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Vision Masthuggskajen (Masthuggskajen, n.d.).

Coordinating construction logistics for multiple projects in an urban development district

A case study of Masthuggskajen

Master's thesis in Design and Construction Project Management

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ABSTRACT

Even with a continuous flow of studies proven its potential, construction logistics is an often-negligible part in the construction industry, particularly in dense cities. This thesis aims to investigate how the construction logistics plan in the project Masthuggskajen including adherent actors' collaboration and logistics solutions contribute to the realization of Älvstranden Utveckling's visions of Älvstaden. Through an abductive research process, both a literature study including topics of supply chain, supply chain management and construction coordination, as well as an empirical study including an interview- and an observational study, a holistic approach is taken on the current logistics situation. Contractors, project managers, and construction coordinators involved in project Masthuggskajen were interviewed. To guide the work, research questions encompass the collaboration in project Masthuggskajen and how it affects the coordination of construction logistics, how the current logistic plan is structured and adhered and what implementation of the logistics plan could benefit future projects are developed.

The study shows that the current logistics mainly is individually coordinated in the different projects with a unified progress plan regulating the delivery routes. This progress plan is however not sufficiently adhered. Together with a decentralized view and focus on the individual project the common negative effects are overseen. Moreover, Älvstranden Utveckling needs to explicitly define their role towards the rest of the consortium to ensure the city of Gothenburg's aims. They also need to develop the framework for representing and cooperating with the other local authorities. Finally, ensuring that information reaches throughout the supply chain down to the suppliers is shown as a success factor for a multi project district construction supply chain.

This master thesis provides contributions for project Masthuggskajen in general and its coordination of construction logistics in particular by enlightening improvements and success factors to import to the eastern part of Masthuggskajen. To add a more comprehensive construction logistics solutions requirements into the land allocation agreements and an extended coordination is needed in future projects in *Vision Älvstaden* and other urban development districts with multiple projects.

Key words:
Construction logistics, Construction coordination, Logistics solutions, Construction supply chain, Urban development

Koordinering av bygglogistik för flera projekt i ett urbant stadsutvecklingsområde

En fallstudie om Masthuggskajen

Examensarbete inom masterprogrammet Master' Design and Construction Project Management

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SAMMANFATTNING

Trots ett kontinuerligt flöde av studier som bevisat potentialen är bygglogistik en ofta nonchalerad del av byggbranschen, särskilt i täta städer. Detta examensarbete syftar till att undersöka hur bygglogistikplanen i projekt Masthuggskajen inklusive anhöriga aktörers samarbete och logistiklösningar bidrar till förvekligandet av Älvstranden Utvecklings visioner av Älvstaden. Genom en abduktiv process där både en litteraturstudie med fokuspunkterna: försörjningskedja, försörjningskedjeledning och byggkoordinering, samt en empirisk studie med både intervju- och en observationsstudie, tas en helhetssyn på den nuvarande logistikstrukturen. Intervjuobjekten är entreprenörer, projektledare och byggkoordinatorer involverade i projektet Masthuggskajen. För att vägleda arbetet har forskningsfrågor rörande samarbetet i projektet Masthuggskajen och hur det påverkar samordningen av bygglogistik, hur den nuvarande logistikplanen struktureras och följs och hur implementering av en logistikplanen kan gynna framtida projekt, använts.

Arbetet visar att den nuvarande logistiken huvudsakligen samordnas individuellt i de olika projekten med en enhetlig framdriftsplan som reglerar leveransvägarna. Denna framdriftsplan följs dock inte tillräcklig utsträckning. Tillsammans med en decentraliserad syn på det enskilda projektet, förbises ofta de gemensamma, negativa effekterna. Älvstranden Utveckling behöver vidare uttryckligen definiera sin roll gentemot resten av konsortiet för att säkerställa att Göteborgs mål efterföljs. De behöver också utveckla sättet de representerar och samarbetar med de andra lokala myndigheterna. Slutligen, att se till att information når igenom hela försörjningskedjan ner till leverantörerna, är en bevisad framgångsfaktor för en den totala bygglogistiken i stadsutvecklingsområden med flera närliggande projekt.

Detta examensarbete ger bidrag till projektet Masthuggskajen i allmänhet och dess samordning av bygglogistik, särskilt genom att belysa förbättringar och framgångsfaktorer att exportera till östra delen av Masthuggskajen samt andra kommande projekt. För att använda det nyutvecklade strategiska logistikdokumentet och lägga till mer omfattande bygglogistikbehov i markallokeringsavtalen kommer logistiken att bidra mer till *Vision Älvstaden*.

Nyckelord:
Bygglogistik, Byggkoordinering, Logistiklösningar, Byggförsörjningskedja, Stadsutveckling

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As Queen once sang, the show must go on. Our time at Chalmers is coming to an end, and this master thesis is a summary of the knowledge we have conducted during our five years at Chalmers. It must be acknowledged that this thesis has been written on for Inhouse Tech during the covid-19 influenced spring semester of 2021. In this process we have been given the opportunity to visit coordination- and site meetings and to get priceless insights we will bring into our coming carriers. A special thank will be directed to our supervisor at Inhouse Tech, Olle Valentin, for quick responses and support throughout the process.

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Göteborg, June 2021
Magnus Berg
Carl Thorpö

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1 Introduction

This chapter introduces the thesis. First, the background is presented. Thereafter, the aim of the thesis is described followed by the research questions and the limitations.

1.1 Challenges of urbanization

The cities of the world are growing and are densifying rapidly due to an increasing urbanization. By the year 2050 it is estimated that over two thirds of the world's population will be living in urban areas (Guerlain et al., 2019). A larger population put pressure on the infrastructure of the cities as the infrastructure needs to be able to handle a larger number of residents and the demand for housing and offices will increase. Therefore, cities are increasingly required to invest in new buildings and refurbishments of existing infrastructure primarily in dense city areas (Civic Project, 2018; Guerlain et al., 2019).

However, building in urban environments do come with several logistical challenges. Construction both increases traffic as well as hinders it (Browne & Lindholm, 2015). Transportation of materials related to the construction industry is a major contributor of the total freight movement in cities. According to Guerlain et al. (2019) it constitutes almost a third of all the freight movement in cities. The problem with construction traffic is exacerbated by the ongoing densification that is taking place in the cities. All the more construction is taking place in dense city areas that suffer from congestion, which creates challenges as the construction industry generally is heavily dependent on the road network for transport (Browne & Lindholm, 2015). When building in a city center routes for the related movements needs to be carefully planned as to minimize the disturbance on the local traffic and other activities (Sullivan et al., 2010). Moreover, the construction sites in dense areas may need to close down roads as the extra space is needed (Browne & Lindholm, 2015) and the characteristics of construction deliveries differs from other kind of urban freight deliveries (Guerlain et al., 2019) is also something that should be taken into consideration when planning the construction logistics for a project.

The volumes of materials needed in construction are extensive, but deliveries can be sporadic and relate to the different project phases (Civic Project, 2018; Transport for London, 2019). In the early phases, the pressure put on the near traffic is especially high. At the foundation work, extensive shuffle traffic is needed and if a prefabricated frame is used daily large and heavy transports are needed. According to Dubois et al. (2019) a large construction site may need approximately 7'000 deliveries each month. This large amount of freight transport requires well-executed planning to reduce the pressure on the existing transport system and minimize the impact on the daily lives of citizens (Browne & Lindholm, 2015; Transport for London, 2019). Furthermore, if the planning is not managed well a project is more susceptible to economic losses and delays (Guerlain et al., 2019). Even if no project is an island and knowledge from previous experiences can be applied (Engwall, 2003), the location of a construction project is unique thus every project needs its own logistics plan (Civic Project, 2018; Ying et al., 2018). In the early phases, different pressure is put on the near infrastructure. At the foundation work, extensive shuffle traffic is needed and if a prefabricated frame is used daily large and heavy transports are needed.

In the construction industry there are many involved actors within a project's different phases whose activities are interdependent. The considerable complexity of the industry is mostly due to the amount of coordination needed between the different actors and activities (Bankvall et al., 2010; Dubois et al., 2019). Love at al. (2004) argue that communication and sharing information between actors is crucial to improve the efficiency of the construction supply chain. However, lack of communication and information sharing are major problems in the planning process of construction projects (Thunberg et al., 2014). Traditionally the coordination for deliveries to a construction site is kept on a minimum, whereas each contractor organizes their own deliveries (Dubois et al., 2019). Reducing the amount of freight movement by coordinating joint logistics is becoming more essential as the cities are getting denser (Browne & Lindholm, 2015). Configurations with increased coordination could improve the efficiency on-site and reduce congestion due to more optimized deliveries. The configuration could even expand unto nearby construction sites increasing the coordination and the efficiency in the supply chain even further (Dubois et al., 2019).

A course of action to facilitate the coordination and communication in relation to construction logistics is to use a construction logistics plan (CLP) (Agapiou et al., 1998), that provides a framework how the coordination and communication in a project should be handled (Sullivan et al., 2010; Transport for London, 2019). A well-planned CLP should, according to Transport for London (Transport for London, 2013, 2019) include: introduction and summaries of the construction process during its different phases, information about the sites characteristics, construction details and the material supply chain, traffic management, developing and using policies, how the CLP will be monitored and how it will be managed. Different projects vary in size, complexity, and level of impact the construction site is estimated to have on the surrounding area, thus the requirements of the CLPs also differ.

The benefits of using a CLP are that it not only reduces pollution, congestion, and overall road risk by reducing the number of transports going in and out of a construction site but also fosters higher efficiency. Larger projects, for example, the city development project Masthuggskajen in Gothenburg, with a large impact on the local community and traffic could therefore consider adopting a logistics plan. After all, the success of a project is highly reliant on the coordination and logistics (Ying et al., 2014).

1.1.1 Masthuggskajen

The city of Gothenburg is no exception to the densification trend. According to their annual report (Göteborgs Stad, 2019), the municipality of Gothenburg (Göteborgs stad) concludes that the population have increased, and will continue to increase, with approximately 7'000-8'000 citizens per year. To meet the increasing demand of housing and offices, multiple exploration projects have been initiated over the last few years (Browne & Lindholm, 2015; Göteborgs Stad, 2019). The most comprehensive exploration initiative is *Vision Älvstaden*. It contains multiple urban developing projects located in central city districts surrounding Göta Älv, all driven by the public company Älvstranden Utveckling. One main area targeted by exploration is the bay area and the shoreline of Göta Älv. Due to a gradual dismantling of the previous shipbuilding yards and docks, this area has been unutilized since 1970 (Älvstranden Utveckling, 2014) but will, through *Vision Älvstaden*, contribute to the much needed densification of Gothenburg.

The geographical areas included in *Vision Älvstaden* are; Backaplan, Centralenområdet, Frihamnen, Gullbergsvass, Lindholmen, Ringön and Södra Älvstranden. Together they cover a buildable area of 5 million square meters and contain approximately 25'000 new dwellings and 40'000 new workplaces. To be able to finance and monitor these projects, Älvstranden Utveckling developed a business strategy called Älvstadsmodellen (Bladini & Petrusson, 2019). This strategy explains how business should be implemented through collaboration-consortiums to secure the financing and ultimately, to fulfill Älvstranden Utveckling's vision. Within this vision, the goals are to reduce greenhouse gas emissions by 50% and to become the national leader in sustainable urban development.

One of these formed consortiums operates the Masthuggskajen project. Located west of the inner-city, on the south bay, is a new district in the making. 310'000 square meters of gross area divided into dwellings, commerce, public areas, hotels and two pre-schools are included in the plan. It is also said that the whole project shall pervade with a clear sustainable ambition. Today the area is dominated by parking spaces and traffic. The vision is to contribute to the city's spatial- and social integration with a special consideration to the child perspective. The operating consortium consist multiple private actors as well as Älvstranden Utveckling. The private actors, who through land allocation agreements with Göteborgs stad, have the rights to exploit the area, will develop residential buildings, offices, and other real estates with some collaboration between the parties. Appointed to coordinate the on-going construction is the company Inhouse Tech. Their statement of work also includes to call and moderate coordination meetings, plead the project's opinions to concurrent projects and to coordinate the construction logistics.

Due to the location of Masthuggskajen, there are several challenges regarding construction logistics. Surrounding the construction area are big public transport hubs and already congested roads as well as simultaneously major infrastructure projects. In addition, the construction area itself is narrow with limited storage space resulting in an increased need of well-planned deliveries. Nonetheless, there is no mutual logistics plan developed besides the compulsory APD-plan. The different actors are responsible for their own construction logistics, supported by the project coordinator. Earlier, in the design phase, a mutual logistics plan was provided by a TPL-consult but was considered too expensive, and thus not implemented in the construction phase.

With that in mind, to be able to realize the vision and implement the ambition, the construction logistics is crucial. To generally analyze the current construction logistics situation at Masthuggskajen and the coordination (or lack of coordination) between the different actors, needed adjustments can be presented to facilitate the continuing project as well as forthcoming similar projects.

1.2 Aim of the thesis

The aim of the thesis is to investigate how the construction logistics plan in the project Masthuggskajen including adherent actors' collaboration and logistics solutions contribute to the realization of Älvstranden Utveckling's visions of Älvstaden. The thesis is carried out in collaboration with Inhouse Tech.

1.3 Research questions

As to fulfill the aim of the thesis, three research questions are identified:

RQ1: How is the collaboration among the various project actors organized in project Masthuggskajen and how does it affect the execution and coordination of construction logistics?

RQ2: How is the current logistic plan for project Masthuggskajen structured and adhered?

RQ3: What can be learned from the implementation of the logistics plan at project Masthuggskajen that could benefit the organizing of construction logistics in future projects?

1.4 Limitations

In line with the aim and research questions, some limitations to the study are identified.

Firstly, to be able to make a relevant in-depth investigation over the current logistic- and traffic plan, and its solutions at Masthuggskajen, the main target is the freight, delivery, and storage solutions. The individual packaging of goods, and on-off loading methods will be just briefly investigated.

Secondly, the role of Inhouse Tech in the project is more comprehensive then to coordinate regarding construction logistics. Their remit is construction coordinator which includes multiple commitments. However, it is their role as construction logistics coordinator, categorized in this thesis, and consequently, that role is investigated towards the other actors.

Finally, a geographical and time-based limitation is made. Masthuggskajen is a major project that covers a whole new district and will prolong for a couple of years. To stay in line with our aim and research questions, only the ongoing projects during spring 2021 (time of the thesis project) are investigated. Hopefully, the findings can contribute to the forthcoming projects.

1.5 Thesis structure

The thesis consists of six chapters in the following order: Introduction, Theoretical framework, Methodology, Empirical data, Analysis, and Conclusions.

2 Theoretical framework

This chapter presents characteristics of the construction industry followed by construction logistics and some of the challenges that the industry faces in terms of construction in urban areas. Further, coordination and communication within and between different construction actors are presented. The importance of logistics and supply chain management are highlighted, and finally various logistical solutions are presented.

2.1 Characteristics of the construction industry

The construction industry is a major player on the global market considered the industry's total turnover as well as number of employed personnel (Ekeskär & Rudberg, 2016). In Sweden, the construction industry's turnover in 2018 added up to 535,8 billion SEK which corresponds to 11,2% of the Swedish GNP (Byggföretagen, 2021), and employed 327'000 people which is a considerable part given Sweden's 10,4 million inhabitants (Byggföretagen, 2020).

There are several phenomena that characterize the construction industry. One is the substantial ineffectiveness regarding its setting, fragmentation, and complex organizational structures (Fellows & Liu, 2012; Xue et al., 2007). Construction projects could be seen as temporary factories, necessary due to the environmental characteristics of construction projects (Ekeskär & Rudberg, 2016). Resulting in, as opposed to manufacturing factories, minimized opportunities for continuous, long-term, local optimization and suppressed innovation (Bygballe & Ingemansson, 2014; Dubois & Gadde, 2002a). Furthermore, the construction business is project based. When a project ends, the involved parties; contractors, sub-contractors, consultants etc., gets engaged in another project with different pre-conditions and different constellations which hinders long-term relationships in the construction industry (Dubois & Gadde, 2002a; Janné, 2018; Love et al., 2004).

Further effects of the project-based business that characterize the construction industry in terms of standardization. The industry is resource dependent regarding both physical and human knowledge (Dubois & Gadde, 2000), and all projects requires these resources to be joint between the involved parties. Due to the fragmentation and fluctuated relationships, the construction industry relies on standardized parts rather than standardized processes or activities, resulting in lower efficiency (Dubois & Gadde, 2002a). This low efficiency has been shown in several studies (Forsberg & Saukkoriipi, 2007; Josephson & Chao, 2014; Lindén & Josephson, 2013). For instance, waste produced in a project can amount to as much as 30-35% of the total production cost (Lindén & Josephson, 2013). Moreover, the space limitations the construction site imply aggravates the numerous simultaneously ongoing activities needed. To reduce the effects on one another, interdependency must be handled (Janné, 2018). Concerning this setting, multiple intertwined actors in tight schedules, relational issues are inevitable (Lu et al., 2016).

A final characteristic is the cultural resistance to change. There is a general inclination throughout the industry to use well-tried methods rather than integrating new unfamiliar ones. Motives behind this are argued to be the tight time-schedules construction projects often work with and the temporary coalition of involved parties with varying targets (Dubois & Gadde, 2002a; Sullivan et al., 2010). The need to deliver the project on-time

and lack of knowledge transfers between projects have discouraged innovation despite the competitive nature of the construction market.

2.2 Construction logistics

Construction logistics is a crucial component in construction projects and can heavily affect central aspects, in particular the project's cost and construction time (Sullivan et al., 2010), and is defined by Janné (2018, p. 9) as "*dealing with supplying the right materials to the correct customer and construction site to meet customer's requirements"*. Delivering a product that stays within its scope, considering time, cost, and quality are the ambitions of every construction project (Janné, 2018). Thus, improving logistics should be a focal point in the industry. However, according to Sullivan et al. (2010) inadequate attention has been devoted to logistics in the construction industry.

Multiple activities are included in construction logistics, such as materials handling, storage, shipment, and resource allocation (Sullivan et al., 2010). Construction projects are dependent on a heavy flow of materials to site (Dubois & Gadde, 2000) that has to arrive at the right place and time (Civic Project, 2018; Ekeskär & Rudberg, 2016), which generates a great deal of construction related freight movement (Dubois et al., 2019). Increased efficiency of the large amount of inbound transports can be achieved through reduced vehicle mileage and increased capacity (Ying et al., 2014). Improved logistics and increased efficiency of this freight movement could, in addition to reduced environmental impact (Ying et al., 2014), save up to 20% of a project's total cost (Sveriges Byggindustrier, 2010). However, in Ying et al. (2018) study it is shown that a majority of construction materials are delivered on an ad hoc basis, making it challenging to streamline. Further, materials handling and unloading is often performed by construction workers, disturbing their work and adds on non-value adding time (Sullivan et al., 2010; Ying et al., 2014).

Furthermore, key aspects in construction logistics are on-site and off-site logistics and the progress of construction projects are highly reliant on the interface and coordination between them (Sundquist et al., 2018; Ying et al., 2014). The logistics on-site encompass activities subsequent to construction materials arrival on-site. The incentive for improving on-site logistics is to reduce non-value adding time spent by construction workers through more efficient material flows and handling (Sundquist et al., 2018). Off-site logistics accounts for all the activities taking place outside of the construction site. The goal of developing the off-site logistics is to synchronize actors in the supply chain to make it more profitable and efficient. *Figure 1* below portrays how the relationship between a supply chain and logistics can be intertwined in complex industries. As stated above the logistics synchronizes the actors in the supply chain (Sullivan et al., 2010), which is especially important in the construction industry that has a multitude of interdependent activities (Bankvall et al., 2010). Further, decisions made in relation to on- or off-site logistics have different impacts on the surroundings. On-site logistics impacts are local and can for example highly affect the nearby traffic, whereas off-site logistics can impact the whole of society through solutions that reduce the amount of transports, also reducing the environmental impact (Sullivan et al., 2010).

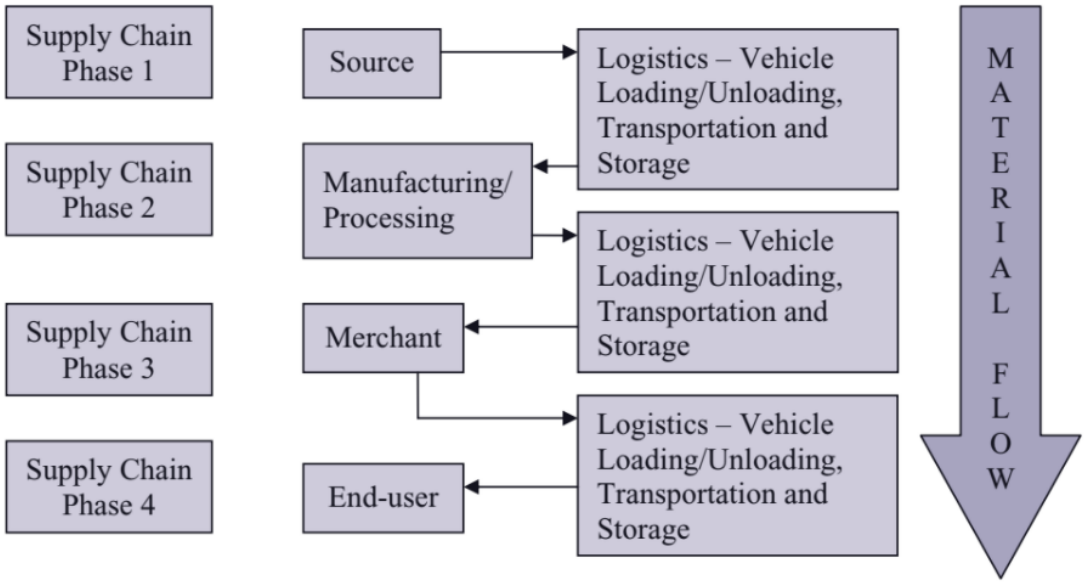

Figure 1: The relationship between logistics and a supply chain (Sullivan et al., 2010).

Practically, in construction projects located in dense urban areas it is important to recognize the restrictions regarding space, congestion, and impact on third parties to successfully operate construction logistics. To overcome these sub-optimal circumstances extensive planning is needed well before the first sod is dug. Additionally, knowledge about what tools and methods are accessible and when they are suitable is crucial for improving construction logistics (Sullivan et al., 2010; Ying et al., 2014).

2.3 Construction in urban areas

The urbanization in the world is growing rapidly and by the year 2050 it is estimated that the population of urban areas will encompass over two-thirds of the world's population (Bretzke, 2013; Guerlain et al., 2019). The increased population strains the existing infrastructure and creates a high demand for refurbishment of the old and construction of new infrastructure and buildings (Civic Project, 2018; Guerlain et al., 2019; Ibrahim et al., 2018). However, densifying urban areas creates logistical challenges for construction projects (Choi et al., 2019). According to Browne & Lindholm (2015) the major challenge when building in urban environments is that construction both increases traffic as well as hinders it. Additionally Bretzke (2013) states that traffic congestion is commonly mentioned as biggest infrastructural issue the most large cities and that freight traffic is both a culprit and victim of congestion. As construction projects are heavily material dependent (Dubois & Gadde, 2000) a large construction site may need several thousands of deliveries each month (Dubois et al., 2019). The vast amount of transportations needed for construction projects adds up quickly, the industry is responsible for 20% of Sweden's greenhouse gas emissions and approximately the same amount of the total weight transported on Swedish road network is to or from a construction site (Sveriges Byggindustrier, 2010).

Furthermore, construction sites in dense urban areas also often face limitations due to the lack of space available (Choi et al., 2019; Janné, 2018; Sullivan et al., 2010). It is not uncommon that roads needs to be closed down for freight movement to and from site or other construction activities, further increasing congestion and pressure on the

existing road network (Browne & Lindholm, 2015). The lack of space also hinders the possibility to store material on site (Agapiou et al., 1998) which creates an amplified need for material to arrive at the right place and right time (Civic Project, 2018). Guerlain et al. (2019) acknowledge the importance of a well-planned construction site, especially the placement of gates as they have a strong impact on the sites accessibility how transports can take place to and from the site. However, problems arise nearby construction sites (Browne & Lindholm, 2015) and in Thunberg & Persson's (2014) study it was show that as little as 38% of the deliveries arrived at the construction site as perfect order fulfilments (right volume, time, place, condition, and documentation).

Additionally, the non-optimal conditions when constructing in urban areas is not only problematic for the project itself but also for the surrounding community (Gilchrist & Allouche, 2005; Guerlain et al., 2019; Janné, 2018). The negative impacts and social costs a construction site can have on the surrounding community can be summarized into four categories (Gilchrist & Allouche, 2005):

- *Traffic* – Increased travel distance and delays are common negative impacts caused by construction sites (Gilchrist & Allouche, 2005; Ibrahim et al., 2018). Higher amounts of heavy vehicles operating in the area and roads that have been closed for construction activities further pressures a road network with already high levels of traffic and causes congestion (Anderson et al., 2005; Ibrahim et al., 2018). The elevated number of heavy vehicles, speed changes and stops related to construction also becomes a safety issue as it increases the risk of accidents (Gilchrist & Allouche, 2005; Janné, 2018).
- *Pollution impacts* – As mentioned earlier in this chapter, the construction industry is responsible for a large portion of the greenhouse gas emissions in Sweden (Sveriges Byggindustrier, 2010) , thus the amount of air pollution is increased nearby construction sites (Guerlain et al., 2019). Furthermore, close by construction sites other kinds of pollutions becomes evident, noise (Ibrahim et al., 2018) and vibration (Gilchrist & Allouche, 2005) pollution are often experienced significant disturbances and is thus a major source of complaint by citizens.
- *Economic activities* – Long-term, construction often increases the number of economic activities in the area. However, during the construction phase it can disturb nearby businesses. Access to shops may be limited due to construction sites and pollutions such as noise and vibration can cause businesses to lose income (Gilchrist & Allouche, 2005). Furthermore, costs due to the increased congestion in the area leads to costs for businesses as well as citizens (Bretzke, 2013; Janné, 2018).
- *Social/ecological/health impacts* – In addition to the fact that greenhouse gas emissions from construction freight movements and other construction activities have a negative impact on the environment, it also has a negative impact on human health (Janné, 2018). Through emissions and the other mentioned disturbances created by construction projects, the quality of life of the residents living in the project's "*radius of influence*" is reduced (Gilchrist & Allouche, 2005). Additionally, construction projects can greatly disrupt the ecosystem around them. Even if the ecosystem in urban environments already have been affected by many years of urbanization, a construction project can

affect water movements in the area, which itself can disrupt the existing ecosystem (Gilchrist & Allouche, 2005).

Several of these impacts can be related to freight movement, but as it is of great importance for the urban environments and its activities (Anderson et al., 2005) but it is difficult to compromise. This importance correlates well with the construction industry as it is heavily depended on the road network for its deliveries (Browne & Lindholm, 2015; Sveriges Byggindustrier, 2010). However, the issue of congestion needs to be addressed as it is reported as a major problem in large cities infrastructure (Bretzke, 2013). In Janné's (2018) study it is noted that cities and authorities generally have not prioritized the development of urban freight movements and he argues that due to its importance for the urban economy, impact on the environment and third parties it should been seen as a priority. Finding smarter solutions when planning urban freight movement and optimizing space usage becomes even more important as cities are becoming denser and denser. The construction industry is no exception to this and plays an important part as an complicated part by both hindering traffic as well as increasing it (Browne & Lindholm, 2015).

2.4 Interdependencies and construction coordination

Hossain (2009) presents construction as *"a process of putting together all the materials in an orderly and timely manner by utilizing relevant resources to complete a structure as per designed specifications and quality standards."* Using this view of construction includes that there are multiple pre-determined tasks needed to be executed within a construction project. These differentiated and specialized tasks are performed by different actors with varying level of interdependency (Dubois & Gadde, 2002a).

Every industrial activity or process is to some extent dependent on one or multiple other activities creating an interdependency and couplings between them. These couplings can occur in many different dimensions: among individuals, among subunits, among organizations, between organizations, and between activities (Dubois & Gadde, 2002a; Weick, 1976). If these activities are dependent in such way that it e.g., cannot start or finish without knowing the outcome of the other, like most of the activities at a construction site, the level of interdependency is high and the couplings between them are tight. To be able to handle the complexity and uncertainty that a construction project entails, different parties are variously dependent on each other's activities. Even if the activities are interdependent and tightly coupled on-site the actors are seldom connected beyond the individual project (Bygballe & Ingemansson, 2014; Dubois & Gadde, 2000, 2002a). Together with the focus on individual project, decentralized decision making, and financial control the construction industry is mainly defined by loose couplings (Dubois & Gadde, 2002a). This makes the construction industry a mix of tight and loose couplings, where the individual project is characterized by tight couplings and the permanent network by loose couplings. It can be said that a lack of match exists between the tight couplings consisting of the technical work and the organizational loose couplings of those who control the work (Darshi de Saram, 2001). These loosely coupled systems are better adjusted for modification of one element without affecting the whole system as well as a better serving as a buffer against external disturbances and gives actors more self-determination than in tighter coupled system (Weick, 1976). On the other hand, the loose couplings among firms make it difficult to coordinate

urgent adaptions, handle uncommon complexity, and complicates the overall coordination.

According to Malone and Crowston (2012), to identify and analyze interdependencies are the most crucial steps for a successful coordination. Even if most activities are unique according to its location, extent and involved actors, some interdependencies are reoccurring and its coordination processes can therefore be seen as generic (Thompson, 1967). Three generic interdependencies have been investigated further in relation to the construction site by Kalsaas and Sacks (2011), these are:

- *Pooled interdependence* – Is found between the head office and its different branches where the branches don't interact at all but rather report directly upwards in the hierarchy.
- *Sequential interdependence* **–** Is when actor A must act properly before B can act; and B must act before A can finish its action.
- *Reciprocal interdependence* **–** Is when the outputs for one actor is the input for the consecutive actor.

Coordination can be seen as managing dependencies between activities (Malone & Crowston, 2012) and is defined as *"The organization of the different elements of a complex body or activity so as to enable them to work together effectively"* (Oxford University Press, 2020). Coordination is implied in almost every activity in the everyday life, but it's only when coordination is bad its noticed. The need for coordination depends on the level of interdependency between activities and its actors (Malone & Crowston, 2012). This contains both computational- and technological processes, biological systems as well as human interactions, with the distinction that human interactions are concerned by *incentives, motivations, and emotions*. These human incentives, motivations and emotions are complex and irrational, making the understanding of them crucial for coordination whenever humans are involved. The interdependency varies between activities and thereby also the coordination needed.

2.4.1 The role of the construction coordinator

Good coordination is almost always invisible, and wouldn't be needed if things always worked as planned (Hossain, 2009). Like Chitkara (1998, p. 202) states: *"If the situation variables are measurable, the policies and the procedures are well defined and communication flows smoothly in all directions, then esprit de corps prevails, everyone is interested in his task and all work collectively to achieve the ultimate project objectives in a fast changing project environment".* However, such a utopia is rarely found in construction projects. To be able to handle the interdependent activities in a construction project, coordination is crucial. A common way of facing the issue of coordination in larger projects is to use a project coordinator. The role of the project coordinator can be described as; a representative, chosen by the project manager to objectively monitor and proactively work to assure that future event will progress as planned, enlighten arisen problems and provide solutions (Hossain, 2009). Furthermore, the coordinator is supposed to act as an independent, mediating bridge between actors and provide needed information to concerned parties. In practice, the coordinator should know how the project organization works, ensure that milestones and plans are pursued, and if needed alarm the project organization. The activities of this role, as well as coordination in general in construction, is often carried out on site,

with short notice and commonly through informal communication channels (Darshi de Saram, 2001; Hossain, 2009). To achieve desired result, the construction coordinator must, without a monetary empowerment, be allocated or oneself possess sufficient prominence and influence (Hossain, 2009).

2.5 The supply chain and supply chain management

Mentzer et al. (2001, p. 4) defines a supply chain as "*a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer"*. With this definition the number of different supply chain configurations is infinite, with different flows and number of actors involved. However, three levels of complexity can be recognized: a "direct", an "extended", and an "ultimate" supply chain, illustrated in *Figure 2* below.

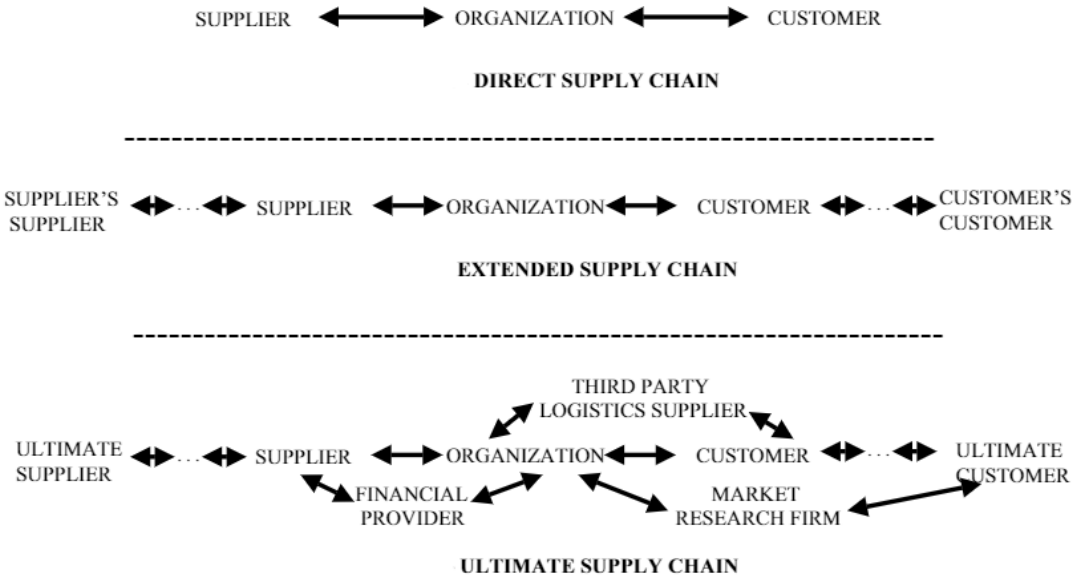

Figure 2. Three different levels of complexity in supply chains (Mentzer et al., 2001).

These three different levels of complexity illustrate how a supply chain can be structured. In its simplest form, the direct supply chain, up-/downstream flows of information, material, services, and products etc. are linear and the supply chain that only consists of a supplier, organization, and a customer. The extended supply chain has the same types of flows as the direct supply chain, but it also includes additional suppliers and customers illustrating the lengths a supply chain could have. Lastly, the ultimate supply chain includes all organizations involved from the first supplier to the final customer and shows how convoluted supply chains can be. This supply chain includes parties such as third-party logistics suppliers, external consultants, and financial providers that work between the organizations in the extended supply chain. However, supply chains are something that exist in all types of businesses, even if not noticed. The significant question is how they are managed or not, which is what distinguishes the two concepts (Mentzer et al., 2001).

2.5.1 Supply chain management

Xue et al. (2007) defines supply chain management in general as "*an integrative philosophy to manage the total flows of the entire business process. Systemic, client-oriented, win-win and cooperative management strategy is the core philosophy of SCM" (Xue et al., 2007, p. 151).* The philosophy, or concept, of supply chain management is essentially a tool to gain an competitive advantage by advancing the collaboration within the supply chain (Mentzer et al., 2001).

The management of supply chains began in the manufacturing industry (Aloini et al., 2012), and has since been adopted into several other markets (Xue et al., 2007). The objective of the concept supply chain management is to increase the supply chains transparency, coordination (Love et al., 2004; Vrijhoef & Koskela, 2000), and efficiency to increase the profitability throughout the whole supply chain (Aloini et al., 2012). The concept achieves these objectives by recognizing the interdependencies within the supply chain and focuses on developing the acumen of flows within and between different organizations (Love et al., 2004). Furthermore, the concept portrays the supply chain as a whole, rather than separate organizations simply carrying out their own part not affecting the rest of the chain (Aloini et al., 2012; Mentzer et al., 2001; Vrijhoef & Koskela, 2000).

2.6 The construction supply chain

The construction supply chain differs from other supply chains due to the industry's particular characteristics. A temporary factory is formed on site that handles incoming materials where the final product is produced for the ultimate customer, which differs from "traditional factories" that produce many products for many different customers (Vrijhoef & Koskela, 2000). As construction projects are heavily material dependent (Dubois & Gadde, 2000), thus require many deliveries, there are many opportunities for increased productivity by planning the logistics more thoroughly (Agapiou et al., 1998). The possibility of storing material on-site is often limited due to lack of space and even if the possibility exists the risk of damages is increased caused by additional material handling and external conditions (Agapiou et al., 1998). As a result, the demand for deliveries arriving at the right time and place, or just-in-time, is increased which requires trust and developing long-term relationships between the contractor and supplier (Akintoye, 1995).

However, the supply chain in construction is also affected by the high fragmentation and the project-based nature the industry reconciles with. As each project is built under different circumstances such as location and design the amount of repetition is limited (Vrijhoef & Koskela, 2000). Thus, as mentioned in Chapter 2.1, the construction industry relies on standardized parts rather than standardized processes or activities, resulting in lower efficiency (Dubois & Gadde, 2002a). Continuously, due to the project-based nature the involved actors in a project diverges making long-term relationships more challenging (Dubois & Gadde, 2002a; Janné, 2018; Love et al., 2004). As a result, it is not only the "factory" that is temporary, but the entirety of the supply chain as well (Thunberg, 2016; Vrijhoef & Koskela, 2000).

According to Xue et al. (2007) the construction supply chain is not really a chain but rather a network of organizations with several flows, see *Figure 3* below.

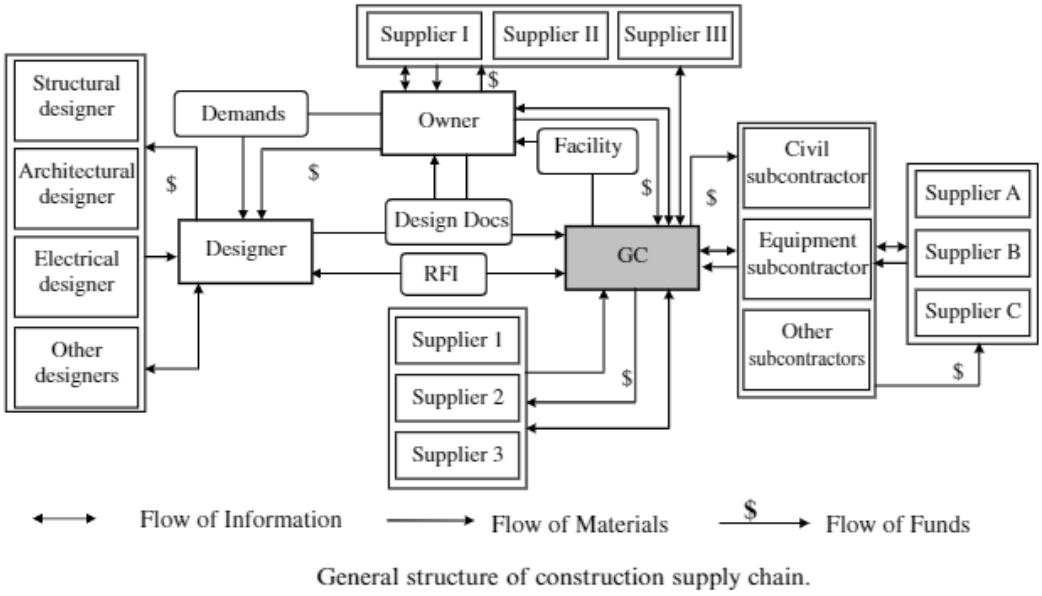

Figure 3. Example of the structure in a construction supply chain (Xue et al., 2007).

However, the structure could be considered a highly complex ultimate supply chain presented in Mentzer et al. (2001) study, see *Figure 2*, with several suppliers, organizations, and external actors. In either case, several studies show that low levels of coordination and communication are key challenges when managing a construction supply chain (Bankvall et al., 2010; Love et al., 2004; Thunberg, 2016; Xue et al., 2007).

2.7 Supply chain management in construction

Compared to many other industries supply chain management in the construction industry is a fairly new concept that is still emerging (Love et al., 2004; Thunberg, 2016). Several instances of implementing supply chain management in the industry have been seen in recent decades (Vrijhoef & Koskela, 2000), but the industry has encountered challenges with its implementation (Aloini et al., 2012; Love et al., 2004; Xue et al., 2007). Therefore, even if studies have shown the benefits of supply chain management the "*industry is lagging behind in terms of supply chain practices and efficiency"* (Bankvall et al., 2010, p. 385). The challenges that the industry faces when trying to implement supply chain management, inter alia, the fragmented nature of the industry. Traditionally, contractors and subcontractors are responsible for their own deliveries and supply chains, with little synoptic control (Sullivan et al., 2010). It has become increasingly common for contractors to outsource large portions of their projects. As a result, they have become significantly more dependent on other involved parties in the supply chain, such as subcontractors and suppliers. This method of dividing the responsibility and supply chain is not sufficient and a new way of managing supply chains in construction is required (Vrijhoef & Koskela, 2000). Furthermore, Bankvall et al. (2010) highlights the impact of mutual interdependencies in the construction supply chain. Compared to the manufacturing industry where interdependencies in the supply chain are sequential, the construction industry is shaped

by activities sharing mutual interdependencies. Therefore, the planning of construction supply chains needs to be flexible due to unanticipated events and potential delays. Additionally, it is essential to acknowledge that alterations to the supply chain occurring on-site in a construction project will affect the rest of the organizations up-stream (Bankvall et al., 2010).

Vrijhoef and Koskela (2000) recognizes four different roles in construction supply chain management, illustrated in *Figure 4* below.

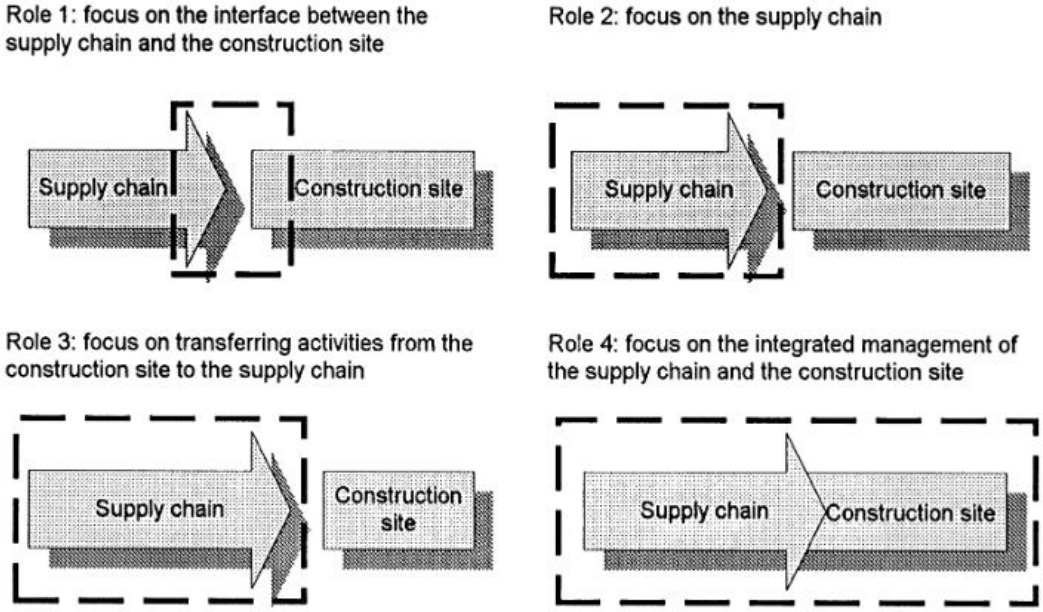

Figure 4: The four roles of supply chain management in construction (Vrijhoef & Koskela, 2000).

- The first role focuses on "improving the interface between site activities and the supply chain". It targets the relationship between actors in the supply chain and on-site, e.g., supplier and contractor, to improve material and labor flows. By improving the interface and coordination between these relationships material and labor flows become more reliable, thus decreasing disruptions on-site and increasing productivity. However, in this role, only a small portion of the supply chain is taken into consideration and more comprehensive improvements to the whole supply chain would be more beneficial (Vrijhoef & Koskela, 2000).
- In the second role, enhancements of the supply chain are in the center of attention. The goal is to reduce expenses through improved logistics in the supply chain (Vrijhoef & Koskela, 2000). According to Sullivan et al. (2010) supply chain management and logistics share several characteristics and can highly affect one another. For example, an improved supply chain can lead to reduced freight movement, which also leads to reduced costs and environmental impact. Correspondingly, a logistics plan reducing the amount of waste on-site can improve the supply chain. In this role, logistics needs to be analyzed in order to improve the supply chain and its uncertainties needs to be solved (Vrijhoef & Koskela, 2000).
- The third role focuses on reducing activities taking place on-site by moving them upstream in the supply chain. The goal of moving activities upstream is to

cut down the time spent on the less favorable conditions on-site, reducing expenses and decreasing construction time (Vrijhoef & Koskela, 2000). Prefabricated frame elements are a commonly used and a good example of industrialization of activities that used to take place on-site. In Sweden, prefabricated frames have been increasingly used in the decades and are now used in 88% of apartment building projects. However, any connection between this development and cost savings are difficult to find, but the benefits lie in the reduced construction time (Åfreds, 2018). According to Vrijhoef and Koskela (2000), this may be due to the fact that the profits gained by moving activities upstream are often countered as the supply chain becomes more complex and not adequately managed.

- The final role focuses on "the integrated management of the supply chain and the construction site". In this role, supply chain management also contains on-site production, and the goal is to create more consistent supply chains and standardize building materials, resulting in a more effective construction process. The disadvantages of this goal, however, are that it could hinder flexibility regarding design and opportunity of innovative solutions. Additionally, it is noteworthy that these roles are not merely used individually but frequently used collectively (Vrijhoef & Koskela, 2000).

2.7.1 Freight movement in the supply chain

Freight movement usually constitutes a considerable part of supply chains. In the construction industry approximately 10-20% of costs are connected to transports and has a lot of room for improvement (Sullivan et al., 2010). In Sveriges Byggindustrier (2010) study it is shown that improved logistics and more efficient deliveries can decrease overall cost of construction by 20%. Nevertheless, the attention given to transportation (Sullivan et al., 2010) and supply chain management in the industry is poor, perhaps because the advantages have not become well-known (Sundquist et al., 2018).

In Ying et al. (2014) study vehicle movement, to and on-site, were observed to recognize issues in construction material handling. The importance of coordination between off- and on-site logistics is highlighted as a major influence on a project's success. However, a lack of planning regarding transports and its unloading on-site is exposed. In addition, most materials were delivered during rush hours adding on and getting stuck in traffic, further decreasing efficiency. To improve the efficiency of construction transports, the interface between on- and off-site activities should be developed through heightened information exchange and cooperative planning (Sundquist et al., 2018).

2.7.2 Information exchange

The construction industry is incredibly dependent on information. Everything from contracts, time- and cost-analyzes to attachment drawings and adjustments of plans are important for a construction project and for its various actors (Xue et al., 2007). However, a challenge that often is encountered is that the information available is incomplete, irrelevant and / or insufficient (Ala-Risku & Kärkkäinen, 2006). A majority of issues between organizations in the supply chain are caused by inadequate handling and distribution of information (Xue et al., 2007). Therefore, integration is central to

developing the level of communication, transparency, reliability, and relevance of the information up- and downstream in the construction supply chain (Thunberg, 2016; Xue et al., 2007). A way to alleviate the integration could be to hire a specialist who is responsible for information handling, material flow, and / or coordinate the logistics between the involved actors to streamline the process of a construction project (Sundquist et al., 2018).

2.7.3 Implementation of supply chain management in construction

To succeed with the implementation of supply chain management in construction, there are certain issues that need to be evaluated. To begin with, knowledge of what methods and tools are available and what suits a particular project and its unique properties is needed. However, in Ying et al. (2014) research it is revealed that a lack of knowledge regarding the importance of planning for logistics and material handling exists amongst practitioners in the industry. Generally, the site manager is responsible for how a construction project will handle issues regarding supply chain management and logistics. Lack of knowledge or interest from the site manager to improve the supply chain and logistics can prove to be a challenge and the project is most likely to encounter issues in these areas. Additionally, this could also be the cause for the lack of coordination and the unreliable supply chain that exists in the industry (Bankvall et al., 2010; Dubois & Gadde, 2002a; Thunberg, 2016).

Furthermore, for the implementation of supply chain management to be successful, all actors need to be involved early in a construction project (Love et al., 2004; Xue et al., 2007). The actors should be involved in the design phase in order to provide valuable inputs on the design, construction process, and material handling (Agapiou et al., 1998). In addition, early involvement simplifies the exchange of information and creates space for improved communication (Bankvall et al., 2010; Love et al., 2004). Several studies (Akintoye, 1995; Aloini et al., 2012; Bankvall et al., 2010; Browne & Lindholm, 2015; Thunberg, 2016; Vrijhoef & Koskela, 2000) highlights trust as a crucial part for the implementation of supply chain management. However, the industry suffers from a lack of trust between actors (Sundquist et al., 2018; Thunberg, 2016). By creating longer lasting relationships between the organizations in a supply chain, it is possible to successively develop a higher level of trust and increased coordination in the supply chain and overall performance (Thunberg, 2016).

2.8 Coordinating tools in construction logistics

To reduce the impact generated from the construction logistics and its supply chain, there are several solutions that can be implemented. Slight changes in working practices and, more or less, extensive models including freight delivery planning services, just-in-time deliveries, consolidation centres and third-party logistic providers can all be used to enable a simplified and improved performance (Janné, 2018).

2.8.1 Construction logistics plan

A construction logistics plan (CLP) is a management regulation tool used by governments to, already in the pre-planning, establish a framework and force actors to get an overlook on the construction supply chains and how their impact on the road network can be reduced (Transport for London, 2019). The CLP should include delivery routes, the amount of traffic generated, any traffic management that will be used, and any policies which encourage modal shift. Furthermore, the CLP must be

frequently updated to contain the current status of the project's logistics situation. Later in the project, the procured contractor is imposed to carry over the CLP. The document is supposed to follow the project from the cradle to the grave. Depending on the characteristic of the project and its impact level, the concerning government can choose to what extent the CLP needs to contain. According to Transport for London (2019), a well written CLP will apart from save costs by encouraging reduced deliveries and efficient processes also reduce impact on civilians and provide environmental benefits.

2.8.2 Checkpoints

For projects in urban environments, it is common that only one discharge zone is possible for all contractors to use (Carlsson, 2019). Problems can quickly arise if multiple deliveries arrive at the same time which creates waiting times before all can get unloaded. Even if its digitally planned, traffic situations in urban areas can cause the deliveries to miss their timeslots. To reduce the chance of this problem to occur, checkpoints can be used. Checkpoints are close-by parking areas where the driver contacts the logistic manager when arriving to the checkpoint and waits for approval. When an unloading is possible the driver is being contacted again and drives to the construction site. This ensures a good material flow and a just-in-time delivery into the construction site which reduces the need for storage and the risks and costs storage implies.

2.8.3 Construction consolidation centres

Regarding the nature and phase of a construction project, a reoccurring presented solutions to construction logistics is the construction consolidation centres (CCC) (Dablanc, 2007; Guerlain et al., 2019; Sullivan et al., 2010). The CCC is a buffer storage facility where goods and materials are storage for a limited period until delivered to the construction site (Sullivan et al., 2010). The general concept of a CCC is to consolidate and sort deliveries from different suppliers before delivered to the construction site. Therefore, the building material is handled with appropriate equipment and storage in a dry and safe area. When called-off, the operator at the CCC prepares consolidated loads and deliver to the construction site with just-in-time precision. The CCC is preferably located close to city-centre, less than 50 kilometres away, to provide easier access but still be close enough to improve the precision. Moreover, the CCC can also provide several other value-adding logistical solutions such as off-site assembling, quality control and waste management (Guerlain et al., 2019; Sullivan et al., 2010).

2.8.4 Third party logistics

A commonly used term in supply-chain management is third party logistics (TPL). TPL is a concept where an external actor handles deliveries and/or storage of the construction material (Carlsson, 2019). The main function of a TPL-service is to streamline the organization and let a niched actor handle the logistics, thereby can the contractor put its resources on their core activity. Moreover, TPL is an umbrella term for any use of an external logistic actor and with varying comprehensiveness (Ekeskär & Rudberg, 2016). This can be after hour material handling as well as solutions including CCCs, checkpoints and on-site material handling.

All these solutions can be initiated separately or parallelly and by various levels of actors. Thus, due to the cultural nature of the construction industry is initiation by a government level the most common. However, it can be initiated by developers (Ekeskär & Rudberg, 2016), but most clients don't see the benefits of using these tools

and only the bill it brings. Most of the contractors rarely wants to adapt new practice due to tight schedules and temporary, unfamiliar constellations. That leaves it up to publicly driven projects and the different levels of government to push the tools to practice. One main reason behind the disinclination of using the construction logistics tools is that it seldom effectively used. As many of the processes in a construction project, construction logistics solutions needs to be addressed in an early stage to get desired effect (Dubois & Gadde, 2002a; Sullivan et al., 2010).

3 Methodology

This chapter presents how the thesis has been carried out, including choices of research strategy and research process. Firstly, the research method and the qualitative study are presented. Secondly, the research process is presented, including the theoretical framework and empirical data. Lastly, the ethical aspects, sustainability aspects, and the quality of the study are taken into consideration.

3.1 Research method

There are generally two different types of research methods: quantitative and qualitative. The quantitative method is suitable when the gathered empirical data consists of tests and numeric data. The qualitative method is applicable when the research is based on spoken or written words, rather than hard values used in quantitative research (Bell et al., 2019). As this thesis is partly based on an interview- and observational study, a qualitative approach was therefore chosen at an early stage.

By choosing this method, the essential in-sights of involved actors will benefit the analysis of the topic (Bell et al., 2019). Considering the aim of the thesis, the strengths of the qualitative method provide tools to investigate and evaluate the contemporary setting of the construction logistics plan and how the coordination of construction logistics plan can contribute to the realization of Älvstranden Utveckling's visions of Älvstaden.

The research process for the study has had an abductive approach. Theory and empirical data have been alternately collected and analysed in order to be able to match and redirect all parts of the report towards relevant findings (Dubois & Gadde, 2002b). The abductive research approach is illustrated in *Figure 5* below.

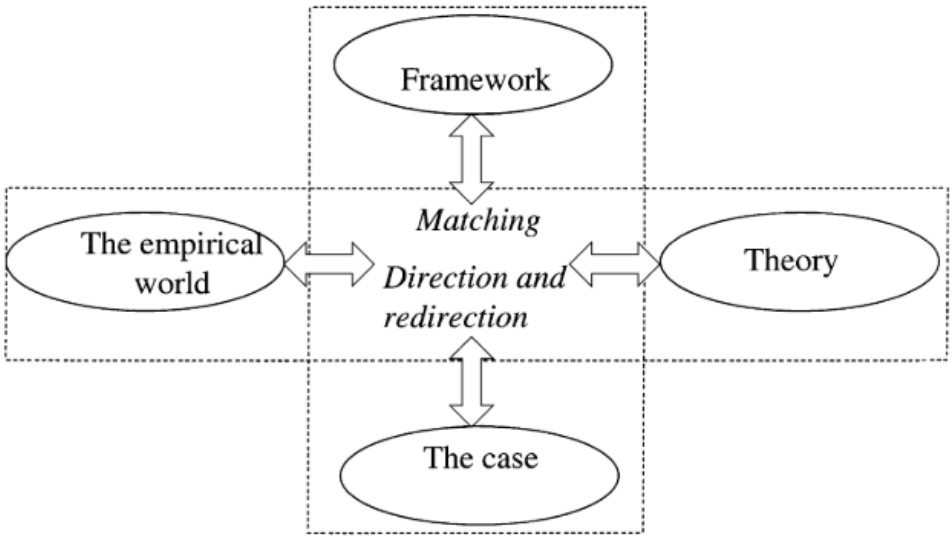

Figure 5: Illustration of an abductive research approach (Dubois & Gadde, 2002b).

3.2 Research process

In the beginning of the research process, the phenomenon, scope, aim, and research questions were determined. This was done through a foundation of previously read literature and acquired knowledge, discussions with the supervisor at the university, and with the supervisor from Inhouse Tech to keep us within the framework of the education as well as making findings from the report practical for the company. To carry out the study, work began on a literature study to build a foundation of understanding within the subject. In addition to the theoretical sources found in the literature, internal project documents received from Inhouse Tech and public material about Masthuggskajen was studied to get a better insight into the project. This understanding was used to further gather empirical data through an interview study. The interviews that were conducted were with different actors with varying responsibilities to get an overall picture of the project and how the coordination is structured between different organizations. Furthermore, an observational study was conducted to be able to analyse the traffic situation in the surrounding area. In this study, concise questions were answered by suppliers on-site to find out what information they had received and how the delivery was carried out.

The thesis was executed during the spring semester of 2021. Under normal circumstances, the study would have mostly been carried out at Inhouse Tech's office, but during the current pandemic it would not have been appropriate. Due to this, everyday communication has become more challenging which probably have affected the thesis negatively. Further, all interviews have been conducted online, via Microsoft Teams, to minimize physical contact during the interviews.

3.2.1 Literature study

To create a solid foundation, a literature study containing relevant books and articles was made. To broader our knowledge in the subject, cases from domestic and foreign logistic solutions were studied. This literature was found by using the Chalmers library, complemented by Google Scholar, with the keywords; *'construction logistics', 'construction coordination', 'logistics solutions', 'construction supply chain', and 'urban development'.*

Thereafter, the relevance of the found literature was examined to see if it was suitable for the thesis. Firstly, the title and number of quotes were reviewed. Secondly, the abstracts were read followed by introductions and conclusions. Lastly, if the literature was considered applicable, it was read in its entirety and used to build up the thesis literature study. As the study has had an abductive approach, this process has taken place continuously throughout the study's timeline to match the findings from the empirical study. In this way, the theory generated from literature and the empirical material interplay during the process.

3.2.2 Empirical study

The empirical data has been collected mainly through three different methods: interviews, observations, and internal and public documents about the project. The data have been used jointly to establish an overall picture, from different perspectives, that constitutes the empirical study of this thesis. The studied internal and public documents consisted of, for example, work disposition-, time-, detailed development-, logistics plans, and development and land distribution agreements.

3.2.3 Semi-structured interviews

For this thesis, eight people involved in the project Masthuggskajen, presented in *Table 1* below, were interviewed. The interviewed actors were recommended by the supervisor from Inhouse Tech and consist of a mixture of different actors with varied assignments and roles to gather results from several perspectives. A semi-structured interview technique was used to get a natural flow in the conversation and to bring out the actors' perspective without aimed questions. Some key questions were prepared in advance, see Appendix A, and formed the basis for the interviews. The prepared questions were partly adapted for each interview to not ask irrelevant questions. The questions were also divided into different categories: preface, the consortium, logistics, and sum up / other. Further, all interviews took place online via Microsoft Teams and lasted approximately one hour each.

Table 1: List of interviews.

Companies/ Organizations	**Reference in report**	**Assignments / Role**	**Date**
Älvstranden Utveckling	Project Manager A	Project management, Client, Coordinator	21/04/05
Älvstranden Utveckling	Project Manager B	Project management	21/03/22
Trafikkontoret	Traffic Engineer A	Traffic solutions / management work	21/03/29
Inhouse Tech	Coordinator A	Construction Coordinator	21/03/19
Inhouse Tech	Coordinator B	Construction Coordinator	21/03/19
Contractor	Contractor A	Site manager	21/03/16
Contractor	Contractor B	Logistics manager	21/03/16
Contractor	Contractor C	Logistics manager	21/02/22

3.2.4 Observational study

The observational study has been performed in two distinct ways. Site and construction coordination meetings have been observed to evaluate how the communication and coordination is structured between the various actors in the project. The meetings have also been an effective way to follow the project's progress and a way to note how challenges that arise are addressed. The on-site observations were performed by doing spot checks two mornings between 06:45 and 12:00 as a clear majority of construction related traffic takes place during this time. In the "*Deliveries on-site*" observation, brief questions, see Appendix B, were asked to the suppliers to get a perception of what information they had received regarding the area and that specific delivery. The second on-site observation was made by studying the most critical part of the traffic plan and whether the plan was followed or not. The meetings observed and on-site observations are listed in *Table 2* below.

Table 2: List of observations made.

Observed	Setting	Date
Site Meeting	Online	21/03/16
Site Meeting	Online	21/04/06
Site Meeting	Online	21/04/27
Site Meeting	Online	21/05/18
Construction Coordination Meeting	Online	21/03/24
Construction Coordination Meeting	Online	21/04/28
Construction Coordination Meeting	Online	21/05/26
Deliveries on-site	On-site	21/04/14
Construction traffic in the surrounding area	On-site	21/04/15

3.3 Ethical and Sustainability aspects

In research based on interviews and observations, it is important to keep the ethical aspect in mind. In the beginning of each interview, it was made clear that the interviewed actors will be anonymous to receive answers that best represent the reality. It was also presented that the thesis is performed by two students at Chalmers in collaboration with Inhouse Tech. The interviewed actors were also asked if it was accepted that the meeting was recorded. Further, all the interviews were performed via Microsoft Teams to follow the Public Health Authority's guidelines during the covid-19 pandemic.

In this thesis, the importance of the sustainability aspects and the construction industry's major role in its development are recognized. The City of Gothenburg has set environmental goals they work towards and improved construction logistics can be used to achieve these goals. Strengthened coordination between organizations involved in major construction projects can help to implement logistical tools and reduce impact on third parties, improving social sustainability.

3.4 Quality of the study

To ensure the quality this thesis, Bell et al. (2019) propose trustworthiness and authenticity as foundations for a qualitative study. Four stated criteria need to be achieved in order to fulfil trustworthiness:

- Credibility
- Transferability
- Dependability
- Confirmability

One way to ensure the first criteria, credibility, is through respondent validation (Bell et al., 2019). In this case, the thesis respondents were, before published, contacted to verify that their contribution to the empirical study was agreed upon. Qualitative research tends to limit itself towards a narrow focus. This study consists of one only case, but with a rich description including a broad literature study where the

construction logistics and coordination is generally discussed and a broad analysis, the study will be applicable on similar construction projects. Further, multiple views of the involved actors are presented which together fulfils the criteria of transferability.

The research processes of this thesis are strictly described and motivated. The method has throughout the work been revaluated together with the supervisor and, to ensure transparency, been analyzed and opposed by an opponent group. The critic was then evaluated and adopted to raise the quality of the study and to ensure the third criteria, dependability. The fourth criteria, confirmability, exists to safeguard the research from personal values. To ensure a detached study were both authors attending to all interviews. The interviews were also recorded to justify the empirical study.

Finally, the second foundation a qualitative study needs to ensure is authenticity. To avoid a single tracked and narrow research process, multiple views of construction logistics and -coordination is discussed and analyzed both in the literature study and in the interviews. Since the purpose of the thesis is to develop basis of discussion and areas of improvement for construction projects in general and project Masthuggskajen in particular, embellish or withhold any type of information, empirical or theoretical, would be completely pointless.

4 Empirical data

This chapters presents the empirical data. Firstly, the studied case, Älvstaden and Masthuggskajen, are presented. Secondly, the structure of the coordination in the consortium, the role of the coordinator, and the different actors' impressions of the coordination are illustrated. Thereafter, logistics solutions implemented in the Masthuggskajen project and the dismissed logistics plan that was developed earlier in the project are presented. Lastly, the current pandemic is addressed to investigate how it has affected the construction processes.

4.1 Älvstaden

Vision Älvstaden is the most comprehensive urban development project in Scandinavia and is exclusively developed by the public company Älvstranden Utveckling. It contains multiple project areas such as: Backaplan, Gullbergsvass, Centralenområdet, Frihamnen, Lindholmen and Södra Älvstranden, located on both sides of the river, illustrated in *Figure 6* below. These projects together comprise over 5 million square meters of buildable surface and will develop 25'000 new dwellings and 50'000 new workplaces. The vision was developed to set the direction of Gothenburg's forthcoming development and was elaborated through a comprehensive dialog and idea work containing citizens, municipal administrations, business sector and academics. The aim for the vision states that the included projects should be including, green, dynamic as well as designed to connect the city, embrace the water, and strengthen the regional core. Furthermore, the vision is also meant to increase the international presence in Gothenburg and to facilitate international actors to establish in Gothenburg. At last, the proposal for the development plan was accepted and voted for in the municipality of Gothenburg in October 2012. The vision was shortly thereafter initiated, and the last project is planned to be finished in 2050.

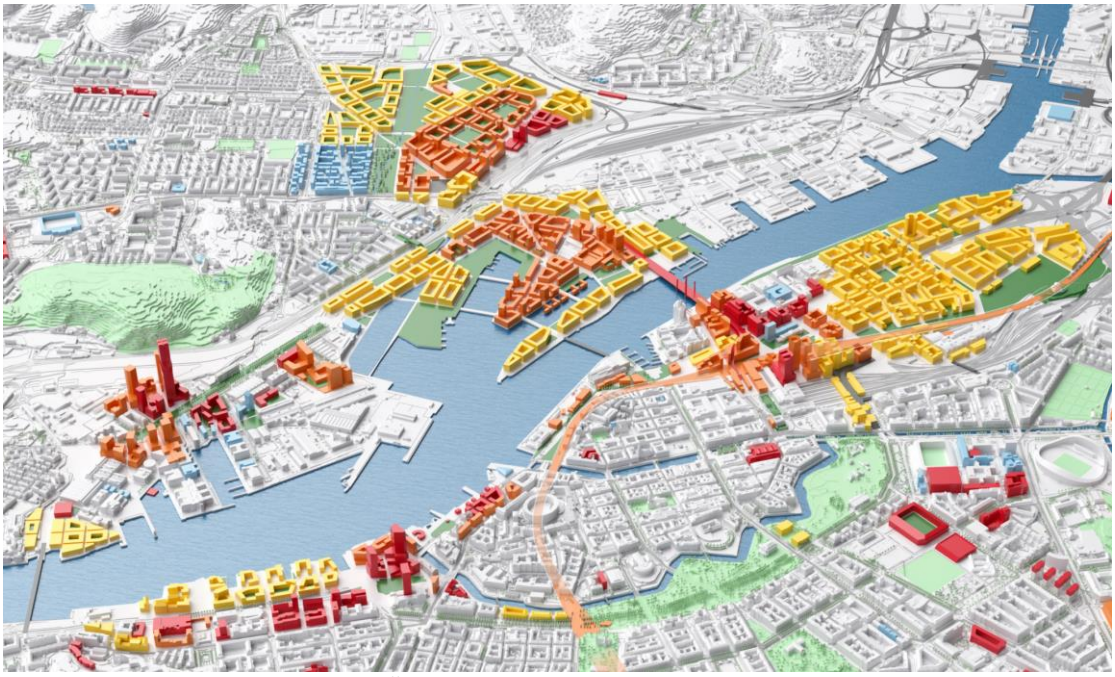

Figure 6: Overview of Vision Älvstaden. The colors represent the year the construction is planned to be finished, red – 2021, orange, 2028, yellow 2035-2050, blue 2012 (Älvstranden Utveckling, 2018).

The first project areas to be initiated in *Vision Älvstaden* was Backaplan, Lindholmen and Frihamnen. These were planned to come to light in time for Gothenburgs 400 years anniversary, 2021. Due to different delays are only Backaplan and bigger parts of Lindholmen ready for this jubilee. As the rest of the projects these are locally divided into smaller projects, driven by each landowner, and coordinated by project made consortiums. Current ongoing projects are Södra Älvstranden, Göta Älvsbron and Centralenområdet. These will span over remaining time of *Vision Älvstaden* and be complemented by Gullbergsvass, the last planned project area.

4.2 Project Masthuggskajen

One of the areas contained in *Vision Älvstaden* is Masthuggskajen. Masthuggskajen is located at the southwestern shore of Göta Älv and a part of the project area Södra Älvstranden. Placed between the popular restaurant streets Långgatorna, the public transportation hub Järntorget, and the harbor, this area has been a frequently visited but undeveloped block. Älvstaden's project-vision for Masthuggskajen says that the new area should be a culturally dynamic place with stimulating international impressions that ties the city together. With that in mind have the developers at Älvstranden Utveckling together with the private landowners developed a well-balanced, diversified plan. All together does Project Masthuggskajen contain 22 construction rights that together will become is a mixed area containing both dwellings and offices as well as a new multistorey carpark, preschools, commercial buildings, and recreation areas. These different construction rights are grouped, as can be seen in *Table 3* by its landowner and geographical position and thereby given a code. Furthermore, all construction rights have been sold and contracts have been signed by the city and each landowner. Contractors have not yet been precured to each area.

Masthuggskajen is divided into two areas: an eastern and a western part. They share the same development plan and project structure but have different time-schedules and different land development agreements. Both areas are driven by their own consortiums, consisting of different organizations, where Älvstranden Utveckling represents the city of Gothenburg. Each project area has its own consortia and consortia budget. The western part was initiated in 2019 and the first buildings are meant to be completed in 2023. The eastern part has been delayed; the first sod is planned to be dug in June 2022.

Table 3: The construction rights and involved operating actors in project Masthuggskajen. Älvstranden Utveckling's land will be allocated.

Construction right code	Contractor	Developers	Area of use	Planned start
Eastern area				
A1	-	Stena fastigheter	Dwellings	2024
A2	-	Stena fastigheter + Riksbyggen	Dwellings	2024
A3-A4	-	Elof Hansson	Offices	2023
B1	-	Stena fastigheter	Dwellings	2024
B2	-	Stena fastigheter + Riksbyggen	Dwellings + offices	2024
Western area				
C3	K21	Balder	Commercial	2019
D1, D3, D4	NCC	NCC-PD	Offices + commercial	2019
D2	Veidekke	Nordr	Dwellings	2021
E1, E5	Betonmast	Stena fastigheter	Offices	2020/2024
E2	NCC	NCC-PD	Offices	2022
E3, E4	-	Riksbyggen	Dwellings	2022/2024
F2	-	Elof Hansson	Dwellings	2022
G1, G2	LP Entreprenad	Göteborgs stad parkering	Commercial + operational	2020
G3, G4, G5, G6	-	Älvstranden Utveckling	Dwellings + operational	2023

4.2.1 The western area and its projects

The western part of project Masthuggskajen was previously dominated by parking lots and a few commercial buildings which contributed to a low level of exploitation. This exploitation will now be greatly increased to better suit the City of Gothenburg's future plan. In addition to the actors seen in *Table 3* will Trafikkontoret and Kretslopp och Vatten start their water and media supply and management work needed to operate this new district as soon as possible. The ongoing projects in the western area are the ones with a set contractor, except for E2 and D2. C3 is a hotel project that will be integrated into Draken/Folkets hus which in turn will get renovated simultaneously. This project is about one week behind the schedule due to wind and weather. D1, D3 and D4 are three assembled office buildings called "Våghuset" and "Brick Studios". These projects are delayed two weeks due to a covid-19 outbreak in a foreign sub-contractor. E1 is the last on-going project with a building permit, it is an office building that is going according to schedule. G1 and G2 have started their earthworks but had to pause due to a more contaminated soil than expected. They are now preparing for a more

comprehensive decontamination and can't therefore estimate the magnitude of the delay. The remaining projects in the western area are in the designing phase and have not started their construction phase yet.

4.2.2 The eastern area

As seen in *Figure 7*, the eastern part is protruding into Göta älv. This will be managed through an artificial peninsula that form this new buildable area as well as the foundation of the buildings. This part of project Masthuggskajen, which is the technically more testing part, is starting to get their organization on track and will, if things stand, start constructing the peninsula according to plan in October 2021 and the building construction in 2024. Thus, there is no ongoing construction and construction logistics in this area in spring 2021.

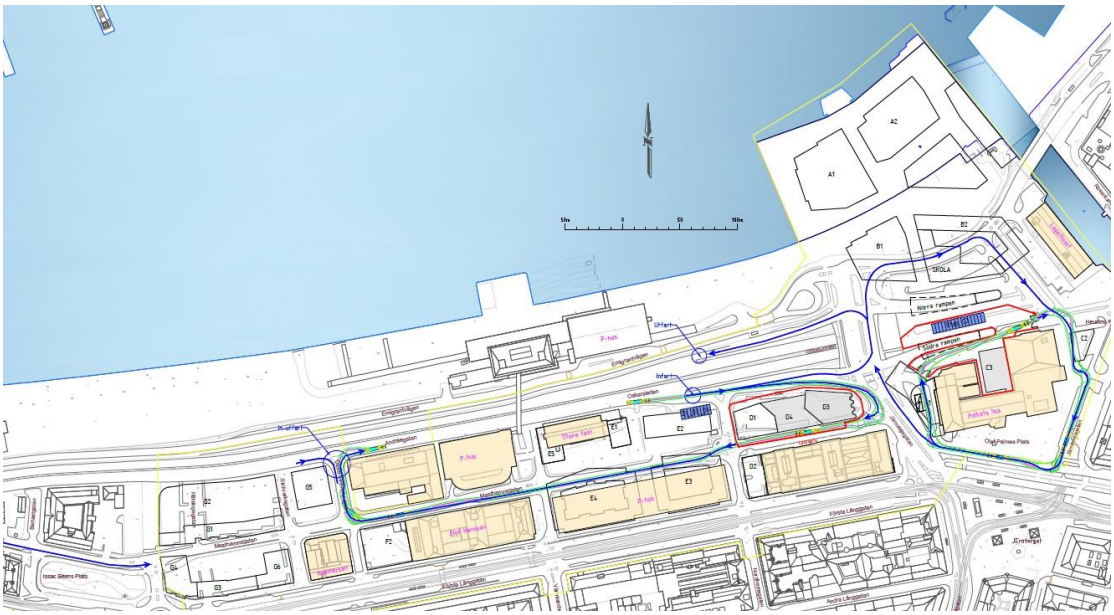

Figure 7: The assigned construction rights in project Masthuggskajen (Internal document).

4.3 Structure of the coordination in Masthuggskajen

In the work with *Vision Älvstaden*, Älvstranden Utveckling represents the City of Gothenburg. At their request, the project Masthuggskajen uses the so-called *Älvstadsmodellen*, which is used to strengthen the collaboration between the involved organizations in urban development projects. In Masthuggskajen, as in the rest of the *Älvstadsmodellen*-projects, a consortium is formed, through various agreements, which consists of Älvstranden and all developers who build in the area. Älvstranden is responsible for leading the consortium work forward and the developers must actively participate in the coordination regarding time schedules, construction logistics, and expansion arrangements etc. The consortium's work began in 2013 with all participating landowners in the area, private and Älvstranden Utveckling who then sold land to developers. In 2019 a final development and land distribution agreement was signed with all organizations in the consortium. The development and land distribution agreement determines how the consortium work is to be structured and how the goals of *Vision Älvstaden* are to be achieved. Furthermore, it is stated that the consortium actors are supposed to share the responsibility regarding e.g., the construction logistics.

According to Project Manager A, Älvstranden has a particular role in the project as they both have allocated land and have a leading role in the consortium. Älvstranden thus has both a role as customer as well as a coordinating role in the consortium and coordinating assignments towards other parts of the city.

Further, Älvstranden is responsible for ensuring the city's delivery of infrastructure, municipal technical supply and construction of public space, and coordinating this with the expansion of adjacent construction projects. As a result of this, the parts of the city that precures these services, Trafikkontoret, are not involved in the consortium. According to the Traffic engineer A, it is not of interest either as many issues raised in the consortium are not of interest to them and it is more efficient if they have their own planning. However, they do participate in Site meetings and will have be a part of a new series of meetings regarding coordination when their on-site work has begun as it will greatly affect the nearby construction sites. Nearby roads have been dug up to install the technical supply which will make it tougher for transports to arrive and increasing overall congestion in the area.

The project is structured with a clear hierarchy, as described in the development and land distribution agreement, that follows the financial responsibility. If issues are too comprehensive or costly to solve it is directed upwards in the hierarchy. At the top level is the Steering group consisting of one representative from Älvstranden and one from each of the various developers who handle overall issues regarding coordination and exploitation. The Steering group has in turn appointed a Working group that acts as the Steering group's drafting body. This group, like the Steering group, is led by Älvstranden and consists of the developers. The Workings group shall provide information on the project's progress, schedules, and budgets. Further, the Working group can create Theme groups. One of these is the Construction Coordination group with the purpose to strengthen the coordination between the different construction sites. The Construction Coordination group structure is similar to the previously mentioned Working Group but also includes Inhouse Tech, in the role of coordinator over the contractors. This group has a meeting every four weeks where the progress, schedules, and progress plans etc. are reviewed. Jointly, issues that need to be resolved for the contractors to be able to carry out their work are discussed. A reoccurring topic has been how the construction site facilities should be coordinated and where they should be placed as space is severely limited in the central area. To coordinate the contractors, Inhouse Tech convene Site meetings every three weeks. At the Site meetings, more hands-on issues are discussed, and Inhouse Tech informs about new updates regarding the surrounding area and new progress plans. However, the contractors are themselves not a part of the consortia but are procured by each individual developer. The structure of this coordination is illustrated in *Figure 8* below.

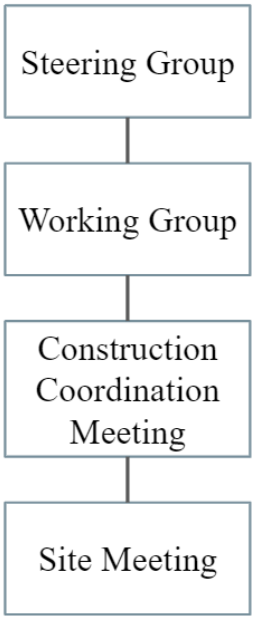

Figure 8: Illustration of the coordination structure in project Masthuggskajen.

Smaller issues between adjacent construction sites are usually solved between the concerned actors. According to Coordinator A, the contractors are generally helpful and solution-oriented towards each other as they know that is highly possible that next time it is they who need a favor. Additionally, every individual project has its own coordination between developer-contractor and contractor-subcontractor. Contractor C highlights the importance of clear communication and states that "*communication is crucial*". Further, Contractor C emphasizes the importance of sharing information with subcontractors as it is often downstream in the supply chain that information is lacking although information regarding routes etc. is essential to the one delivering materials to the construction site.

It is noteworthy that project Masthuggskajen is affected by other major construction projects underway in the city. The project that has the most impact is the reinforcing of the nearby Göta tunnel. The nearby traffic in the area has become significantly more congested as only half of the highly trafficked tunnel is in use. To counteract the impact of the other ongoing projects the transports to Masthuggskajen are planned to arrive and depart to the west. Inhouse Tech have developed transport routes to be used to minimize disruption to third parties, facilitate the already congested local traffic, and to ensure that deliveries can get to the area smoothly. These routes are illustrated in progress plans with updated changes in the various stages of the project.

4.3.1 The role as construction coordinator in Masthuggskajen

In project Masthuggskajen, Inhouse Tech has the role of construction coordinator. In addition to coordinating the contractors, they also have contact with nearby project, such as Göta tunnel, to keep track on vibrations and coordinating other activities. All organizations in the consortium have access to Projektnavet, where joint measurements are posted. Further, it is also a part in their role as construction coordinators to compile and continuously update documents, expansion arrangements, time-, occupational health and safety-, and construction site layout plans and to document deviations and disturbances that can provide a basis for developers to make decisions in the

Construction coordination group, Working group, or Steering group. According to Coordinator B, their role consists of a great deal of problem solving and "*thinking outside the box*" to find new solutions which can benefit several actors. However, decisions have had to be made that does not benefit all actors. Most of these decisions have had to do with the space distribution as the space available is severely limited and each individual project crave as much space as possible, which plainly has not been possible due to the nearby projects and the impact on the local traffic.

To perform their role in an efficient manner, Coordinator A highlights that it is incredibly important that they become involved early in the project and that they are a part of the entire chain of information flow. In a major project like Masthuggskajen there is an extremely large amount of information generated and it is important that those who coordinate gets a hold of all information. In that way they can filter out and disseminate the necessary information. Additionally, it is important for the construction coordinator to have authority. When making decisions the parties concerned must listen and respect it. Coordinator A also addresses that it is important that they perform in their assignment well so that trust is built up for their role.

To coordinate the construction logistics, progress plans for the area have been developed by Inhouse Tech and are updated monthly, see *Figure 9* below. For future progress in the area there are quarterly plans used to visualize when and where activities will take place. In these plans, transport routes have been outlined for the freight movement to and from the area. For example, incoming deliveries should take the less congested Emigrantvägen instead of arriving from the highly congested E45. On this planned route, there is a checkpoint located where suppliers can wait for call-offs. The basic idea is that the construction transports should arrive and depart to the west to reduce the impact on the traffic network and because other major projects, Karlastaden and Västlänken etc., are located in and pressures other parts of the city. However, Inhouse Tech is not involved in developing each individual project logistics plan but assist with insights and comments to improve the overall logistics in the area.

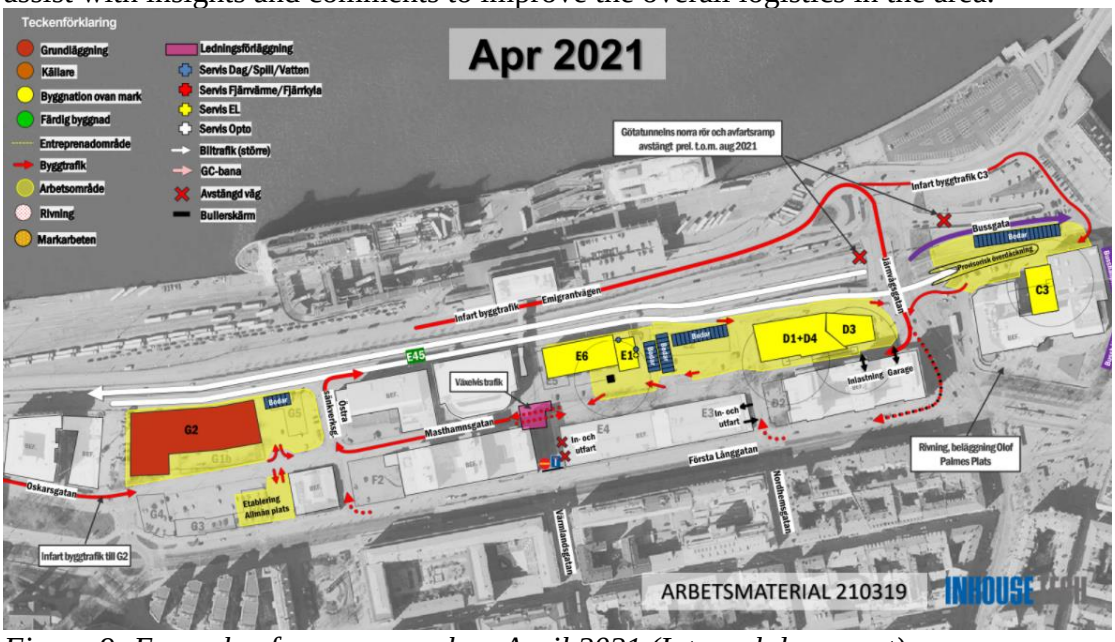

Figure 9: Example of a progress plan, April 2021 (Internal document).

4.4 Stakeholders' perceptions of the coordination

There are several stakeholders, such as contractors, construction coordinators and the city of Gothenburg, involved in the logistical coordination of project Masthuggskajen. They have varying incentives and possess different perceptions of how the coordination should be executed in general as well as how the construction logistics should be coordinated. Following are summarizes of their perceptions:

4.4.1 Contractors

The general impression of the coordination among the contractors is good, which has been concurred through the interviews. Mutually throughout the interviewed actors, the limited number of meetings are favorable. Thus, these meetings are the only reoccurring coordination among the contractors. Further need of coordination occurs informally between the affected contractors, or with the construction coordinator as intermediator. The interviewed contractors consider that the coordination is enough and don't see predominant benefits of more coordination or tighter bonds between each other, they want to mind their own business. One reason behind this is that the ongoing projects are not yet adjacent on an aggregating level, they emphasize that they can see issues tower later on when more projects, both in Masthuggskajen as well as close by infrastructure projects, are commenced. Contractor C's construction site is not adjacent to the other ongoing projects in the western part of Masthuggskajen. This have given them their own freight route and a more independent project. When more of the projects are initiated Contractor A mentions that they have unsolved problems with their construction site facilities. Their current site facilities must be moved due to an upcoming project that is planned at the same area this November. However, this new project's start date is not entirely clear yet, thus the issue cannot be planned for.

To be able to increase the coordination in Masthuggskajen further, e.g., to co-load deliveries, Contractor C says: "*We can't call the other contractors if they need a drywall, we can't acquaint oneself into their work*". To implement co-loading without a CCC or a much bigger organization, it would have to be on the material suppliers' initiative.

Contractor B points out that the coordination with Trafikkontoret is the main issue they have encountered regarding coordination. According to Contractor B, Trafikkontoret came in late in the designing phase and will now start their maintenance which implies tearing up the nearby street Masthamnsgatan. Furthermore, Contractor B continues with that Trafikkontoret seems to just blindside moving on, and if that is not done with proper coordination, they will get trouble receiving their deliveries correctly. In their project area, Contractor C does not see any specific problems in the near future. Other public maintenance work is planned to start later which can, if not coordinated and communicated correctly, disturb their daily work.

4.4.2 The City of Gothenburg

In the Masthuggskajen project, multiple parts from the City of Gothenburg are involved and since the designing phase they are represented by Älvstranden Utveckling. This spokesperson role along with the coordinating role is sometimes difficult to navigate and makes it an ungrateful role, according to Project Manager A. In earlier projects, Älvstranden owned a larger, or every, part of the land to be allocated which had given them a greater influence as well as resourcefulness throughout the negotiation of the

development- and land distribution agreement. However, in this project did Älvstranden Utveckling not enter with the same authority. Private developers owned greater parts of the allocated land at Masthuggskajen before for the exploitation plan was initiated which levelled out the initial negotiation values. In hindsight, Project Manager A would have preferred that more explicit requirement specification regarding construction logistics should have been written into the development and land distribution agreement, not only to be able to implement the City of Gothenburg's agenda but also to facilitate the overall logistics management. This could have contributed to a usage of the early involved third-party logistics consultant.

Project Manager B has been developing a new construction logistics strategic document that Älvstranden Utveckling now will implement and use in all their forthcoming projects. To be able to reach their sustainability goals, this document contains checklists that every new project driven by Älvstranden Utveckling will analyse and then adapt the presented suitable tools. Given the fact that the agreement was already signed, it will not be applied on western Masthuggskajen. Project Manager A expects however that it will be used on the peninsula, and both Project Manager A and B indicate that they will investigate the possibility of using the water way in eastern Masthuggskajen. Furthermore, highlighted by both the Project Managers were the importance of early addressing the construction logistics in a project. Project manager B points out, as written in the regulatory document, that they as public developers are the ones that need to address the issue and make sure to drive the question.

Project Manager A explains that to coordinate the different developers' and to keep the surrounding businesses undisturbed are their trickiest exercises overall. As mentioned above, the developers have equal power and prior their own agenda which creates a power vacuum in some questions of fact that Älvstranden Utveckling has to intermediate. Due to their responsible towards the city, Älvstranden Utveckling needs to drive questions regarding public space and media maintenance, themselves.

The interviewed Traffic Engineer A works as a consultant for a public administration involved in project Masthuggskajen. To get public activities in motion is a densely job, says Traffic Engineer A. Numerous paperwork must be done and be send to different authorities before an answer can be given or a project initiated. This occasionally conflicts with private actors where the decision-making process are more concrete and locally connected. These different work procedures between the public and private actors also displays itself in big projects like Masthuggskajen where multiple private actors want their technical supply concurrently. *"Everybody wants to have their own time-schedule, crane and their media installed simultaneously. Choose what you want to prioritize."*. Traffic Engineer A continues that they need to take the whole city into account, when the private actors only have to see to their own good. Moreover, they are often questioned to answer for and held accountable for other public administration in projects that they have no influence over.

Project Manager A agrees with the contractors that Trafikkontoret got involved and came on stream a bit late. Trafikkontoret's project planning document got delayed because a new consultant, who did not do the execution plan, won the tendering and had to acquaint themself with that took longer than expected. Yet, Project Manager A means that this could have been foresighted. However, Traffic Engineer A thinks the

coordination will go smoothly when they start their maintenance work if every actor is ready to compromise and cooperate.

4.4.3 Construction coordinators

The construction coordinators are both, in current circumstances, satisfied with the current coordination and considers that they have developed a functioning coordination structure. Their role has been changing throughout the project and does now include coordinating Trafikkontoret's and P-bolaget's operations as well as the contractors, although they are not parts of the consortium. These additional assignments are however seen as necessary. Coordinator A states that the processes need to start simultaneously by all actors for a project to progress as scheduled. That is however not the case in Masthuggskajen where the City of Gothenburg's involved administrations have been out of step and with a varying project planning. For example, Trafikkontoret has been up to a year behind in their process. Coordinator B implies that the contractors believe Trafikkontoret started too late and Trafikkontoret believe the contractors started too early. Usually, you start a project with media maintenance and public space before the developing and raising the buildings. In this case, it is vice versa which aggravate the prevalent lack of space.

The lack of space is one preeminent topic for the coordinators to manage and is solely where the coordinators have had to force decisions. These decisions have had to deal with movement of material, compromising bearing surface or temporary logistical solutions that affected actors, but they have been understanding and accepted the decisions without hard feelings. A potential risk with the coordination is that the contractors are in fact only responsible towards their client and not towards the construction coordinators, this has the coordinators however not yet seen any indication towards. The actors attending the site meetings are pragmatic and solution-driven which ease the coordinators job, discussions and disagreements are more common in the higher up in the hierarchy.

The projects in Gothenburg are growing and many actors are not used to work in such dense areas. Even though actors generally tend to prioritize their own good in the higher levels of the consortium, Coordinator A thinks the project would not have been practicable without it and that this consortium model should be used more often. More actors, like adjacent projects, could be included into the consortium, for even better coordination throughout Gothenburg, but the matter of costs is unfeasible in the current execution.

4.5 Logistic solutions implemented in Masthuggskajen

Albeit no mutual logistic solution is implemented in project Masthuggskajen, all actors receive a progress plan from the construction coordinator in addition to their own planning. This progress plan, an example shown in subsection 4.3.1 *Figure 9*, is updated monthly, and is henceforth coordinated with Trafikkontoret and the other public actors as well. The contractors are obliged to handle their on- and off-site logistics and waste management themselves. Mutually throughout project Masthuggskajen, the interviewed contractors use supply calendars that all their deliveries are supposed to be planned into. These calendars are however used differently. Contractor C declare their use of a supply calendar as crucial for the project's execution. As a result of their limited space, just-in-time have been necessary throughout the project. No delivery gets in

without the logistics manager's approval. The practical use of the supply calendar is not as strict at Contractors A's site, neither is the need as compelled due to a more generous storage possibility. Therefore, a more ad hoc base is practised and a few unplanned deliveries appears on a daily basis, mostly ordered by subcontractors. Nevertheless, this generosity will shortly decrease when large parts of the storage area will become developed ground. To face this upcoming problem, a TPL that provides after-hours carrying is said to be used.

Masthuggskajen is a changing project area where new grounds are continuously being exploited. This evolvement entails changes in the logistic condition that have not been prepared for, although the land allocation agreement and time-schedule were set and signed before construction. It is mentioned by Coordinator B that the logistics preparation is announced approximately six months beforehand, but is now carried out in a more ad hoc manner. For instance, within the near future, Contractor B's construction site facilities need to be moved. The land lots E3 and E4 are mentioned by the consortium as the solution but are currently occupied with the car park Snipan. Snipan was already planned to be teared down, but in connection with construction, meaning the time-schedule had to brought forward and creating a new matter of how the costs should be allocated. Due to an appeal and unforeseen events are the planned additional car park delayed up to a year. This may affect coming build permits and because coordinating the need and distribution of parking lots in included in the construction coordinators' statement of work future coordination can be affected.

In view of logistics management, the construction logistics are currently handled decentralized between actors or centrally in theme groups depending on the magnitude and urgent nature of the concerned issue. According to Project Manager A, despite a unified logistics budget and some requirements included in the land allocation agreement, insufficient efforts were put on construction logistics in the earliest stages. This was later acknowledged and a TPL provider were therefore involved to make a pre-study investigating prerequisites to support the consortium in the process deciding a suitable logistic solution. The pre-study included:

- Estimations of quantities the construction transports will entail.
- What stress the construction transports will imply, within and outside of the project area, on critical points in the traffic network.
- Staffing graphs and -transports, areas for: project facilities, parking, machinery, cranes, materiel.
- Action plan proposals for solving the overall logistics management during the varying levels of strain.

Some interesting key numbers developed and mentioned in the pre-study are that 150'000 heavy construction related deliveries can be expected on the traffic network area throughout the project. In the most intensive phase, Q1 2021 to Q1 2023, an average of 168 deliveries each day can be expected. Further, the pre-study announced a continuously aggravating set of problems regarding lack of space. Both space for parking and construction facilities are identified as potential issues that must be mutually dealt with early on. To what extent these questions were discussed at the time is unclear, but the same issues are main topics at the different project meetings today. Moreover, an overall solution was proposed with some scaling possibilities. In the basic package several checkpoint proposals, a mutual booking system, a monitoring and improvement work, and co-packing solutions were included. The cost allocation of the

solution suggested by the TPL provider was based on each developer's gross total area. Although a budget showing potential savings exceeding the costs, indefinite project conditions made the consortium turned down the solution proposed. This uncertainty advocates the implementation of a logistical clause in the contractor agreement to retain flexibility but increased the construction coordinators commitments and contributed to the decentralized logistics management. Logistics solutions are difficult to motivate with multiple actors involved in different phases and an ambiguous division of responsibility. Coordinator A states, the consortium settled for the coordination we provide. It is another type of coordination, not the same level of analyzes but it is a system that works.

When construction in the eastern part begins, the logistics management will become an even more crucial for its progress. The delay of the peninsula might however have come handy as it releases pressure from the traffic network and flattens the delivery curve. What logistics solutions that will be implemented at the eastern part is not yet decided. It is said that specific logistic meetings will be held closer to its initiation and some of the interviewed actors indicate that a more centrally coordinated supply chain will be coordinated but with what tools and to what extend is still uncertain.

4.5.1 Älvstranden Utveckling's role concerning construction logistics

In the construction logistics strategic document developed by Project Manager B it is emphasized that improved construction logistics are necessary to reach Älvstranden Utveckling's goal of reducing greenhouse gas emissions by 50% and become the national leader in sustainable urban development by 2024. Additionally, benefits with increased advancements in construction logistics such as reduced impact on third parties, improved accessibility, reduced risk of delays for deliveries and projects that can lead to a more expensive and inferior end product are highlighted in the document.

Further, advocated logistical tools that Älvstranden Utveckling can use in their future project are presented in the strategic document. For example, CCCs, checkpoints, and CLPs. Since each project consists of unique conditions regarding location, size, and scope, there is no universal solution for construction logistics that suits all projects thus it must be adapted to each individual project. Through checklists, the document can be used as a framework to assists in tailoring a logistics solution that suits the conditions of a specific project. Regardless of the conditions, Project Manager B underlines that it is crucial that the construction logistics issue is addressed in an early planning stage of a project. Otherwise, the available alternatives are limited, and the optimal solution may not be possible to implement and the above-mentioned benefits of enhanced construction logistics cannot be achieved. The consortium model can be used to raise the issue at an early stage and Älvstranden Utveckling can, together with the developers, develop a logistics plan. However, experience has shown that Älvstranden Utveckling cannot expect developers to take the initiative for logistics solutions like a construction consolidation center, but the driving force must come from Älvstranden Utveckling themselves. In order to successfully implement coordinating logistics tools, Älvstranden Utveckling, as landowners and as a part of the City of Gothenburg, can set requirements for how construction logistics are executed. By demanding a logistics plan to be developed early on in a project, fining if chosen solutions are not used, or that solutions, like a construction consolidation center, are mandatory to join the be granted access to the area.

4.6 Observational study

In this chapter the results from the two on-site observations are summarized and presented. The goal of this study was to observe the deliveries to and from Masthuggskajen answer questions such as:

- Has the required information reached all the way in the supply chain?
- Are the deliveries arriving according to the schedule?
- Are the deliveries following the planned transport route?
- Did they have to wait for call-offs?
- Did they wait at the intended place?
- Are the deliveries affected by each other?

To answer these questions, suppliers that arrived at the construction site were asked questions, see Appendix B, and an overlook on the construction traffic in the surrounding area was made. It is important to note that the observations that have been performed by the authors of this thesis and are thus presented from the authors' perspective.

The first thing that was observed was that the area is highly congested. During both visits there were traffic jams throughout the day with almost no exceptions. The congestion is mostly due to the closure of half of the Göta tunnel, but two lanes were closed off for one of the projects in Masthuggskajen which does not facilitate the traffic situation. It was further noted that Masthamnsgatan and Emigrantvägen, to which the progress plan refers, have a significantly lower traffic level compared to the road E45.

The visited construction site has four unloading zones and deliveries are planned via an online supply calendar where it is possible to see which zones, or if a crane was needed, that was available. In the case that a delivery was delayed, the supply calendar could be used to see if / when the delivery can be received. Should there be a collision with the deliveries arriving to the site, a prioritization scheme is used where prefabricated frame- and facade elements are given the highest priority. During the site visit at the construction site, several deliveries from different suppliers with a wide variety of materials arrived and some of these suppliers agreed to be asked questions to contribute to this thesis. The suppliers who answered the questions had all arrived on time, within time slots that commonly lasted for one or two hours. One of the deliveries that was ordered by a subcontractor even had the entire working day to arrive and was ordered on an ad hoc basis. However, a delivery from abroad with prefabricated elements was planned to arrive first thing in the morning was severely delayed, which affected another delivery that was waiting for a call-off to drive in behind it for effective unloading. After a while when the delivery with the prefabricated elements still hadn't shown up the supplier who was waiting had to drive in for unloading anyway. When the suppliers were asked how they manage just-in-time deliveries, the prevalent answer was that it merely usually resolves itself and that the deliveries from Masthuggskajen didn't differ significantly from other deliveries. Additionally, it was observed that for each delivery, there were one or two construction workers whose work was disrupted to receive the materials and to check off so that the delivery was correct. At the beginning of the working day, it was noted that non-value adding time was spent waiting for deliveries and that materials on-site were being moved continuously during the day.

Furthermore, it appeared that the suppliers had not taken note of the progress plan or the planned transport route. Instead, they had received directions when they called and said that they were approaching the area or had simply used a GPS. This was further confirmed in the *Construction traffic in the surrounding area* observation where for one morning only one delivery could be confirmed to take the exact planned route regarding the progress plan. Some of the deliveries arrived from the intended Emigrantvägen, but the concept of both arriving and departing to the west seemed to have completely disappeared down the supply chain as a predominant number of transports left the area to the east, through the Göta tunnel. As information of the planned route through Emigrantvägen has not reached the suppliers, information about the intended checkpoint further down the that street has not reached the suppliers either. Instead, it was observed that some vehicles were waiting for call-off just outside the construction sites. According to the logistics manager on site, the subcontractors have received the progress plan and should forward it to their suppliers about what routes to take, but a clear difference regarding planning was noticed between the deliveries ordered by the contractor compared to the subcontractors' deliveries.

4.7 Operating during a pandemic

The current covid-19 pandemic must be addressed as it has affected the whole society, the construction industry included. On construction sites, new logistical challenges have appeared. How will meetings be conducted? How many can/should fit in an elevator at the same time? When should people on-site have their breaks and where should they be seated? These are questions that have appeared in the interviews.

Under the current circumstances, meetings are carried out online. According to Project Manager A, this has led to more effective meetings, but those discussions can't be held the same way. Project Manager A states: "*I've never seen such effective meetings*" and continues "*but it is more difficult to start a dialogue and it can in itself affect the end result. It is not certain that what we have agreed on at the meetings means that we get the best results. Sometimes the dialogue can lead to people thinking outside the box and places another thought on the matter, coming to the conclusion that they can develop in a better way."*. Several of the interviewed actors believe that the meetings will mainly go back to them being in person, but as work from home will become more common, even after the pandemic, online meetings will still be viable.

At the construction sites issues have arisen as many people are needed on site for the projects to progress. Initially, several actors were worried that the pandemic would hamper the project's progress. The expansion scheme has not been affected much aside from one of the projects that has been delayed two weeks due to spread of the virus amongst a subcontractor. A number of measures have been made on the construction site to reduce the interaction between the people there. For example, in Contractor A's project the cleaning has been increased, a maximum number of people and a lunch schedule has been set in the construction site facilities and in Contractor C's project each professional group is working on different floors. The pandemic has clearly made the logistics on-site more complicated. However, considering the congested area Masthuggskajen is located in, the pandemic might have benefitted the project somewhat as the surrounding traffic levels have decreased.

5 Analysis

In this chapter the empirical data presented in chapter 4 is discussed and compared to the theoretical framework presented in chapter 2. Firstly, an analysis of the coordination in project Masthuggskajen is made. Secondly, the current logistic solution is analysed. Lastly, an analysis of what can be learned from project Masthuggskajen that could facilitate the coordinating of construction logistics in future projects is made.

5.1 Analysis of the coordination in project Masthuggskajen

The location on which project Masthuggskajen is being constructed can be described as a dense urban area. The area suffers from several of the characteristics such as lack of space (Janné, 2018), limited storage area (Agapiou et al., 1998), and high levels of traffic (Anderson et al., 2005), which creates logistical challenges (Choi et al., 2019). That construction activities both creates and hinders traffic as stated by Browne and Lindholm (2015) is highly visible in the area. In order to manage these problematic conditions and handle interdependent activities between the various projects in Masthuggskajen, good coordination is required (Hossain, 2009; Sullivan et al., 2010). Through improved coordination and logistics, the impact on third parties regarding traffic, pollution impacts, economic activities, and social/ecological/health impacts can also be improved (Gilchrist & Allouche, 2005), which is crucial for sustainable urban development (Civic Project, 2018) and in line with Älvstranden's goals. Contradictory to Janné (2018), Älvstranden as a representative for the City of Gothenburg has addressed the importance of freight movement and its impact on the environment and third parties through the developed construction logistics strategic document.

The usage of *Älvstadsmodellen* and the structure of the consortium strengthens the collaboration and simplifies the communication between the involved organizations, which according to the interviews and several studies (Bankvall et al., 2010; Love et al., 2004; Thunberg, 2016) has been expressed as something essential to improve. Further, it creates a forum where developers are involved early and the issue of construction logistics can early on become part of the collaboration's DNA, also expressed as essential in several studies (Dubois & Gadde, 2002a; Sullivan et al., 2010). However, in project Masthuggskajen, as expressed by Project Manager A, even though the logistics issue was introduced early, in the land allocation agreement, inadequate effort was put in and there was potential to have much more explicit requirements concerning construction logistics. The logistics solutions proposed by the TPL provider were rejected by the developers on account of being too expensive, even though the proposal presented that it would have been more profitable than for the construction to go on as usual. This declination may indicate a cultural resistance to change (Dubois & Gadde, 2002a; Sullivan et al., 2010), and that there is a lack of knowledge regarding the importance of logistics and how different logistics solutions can benefit the construction process (Ying et al., 2014). Since the industry suffers from incredibly tight time-schedules, it can seem riskier to try something unfamiliar compared to something familiar even if it could have been an upgrade (Sullivan et al., 2010). Further, in previous projects in *Vision Älvstaden*, Älvstranden Utveckling has owned larger parts or all the land that was allocated for exploitation making it easier to set requirements regarding logistics. In project Masthuggskajen, Älvstranden Utveckling owned a smaller portion of the land which may have led to a reduced authority over the rather homogeneous group of developers. Project Manager A empathizes authority as something important to successfully coordinate and the lack thereof may have led to

Älvstranden Utveckling finding it more difficult to push their agendas in this project. As declared in the logistics strategic document developed by Älvstranden Utveckling, setting requirements for logistics solutions in land allocation agreements may be the only way to ensure that the solutions will be used in their future projects.

Good coordination is almost always invisible (Hossain, 2009) and is only noticed when it is not functioning (Malone & Crowston, 2012). The results of the empirical data both disagree and agree with this statement. The coordination has been recognized and expressed as good from several actors in the observed meetings and during interviews, which is evidence that good coordination can be visible. However, the deficient coordination with Trafikkontoret has been highlighted in a larger sense, which would suggest that it is significantly easier to notice when the coordination is not working well. The evident need for increased coordination together with the hitherto successful coordination of the contractors and the accompanying trust that has been developed may be the reason why Inhouse Tech's responsibilities have been expanded throughout the project. Inhouse Tech's role as construction coordinators can be seen as them being the "head office", reporting upward in the consortium structure, and the contractors can be seen as the branches with limited interaction between each other (Kalsaas & Sacks, 2011). However, the pooled interdependence relies on the coordinators having the authority needed as the sole monetary responsibility the contractors have is towards their developers. Further, a sequential interdependence can be found between Trafikkontoret and the individual projects as technical supply must be completed for both actors to be completed, an interdependency that needs to be identified for successful coordination (Malone & Crowston, 2012).

An option could be to involve Trafikkontoret in the consortium to increase the coordination to a higher level, facilitate information distribution, and everyone in the consortium would receive the same information. It would also transfer the responsibility of being their spokesperson from Älvstranden Utveckling and would allow Trafikkontoret to represent themselves. However, as Traffic Engineer A indicates that being a part of the consortium is not of interest for Trafikkontoret together with the issue of how the cost allocation would be distributed could make that option unfeasible. In either case, Trafikkontoret being a part of the consortium or not, an earlier involvement of Trafikkontoret (and other municipal actors), formulated roles, and a clarified division of responsibilities are needed to avoid similar problems in future projects.

As underlined in the theory the construction industry is incredibly information dependent (Ala-Risku & Kärkkäinen, 2006; Love et al., 2004; Thunberg et al., 2014; Xue et al., 2007) and its exchange is critical to improve the interface between on- and off-site logistics (Sundquist et al., 2018). In accordance with the theory Coordinator A states that it is crucial to be a part of the information flows to successfully coordinate construction projects. In the structure of the coordination in project Masthuggskajen information has to flow through several actors to reach the contractors and their final supplier, which requires a high level of transparency (Thunberg, 2016). Although not perfect, the enhanced coordination in project Masthuggskajen with the consortium, Steering group, Working group, Construction Coordination group, and Site meetings has aided the project's overall performance.

5.2 Analysis of the current logistic solution

A reoccurring term used throughout the analyze of the current logistic solution in project Masthuggskajen is "to settle for". As Sullivan et al. (2010) argues, inadequate attention has been devoted to logistics in the construction industry and project Masthuggskajen is not an exception, despite the large number of expected deliveries. The consortium settled for the logistic solution construction coordinators Inhouse Tech offers and the actors interviewed are overall pleased with the current solution. Nonetheless, as the observational study showed, the solutions used, checkpoints and dedicated delivery routes, are not to the required extent pursued. Contrary to Love et al. (2004) and Ying et al. (2014), all involved actors were not addressed early regarding the construction supply chain. The varying time-schedules aggravates that as well as disagreeing intentions in the consortium. Moreover, the observational study can be seen as only a spot-check but does nevertheless show that the information needed is either neglected or lost downwards the supply chain, resulting in increased stress on the nearby traffic network. One answer to this lack of information is the loose couplings defining the construction logistics (Darshi de Saram, 2001; Dubois & Gadde, 2002a). One could argue that the mixed level of interdependency, where the contractor is highly dependent on the supplier to be able to perform its work, but the supplier rarely gets more than a timespan to approach towards the contractor. Therefore, the nature of construction supply chains eliminates retaliations for the supplier. Resulting in a supply chain where the supplier possesses the power and the fragmented, time-pressured and project-based structure impedes contractors to change (Lu et al., 2016).

The different project areas have varying pre-conditions and thereby varying logistic needs (Ying et al., 2014). The needs are reflected by the level of interdependencies occurring at the individual construction site. At the visited construction site, the different subcontractors have own materiel storage, ordered their own material and their multiple off-loading zones creates an environment with less interdependency and looser couplings regarding the project's logistics. Out of the generic interdependencies, only pooled interdependence is distinctive enough to affect the logistics (Kalsaas & Sacks, 2011). The otherwise common sequential- and reciprocal interdependence (Kalsaas & Sacks, 2011), that can be observed at Contractor C's site where the JIT system is crucial to handle the interdependence, are negligible. Indubitably, this brings flexible elements and tools to handle emergent incidents such as unscheduled deliveries and delays (Bankvall et al., 2010) but also decrease the performance. Higher interdependency and tighter couplings between the on-site actors as well as with the supplier would need more coordination and planning but would decrease the needed storage area and the time spent to wait on deliveries and on-site material handling (Sullivan et al., 2010).

In the light of the current supply chain, the residents- and the City of Gothenburg can be seen as ultimate customers to project Masthuggskajen (Mentzer et al., 2001). From that perspective, the ultimate customer is the same for all projects in Masthuggskajen, but the supply chains can both be seen as individual and unified. Either way, the multiple actors both within and among each supply chain indicates a high level of complexity making the illustrated "ultimate supply chain" a suitable comparison (Mentzer et al., 2001). Moreover, Xue et al. (2007) example of a construction supply chain structure with several suppliers and actors interacting in different levels is also an applicable portrayal. The flow of information shown in *Figure 3*, subchapter 2.6, illustrates the difficulty to reach each supplier with essential information and the level

of transparency needed. Theorizing the supply chain as one entails coordination too comprehensive and complex for the current organization and its solutions to handle. Applying this approach together with Vrijhoef and Koskela (2000) different roles in construction supply chain, some key aspects can be differentiated. Highlighting the second role, where enhancements of the supply chain and reducing its expenses are in focus, the outcome is affecting the actors cost as well as the ultimate customer. The TPL-suggestion, including possible checkpoints and CCCs are typical solutions improving the stress put on nearby traffic network by reducing the number of transports. Arguably, the first role would also benefit using the suggested TPL solution improving the interface between the material and labor flows (Vrijhoef & Koskela, 2000). However, the first role, as well as the third and fourth role, are differentiated to such extent in the different projects that implementing a TPL-solution where every actor benefits equally is problematic and the level of interdependency would increase to a, for many actors, unfamiliar degree.

In the current logistics solution, the late involved Trafikkontoret is the most noticed and mentioned concern. According to the current logistics, the outcome seems to be manageable but facing the logistics consequences are the construction coordinators and the private contractors. Tearing up the road to maintain the technical supply is inevitable, but in this phase when the nearby projects are in a delivery peak and their buildings are to some extent completed, Trafikontoret's presence becomes unnecessarily difficult to manage for the other actors. Creating an inconsistent freight route and changing already set conditions, such as locations of technical supply attachment, are situations the TPL-suggestion could not fix but would facilitate with less deliveries. To conclude, the current logistic solution is individually structured, within each project suited after their pre-condition. An appreciated general coordination regarding progress plans and multi-effecting occurrences are managed by the construction coordinator where the progress plan is inadequate complied.

5.3 Analysis of what can be learned from the logistics and coordination in project Masthuggskajen

The trend of urbanization in the world can be clearly seen in the City of Gothenburg through the many extensive urban development projects that are underway or planned, as to provide for the city's increased need for more housing, infrastructure, and offices (Civic Project, 2018; Guerlain et al., 2019; Ibrahim et al., 2018). According to Coordinator A, many construction actors are not familiar with working in such dense areas, which creates a need for cooperation and coordination to a greater extent than before. The enlarged number of construction projects increases the pressure on the traffic network and existing infrastructure (Civic Project, 2018; Guerlain et al., 2019) especially during the earliest phases of construction (Dubois et al., 2019). Project Masthuggskajen is expected to require 150'000 heavy deliveries, which needs well-executed planning to reduce the pressure on the surrounding environment (Browne & Lindholm, 2015; Transport for London, 2019) and for Älvstranden Utveckling to be able to achieve their goals regarding urban development and greenhouse gas emissions.

At the time of writing, the current logistics are operating, but when more projects and the eastern part of Masthuggskajen is initiated and added to the equation, an increased impact on the nearby traffic and third parties can be expected. To avoid this counteraction to Älvstranden Utveckling's vision, enhancements to the on- and off-site

and the interface between them must be made (Sullivan et al., 2010). The even denser environments make it more difficult to store materials (Agapiou et al., 1998) and increasing the demand for deliveries to arrive on time (Akintoye, 1995), thus substantial planning and coordination is required (Browne & Lindholm, 2015; Transport for London, 2019). A properly executed logistics plan, adapted to the specific pre-conditions, not only facilitates the construction process but there is also a potential to save up to 20% of a project's total cost (Sveriges Byggindustrier, 2010). However, when the external circumstances such as the reinforcement of the Göta tunnel is completed and the covid-19 pandemic restrictions subside, several logistical issues will be eased, but to what extent is difficult to predict. After the pandemic, a combination of online and in-person meetings will probably be used in the industry, to get both the efficiency and the opportunity to work from home through the online setting but in-person meetings for more comprehensive issues that require a clearer dialogue and discussions expressed by Project Manager A. All these circumstances may be the reasoning to Coordinator A's statement that the project probably would not have been possible without the augmented collaboration and coordination and that it is a model that should be used more frequently.

The industry's particular characteristics that differ the construction supply chain and management from the manufacturing industry has to be recognized (Bankvall et al., 2010; Bygballe & Ingemansson, 2014). Increased collaboration and coordination can be used as a means to work against the fragmented nature of the industry (Vrijhoef & Koskela, 2000) and facilitate the creation of long-term relationships. Further, by removing focus from individual projects and having a more holistic perspective, focus can be put on standardizing processes and activities to increase efficiency (Dubois & Gadde, 2002a), especially Vrijhoef and Koskela (2000)'s first and second role. In order to coordinate logistics between many projects, it is essential to involve all actors early in the process and addressing as well as driving the construction logistics issue forward. However, to successfully implement a more comprehensive logistics solution such as a CCC, it is seemingly necessary to set requirements in the land allocation agreement, due to the industry's cultural resistance to change (Dubois & Gadde, 2002a; Sullivan et al., 2010). When logistics plans are implemented, it is important to follow-up that they are de facto executed, which has not been the case in project Masthuggskajen. Continuously, it is crucial to ensure that necessary information for deliveries, such as routes and schedules, reaches all the way down the supply chain to the final supplier.

6 Conclusions

In this chapter, conclusions are drawn based on the analysis in Chapter 5 to answer the thesis' research questions, in line with the aim of the thesis, followed by suggestions for future research in the field.

6.1 The coordination's effect on logistics

In conclusion, due to the less-than-optimal preconditions regarding space and congestion in project Masthuggskajen a need for coordination and improved logistics is noticed to reduce the impacts on third parties and for the success of the project. The use of *Älvstadsmodellen* and the collaboration in the consortium creates a forum to develop coordinated logistics and facilitates between the involved organizations. However, in project Masthuggskajen, the focus on logistics early in the collaboration was deficient, which has led to the individual projects being given more or less free rein over their own logistics. Further, the structure of the coordination can complicate the exchange of information due to the many actors involved. It requires a high level of transparency for relevant information to be able to flow up- and downstream to reach each actor. These flows have been facilitated in the project with Inhouse Tech as construction coordinator. It has been shown that it is important to note what interdependencies exist in the project and to assure what role Älvstranden Utveckling should have regarding construction logistics as well as how the collaboration between the different municipal actors should be operated.

6.2 Different views and structures of the construction logistics

The study shows that the views of project Masthuggskajen differ between the actors. The contractors see their individual obligations as an indeed comprehensive but standardized project, with only the customer as real counterpart and experience limited affinity with nearby contractors. Conversely, the construction coordinators and project managers, who operates more holistically, perceives an extensive, unique project with multiple actors to deal and cooperate with. These different views together with varying pre-conditions and time-schedules have made the structure of the construction logistics plan decentralized where the different contractors are responsible for their own supply chain, synoptically coordinated through a monthly updated progress plan produced by Inhouse Tech. The individual logistics plans are adhered and fulfil the pre-requested requirements, whereas the progress plan is inadequately obeyed due to a lack of repercussions. Zooming in on the different construction sites, delivery calendars are used in varying extent and success. Due to construction site and experience, the degree of austerity in the everyday use of just-in-time and delivery calendars fluctuates with required need. Throughout the different project phases, construction logistics has been discussed. Nonetheless, obstacles are still reoccurring and handled in an ad hoc manner whereas some are unpredictable, but some could have been foreseen and prevented. Changing the aim of the logistics towards a unified supply-chain and third parties as ultimate customer is one option to optimize the overall logistics and reduce its negative effects.

6.3 Developing multiple projects in urban areas

Conclusively, the many large projects that are taking place in the City of Gothenburg places a high demand on the actors in the construction industry to adapt to the sub-optimal circumstances that comes with urban development in dense areas. In order for Älvstranden Utveckling to achieve their goals for *Vision Älvstaden*, extensive planning is needed to reduce emissions and impact on third parties. The current logistic solution implemented in project Masthuggskajen is operating but it could become problematic when more projects and the eastern part is commenced. For urban development districts with many projects, collaboration, coordination, and focus on the holistic perspective are needed. Furthermore, it is essential to involve all actors, structure the coordination, raise the logistics issue, and determine who will be responsible for driving the logistics issue forward early in the collaboration. Lastly, when logistic solutions are undertaken, all actors, down-and upstream, in the supply chain need to be able to get the information required to be able to execute the solution and assurance that the solutions are being followed must be made.

6.4 Further research

In this thesis, the aim has been to investigate how the construction logistics, collaboration, and coordination in project Masthuggskajen contributes to the realization of Älvstranden Utveckling's visions of Älvstaden. Currently, only a few projects have initiated construction and due to time constraints, it has not been possible to study project Masthuggskajen in its entirety. It would be interesting to research how the rest of the development of the project will unfold. For future research three main topics are recognized. Firstly, to further investigate how logistics can be coordinated, implemented, and followed up. Secondly, how the division of responsibilities, roles, cooperation between authorities, and cooperation between private and public actors can be structured. Lastly, how it can be ensured that logistics solutions are followed and how to make sure that necessary information reaches all the way down the supply chain.

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8 Appendixes

8.1 Appendix A

Interview questions for Älvstranden Utveckling:

Preface:

- Name:
- Education / Background:
- What is your company's role in the project?
- What is your role in the project?

The consortium:

- What is the goal with the consortium?
    - How has it gone this far?
    - How does the communication take place?
- How is the is the consortium structured?

Logistics:

- What requirements have you set for construction logistics?
    - Any special requirements regarding congestion, noise, environmental footprint, or impact on surrounding activity?
- When in the planning process did the construction start to be discussed?
- Earlier in the project a logistics plan was developed, is something used from this today?
    - Why was it developed?
- In your assignment, do you have a strategy developed for construction logistics?
- How do you collaborate with the other parts of the city, Trafikkontoret, Stadsbyggnadskontoret e.g.?
    - Are you sharing information?
    - Are you discussing construction logistics?

Coordination:

- How involved are you in the logistics coordination?
- Do you believe the coordination works well between the different actors?
    - What could be improved?
- How do you think your guidelines are followed in Masthuggskajen?

Sum up / Other:

- Have the corona-pandemic changes anything in the construction logistics or its coordination?

Interview questions for contractors:

Preface:

- Name:
- Education / Background:

- What is your company's role in the project?
- What is your role in the project?

Logistics:

- Have you been involved in any similar project in terms of construction logistics?
- How is the logistic work structured? Who is responsible for e.g. deliveries arriving at the right place and time?
    - Are you using TPL/CCC/Delivery calendar/Cloud services?
- What aspects do you believe are important when building in dense environments, like Masthuggskajen?
- How are changes in time- and logistics plans handled?
- How many deliveries would you estimate your project will need?
    - How many different suppliers?
    - Do you believe the construction supply chain is problematic?
- How do you proceed to reduce congestion, noise, environmental footprint, and impact on surrounding activities?
    - How is it measured?
- *If construction have started:* How is the traffic situation looking in the area?

Coordination:

- How does the collaboration between the contractors look?
- What do you think of the coordination between the actors within your project?
    - What could be improved?
- Are you coordinating your deliveries? Are deliveries coordinated within the project or with other projects?
    - Does your work with suppliers change when building in dense environments? Is more coordination, more frequent deliveries etc. required due to surrounding conditions?
    - Do you and the suppliers work together to find or develop improved logistics?
- How has the work with the consortium worked? What requirements / guidelines have you received?
- How much are you affected by the other contractors?
- How (much) do you think your logistics solution affects the other contractors?

Sum up / Other:

- What do you believe is important to focus on to avoid today's problem in construction logistics?
- How do you think construction logistics and collaboration/coordination will look in 10/20/50 years?
- What would have been optimal for the "own" project which has not been possible to implement due to nearby projects & traffic?
    - Taken in a TPL / CCC solution?
- Have the corona-pandemic changes anything in the construction logistics or its coordination?

Interview questions for coordinators:

Preface:

- Name:
- Education / Background:
- What is your company's role in the project?
- What is your role in the project?
- Have you been involved in any similar project or assignment?
- When were you involved in this project? You and your company?
    - What did the logistics plan look like then? How is it different from today?
    - Has your assignment changed during the project?

Coordination:

- How is the coordination structured today? Who does what?
    - Division of responsibilities?
    - Responsible for updating plans and drawings?
    - How do think it works?
    - Any suggestions for improvements?
- How does the coordination usually look?
- Is there an active coordination between nearby projects? TK at Järntorget? Västlänken?
- How does the cooperation between the contractors' work? Is there any?
- Have there been any conflicts?
- What kind of information is exchanged between the actors within the consortium?
    - In what media does information exchange take place?
- How is the information organized, structured, shared and stored? Internally and externally?
- What are the most important aspects for you as a coordinator?

Logistics:

- Do all actors use the same logistics plan?
- How are changes in time- and logistics plans handled?
- What do you think is important for the contractors to think about in terms of construction logistics?
    - Do you think they take responsibility for this?

Sum up / Other:

- What do you think it is important to focus on to avoid today's problems in construction logistics?
    - What would be required to further improve construction logistics (driving forces, requirements from customers)?
    - What can be further improved?

- In projects like Masthuggskajen, where collaboration is of particular importance, have you seen tendencies that different actors mostly look after their own best interest before the best interest of the project as a whole?
    - *If yes:* In what ways?
- Have you made any forced solutions that have benefited the area but not all individual actors?
- Would you like to bring in a TPL/CCC solution?
- Have the corona-pandemic changes anything in the construction logistics or its coordination?

Interview questions for Trafikkontoret (Traffic office):

Preface:

- Name:
- Education / Background:
- What is your company's role in the project?
- What is your role in the project?

Coordination:

- How have you been involved and developed the project?
    - How active are you in the project today?
- What to you take most into account regarding traffic solutions?
    - What aspects needs to be considered?
    - What steps do they have to go through?
    - How are changes informed?
- How involved are you in the logistics coordination?
- How do you think the coordination in Masthuggskajen has worked?
    - Improvements?
- How is the project coordinated compared with other projects?
    - How does it usually look?

Logistics:

- Do you set requirements regarding construction logistics?
    - If yes: What kinds of requirements?
    - How are they followed up?
    - Any special requirements regarding congestion, noise, environmental footprint, or impact on surrounding activity?
- Are there any requirements for the contractors to account for their construction logistics?
- How does this project compare to others?
    - What does it usually look like?
- What aspects do you believe are important when building in dense environments, like Masthuggskajen?
- How do you collaborate with the other parts of the city, Älvstranden Utveckling, Stadsbyggnadskontoret e.g.?
    - Are you sharing information?

- Are you discussing construction logistics?

Sum up / Other:

- Have the corona-pandemic changes anything for your construction logistics or its coordination?

8.2 Appendix B

Questions for suppliers (used during on-site observations):

Company:	Is it your first delivery to this area?
Is it your first delivery to this area? What was delivered?	Was the delivery set for a specific time? Did the delivery arrive on time?
Was the delivery registered in the delivery calendar/leveranskalender?	Did you wait anywhere until called off? If so, where?
Have you received information on who to contact?	Have you received information on what route to take into site?
Where is this delivery coming from?	Any problems due to traffic?
How do you manage Just-in-time deliveries?	Did this delivery differ from “regular deliveries”?
Observations: How long does the unloading take?	**Observations:** Did the vehicle leave empty?
Observations: Is the driver unloading him/herself?	**Observations:** Did the delivery match the order? Damages etc..

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