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Optimized Transport and Efficient Goods Reception -

Using Time Slot Management to Optimize Performance at the Interface Between External and Internal Logistics

Master's thesis in Supply Chain Management

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Optimized Transport and Efficient Goods Reception

Using Time Slot Management to Optimize Performance at the Interface Between External and Internal Logistics in a Production Setting

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Summary

This master's thesis study investigates the possible use of Time Slot Management (TSM) in live-unload goods receptions at automotive production facilities. The study was conducted in collaboration with the Volvo Group and is based on their pilot study of a TSM software at their production facility in Bourg, France. Volvo Group's production facility in Tuve and its surrounding context has been used to exemplify the theoretical findings of this study by placing them in a real-world context.

The use of TSM in different industry settings was mapped and analyzed through multiple, iterative literature reviews and semi-structured interviews with people in the logistics field. The findings from the literature review and interviews were combined to create an analytical framework. The framework describes a live-unload goods reception at an automotive production facility from a TSM perspective and was used to conduct the analysis. The analysis discusses each of the seven parts of the framework: geography and infrastructure, incoming goods flow, at the gate, the goods reception, internal logistics, time slot management and disruption management. Each part results in a number of recommended considerations when designing or choosing a TSM solution.

To conclude each of the three research questions posed to be able to evaluate the study's fulfilment of its purpose were answered. The first and second research questions were adequately answered through a presentation of important aspects to consider when designing a TSM solution along with important contextual conditions that can affect the suitability. The third research question regarding a suitable design of time slot management practices at the live-unload goods reception at the Tuve production facility was not possible to fully answer as there was not enough information available. Hence the first step in finding a suitable TSM solution for the Tuve production facility should be to gather more information about the facility, its context, and incoming goods flows.

Keywords: Time Slot Management, TSM, Live-Unload Goods Reception, Truck Appointment System

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Lars Medbo has helped us through our many revisions of our study, which were required by the many changes of the study conditions due to the Covid-19 pandemic. Lars has also been very helpful in providing literary guidance and supplying contacts with relevant knowledge for this study.

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Best Regards,

Erika and Emil

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Nomenclature

Live-unload goods reception	A goods reception where goods are unloaded right away at arrival, and the truck drives off again as soon as possible.
Seaport container terminal	A seaport container terminal is a facility at which cargo containers are delivered to be transferred to a vessel or collected from a vessel.
Seaport drayage operations	Seaport drayage is the collection or delivery of containers to a seaport container terminal.
Truck turn time	The elapsed time from arrival until departure for a truck making a delivery to a goods reception.
Walk-in	Unscheduled arrival of an incoming delivery.
No-show	Scheduled arrival of an incoming delivery that fails to arrive.
Outpatient appointment systems	An appointment system for outpatients, who are patients that arrive, receive their treatment, and then leave the healthcare facility during the same day without being admitted.
Fishbone style factory	A factory design with multiple goods receptions instead of just one main goods reception.
ETA	Estimated Time of Arrival
OEM	Original Equipment Manufacturer, the original manufacturer of a component or assembly of components.
FTL	Full Truck Load, transport using the full cargo capacity
LTL	Less Than Truck Load, transport not using the full cargo capacity
3PL	Third-party logistics provider. Logistics providers offering additional services to transportation, such as cross docking, sequencing, repackaging, and warehousing

1 Introduction

Volvo Group initiated this Master's Thesis project to examine and search for possible performance improvements in the interface between external and internal logistics. The initial problem description discussed Volvo Group's wish to explore possible improvements to their goods receptions by creating a more levelled flow of incoming goods to their factories. A levelled and predictable flow of incoming goods would simplify both the goods reception as well as the internal logistics operations in multiple ways. The number of staff needed could be more accurately predicted to limit the idle worker time as well as limit the waiting time for incoming deliveries. The amount of space available for goods reception and internal logistics could be better utilized without being neither empty nor overcrowded at times throughout the day. Making sure that goods are unloaded in time for when the materials are needed in production helps ensure there are no delays, stand stills or loss of value generating activities. A levelled and reliable incoming goods flow can contribute to lower safety stock levels and thereby lower the tied-up capital.

For the hauler coming to unload at a factory the turnaround time is essential as it impacts any other collections or deliveries planned to take place afterwards. Less time spent waiting to load or unload means that the truck driver can fit more collections and deliveries into his or her workday, increasing the utilization of both the truck and the driver's time. Due to the strict regulations for truck drivers, the number of hours a truck driver is allowed to drive during a day is limited and there are mandatory break times that must be respected. Therefore, unexpected waiting time can lead to complicated scheduling troubles in addition to the truck being late to its next assignment. In a best-case scenario, an incoming truck can be driven to an unloading area straight away at arrival. The truck will be unloaded quickly and soon after arrival it can be on its way again to the next assignment. This however relies on there being an available unloading area as the truck arrives, as well as enough available staff to unload quickly. A levelled and predictable incoming goods flow can make this more likely to happen as the goods reception will not be overwhelmed by peaking numbers of arriving trucks.

The use of time slots can be one solution to achieve a more levelled and predictable arrival of incoming goods deliveries. This master's thesis will focus on how to use and manage time slots at a live-unload goods reception.

1.1 Background

Prior to this master's thesis Volvo Group have performed a pilot study on the use of a generic Time Slot Management software provided by the company Transporeon, one of the leading actors in the field of digitalized logistics solutions. The study was performed at Volvo Group's production facility in Bourg outside of Lyon, France. During the pilot study, Volvo Group encountered several problems which they linked to the usage of Transporeon's software, ultimately leading to the termination of its use. However, Volvo Group did also see positive effects from the use of a time slot management solution which indicate that there are benefits to obtain from the use of bookable delivery time slots. A different and more tailored system design might be able to provide the same and more benefits with less or none of the drawbacks of the generic trial software.

From an academic point of view, the subject of time slot management is a defined part of scientific literature. However, time slot management specifically related to incoming deliveries at a live-unload goods reception at an automotive production facility is a sparsely explored subject. A closer investigation of a production company's possible use of time slot management could provide inspiration for further research, new ideas and suggest solutions on how to use time slot management at a live-unload goods reception at an automotive production facility. The subject is therefore scientifically relevant as it aims to improve the current knowledge base and inspire future research on the use of time slot management in the interface between external and internal logistics at an automotive production facility.

1.2 Purpose

Traditionally transportation is booked with a set delivery date but no specified delivery time other than "within opening hours of the goods reception". Higher delivery time precision will increase the price of the transport as the hauler needs to take costly precautions to ensure a timely arrival within a narrower delivery window. Delivery within the opening hours of a set day is generally considered the largest delivery window a goods reception can allow without suffering too much from the uncertainty while simultaneously keeping the cost of the transport as low as possible. Allowing haulers to arrive at any time within opening hours creates peaks and valleys in the flow of incoming trucks. Depending on the context of the goods and goods reception certain times during the day will be more suitable for haulers to deliver. For example a common reason for morning congestion at goods receptions is that long distance haulers arrive at the goods reception after closing, take their daily long break during the night and then wish to unload first thing in the morning to be on their way again as soon as possible.

Transportation of any kind is unreliable to some extent as there are always things that can and will take place along the way from collection point to delivery point. Some transport modes at certain distances can estimate their arrival time within minutes, others barely within days. This built in, unavoidable unreliability of all goods deliveries needs to be absorbed somewhere in the goods reception system as to not disturb the production lines or incur high stock levels to compensate.

The issues of unreliable arrival times of incoming deliveries combined with a full day delivery window will lead to a situation where at certain times during the day the goods reception will be incapable of keeping up with the incoming flow of goods to unload, creating a backlog of waiting trucks. At other times during the day the goods reception will have a lack of incoming trucks and the workers and machines will be idle. The purpose of this study is to connect with Volvo Group's earlier efforts of improving efficiency at the interface between external and internal logistics and further explore time slot management practices.

1.3 Problem Description

Time slot management can be one way to mitigate fluctuations of the incoming goods flow in a low-cost way whilst still being able to accommodate the unavoidable discrepancies between estimated and actual arrival times. The goods reception will be able to work at a reasonable pace throughout the day instead of being overloaded at times and idle at others. This ensures that deliveries can be unloaded in a timely manner avoiding queues and making sure that materials reach the production lines in time to keep operations running smoothly.

The basic premises of using time slot management is simple, the use of bookable time slots, however in practice there are endless variations available. Successful time slot management practices need to be designed carefully and suit the context in which they are being used. This study will explore suitable time slot management practices for live-unload goods receptions at production facilities like Volvo Group's factory in Tuve, Gothenburg. The Tuve factory will be the focal point of a minor case study as a part of this master's thesis study to put the research results into a real-world context.

1.4 Scope

The scope of this master's thesis study is to explore suitable time slot management practices for live-unload goods receptions at automotive production facilities. To be able to find suitable time slot management practices the study will investigate necessary considerations when designing a time slot management solution for a live-unload goods reception at an automotive production facility. The study will also explore the contextual conditions which might influence an automotive production facility's suitability for time slot management practices at their live-unload goods reception. The geographical location and contextual conditions of the Tuve factory will be used to put any findings into a real-world context through a small case study.

1.5 Research Questions

This master's thesis study will address the previously described problem of design and context considerations for a time slot management solution within the defined scope, concluding in the answering of the following three research questions:

RQ1. Which important aspects should be considered when designing a time slot management solution for a live-unload goods reception at an automotive production facility?

- *Important aspects to be considered when designing a time slot management software or choosing a time slot management software from an external provider.*

RQ2. Which important contextual conditions can affect the suitability of a live-unload goods reception at an automotive production facility for time slot management practices?

- *Contextual conditions vary from one goods reception to another depending on its geographical location, surrounding environment, incoming goods flow, and the design of the facility.*

RQ3. What is a suitable design of time slot management practices at the live-unload goods reception at Tuve production facility?

- *How could a suitable Time Slot Management solution be designed for the live-unload goods reception at the Tuve production facility, taking into consideration the findings from the answering of RQ1 and RQ2.*

2 Company Description

This chapter gives a general introduction to the company and a short explanation of the organizational structure of Volvo Group. The chapter contains a more in-depth presentation of the pilot study on time slot management conducted in Bourg, France. The pilot study was mentioned briefly in the previous chapter and will from here on be referred to as *the Bourg study*. Further, the chapter introduces the Tuve production facility and its relevant processes and contextual conditions.

2.1 Volvo Group

Volvo Group is currently the largest enterprise in Sweden with its headquarters located in Gothenburg. The most recent available annual report from 2019 reports a record-breaking turnover of 432 billion Swedish crowns. Volvo Group operates in several business fields with the largest one being the construction and production of commercial vehicles and equipment. Volvo employs over one hundred thousand people all over the world with ongoing production in eighteen countries, together supplying 190 countries with Volvo products. The sales figures for 2019 shows a delivery of 233 000 Trucks, 9700 busses, 18 000 marine propulsion engines and 87 000 construction equipment machines. The three largest markets for Volvo are the European market with 38 percent of net sales, North America with 30 percent and Asia with 19 percent. (AB Volvo, 2020)

During the years of 1999-2011 Volvo conducted several acquisitions to enhance corporative growth and enlarge their trademark range. During those years, Volvo acquired Renault Trucks, Mack Trucks, Nissan Diesel and Samsung excavators amongst others. This acquisition phase led Volvo to significant growth and induced a need for future alignment of processes and organisational structures. A phase of organisational transformation followed where focus was directed towards increasing efficiency and profitability. This was mainly achieved by reducing overlaps in offered product ranges of the acquired brands, through structural changes and the creation of cross functional service divisions. From the year 2016 Volvo have been even more dedicated towards improving their corporate performance and have organic growth. (AB Volvo, 2020)

Volvo´s organisational structure as of 2020 is made up of group functions, business areas and truck divisions. The group functions provide services to all other functions within the organisation and their work affects the whole organisation. One example of a group function is the human resources division which cooperates with all other functions. The business areas are sales organisations for brands or groups of similar products. Renault Trucks' and Volvo Trucks' business areas are truck business areas, responsible for sales and sales promotion of their respective brand and products, however not production nor development. This is not the case for business areas of products other than trucks as these business areas are, in addition to sales and promotion, also responsible for development and production. Truck divisions are responsible for production, development, and procurement, which is done centrally. This enables the exchange of OEM (original equipment manufacturer) parts and information between the truck brands lowering costs and increasing performance simultaneously. A visualisation of Volvo Group's organisational structure is shown in Figure 1. (AB Volvo, 2020)

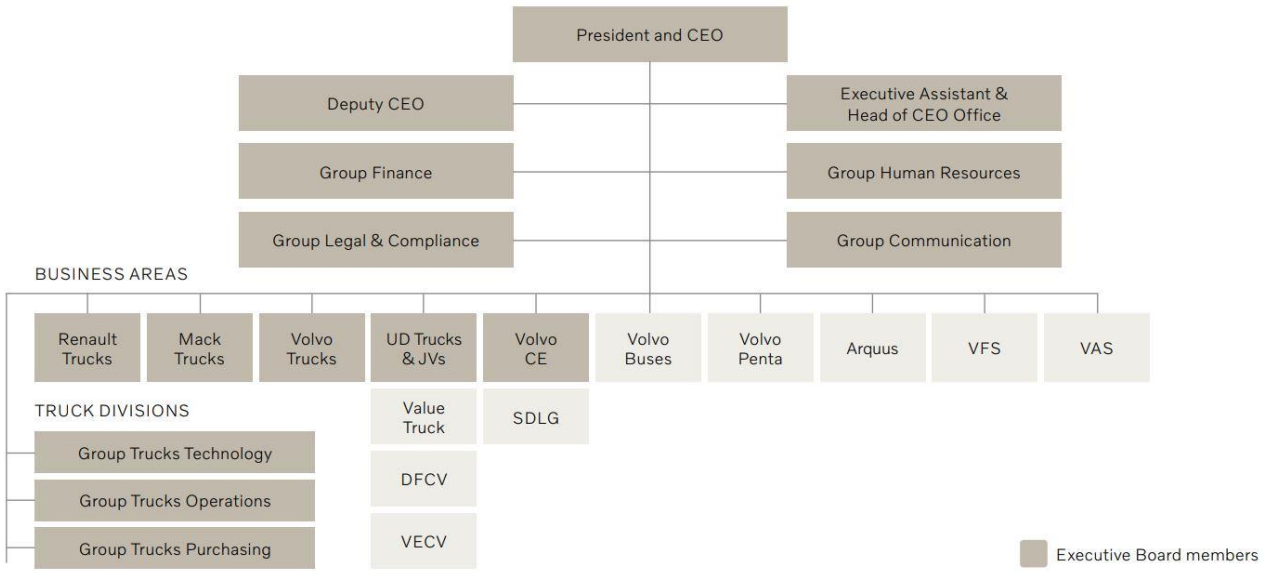

Figure 1, Volvo Group organisational structure (AB Volvo, 2020)

2.2 The Bourg Study

Prior to this study, Volvo Group conducted a pilot study to test a generic time slot management solution by a market-leading actor, Transporeon. The study was conducted during six months in 2018 and 2019 at the Volvo-owned Renault Trucks production facility in Bourg, France. The aim was to reduce waiting cost and unloading time, increase productivity and improve the goods reception layout. Each bookable time slot was 30 minutes long and the haulers were responsible for the booking of time slots prior to arrival. The haulers were responsible for the estimation of the required time to unload the delivered goods and expected to book a suitable number of 30-minute time slots in accordance with their estimation. One 30-minute time slot corresponded roughly to the handling of 30-50 pallets, hence shipments larger than 30 pallets might need additional slots.

The main findings were that TSM had a positive effect on the overall performance of the goods reception at the site. One specific improvement was a smoothing effect on the flow of incoming trailers throughout the day. An illustration of the average demand for each hour before and after TSM implementation can be seen in Figure 2 and Figure 3. The implementation of TSM had a positive effect on the distribution of incoming deliveries throughout the day by reducing peaks and creating a more even flow. However, the smoothing effect was not large enough to enable the removal of a full-time worker and therefore did not cross any major threshold of cost saving. This was the main reason for the termination of the pilot study, as Volvo Group could not find sufficient financial incentives to offset the license costs of the Transporeon software.

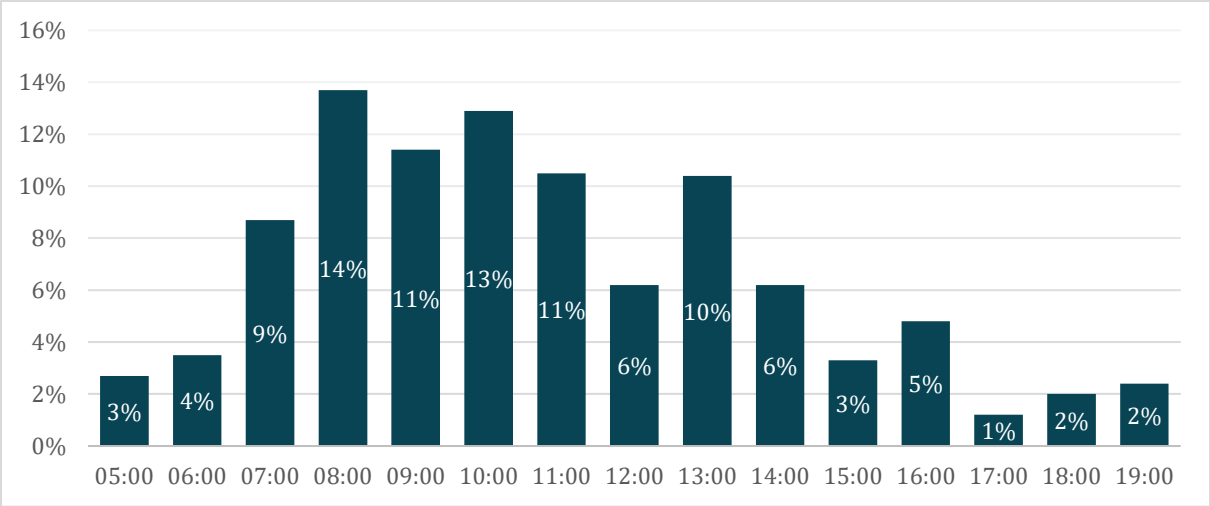

Figure 2, Distribution of incoming goods flow before pilot study without use of TSM.

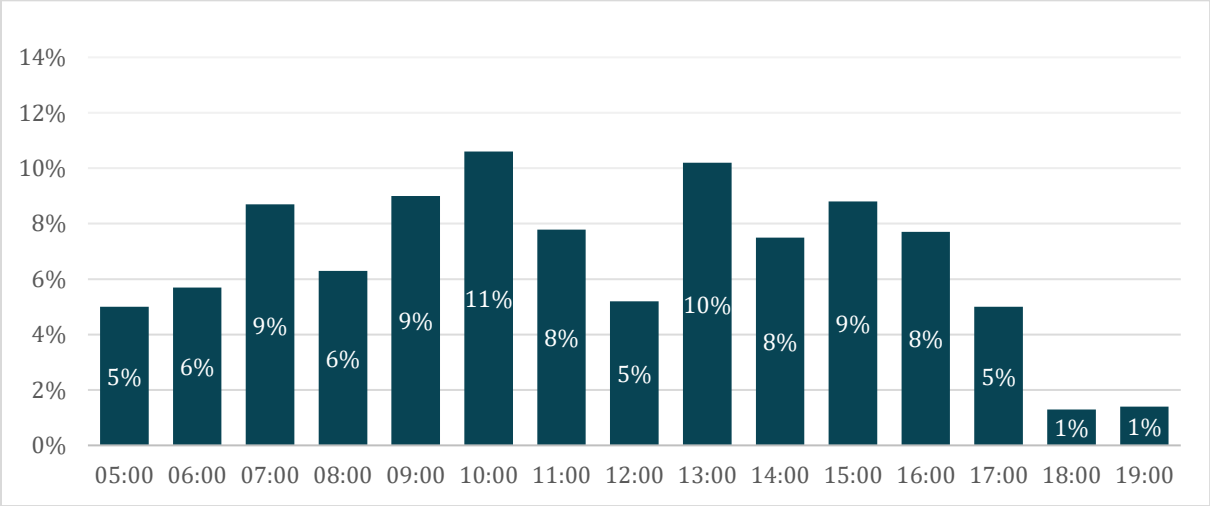

Figure 3, Distribution of incoming goods flow after implementation of TSM

Initially the proportion of haulers doing slot bookings prior to arrival was at around 75-80 percent. This number was expected to increase as haulers became more familiar with the booking procedure, but this expectation turned out to be false. During the final weeks of the study, the proportion remained at 75-80 percent, and no positive trend could be seen. Whether Volvo Group put sufficient effort into improving the numbers and still were unsuccessful or if they were occupied with other matters is unclear.

2.3 The Tuve Factory

The Tuve production plant located in the outskirts of Gothenburg produce Volvo trucks by a traditional assembly line. The factory also prepares truck kits to be shipped abroad for assembly and sales. These two types of production induce a substantial variety of parts to be handled than what is common at most other Volvo factories. This variety increases the logistic complexity at Tuve due to the sheer number of unique articles to be sourced and stored. The geographical location is close to Gothenburg harbour where much of the goods arriving have passed. Close to Tuve factory are also Torslanda production facility, owned by Volvo Cars, which together with Tuve cause lots of traffic during work shift change.

The goods reception at Tuve are traditional with several manual procedures for each arrived transport. The time slot bookings are currently made manually according to the haulers ETA at commenced transport. This ETA is rarely updated during transport and can therefore differ due to various delays. Sometimes the hauler does not communicate an ETA which means that the goods reception can only wait and see when the transport arrives. Tuve use extensive amounts of paper documents in their daily administrative processes which to a large extent are saved as paper copies in binders, those are put to storage in a separate room at the goods reception.

The unloading of arrived trucks is made by goods reception operators with use of forklifts. The unload goods are placed on the reception area after which it is inspected to correspond the expected. The goods are thereafter either placed onto wagons for outdoors transportation at the area or onto a fully automated conveyor system for transport into the facility where an automated warehouse handles the goods. The goods placed on wagons are transported to one of the factory's other material inlets where they are used to supply the assembly line.

The factory uses three partly parallel assembly lines, one of which are the main assembly line and the other two being cab preparation and engine preparation. The two partly parallel assembly lines prepare installation of truck cabs and drivetrain at the main assembly line.

3 Method

This chapter presents a description of the method used in this master's thesis study along with considerations of validity and reliability. First the overall approach is presented to give an understanding of the general course of action throughout the study. Following is a more detailed description of the methods for the literature review and the interview process, respectively. To conclude the reliability and validity of this study are addressed along with measures taken to address the reliability and validity issues encountered during the study because of the Covid-19 pandemic.

3.1 A Grounded Theory Approach

To ensure high quality this study was conducted using a grounded theory approach. The grounded theory method of doing research was invented in the 1960s by Barney Glaser and Anselm Strauss and is a thoroughly tested method known to help provide valid and reliable results (Corbin and Strauss, 2015). The core advantages of using grounded theory for this study is the method's potential to encourage creativity and its systematic way of gathering and analyzing ample amounts of data (Hussein, Hirst, Salyers and Osuji, 2014). It became clear already in the preparational work for this study that the subject of time slot management (TSM) in the setting of a live-unload goods reception at an automotive production facility has not been heavily researched. The subject does not have a large body of research to it, despite TSM in general being a well-established concept, exemplified by the fact that one of the first studies on TSM in a healthcare setting was conducted by Bailey already in 1952. The limited research on the subject of TSM in the setting of a live-unload goods reception at an automotive production facility required a research method which would inspire new findings and support research in an area with limited existing research. The grounded theory method has provided substantial knowledge over the years and allows for multiple angles of approach (Corbin & Strauss, 2015). For this reason, a grounded theory approach was deemed suitable for this master's thesis study.

Over time many different variations of grounded theory methods have evolved (Timonen, Foley, and Conlon, 2018). In this study a simplified version of the approach outlined by Corbin and Strauss (2015) will be used as the focus on objectivism and reflexivity ascribed to their approach is considered beneficial for this study (Timonen et al., 2018). According to Corbin and Strauss (2015) grounded theory has two significant unique features. First, theory is not chosen prior to study but rather based on collected data in an iterative process. Second, research analysis and data collection are interrelated. Data is collected and analysed, based on the analysis new data is collected and analysed and so on. Throughout this master's thesis study these two core features will frame the research process. After an initial literature review interviews will start being conducted. After each interview, the findings will be analysed, and a new literature review will be conducted based on the interview findings. This iterative process of literature review, interview, literature review, interview and so on without any pre-chosen theory is right in line with the grounded theory approach.

Hussein et al. (2014) point out several possible disadvantages of using grounded theory. The process can be exhaustive and there is a risk of methodological errors given the complexity of the method. In this master's thesis study, a simplified grounded theory approach focusing on the two core features presented above will be used as a base for the research process, eliminating the risk for an exhaustive process. The simplification of the method will also prevent methodological errors, as the approach will be understandable enough not to cause any confusion. Additionally, Hussein et al. (2014) explain that the results of using a grounded theory approach can have limited generalizability. Timonen et al. (2018) on the contrary argue that greater conceptual clarity is a satisfying result and that it is not necessary to provide a

generalized theory for a study to be successful using grounded theory. It is not considered necessary nor something to strive for that this master's thesis study results in a generalized theory given that the purpose of this study is to explore the subject of TSM and put it into specific contexts.

3.2 Theoretical Framework

Theoretical frameworks are fundamentally not in line with Grounded Theory, as experiences and observations should lead the way (Corbin & Strauss, 2015). Hussein et al. (2014) explain that researchers might develop assumptions during the literature study which will later influence the study negatively. Timonen et al. (2018) conversely suggest that the literature study does not need to influence the rest of the study negatively. It can just as well contribute positively as it gives the researchers a better understanding of the subject about to be studied. As this is a master's thesis study performed by students, any actions giving the authors a better understanding of the subject at hand are very valuable. Thus, performing a literature review is considered having enough benefits to warrant the possible risk of the literature review influencing the study negatively.

In this master's thesis study, an initial literature review will be conducted to establish the current academic best practices of time slot management. In line with the grounded theory approach, rather than building a theoretical framework to be tested, the literature review will act as a theoretical frame of reference to be helpful during the study. The literature review will be revisited multiple times alongside the data collection process and expanded with any additional, relevant information found along the way. To ensure credibility and reliability literature from modern and credible sources will be prioritized. Meta-analyses and systematic reviews are used when possible. Other studies or reports should preferably not be older than ten years old, peer-reviewed and written by accredited researchers within the study field. All sources are checked for credibility before being used in this study.

3.3 Interviews

The grounded theory method can be applied both to individuals as well as large organizations, making it suitable for this study as interviews will be conducted with both large organizations as well as individuals (Corbin & Strauss, 2015). The interviewees will be chosen with the aim to cover the subject of time slot management from many different angles.

Interviews can be divided into three levels of structure according to Corbin and Strauss (2015); unstructured, semi-structured, and structured. **Unstructured interviews** are conducted without any pre-structured interview guide giving the interviewee space to talk freely. This level of structure is considered to give the richest data, finding the problems and issues most important to the interviewee rather than the interviewers. However, there is a risk of the opposite happening and important information becoming left out simply because the interviewee did not think about it at the time. **Semi-structured interviews** have some topics chosen beforehand, but nothing is specified about when or how the topics should be addressed. This list of topics often works as a comforting fall-back for the interviewer. After the topics are covered the interview can continue as an unstructured interview. This can compensate for the risk of one or more topics being overlooked associated with unstructured interviews. **Structured interviews** are conducted using a pre-written set of questions for the interviewee to answer. This is considered one of the least effective ways to collect data in grounded theory. The questions rule the interview and no adjustments are possible during the interview making the format inflexible. The greatest issue is that this approach goes against the foundations of grounded theory as the questions only cover what the interviewers deem important and not what the participants deem

important. Interviewees become less likely to bring forth their own opinions and instead just answer the questions posed to them (Corbin and Strauss, 2015).

In this master's thesis study, interviews will be conducted to collect real world experiences from people working with or without time slot management practices at or in contact with live-unload goods receptions. The aim is to cover many different viewpoints on time slot management practices. Interviewees will therefore be chosen based on them providing a viewpoint not already cover by previous interviewees. The interviewees are expected to only be available for one interview session, making it important to take full advantage of that one session. To do this the decision was made to structure the interviews based on the three different interview structure levels presented above. Interviews will start as unstructured interviews to be able to catch the uninfluenced thoughts of the interviewee. Follow up questions will be asked along the way to make the interviewees expand on their thoughts to ensure no aspect of the issues deemed important by the interviewees are missed. The interview will then move on to become a semi-structured interview where a pre-written list of topics will be used to ensure no important topics are missed simply because they were not on the interviewee's mind. The list includes topics such as late truckers, missing documents, or time slot management. Topics will be added as needed throughout the study. To conclude the interview will turn into a structured interview where a list of specific questions will be used to make sure all details or facts needed for the study are collected. Specific questions can be about company size, daily number of incoming trucks or the name of any TSM software used at the company. Just like with the topics, specific questions will be added as needed throughout the study. Topics or questions from the lists are only brought up if they have not already been covered earlier in the interview. The resulting lists of topics and questions after all interviews had been conducted is presented in Appendix A.

3.4 Qualitative Reliability and Validity

This study was started January 20th and January 31st Sweden had its first confirmed case of Covid-19 (Folkhälsomyndigheten, 2020). By mid-March the Public Health Agency of Sweden recommended that if possible, work should be done from home (Persson, 2020). On March 20th Volvo Group announced that they would suspend work at all Swedish production sites (Kejerhag, 2020). This had several implications for the reliability and validity of this study. Contacting and visiting any of the Swedish Volvo Group production sites was not possible. Any types of site visits or observational studies at other companies were not possible either. The empirical part of this study was therefore limited to consisting of interviews performed over phone or video call, making this study a qualitative study only.

3.4.1 The Reliability and Validity of a Qualitative Study

Stenbacka (2001) states that reliability is completely irrelevant in qualitative research because of the absence of measurement methods. In a qualitative study it is impossible to disconnect the researchers' own opinions from the research results and this leads to differences in results depending on who is performing the study. In addition, a researcher's opinion, experiences, and social attitudes are inconsistent over time, leading to different results when replicating the same study even with the same researcher in charge, the same applies to interview participants.

Reliability is defined by Golafshani (2003) as the used method's ability to generate consistent results when being iterated with similar contextual conditions. A similar but extended definition is given by Bryman (2016) who defines total reliability as a mix of internal and external reliability. **Internal reliability** is to the likelihood that a group of people conducting a study will witness and interpret the results equally. **External reliability** is a study's ability to be

replicated. External reliability can be difficult to ensure in qualitative research due to the ever-changing societal and personal opinions. An interviewee may be convinced of something today but change their mind tomorrow.

Validity is according to Golafshani (2003) a method's ability to provide accurate results in line with the users' intentions. Bryman (2016) extends this definition with the use of internal and external validity. **Internal validity** is the ability of researchers to draw conclusions and introduce theoretical ideas in line with the research findings. **External validity** is used to describe the likelihood that a research study can be iterated and produce the same results when it is performed with different participants who also differ from one another through social conditions such as wealth, education, and ethnicity. The pursuit of high external validity is particularly difficult in qualitative research because of the often much lower number of participants compared to in quantitative research. Research with many participants is less sensitive to participants with extreme opinions because of the many more people who weigh and correct the extremes.

Bryman (2016) describes **face validity** as a way to ensure an appropriate line of questioning is chosen to collect relevant information for the study. The researchers give a person with experience or expertise in the research area the opportunity to comment on and suggest improvements to the planned interview procedure. This provides the authors with an initial clarification as to whether their intended research procedures will be able to gather the desired information or not. This method requires that the participating expert is indeed an expert of the research area and has sufficient knowledge. The method can use more than one expert and create even more accurate results by combining their views.

Denscombe (2014) presents **respondent validation** as a way validate qualitative research. It aims to confirm the researcher's interpretation of interview responses by asking the interviewee whether the researcher's interpretations are correct or not. Bryman (2016) discusses the topic as well and states that the method is commonly used to validate research on qualitative research. There are three main concerns associated with respondent validation, which need to be addressed before it is performed.

1. The validation method may lead to the interviewee becoming defensive about the interpreted information, as if confronted with the information rather than asked to validate it. This can cause a situation where the interviewee tries to remove sensitive information about themselves or the organization they represent.
2. Qualitative interviews might be performed several times with each participant which may lead to the establishing of personal relationships. This could lead to participants being less likely to express criticism in their responses.
3. The researcher's way of expressing their interpretation of the interview might not be understood by the interviewed person. This could lead to misunderstandings or the interviewee validating an incorrect interpretation of the interview.

Triangulation is the use of multiple sources and methods to confirm the study results. According to Golafshani (2003), triangulation can be used to increase both reliability and validity in qualitative research. Triangulation makes it possible to analyse information from multiple perspectives, creating a better basis for analysis and conclusions as they will be based on several independent sources or methods. Thus, a study using multiple methods such as observations, literature review and interviews is more likely to have good validity and reliability compared to if only one method is used. (Bryman, 2016)

3.4.2 The Reliability and Validity of this Master's Thesis Study

To enable reliable and valid results from this master's thesis study the methods presented above were used.

Internal reliability was ensured by conducting interviews and analysis in tandem with continuous discussion of individual interpretations of the data at hand to reach agreement between the researchers. External reliability was achieved primarily using triangulation and several sources to confirm the gathered data. This limits the risk of including information which later cannot be corroborated by subsequent studies. The risk of study results becoming impossible to corroborate due to changing social settings and personal opinions has been difficult to mitigate in this study. The problem could possibly have been mitigated using a combined qualitative and quantitative study, but this was not an option because of the issues created by the Covid-19 pandemic explained above. The interview guide also helped create external reliability by documenting the questions and topics addresser during the structured and semi-structured parts of the interviews. The interview guide in its final form can be found in Appendix A.

Internal validity is established through face validation and respondent validation. Face validation was implemented by showing the interview guide to the supervisors, discussing it with them and changing it in accordance with their suggestions. Respondent validation was used to confirmation that the researchers' interpretations of the interview findings were in line with the answers that each interviewee wished to convey. External validity is one of the most difficult areas of quality assurance in qualitative studies and this was further escalated by to the Covid-19 pandemic going on during this study. The pandemic caused many interviews to be cancelled and many companies stopped responding to emails. The number of interviews planned at the beginning of this study needed to be reduced resulting in fewer interviews and less collected data. Additionally, no site visits, observational studies or extensive interviews with Volvo Group personnel were possible. To mitigate these external validity issues the interviewees were chosen very carefully to try to cover as many perspectives as possible such as transport planners, internal logistics operators and TSM software developers. The literature study was significantly expanded to ensure no relevant parts of available research on TSM were missed.

4 Theoretical Framework

This chapter presents the findings from the literature studies. Multiple rounds of literature searches have been conducted, starting with an initial, more extensive literature search before conducting interviews followed by complementary literature searches based on new findings or ideas from interviews or talks with professors or experts. The literature searches have been compiled into a theoretical framework which used to set boundaries and create a frame for analysis.

The first subchapter presents core concepts of supply chain management relevant to this master's thesis study, including external road transport, goods reception, internal logistics, planning levels and the transport market. The concepts will be addressed from a TSM perspective. The subject of TSM in the setting of a live-unload goods reception was found to be sparsely researched and the literature search was therefore expanded to include TSM practices in other fields as well. Certain elements of TSM practices can be the same or similar between industries, thus other industries can provide valuable information about TSM practices that can be directly implemented, modified to be implemented or serve as inspiration for TSM practices to be implemented in an automotive production facility with a live-unload goods reception. The second subchapter presents the findings on TSM procedures in two other settings, seaport container terminals and healthcare facilities, as they were deemed highly relevant and had a large body of research to them.

4.1 Core Concepts

Core concepts in goods reception and TSM are presented and described in this subchapter. The core concepts explain relevant logistics processes from a TSM perspective and the concept of TSM itself. The logistics processes cover the physical transport of goods as well as the accompanying administrative processes. The subchapter on TSM also addresses the transport market and evolving new technologies for transport administration.

4.1.1 External Road Transport

External road transport relates to transport activities taking place between a supplier and buyer. The transport can be performed by the buying company, supplying company or a hauler. A hauler refers to a company that provides transport and logistics solutions for their customers' supply chains. The services can be provided as singular or recurring occurrences. Much like in other business areas some companies differentiate themselves by providing additional services and value adding activities for their customers. These companies are generally referred to as third-party logistics providers (3PLs) and offer their customers additional services, for example cross-docking or warehousing. One of the drawbacks of partnering with a 3PL provider is a loss of transparency for the buyer who possesses less control over the transport compared to when performing the transport themselves or using a regular hauler. (Baudin, 2004)

Rushton, Croucher and Baker (2017) distinguish between two types of road-based transport; primary and secondary. Primary transport is when the transport has a specific destination where all transported goods are unloaded. Primary transport is often performed as full truck loads (FTL) due to the economic benefits of fully utilizing the entire cargo space. Transport that does not fully utilize the cargo space is called less than truck load (LTL). Secondary transport is when a truck visits several stops where cargo can be loaded and unloaded. It is common for this type of transport to be carried out with a higher focus on service and adaptability to customer needs. Baudin (2004) discusses secondary transport and suggests the use of milk runs to increase logistics efficiency in some scenarios. In many business areas it is common to drive

full truck loads from each supplier to the production facility, also called the hub. The use of FTL transports binds significant capital and creates an uneven pattern of incoming goods levels. A visualisation of a hub logistics approach is shown in Figure 4. Milk runs are an alternative to the hub method, which can be used to reduce tied up capital and smoothen out the incoming goods levels. In this approach one truck is used to collect goods in several places, enabling smaller ordering sizes. This leads to less tied up capital and lower levels of inventory at the receiver's facility. Milk runs are usually carried out several times per week according to a predetermined schedule. The truck visits the same suppliers every time, making the replenishment more predictable and manageable by the goods reception. Milk runs are not suitable if a supplier sends enough goods to fill several FTLs per day or if they rarely send goods in small quantities. When using milk runs, it is important that each supplier is not too distant in relation to the others as this would lead to unnecessarily costly transport distances. A visualisation of a typical milk run flow can be seen in Figure 5.

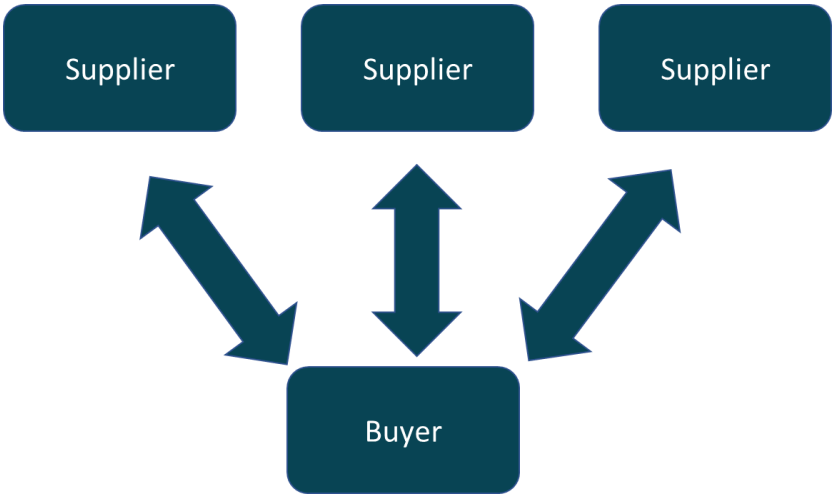

Figure 4, A typical hub flow, the buyer constitutes the hub

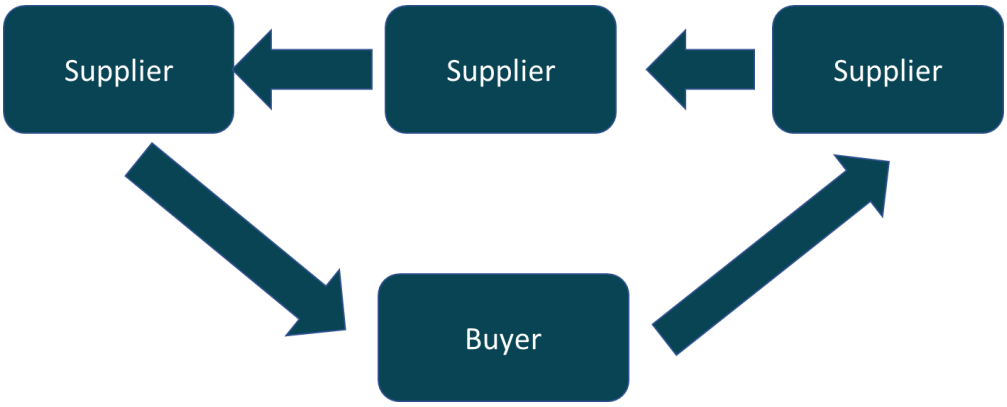

Figure 5, A typical Milk run flow

4.1.2 Goods Reception

Richards (2014) presents the traditional goods reception operation as a five-step process shown in Figure 6.

Figure 6, The goods reception process

The first step of goods reception is the **pre-receipt** taking place prior to any transport being carried out. Here, the goods reception plans the transport and make decisions hoping to increase the transport quality and reduce the risk of problems. The goods reception should, in collaboration with the hauler and shipper decide on packaging, for example whether pallets should be used, how unloading should be handled or where labels should be placed. The **preparation** step involves activities performed to secure a smooth goods reception operation. One such activity is to ensure that the truck arrives according to plan and another is to check that the goods are delivered in the specified manner, for example palletized. Decisions about suitable opening hours for the goods reception should be considered, including whether the goods reception should close during break times or not. **Offloading** starts with an initial control to ensure that the correct delivery has arrived. After the initial check, the vehicle is given an unloading slot where an operator takes care of unloading the goods. Unloading can be done in several ways depending on the type of goods and the carriers, for example pallets or boxes. The **checking** is an inspection step carried out by an operator who checks that the number of items delivered corresponds to the number stated in the transport documents. Usually this is done by counting each article or by scanning unique bar codes. This is also a step where quality inspection might take place. **Put-away** is the last step of goods reception and refers to the internal logistics taking over control of the goods. This step is covered in chapter 4.1.3. (Richards, 2014)

4.1.3 Internal Logistics

Internal logistics from a TSM perspective refers to the movement of goods within a production facility or warehouse. Taking a more generalized perspective, internal logistics would be a wider area with more processes in addition to moving goods, such as kitting operations, sequencing of materials and repackaging of components. The internal logistics department is responsible for the material supply to the production line in a production setting. Richards (2014) argues that internal logistics should be based on standardized processes to enable a continuous flow of goods lowering the risk of disruptions. Disruptions in internal logistics might cause component shortages at the production line or delays in outgoing transports, incurring potentially costly consequences. The author also claims that built-in simplicity reduces the risk of disruptions and is therefore something to strive for.

4.1.4 Planning for Logistics at Strategic, Tactical and Operational Level

Rushton, Croucher and Baker (2017) present the use of logistics planning at three levels to increase performance and control of the logistics chain. The levels differ by focusing on different time horizons, and the suitable time horizons differ between industries and companies. This is the case because every company operates within a different context and different contextual conditions. Each industry develops at different speeds and one year may be within the strategical level time horizon for one company whilst being within the tactical level time horizon for another company. In descending order from longest to shortest planning horizon are; strategic, tactical and operational.

Mattsson and Jonsson (2013) explain the strategic level as the level where a company decides their placement and adaptions to its surroundings. Which products should be produced, their price segments and which markets they should be distributed to are examples of decisions to consider at the strategic level. The company must also decide which components are to be produced internally and which ones are to be source. In a goods reception context, the strategic level could entail decisions of whether the company should outsource logistics activities such as unloading or possession of utility vehicles like forklifts.

Decisions at the tactical level should aim to develop and improve the company within the boundaries set at the broader strategic level. The tactical level can be said to be where the company collects all the upper-level expectations and comes up with an answer on how to meet them. Things to consider in a production setting can therefore be to decide the capacity a production line should have, how the production schedule should look like or if the planning of production should be centrally made or not. If the tactical level is considered from a goods reception perspective, it entails decisions on things such as whether the goods reception should use a TSM solution or a strict queue system. Another example of a decision is whether the goods reception operators should unload incoming goods or if the truck drivers should do it themselves. (Mattsson and Jonsson, 2013)

Decisions at the operational level are closest to the value-adding activities and relates to the many work-related decisions taken by employees throughout the day. The operational level is characterized by the need for subsequent administrative work in connection with decisions. For example, an operational decision is the allocation of human resources that would be followed by the administrative work of assigning each operator to their workstation and communicating this to everyone affected by the decision. An example of an operational decision in a production setting is to track incoming transports to secure sufficient unloading capacity is available upon their arrival. In a goods reception, an operational decision could be to decide which transports should be prioritized on arrival or which operators will take care of the unloading of a certain day. (Mattsson and Jonsson, 2013)

4.1.5 Transport Market and Time Slot Management

Riedl et al (2018) state that road freight for a long time has been a highly competitive business area with low margins. The authors further state that competition from new business models are likely within the following years. The new business models are said to be competitive due to the traditional road freight companies being ineffective in four main ways. First, they under-utilize their assets. As an example, companies in Western Europe had a load capacity utilization of 60 percent in 2016. Second, they lack automation and digital solutions for many of the performed administrative activities and rely on paper-based information which increases the risk of losing information during the handling processes. Third, they use outdated customer interfaces compared to many of the other business areas their customers interact with on a daily

basis. Road freight interfaces are rarely possible to integrate into customers ERP systems, which is common in other business areas. Fourth, there is a high level fragmentation within the road freight business that stems from the large number of players with very small market shares. The authors give an example of this; DB Schenker is the largest player in Western European road freight but only have a total market share of 2,1 percent. Road freight operations are said to have more than 300,000 active companies operating in the European market.

Riedl et al (2018) discuss examples of digital transport solutions that are likely to be developed and improved over the following years. The authors point out two types of transport management systems where the first is a cloud-based solution such as Transporeon and Bluejay. The second is an "on-premises solution" where the operator integrates digital support for a specific customer into their own interface. Digital marketplaces where shippers and haulers can express their need for transport or offer up available capacity are also likely to become more common in the following years. Virtual freight forwarders providing seamless logistics services to their customers are also likely to be common in the future. A virtual forwarder contracts transport of goods with different logistics providers and their customer pays an “A to B” fee. This solution is similar to what 3PL companies offer today but the difference is that DHL, DB Schenker and others also carry out much of the transport themselves. Tender platforms are likely to be common in the future. It is a digital interface where buyers and logistics providers can arrange transport and negotiate terms. This solution can also be followed by efforts of aggregation in the transport industry, where several companies come together in a collective to increase the brand claim.

Riedl et al (2018) define TSM as the use of digital tools to provide truck drivers with the possibility to do time slot bookings for unloading at the goods reception. The truck driver books their slot according to their estimated time of arrival at the goods reception. The goods reception will then allocate resources and prepare accordingly. There are several actors on the market supplying TSM software and accompanying services. Transporeon are commonly said to be the leading actor. TSM is according to Transporeon (2020) a way to master the challenges of planning loading and unloading. Transporeon makes use of a smartphone application through which the truck driver can interact with the goods reception, do slot bookings, and announce delays.

4.2 Time Slot Management in Other Industries

There is a limited amount of scientific literature on the subject of time slot management within the automotive and production industries, but not in other settings. Two other settings were chosen based on both of them being highly relevant and established fields with a large body of research behind them. Presented below is a selection of information about time slot management practices at seaport container terminals and healthcare facilities. The selection was made based on relevance to a production or automotive setting.

4.2.1 Seaport Container Terminals and Drayage Operations

A seaport container terminal is a facility at which cargo containers are delivered to be transferred to a vessel or collected from a vessel. Seaport drayage is the collection or delivery of containers to a seaport container terminal. Generally, the term drayage covers shorter distances within the same urban area as the seaport, but longer distances will be included under the term drayage for the purposes of this study. (National Academies of Sciences, Engineering and Medicine, 2011)

Jacobsson, Arnäs and Stefansson (2018) identified five main categories of access management services used at seaport container terminals. This master's thesis study primarily deals with pre-notification and appointment services, but it is worth noting the other four services as they could act as a compliment to an appointment system depending on the circumstances. Information access services provide haulers with information from the terminal, automated gate services provide automated container inspections, real-time information exchange platform services enable better communication and dedicated access services prioritize access, for example through priority lanes. This master's thesis study is limited to cover delivery at live-unload goods receptions at production facilities, as the deliveries are assumed to be too different from the collections to be considered simultaneously. At a seaport container terminal, the deliveries and collections are more similar and for the purpose of this study they will be considered equal from a time slot management perspective. In all the below included studies no distinction is made between delivery and collection, unless specifically stated.

Truck Arrival Patterns

Computer simulation studies have been conducted on the influence of truck arrival patterns on waiting times outside the seaport gates. Azab and Eltawil (2016) simulated different arrival patterns and looked at the resulting truck turn times, the time elapsed from arrival until departure of a truck. The authors concluded that the arrival pattern of trucks affected the turn time to such a high degree that it was considered one of the most important factors influencing the truck turn time. A decrease in delays at a seaport container terminal could theoretically be achieved just through a change in the truck arrival pattern without increasing the terminals capacity or reducing the number of incoming trucks. Chen, Govidan and Golias (2013) conducted a similar simulation study on truck arrival patterns but with a focus on the idling emissions of waiting or queuing trucks. They stress the impact of shifting truck arrivals from peak-hours to off-peak hours could have on the truck idling emissions, and by extension the queuing and waiting time for trucks. The simulations indicate that shifting just 4 percentages of the peak-hour trucks to off-peak hours can reduce up to one third of the total truck idling emissions. To be able to optimize the arrival pattern of incoming truck in practice, it is important to first know what an optimal arrival pattern is for the seaport container terminal in question (Chen et al., 2013). Computer simulations can be a useful tool when identifying the optimal arrival pattern of trucks as well as in the design of an appointment system for a seaport container terminal (Azab & Eltawil, 2016).

This study focuses on exploring the use of time slots to control the incoming flow of trucks at an automotive production facility's goods reception, however there are other ways to change the patterns of incoming trucks which can be of interest alone or in tandem with an appointment system. Studies have been conducted trying to change the pattern of incoming trucks at seaport container terminals without outright asking the truckers to change their arrival pattern. Sharif, Huynh and Vidal (2011) explored the possibility of evening out the flow of incoming trucks to a seaport container terminal by use of webcams. The webcams provided real time information to truck dispatchers about the length of the queue outside the container terminal, making it possible to take the queue lengths into account when deciding if a truck should be dispatched or not. The study hoped to be able to limit queuing outside the gate by keeping trucks waiting elsewhere and being dispatched when the queue is short. At the same time, if all available trucks are dispatched when queues are short, a whiplash effect will occur creating a wave of incoming trucks a while after the queues were seen to be short. Hence dispatchers need to be strategic about their decisions to dispatch. The authors investigate different strategies for dispatchers and conclude that crowding and waiting time can be successfully lowered with a live feed of the queue lengths outside the gate, but it depends on the strategies of the dispatchers. Most importantly they cannot all use the same strategy (Sharif et al., 2011). There are currently a

number of seaport container terminals that offer live coverage of the queues outside their gates. The aspiration is to encourage drayage firms to adjust their operations in accordance with the live feed and thereby mitigate congestion at the gate. The cameras have the added benefit that they can be used to conduct studies on things like queue lengths, gate processing times and idling emissions. It is worth noting that these cameras can have legal issues associated with them, and these concerns need to be taken into consideration (National Academies of Sciences, Engineering and Medicine, 2011).

Another way to move truck arrivals from peak-hours to off-peak hours without outright asking the truckers to arrive at certain times is to apply monetary incentives and longer opening hours. The OffPeak program in southern California was created in 2005 by the non-profit company PierPASS Inc. The program aims to move incoming trucks from peak hours to off peak hours to address amongst other issues congestion and emissions. The program has implemented both extended opening hours and a traffic mitigation fee on trucks delivering during peak hours of the day. The fee amounts as well as the hours during which they are imposed varies based on variations in the levels of truck arrivals. The OffPeak program has been very successful in increasing terminal capacity (Pierpass, 2020). It is worth noting that the New York/New Jersey Maher terminals have reached close to the same success level by only extending their opening hours and not using any types of monetary incentives. This indicates that simply making more time available can have a significant impact on congestion levels at seaport container terminals, as truck drivers already have enough incentives to try to avoid peak hours when possible (The Tioga Group, 2009).

Cooperation and Information Sharing

Many appointment systems at seaport container terminals focus on limiting the number of arrivals in different ways without taking the interests of the haulers into consideration. There are some studies on TSM or appointment systems taking the haulers perspective into account as well. Nambothini and Erera (2008) used models to study the use of time slots from the perspective of companies accessing the port by providing drayage services to it. They conclude that the productivity of the haulers is affected by the design and accessibility of the time slots. There needs to be enough slots at suitable times available, or the productivity of the drayage firm will suffer. But the drayage firms also need to select their time slots wisely to maximize productivity. The length of the time slot windows affects drayage firms' productivity as well. The study concludes that any time slot system implementation needs to be well designed to make sure it creates the best possible outcome for all involved parties, specifically taking the productivity of drayage firms into consideration.

Phan and Kim (2015) propose smoothing out the flow of incoming containers by negotiating the truck arrival times with the different haulers. Using a decentralized decision-making model, they try to find an acceptable solution to the scheduling problem, that could be used as an aid in the negotiation process. They conclude by pointing out the importance of taking disruptions into consideration when using the study's results in a practical application. Phan and Kim (2016) followed up with a study on collaboration between haulers and terminals when scheduling appointments for trucks at a container terminal. The authors propose a mathematical model to aid in jointly scheduling the truck appointments at the container terminal, taking both the haulers' scheduling problems and the terminal's scheduling problem into consideration. The model was found to be robust to unplanned events and some common practical problems were considered by the model, but the study concludes by stressing the importance of taking the real-world context and unexpected events into consideration.

To ensure that the scheduled appointments work well in practice sharing arrival information between haulers and terminals is important according to Zhao and Goodchild (2010). Their study aims to increase yard productivity, ensuring the work before a container collection or after a container arrival is as efficient as possible, and reduce the truck turn time. Different scenarios are modelled, and the results show that information sharing improves operations, regardless of the level of detail in the information shared. If the information is updated in real time, even small amounts of information can be of value as the information will be relevant and correct. Information from only a portion of the incoming trucks can be enough to be helpful. The authors note that the possible improvements of information sharing depend on the level of stress the terminal can handle, and a terminal with a lot of space and capacity will see less improvements than one with a tight operations schedule. Systems operating near the limit of their capacity will benefit particularly well. Both the seaport container terminals and the haulers benefit from the information exchange, as the handling in the yard and the truck turn times can be lowered. As both sides benefit from the sharing of information it can make the terminal and haulers more likely to cooperate compared to if the benefits were one sided.

Time Slot Management Solutions

Seaport container terminals have made use of different kinds of TSM solutions. In a large report by Morais and Lord (2006) they investigate the use of different TSM solutions and other methods to expedite the handling operations of freight goods at North American ports. Due to environmental concerns and legislation many North American ports implemented TSM solutions to try to limit the ques and emissions from idling trucks. Many implementations were deemed unsuccessful at limiting the queues and idling time, but some implementations were successful. The successful TSM solutions all had one thing in common: flexibility. The authors conclude that a good TSM solution should be able to handle same-day bookings, cancellations, and re-assignments. The system should allow some margin for trucks to arrive a bit late, the authors suggest up to one hour, but fine trucks that miss their appointment. Additionally, a good TSM solution should make appointments for containers rather than trucks, only allow one appointment per container and allow reservations to be made by phone. In their final recommendations the authors stress the importance of having all stakeholders on board with the implementation of a TSM solution for it to work well. Another aspect that influences the TSM solution although not tied to the design of the TSM solution is the importance of always having staff available during the day. Breaks should be staggered as the closures for breaks will otherwise commonly result in queues (National Academies of Sciences, Engineering and Medicine, 2011).

When designing an appointment system there are many aspects to take into consideration. Chen, Govindan, Yang, Choi, and Jiang (2013) have studied the use of a static or a dynamic system. The static TSM system, called STAS, uses the input of expected arrivals and books appointments as close to the truckers preferred arrival times as possible with the aim of low rescheduling rates. STAS tries to optimize the appointment quotas on the day before the trucks arrive, meaning that the schedule is set one day before the trucks start arriving at the terminal. STAS is considered a static system as appointments are set beforehand. The large downside to this system is that at the time of setting the schedule the system might not have correct information on when truckers really wish to arrive. To overcome this, the authors propose another version of the STAS called DTAS which is dynamic real-time system where truckers make appointment requests as needed. DTAS provides truckers with waiting time estimations based on the number of other booked trucks to try to encourage truckers to request appointments during uncongested hours. The requested appointment is then either accepted or denied depending on the queue length anticipated by the system at the requested time. Huynh (2009) used a simulation model of a container terminal to investigate the effectiveness of TSM

solutions using individual and batched appointments. The study found that for a terminal without any previous appointment system the use of batched appointments created a high utilization of the yard equipment but did not improve the throughput or reduced the queues. The implementation of an individual appointment system did on the other hand create a clear improvement of the throughput. If the individual appointments are arranged in a good way the appointment system can be effective even when there are many walk-ins, no-shows, or late arrivals.

There are two versions of TSM systems used at seaport container terminals which might not be relevant to most goods receptions at production facilities, but still common enough to be mentioned. First, a seaport container terminal has much less responsibilities towards the haulers than an automotive production facility generally does. The terminal does not need to pay any fees to haulers who have had to wait for service for too long, whereas a production facility often does. The terminal does not pay the haulers directly or indirectly, thus if their decisions make deliveries more expensive, they are not the ones affected by raising prices. A production facility often is affected by these raising prices. This has allowed for seaport container terminals to use appointment systems aimed at capping the number of arriving trucks without taking the haulers perspective into consideration such as described by Huynh and Walton (2008). As a hauler, if the appointments suitable for you are taken you are simply out of luck and will have to adjust to the appointments that are available. It is assumed that these types of appointment systems are generally not feasible at a production facility without raising costs either directly or indirectly. Second, the number of containers coming in, being stored, or leaving a seaport container terminal is tied to when the haulers wish to collect or deliver. The terminal has to store delivered containers until they are loaded onto a vessel and unloaded containers have to be stored until collected. Studies, such as by Govindan and Yang (2013), suggest using Vessel Dependent Time Windows to limit haulers to arrive only during a time window set based on the departure or arrival time of the vessel. At a production facility the company has more control of the flow and can influence the amount of goods delivered as well as how it will be handled, stored and used once delivered to a much greater extent.

Disruption Management

After presenting ways to make a TSM solutions work well, one also needs to mention the scenario of when a TSM solution fails. Li, Chen, Govindan, and Jin (2018) performed a simulation study to explore different strategies on how to proceed in the case of disruptions of a TSM solution. The authors explain that any truck appointment system can work well under the predicted circumstances for which the system was developed, but a good TSM solution also works well when disruptions and disturbances occur. The authors stress that having a plan for dealing with disruption is important, making sure that any implemented strategies are fair to all involved parties as well as green. A fair strategy is one that balances the interests of taking care of high priority trucks, the receivers' interests, and taking care of on time trucks, the haulers interests, to encourage the use of the appointment system. The study looks at late, early, and unappointed arrivals at a container terminal and develop four strategies that can be used to cope with said disturbances. The first strategy is a first come first serve prioritization. The second strategy is a prioritization based on how timely the arrival is in comparison to the appointed time, where a ten minutes late truck is prioritized over a one hour late truck even though the ten minutes late truck might have arrived after the one hour late truck. The third strategy prioritizes efficiently using the yard cranes and the fourth strategy is a combination of the second and third strategies. The fourth strategy appears to be the clear winner as it works best at lowering truck waiting time and idling truck emissions in most of the simulated scenarios. Although the study should only be used as an indication, it is clearly showing the importance of balance between different interests, truckers' compared to the yard's, when disturbances occur.

4.2.2 Healthcare Facilities

Huynh and Walton (2011) mention in their study on the use of appointment systems at seaport container terminals that the scheduling problems arising from fluctuating demand at healthcare facilities are similar to those experienced at container terminals. Although caring for patients is different than the unloading of goods at a production facility, the issue of scheduling arrivals is similar in many aspects. In the end, both haulers and patients are human. The research area of appointment scheduling in the healthcare industry has existed for a long time, starting with a study conducted by Bailey (1952). Almost 70 years later a significant body of research has been generated on the subject worth giving a closer read when investigating different TSM practices.

Ahmadi-Javid, Jalali, and Klassen (2017) conducted a substantial review of optimization studies of outpatient appointment systems. Outpatient refers to patients which are not admitted to the healthcare facility, but instead arrive, receive their treatment, and then leave during the same day. The study provides a framework for classification of decisions related to the design and planning of an appointment system, which could act as a guidance or inspiration when designing a time slot management system for a goods reception. The decisions are divided into three levels; strategic, tactical and operational.

At the strategic level four design decisions are presented, covering access, resources, walk-ins, and scheduling types. **The access policy** dictates how far ahead appointments should be made. Three different types of access policies are mostly used. The traditional access policies book all appointments ahead of time, open-access policies book appointments the same day and hybrid access policies combine the two approaches. An open-access policy generally outperforms a traditional access policy, but open-access policies are vulnerable to high variabilities in demand. A hybrid access policy can offer the best of both worlds. If the hybrid policy is designed to be dynamic and flexible it often significantly outperforms the other two policies. **The resource allocation** decides the amount and type of resources that are needed, such as staff, equipment, and space, to be able to care for the expected patients. A policy on the **acceptance of walk-ins** instructs how or if at all patients without appointments will be allowed. In healthcare the urgency of the patient's need for care often decides whether the patient should be accepted or not, or if the patient can be accepted because of no-shows. No-shows is an issue in healthcare, and accepting walk-ins is one way to mitigate idle time due to no-shows. There are two **types of scheduling**; online or offline. Online scheduling means that patients are scheduled at available times right away, whereas in offline scheduling one waits until there are a number of patients to schedule and then they are all scheduled at once. The online, or sequential, scheduling has the benefit of providing the patient with an appointment immediately, whereas they must wait a bit for the offline appointment to be scheduled. The offline, or simultaneous, scheduling offers the benefit of being able to plan multiple appointments at once making it possible to optimize the planning better. (Ahmadi-Javid et al., 2017). At the tactical level seven planning decisions are presented. **The allocation of capacity and resources** dictates the amount of capacity and resources reserved to different patient groups. **The priority of patient groups** determines which patient groups should be seen before others. The prioritization can be hard or soft depending on the urgency of care of the patients. The choice of **the appointment intervals** decides the time between consecutive appointments. Under normal circumstances longer slots are needed in the middle of the day, creating a dome shaped pattern of interval lengths throughout the day. If there are a lot of disturbances and interruptions a linear shape of the interval lengths with increasing time slot length later in the day might be more suitable. The optimal time slot length is very dependent on the behaviour and need for care of patients, so context needs to be considered carefully when choosing slot intervals. **The scheduling window** defines how far into the future appointments can be made.

A smaller scheduling window mitigates no-shows but might also decrease the number of patients seen during the day and different scheduling windows for different patient groups is an option. **The block size** dictates the number of patients to be scheduled at the same time and **the number of appointments in a consultation session** determines the workload. It is important not to overbook too much as this causes overtime costs, but at the same time overbooking helps mitigate idle time from no-shows and might not be advisable to avoid completely. Environmental or contextual factors have a particularly great influence on the suitable number of appointments to book. **The panel size** is the size of the population around the healthcare facility that might seek care at the hospital and help estimate the number of patients which might seek care at the facility. (Ahmadi-Javid et al., 2017)

Operational level planning decisions all refer to decisions made for a specific patient and will not be included in detail here as they are not considered relevant to a goods reception setting. It is sufficient to mention that there are two fundamental approaches when making operational level decisions: optimization-based and rule-based. Optimization-based decision-making uses optimization models to make the best decisions whereas rules-based decision-making uses a set of predefined rules to make decisions. Optimization models are sometimes used to create said rules in the first place. The authors also dedicate a full section to address environmental factors that can influence a patient appointment system, including for example patient unpunctuality, physician lateness and type of appointment needed by patients. Although these contextual factors are not considered relevant in a goods reception setting it is worth noting that environmental factors were deemed influential enough to warrant their own section. (Ahmadi-Javid et al., 2017)

Multi-appointment scheduling and patient flow

In a healthcare setting the term multi-appointment scheduling refers to the scheduling of patients in need of appointments with more than one resource at a hospital, for example both an x-ray and a blood test. Instead of having every department schedule the patient independently from one another a centralized approach is used where all appointments are scheduled taking the interests of all relevant stakeholders into account. Patient flow is another large research area concerned with patients in need of visiting multiple resources at a hospital. The difference between the two areas is simple; in a multi-appointment scenario the patient needs appointments with multiple resources whereas in a patient flow scenario the patient starts queuing for the next resource as soon as they've finished their visit to the previous resource. As a result, multi-appointment scheduling research strives to optimize the scheduling of multiple appointments with different resources whereas the patient flow research strives to optimize the flow between resources. (Marynissen and Demeulemeester, 2019)

Both areas of research can have relevance for goods reception operations if the unloading of some of the incoming trucks is done at more than one place. One common scenario where this is the case is at fishbone style factories. The truck can be thought of as making multiple visits to different goods receptions as it visits the different unloading docks at the factory. These visits can be treated either as appointments, creating a multi-appointment scheduling scenario, or the visits can be treated as part of a flow, creating a flow scenario. In their literature review Marynissen and Demeulemeester (2019) examined 56 papers published in the last 25 years within the field of multi-appointment scheduling in hospitals. They found that a centralized multi-appointment scheduling approach has the benefit of ensuring that all involved parties are taken into consideration when scheduling appointments. If single-resource scheduling is used, where each resource schedules their own appointments regardless of the interests of others, it might lead to long waiting times in between resources. Unfortunately, the centralized approach has in some cases been resisted by planners on department level, as they would rather keep the calendar local. This is suggested as a reason as to why multi-appointment scheduling is a young

field of research and is currently only found in a limited number of hospitals, and the authors conclude that more research is needed. Tlapa et al. (2020) conducted an extensive systematic literature review of 40 papers on the effects of using Lean Healthcare on patient flows. Their review found that Lean Healthcare initiatives decreased the length of stay and waiting time of patients. The authors conclude by noting that the studies have relatively weak designs, and further research of higher quality is needed.

5 Interviews

The empirical data collected during this master's thesis study consists of interviews with people within the logistics field. The interviewees were chosen based on them being able to provide a unique viewpoint on TSM practices. The main target was to have a large spread of responsibilities and corporate ranks among interviewees to enable a broad spectrum of the gathered information. Interviews were held with one or two persons at a time, either representing a company or themselves. The first interview was held at the company, and subsequent interviews were held by phone- or videocall due to the Covid-19 pandemic. Conducting the interviews remotely did hinder any observations on site at the company but is otherwise not considered having lowered the quality of the interviews themselves. Each interview is further referred to as interview X, Company X or interviewee X.

5.1 Interview 1

Interview 1 was conducted with two managers at a large company with global operations (from here on referred to as Company 1). The scope of the business is rather narrow, manufacturing highly customer specific products with only B2B sales. The products are difficult to handle owing to their large size and heavy weight. Additionally, the products are often made of titanium or steel alloys which complicates the handling further due to different restrictions. The company accepts goods deliveries between 07:12 and 15:42 o'clock Monday to Friday without any required slot booking prior to arrival. The goods reception at Company 1 is currently running at overcapacity, hence they do not have the problem of truck drivers having to wait to be unloaded. Instead they are waiting for trucks to arrive to be unloaded and during this idle time the unloading personnel support other areas of the goods reception, such as quality control or packing. Once a truck arrives the unloading procedure takes approximately 20 minutes to complete.

The interview resulted in the following main takings:

- The most important part of a high performing goods reception is to have the responsible people in-house with a close connection to where the activities take place. Since Company 1 have all relevant and needed functions in-house they can be flexible when unexpected situations arise and swiftly solve any problems.
- The most common problem is drivers arriving without appropriate transport documents which creates extra administrative work and additional costs. This problem is said to emerge from insufficient internal communication at the hauler. The same issues occur with several haulers regardless of the haulers size or the type of cargo to be delivered.
- Company 1 divide their incoming flow into one or more flows from day to day using prioritization lists. Business critical products will almost always be at the top of the list which then can be used to prioritize unloading of trailers upon arrival.
- Company 1 have not been interested in TSM as, in their opinion, it will not create a significant cost reduction compared to the current process.

5.2 Interview 2

Interview 2 was conducted with a transport planner with many years of experience in logistics planning and logistics related processes from different industries and companies. As a transport planner, the interviewee has been the link between truck drivers and goods receptions for transports all over the world for more than 20 years.

The interview resulted in the following main takings:

- When a TSM solution is used it is important to always have a back-up plan in case of truck delays or other problems. A TSM solution's true performance is shown when it encounters problems and not during perfect operating conditions. A good system should have the built-in competence to be able to handle any situation that might reasonably arise.
- Trucks that arrive late to their booked time slot should always wait for the next unoccupied slot by being put in a separate drop-in flow in which they can queue. Some goods receptions allow trucks to be late and miss their assigned unloading time slot yet still be unloaded directly upon arrival. Letting timely arrivals wait while late arrivals are cared for directly puts a strain on the system for the rest of that day by displacing following bookings. Additionally, it creates frustration amongst timely haulers which might damage the relationship between the haulers and the goods reception as well as the goods reception's reputation.
- There are many different TSM software on the market, and they are all quite similar and work fine from a hauler's perspective. However, it is not enough to just implement a TSM software or a booking system. To be successful TSM practices also need to be implemented in a practical sense. For example, this can include having a plan on how to deal with late arrivals and making sure the capacity of the goods reception matches the incoming flow of goods.
- A goods reception protected from the elements is superior to one that is not. When the goods and unloading process are protected from the elements any harsh weather conditions would not affect the unloading efficiency.
- Environmental factors can significantly influence the incoming flow of goods. One example is if a factory is located close to a port and receives a significant portion of their goods through the port. After a ferry arrives with several trucks destined for the factory one will see a spike in the incoming number of trucks at the factory.
- Regardless of how well the goods reception and unloading works, it can never work faster than the internal logistics operations. It is therefore important that internal logistics work well and do not create a bottleneck that slows down the goods reception.
- Companies generally do not track their expenditures on truckers waiting time, and thus do not see the full cost of having a subpar goods reception. Some companies try to avoid paying waiting times by demanding extensive proof of the truck having waited, but this puts a strain on the relationship to the hauler.
- Some companies want the driver to load or unload the truck, but this creates issues regarding responsibility and liability that are hard to solve.
- Language barriers are generally a problem, but especially when the driver is asked to do more than just drive, since it is difficult to make sure everyone understands each other. This is further complicated by the increased importance of being able to communicate when something is different from the usual.
- Most paperwork is not standardized and is easily lost along the way. A lot of documentation within the transport business is still done manually or even by hand. Some haulers scan and email documents to try to prevent losing papers.
- Transports are sold between haulers, freight brokers, forwarders and other entities and there can be many actors involved, yet each actor knows only the one before and after themselves in the chain and not the full chain. This creates a situation where issues or questions can be very complicated and time consuming to solve.

5.3 Interview 3

Interview 3 was held with a manager responsible for certain product types at the facility and its goods reception. The facility belongs to one of the leading players in the Swedish grocery stores business area (from here on referred to as Company 3). Company 3 recently implemented a TSM solution for their incoming freight transport. Prior to implementation, they had problems with long queues for unloading and a build-up of unloaded goods that limited the flow. The use of time slots has according to the interviewee been positive and increased their efficiency. The system was created in collaboration with a company that usually develops regular queuing systems, thus Company 3 had the opportunity to tailor the system to suit their processes. The system is designed to be highly flexible which according to Company 3 is one of the most important factors in goods reception. Both the number of time slots and their individual length can be changed throughout the day depending on the available capacity and demand. The truck driver may book a time slot whenever they wish but are advised to book the same day as expected arrival.

The interview resulted in the following main takings:

- The goods reception is open for goods reception 24 hours a day which is said to have great benefits. Partly because of haulers not always preferring to deliver during daytime hours, but also because the internal logistics at the site is 10-15% more efficient at night. This is because fewer people work in other departments during the night shift enabling the internal logistics to have a higher throughput.
- The routine of unloading is based on the truck driver unloading the cargo. This is said to be a heritage of the past when everyone who drove a truck was also licensed to drive a forklift. However, this is said to have changed and is now creating problems as some truck drivers are unauthorized to use forklifts.
- Truck drivers and haulers have extensive internal communication about different goods receptions and their work in general. This is said to contribute to the fact that a lot of truck drivers already know the procedure when they arrive at the gate of Company 3.
- It is uncommon with returning truck drivers to the site, most truck drivers arrive for the first time.
- The used TSM system has been translated into several languages, which is said to be of great help in communication between the goods reception and the truck drivers
- Beside the TSM system, they use a queue system for walk-ins and late trucks.
- Truck drivers and logistics providers are sometimes biased towards themselves and exaggerate the waiting time upon arrival. This problem was limited by the introduction of the TSM system as it records the time of arrival, unloading and site exit.

5.4 Interview 4

Interview 4 was held with an employee at a company that supplies logistic services to Volvo group (from here on referred to as Company 4). The interviewee worked as a supplier manager. Each day, they handle 80-100 trucks at the goods reception. The company uses an internally developed TSM solution which assigns arrival times for incoming transports prior to their arrival. The assigned time slots can be changed at the request of the hauler up to 60 minutes before the expected arrival time. Late arrivals are put into a queue system which is used to fill empty time slots to smoothen out the flow and utilize resources better.

The interview resulted in the following main takings:

- Haulers do not always prefer fixed time slots, which is common among the company's competitors. This is because it restricts the haulers scheduling which can instead be more flexible with changeable time slots from day to day.
- Interviewee 4 does not think it would be of any benefit to use economic punishments for haulers that arrive late. The economic loss of the hauler's late arrival would not be greater than the induced consequences of such approach.
- All kinds of flexibility in the goods reception process are of major importance. The length of the time slots should be flexible as each truck arrives with different loads, meaning that the unloading time varies. The amount of bookable time slots each hour should also be flexible since the goods reception's capacity can vary from day to day and even from hour to hour.
- The incoming transports can be divided into different flows to increase efficiency and lower costs. This can be done giving priority to some haulers who can book their slots earlier than others or prioritize transports with certain goods types.
- Time slot bookings should preferably be done by email or digital software to decrease the risk of misunderstandings and it can be useful to have the conversation saved in writing in case it is needed in the future.
- Late arrivals should be placed in a queue system where they can be used to fill empty time slots and not restrict the timely flow.

5.5 Interview 5

Interview 5 was conducted with a preplanner of incoming goods at a 3PL company providing crossdocking services for Volvo Group (from here on referred to as Company 5). Company 5 is a global company with activities in several business areas related to logistics and warehousing. The interview was centred around the goods reception of the crossdocking operations performed on behalf of the Volvo Group.

The interview resulted in the following main takings:

- Well-functioning communication between the goods reception and other parties is important to ensure that everyone has access to the latest information as soon as possible. Any problems can be addressed briskly and any changes in the priorities of trucks can be accommodated.
- Using staggered breaks ensures that the goods reception is always manned during opening hours.
- A good priority system is important to ensure the most important deliveries are cared for before less important deliveries.
- A TSM solution with different time slot arrangements for different haulers accommodates the different needs and requirements of the haulers.
- Employees having multiple competences so that staff from different sections can help each other out makes the system flexible and better equipped to deal with fluctuating workloads and problems.
- Correct information about incoming deliveries is important to be able to plan the goods reception operations as well as possible. Missing documents and delays cause additional work as the goods reception needs to find out where the documents or delivery are.

5.6 Interview 6

Interview 6 was conducted with a goods reception operator at a central distribution centre of one of the major players in the grocery store business area (from here on referred to as Company 6). An additional interview was held with a logistics planner at the same company. The distribution centre handles 50 incoming trucks each day which are usually unloaded by the truck driver. The goods reception at company 6 uses a traditional queuing system where incoming trucks are placed on arrival, whereby they have limited ability to move demand from high peak to low peak. This problem is somewhat counteracted by the fact that in addition to the queuing system, a wide time window is used for which their delivery is expected. Thus, the time windows at company 6 are used for demand distribution but not for booking an exact arrival time, which allows for some of the positive effects with TSM while lowering the administrative needs.

The interview resulted in the following main takings:

- The interviewee does not believe that a TSM solution would benefit the company.
- Transport documents are missing for five percent of the incoming transports, those shipments need to be taken care of by a deviation coordinator. This person tracks the shipment manually by contacting the supplier and logistics companies throughout the supply chain to verify the transport. Company 6 charges a fee when transportation documents are missing to cover the administrative cost of tracking the shipment.
- By assigning a fixed time window for delivery to each supplier it is possible to distribute demand at an early stage. The primary disadvantage of this method is when suppliers use 3PL companies for delivery, as they consolidate several shipments in the same truck, making it impossible for each supplier to have their goods delivered on time. When this happens, Company 6 charges a fee for late delivery to the supplier.

5.7 Interview 7

Interview 7 was held with a software development company providing products for improved transport efficiency and logistics (from here on referred to as Company 7). The company started in 2014 but their first year generating revenue was 2018. Company 7 aims to provide the market with new and modern logistics software tools that can be used by anyone. One of the core design features of their products is simplicity. They aim to provide an interface that can be used and understood by operators without extensive education nor knowledge. One of the key components of achieving this is to use few but accurate key performance indicators to help operators correctly oversee ongoing processes and performance.

The interview was divided into two sessions with two different interviewees. The first interview was conducted with one of the board members who has extensive knowledge of the logistics field and business in general. This person was not in possession of in-depth knowledge of the company's products and software designs, hence a second interview was held with the CEO who had in-depth knowledge of the system design and functions.

The second interviewee presented one of their logistics software, made to help users book and follow deliveries. The system has three parts; book, track and deliver. Book helps the user choose a suitable transport option based on their already negotiated contracts with haulers. Track uses the truck driver's phone GPS to track the shipment in transit and calculates an ETA based on current road conditions using google services. Deliver monitors the arrival and unloading procedures. The GPS is used to decide the arrival and departure time of the truck and any other information is entered manually by the goods reception personnel. The information which is entered into the system depends on which metrics the goods receptions wishes to track.

Papers can be sent electronically through the software if one wishes, but no other safeguards have been put in place to ensure no documents are lost. English is the only language available. The software does not provide any time slot booking function, but a delivery time set when the transport is booked can be followed up to see if the delivery was on time or not. The truck drivers cannot book or inform about delivery times or rest times, only the ETA calculated by the system is used.

The interviews resulted in the following main takings:

- KPI indicators should be sparsely used and only used if they are accurate and well understood by those who are to use them. The use of too many KPIs will usually lead to information overload and limit the decision making than helping it.
- The software interface shown to goods reception operators and truck drivers should be easily understood and simple to use, this is especially true for the truck driver interface.
- It is important to have a rough planning report that everyone on the site has access to, as it allows other departments to effectively plan their activities and allocate resources in accordance with the plans of the goods reception.
- The software should be translated into the preferred language of the truck driver, in most cases Swedish, English, Polish, Russian and German are sufficient in the Swedish market.
- It is important to allow customization and taking customers contextual conditions into consideration. The TSM system is designed in a generalized way to about 85% and the last 15% are customized for each customer to ensure that the system fits the customer.
- Company 7 believes that it is fruitful to implement the TSM system in small steps, giving their customers time to adapt to the new way of working.

6 Analytical Framework

Throughout the iterative literature studies and interviews it became clear that some parts of goods reception appeared to have very little influence on the success of a TSM solution, whereas other parts appeared to have significant importance and some could even be deemed crucial. To ensure that TSM efforts are directed towards the influential parts of the goods reception and not wasted on the insignificant parts, the need for a TSM perspective on goods reception was identified. No satisfactory description of a live-unload goods reception at an automotive production facility from a TSM perspective could be found in literature, instead one had to be developed. The combined knowledge gathered throughout this master's thesis study is considered sufficient to lay the foundation of an analytical framework, presented in this chapter, describing a generalized goods reception process at an automotive production facility from a TSM perspective. The framework describes both the physical flow of goods as well as the flow of information through a live-unload goods reception at an automotive production facility from a TSM perspective.

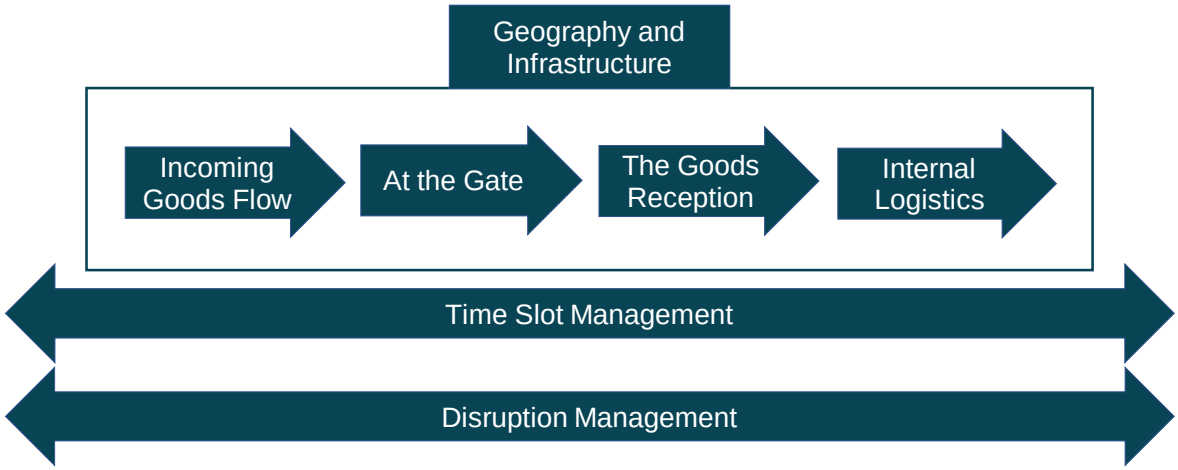

Figure 7, Analytical Framework

6.1 Flow of Goods

The physical flow of goods has been divided into four segments surrounded by the geographical and infrastructural context of the flow (see Figure 7). Each part will be presented in more detail below. The four segments are a representation of the physical flow of goods through a live-unload goods reception at an automotive production facility from a TSM perspective. In practice there are no clear-cut borders between the segments, and they often overlap in different ways. For example, the goods reception and the internal logistics can often be managed by the same staff and in practice work as one section rather than two separate sections. This division of segments should be regarded as a theoretical construct to facilitate the analysis of a goods reception from a TSM perspective, and not as an accurate depiction of the different parts of a goods reception.

6.1.1 Geography and Infrastructure

The geographical and infrastructural context can be regarded as setting the scene for any transport coming to or leaving a goods reception. The physical flow will inevitably be affected by the context surrounding the goods reception and this context should be included in a comprehensive TSM solution. This section will analyse the information gathered on the influence of the surrounding geography and infrastructure on the performance of TSM solutions and incoming goods flows.

6.1.2 Incoming Goods Flow

The incoming goods flow describes the characteristics of the incoming deliveries to the goods reception. Once a delivery has arrived at the gate of the goods reception it is no longer considered part of the incoming goods flow but instead part of the goods reception operations. This section will analyse the information gathered on the characteristics of the incoming goods flow from a TSM perspective.

6.1.3 At the Gate

Often when a truck arrives at a goods reception there is some sort of gate to pass through to be allowed to enter the premises. To be allowed to pass through the gates certain administrative procedures need to be completed. In practice there can be more points than just at the gate at which administrative tasks need to be completed, but for the purpose of this analysis all administrative tasks associated with the delivery and reception of goods will be assumed to occur at the gate. This section will analyse the information gathered on administrative procedures at a live-unload goods reception at an automotive production facility.

6.1.4 The Goods Reception

The goods reception is where the unloading of the incoming goods takes place. This includes practical operations necessary to unload, such as opening trailer curtains or removing straps or other fixtures used to secure the goods. The goods reception operations are considered finished when the goods are outside of the vehicle and the vehicle is ready to leave. This section will analyse the information gathered on the operations of the live-unload goods reception from a TSM perspective.

6.1.5 Internal Logistics

The internal logistics describe the logistics operations at the production facility after the goods have been unloaded. From a TSM perspective the flow of goods ends with the internal logistics operations. The internal logistics operations can look very different depending on the design and operations of the production facility and will not be fully analysed. This section is limited to analyse the information gathered on the influence of the internal logistics operations on the other sections, as this is the part considered relevant from a TSM perspective.

6.2 The Flow of Information

The flows of information required to facilitate any transport reach far beyond the two flows of information chosen for this analysis (see figure 7) and far beyond the scope of this study. The two flows presented below represent the information flows considered most closely tied to the design of a TSM solution, but other information flows will be affected by and affect the use of a TSM solution.

6.2.1 Time Slot Management

Once the physical flow of goods has been thoroughly considered, it is time to look at the actual TSM solution. The design of almost any Time Slot Management practices requires certain questions to be answered and certain aspects to be considered. This section will analyze the information gathered on the design of TSM practices for a live-unload goods reception at an automotive production facility, specifically the design of a TSM solution and considerations when choosing from existing TSM solutions.

6.2.1 Disruption Management

No TSM solution, regardless of how successfully it was implemented, can be expected to work one hundred percent of the time, thus it is important to be prepared for any disruptions which might arise or other failures of the system. This section will analyze the information gathered on the development of disruption management practices at a live-unload goods reception at an automotive production facility.

7 Analysis

The analysis uses the previously presented analytical framework as a guide to analyze the information and knowledge collected throughout the interviews and iterative literature studies. Each of the sections presented in the analytical framework are addressed in subsections 7.1-7.7. These subsections aim to answer the first and second research questions posed in subsection *1.5 Research Questions*. Subsection 7.8 aims to answer the third and final research question by analyzing suitable TSM practices at the Tuve factory, using the analytical framework as a support.

7.1 Geography and Infrastructure

No goods reception exists unaffected by the environment in which it is located, and some geographical or infrastructural factors will inevitably influence the behaviour of the incoming flow of goods. These geographical or infrastructural factors can include any elements along the route from shippers to goods reception that might influence or cause fluctuations in the incoming flow of goods. To be significant these elements need to influence a large enough number of incoming deliveries to affect the flow, not just a few trucks. Environmental factors are clearly recognized as having an important influence on the scheduling of appointments within the healthcare industry, and they can be assumed to be important for appointments to an automotive production facility as well (Ahmadi-Javid et al., 2017). Although the environmental factors within a healthcare setting differs substantially from the environmental factors of a goods reception and cannot be directly applied, the importance placed on environmental factors within such an established field of research motivates taking environmental factors into consideration in a goods reception as well.

Some common geographical and infrastructural factors to take into consideration were found during interviews. In interview 2 the interviewee talked about the influence of ferries on the goods flow. If goods are bought abroad in a country that requires a ferry ride to get to the goods reception, one can expect a surge in incoming goods after the ferry arrives at the local port. Another common factor is the level of congestion surrounding a seaport container terminal, something that has been used to their advantage by some North American seaports to try to level out their flow of incoming containers. By extending their opening hours they have made it possible for haulers to deliver during hours when road congestion is limited or non-existent, making the drive to and from the port much faster. This creates an incentive for truckers to deliver at off-peak hours as they will save time having less congestion and traffic jams on their way to the container terminal. Some truckers have used this opportunity to deliver at off-peak hours and extending the opening hours has been seen to even out the flow of incoming containers (The Tioga Group, 2009). Monetary incentives have been used in tandem with extended opening hours to move traffic to off-peak hours, but it appears that the primary success factor is the extension of the opening hours. Using monetary incentives adds another level of possible problems as well. For example, it is not possible to impose a fine or pay out a bonus if the goods reception does not have a way to do so. This can happen when the shipper books and pays for a transport with no involvement from the receiver. Although monetary incentives have been part of the off-peak efforts, the extended opening hours is the more important factor in shifting deliveries to off peak hours.

It is recommended that before work starts on a TSM solution, the geographical and infrastructural context of the goods reception should be well known and opportunities to use the context to the goods reception's advantage should be explored.

7.2 Incoming Goods Flow

The incoming flow of goods to a goods reception is far from a single homogenous flow and is better described as a collection of heterogenous flows. Each flow has its own characteristics, and the possible categorizations of the different flows are endless. The number of different flows the incoming goods flow should be divided into varies depending on context, but some categorization of the flows is advisable to perform. Through several of the interviews as well as during off-the-record talks people expressed a feeling that a few of the incoming goods flows were causing most of the fluctuations and inconveniences. There was no way to confirm these feelings, as the incoming goods flows had not been categorized or tracked to a large enough extent. Finding these problematic flows could have serious benefits as simulation studies on arrival patterns at seaport container terminals indicate that moving only a small percentage of the peak hour traffic to off-peak hours can have significant impact on the truck waiting time (Chen et al., 2013). Knowing which incoming goods flows a goods reception has makes it possible to analyze the flows and adjust the goods reception process to fit the context of the incoming goods flows. The incoming goods flow can be categorized in different ways and using more than one set of categories to divide the flow into might be useful. Throughout this master's thesis study, several generally suitable divisions of the incoming flow have been found.

The pilot study at the Bourg facility suggests that transport distance is an influential factor worth considering as it appeared to influence the timeliness of the arrivals. The transport distance is therefore the first suggested division of the incoming flow. The second suggestion is based on the fact that in the healthcare sector one of the best indicators on patient tardiness to appointments is previous tardiness, thus this can be worth tracking from a flow perspective as well (Ahmadi-Javid et al., 2017). This is corroborated by interviewee 1, 2, 3 and 6. They state that the amount of late arrivals differs between logistics providers where some are almost never late and others quite often. It should be noted that company 1 suggests the use of fewer logistics providers for deliveries where timely arrivals are important, as this is argued to provide better opportunities of collaboration with stronger personal relationships and mutual trust. The likelihood of late arrivals will also differ between goods receptions depending on the environmental factors surrounding the goods reception, discussed earlier in subchapter 7.1. Hence, as a third suggestion the flow should be divided based on geographical and infrastructural factors, such as deliveries arriving by ferry compared. Several of the interviewed companies in this study distinguished flows by carried goods type or characteristics such as container flows or palletized flows, and this will be the fourth suggested division of the flow. Company 5 divides their incoming transports into two flow categories with different prerequisites depending on their carried goods type and business importance. One flow consists of common goods not considered business critical, which may be delayed without costly consequences. The other flow consists of business-critical goods. Business-critical transports are performed internally by Company 3 to strengthen their control of each shipment. The business-critical flow is also given priorities regarding time slot bookings. The fifth suggested division of the flow is urgency of the goods to be delivered. Prioritization will be discussed further in later subchapters.

The five suggested general divisions of the flow, transport distance, previous tardiness, geographical and infrastructural factors, carried goods type and urgency, are in most cases not enough to create a comprehensive picture of the behaviours of different parts of the incoming goods flow. They will provide a good starting point, but additional divisions need to be added based on the unique situation of the goods reception in question.

7.3 At the Gate

The gate to a goods reception is usually where the truck drivers meet the company for the first time. Therefore, the truck drivers may not have previous experience with procedures for goods reception upon their arrival. It is important that the goods reception is clear with the routines and safety regulations that apply in the area to ensure efficiency and safety. Interviewee 1, 2, 3 and 7 argued that communicative misconceptions and lack of understanding are common problems at the gate to the goods reception, often due to language barriers. This is probably a problem for some goods receptions and not for others as it should be correlated to the volume of transport from other countries and use of international haulers or 3PL. According to interviewee 2, this problem is particularly serious when something deviates from the routine procedure.

Interviewee 3 and 7 explained that their TSM software can handle multiple languages, which give the truck driver the opportunity to choose his or her preferred language. According to interviewee 7 it is sufficient in most cases to include Swedish, English, Polish, Russian and German within Sweden. The benefits of having a translatable interface is that it enables the truck drivers to understand and comprehend the documents they are expected to read. These documents are often safety regulations that are important to understand and follow within the goods reception area.

Missing transport documents is a common problem that appears at the gate. Arriving trucks that lack proper documents cannot be unloaded before the documents are in order. If the proper documents cannot be found, the goods must be traced back by an operator in the goods reception. Backtracking of shipments is a costly and time-consuming procedure which also forces the goods reception to re-plan the slot booking schedule in most cases due to the incurred delay. Interviewee 1 said that the problem exists among all their logistics providers regardless of company size, transport origin or type of cargo. Interviewee 6 said during the interview that transport documents are missing for five percent of all incoming transports to Company 6. Interviewee 2 argues that the problem to some degree can be linked to a lack of standardization amongst transport documents. In addition, a transport can be sold several times before a subcontractor performs the transport. This creates layers between different companies where the transport documents are at risk of being lost. According to interviewee 2 and 7, the problem can be reduced by using digital transport documents instead of physical. Road freight business are, according to Riedl et al (2018) very fragmented with many logistics providers that do not use digital software in their daily activities. A transition to digital transport document will lead to challenges for haulers who need to change and develop their business model.

7.4 The Goods Reception

The goods reception focus on the procedure of unloading goods. During interview 2 it was said that goods receptions with the possibility of performing unloading indoors, which provide protection from the elements generally perform better. This was claimed especially for windy days which in general cause the forklift operator to perform their work slower to maintain a safe process both for other employees and the goods. The effect of windy conditions probably varies depending on the type of goods and the wind speed, goods of low density are probably affected more by windy conditions than heavy goods.

During interview 1 it was stated that it is advantageous to have all the necessary competences internally in the goods reception area. By having the expertise at a local level with offices in the same building as the goods reception the ability to be flexible and handle disruptions is improved. Disruptions are further discussed in Chapter 7.7 Disruption Management.

Interviewee 5 and 7 stressed the importance of having a rough planning report for the goods reception operations each day. This planning report should be available at the beginning of each shift and be available to anyone working with Goods reception or the subsequent management of internal logistics. The planning report can be used by workers to keep track of the ongoing and upcoming work for that day to increase efficiency and reduce disruptions.

Both companies 3 and 6 operate in the grocery business area and assign truckers the task of unloading goods. Each of the other interviewed companies performs the actual unloading of incoming trucks where the truck driver is only responsible for opening the cargo space and making unloading available. According to interviewee 2 the performance is often superior at goods receptions where a goods reception operator unloads the cargo. This is because the operators in the goods reception are accustomed to the forklift, the type of goods and how it is packed. This results in less damaged goods and higher efficiency. Another problem with truck drivers unloading the goods is to determine who is responsible in the event of an accident. Since the truck driver performs unloading, it can be said that he was responsible, but unloading takes place at another company's facility where they are responsible for safety. It seems that companies with expensive goods are more likely to unload themselves, while companies with cheaper goods let the drivers unload. Company 1 receive goods with an extremely high value on each pallet and performing the unloading themselves. The interview results indicate that the unloading procedure tends to depend on the value of the product, but no support has been found for this in literature and would need more support to draw certain conclusions.

7.5 Internal Logistics

When the goods reception has unloaded the incoming goods the internal logistics department takes over responsibility for the goods and moves them either straight to production or into storage. The main concern from a time slot management perspective is that the goods are removed from the goods reception area and do not interfere with the goods reception operations. During several interviews, the subject of having balance between the unloading and removal of goods was touched upon. Interviewee 2 explained that the unloading can never be faster than the speed with which the internal logistics can remove goods. The interviewee stressed the importance of the internal logistics keeping up with unloading as not to become a bottleneck slowing down the entire goods reception operation. Interviewee 3 explained that even though it is more expensive they are open at night as well. One reason for this is that the internal logistics operations run much smoother during the night when there are less people from other departments moving around in the facility. It is estimated that the internal logistics works 10-15% more efficient during nighttime compared to daytime.

During both interview 5 and 7 communication and information sharing were discussed. In interview 5 the more general aspect of ensuring good communication and that all involved parties have access to the latest information was discussed. This makes it possible to solve any problems quickly. Interviewee 7 specifically mentioned the importance of communicating with the internal logistics operation so they are up to date with the latest information to be able to plan their work in the most optimal way. As the goods reception operations and internal logistics operations are close and sometimes even one and the same, it can open up the possibility of moving staff between the sections. During interview 5 the interviewee explained that when employees have multiple competences and can work in more than one section it makes the system better equipped to deal with fluctuating workloads.

A well-functioning TSM solution relies on the internal logistics having enough capacity to keep up and not slow down the goods reception operations. How this can be achieved differs between goods receptions, but this issue will need to be addressed for the implementation of a TSM solution to be successful.

7.6 Time Slot Management

The way incoming goods deliveries are planned can vary significantly from one goods reception to another. Some goods receptions do not use any TSM practices, like Company 1, some manually enter bookings in an excel document like Company 6, and others use full or partial TSM solutions, like Company 3, 4, and 5. The companies interviewed in this study which were using TSM solutions advocated their use, while those who did not seemed to be of the opposite opinion. Whether the different views stem from the different companies thinking that they already have the best solution making them biased towards their own solution is unclear. The choice of TSM software varies amongst the companies using TSM solutions, showing that there are several TSM software providers supplying competitive solutions to their customers.

The three interviewed companies using TSM solutions do have one thing in common; they all have TSM solutions tailored to their specific contextual conditions. Whether the fact that their TSM solutions were tailored to their needs affected their perception of TSM solutions in general is unclear. The TSM solution used in the Bourg Study was a generic solution, and the result of the study could possibly have been different if the solution was more tailored to the specific needs of the goods reception at the Bourg production facility. Below the general considerations and specific considerations when tailoring or choosing a TSM solution are presented.

7.6.1 General Considerations

The most prominent recurring topic throughout the interviewing process was flexibility. A company or process can be flexible in many ways, but in the context of time slot management and goods reception flexibility was primarily mentioned regarding the time slots. Booking procedures, slot lengths, coping with disruptions and rescheduling were aspects mentioned as being important to make sure that they are flexible. Interviewee 2 expressed this as always having a second option for each decision as there will always be situations where the original plan cannot be executed. A good TSM solution should be capable of handling any situation directly through rescheduling and information sharing. Interviewee 2 goes as far as stating that during disruptions is when the true performance of a TSM system can be shown. This statement was discussed during interview 4 as well, where the interviewee defined flexibility in a similar way. Flexibility was a recurring topic in the literature as well with Morais and Lord (2006) claiming it was the most important factor of successful TSM solutions at North American seaport container terminals and Chen et al (2013) promoting a more flexible dynamic real-time appointment system over a static appointment system.

Another common topic during interviews as well as in literature is the usability of the TSM solution. The booking of time slots should preferably be possible to do in more than one way to ensure that the hauler always has the possibility to book a slot. The interviewee in interview 4 preferred if bookings were made using written communication or through an app as it mitigates the risk of misunderstandings. Morais and Lord (2006) state that the possibility to book time slots by phone is important to the success of a TSM solution. One way to merge these two preferences in an easy way is to allow time slot bookings by text, combined with the option to book through e-mail, a portal, or an app.

According to the interviewee in interview 7 who's company develops TSM software many of the existing digital TSM tools are too complicated for most operators. One example of this overcomplication is that the tools contain a multitude of performance indicators which the operators are not trained to interpret or use. Instead of helping the goods reception keep track of their incoming flows, processes, and performance the overload of KPIs hinder the operators from understanding the ongoing situation and creates room for misinterpretations and misunderstandings. The interviewee explained that KPIs are better used in limited numbers as a few strategically chosen KPIs are enough and do not cause information overload or overcomplications. The interviewee in interview 7 recommended that the software interface shown to goods reception operators and truck drivers should be easily understood and simple to use. Errors or misunderstandings due to a complicated interface are simply unnecessary, and the interviewee went on to say that the most important part of any software is to have a design that is understandable and usable by everyone who might need to use the software.

When designing a TSM solution or choosing a pre-existing solution it is important to not only focus on the goods reception, but the haulers as well. Nambothini and Erera (2008) found that the design of a TSM solution can have a significant impact on the operations and earnings of haulers and it is important to take them into consideration. Morais and Lord (2006) stressed the importance of having everyone on board with the implementation of a TSM solution for it to be successful and this includes the haulers. The interviewee in interview 2 explained that it is not enough to simply implement a TSM software or booking system. A successful TSM solution is implemented in practice as well and is accepted by all affected parties.

To conclude the general concerns of the design and implementation of a TSM solution it is important to remember that small changes can have a large impact. A perfect TSM solution might not be necessary as a much simpler solution could solve a large enough portion of problems. Chen et al. (2013) showed that moving just a small portion of peak-traffic to off-peak times can have significant benefits.

7.6.2 Specific Considerations

Inspired by the strategic design decisions and tactical planning decisions identified by Ahmadi-Javid et al., (2017) in the healthcare sector, a number of decisions to consider when designing a TSM solution for a live-unload goods reception at an automotive production facility are suggested.

Policies

The **access policy** dictates how long in advance one must make a time slot reservation at the goods reception. Pre-scheduling all deliveries even 48 hours in advance is likely not a viable nor advisable option at a live-unload goods reception at an automotive production facility. Time slot bookings made too far in advance are more likely to have a high number of early or late arrivals than bookings made closer to the expected arrival time. A hauler is more likely to make a correct judgement of the ETA with more information on hand, and the hauler is likely to have more information on hand closer to the ETA. To ensure timely arrival at a time booked far in advance the hauler might need to take precautions, such as being too early and waiting close to the goods reception until the booked time slot arrives, and this might incur additional costs. An open access policy where bookings can be made all the way up until arrival is more likely to have a high number of timely arrivals than a traditional access policy that requires bookings to be made well in advance.

One issue associated with the open access policy is that it does not take recurring deliveries nor contextual factors into consideration. If a delivery arrives every day at seven o'clock the hauler will expect the goods reception to be ready at seven o'clock, but with an open access policy the hauler would need to always book the seven o'clock time slot as soon as it is released to ensure that they can deliver at their usual time. The contextual factors, such as for example ferries, are not accounted for either. The time slots most convenient for a group of trucks arriving with the same ferry might become reserved by other trucks which are not on the ferry. This creates an incoming flow of goods above the capacity of the goods reception, resulting in a stressful situation for the goods reception workers and waiting time for the truckers. A combination of a carve out policy and an open access policy would be a good solution to this problem. Most appointments will be open access, but some time slots will be reserved, carved out, for recurring deliveries and unavoidable spikes due to contextual factors, such as the ferries.

The access policy also dictates how long in advance a time slot reservation can be made, known as the scheduling window. A scheduling window of 24-48 hours is recommended as a smaller window mitigates no-shows and untimely arrivals. Depending on the incoming flows of goods it might be advisable to have different scheduling windows for different flows. There is evidence that previous lateness or timeliness are good indicators of future behaviour, hence the timely haulers could be rewarded with a larger scheduling window. The haulers might have preferences regarding the booking of time slots, and in some cases, it could be warranted to accommodate their preferences if possible.

The **walk-in policy** dictates whether walk-ins are accepted and if they are, to which extent and under which conditions. Not accepting walk-ins is not considered a viable option in the setting of a live-unload goods reception as it might lead to increasing costs and a strained relationship to the haulers. Therefore, a policy accepting walk-ins should be chosen, but there should be some rules in place. Putting all walk-ins, late and early arrivals, in a separate que where they are served at the earliest convenience is a simple solution suggested by interviewee 2 and similar to the queuing systems used at company 3 and 4. In case the time slot of an early arrival arrives before their turn in the que, they can simply leave the que and use their booked time slot. This gives the early arrivals a fair chance at catching an earlier time slot than the one they booked, and the late arrivals will just have to wait for a time slot to become available as they missed the one they booked.

The **personnel policy** dictates whether personnel should exclusively work in their section or if staff exchanges between sections should be implemented. It is worth noting that if an even enough flow of incoming deliveries is achieved, there might not be a need for staff exchanges.

The **scheduling policy** dictates how reservations are carried out. Online scheduling of individual appointments puts the responsibility on haulers to book suitable slots based on their ETA and is recommended as the general method of scheduling as no apparent advantages were found with the use of offline scheduling. But, carved-out times are better planned using offline scheduling where the distribution of the carved-out times are optimized and then implemented. If time is carved out for a group of trucks, for example arriving from a ferry, they can either be scheduled as a group in an offline manner or they can be allowed to book their own timeslots within the carved-out window in an online manner. Neither approach can be dismissed or recommended above the other as both approaches appear to be equally good.

Allocations

Allocation of capacity and priority to different groups. In the healthcare industry different patient groups can have very different needs whereas at an automotive production facility most deliveries need roughly the same "treatment". In case the production facility receives a mix of deliveries, for example dangerous goods, heavy goods and normal palletized goods, it might be

necessary to allocate resources to the different incoming delivery types. Regardless of the type of incoming deliveries a goods reception receives an allocation needs to be made based on the urgency of the goods to be delivered. A simple priority order of regular, urgent and critical can suffice in most cases. The interviewee in interview 5 stressed the importance of having a system in place to ensure that critical deliveries are cared for before less time sensitive deliveries.

Allocation of time to slots. The time slot length can be chosen based on the average or median unloading time of deliveries, which will likely work well if the deliveries are quite homogenous. The time slots do not all need to be of the same length if operations tend to run faster or slower during certain times of the day. The time slots for those time periods can be shortened or elongated as needed making the time slots more tailored to the specific context of the goods reception. If time slot lengths are chosen in either of these ways, the hauler just needs to book a slot that suits their ETA and nothing else. Another option is to have short time slots of which the haulers need to book multiple depending on the estimated time needed to unload the goods they are delivering. This assumes that the haulers can estimate the time it will take to unload correctly and could create issues of haulers booking too many time slots to ensure there is enough time allocated to them. A guide or calculator could be provided to the haulers to help them correctly estimate the required number of time slots to book. A third option is that the haulers do not book the time slots, but rather apply for them and an employee of the production company decides if the applied for number of slots is suitable for the delivery in question. This incurs the extra cost of the employee and might not be a financially viable option. Instead incentives such as fines for booking too many time slots could be implemented to mitigate issues of overbooking. On the other hand, the interviewee in interview 4 opposed this approach stating that fines would not carry any benefits, and there is not enough information to make a recommendation either way.

The time slot length should according to the interviewees in interviews 3 and 4 be flexible and adaptive to the incoming deliveries' loads and the complexity of the cargo. To evaluate an incoming delivery's load and complexity it is important to have sufficient information about the delivery such as the number of pallets or goods carriers. Each incoming delivery is unique, at least to some extent and if the time slots are fixed without any room for adaption waiting time for truckers or idle time for the goods reception worker might ensue. For this reason, it is recommended that they time slots are flexible, at least to some extent.

Allocation of block sizes. The block size dictates the number of arrivals scheduled to arrive at the same time. For example, if the goods reception has four spots for unloading, it needs to be decided if all of them should be bookable or if one or more are better used as buffers or dedicated to walk-ins.

Allocation of delivery acceptance windows. The delivery acceptance window at a goods reception is generally from opening until close. Depending on the type of incoming deliveries the goods reception receives it might be advisable to start accepting certain deliveries later in the day or finish taking certain deliveries earlier in the day. The number of arrivals with a certain type of goods that are allowed to arrive within one day might need to be decided as well. This ensures that workers can complete the work at hand just before the end of their shift.

Functionalities

Data collection is not just a recommended functionality to incorporate in a TSM solution, it is also a requirement to be able to design a TSM solution tailored to the goods receptions needs. Both interviewees in interviews 2 and 3 mentioned that TSM systems should be able to register time stamps for truck arrivals, unloading and when each truck leaves the facility. Saving this information can sometimes help in situations where haulers claim monetary compensation for waiting time. This information can then be used to directly know exactly how long the driver

was waiting, although the aim of the TSM solution should be to not incur any waiting time at all. It is recommended to collect data on the unloading times of the deliveries, as this can help improve the accuracy of the time slot lengths discussed earlier. Information should also be collected to help the division of the incoming flows as discussed in subchapter 7.2. There are many other types of information that could be collected through a TSM solution, but it might not be advisable to do so. As explained above KPIs and datapoints to collect need to be chosen carefully as there is such a thing as too much information.

Information sharing can solve a lot of problems encountered along the way from shipper to receiver, and a TSM solution can help enable the sharing of information. The interviewees of both interview 2 and 4 argued for the importance of rapid response when a hauler reaches out to communicate an expected late arrival or other problems. Many situations were said to be easier to handle if the response is fast since less time will be lost and the time window during which action can be taken will become larger. This opinion is reflected in the literature as well where Zhao and Goodchild (2010) state that information sharing is beneficial to all involved parties. Multiple languages as well as simple translation services can be offered through a TSM solution, enabling a better sharing of information. Both are highly recommended, and the interviewee in interview 7 suggests translating the TSM solution to the most common languages of the drivers delivering to the goods reception. Company 3 confirms this recommendation through their statements about the benefits they have had from the multiple language options of their TSM solution.

7.7 Disruption Management

Disruption Management from a TSM perspective covers the handling of all expected and unexpected events which disturb or might disturb the scheduled arrivals of trucks at the goods reception. If one wishes to do a deep dive there is plenty of literature on the subject of disruption management in general and exploring the subject thoroughly might be beneficial if one wishes to find methods to safeguard against the unexpected. In this study the focus will be on managing common and expected disruptions as being able to manage those is considered to likely be enough to be able to create a well-functioning TSM solution. Looking at seaport container terminals, truck appointment systems generally work well under the circumstances for which they were designed but can quickly break down when exposed to events not accounted for in the appointment system (Li et al., 2018). Preferably a TSM system is designed to accommodate as many disruptions as possible without failing, but in case it does fail it is important to have a plan in place.

To be able to create a disruption management plan the expected disruptions and the consequences of said disruptions need to be identified. From a TSM perspective, the specific disruptions are not necessarily as relevant as the consequences they impose. The different disruptions and their causes can still be good metrics to track to be able to be more prepared for similar events in the future. This study can establish three general disruptions that one can expect: early arrivals, late arrivals, and lowered efficiency of the goods reception. Another disruption mentioned during interview 1 was that the company received imported goods which had not been declared. For the company it was deemed necessary to have their own small customs office to be able to solve such issues. During the interview they stressed the importance of having many competences in-house to be able to solve many problems on site right away.

None of the three disruptions mentioned above will result in delays unless the capacity of the goods reception is exceeded which in turn can be countered by temporarily raising the capacity of the goods reception. This strategy is used by the companies in interviews 1 and 5. Both companies have their staff trained to man more than one department, making it possible to

borrow capacity between departments when needed. The company in interview 6 has taken a different approach to this. Most of their incoming transports unload the trucks themselves, and as they have many unloading docks, they rarely have more trucks to unload than available unloading docks. When raising the capacity of the goods reception it is important that it does not exceed the capacity of the internal logistics operation, making the internal logistics operation into a bottleneck.

Assuming that the goods reception's capacity cannot be raised enough to accommodate the incoming arrivals, the build-up of a queue becomes inevitable. Regardless how the goods reception chooses to handle the situation, the strategies need to be fair, taking both the interests of the goods reception and the haulers into consideration (Li et al., 2018). This is also mentioned by the interviewee in interview 2. Having a strategy on how to deal with disruptions is important, and it is unfair if haulers that make sure their trucks are on time must wait for late arrivals to be unloaded before them. Translating the four strategies for seaport container terminals presented by Li et al. (2018) to an automotive production facility the result is three strategies to be used independently or in different combinations. In the study the fourth strategy, a combination of two other strategies, was the clear winner. Hence it is encouraged to combine the below strategies:

Prioritization – Unloading the most production critical trucks first. A coding system can be a simple way to accommodate this. The interviewee in interview 5 talked about the company prioritizing incoming deliveries by marking certain deliveries as "rush" or "super rush", giving those deliveries a fast track to being unloaded. The interviewee noted the importance of caring for important deliveries before less important ones.

Order of arrival – Unloading trucks in order of arrival. The interviewee of interview 2 explained that some goods receptions do this despite having a time appointment system in place, creating an unfair situation where timely arrivals must wait to be unloaded because late arrivals are unloaded before them. The interviewee suggests that a much fairer solution is to put all trucks that miss their assigned time slot in a separate queue and unload them during the next free time slot regardless of if they might have to wait all day. The interviewee stressed the importance of the TSM system being respected by all haulers and suggested this could be encouraged by making late haulers wait for empty time slots as a form of punishment for their tardiness. The company in interview 3 has TSM practices in place, and supplements them with a queuing system for late arrivals and walk-ins. The interviewee in interview 4 suggests a similar approach, noting the importance of not letting late arrivals constrain the flow of timely arrivals.

Goods reception or internal logistics operations preferences – Unloading trucks based on convenience for the goods reception or internal logistics. Certain loads of cargo might be easier to handle before or after other loads of cargo.

7.8 TSM Suggestions for Tuve

To visualize the information presented in the previous subchapters 7.1 to 7.7 a simplified case study has been performed. Using the some of the context of Volvo Groups production facility in Tuve, Gothenburg, some suggestions for a TSM solution are presented below. The analytical framework presented in chapter 6 will be used as a guide.

7.8.1 Geography and Infrastructure

The Tuve production facility has two significant geographical and infrastructural factors in its environment: the boats and the congestion. The factory is located close to Sweden's largest harbour, Gothenburg Harbour. From a logistics perspective it is an advantage to be located close to a major seaport terminal, but from a TSM perspective this means that a not insignificant part of the incoming goods flow will arrive by boat at the harbour. Whenever a boat arrives at the harbour there will be a wave of incoming trucks at the production facility soon after. The factory is also located close enough to the town of Gothenburg that incoming trucks during certain times of the day will be affected by rush hour traffic, making their arrival times harder to estimate accurately.

Both factors are considered influential enough to warrant being taken into consideration when designing or choosing a TSM solution. The incoming boats containing a large enough number of trucks to create a spike in the incoming flow of goods to the factory should be identified and prepared for. Suitable preparations can be to allocate more staff to the goods reception at those times or ensure no other trucks arrive at those times making it possible for the staff to focus their attention only on the trucks arriving by boat. The congestion can be taken into consideration by having a bit more time between booked arrivals during rush hours. This gives the goods reception less prearranged workload and enables them to be more flexible towards early, late, or unexpected arrivals.

7.8.2 Incoming Goods Flow

The incoming flow of goods at the Tuve factory is currently not documented carefully enough to be able to analyze it properly. Thus, the first step should be to start documenting the behavior of the incoming goods flow. Once the incoming flows are mapped and can be analyzed a proper division of the flow can be made. Based on how the incoming flow is described to behave, or rather guesstimated by the workers at the goods reception, tree different divisions of the incoming flow are suggested:

1. Division by means of transportation. This identifies the flows affected by the boats' arrival times at the harbor.
2. Division by transportation distance. The Bourgh study showed that the transport distanced influenced the reliability of the estimated arrival times, and the same can be true for Tuve.
3. Division by reoccurrence. Tuve receives deliveries from milk runs and other recurring arrivals that tend to arrive at almost the same time every day.

Additionally, a flow for prioritized and business-critical trucks can be advisable to ensure that desperately needed goods are unloaded as soon as possible.

7.8.3 At the Gate

The administrative procedures in the logistics field are generally a bit old fashioned, using hard copies rather than electronic documentation most of the time. The same is true at the Tuve factory. It is ot clear if the issues with missing documents are severe enough to warrant a possibly expensive conversion to electronic documentation right now but given the trend towards digitalization the documentation will need to be made digital eventually. One issue that can be solved with a TSM system is the language barrier issues. Safety regulations currently in written form should be converted to pictures and if supplemental text is needed it should be translated to the most commonly encountered languages: Swedish, English, German, Polish,

Russian and possibly Romanian. The TSM system should preferably be translated to as many languages and include some sort of situation specific translation service (for example translation of a set of commonly used phrases). The TSM system should also facilitate some simple communication between haulers and the gate, at least to make it possible for truckers to announce if they are late or early.

7.8.4 The Goods Reception and Internal Logistics

At the Tuve factory the goods reception has a fair amount of space and a buffer area between the goods reception and the internal logistics is already in place and appears to work well. The buffer function is well designed and does not need any apparent improvements.

Standard unloading procedure is to unload the goods from the truck and place them on the ground where the goods are checked. Once checked the goods are brought away and turned over to internal logistics. There is space enough that more than one truck can be unloaded and checked before it gets crowded and anything needs to be taken away. This means that the unloading can be temporarily sped up by unloading and checking the goods of multiple trucks without moving the goods to the internal logistics right away. Once the incoming flow of goods is lower the staff can move the unloaded goods to internal logistics. Internal logistics appears to have enough staff and room that they do not cause any bottleneck.

7.8.5 Time Slot Management

For the Tuve factory some TSM practices are already in place, but do not work very well in practice. As Volvo Group buys all incoming transportation to the Tuve factory themselves they have a great opportunity to communicate and negotiate with the haulers and try to find suitable solutions for everyone. A suitable TSM system does not need to be complicated but should include all basic functions described in chapter 7.6. A simple, flexible, and useable system will likely be enough to have the desired effect on the incoming goods flow. After a thorough mapping of the geographical and infrastructural context and the incoming goods flow the suggested considerations of subchapter 7.6 can be used to outline a TSM solution.

7.8.6 Disruption Management

For the Tuve factory it is deemed enough to consider two of the strategies from section 7.7. The third strategy, goods reception or internal logistics operations preferences, is excluded as the goods reception is well prepared for all kinds of goods that might arrive and do not have any preferences. The first strategy, prioritization, should be implemented as the production at Tuve has a Just in Time approach, making them possibly vulnerable to late deliveries. One suggestion is to label all incoming deliveries as green (no rush), yellow (when possible) and red (as soon as possible). The second strategy can be used in tandem with the first strategy to decide in which internal order the three truck-categories should be served.

8 Discussion

This chapter discusses possible TSM opportunities and improvements found during this master's thesis study. Concerns regarding validity, reliability and quality are addressed and some suggestions for future research are given.

8.1 Time Slot Management Opportunities and Improvements

There are plenty of technological advancements that could enhance future TSM systems, but there is an argument to be made that a complicated and advanced system might be unwarranted and just unnecessarily expensive. Our experience throughout this study has been that there is a severe lack of systematically collected data about the incoming goods flows at production facilities. If the problem is not fully known, it is hard to solve. The problem might turn out to be hard or it might turn out to be easily solved, but without a clear picture of the current state any implemented measures will be done blindly. Before implementing a TSM system we think it is advisable to implement some sort of data collection system on the incoming goods flows. This would significantly improve any following implementation of a TSM system as the most successful TSM systems appear to be the ones well-adjusted to the context in which they are implemented.

When designing a TSM system simplicity and user friendliness appear to be more beneficial than advanced functions. The people that will interact with a TSM system will likely have very different backgrounds, language skills and technical competences and a complicated system runs the risk of being used wrongly. A simple system used correctly might work better than a complicated system used incorrectly.

One way to work around language barriers without having to pay for translation services is to use pictures rather than words. Organizations such as the Red Cross and Red Crescent that need to communicate crucial information on many languages to people who are sometimes illiterate commonly use illustrations to communicate. These techniques might be useful to solve some of the language problems experienced at goods receptions, for example the communication of safety regulations.

From the perspective of a truck manufacturer such as Volvo Group it might be worth considering developing some sort of build in TSM functionality in their trucks. Especially when considering a futuristic scenario with self-driving trucks it will be important that the trucks can announce their arrival and share information with goods receptions they are scheduled to visit.

8.2 Validity, Reliability and Quality

The analytical framework used in the analysis was formed according to the findings from the literature review and interviews. The study results mix theoretical knowledge and empirical knowledge to provide a reliable result. The different sources of information have to a great extent been triangulated to investigate the validity of the information. However, a few exceptions have been made but, in those cases, it has been clearly communicated that the specific bit of information only relies upon one source. In addition to the triangulation we have used face validation with people who possess significant knowledge in the studied field.

At the beginning of this project the plan was that the results should act as a guide as to how an implementation of Time Slot Management should be designed at the Tuve Factory. This was already from the start an ambitious goal considering the general lack of literature within this field and the diverse definitions of what Time Slot management is and how it is supposed to be managed. It would have been feasible to provide such results under normal circumstances,

however circumstances have been far from normal. A few weeks into the material gathering process and just before the start of goods reception visits and interviews the global pandemic of Covid-19 struck Sweden. The pandemic turned our plans upside down and forced us to modify large parts of the study, scope, research questions and methods. This has limited our ability to understand the full flow and processes at the Tuve factory which was the focal point of RQ3. The mapping of the Tuve plant could be much better and more thoroughly performed if this study was to be remade. Because of the visitation restriction it was only possible for us to visit the factory twice which was not sufficient. However, we feel satisfied with the methods used and believe that they helped produce a reliable and valid result taking the prevailing situation in consideration.

8.3 Suggestions for Future Research

As discussed in Chapter 8.1, there seems to be a demand for simple TSM solutions without costly implementations and complex user interfaces. This is an area which needs attention in future research since it is almost unexplored in scientific literature with possibly large user demand. Almost all literature used in this study takes the logistics supplier's perspective, which is an important perspective, but we believe that scientific literature should also try to understand and evaluate TSM from the perspective of goods receptions that have other needs and challenges.

9 Conclusions

This master's thesis study was initiated by Volvo Group to explore the possibilities of using time slot management in live-unload goods receptions at automotive production facilities. Three research questions were posed to be able to evaluate the study's fulfilment of its purpose. The resulting answers of research questions one and two were used to answer the third research question, which aims to put the theoretical findings of this study into a real-world context. Below each research question and its resulting conclusion are presented.

RQ1. Which important aspects should be considered when designing a time slot management solution for a live-unload goods reception at an automotive production facility?

The important aspects to consider when designing a TSM solution were found to boil down to three things.

- **Simplicity and usability beat advanced functionalities**. A system needs to be useable by everyone to work well in practice and more often than not a much simpler TSM solution than expected can be enough.
- **Always prepare for failure**. No system is perfect, but by being prepared many failures and disruptions can be easily taken care of.
- **Information sharing**. Good and open communication between all involved parties can solve many problems in a low-cost way.

RQ2. Which important contextual conditions can affect the suitability of a live-unload goods reception at an automotive production facility for time slot management practices?

The contextual conditions were found to have a great impact on the suitability and possible uses of TSM solutions at a goods reception. Several areas of interest connected to the contextual conditions of the goods reception were found.

- **Geographical and infrastructural context**. The environmental context of the goods reception needs to be considered at all stages of the design or choosing of a TSM solution.
- **Knowledge of the current state**. Throughout this study is has become evident that many goods receptions do not document the incoming goods flows or their operations to a large enough extent to be able to tailor a TSM solution to their specific requirements, decreasing the likeliness of the TSM solution being successful.
- **Efficient operations in all stages of the goods reception**. A TSM solution cannot work better than the goods reception it is implemented in.

RQ3. What is a suitable design of time slot management practices at the live-unload goods reception at Tuve production facility?

This research question turned out to be impossible to fully answer at the present time. To design a suitable TSM solution one needs to tailor the TSM solution to the goods reception in question and this can only be done if enough information about the goods reception and the incoming flows of goods are known. At Tuve sufficient information to be able to tailor a successful TSM solution to the goods reception is not available at the present time. The first step towards designing or choosing a suitable TSM solution for the Tuve factory is therefore to implement sufficient practices of documentation regarding the work at the goods reception, contextual factors surrounding the factory and the incoming flows of goods to the factory.

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Appendix A

Intervjufrågor

Ostrukturerad inledning med öppen fråga om att berätta om sig och företaget.

Efter att personen/personerna börjar få slut på saker att berätta om självmant introduceras ett antal teman om de inte redan nämnts;

1. Kan du berätta lite om företaget du jobbar på?
2. Kan du beskriva er godsmottagning?
3. Kan du berätta hur ni jobbar?
4. Hur tycker du att arbetet fungerar?
5. Vad känner du till om time slot management?
6. Hur är det att köra en leverans till er?
7. Finns det en perfekt godsmottagning? En perfekt transportör?

Därefter följer mer strukturerade frågor: med lite struktur/tema:

1. Finns det något du tycker kan förbättras?
2. Har ni något ni är duktiga på?
3. Några skillnader mellan er godsmottagning och andra godsmottagningar som du känner till?
4. Vad görs sämre hos andra vid deras godsmottagning och relaterade aktiviteter?
5. Vad görs bättre hos andra vid deras godsmottagning och relaterade aktiviteter?
6. Hur fungerar det att leverera till er godsmottagning?
7. Hur går det till när en chaufför får en körning till er?
8. Vilka transportörer fungerar bra?
9. Varför fungerar vissa transportörer bättre än andra?
10. Vilka transportörer fungerar dåligt?
11. Varför fungerar vissa transportörer sämre än andra?
12. Vad utmärker en bra transportör?
13. Vad utmärker en bra godsmottagning?
14. Vad gör ni vid förseningar eller överbelastning eller annat strul?
15. Har ni ett förebyggande arbete med syfte att motverka operativa problem?
16. Hur fungerar hanteringen av dokumentationen kring leveranserna?
17. Fluktuerar mängden inkommande gods över dagen?
18. Ifall mängden inkommande gods fluktuerar över dagen, försöker ni att sprida ut det?
19. Alternativa sätt att hantera godsmottagningen på som ni valt bort? Som ni gärna hade haft? Varför?
20. Vad är de vanligaste problemen med att boka transporter?
21. Vad är de vanligaste problemen med att ta emot gods?
22. Vad är de vanligaste problemen med det administrativa kring en bokning och leverans?
23. Hur tänker ni kring antal/mängd personal samt arbetstimmar?
24. Vad kan en speditör/leverantör göra för att förenkla er godsmottagning?
25. Vilken administrativ support ger ni till godsmottagningen?
26. Vilken administrativ support ger ni till speditörerna?
27. Vilken administrativ support ger ni till chaufförerna?

28. Om det finns datasystem för någon del av processen, hur funkar det?
29. Finns det någon omställningstid mellan lossningar? Skiljer det sig mycket mellan transporter? Varför?
30. Finns det någon föredömlig aktör på marknaden?
31. Finns det någon avskräckande aktör på marknaden?
32. Om du själv fick utforma transportörens administration, hur skulle den fungera?
33. Vad är det vanligaste problemet när chaufförer ankommer er?
34. Hur utbrett är TSM? Använder ni det? Vet du andra företag som använder TSM?

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