cheng et al., 2004). On the other hand, project partnering are conducted on single projects were a range of parties within the project whom all are a part of the supply chain (Walker & Lloyd-Walker, 2015). The question whether project partnering actually should be classified as a form of partnering is discussed in the literature (Kadefors et al., 2004). The discussion addresses if it is possible to engineer relations, corresponding to the definitions above, to reach project success for just one project, project partnering, or if it is necessary to be a more long-term process, strategic partnering. Furthermore, Kadefors et al. (2004) conclude that clients often prefer the more traditional forms of procurement due to a general feeling of being vulnerable in relation to the contractor. On the other hand, this mind-set towards the contractor risks to create a climate of distrust due to detailed specifications in the procurement phase and close monitoring of the contractor itself. Another result of this is lowered project performance due to mistrust.

2.6 Theoretical context

The concepts and the theory presented in this chapter is selected in order to present the context for and understanding of logistics in the construction industry. Construction logistics is described as being uninventive and slow to adapt to new technologies and ideas. The definitions of construction logistics also differ but fundamentally aims to enable the activities of ensuring material in the right place; at the right time; in the right quantity and with the right quality. SCM includes cutting costs and waste along the supply chain are key points when working with logistics and concepts from lean manufacturing have been introduced and used in the construction industry. The role of a logistics manager has also emerged in the project process in order to coordinate logistics in a complex environment in relation to the densification of cities. Several logistical solutions to improve the efficiency in the industry have been developed since logistics planning is connected throughout the entire project process. Tools like a construction site layout, CLP, different delivery management systems and working with logistical solutions like CCC are constantly being developed. With focus on planning and efficiency on logistical processes in the construction industry, the procurement process plays a significant role in the logistics outcome of the project.

To connect the theory to the purpose of the study, the research questions is related to the theoretical framework in the following way: Research question 1, how logistical processes at Serneke are conducted today, is treated in subchapter 2.1, *Introduction to construction logistics* and 2.3.1 *Push and pull in the construction industry*. Research question 2, which barriers and which factors that are affecting construction logistics is supported by subchapter 2.1 and 2.5, *Procurement's effects on logistics*. Research questions 3 and 4, how the logistics plan is utilised today and how it could be developed is supported by section 2.4, *Logistical tools*. A visualisation of the theoretical framework is presented in Figure 2.2.

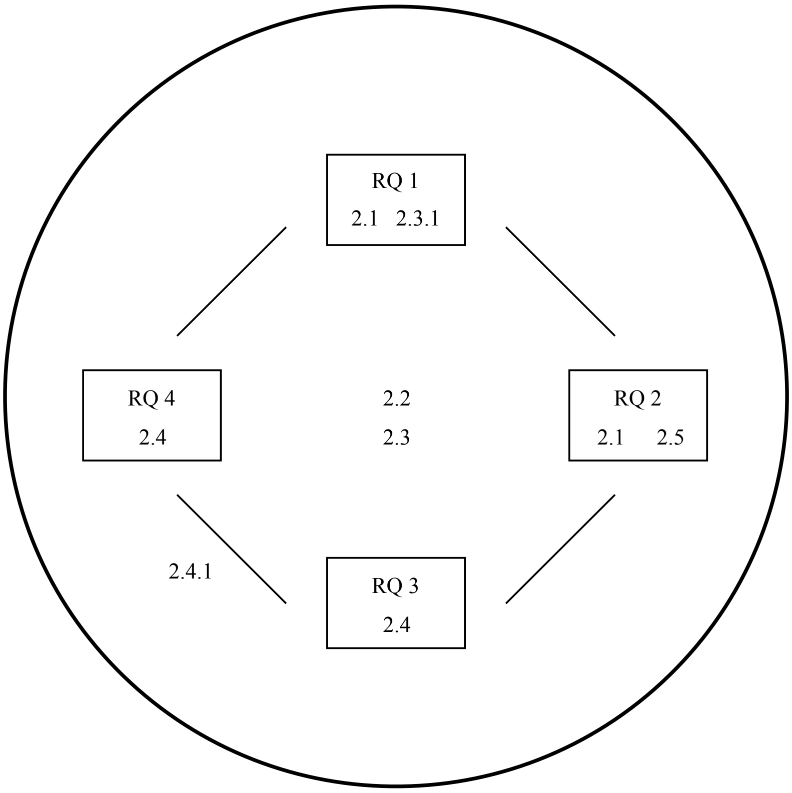

Figure 2.2 – Visualisation for the theoretical framework

3 Methodology

The following chapter describes the thesis methodology and contains the sections *Research process, Research design, Ethical conduct and Trustworthiness.* The chapter aims to explain how the thesis was conducted and why the different methods were chosen, considering both the literature search and the empirical data collection. The chapter also strives to describe how validity was ensured and how bias was avoided during the process of the thesis.

3.1 Research process

The subject of the thesis emerged when observing the complexity of construction city projects and the insufficient working space construction sites are facing. The need for an efficient supply chain and well-planned logistics could be key components for the up-coming construction projects. The four investigated projects were decided in conjunction with Serneke where all projects faced both common and unique challenges regarding construction logistics. The deciding factors were related to three main issues. First, the projects would have to be within a certain range from Gothenburg in order to enable study visits and the interviews possible to conduct. Second, there was a limited number of projects to investigate within this area and also limited time to investigate them. Third, the authors aspired to choose projects in separate cities to be able to investigate if and how the logistic process differed within the organisation.

The four projects chosen were: *Borås Congress Centre*, *Kvarteret Mars*, *Gamlestads Torg* and *Kongahälla Shopping*. The first one, Borås Congress Centre, was chosen mainly because of good insight in the project due to one of the authors part-time work at the construction site, but also by its complexity and limited space. The second one, Kvarteret Mars, was chosen due to its location outside of Gothenburg and right by the central station in Trollhättan, which entails limited space and hence an interesting case from a logistical point of view. The third project, Gamlestads Torg, was known to possess more available space but also surrounded by various other construction projects, several train tracks and a newly constructed train station just next to the construction site. The last project, Kongahälla Shopping, was selected also because of its closeness of several other construction projects, but also because of its high budget and the fact of having a CLP and a logistics manager.

The fundamental idea of the thesis was developed together with supervisors at Chalmers University of Technology and Serneke. Together with supervision meetings, the aim and research questions were specified and the literature review was started. Parallel to the literature review, several study visits were performed in relation to the projects in order to establish a first contact and to gather initial observations to support and develop the literature research. The interviews where held a couple of weeks in the project, simultaneously as the literature research was adapted to support the empirical findings. After summarising the empirical findings, the process of analysing the empirical findings by make use of the theoretical framework was started. Where further insights and ideas were found, the theoretical framework and research questions were adapted and complemented, making the research process iterative as shown in Figure 3.1. When the empirical data was analysed and compared to the theoretical framework, conclusions of the thesis aim and research questions could be performed.

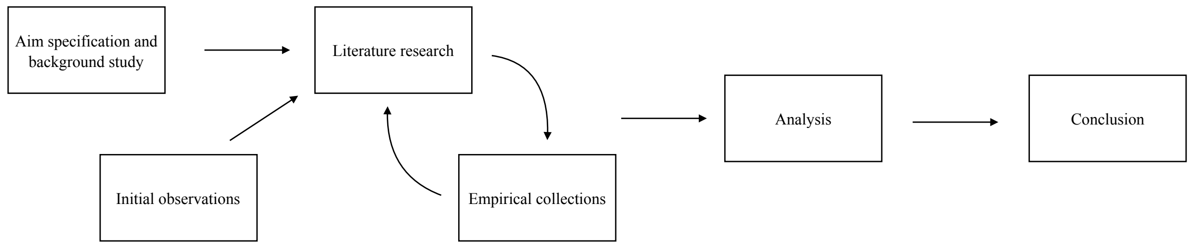

Figure 3.1 – The research process of the thesis

3.1.1 Literature search

Parallel to the initial observations at the sites, the literature search was constructed with the purpose of creating a theoretical foundation for the thesis. The literature search also functioned as a source of inspiration and knowledge for the authors. The research strived to provide relevant literature for the purpose of the study from conference papers, scientific articles and books which were found both from articles and from searching for key words at databases like Summon from Chalmers library, Scopus and Google Scholar. In addition, some website was used. Some of the key words used in the search included 'Construction logistic', 'Construction standardisation', 'Just in Time', 'Logistic planning', 'Construction planning', 'Lean Construction', 'Supply Chain Management' and 'Construction procurement'. English literature was mainly considered but also literature in Swedish were used, and the research strived towards finding several sources considering the same subject to ensure validity. Furthermore, publication date and the number of citations of the articles were also considered when choosing literature. The literature research was an iterative process which, after new findings and insights, were complemented by further research and the research questions were also adapted to reflect what the thesis examined. In total, approximately 60 scientific articles and 5 books were used in the process.

3.1.2 Empirical data collection

The case study involved the construction company Serneke and four of their current projects. All projects faced challenges regarding construction logistics and were also in reasonable distance in order to be able to conduct the study which involved several visits. The empirical data collection consisted of site observations, official documents and interviews with Serneke employees within a specific project or the organisation. The documents consisted of a logistical plan at one of the project and site dispositions of the projects. Table 3.1 presents the interviewees.

Table 3.1 – Conducted interviews at Serneke.

Company/Project	Position	Date
Serneke – Kvarteret Mars	Project manager	2018-03-12
	Construction superintendent	2018-03-12
	Forklift driver	2018-03-12
Serneke – Gamlestads Torg	Site manager	2018-03-15
Serneke – Kongahälla Shopping	Project manager	2018-03-19
	Logistics manager	2018-03-19
Serneke – Borås Congress Centre	Project manager	2018-03-21
	Construction superintendent	2018-03-21
	Site manager	2018-04-03
Serneke	Assistant Construction Manager	2018-04-06
Serneke	Logistics manager	2018-04-18

Since the aim of the thesis was to highlight and address challenges concerning logistics at construction sites, the view on logistics could vary depending on the person's role at the specific project or within the company. Therefore, the interviewees were selected by hand, resulting in a suitable mix of people in the organisation.

The interviews were conducted in a semi-structured manner with prepared questions. Nevertheless, the interviewees got the opportunity to elaborate in a broader context allowing the authors to gain new insights. Prior to the interviews, a question template was constructed with regard to the initial observations and findings made in the literature research. The template was reviewed several times together with supervisors at Chalmers and Serneke. All interviews were recorded and transcribed to ensure that gathered material was correct interpreted. The transcriptions were also summarised in a Microsoft Excel spreadsheet to facilitate an overview of the answers and be able analyse it, in order to discover if any new literature was needed. In total, 11 interviews were performed with the duration of approximately 60 minutes each and were all conducted face to face.

3.1.3 Iteration between theory and data

In order to ensure that the right questions were asked during the interviews, the literature research had to be conducted prior to the interviews to gather enough knowledge within the subject. However, the result from the interview turned out to contribute with new insights which resulted in that additional literature research were necessary. Even though some results were not directly related to a specific theory, parallels between the empirical data and different theories could be made whereon some literature parts needed to be extended and some removed if not used. The iteration process included the aim of the thesis as well where new insights and ideas could turn the focus of the thesis and thereby the aim and the research questions of it.

3.2 Research design

In accordance to the research process in this thesis, an abductive research approach was used. According to Bryman and Bell (2015), the abductive reasoning emerged as an attempt to overcome the limitations connected with the inductive and the deductive approach. The criticism towards the inductive approach is related to that there is no guarantee that the amount of empirical data collected enables theory-building. Regarding the deductive approach, the associated drawbacks are due to lack of how to select the theory that should be tested.

The main reason for why the abductive approach was chosen was due to the number of sites that were to be visited and the numbers of interviewees to be addressed. Furthermore, it allowed the direction of the study to change by taking data collection into consideration together with theoretical insights. As a result of this iterative process, new questions were likely to arise throughout the process. One advantage with the abductive approach, in contrast to deductive or inductive, is that the authors are given the possibility to change the main focus parallel with new discoveries in as well the theoretical framework as in at the empirical findings at site (Dubois & Gadde, 2002b). This made the method suitable for this study and correlates well with the research process shown in Figure 3.1. Bryman and Bell (2015, p.27) states that "Abduction starts with a puzzle or surprise and then seeks to explain it". The puzzles that are mentioned are in fact when researchers identify empirical problems which existing theory is not suitable to address, i.e. becoming surprised. From a historical point of view, being surprised, has been considered as not having control at the research situation and therefore also regarded as a bad thing (Alvesson et al., 2007). However, being surprised also gives the possibility to new insights and new preunderstandings which in turn may give additional facts to the subject and not only confirm an already existing preunderstanding. The abductive research process by Bryman and Bell (2015) is illustrated in Figure 3.2.

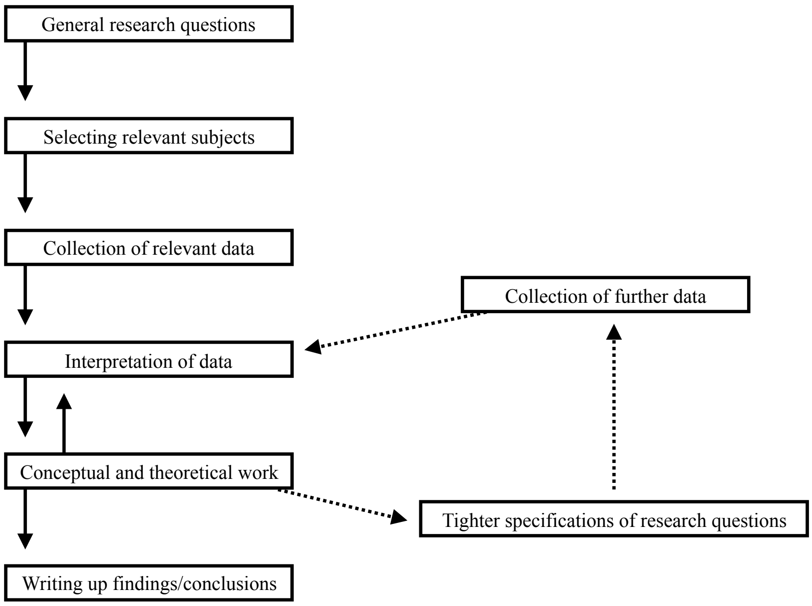

Figure 3.2 – Main steps of a qualitative research (Adapted from Bryman & Bell, 2015 p.395)

Furthermore, Dubois and Gadde (2002b) advocate that a "both way"- kind of approach, like the abductive, enables a deeper understanding of both the empirical aspects as well as the processed theoretical framework. According to Suddaby (2006) the empirical world is the basis that awakens new questions that could be matched with already existing research. It is stated to be an "analytic induction" and were the researcher is commuting between induction and deduction i.e. jumping between the empirical world and the one of theory. A well-structured abductive research approach is stated to be more suitable towards case studies than solely the inductive or deductive approaches (Markus, Hawes, & Thasites, 2008). The aim was to identify different logistical challenges construction projects are facing by conducting site visits and interviews. As a result of this, a single case study research design was chosen. According to Bryman and Bell (2015) this method is suitable when several projects are to be investigated and were data is collected through qualitative interviews. Furthermore, Paisey and Paisey (2010) state that it is a methodology used to examine several objects with the aim of spotting differences and similarities.

Qualitative interviews falls under the term of semi-structured interviews which enables the interviewer to deviate from the prepared questions and to follow-up questions (Bryman & Bell, 2015). Due to the number of planned interviews, the qualitative approach was suitable and chosen since it emphasis more on specific answers and reflection rather than the number of interviews. In addition to the data collection through interviews, site visits were also used as a tool to generate a holistic impression of how the sites were coping with their logistical challenges. These site visits can be seen as a tool of what Bryman and Bell calls participant observations which also is an approach used in the qualitative research method.

3.3 Ethical conduct

In order to ensure that the thesis was constructed ethically, several actions were taken. Prior to all interviews, all interviewees were informed about the scope of the project and their role in the thesis. Furthermore, the interviewees were asked before the interview if recordings could be performed, in order to enable for the authors to re-listen to the interviews and thereby ensuring that any details were forgotten, where the unanimous answer was yes. All interviewees were clearly informed that they would have the possibility to review the answers given in the report and that only their current position will be stated along with their answers, which was supposed to encourage the interviewee to speak freely and be open-minded during the interview. Furthermore, throughout the process, a close collaboration with the supervisors at Serneke and Chalmers has been managed.

3.4 Trustworthiness and authenticity

Trustworthiness contains four aspects: credibility, transferability, dependability and confirmability (Morse, Barrett, Mayan, Olson, & Spiers, 2002). *Credibility*, or feasibility, shows how trustworthy the results are. All interview participants were able to take part of the findings in the thesis in order to ensure that their answers were correctly understood and interpreted by the authors. This was conducted in order to seek correspondence in the findings made by the researchers and the impressions of the participants of the study, also known as respondent validation (Bryman & Bell, 2015). By striving towards producing rich details of the qualitative study, a higher level of *transferability* can be accomplished. This is also called thick description and aims to make the results of the thesis to be applicable on other studies in the future. Furthermore, Bryman and Bell (2015) explain that researches should seek an auditing approach to the project. By keeping record of all phases of the thesis, including the research process, transcripts from interviews and selection of the participants, a high *dependability* was reached. *Confirmability* ensures that the thesis was constructed in an objective manner, and not biased by personal values of the findings or of the research data. This was achieved by both authors contributing equally throughout the entire thesis in all parts. Finally, beside form the trustworthiness criterions, authenticity comprises several other criteria e.g. fairness where the study should represent several viewpoints on the subject such as interviewing other stakeholders than just senior executives in the company.

4 Empirical findings

This chapter provides the empirical findings of the study. It starts with *The strategic view on construction logistics at Serneke* where a construction manager and the chief of logistics operations explained how the organisation treat and work with logistics today and what could be improved. This section is followed by *The existing logistics plan* that provides an insight in the important parts of the logistics documents and their functions. Finally, the four projects are presented and their prerequisites, challenges, solutions and view on construction logistics are explained.

4.1 The strategic view on construction logistics at Serneke

Representing the organisational level, with regard to logistics at Serneke, was a construction manager and the chief of logistics operations. In addition, the chief of logistics operations was also involved as a logistics manager at Karlatornet, a high-rise building being constructed in Gothenburg.

The stated main reasons for working with logistical planning and execution on the strategic level are to save money, gaining an increased efficiency and creating a smooth flow in the production and thereby avoiding the need of "putting out fires". In addition, the chief of logistics also pointed out that in today's complex environment, much information gets stuck in peoples' heads instead of being relayed and systematic integrated in system which often causes inefficiencies. Unshared information, regardless reason, is often directly linked to unannounced deliveries or material being stored at the wrong place on site. Even though it was stated that the organisation was aware of this problem, no strategic decision or guidelines for how the main organisation wishes the projects to work with logistics is mediated to the sites. Instead, the logistics responsibility is delegated to each site. Further, it was stated that progress of construction logistics starts initially at the organisational level.

The construction manager expressed the importance of addressing logistics early in the projects and that these processes is mainly about ensuring that a sufficient planning is submitted which could save money in the later stages of the project. Fundamentally, this planning was stated to ensure that the number of construction elevators, construction modules, construction cranes etc. is sufficient and if there exists a need for a software system to aid the logistical issues and planning. Further, the construction manager stated that if one does not treat and plan for these kind of questions in the early stages of the project, there will simply not have space for it in the budget. Therefore, it is of great importance that a sufficient planning is conducted early in the project. However, it was also explained that the organisation does not intrude in the logistics execution for each specific project but instead it is up to the chosen project members to solve the equation. This was also described as the mind-set of the organisation in order to give the project organisation a possibility to design a suitable way of working, through creative thinking and problem solving. Nevertheless, the organisation was stated to still be able to support the projects if necessary. The chief of logistics operations claimed that a more advanced chain of command could be a sufficient way of addressing the problem. The presented idea was to create a centrally conducted support division that could aid the projects if they struggled and, in addition, also benefit the knowledge management within the organisation and between projects. Adapting a hierarchy where a full-time employee addresses logistics questions from a strategic perspective with close collaboration with the project specific logistics managers was stated to be one way of constructing this support division.

One of the main issues emphasised when advocating for the importance of construction logistics was stated to be the measuring of actual gain or loss by having an appointed logistics manager. The chief of logistics operations expressed that it is simple to measure the gain from a good procurement or purchase but hard to measure the effects of ensuring that the right material is at the right place, at the right time and thereby minimising the additional work. Further, the chief of logistics operations stated that:

> "Every project over 300 million SEK should appoint an on-site logistic manager and smaller project should at least have a logistics coordinator. Otherwise, there is an imminent risk of miscommunication, double booking of cranes, forklifts, etc. and unnecessary material movement."

The characteristics of the project together with its budget would also influence the level of detail in the logistics plan depending on the capacity and available resources at the site. Another mentioned issue was the inexact production planning which is affecting the logistics. Often the execution of construction activities is not planned in detail and it was stated that planning often includes terms like "this will be done next week" instead of the more sufficient and detailed way "this will be done on Monday at 4pm".

The context of the construction industry was also discussed. Instead of being repetitive, like the processes in the manufacturing industries, the construction activities are renewed every day. Nevertheless, the chief of logistics operations stated that the processes should still be able to be more synchronised and well planned. Further it was highlighted that different procurement methods may affect the logistics. In partnering, it should be specified how the logistics processes are conducted and there was also often a demand from the client for a logistics coordinator. It was also stated to be easier to influence on the budget than in a DBB process where the contractor has a limited amount of money and should choose wisely how to spend them.

Concerning CCC, the mentioned decisive factors deciding whether the projects should or should not use a CCC is in parity to the available space at the construction site and if there exist any bottlenecks such as one point of intake. Further, it was stated that during the construction of Karlatornet, a logistics centre will be used at Säve airport and every transport will be required to have a high fill-rate in order to reduce the number of transports to the site. In addition, it was also described that a checkpoint together with unloading and waste services will be used and procured on a specific contract with a designated third part logistics firm. Sub-contractors will use the logistics centre and the logistics plan for this project will precise how the process should be performed, in order to create a strong cooperative process.

4.2 The existing logistics plan

Serneke's first logistics plan was conducted at the construction of a multisport arena in Gothenburg in 2012. Thereafter, the logistics plan has been developed and adapted to other projects. It was stated that the fundamental idea of the plan was to complement the contracts and to clarify how the main contractor wishes that the logistics processes should be performed in the project in question. Above all, the plan was expressed to be an external document constructed to align the sub-contractors, the suppliers and the main contractor's view on how to perform construction logistics. Creating an internal document was expressed to be harder due to its dependency on the available competences at the current project. The chief of logistics operations stated that:

> "The logistics plan is a complement to the "branch-standard" and the community of practice, where each supplier delivers in their own certain way and the way most suitable for them. Instead, the main contractor should address the problem in a proactive way where the contractor's logistics plan could ensure that all involved parties in the project work in the same manners."

The existing logistics plan was studied, and its content is presented underneath. The first parts of the logistics plan consist of a brief introduction explaining the importance of construction logistics in the project and what kind of demands that will be required of the project actors. Further, the plan also treats how material deliveries are to be conducted with emphasis on marking, packing, eventual announcing in a software system and what responsibilities the sub-contractor is bound to regarding deliveries. These requirements are also clarified through exemplifications in the logistics plan. In addition, the chief of logistics operation stated that these material specifications are the most important parts of the plan. Furthermore. The plan also states who is responsible for the logistics processes at the project on behalf of Serneke alongside the appointed logistics coordinators of the sub-contractors and how communication should be forwarded in the project and between the parties. The appointed logistics coordinator is obliged to attend weekly meetings where upcoming logistics and logistical problems are treated. Furthermore, if a digital delivery system is used, its functions is explained, and the plan determines what is expected from each sub-contractor regarding time frames and specifications in each booking. The logistics plan also states that specific resources needed i.e. forklift and elevators, should be booked in the software booking system prior to delivery. The last parts of the logistics plan treats specification regarding safety rules, storage possibilities, machines, elevators, tools and route directions to the construction site.

4.3 Borås Congress Centre

In the central parts of Borås, Serneke is responsible for a conservation project of an already existing building which will be integrated with a new construction (Borås Kongresscenter AB, 2018). The general idea of the project is to restore the old buildings function as a central meeting place in a partly new building. It is stated to be a new, modern, and flexible house easily accessible for the citizens of Borås and its visitors, see Figure 4.1. In regard to its flexibility, the new Congress Centre should be able to handle three independent activities at once, the largest one containing 1000 persons, and about 700 seated visitors at a banquet.

Figure 4.1 – Borås Congress Centre (Tengbom, 2018)

Borås Congress Centre is estimated to be completed in late September 2018 and contains a budget of approximately 200 million SEK. The project is procured as a partnering between Serneke and the public real estate company Industrial Buildings in Borås AB, IBAB, and is expected to be an important piece in actualising the 2025 vision of Borås which emphasises on the importance of meetings (Serneke, 2018a).

4.3.1 Logistical prerequisites and challenges

Due to its location in the centre of Borås and situated at a highly trafficked street, it was stated that unloading and storages was essential challenges throughout the whole project. Further, the closeness of public transportation lines, railroads and the University of Borås, where 12 000 students studies (Högskolan i Borås, 2017), added to mentioned challenges. In the worst cases, due to material or vehicles blocking the unloading-zones, the site management was forced to unload materials at the main street outside the construction area. Another issue relating to material handing was explained by the project manager who stated that

> "Purchases of bulky products with delivery dates in the latter parts of the project causes problems. Due to its size, we have been forced to consider maintaining openings in the construction so that the material can be brought inside."

The importance of logistics was also highlighted by the construction superintendent who stated that in order to be able to work efficiently one must focus on the logistics and that 70 % of the production is directly related to logistics. These kind of issues was stated to be an especially large concern during casting or when receiving weather-sensitive material like gypsum boards. Furthermore, it was observed that the density around the site prevented a smooth flow regarding logistics at the site. In addition, the four gates for unloading were, due to cranes etc. blocking the transportation routes, in some phases designed as "one way in and the same way out" routes. Marking of the gates were absent.

It was stated that the building design was an on-going process along the construction of the building, which has affected the site planning negatively due to the design not being completed in a sufficient pace. In addition, the final users, responsible for the everyday business, was not appointed at the time of construction start. It was explained, due to this late involvement, that some re-adjustments of already completed work has been performed and decisions have been made late in the process. However, the site manager argued that the logistics working processes are the same, independent of procurement form. Even though it was first stated that the logistics is independent of the procurement form, the site manager explained that a partnering procurement may result in a more patient mind-set from the contractor leading to decisions being made late in the processes which causes challenges regarding the logistics. Stressing the other side of the coin of partnering, the project manager expressed that a strategic partnering may stimulate innovative logistical solutions and create a precedent for up-coming project where the involved parties can cooperate in a more efficient way.

4.3.2 Logistical solutions and planning

Regarding the site management, it was stated that no single individual was responsible for the logistics at this project. Instead, the responsibility was shared among the three superintendents. Further, the construction superintendent expressed that appointing one person responsible for the logistics work in the project would have been beneficial. However, it was also argued that some responsibility of the site and its logistics need to be added on the sub-contractors who handles their own deliveries. Throughout the project, neither a centrally conducted logistics plan or a digital delivery system was used. Instead the transportations to the site was coordinated through the usage of a whiteboard in the conference room. In addition, it was stated that if it exits any centrally documents with emphasis on logistics at site, the head organisation had not been able distribute them in a sufficient way. However, a common opinion was that some tasks could be done more efficient with more centralised solutions, but the site manager also stressed the importance of having the right competence at site since all the other decisions and work are conducted at the site. It was also stated that the lack of resources on site resulted in that people performed other tasks than they normally would do.

The project manager stated that there are large economical savings to be made regarding construction logistic. Furthermore, logistics is a very time-consuming activity and therefore the site could benefit from more centralised solutions. It was stated that this project purchased the shipping of goods together with the material meanwhile other contractors on the market uses a third-part-logistic firm for this purpose. This was expressed as being one way of reducing the number of transportations to and on the site and in the same time transferring some additional work to the shipper along with intermediate storage. In addition, ensuring that trucks transporting material to the site has a high degree of fill-rate through mixed deliveries of e.g. gypsum boards and inner doors together with the sub-contractors' materials could make a more standardised delivery process and also reduce the number of transports. Regarding deliveries to the site, it was expressed that anarchy often prevails and that it is sometimes like the "wild west" where unannounced deliveries show up and no one really knows what kind of material it is or where is should be unloaded. Furthermore, a common view was that the projects nowadays lack a general picture of the entire project and what is supposed to be accomplished. As a result, the number of "fires" and problems in need of immediately attention or information was stated to increase. It was expressed that when this kind of information regarding changes or problems in need of attention do not reach the site management, problems will occur.

4.4 Kvarteret Mars

In the city core of Trollhättan, located only 50 meter from the main station and in direct contact to one of the larger streets of the city, a new apartment block is being constructed. Procured as a DBB contract together with the public real estate company Eidar, Serneke is constructing 177 apartments including sheltered housing together with space for commercial activities in total six separately buildings (Eidar, 2018), see figures 4.2 and 4.3. In addition, a large underground parking garage is planned to be constructed which will connect the six buildings (Serneke, 2018d). The project budget is approximately 320 million SEK and estimated time of completion is in December 2018.

Figure 4.2 and 4.3 – Visualization of the high-rise building in Kvarteret Mars and an overview of the block (Eidar, 2018).

4.4.1 Logistical prerequisites and challenges

The project's location next to one of the busiest streets in the city and the nearby central station was stated to require a genuine logistics planning. Managing free and occupied space on the site to ensure a possibility of flow around the construction area was expressed as the main focus regarding the logistics. Nevertheless, the site management highlighted that they have experienced issues preventing this flow when the duration of unloading trucks has been longer than planned. In addition, this was stated by the project manager to be a recurring problem especially in connection to unannounced deliveries which was also frequently occurring at the site. From to time to time, the flow structure was also blocked by a truck or material that was unloaded at the wrong gate. This issue was also confirmed by the forklift driver at the site who often received late information about deliveries, and thereby was forced to unload the material, unaware of its recipient or storage location. Furthermore, the forklift driver claimed that there often is a communication issue between the suppliers and the contractors where even the announced material creates disturbances in the daily work. When material get stored at the wrong locations, a substantial amount of "5-minutes-work" was created. Further, it was advocated that these tasks could be eliminated if the materials would have been placed in the right location from the beginning.

Furthermore, both the project manager and the construction superintendent argued that space at the sites is always a concern. They expressed that throughout this project, this has been a problem in the early stages and particularly before the underground parking garage and thereby the courtyard was constructed. When these activities were preformed they could beneficially use two larger stockpiles. The site management further stressed that this creates an interesting paradox to be solved. On the one hand, a lot of free space could be used as temporary storage, but on the other hand it might encourage the contractor to purchase larger quantities of materials than necessary for the particular moment and thereby there is a risk of damaging material and additional logistical work. Before the courtyard was constructed, the only possibility to store material was between the public road and the building.

4.4.2 Logistical solutions and planning

In order to overcome the challenges regarding material handling to and at the site, the general opinion was that logistics needed to have a central part of the planning processes and that it would impact the projects outcome. However, it was early stated that the logistical planning for the project was created by the site management and not controlled from an organisational level at Serneke. Consequently, no centrally conducted logistic plan was used in the project and the site management also claimed that such a standardised tool from the organisation most likely had be hard to both conduct and to implement. In addition, they expressed that such a document must also include sub-contractors as well if it is to be efficient. Nevertheless, the project manager stated that a centrally well-conducted checklist at the project start considering logistics and production planning was of interest. It was expressed that a project based version of such a checklist was used during the mounting of the pre-fabricated concrete walls.

Due to its location in Trollhättan and the mentioned limitation in space, much effort was put into conducting a sufficient construction site layout. Another activity preformed to achieve smoother logistics during the project was the fact that all materials that were supposed to be used at the floors, e.g. gypsum boards, wall studs etc., were lifted in before the next floor was added on top. Even though this was stated to be one of the logistical solutions, benefitting the project, the interviewees mentioned that this way of handling the material supplies to the floors occupies a lot of the free space. As a result, it could be hard for the craftsmen to perform their job when they also needed to navigate their way through materials and wall studs. However, the site management stated that the advantages of this approach were clearly overweighing the disadvantages. Furthermore, transports routes to the building site were clearly marked on the construction site layout and the way around the site has been marked as one-way in order to create a flow structure on site. The project used three separately gates distributed a long side the transport route. Which gate that should be used was clearly stated to each supplier through a delivery plan attached together with the confirmation of the purchase or contract. However, both the project manager and the construction superintendent stressed the importance of rejecting deliveries which arrives at the wrong time in order to follow the ordinary plan and be able to receive and unload other deliveries.

As a part of the logistical framework, one of the construction superintendent explained that the project outsourced the replenishment of some of the more frequently used bulk materials. The supplier has, free of charge, established a container with these materials and is thereafter visiting the container and replenishes what is needed through an order-up-to-level. One of the construction superintendent at the project stated that this saves both time and reduces the risk of run-outs which could cause disturbances in the project or even stoppage.

4.5 Gamlestads Torg

As a part of the West Swedish Agreement Serneke develops the district of Gamlestaden together with the private real estate company Platzer (Serneke, 2018b). The vision of the project is that Gamlestads Torg should become Gothenburg's next large hub of public transportation (Platzer, 2018). It is estimated that in 2028, 40 000 travellers will integrate with the stations and the surrounding accommodations. The project is procured as a partnering between Serneke and Platzer to an approximately value of 350 million SEK. At completion the project of Gamlestads Torg will offer a total area of 17 000 square meters with focus on office spaces but also with public accommodations such as waiting hall and cafés among others. An overview of the project is presented in figure 4.4 and 4.5.

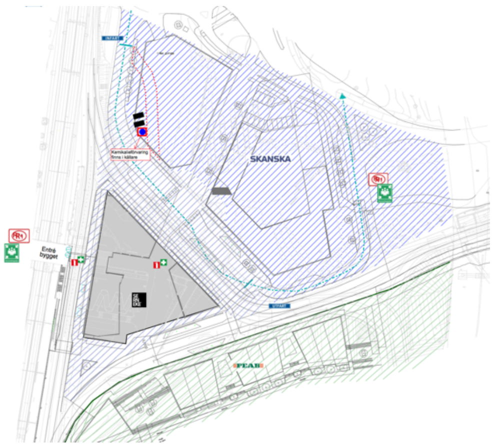

Figure 4.4 and 4.5 – Gamlestads Torg (Platzer, 2018)

4.5.1 Logistical prerequisites and challenges

From a logistics point of view, available space at the site was not regarded as an imminent challenge. Furthermore, due to the fact that Serneke only was responsible for the actual construction of the houses meanwhile the surrounding areas, such as the plaza and adjacent paths, are assigned to a cooperative contractor. This resulted in less space for storing material which in some phases of the project created severe problems. The site manager explained that the buildings structure was not finished by the time of when the surrounding construction were to start, which caused problems. In addition to the cooperation contractor at site, several other contractors performed other projects in direct proximity to the studied one, contractors that also need to be taken into consideration.

As a direct consequence of developing an already existing hub of transportation, to one of the larger hub in the city, was that it is already fairly connected. Closeness to both railroad, busses and trams forced the contractor to plan and distribute their resources right. A direct logistical problem regards the construction modules and as a result, due to lack of available space, the modules were positioned next to the railroad which in turn had effects. There was no possibility to add or remove modules from the site without lifting them over the railroad resulting in some logistical difficulties. Another challenge with being surrounded by railroads and other project was the risk of harming third party when lifting and transporting material.

4.5.2 Logistical solutions and planning

Regarding the planning of the project, a logistics plan was supposed to be used but was later ignored due to several reasons. The most important reason for this was stated to be due to a very complex mounting of the facade. In order to manage a digital delivery system where deliveries are communicated between the contractor, sub-contractors and suppliers, an IT-software called Myloc were supposed to be used as a part of the logistics plan. The system was stated to allow the project to allocate individual deliveries to one specific point of delivery and the resources needed to unload the goods. However, due to the necessity to always prioritise the facade, even though other sub-contractors may have booked e.g. the crane for lifting their materials, the site management felt that it was just too much additional work administrating all of these changes. Therefore, Myloc and the logistics plan as such were neglected even though licenses were purchased, review of the software and the logistics plan were completed.

The site management explained that they have experienced problems with scheduled deliveries that does not show up at determined time. The site manager explained that unannounced deliveries often show up at the construction site. Even though storage was not a large issue, being interrupted when performing other tasks takes time. The solution was claimed to be stricter towards the demands for the companies delivering material, but at the same time the project is often in great need of the resources which causes a paradox. Whether this could be solved with Myloc or another digital delivery system is not clear. No CCC was used during this project which also was stated to diminish the risk of deliveries running late and in the long run, the risk for project. However, Serneke made use of divided deliveries and all the material designated to one specific floor has been lifted directly on to that floor before the next floor were added to the structure.

4.6 Kongahälla Shopping

Serneke is, together with Adapta Fastigheter, constructing a large shopping mall in the area of Gothenburg (Serneke, 2018c) and the project is the largest ongoing shopping mall project in Sweden today (Adapta Fastigheter, 2018). The shopping mall is situated in Kungälv, just north of Gothenburg right next to the European route E6, see figure 4.6 and will house 100 retailers, restaurants etc. distributed over a total space of 37 000 square meter. The project is procured as a partnering to a total amount of approximately 1000 million SEK and is estimated to be completed in spring 2019. The project is divided into two major sequences where only the first phase, called a stop standard, is included in the procurement mentioned above. The second phase includes client customisation, where about 100 stores will be custom made to fit their specific needs and will be billed on top of this amount

Figure 4.6 – Kongahälla Shopping and nearby construction of new housing (Adapta Fastigheter, 2018)

4.6.1 Logistical prerequisites and challenges

Regarding logistics, Kongahälla faced challenges due to its location with on-going construction projects in a close proximity and a highly trafficked road on the west side of the project. In total there were four other construction firms working in the same area which caused the need for coordination between the contractors. In addition, there were only one main route leading in and out of the construction area which is supposed to be used by all the projects. Even though the amount of storage space at the construction site in the early stages in the project was extensive, the logistics manager explained the logistical challenges of constructing something before given the right drawings. The project decided to purchase prefabricated indoor gypsum walls, a decision that caused a lot of extra work due to not receiving the drawings at the same pace as production, resulting in the inner walls being stored instead of installed.

4.6.2 Logistical solutions and planning

The project had in average 230 people working on site every day. According to the logistics manager in the project, the second phase was explained to probably be the most challenging phase out of the two. In addition, there were also a limited set of elevators that the craftsmen, which often are connected and specialised on just one kind of business, can use. Hence, time scheduling, booking of the elevators and material handling was stated to be of great importance and a checkpoint was to be used for incoming deliveries in the latter phase.

Logistics were of importance early in the project. One of the first solutions was to conduct a traffic arrangement plan in order to access the construction site directly from the main road E6 and thereby enable more gates at the site. The solution also enabled that two different cranes could be used independent of each other. The logistics manager also explained that the logistics plan has been used in the project. The plan worked as a logistical framework and was explained to be an important puzzle-piece in order to ensure a smooth process throughout the project. Furthermore, the logistics plan also ensured that sub-contractors, suppliers etc. were aware of the logistical processes that rules in the project. The logistics manager claimed that in addition, this needed to be written in the contract between the parties so that, in case of disputes, there exists a signed agreement that could be followed. It was also stated that the need for a logistics plan is of outmost importance in large complex project with many actors and persons involved.

However, there were also a general opinion that some kind of document or checklists were needed in the smaller projects as well, but with less specifications. According to the project manager, the most important task was to discuss logistics during meetings and ensure that one person is responsible for logistic planning at the site instead of a shared responsibility, which easily could create misunderstandings. This was also one of the main reason for the logistics plan to be used because otherwise sub-contractors and suppliers will perform their notification and deliveries their own certain ways.

In order to coordinate deliveries and to schedule the resources needed at this project, Myloc was used along with three separate delivery gates which were clearly marked from the outside. At site, there were several unloading zones which also were clearly marked from both the inside and the outside which was stated to be important on such a large area so that everyone knows exactly where goods are supposed to be located. In addition, the parking garage among other free areas were used as storage. This was almost inevitable and denotes that priority at Kongahälla lies with keeping the transport routes, both in-house and outside, clear from goods so that material could be moved without obstruction. To keep these routes clear was also one of the crucial work tasks for one of the two persons that are responsible for moving the goods at the site, who are directly subordinated the logistics manager at site. Another logistical solution mentioned was that they have bought in prefabricated indoor gypsum walls. The logistic manager stated that this was initially a great idea, but due to design and rental of the areas falling behind schedule and that the deliveries keep on coming in a smooth pace they now have to store some walls waiting to be mounted.

5 Analysis

This chapter aims toward synchronising the theory with the empirical findings. The chapter covers the background of today's logistical challenges, how Serneke chooses to work with logistics and how it is aligned with the presented research. The analysis also covers differences between the head organisation and the projects logistical work and how communication between parties is conducted. Finally, the procedures around the logistical tools and the logistics plan is analysed and discussed.

5.1 Urbanisation and logistics

Overall, it is a common perception that logistics concerns all processes in construction and therefore it is an important aspect to consider. With Sweden as the fastest urbanising country in all of Europe (Ljungberg et al., 2012) and the fact that the number of inner city projects are increasing (Lindholm & Browne, 2015), logistical challenges are getting more present and intense than before. The logistical challenges in the investigated projects are in some cases similar where congestion at the site, difficulties to unload material and coordinating the supply chain are stated to be the most common. According to the head organisation, the main objective for working with logistics at Serneke is to gain positive numbers at the final row in the budget i.e. to save money by having a smoother process. However, since savings made from sufficient logistics processes is hard to measure and therefore not prioritised, the logistical efforts are insufficient at the company today. Furthermore, according to Lee (2002), working with logistics in forms such as SCM is stated to be one of the most important tasks in order to gain competitive advantages within the industry. If measuring the gains of logistical processes would have been easy and the benefits of the tasks easy to demonstrate, probably all active contractors on the market would allocate more resources to address the issues of logistics. Thereby, the probability of gaining advantages would decrease along with the impact of excellent logistics processes. As the current characteristics of the construction industry is today there is still a huge potential if one could, in a sufficient way, find key figures and/or output measures advocating for an increased focus on logistics. In addition, the slow and uninventive industry, as supported by Vrijhoef and Koskela (2000) and Persson et al. (2010), is also exposed in the logistical context where many solution and processes can be seen as out-dated and uncoordinated in comparison to its complexity with inner city construction projects.

5.2 The logistical processes at Serneke

A standardised logistical process at Serneke is yet to be implemented. There is neither an alignment on how to use logistical tools nor an organisational logistical structure, resulting in logistical work-procedures and planning procedures as the CLP not being conducted at most of the projects. Together with the introduction of new IT-solutions and techniques the different management roles on the site changes. Even though most of the studied projects working according to the traditional processes and conventional construction, the complexity in today's construction projects puts the site management, e.g. the site manager and the construction superintendent, into a more administrative context. In addition, more extensive project documentation connected to e.g. documents on what has been performed and environmental regulations also puts the traditional roles of a construction process in questioning where clearer coordination between the site management and the actual production on site need to be improved. Hayes-Roth et al. (1992b) stress the importance of site management been given sufficient amount of time to conduct the site disposition and that planning will pay off eventually. We believe that this mind-set is applicable for the planning of other logistics processes as well. Due to the many tasks that are to be performed by the, from times to times understaffed, site management, production may be affected negatively and the handling and planning for logistics might become just a 'necessary evil'. However, time is not the only issue but the mind-set and prioritisation of logistics need to be changed since more time may not result in that logistics is given more attention. Balancing between utilising the resources to it maximum, which is of importance (Dubois & Gadde, 2002a; Lundesjö, 2015), and adding too much pressure on the persons involved is a tough call. Our general opinion is that the site management from time to time are exposed to stress. According to the thesis authors, this advocates for adapting a more standardised process regarding planning of logistics due to be able aid the involved persons. To be able to fall back on documents or checklists on what are to be done and why, is believed to reduce the level of stress since it exists predetermined documents instructing what tasks that you should perform and you "just have to do it". Furthermore, this promotes a logistics plan at every project at Serneke which could solve the issues the site management otherwise would ignore, neglect or forget when not instructed to.

Throughout the construction industry, capacity is often seen as a temporary resource that can be acquired for a limited period of time when it is needed (Paez et al., 2005). In addition, workflow reliability and labour flow is stated to be key determinants steering the outcome of the project. So, on the one hand you want resources when you need them, but on the other hand you do not want to possess them yourself. This paradox causes several interesting problems to be solved. From a workflow perspective and the fact of realising the construction with minimum risk of delays it would be beneficial to own all the resources needed since the risk of project delays due to capacity shortage would be minimised. However, owning resources and storing them when they are not needed occupies both money and space. Somewhere the organisation, or the project, need to decide what areas to prioritise and this will probably be different from case to case. The solution of this equation is yet to be solved, however having the right competence on site must be of top priority and is truly a matter for the organisation to solve. Without the right competence to carry out the determined tasks the outcome will not be maximised, which is supported by several of the interviewees and by Vrijhoef and Koskela (2000).

5.2.1 Integrating SCM at Serneke

Vrijhoef and Koskela (2000) state that there are four different roles connected to SCM, focus on cutting cost on the site, focus on the entire supply chain, focus on transferring activities up-stream and the last role focuses on getting a holistic view on the entire system both the construction site and the supply chain. Out of these four roles, the authors of this thesis have identified three levels of SCM that can be applied on the main contractor, and their relations are presented in Table 5.1. The first level is in direct connection to the first role and focuses on reducing the overall costs at the construction site. This level is fundamental in the business and probably performed by every site management in the industry due to its very nature of cutting costs at site. The second level contains both the second and third role presented by Vrijhoef and Koskela (2000) and deals with issues regarding transferring the mind-set of the first level outside the construction area and focus on the supply chain and transferring on-site activities up-stream the supply chain. The third level is treated as more of an ideal solution and can be compared to a fully lean process or the ultimate SCM.

Table 5.1 – Interconnection between levels of SCM and the focuses of the roles by Vrijhoef and Koskela (2000)

Levels of SCM	**Focuses of the roles**
First level	Cutting on-site expenses.
Second level	Cutting cost along the entire supply chain.
	Transferring on-site activities upstream the supply chain.
Third level	Integrated management with a holistic view on the entire supply chain.

Throughout the site visits and the conducted interviews, it was obvious that some of the projects having a hard time to reach a sufficient degree of even the first level i.e. having a clear logistical coordination on-site and thereby not taking on the first role. Even though several good examples on solving issues at this level were observed, there were also cases where sites showed examples of poor planning, routines and how to tackle issues connected to this level. This advocates that even more resources need to be allocated to ensure the beneficial outcomes even at this the first level. Regarding the second level, all projects treat tasks related to this level in various extent. Usage of prefabricated elements in varying degree and divided deliveries are some of the examples observed during the visits and interviews. However, it is hard to advocate that either of the projects reaches the criteria of this level to full extent. Even more involvement in how the suppliers deal with their upstream supply chains would be needed which also could result in the contractor influencing the suppliers. As a direct result due to neither of the projects achieving level two, neither of them have positioned themselves in the third level.

5.2.2 Degree of logistical centralisation

Due to the nature of construction projects and the fact that it is conducted on a project basis, there could easily be a gap between the main organisation and the project creating barriers which could be hard to overcome. These barriers are expected to become even greater in business that operates in a national context due to for example distance and local characteristics. Engwall (2003), describes this phenomenon as lonely islands and closed system and states that instead all projects that a contractor is involved in should be regarded as a part of the larger organisation. In addition, the local offices could also be regarded as "projects" in the larger context of the parental organisation and the reasoning should therefore be addressed on all the levels underneath the head office as well. However, this view of increasing the interplay between the parental organisations and the local offices and finally the projects is considered to be a step toward a less decentralised structure. On the other hand, maintaining a decentralised structure has been found to be of importance both from the perspective of several interviewees as well as by Dubois and Gadde (2002a). Knowledge of local characteristics and being able to adjust decisions quickly as changes are observed at site are some of the stated reasons for maintaining the decentralised structure.

Even though logistics are a truly a matter of local adjustment and decision making which opposes a more centralised structure, the processes and control of output is of importance for the head organisation. There might exist reasons for conducting processes in a certain way that does not benefit the single project directly but the larger entity. Besides, a more holistic view enables for better knowledge management and thereby a greater possibility for the projects to influence the main organisation as well as the other way around. Nevertheless, the logistical differences among the projects at Serneke are substantial where the responsibility of handling the construction processes often is delegated to the site management, hence a decentralised structure. In addition, the logistical responsibility is often shared among the superintendents at the site, often resulting in miscommunication at the construction site but also along the supply chain. Instead, an implementation of a more standardised logistical system in the contracts between the main contractor, sub-contractors and suppliers would create a more coherent process within the entire organisation.

However, as stated by Liker (2004) remaining flexible around the production line is a core factor in lean production and hence it would be of importance in lean construction as well. Standardise or maintain flexible is not necessary the opposites of each other but still there is a possibility that moving toward centrally standardised processes could interfere on the sites flexibility and their ability to decide on their own. However, from this study it becomes obvious that, from project to project, there exists potential areas of improvement regarding the logistics at site and their supply chains whereon the close cut between the organization aiding or interfering becomes in focus. In addition, it was stated during one of the interviews that:

> "due to local adjustments and the characteristics of the particular site, standardising a process or a logistics plan to fit all the projects of the organisation would be hard."

However, we believe that this is not the case. A standardised logistics plan, but still tailored for each project, would require time and effort to implement but the result would generate a more controlled environment on the construction site and a controlled logistics system.

As mentioned, having one person responsible as a logistics manager, is not obvious in every project. Instead, the role is just assigned to projects where complexity and coordination is of great importance. Lundesjö (2015) explains that the logistics manager oversees the entire supply chain and ensures the logistical progress of the project. As a result, having one responsible logistics manager may be seen as a prerequisite for achieving the second level of SCM, as presented in the first paragraph of section 5.2. Furthermore, Lundesjö (2015) states that JIT-deliveries and having material and services completed in time is crucial for a construction project, which directly is affected by logistics management. By having logistics as a secondary objective to the construction, many of the key aspect regarding material handling and deliveries could easily be put aside resulting in complication. It may be unnecessary and even waste of resources to assign a fulltime logistics manager at every project. However, ensuring that the responsibility of the logistical planning and performing lies with one person is vital for the coordination of the logistics which is highly influential for the project. This is also related to the delivery management systems, where the choice of system is not the important thing but instead to use the functions and ensuring a coordination of deliveries and logistics is most important, regardless of the use of software systems. From the projects at Serneke, it is stated that these delivery systems are updated and controlled in different ways where the Kongahälla project uses Myloc as a delivery system and ensuring that all deliveries made by sub-contractors are synchronised as well. The other projects use whiteboards and some suffers from a higher amount of unannounced deliveries, and often finds the sub-contractor managing their own deliveries, which could be problematic for the site management.

5.2.3 Integrating lean processes and CCC

Assigning a logistics manager at the project will also benefit the implementation of a pull system in production rather than a push system. In conventional construction, the production and thus the deliveries are decided by the main schedule, based on production estimations and is therefore a push system (Kalsaas et al., 2015). Having a push system often results in congestion on the construction site due to production delays and uncertainty but still, the deliveries are continuous. By moving towards a more pull oriented system, the logistics become pushed instead of the production which can control the deliveries and decrease the congestion on the site. However, a pull system requires more supervision, planning and control systems which also requires more attention to logistics planning apart from what is standard today. This was especially visualised at the Kongahälla project where the coordination clearly gave effects on the production and the logistics and the feeling of being in control, probably due to the fact that the project assigned a logistics manager. The pull system crated room for planning and coordination which otherwise pushed the production where a logistics manager was not present.

Furthermore, Daniel et al. (2017) describes that by incorporating LPS in the supply chain, uncertainty will be minimised and achieve a more sufficient logistical flow. From the empirical study there was especially one solution regarding pull system that caught our attention. One of the studied project were explicit stating that they had transferred the responsibility of replenishment the most common consumable fastening materials, such as screws etc., through an order-up-to point. This is a typical example of a Kanban system were the usage of downstream processes, the site, signals upstream processes, the supplier, through the pre-determined number of boxes what is needed and in what amount. It is also connected to the role of transferring on-site activities up-stream the supply chain, whether it is by prefabricate concrete elements or by assigning a supplier to replenish the storage at the construction site.

When striving toward a smoother logistical flow and a more pull oriented system, an enhanced way of dividing and coordinate deliveries resulting in a higher delivery precision and thereby reduced uncertainty one could beneficially make use from a CCC (Hamzeh et al., 2007; Lundesjö, 2015). JIT deliveries and a reduced risk of material transports causing problem due to variation in activity duration mentioned above is some of the usage of CCC could help to aid. Nevertheless, moving from a push-oriented system toward a pull oriented one is not only beneficial. On the one hand this will require more attention and control from the logistics management on site regarding planning and awareness of the present on-site activities. In return, a greater precision will be achieved, and the responsibility is moved upstream the supply chain resulting in a more proactive course of action. On the other hand, the pull system and LPS is also dependent on the flexibility of the upstream supply chains, such as the ones from suppliers etc., who would have to be able to deliver within shorter notice i.e. shorter lead times and increased flexibility. According to the Fernández-Solís (2008) the construction industry suffers from longer lead times than other industries. Reducing lead times might be the single most important factor to enable a more pull-oriented approach in the industry. Having long lead times complicates the logistics since the period of time from ordering point to delivery is longer and thereby the risk of production delays becomes greater. At the moment, using a CCC may not be an economical solution for every project at Serneke, but planning for logistics in more detail and ensuring the relations with the suppliers could strengthen the possibility to pull production instead of push. However, in a long term planning, Serneke should consider to implement CCC in their projects within larger cities where the densification and complexity is imminent.

5.3 The procurement's effect on construction logistics

In the thesis, three of the projects are procured as project partnering and one is procured as DBB. In addition, the partnering projects are considered to be similar to the DB procurement due to the design being carried out continuously as the construction of the project. Addressing the issue with the DBB procurement as point of departure, this should be the best form of procurement when observing the logistics. Since the design should be completed at the time of tendering (Masterman, 2001) this is the only studied form of procurement were all the information should be available at the time of construction. Even though on site changes is probably to occur due to insufficient documents (Walker & Lloyd-Walker, 2015) the contractor has the holistic responsible of the planning and the parties involved. Insufficient design is one main reason for delays which could disturb the involved supply chains. In addition, the contractor is solely responsible for the budget and could therefore, on their own, decide whether a logistics manager should be appointed or not. However, due to problems to prove potential savings there is hard to advocate for the implementation of a logistics manager if it is not included in the projects budget at the point of tendering. There is also a possibility that this function is down prioritised and neglected in favour of winning the tendering and receiving the project.

Communication is stated to be of great importance when observing logistical processes (Hagenbjörk, 2014; Lundesjö, 2015; Paez et al., 2005). In addition, communication can, depending on how it is performed and received, create friction and barriers or enable for a smoother process were everyone is focusing on logistics. According to Briscoe et al. (2004) different form of procurement may affect the communication patterns between the parties, the flow of information and hence the supply chains and the logistical processes. Even though neither of the interviewees stated directly that the form of procurement would have a direct impact the logistics and the logistical processes, their reasoning and discussion points in a different direction. In a partnering project, the general perception from the interviewees is that it may be easier to get to assign a logistics manager, since the cost and the risk is shared and the fact that the client is often interested in having a smooth process, which gain support by Lundesjö (2015). In addition, the benefits of engage in a strategic partnering may stimulate innovative solutions was mentioned and the fact that the involved parties may develop a common understanding for the involved processes which should lead to a more efficient process. The possibility of teams performing better from project to project if they have the same composition is supported by (Gidado, 1996).

DB is stated to enable a faster construction processes than the DBB approach (Beard et al., 2001; Forbes et al., 2011; Sacks, 2013; Walker & Lloyd-Walker, 2015) and even if no DB project was observed during the process of this thesis, the holistic responsibility with one organisation in charge of the entire process advocates this statement. The early contractor involvement and the fact that the contractor itself is responsible for the construction and composition of the documents should lead to less errors in the documents and thereby also reduce the number of on-site changes. However, when conducting the design during the progress of the construction there is always a risk that design does not keep the same pace as the production. Even though the remaining three studied projects are procured as partnering projects, they have all three suffered from insufficient pace of the design team, from various reasons. A typical observation made on this behalf was at the project were prefabricated gypsum walls was used. Instead of installing these walls in a smooth pace, as planned for, the site management found themselves forced to store the walls pending mounting due to the mentioned reason. Our general opinion concerning partnering from the study is that the contractor often suffers from incomplete design which of course affects the deliveries and the logistics in the project. This is also supported by one of the site managers who claimed that:

> "Of course, we should be more demanding and have deadlines toward the design in order to receive the orders in time, but the road to decision making is often too long and is often pushed forward."

Even though one of the corner stones in partnering is to enhance the collaboration and thereby the understanding of other sub-branches difficulties (Cheng et al., 2004) which also is advocated in lean construction (Koskela et al., 2002), one must also ensure the success of the own firm. From a logistics point of view it is favourable to have a smooth and even process (Koskela et al., 2002; Paez et al., 2005) and when design is running late there is an impending risk that the project is forced to produce a substantial amount of work at a short period of time in the end of the project i.e. the project becomes more pushed instead of pulled.

5.4 The Construction Logistics Plan

A standardised logistical process is yet to be implemented at the projects at Serneke. As previous mentioned, a logistics plan is only used in one of the projects investigated. Even if the industry is in need of a structural way of working with construction logistics (Lundesjö, 2015), few documents exists at Serneke on how to handle the logistics in the projects. According to the content of a CLP, described by Sobotka and Czarnigowska (2005), Serneke is in one project fulfilling the different CLP stages with success. These stages are above all the planning and execution stages.

On the one hand, more resources are needed in order to fulfil the tasks presented in Table 2.2 in chapter 2 and for an efficient logistics procedure to work, one person should dedicate time to this. On the other hand, during the observations and the interviews it was stated that some parts still are "manageable" as it is and that standardised solutions may be hard to implement. However, for all project to have a logistics plan constructed regarding logistics will improve the efficiency of the supply chain and also be a tool of communication toward suppliers and sub-contractors. The logistics plan itself may come in different versions depending on the complexity of the project and will function as a logistics "playbook". The cornerstones of the CLP will contain material specifications regarding deliveries, packaging, announcing and the logistical management of the specific project but can differ depending on if the contractor is using a digital delivery system or CCC etc. Since the logistical prerequisites seldom is specified in the contracts the plan will fill that gap from the accepted community of practise in the industry and minimising communication issues and operator errors. Further, it will also ensure a desired logistical outcome instead of an accepted one. These points are considered the most critical since they reflect the problem otherwise occurring on site where the logistics plan is not used.

Furthermore, Lundesjö (2015) states that the CLP should be constructed by the main contractor, as a coordinator, which also stresses the importance of allocating sufficient resources at the construction site. Since insufficient resources is a common problem at Serneke, moving to a more standardised process will benefit the logistical process. The content of the logistics plan should include a construction site layout, which all investigated projects had but in most cases rarely updated. One could argue for the purpose of logistical tools and aids if not used or updated correctly and the same goes for a logistics plan. It is therefore a necessity to visualise the possible economical gains from implementing logistical solutions in the processes at Serneke and the logistics plan would be the core of this implementation. Furthermore, the suppliers and sub-contractors of Serneke would benefit from this as well as they will be familiar with the logistical processes and therefore a closer relationship with partners to Serneke will be possible. The organisation of Serneke will also benefit from the logistics plan since the planning of the projects would be more or less the same and the project structure of the organisation would therefore not be an obstacle. The plan could affect both smaller and larger projects of Serneke since logistical processes will be similar but differs in extensiveness and the CLP will create the necessary conditions for more efficient construction logistics.

6 Conclusions

This chapter contains the concluding remarks to answer the research questions and thereby synchronising the findings from the theoretical framework and the ones from the empirical study. The chapter is also addressing suggestions for Serneke regarding construction logistics along with further research proposals.

6.1 Managing logistics

Even though Serneke is working with logistics in their everyday business, there is not a unified way of conducting these processes. It differs from project to project and it is stated from the head organisation that the processes regarding logistics is a matter of the individual project. In addition, there is, on the operational level, differences between the local offices and the head organisation. However, whether these differences are due to the geographical positioning or the uniqueness of the projects is yet to tell.

The main barriers identified that prevent a sufficient working climate with enhanced focus on logistical challenges and processes can be summarised into four categories. First of all, there is not a sufficient way of measuring the benefits of assigning a logistics manager and the true outcomes of proactive working with the logistical challenges. This often results in logistics processes being treated reactively instead of proactively due to insufficient amount of time and attention. Second, the competences at site and within the organisation must correspond with the performances that the person is expected to carry out. No team will be stronger than the weakest link and if the competences are not matched with the work tasks the utilisation will not be maximised. Third, there is no clear guidelines or detailed specifications embedded in the procurement of sub-contractors and materials. This gap creates possibilities for the suppliers and sub-contractors to create their own way of addressing issues and if the main contractor is often left without possibilities to really affect how these processes are conducted. Finally, there is a necessity of enhanced communication between all involved parties of the construction project. Communication, predetermined ways of execution and knowledge management is of importance not only to deliver the highest added value to the customer but also to evolve as organisation and to learn from previous projects, not only on the individual level but rather on an organisational level.

Regarding the existing logistics plan Serneke uses for larger projects, a logistics manager is responsible for the logistics. The function of the plan is to bridge the gap between the community of practise and how Serneke would like the logistical processes to be conducted. However, the utilisation of the logistics plan needs to be expanded to several other projects at Serneke in order to reach synergy within the specific project but also in the entire organisation regarding construction logistics. The project where the logistics plan is used tend to be more organised from a logistical point of view and the logistical frame of the project is clearly stated where every actor involved have the right information to know what is expected from them. When conducting a formal document, this shows the importance of a well-functioning supply chain and therefore an advantages in getting all individuals in a project to work toward a common goal.

With an increasing number of inner city projects, construction logistics is in need of coordination in the projects at Serneke. The coordination should permeate the entire organisation, the projects and the actors involved in the projects. The logistics plan should therefore be developed as a standardised document for all projects to use, in different versions depending on the complexity in each project. The plan should also clearly state who is responsible for logistics in the project in order to avoid confusion at the construction sites. Further, the plan should also be an internal document to work as a core document for how to plan for logistics. Once the logistics plan is tailored for a specific project, it is also an external document, setting the logistical prerequisites for the project and avoiding what would otherwise be inevitable interruptions.

6.2 Suggestions for Serneke

The general suggestion for Serneke is to continue to improve the logistical processes within the company and to integrate logistics throughout the entire process and not solely the process of the construction. Through systemising and conducting more standardised processes while maintaining the decentralised structure that exists today, several of the barriers mentioned above will be diminished. As a result, the productivity, efficiency and the profitability of the projects will increase. In addition, working proactively toward achieving a logistics climate where Serneke, as main contractor, sets the fundamental rules in how the game is played instead of accepting a reality where other dictates the terms are seen as highly important. Due to being one of the last processes downstream the supply chain, only the client should be able to interfere in how the processes are conducted. This also relates to the chosen form of procurement.

6.3 Further research

During the accomplish of this thesis, additional areas of research were discovered of which this topic could benefit from. One suggestion is to develop a way of measure the efficiency of different logistical solutions in order to identify which one that suits a company best. In addition, this way of measuring should enable the possibility to compare different projects through key figures and thereby determine where and when the processes align with the organisations targets. Further investigation could also be addressed deeper down in the organisation including the craftsmen at site and in addition, the sub-contractors and their view on how the logistical processes should be performed. Finally, it would be of interest to investigate the view of the final downstream process, namely the client to consider how they preferable would like to address the logistical issues. By combining the views on construction logistics between the suppliers, contractors, sub-contractors and the client, the best way of handling construction logistics may be reached.

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Appendix

Appendix A

1. Berätta om din roll på Serneke samt tidigare erfarenheter
2. Vilka är anledningarna att Serneke väljer/inte väljer att arbeta med logistikfrågor på en strategisk nivå?
3. Vad anser du är det största utmaningarna/problemen inom logistik i produktion (operativ) och hur jobbar man som organisation för att möta detta?
4. Hur anser du att Serneke ska arbeta ute i produktion med logistikfrågor?
    a. Vill Serneke att man ska arbeta mot ett mer standardiserat tillvägagångssätt?
    b. Vill man att varje projekt ska styra sin egen logistik helt när det kommer till planering och genomförande?
5. Vad är syftet med logistikbilagan?
    a. När ska den användas och vad avgör när den används?
6. När anser Serneke att en logistikansvarig ska finnas i projektet?
    a. Vad avgör om det ska finnas?
7. Vilka verktyg/hjälpmedel finns centralt i organisationen som kan kopplas till logistik och användas ute på projekten?
8. Finns det ett behov att standardisera logistikarbete inom organisationen?
    a. Likt KMA eller inköp med mera
9. Hur ser kunskapsåterföringen ut från projekten, finns det något forum för kunskapsutbyte och tas detta med in i nya projekt?
10. Märker du någon skillnad på logistikplaneringen beroende på upphandlingsform?
11. Hur ser arbetet ut framöver och vilka nya utmaningar finns?

Appendix B

Allmän information

1. Berätta om projektet från Sernekes sida och din roll i det.
    - Bakgrundsinformation av intervjuperson (erfarenheter, utbildning, roll i detta och tidigare projekt)
2. Vad har logistik inneburit i detta projektet?
    - Vem har det logistiska ansvaret i projektet och vad är dennes uppgifter?
    - Hur utseddes denne?
    - Vad avgör om det ska finnas en renodlad logistikansvarig person?

Projektets förutsättningar

3. Vilka logistiska svårigheter har ni kunnat koppla till just detta specifika projekt?
    - Närliggande verksamheter
    - Platsbrist
    - Andra saker som bidragit till projektets logistiska komplexitet
4. Fanns det särskilda krav från beställaren, eller andra aktörer, som påverkade er/tvingade till att fatta vissa beslut med avseende på logistik. Hur hanterades dessa och vilka "krav" har ställts?
    - Beställare
    - Stad/Kommun
    - Övriga intressenter
    - Andra projekt som påverkar, både från Serneke och andra entreprenörer.

Projektets logistiska lösningar

5. Hur har ni i detta projekt hanterat logistikutmaningarna?
    - I vilket/vilka stadier har problem kopplat till logistik diskuterats och planerats för, ex. vilka problem som kan komma att uppstå och hur dessa kan lösas.
    - Vilka aktörer har ni valt att involvera i logistikplaneringen i projektet och varför? Finns det någon ytterligare som ni anser är bra att "ha på banan"?

6. Vilka riktlinjer/verktyg har ni fått till er från Serneke (Centralt) och hur har dessa förmedlats. Har ni använt er av de "verktyg" som funnits tillgängliga.
    - Om olika verktyg använts, vilka problem har det kunna avhjälpa och vilka brister anser ni verktygen har
    - Om inga verktyg använts, förklara gärna om ett centralt stöd är önskvärt och hur ett sådant system skulle kunna utformas. Vilka behov har ni på plats som den större organisationen skulle kunna tillgodose.

7. Finns det behov av ett standardiserat arbetssätt i alla projekt gällande logistik?
    - Finns det speciella förutsättningar som behöver ha en standardisering?
8. Hur arbetar ni med era flöden till och från byggplatsen?

a. Hur många leverantörer är involverade i projektet?
b. Direktleveranser/konsoloderingscenter?
c. JIT - används system för att boka leveranser och hur går det till?
d. Delade transportlösningar med andra Serneke-projekt?

Övriga frågor

1. Utifrån er tidigare erfarenhet, anser ni, och då på vilket sätt, att logistikutmaningarna/arbetet skiljer sig beroende på upphandlingsform i projektet?
2. Utifrån er synvinkel, hur tar Serneke åt sig av de lösningar och den kompetens som finns ute på projekten gällande logistik?
3. Vad anser du behövs för kompetens för att kunna ansvara för logistik? Utbildning, erfarenhet från produktion etc.
4. Vilka åtgärder är viktigast för att underlätta/förbättra logistiken? Vem är ansvarig för att förbättra det?
5. Hur har arbetet med logistik sett ut över tid och hur har det förändrats till idag? Vilka nya utmaningar finns?
6. Är ni okej med att de svar ni gett kommer publiceras i rapporten, självklart efter granskning av er.