Impact of RoRo terminal logistics operations on Estimated Time of Arrival of containerized goods

Master thesis in logistics and maritime management

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Abstract

Supply chain disruptions, such as delayed shipments, can have severe consequences for businesses and customers alike. These disruptions, caused by natural disasters, transportation issues, and problems with suppliers and manufacturers, result in increased costs, reduced customer satisfaction, and reputational damage.

This thesis focuses on the importance of accurate prediction of Estimated Time of Arrival (ETA) in containerized shipping of goods in a RoRo Terminal. The thesis explores the benefits and challenges of providing real-time information about arrival and departure times for stakeholders. By identifying strategies to improve communication and transparency in the supply chain, the study aims to minimise the adverse effects of delays on businesses and customers.

The research utilises a mixed methods approach, combining qualitative and quantitative methods. A systematic literature review establishes a frame of reference and systematic mapping results in a model for ETA estimation based on terminal operations and structures within a Ro-Ro terminal. Empirical data is collected through a case study, which employs qualitative methods such as semi-structured interviews and direct observations, as well as quantitative methods including collected container discharge data.

The study reveals challenges in predicting accurate collection times, including unit prioritisation, cargo location onboard vessels, involvement of multiple actors, and standardisation of cargo handling. However, benefits are identified to include optimised facility utilisation, improved resource allocation, enhanced supply chain planning, and reduced downtime for operations. The introduction of a Truck Appointment System (TAS) is verified as a promising solution to prioritise units for handling and improve collection time accuracy. Additionally, software systems and applications utilising real-time data, such as designated spot assignments and past operational patterns, contribute to more precise ETA predictions. Overall, this project confirms the significance of accurate collection time prediction in enhancing supply chain efficiency and customer satisfaction at Ro-Ro terminals.

Keywords: Ro-Ro Terminal, Containerized Goods, Estimated Time of Arrival (ETA), , Terminal Operations, Port Management.

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We hope that this thesis can provide some insights to the industry.

Thank you!

Christopher Bolin Lucero and Hampus Hammond
Göteborg 2023

Introduction

This chapter introduces the topic of the MSc thesis whilst also explaining the importance of this chosen research subject. In addition, the purpose of the study along with the research questions are found in this chapter. Lastly, the section finishes with delimitations and a report outline.

1.1 Background

Supply chain disruptions, also known as delayed shipments, can have serious repercussions for both businesses and customers (Ouyang et al., 2010). Natural disasters, transportation problems, issues with suppliers, and issues with manufacturers are just a few of the causes of these disruptions. These disruptions can increase costs, decrease customer satisfaction, and harm a company's reputation (Ouyang et al., 2010). Disruptions to the supply chain can also lower a company's profitability and market value (Alora et al., 2021). Therefore, it is crucial for companies to have backup plans in place to lessen the effects of delayed shipments and to guarantee the uninterrupted flow of goods and services.

In addition to the impact on businesses, delayed shipments can also have a negative effect on consumers. According to Alora et al. (2021), supply chain disruptions may affect customers' delivery times which in turn affects the reputation and credibility of the firm. Furthermore, these events will raise questions in stakeholders and investors when it comes to the organisation's ability to perform (Alora et al., 2021). Consequently, it is important for businesses to prioritise timely delivery and minimise disruptions in order to maintain customer loyalty and satisfaction.

The opportunity to receive information about goods movements within international containerised maritime shipping of goods has been increasingly important. For example, in March 2021 the Suez Canal was blocked, which caused a delay of almost one week within international shipping of goods (Burns, 2021) which resulted in countless impacts on European goods owners' business (Russon, 2021).

According to Lumsden et al. (2019), international shipping of containerized goods reduces the number of transshipments, speeds up the handling process of goods, reduces the number of trips for transport, enables the use of standardised equipment in handling, simplifies inventory, and streamlines stacking of goods. Due to the advantages and development of e-commerce, inbound volumes of containerised goods at ports is increasing (Port of Gothenburg, 2021). For example, published reports on e-commerce show that the annual turnover of the Swedish e-commerce industry reached 87 billion SEK in 2019 with a continuous increase during the Covid-19 pandemic (Postnord, 2020; Göteborgs universitet, 2020). The increased inbound volumes of goods imply extended requirements for both goods owners and consumers in order to track their goods based on real time information about Estimated Time of Arrival (ETA) of their goods.

Previous studies have been conducted where *Estimated Time of Arrival* have been explored. One study explored the possibilities in predicting the arrival time for container vessels, based on the Estimated Time of Arrival retrieved from a vessel's Automatic Identification System (AIS) (Ringborg & Svanborg, 2022). *Estimated Time of Arrival,* refers to when a ship, vehicle, or other modes of transportation will arrive at its final destination. The arrival estimates are used to give goods-owners and customers an approximation of when the transport carrier carrying their goods will arrive at their location (Rami & Yuriy, 2021). On the other his the opposite of arrival times, as in it is an approximation of when the goods are ready to be picked up by the transport carrier for delivery or the next leg of transport (Fabbri & Vicen-Bueno, 2021). The study by Ringborg & Svanborg (2022) found that using ETA as an input for developing a verified model for the prediction of goods is a valuable asset for enhancing the efficiency within various supply chains (Ringborg & Svanborg, 2022). The students also determined that ETA should not be the sole input for the solution and that further research should be conducted in order to further enhance a verified model, e.g., input data from terminal processes and operations (Ringborg & Svanborg, 2022).

Even though vessel arrival times are well known ahead of time, Ro-Ro terminals are currently unable to give customers precise information about when their cargo is available for collection from the terminal (Paternina et al., 2019). However, if a Ro-Ro terminal can provide its customers with a concrete pick-up time, then it may enable customers to increase the utilisation of their logistics resources (Paternina et al., 2019). This can also reduce congestion at the terminal gate(s) because with accurate time estimations customers will not all arrive at the same time waiting to collect their units (Paternina et al., 2019). Some consequences of higher congestion are longer waiting times for drivers, reduced truck utilisation, increased terminal congestion, less efficient yard space utilisation and dissatisfied customers (Paternina et al., 2019).

Although there are published studies on the thesis subject it is clear that there is a need to conduct further research on the area. Specifically, there is a need to focus on short sea shipping (SSS) via the Roll-on Roll-off segment (Ro-Ro) as there is not a lot of research on the segment. In addition a focus on container flows within a ro-ro terminal is needed in order to improve customer pick-up times, which can result in improved supply chain efficiency, reduced operating costs for customers and terminals, and lower environmental impacts. This thesis explores the possibility of achieving an accurate ETA cargo collection time.

1.2 Purpose

The main purpose of this MSc thesis project is to present a verified model to improve

(ETA) at a Ro-Ro terminal. The second purpose is to explore the potential benefits of providing real-time information about the estimated times of arrival and departure for containerized maritime shipping of goods. The study aims to identify ways in which terminals can provide stakeholders with accurate timings for the collection of cargo from quay. Additionally, the study aims to identify strategies for improving communication and transparency in the supply chain, in order to reduce the negative effects of delays on businesses and customers.

1.3 Research Questions

- RQ1: What challenges and benefits exist at a RoRo terminal in the prediction of an accurate ETA of collection of goods?
- RQ2: What improvements can be conducted to enhance the accuracy of the ETA collection time at a RoRo terminal?
- RQ3: How can current real time data from the RoRo terminal be used to predict an ETA collection time?

1.4 Delimitions

This study is limited to pre-declared and dedicated containerized goods, i.e., logistics operations of de-consolidation of containers is not included. Furthermore, the report includes information flows and terminal structures at Gothenburg Roro Terminal. Hence, other terminals are not included in this study. In addition, the study is limited to stakeholders and companies transporting goods between Gothenburg RoRo Terminal (SWE) and Immingham (UK).
The study only focuses on one route with one liner shipping company which is the Gothenburg to Immingham route, operated by DFDS Seaways, no other routes or shipping lines are included in this study. There is a methodological limitation with the data analysis limitations due to time limitations. The analysis will focus on time averages from the discharge data. Lastly, the study will not conduct any field experiments as this would require more time to be available.

1.5 Report Outline

The outline of this MSc thesis is as follows: Chapter 1 introduces the scholar to the background of the studied topic and why there is a need for investigating this area. Chapter 2 outlines the design, data collection methods and analysis techniques used in this study. Chapter 3 provides the theoretical framework for the study and a review of relevant literature and theories on the chosen topic. Chapter 4 presents the results from the study which are visually represented in the form of tables and figures. Chapter 5 interprets the results to the research questions and compares the findings to literature and previous research. Lastly, Chapter 6 summarises the main results of the study and discusses the implications of the results for future research and practice. In addition, recommendations for future research are provided along with limitations affecting this research.

2 Methodology

For conduction of the MSc thesis, a deductive research approach will be employed, which comprises a systematic literature review of published literature (Creswell, 2018). This is used to develop the frame of reference and a model for estimation of ETA and ETD based on terminal operations and structures at ports (Hesse-Biber at el., 2010). To ensure validity in received results, the MSc thesis project is based on a mixed methods approach combining qualitative and quantitative methods. A mixed methods approach offers a variety of benefits to include potential conclusion triangulation, theory complementarity, and research development (Hesse-Biber at el., 2010; Fusch, 2018). Then a single case study will be used in collection of empirical data comprising both qualitative methods and quantitative methods. The qualitative data collection will be through semi-structured interviews, direct observations at stakeholders resulting in a process map and the quantitative data will be collected through questionnaires and archival data from/ at stakeholders. Qualitative methods will be used in the evaluation of quantity, correctness, and accuracy of information (i.e. information quality) linked to logistic handling and transport operations of containerized goods at different port terminals (Hesse-Biber at el., 2010). Quantitative methods (e.g. statistical, mathematics), will be used in the evaluation of the developed estimation model based on retrieved empirical data from case studies (Hesse-Biber at el., 2010). The evaluation will consider the quality of logistic operations within physical handling- and administrative processes. These will be based on timely-accuracy, operational time of handling, internal transport and administration of containerised goods (i.e right time), as well as physical placement of containerized goods and equipment (i.e. right place) at different port terminals.

2.1 Literature Review

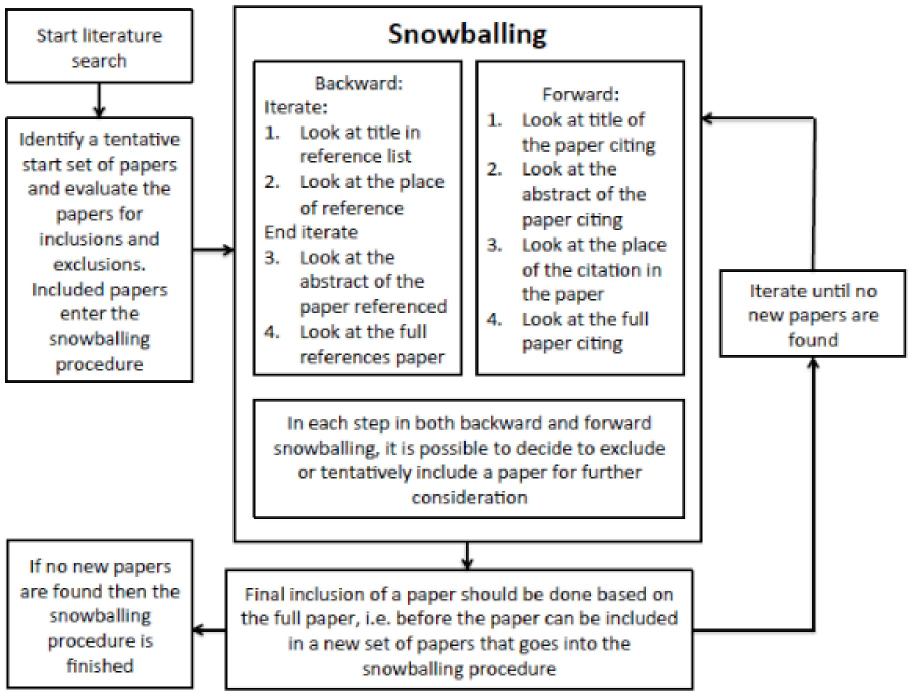
A literature review allows for the authors to build a theoretical foundation on which the project will start from (Saunders et al., 2009). This foundation will provide a good understanding of pre-existing research within the field as well as trends that have emerged (Saunders et al., 2009).

There are various ways of conducting a literature review; however, by conducting a systematic review the authors will be able to implement a replicable, scientific and transparent process (Van Wee & Banister, 2016). The systematic literature review also aims to minimise bias through exhaustive traceable literature searches of published studies (Van Wee & Banister, 2016). The authors utilised Chalmers Library search engine and Google Scholar is also utilised; however, only when the identified source could not be found through Chalmers Library.

2.1.1 Backward and Forward Snowballing

When it comes to the literature selected for this research project, forward and backward snowballing was determined to be a good choice for collecting academic references because of its systematic approach as explained by Wohlin, (2014). The authors followed the methods procedure that Figure 1 outlines.

Figure 1: Forward and backward snowballing procedures (Wohlin, 2014)



Prior to starting the literature search the authors first identify a set of keywords that were deemed relevant to the study (Wohlin, 2014).

Keywords:

- Ro-Ro Terminal
- Containerized Goods
- Estimated Time of Arrival (ETA)
- Supply Chain Management
- Terminal Operations
- Logistics
- Maritime Informatics
- Shipping Industry
- Port Management

As previously stated, Chalmers library, which contains EBSCO, IEEE, Research Gate, Sage, Scopus, and Web of Science, was used for searching for academic literature. First, the keywords were determined and submitted into Chalmers library database. Second, an initial set of papers was established. The authors selected the initial set based on the criterion that the paper had been published within (2023-2013) ten years, or older than 2013 if the literature was deemed to be relevant enough, and the paper description fit into the project's research scope. Third, after collecting the initial set of papers the authors proceeded in executing both backwards and forwards snowballing. The authors determined that doing both procedures simultaneously would reduce the number of iterations. The authors also started an excel spreadsheet to help organise the various academic sources. An example of how this was carried out is as follows: first an initial set document would be reviewed (backward and forward). Second, any relevant sources within that document would be added to the spreadsheet under the initial document that it corresponded to. Third, a new tab was created for every initial set document and the sources that corresponded to that document would be listed on that tab. Similar to the initial set, all of the proceeding sources had to meet certain selection criterions. These criterions included: year published - 2023-2013, main subjects/area of study - relevant to this project, citation numbers - multiple, and source type. The authors required two of the four criteria be met in order to be a valid source. Lastly, once all of the initial set documents were exhausted and the results sets were established all of the references were added to the main tab in the spreadsheet. This allowed the authors to sort the various sources by applying a filter to the spreadsheet. Then proceed by subject area and determine if the source could be utilised in the frame of reference. The forward and backward snowballing procedure resulted in 65 academic sources as references for this thesis.

2.2 Questionnaire Survey

According to Denscombe (2014) when something is surveyed, it’s viewed in detail and comprehensively. Surveys are used to collect information from relevant people and relevant sites with the aim of receiving an input of how things are currently rather than how things have been historically (Rugg & Petre, 2006). Depending on the situation surveyed, the method is either associated with quantitative data or qualitative data. If the survey is used to gather a comprehensive view with a large quantity of participants involved, the method is deemed to be quantitative. If the survey instead is used for examining a situation in detail at a very specific area, it tends to be based on a small quantity of participants and therefore associated with qualitative data (Yin, 2014).

Since surveys are a research strategy, there are several methods of data collection that can be used such as postal, telephone, social networking sites. They all have limitations and possibilities and because of this some methods are more suitable for certain research projects than others (Rugg & Petre, 2006). The selection of survey is based on the objectives of the research, the resources available, speed of responses and response rate, the abilities/disabilities of the respondents capacity to complete the survey-

This Master thesis has used internet surveys and more specifically, web-based questionnaires for collection of data. This decision was taken because internet surveys save time by not having any delays delivering questions or receiving answers. In addition, data processing is sped up as data does not have to be transcribed and can therefore be downloaded directly (Denscombe, 2014). Furthermore, instead of having to interview every single person involved in the operation processes which would take a considerable amount of time to perform. The questionnaire was simply sent out to everybody in the organisation allowing the writers to continue with the research project as they waited for responses.

According to Yin (2014) web surveys work best when a list of email addresses is available for sending the survey to which allows the researcher to target relevant people and thus allows more systematic sampling techniques. For this research project such a list was available and included everybody in the organisation, because of this, web surveys were deemed to be suitable. Getting respondents to access the questionnaire survey can either be done by creating a hyperlink which takes the person to the survey, or by creating a QR code which everybody with a smartphone can scan to access the survey (Denscombe, 2014). For this research project a hyperlink was created and sent out via email. When sending out hyperlinks there is a risk that somebody who was not intended to have the survey, receives it. This can contaminate the findings and due to this risk it is advisable to put a password restriction in place (Denscombe, 2014). Since the questionnaire/web survey in this research project was only sent out to one organisation and only being relevant for this organisation. The authors did not see a risk of the survey being sent externally and therefore did not believe there was need for a password protecting the questionnaire.

Lastly, with a web-based questionnaire the findings can be directly exported into an Excel spreadsheet or similar program. The data can then be made into graphs and tables. directly from the exported data rather than having to manually input the data from the findings to create, for example, a graph (Rugg & Petre, 2006). From the authors perspective this saves valuable time which can instead be invested into improving the research project.

2.3 Interviews

In this Master thesis interviews were conducted as a method for collecting data. According to Denscombe (2014) interviews are a method of data collection using people's opinion to given questions made by the researchers to then use as their source of data. Since the data is coming from people's answers it's important from an ethical point of view to receive consent from the interviewee (Rugg & Petre, 2006). Even though agreeing to partake in an interview carries an understanding about what the situation entails, it's considered good practice to have formal consent from the interviewee. (Denscombe, 2014). Therefore, the authors always made sure to have consent from interviewees before the interview began. It was made clear that their answers would be anonymous and the transcription from the interview would not be included in the appendix.

When it was possible, the interviews were held face-to-face but some interviews could not be held face-to-face due to the distance between the researchers and interviewees. The interviews were held via applications listed below:

- Zoom
- Microsoft Teams

Interviews were decided to be conducted to retrieve qualitative data which according to Yin (2014) is a great method for that kind of data. He also mentions that interviews give the best results when the research explores complex issues. Such as complicated matters that require a detailed understanding of factors and how things work, for example how systems operate. Considering the research project investigates the processes of a Ro-Ro terminal's operation processes, which can be interpreted as a complex area. The authors deemed interviews to be best for collecting data regarding this area.

Furthermore, Denscombe (2014) mentions that where opportunities are given to speak with "key players in the field" who can provide great wisdom and insights based on their experience should be held with interviews. This was also a reason for interviews to be held with staff from the Ro-Ro terminal as their experience and knowledge could not be found from literature.

As several interviews were held with different purposes, the structures varied. According to Rugg & Petre (2006) it is crucial to have decided before the start of a research project if it needs a standardised interview procedure. For this research project it was decided to not include structured interviews. Instead some interviews were semi-structured and others unstructured. Denscombe (2014), explains semi-structured interviews as having a clear list of questions to be addressed and answered. Moreover, the interviewer is flexible when it comes to the order of which the topics are brought up, as well as allowing the interviewee to speak widely about the topic. Furthermore, answers are open-ended and emphasis is put on the interviewee to elaborate points of interest (Denscombe, 2014).

It was therefore decided for this research project to have semi-structured interviews when it came to getting an understanding from the employees how a certain process operated in the terminal.

Unstructured interviews which puts more focus on the interviewee's thoughts were held when the authors wanted to get more of an opinion and idea from the employees regarding an operational process in the terminal. To further explain, the purpose of the unstructured interviews was to allow employees to discuss their thoughts and ideas of certain areas. This was thought to be important as the employees have great knowledge of the operational parts of the terminal and hearing their opinions gave great knowledge and insight to the operational processes. According to Rugg & Petre (2006) the unstructured interview starts by the researcher introducing a topic or theme to the interviewee which initiates a response. It is also important for the researcher to be as non-directive as possible. For the unstructured interviews in this study that method was implemented.

One-to-one interviews were held with all the interviewees in this research project as it is easier to control an one-to-one interview compared to a group interview (Denscombe, 2014). Furthermore, transcribing becomes easier as there is only one voice to recognize rather than several. Also, the interviewer only has one person's idea to grasp and interrogate, this enables more specific ideas (Denscombe, 2014).

Table 1: List of interview respondents

Respondent No.	Department	Area of specialisation	Date	Interview Type
1	Terminal Operations	Unloading & Loading of Vessel	15-02-2023	Unstructured
2	Captain	Navigation of ship	24-02-2023	Semi-Structured
3	Terminal Operations	Terminal Operations	21-03-2023	Semi-Structured
4	Yard dispatcher	Handling of lift units	22-03-2023	Semi-Structured
5	Digital Development	IT, Operations, Systems	30-03-2023	Semi-Structured
6	Digital Development	IT, Operations, Systems	27-04-2023	Unstructured
7	Freight Forwarder	Hinterland	01-05-2023	Semi-Structured
8	Volvo Trucks	Hinterland	04-05-2023	Semi-Structured

Note: Amount of respondents from the same department & area of specialisation varied depending on the availability of interviewees.

The questions in the interviews altered depending on the interviewees' background and department so the questions would be more relevant to the specific interviewee. Please see (Table 1) for a list of all the interviewees with respective backgrounds.

All interviews were audio recorded as they provide a permanent record and allow the authors to re-listen to the interviews in case some important data from the interviews were missed (Denscombe. 2014). Smartphones or laptops were deemed to be adequate for recording the audio as the files could directly be uploaded for transcription. For the interviews that were held online via for example zoom, the built in recording function was used. The authors made sure to receive consent for recording audio from the interviewee before initiating the interview.

Transcribing the interviews were done with the help of an AI tool from a website called "Happy Scribe". After the transcription was completed by the AI, the authors listened to the interview again and made sure the AI transcribed the audio correctly. This decision was taken as it saves time from having to manually convert the audio to text. Instead a fraction of the time was used double checking the correctness of the AI's transcription.

When this was done, the transcription was sent to the interviewee to confirm it is an accurate record, also known as "respondent validation" (Denscombe, 2014). This method ensures that the facts received from the interview are correct and if not, can be corrected.

Lastly, this research project followed the guidelines set by the GDPR with great caution to make sure none of the respondents' data was treated unlawfully. This means none of the transcribed interviews are published in the report, neither are they stored for public access. The authors of this study are the only ones with access to this sensitive information and will not share it with others.

2.4 Systematic Mapping

Systematic process mapping was conducted in this Master thesis in order to track how a containerised unit was handled upon being discharged off a vessel, and to the point of collection by customer. Without this mapping of processes it would not have been possible to get the results this study got. The mapping method was not used to answer a research question but instead to develop a greater knowledge and understanding of how the terminal processes linked together. This fulfils the usage of systematic mapping as according to James et al. (2016) where they claim the method is used for knowledge gaps, topics that are underrepresented in the literature and knowledge clusters. Since a similar study had not been conducted, data from the processes was not available in literature. Therefore, a systematic mapping had to be done. More precisely, this thesis conducted the process mapping according to the EPCIS standard which breaks down the process in several steps (GS1, 2017). The process map can be viewed in Figure 2, in the description of the case study.

2.5 Case description

Case studies are a suitable method when it comes to research projects that focus in-depth into a certain topic (Yin, 2014). The approach is to focus solely on one instance of the thing that is to be investigated as the idea of a case study is to focus very narrowly. In addition, the purpose of a case study is to gain insight to a specific case which would not have been realised with the use of a research strategy that covers a large number of instances. (Denscombe, 2014).

Case studies are used as a method to answer research questions as "what" goes into the setting and questions such as "why" does those things occur. Moreover, this method helps make the complexities of a situation more clear by going into detail. (Denscombe, 2014).

Furthermore, a holistic view was used as a case study approach. Denscombe (2014), explains this approach as viewing the case as a whole and to discover how all the parts affect one another. Considering the operations in a Ro-Ro terminal are based on several processes and factors, this approach was found to be suitable by the authors as they then would discover how the parts affect one another. Which is an aspect of great importance as the research project aims to find factors that affect the ETA/ETD.

Conducting a case study on Gothenburg Ro-Ro terminal was decided to be a suitable and relevant case as the organisation is one of the biggest container handlers in Scandinavia. Therefore, the authors deemed the company to be an excellent choice for the case study. Denscombe, (2014) states that the chosen case must be relevant when it comes to the practical problem or theoretical issue that the authors want to investigate. This selection is crucial for the success of the study.

2.5.1 Gothenburg RoRo Terminal

Gothenburg RoRo Terminal (GRT) is part of the Port of Gothenburg, which is Scandinavia's largest port with over 11,000 ship calls per year. GRT is a roll-on-roll-off hub specialised in the handling of RoRo goods (Alvsborgroro, 2023). Since 2012 DFDS Seaways and C.Ro Ports have owned the terminal with DFDS owning 65 percent and C.Ro Ports owning 35 percent respectively. The terminal has a capacity of seven quays (berths) with the capability of handling vessels up to 280m in length with a maximum draught of 11m. The terminal operations area is 500,000 m^2 (Port of Gothenburg, 2022) and has a variety of cargo handling equipment. RoRo Services, Forklift trucks from 2.5 to 16 tonnes capacity, Forklift trucks from 17 to 40 tonnes capacity, Tugmasters, Reachstacker/piggyback 45 tonnes, Translifter (cassette handling) 90 tonnes, Translifter (cassette handling) 120 tonnes, Lift unit movements from mafi or cassette to rail, Container stuffing and devanning, Movements of heavy project cargo, Re-stowing of cargo and securing .

Currently, the terminal services ships that operate on six liner routes (Immingham, Ghent, Immingham, Kemi, Tilbury, Oulu, and Zeebrüge) (Alvsborgroro, 2023). The cargo transported on these routes are as diverse as commercial cars, trailers, goods on cassettes, forest cargo, equipment, machinery and agricultural machines, Mafi handling up to 75-80 tonnes, chemicals, swapbodies, paper in reel or palletised form, containers, and project cargo are stored and handled on a daily basis (Alvsborgroro, 2023). The railway connections can carry cargo such as steel, paper, SECUs, containers, and trailers.

2.5.2 Actors involved in port operations

The terminal operates in varying cargo sectors as mentioned above. Each of the cargo that the terminal handles have varying levels of communication with the terminal in order to ensure cargo operations are carried out in an efficient manner.

- Terminal Operator - There are several different positions who work within the operations team at the terminal. The various positions work with vessel scheduling, cargo operations (loading and discharging), and customer support.

- Shipping Line - There are two shipping lines, who operate within the terminal. For the interest of this project, DFDS as explained earlier is the shipping line the case study uses. The ships operate on a linear service (fixed schedule) and are considered to be part of the Short Sea Shipping segment.

- IT Manager - The IT Manager is responsible for overseeing the technology related operations within the terminal. This includes ensuring the terminal's computer systems and networks are functioning properly as well as implementing new technologies to improve terminal operations. One example of this is through working with senior management by identifying business areas that can be improved, which can reduce costs and/or improve the terminal's environmental impact. This case focuses on the IT Manager's experience with the terminal's operating system, GTMS.

- Freight Forwarder - This actor serves as a specialized third-party logistics provider. The freight forwarders focus area is on the shipment of goods on behalf of their customers, i.e., an intermediary between shippers and other transportation services. Other examples of transportation services that the freight forwarder works with are shipping lines and trucking companies. Overall, the freight forwarder collaborates with various services in order to organise the most cost effective means of transportation available in the most efficient way possible.

2.5.3 Terminal process

As seen in Figure 2 the process begins when the aft ramp of the vessel is lowered which enables tug drivers to access the vessel. During this stage “work orders” are created in the terminal operating system called “GTMS” by either dispatchers, other authoritarian personnel or automatically by GTMS itself. “Work orders” function as instructions for the terminal workers to follow. This includes, which units to discharge, load onboard, shunt internally, plugin for temperature & control of temperature. Once a “work order” has been performed by a terminal worker they “complete” the task in the system which triggers a status change in GTMS and Phoenix (the shipping line’s operating system), depending on the task performed.

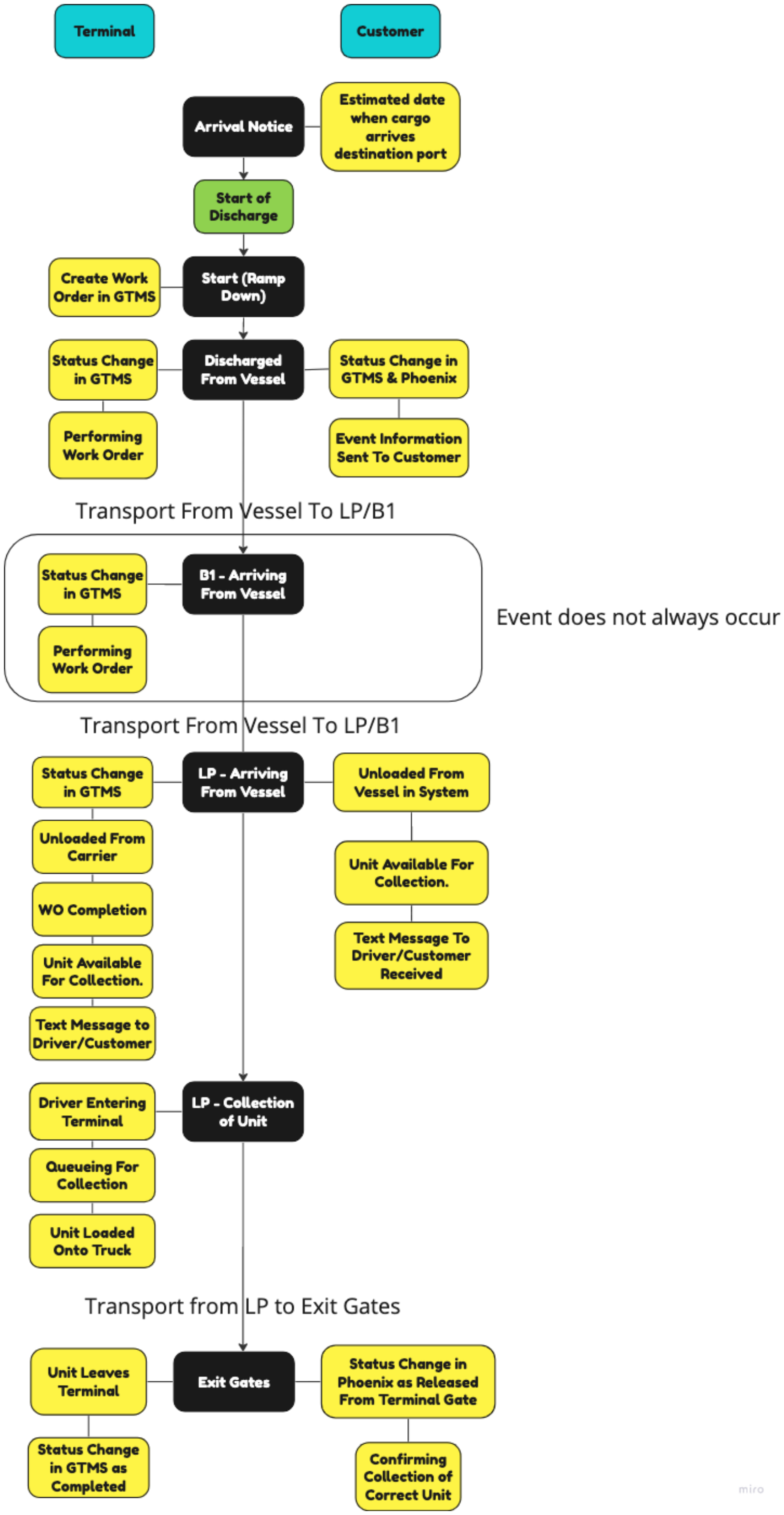
In the discharge phase, “work orders” are used for discharging units from the vessel and transporting them to B1 and “Lyftplan” (if they are container units) by tug operators, which initiates the next step in the process.

This area (B1), is where the units are stored temporarily after being discharged from the vessel and before being transported to “LP” short for “Lyftplan”. LP is the area where lift units are handled for import and export, including lifting containers onto/off a cassette (explained in further detail below). In Phoenix the container unit will receive status “Unit unloaded from vessel”, in GTMS the status is “Discharged from vessel” when the unit is placed in the LP area or B1 area.

When available, a reach stacker initiates the next step by lifting the container unit off from the transport carrier, despite a physical change the statuses in the systems are still the same as in the previous step. The lift from the transport carrier triggers a message to be sent to the waiting driver’s mobile phone, informing them that the cargo can be collected from the terminal.

Following the text message, the driver now has access to the terminal and can therefore make their way to the “LP” area. Depending on the day the queue sizes vary, according to respondent 3 Mondays are the days with the most congestion. The queue impacts the time it takes for the driver to collect the unit as they depend on the reach stacker to lift the container unit onto the truck. Once this has been done the driver continues to the exit gates for the final step of the process. At this step the driver must confirm the correct unit has been collected, when this has been completed they can exit the terminal which triggers status changes in GTMS and Phoenix. In GTMS the status changes to “Completed” which means the unit is no longer on the terminal. Similar status message is made in Phoenix, only difference is the definition of this status, being “Unit Released From Terminal Gate”.

Figure 2: Process map explaining the different steps



Note: Process map produced by authors following systematic mapping

2.5.4 Customer process

The customer process is not, unlike the other two processes dependent on the aft ramp being lowered (see Figure 2). Instead, the process is started by an arrival notice containing information of the estimated time of arrival (ETA) being sent out to the customers. The ETA tells the date the vessel is due to arrive and at what time, it does not include any information of when the unit is available for collection.

The next step of the process for the customer is when the container unit reaches the LP area or B1 area, at this point the status information changes in the systems from “Unit Loaded Onto Vessel” to “Unit Unloaded From Vessel”. Even though the system states that the unit has been unloaded from the vessel, it cannot be collected since it has not been removed from the carrier. As mentioned in the terminal process, that step is performed by the reach stacker, when this has been completed the unit can be collected.

Upon completion of the previous step the customer/driver gets a text message stating that collection of the container unit can now be performed. Following the entering of the terminal and queuing for service by the reach stacker, the driver will, with the container unit loaded on the back, head to the exit gate.

After exiting the terminal the customer can see their booking changing status from “Unit Unloaded From Vessel” to “Unit Released From Terminal Gate”.

2.5.5 ETA used in GRT

In an interview held with a captain onboard one of the vessels occupying the Gothenburg - Immingham route information regarding ETA reporting was received. Firstly, the interviewee indicated that as part of the departure process, deck officers report ETA shortly after departing Immingham. This first report is made roughly twenty four hours before arrival. The ETA is reported to Gothenburg RoRo Terminal and also the shipping line’s traffic department of when the vessel arrives at the quay in Gothenburg but also when they reach a certain buoy outside of Gothenburg. From the buoy it takes approximately one hour for the vessel to arrive and it acts as a waypoint for the terminal to prepare for vessel arrival.

The vessels sailing the Gothenburg-Immingham route are equipped with a system which, with the input of preferred arrival time, can calculate speed, fuel consumption and wavelength. The system suggests several available route alternatives that can be chosen, these alternatives have different speed suggestions, fuel consumption and wavelength. The deck officers choose the route which they deem to be the best alternative depending on fuel consumption, speed and wavelength. Important to note is that no matter which alternative route the officers choose, the ETA will still be the same to quay. The difference between the selections will be speed, fuel consumption and wavelength.

2.5.6 Route

Figure 3: The chosen route between Immingham and Gothenburg (DFDS, 2023)

The figure above (see Figure 3) shows the chosen route for this research project. The reason this route was chosen depended on several factors that had to be fulfilled. Factor 1, the commodity of the route had to include container units as that is one of the delimitations of this research study. According to the shipping line (DFDS) both bulk and tank containers occupy the route, thus fulfilling the first factor.

The second factor had to do with availability, the vessel from Immingham arrives 09:00 every day except for weekends and mondays (see Figure 4). The other routes arriving Gothenburg had nightly arrival times or times which varied during the week. Since the authors had access to the Gothenburg terminal during day time, the Immingham route which had the most morning arrivals was found to be best suited. This made it possible to map all the processes from discharge of units to collection of units. Would a route have been chosen which had evening or night time arrivals it would have been far more difficult to map all processes. In addition, Gothenburg RoRo Terminal claims the Immingham route would benefit the most from this case study as the heaviest terminal congestion happens on Monday mornings following its arrival.

It is of note that the containers that arrive on the Sunday vessels arrive in the afternoon and since the vessel does not depart until Monday evening the cargo handled on Sunday is handled at a significantly slower pace, so the discharge data for the Sunday vessels was not included in the case study.

The total amount of containers that were observed during the 2 month period was 439. The authors used the data for 359 of those containers to ensure better data quality. The 80 containers that were discounted were all from vessels that arrived on a Sunday. Following the systematic mapping portion of the project the authors came to understand that the containers that are moved on Sundays follow the same process, but at a much slower pace. The Sunday containers arrive in the afternoon and since the vessel does not depart until Monday evening the work pace is significantly reduced. Therefore the authors deemed that withholding these times from the results would benefit data quality. Additionally, all container data collected and analysed was first approved by the shipping company and the terminal.This project was subject to a Non-Disclosure Agreement (NDA), which defined what can and cannot be in this report. The authors held to this legal agreement throughout the entirety of the project.

Figure 4: The arrival times into Gothenburg from the Immingham route (DFDS, 2023)

Arrival times from Immingham into Gothenburg	
Wednesday	09:00
Thursday	09:00
Friday	09:00
Saturday	11:00
Sunday	17:00
Tuesday	09:00

The next step in the case was to observe how long it would take for the container unit to proceed through all the steps and processes in the terminal. The systematic mapping (mentioned above) was used for this sake.

Complementing the systematic mapping, quantitative data was gathered from the terminal operations system (GTMS). This data showed the different event statuses along the entire process and made it possible to track a container’s journey from unloading of the vessel and all the steps processes in between until collection. More specifically the data from the system showed how long it took for the container to proceed through the different steps in the terminal. Discharge data from the system was taken from the month of January 2023 & March 2023. These months were chosen as December did not have a normal sailing schedule due to Christmas and New Year, February was not chosen due to bad weather throughout the month which resulted in heavy delays. These heavy delays affected the timings to such an extent that the data seemed unusable. Another reason for selecting these two months had to do with them containing new updated data which showed the current state of the operations. With this information, calculations could be made to get an average time through the different steps and see what affected the times. In addition, to see what events triggered certain delays or disruptions along the steps and for possible solutions to be found. Access to this data showed to be crucial as it provided event based information which could not be accessible elsewhere.

The systematic mapping explained the steps the container proceeded through along the process but did not give precise information regarding the time it took to complete the process.

Internal documents have also been used in the results section, and have been approved by the shipping company for use in this report.

2.6 Analysis framework

This section will describe how the authors analyzed all the data collected in this thesis.

As stated previously, this project utilises a mixed methods approach due to its potential benefits when it comes to verification and analysis (Yin, 2014). The main data collection strategy is that of a case study and as described by Yin (2014) there are five different techniques for analysing a case study. This thesis will use the method of Explanation Building, which focuses on the analysis of case study data by building an explanation about the case (Yin, 2014). Since this thesis uses a single case study to extract data, it can be used to "explain" a phenomenon using a presumed set of links. The set of links used in this thesis are determined during the theoretical framework portion of the project. Once the systematic mapping process is finished the remaining data collection can be used to "explain" comparing against the determined links (Yin, 2014).

Additionally, the authors will utilise triangulation during the analysis of data. According to Denzin (2017) the importance of triangulation cannot be underestimated as it ensures reliability and validity of the data. Since various forms of data were collected from differing sources, i.e., interviews, questionnaires, and quantitative container data the type of triangulation used is methodological triangulation, specifically mixed-methods design (Denzin, 2017). An advantage of using this type of triangulation is it reduces deficiencies from the different methods used. Denzin also warns against the complexity that comes with mixed methods, since there are multiple data collection strategies (Denzin, 2017).

3 Theory

This chapter introduces the necessary theoretical framework for this study.

3.1 Maritime Transport

Maritime transport plays an important role in world commerce with 10.7 billion tonnes being reached in 2017 (Sanchez-Gonzalez et al., 2019). In the same year 80% of international trade by volume was carried by sea (Psaraftis, 2019). Merchant shipping stands for a third of the total maritime activity and can be divided into three segments, dry bulk, liquid bulk and container shipping (Stopford, 2008). Coal, iron ore, and grain are examples of raw materials that are transported by dry bulk transportation. Liquids including crude oil, chemicals, and liquefied natural gas are all transported through liquid bulk transportation. Transporting manufactured items in standardised containers is done through container shipping (Notteboom & Rodrigue, 2005).

Maritime transport is the preferred way of transportation in international trade as it is twenty two times cheaper than air transport, three point five times cheaper than rail transport and seven times cheaper than road transport (Keceli et al., 2013).
According to Stopford (2008) a container vessel is designed to solely carry containerised units. The size of these vessels are often defined by their cargo capacity, measured in amount of TEU (Twenty-foot-equivalent unit).

Roll-On Roll-Off (Ro-Ro) shipping is a method of goods transportation in Europe when it comes to short sea shipping (SSS) due to the extensive coastlines the continent has to offer. The North Sea area is strongly present by Ro-Ro vessels as the distance between the countries are shorter via sea than road (Paternina, 2019). In 2017 over 1.8 billion tonnes of goods were transported through short sea shipping in Europe, falling just below containerized goods.

Ro-Ro shipping operates between two fixed ports on a weekly or even daily schedule depending on the service. However, some services include port calls consisting of 3 to 10 ports in a round trip. (Paternina, 2019). One advantage with Ro-Ro shipping is the flexibility of choosing ports to call since there are no crane requirements for handling of goods, which is needed for container vessels. This allows for a far greater selection of ports to choose from and makes it easier for setting up new routes. (Paternina, 2019.) Ro-Ro ships are loaded horizontally as the cargo is either towed onboard (trailers & containers on wheels) or driven onboard (cars, buses, lorries), this provides cheap and safe movement of cargo (Keceli et al., 2023). The horizontal loading enables for effective and fast cargo handling in ports which also implies low transhipment costs (Christodoulou, 2019). In addition, port dwelling time is reduced as cargo can quickly be discharged from the vessel and collected by a tractor awaiting the arrival. (Zheng, 2021). Furthermore, the RoRo handling allows for quick shifts of modal transport from sea to road. An important aspect when it comes to competitiveness (Zheng, 2021). In contrast, container vessels require their units be lifted on/off with cranes (Christodoulou, 2019). The vertical handling of containers in the loading/unloading phases possess strain on the cargo loaded and taking into consideration the quicker discharge time of a RoRo vessel there is a need for quick and seamless multimodal transport. (Zheng, 2021).

Short sea container shipping is a large competitor to the Ro-Ro shipping segment but also road transport offers competition. Because of this, customers are offered short transit times and reliable schedules as a way to gain market shares (Paternina, 2019). Short sea shipping is represented as an environmentally friendly, safe and energy-efficient alternative for road transport. (Christodoulou, 2019).

Northern Europe, including Scandinavia, UK & continental Europe accounts for roughly 38% of the total European RoRo market. (Christodoulou, 2019). The most common cargo commodities on this market are automotive, electric equipment, forestry, food and drinks. The sufficient cargo volumes in Scandinavia enables high frequency of departures and also high utilisation. Frequency and utilisation are two factors which are essential for the economic feasibility of RoRo. (Christodoulou, 2019). According to Morales-Fusco et al. (2012)(2013), Ro-Ro becomes competitive when the value of the product increases and the volume of goods is stable.

Countries with long shorelines or many islands have short sea shipping as a major transportation mode (Jia et al., 2022). According to Baylon & Dragomir (2022), SSS can be defined as "carrying cargo or people to or from a destination that is not across an ocean". Whereas, Brooks defines SSS into "coasting trade, regional shipping, or marine highway." It involves transporting people and or cargo across relatively short distances along coastlines, rivers and lakes to different points (Baylon & Drogomir, 2022). These points can be domestic as well as international. The transportation mode offers a sustainable link in the door-to-door supply chain and forms an integral part of the European transport system (Baylon & Drogomir, 2022).

Nearly forty percent of domestic goods are done by sea, the road industry tops this with its forty five point six percent being transported (Morales-Fusco, Sauri & De Melo, 2013). Road transport is more flexible than SSS but a major advantage with sss in Europe is that it can take great volumes of goods traffic off Europe's congested roads (Baylon & Drogomir, 2022). In addition, SSS produces fewer polluting emissions than any other transportation mode. Consequently, SSS has the potential to grow in freight volumes without impacting negatively on Europe's congested roads at the same time being more environmentally friendly (Baylon & Drogomir, 2022). Further advantages with SSS is that there is no need to add infrastructure, whereas other transport modes such as road and rail requires expansion and construction of infrastructure, which is expensive and also disturbs local residents. (Baylon & Drogomir, 2022). However, there are also some drawbacks with SSS, shippers deem the transportation mode to be less reliable than road and therefore unless time and cost is reduced the mode is not considered (Morales-Fusco et al., 2013). SSS in cooperation with RoRo does solve the issue with time as they reduce turnaround times and when operation in terminals devoted to RoRo the highest performances are achieved (Morales-Fusco & Sauri, 2010).

In a study comparing SSS to road transport the result indicated that sss attains the best performance as long as some points are fulfilled, one being reliability (no delays in arrivals and departures, no bottlenecks.) (Morales-Fusco et al., 2012). Furthermore, the time cargo spends at the terminal is also an important aspect when it comes to competitiveness of sss. (Morales-Fusco et al., 2012).

Since all cargo is loaded horizontally onto a Ro-Ro vessel, the traditional way of loading containers is not possible (Zheng, 2021). Because of this the containers must be placed on handling equipment such as Mafi (Mobile loading platform, usually referred to by a brand name)(Morales-Fusco & Sauri, 2009) or cassette (Pönni, 2021). This is prepared in the terminal yard by a reach stacker which places the container unit on a Mafi or cassette before being loaded onto the vessel. When the unit is due to be loaded onto the vessel a terminal tractor transports the prepared unit from the yard, during discharge it's the same routine but reversed (Pönni, 2021).

3.2 Supply Chain Management

As described by Jonsson (2008), logistics or the management of companies' supplies of materials, production and distribution, is often a key factor in attempting to meet customer needs efficiently and also creates competition. Supply chain management (SCM) has according to Leggate et al. (2004) the potential to create more value for shareholders beyond lowering transport costs or labour and integrating supply chain processes. Leading edge companies today do not compete against each other as company versus company but instead supply chain against supply chain (Leggate et al., 2004). SCM can be defined as the philosophy to manage the "flow of a channel from the earliest supplier of raw material to the ultimate customer, and beyond, including the disposal process" (Leggate et al., 2004). Competitive advantages can be won by coordinating among the various actors in the supply chain; this requires a high degree of integration between supplies of goods and services with manufacturers (Leggate et al., 2004).

3.2.1 The Role of Ports

The modern port does not only conduct basic activities such as throughput of goods and passengers, new processes have developed recently creating more value (Leggate et al., 2004). These processes have to do with intermodality and diversifying into logistical areas (Demirbas et al., 2014). Ports can be seen as a vital component link in a global logistics system (Leggate et al., 2004)(Demirbas et al., 2014). They are the foundation of transport networks and provide opportunities to improve organisational efficiency and reduce cost (Demirbas et al., 2014).

Increased competitiveness and demands from stakeholders has encouraged ports to become more efficient, applying lean and agile processes to their operations, moreover, implementing a general approach to the supply chain (Demirbas et al., 2014). In addition, ports now try to create new markets in order to increase global competition (Rodrigue and Notteboom, 2009). Moreover, Keceli et al. (2013) writes that if sea ports cannot increase their operational efficiency they have to lower their prices in order to stay competitive. It is crucial for sea ports to be efficient, not only for profitability and productivity of the port itself but also for the sake of the country's economy and competitiveness (Keceli et al., 2013).

An area within ports is that of Port Operations. The operation of a port terminal can be divided into four subsystems: loading and unloading from or to the vessel, transfer from the berth to the storage area, storage, and lastly delivery and receipt (Morales-Fusco & Sauri, 2009) (Morales-Fusco et al., 2013). These four subsystems can then be divided into two interfaces, one being the seaside or quayside interface, and second being the landside interface (Ramírez-Nafarrate et al., 2017). The seaside interface includes loading and unloading vessels whilst the landside interface involves receiving and dispatching cargo from external trucks and rails (Ramírez-Nafarrate et al., 2017). There are also internal links through the diverse activities within the port which are efficiency enhancing (Leggate, 2004). Port logistics plays a crucial role in supply chains and the global economy as they usually serve several supply chains by changing transportation mode of transit cargo (Triska et al., 2022). For example, container terminals link sea transport to land transport via trucks and trains (van Asperen et al., 2013). Many different stakeholders are included in a port terminal for example, shipping companies, port operators, port agents, regulatory bodies and freight forwarders (Ringsberg & Lumsden, 2016).

A port authority runs the port as a physical entity, which can be divided into two groups (port users and service providers) (Leggate et al., 2004). The users consist of shippers, shipping companies and industrial concerns which are operating inside the port. Service providers are pilots, agents, towage, forwarders, suppliers, stevedores and more. Their purpose in the port is to provide a paid service to the shipping companies whilst paying the port authority for a concession (Leggate et al., 2004). All these different actors and parties within the port have their own objectives and with that comes a degree of heterogeneity (Leggate et al., 2004).

3.2.2 Ro-Ro Terminal

Padolak & Khan, (1979) presents that a Ro-Ro terminal should be seen as a system consisting of subsystems that are highly interactive. These subsystems must be optimised to increase the performance of the entire system and to avoid possible bottlenecks (Morales-Fusco & Sauri, 2009). By seeing a port terminal as a large system it simplifies the understanding of all the processes involved and also how to improve the processes. In addition, this approach helps determine the capacity of each subsystem and also the terminal as a whole (Morales-Fusco & Sauri, 2009). In the previous heading it was mentioned how the operation of a port terminal can be divided into four subsystems. A Ro-Ro terminal's operations can also be divided into subsystems, however, it is divided into three subsystems instead of four. The transfer operation is merged into the other three subsystems (Morales-Fusco & Sauri, 2009).

RoRo terminals usually work in cooperation with SSS lines who follow a predetermined schedule and therefore the arrival times are planned in advance (Morales-Fusco & Sauri, 2009). RoRo terminals like other terminals operate with yard management. The yard is the area of which cargo units are stored waiting to be loaded onboard a vessel or to be collected by truck (Morales-Fusco & Sauri, 2009). The amount of stevedoring time spent outside the ship is referred to as "Yard Time" (Morales-Fusco & Sauri, 2009). This includes the time it takes to transport a unit from the vessel ramp to the storage area and also the distance within the storage area itself (Morales-Fusco & Sauri, 2009). In addition, the time required to fetch and unfetch cargo is also calculated in the yard time. Moreover, the size of the yard itself impacts the time as smaller yards might not be able to store all units which means they will have to be placed elsewhere. Thus increasing the transport distance which takes more time and a result of that is a higher yard time variable (Morales-Fusco & Sauri, 2009).

3.2.3 Truck Appointment System

Truck Appointment System also referred to as (TAS) is a system in which customers are assigned a time slot of when they can collect their unit from the port terminal (Ramírez-Nafarrate et al., 2017). The objective of a TAS is to spread out the arrivals of trucks throughout the day and by doing so minimise congestion in the port terminal (Ramírez-Nafarrate et al., 2017). The peak amount of trucks entering the terminal is often a result of vessel activity which causes trucks to arrive simultaneously (Davies, 2009). An advantage with a TAS is that the port terminal can improve its service level to hauliers by planning its yard resources more effectively as the jobs are spread throughout the working day (Davies, 2009).

This eliminates peaks and enables an improvement in the predictability of truck processing transactions, thus allowing effective utilisation for deployment of machinery to load and unload trucks (Davies, 2009). However, for TAS to work most efficiently it requires cooperation and collaboration between the trucking operations and port terminal (Zhao & Goodchild, 2010). In a study performed by Morais & Lord (2006), the TA system had a disappointing result due to the inability of hauliers to plan trips. However, if trips can be planned better, the cooperation and collaboration necessary between the terminal and hauliers can be done by simple measures such as phone calls which does not incur much effort or cost but does improve the operation of container rehandles (Zhao & Goodchild, 2010).

Advanced knowledge of a truck's arrival is necessary, the challenge with road transport by truck is that the mode of transport is the least coordinated (van Asperen et al., 2013). Posing a problem when it comes to the accuracy of the given information, if it is even given at all (van

Asperen et al., 2013). If the advance information regarding the truck's arrival is accurate and correct, preparation work for collection can be done prior, thus when the truck does arrive the container unit is already prepared and therefore minimises the truck's time inside the terminal (van Asperen et al., 2013). In a study performed by van Asperen et al. (2013) the preannouncement of truck arrivals had significant benefits. However, if the preannouncements are too early or too late the benefits are reduced. According to the above mentioned authors study an average announcement time of 0.5-24 hours significantly improves the efficiency. Even an announcement of 4 hours provides benefits to the operations (van Asperen et al., 2013). Furthermore, since the collection date is known it allows the terminal to perform unproductive moves during off-peak hours, preparation work can also be done in advance to speed up the process (van Asperen et al., 2013). For the terminal operations a TA system can provide significant benefits. However, from the haulier's perspective the method of having to book a time slot to collect your unit will decrease the flexibility and by doing so may have a negative impact on customer service (Davies, 2009). Another disadvantage is the fact that hauliers can "block" other hauliers by booking all preferred times, thus gaining a competitive advantage (Davies, 2009).

3.4 Information and Communication Technologies (ICT)

Also expressed as information technology (IT) is about integrating communications between computers, software and storage. to enable users to store, access, transmit and understand information. (Whitson, 2020). IT is growing to be more complex in today's society where artificial intelligence, interconnection, digitalization and mobility are some key factors (Piattini et al., 2019). The maritime industry is far behind the other transport industries when it comes to digitalization. According to Sanchez-Gonzalez et al. (2019), the maritime industry has a share of less than 25% in interorganizational information systems (IOS). In comparison, organisations involved in Hinterland Transport have a share of more than 70% in IOS. Whilst other economic industries are heading towards digitalization for pure survival, the maritime industry is in its early stages (Sanchez-Gonzalez, 2019). According to Bâlan (2020), recently the transport and logistics sector were the fastest to adopt the data-driven technologies over any other sector. A lot of these adoptions have to do with automation and connectivity in the maritime industry, with the use of internet of things (IoT), big data and cloud computing (Bâlan, 2020). It is forecasted that the implementation of these technologies will increase productivity, reduce cost and improve quality (Almotairi et al., 2011). In addition, ships will be more efficient, reliable and closely integrated into the global supply chain (Lind et al., 2021). Other areas of use are big-data calculations, digital modelling and remote control. (Lind et al., 2021).

Port terminals can gain competitive advantage by using collected data with the help of IoT to improve their operations. This had led to ports becoming so called "smart ports" which includes enabling just-in-time (JIT) operations, becoming an information hub and providing predictability with timings of operations during a port visit. (Lind et al., 2021). Furthermore, smart ports initiative can improve infrastructure monitoring, customs information, cargo handling operations productivity, energy consumption and more (Triska et al., 2022).

There comes a challenge with implementing digitalisation of the maritime sector and that is to have a common, interoperable data standard. The risk is that shipping companies and ports of strategic locations implement their own systems and procedures and not common shared ones. (Lind et al., 2021). Considering maritime transport is part of the global supply chain, the consequences of not having common systems is that the supply chain cannot be fully integrated. Therefore, there is a need for data sharing to be standardised so the full potential of IT can be achieved. (Lind et al., 2021). Moreover, lack of information exchange will negatively impact a port terminal's logistical efficiency (Ringsberg & Lumsden, 2016).

As mentioned above IT is about transmitting and understanding information being exchanged. Furthermore, the quality of the shared data must also be reliable (Pontrandolfo & Scozzi, 1999). For the parties to be able to coordinate efficiently and precisely, they must be able to rely on a third party's shared data. (Lind et al., 2021). In other words, it is not enough to just share data. Instead, for the sake of all actors the data shared amongst them must be of high quality with great reliability.

This again confirms the need for standardised data and one area in the maritime domain that requires attention is the When, Where, Who, What, Why and How dimensions when capturing event related information (Lind et al., 2021). Also, shipment tracking and tracing is enabled using ICT (Leggate et al., 2004). This plays an important role as affected actors depend on that data to make decisions for their operations which increases safety and efficiency. Moreover, to create value for society and individuals. (Lind et al., 2021).

According to Sauvage (2003), technological effort plays a crucial role in a highly competitive business and is a significant tool for differentiation of logistics service providers. Furthermore, the technological capabilities may create more effective flow integration in the supply chain and at the same time leverage transport and logistics services. Other advantages with ICT in the supply chain is the assurance of maintaining competitive lead times with the help of the capabilities gained from ICT (Leggate et al., 2004).

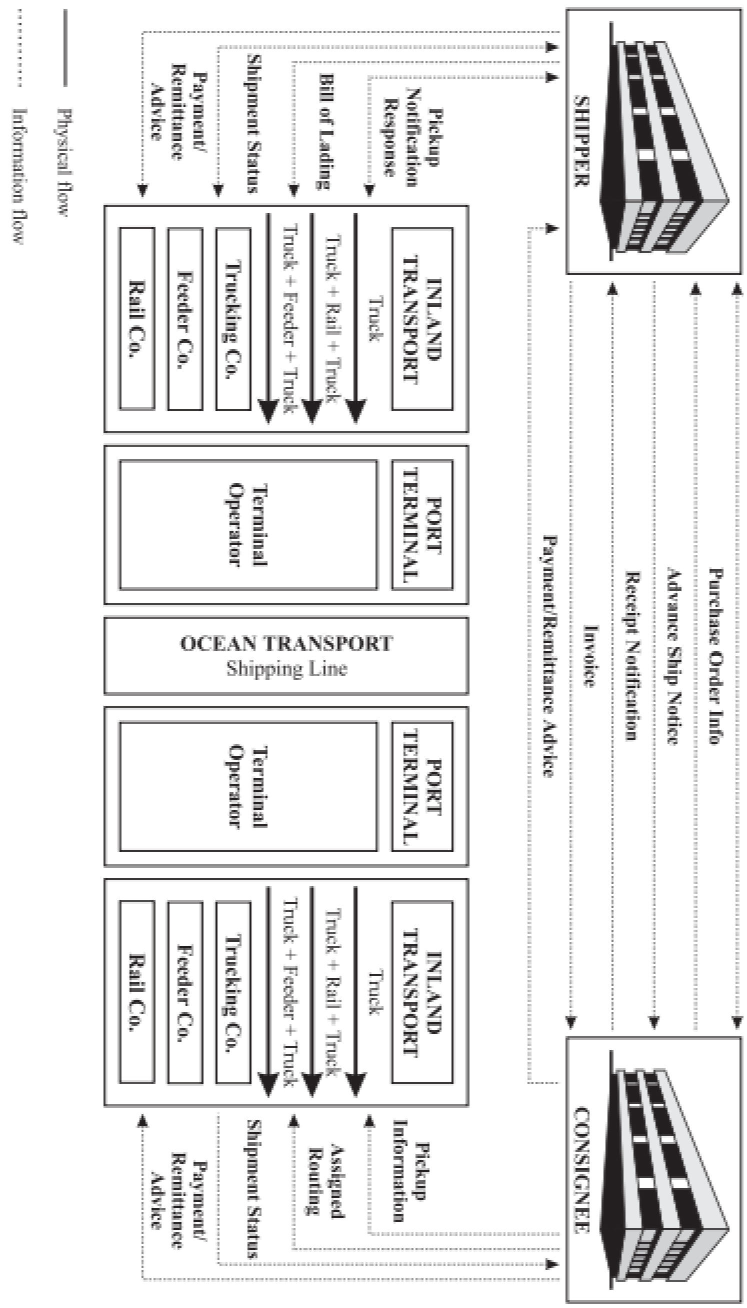
Transparency of the transport and logistics operations are important for the customer as this enables them to monitor performance and assure product availability, something which is possible with ICT (Leggate et al., 2004). ICT has the potential to enhance coordination between carriers, shippers and their supply chain partners (Leggate et al., 2004). Moreover, with the help of ICT real time information such as delay alters, en route tracking, order/shipment initiation can be transmitted via the internet (Leggate et al., 2004). Visibility and communication in information exchange is greatly improved with the help of ICT, this also enhances the efficiency of logistic operations (Demirbas et al., 2014). The maritime industry has strong EDI systems internally but lacks external electronic links to customers and other supply chain participants, compared to delivery companies who are making fast progress in implementing ICT (Drewry, 2000). EDI is greatly important as it according to Paik and Bagchi (2000) improves logistics efficiency by improving customs clearance, reducing lead time and paperwork.

Leggate et al. (2004) mentions areas of logistical deficiencies within the maritime industry, first being lack of transparent information regarding tracking movement of goods in the supply chain. Secondly, reactive supply chain management and workflow and procurement inefficiencies. According to Leggate et al. (2004) just-in-time (JIT) logistics principles are contrary to the supply of maritime transport. The authors mention that the characteristics of maritime transport do not match the demands of JIT logistics, such as high speed compared to the maritime transport's slow speed. In addition, JIT requires on time deliveries in small batches, usually <2 hours production, whereas maritime transport carries large batches and is affected by climatic disturbances and other factors leading to an unreliable service (Leggate et al., 2004).

Maritime transport directly includes several actors and stakeholders in the supply chain such as shipper, modal transport providers, intermediaries, intermodal facility operators, port terminal operators and consignees (Leggate et al., 2004). They all perform activities along the supply chain and therefore are in need of information regarding the activity they are to perform. According to Bender and Smith 1998 the information flows are divided into two types: firstly information flows regarding the planning of transport and lastly; information flows related to the execution of transport. The figure 6 (see figure 6) shows the two information flows and how they affect the different parties in the supply chain. Including, booking transport, invoicing, sending bill of ladings, planning inland transport, providing an estimated time of arrival (ETA).

Leggate et al. (2004) describes the ocean transport industry as an information intensive nature with a large number of documents produced and exchanged during an international shipment. The authors further add that due to the high amount of actors involved in the shipment of containerised goods, information is reworked several times leading to inefficiencies, costs and potential mistakes. These drawbacks should encourage and motivate the implementation of information technology (Leggate et al., 2004).

Figure 5: Information flows and documents in an international shipment (Bender & Smith 1998, page 67)



As freight forwarders are requiring further improvements of track and trace information, it puts pressure on the port industry to widen their role in the supply chain. Instead of focusing on traditional interface with the ship, port terminals are now encouraged to a more logistical orientation of their activities (Leggate et al., 2004). Thus, the landside activities involving port operations will have to implement information technology to extend the information flow as mentioned above and in Figure 5 (see Figure 5).

3.4.1 Semantic Interoperability

Semantic interoperability is the ability of different information systems to share data and communicate effectively, even if they use different terminology or formats (European Commission 2017). In the shipping industry, this is important because it allows different stakeholders, such as port authorities, shipping companies, and cargo owners, to exchange information and work together smoothly. (Cauwer et al., 2021).

However, achieving semantic interoperability in the maritime sector can be difficult because of the complexity and diversity of the information that needs to be shared (Cauwer et al., 2021). For example, a shipping company might have to provide the port authority with information about the vessel's cargo, expected time of arrival, and location. This information can be presented in many different ways using different data formats and standards. (Cauwer et al., 2021). In addition, the lack of semantic interoperability between the different actors and stakeholders minimises the implementation of information technology in general (Leggate et al., 2004).

Using standards helps to ensure that everyone can interpret and use the information consistently (Fabbe-Costes & Jahre, 2008). In addition to standards, achieving semantic interoperability in the maritime sector requires the use of shared ontologies and vocabularies. An ontology is a formal representation of a domain of knowledge that defines the concepts and relationships that are relevant to that domain. By using a shared ontology, different information systems can use the same words to represent and exchange information. (Cauwer et al., 2021) The use of XML standard between actors and stakeholders may improve the interoperability between their systems which is crucial for supply chain integration (Leggate et al., 2004).

To conclude, semantic interoperability is a major challenge in the shipping industry because it is vital for enabling different stakeholders to communicate and work together effectively. To overcome these challenges and allow for efficient information exchange, the use of standards, ontologies, and shared vocabularies is necessary. (Cauwer et al., 2021)

3.5 Estimated time of arrival (ETA)

The term, Estimated Time of Arrival, is commonly used within international communication contexts, which defines a calculated estimation of physical movement and arrival of specified object, vehicle, or services (Rami & Yuriy, 2021). A vehicle or vessel's anticipated arrival time at a particular location is referred to as the "estimated time of arrival" (or "ETA" in transportation and logistics). The distance to be travelled, the mode of transportation, and the current traffic or weather conditions are often taken into account when calculating the ETA. (Altexsoft, 2021).

Accurate ETAs are crucial for route and schedule optimization in the context of transportation planning and management, as well as for making sure that customers and stakeholders are aware of anticipated delivery times. (Altexsoft, 2021). Stakeholders such as goods-owners, customers, and freight forwarders use the arrival estimates for an approximation of when their goods will arrive at the pickup location (Rami & Yuriy, 2021).

ETA can in addition be applied to non-physical tasks, such as computerised services. Further examples where ETA is commonly employed is in navigation systems, logistic tracking systems, as well as aviation and maritime traffic systems (Harmelink & Veenstra, 2021). The definition of ETA can be implemented and utilised in various segments and applications. As such, ETA refers to the duration of a specific trip and the estimated time when the trip is expected to end (Rami & Yuriy, 2021). On the other hand ETD is the opposite of arrival times, as in it is an approximation of when the goods are ready to be picked up (depart) by the transport carrier for delivery or the next leg of transport (Fabbri & Vicen-Bueno, 2021). It marks the estimated starting point of the transportation process, which in some instances repeats and allows for another Estimated Time of Arrival (Fabbri & Vicen-Bueno, 2021).

In the realm of maritime and port logistics, ETA plays a crucial role in determining cargo delivery and reducing costs associated with logistical activities (Harmelink & Veenstra, 2021). Considering the maritime logistics domain, forecasting ETA is of great interest as it enables organisations to organise and prepare for upcoming activities related to a ship's arrival. The ship's arrival is one of the first ETAs reported and as such affects follow on operations if it is inaccurate (Alessandrini et al., 2019).
Container supply chains are complex environments that are characterised by a dynamic range of parameters and stakeholders. As such, cooperation and coordination among said stakeholders is pivotal to ensure efficiency in the logistical flow (Hathikal et al., 2020). Some repercussions of an inaccurate ETA for a vessel's arrival are increased challenges for terminal operations to estimate the required resources, leading to undesirable activities and increased costs (Alessandrini et al., 2019).

4 Result

In this chapter the results from the interviews, questionnaire and case study are presented.

4.1 Interview Result

The results from the interviews are presented in categories and also summarisations from the answers received. From the interviews it was found out that the terminal conducts several operations for the handling of containerised goods. Therefore, this section has been divided up into the different operations which take place and also affect the handling of containerised cargo. The first operation is the discharge of vessel, which can be read under section 4.1.1. This is then followed by yard operations which can be read in section 4.1.2. The other sections in this chapter were influenced by the research questions and also literature that was used in the theoretical framework.The list of interviewees can be seen on Table 1.

4.1.1 Discharge of vessel

From the interview with a terminal operator (respondent 1) it was found that several factors impact the discharge time of a vessel. The first factor that affects the discharge time is the stowage plan from Immingham, according to the interviewee. The issues have to do with clarity as the stowage plans provide more of an overview of the loading scheme rather than a detailed map (see figure 7). Respondent 5 discusses stowage plans as being important since they inform the terminal of what equipment is necessary for discharge. Information such as what kind of unit is loaded next to the ramp and the quantity of that type:

"There are 37 cars, two mobiles, six self drivers. But where are they? Are the cars in the aft right next to the ramp? Are the trailers in the aft? What will we see when the ramp lowers? Will I notice that? Okay, every guy in a tug master will need to exit the tug master because there are 50 cars in the aft that need to be discharged before we can start pulling off trailers." According to respondent 5.

This information is critical as there is a huge time loss when the terminal does not know how the vessel is loaded since no discharge plan can be made, without a discharge plan the operation is severely worsened. The worse the stowage plan is, the worse the result of the discharge will be as said by respondent 5. Production starts instantly when the vessel arrives so if the stowage plan is accurate and provides a good overview then a better plan can be made and fulfilled accordingly:

"The Stow plan is important and the worse Stow plan there is the worse result you get…
… So yeah, the Stow Plan is important for discharge." According to respondent 5.

Another factor which impacts the discharge time according to respondent 1 are machines (forestry, agriculture, construction) loaded onboard. Due to the size and operation complexity of the machines it's difficult for the terminal to know how long it will take to discharge the unit. It's found that some machines are strenuous to start, in some situations the machines will have to be pulled off or even sent back to Immingham as the terminal cannot get the unit unloaded. Units loaded behind the machine cannot be unloaded due to the machine blocking the exit, depending on where onboard the vessel it is loaded. According to respondent 1, machines are the biggest factor to an uncertain discharge time and a recommendation to decrease this uncertainty would be to have manuals in the machines which informs the terminal on how to operate the unit.

Respondent 1 and 5 highlighted Identification issues of units as a third factor, which impacts the discharge, more specifically the number identifying the unit which the customer used to book. This number could be the registration number of a trailer, car, truck. This can also be the serial number of a machine, bus, car. or in fact the number written on all four sides of the trailer. As the unit number of a container is standardised and the identification issue raised above is for other cargo types than container, the result is not relevant for this research project but worth mentioning.

Respondent 5 discusses the importance of knowing where onboard the vessel a unit is located and how this impacts the discharge time. If you don't know where onboard the vessel a unit is located, it is difficult to estimate how long it will take to discharge the unit. The interviewee brought up a random town and asked how long it would take to drive there. None of the writers knew how long it would take to drive to this town as none of them knew where it was located. Which is the point respondent 5 wanted to make:

"So you see my point there really. If you don't know where it is, you can't tell how long it would take to get to it or to discharge it. In the case of that, the more exact location you have will of course make it easier to determine how long it will take to discharge the unit." According to respondent 5.

In addition to location, the operational discharge speed also impacts the discharge time. Saving timestamps on how long it takes to discharge a unit from a certain area onboard, statistics could then be used to calculate more precise discharging times. The more statistics you get the more accurate the timings will be. This will allow for pace calculations and also real time data as it would be possible to see if the tempo is above or below the usual average:

"Of course, the average time, you can never get the exact time, but you can always also compare the current pace with the average time from each and see that you are probably okay. The average discharge time for this unit is, let's say one and a half hours, but at the current pace it probably will be discharged in 1 hour and 50 minutes." According to respondent 5.

Respondent 3 adds their appreciation of timestamps by adding to above that the time it took to load the unit to that specific location should be the same when discharging. The sequence the unit will be discharged will be either similar or at least close to similar as the loading sequence, it's difficult to use a different sequence. For this reason, respondent 3 approves of the timestamp method.

"It's hard to take them in a different sequence. You have to load them in the sequence, you have to discharge them in the sequence." According to respondent 3.

Lastly, the interview also provided information regarding how a container unit is unloaded from a vessel and then handled internally before being collected by the customer. Firstly, the unit is pulled off the vessel and stored temporarily in an area called "B1", this area is located next to the vessel and acts as a temporary storage yard before the units are moved internally. When available, the container gets transported from "B1" to an area known as "LP" where a reach stacker will unload the unit from the cassette carrier and place it in the container yard. It's first when the container has been placed in the container yard that the customer can collect the unit. This information is sent out to customers who have signed up to receive it, more specifically a text message is sent to the mobile phone number of which the customer has provided.

4.1.2 Yard Operations

The absolute best discharge scenario would be for a containerised unit to be unloaded from the vessel and transported directly to the yard (LP) for handling. Where a reach stacker would remove the unit from the cassette or mafi, and directly load the container onto a waiting truck. This would entail the fewest number of lifts and also horizontal transport of the unit. However, respondent 6 claims that this scenario has become more rare since the new sailing schedule was introduced this year. Most often the discharge of the vessel must be rushed, meaning containerised units loaded onboard will be pulled off to the B1 area and left waiting. If there are enough resources there will be a terminal operator transporting the lift units from B1 to LP throughout the discharge operation. Though, if resources are lacking or being used somewhere else, it might be that the lift units are not transported until the discharge operation is completed.

"*Sometimes we have somebody who takes the lift units directly from the vessel to LP, this all depends on the resources available and the discharge scenario." According to respondent 6.*

LP is a relatively large area and everything located there gets the location status of "LP", except those units that have been placed in stacks waiting for collection or preparation for export. One suggestion made by respondent 6 would be to define LP further, more precisely the part of LP where the import units get stored when arriving from the vessel discharge. Respondent 6 claims that if the part of LP where the import units are stored temporarily before being placed in stacks waiting for collection, is divided up into four lanes for example, LPI-1, LPI-2, LPI-3 & LPI-4, where the "I" stands for import. The different lanes can be categorised depending on the priority of the goods, more specifically the order containers are handled at LP. E.g, if a unit is placed in LPI-1 it should be given the highest priority of all other goods. This then enables lift units to be prioritised depending on which lane they are located in and also means that the operator of the reach stacker at LP doesn't need to search for specific units. Instead, they can directly handle the units as per the different prioritisation lanes.

Finally regarding yard management, respondent 6 believes more of the work being conducted at LP should be tracked. One way of doing this is to increase the amount of work orders, even tasks such as moving a cassette or mafi a couple of metres should require work orders. By increasing the amount of work orders and tracking the work being conducted at LP it will be according to respondent 6, easier to discover trends, bottlenecks, high and low peaks. This then enables the terminal to see where and when resources are more needed, rather than having too many resources at the wrong place and time, or vice versa.

"If we can track what's going on at LP and the amount of work being conducted throughout the week it will enable us to see where resources should be spent. Also, errors and deviations can be analysed in a better way".   According to respondent 6.

4.1.3 Vessel ETA Reporting

In the interview held with the captain onboard one of the vessels occupying the Gothenburg - Immingham route information regarding ETA reporting was received. Firstly, the interviewee indicated that as part of the departure process, deck officers report ETA shortly after departing Immingham. This first report is made roughly twenty four hours before arrival. The ETA is reported to Gothenburg RoRo Terminal and also the shipping line's traffic department of when the vessel arrives at the quay in Gothenburg but also when they reach a certain buoy outside of Gothenburg. From the buoy it takes approximately one hour for the vessel to arrive and it acts as a waypoint for the terminal to prepare for vessel arrival.

The vessels sailing the Gothenburg-Immingham route are equipped with a system which, with the input of preferred arrival time, can calculate speed, fuel consumption and wavelength. The system suggests several available route alternatives that can be chosen, these alternatives have different speed suggestions, fuel consumption and wavelength. The deck officers choose the route which they deem to be the best alternative depending on fuel consumption, speed and wavelength. Important to note is that no matter which alternative route the officers choose, the ETA will still be the same to quay. The difference between the selections will be speed, fuel consumption and wavelength.

The Captain in this interview claims that vessels are most often on time and severe delays are very rare. Furthermore, delays in discharge time is more of a result from poor stevedoring rather than vessel being late to quay. Poor stevedoring is explained as units being loaded in certain positions where they perhaps should not have been loaded. Moreover, the stowplans that are received from the stevedoring in Immingham aren't especially clear and act more as an overview (see figure 6). For comparison reasons, a stowplan made by the Gothenburg terminal is included (see figure 7). This stowplan is clearer and provides more knowledge as to what is loaded in a specific bay onboard rather than just showing an overview of what is loaded in certain areas onboard.

Figure 6: Stowplan from one of the vessels occupying the Gothenburg-Immingham route (DFDS, 2023)

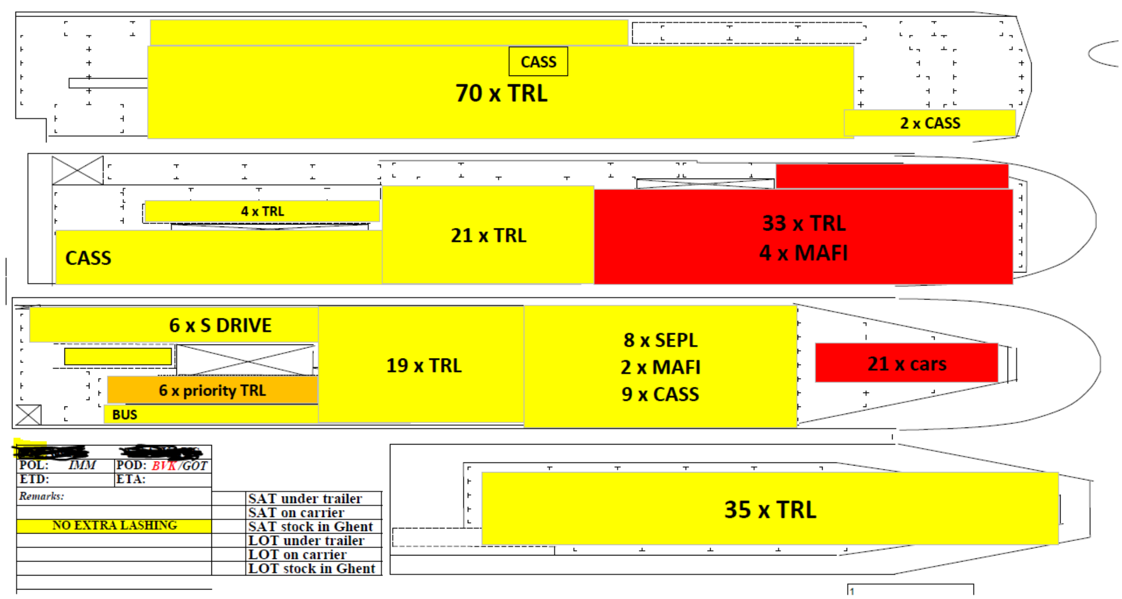
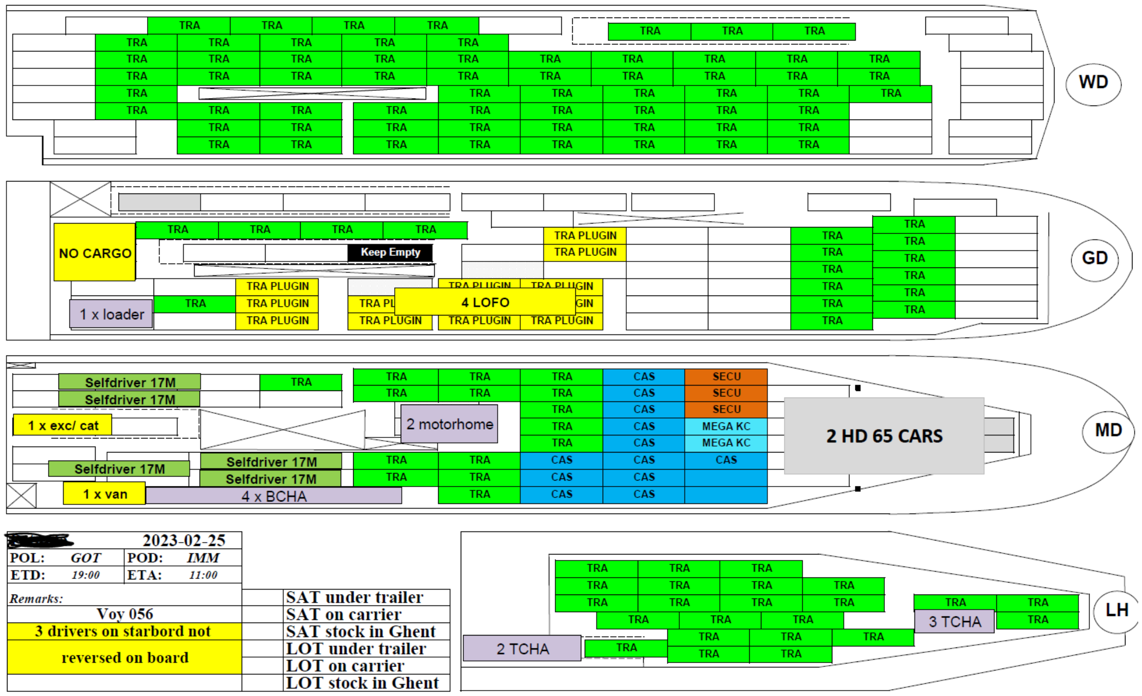


Figure 7: Stowplan from one of the vessels occupying the Gothenburg-Immingham route (DFDS, 2023)



4.1.4 ETA for collection of goods

In logistics and transport, time is money and that's why planning and reducing uncertainties is crucial for freight forwarders. Not knowing when a unit can be collected adds to the uncertainties of the freight forwarders planning and affects the driver's time, which is expensive as an organisation wishes to utilise that time to its maximum.

By knowing when the unit can be collected the driver's time can be planned to a far better extent, for example, if an organisation knows that a unit can be collected 08:00 tomorrow morning, then the driver's day can be more easily planned, what they can do during the night, how far they can drive, where they must rest. It reduces the uncertainties and contributes positively to the planning and timing of operations.

Something else that would reduce uncertainties are the status and event information from the shipping line which informs when a unit can be collected. At the moment for containerised units it is unclear as one event message can mean two different things:

1) Unit unloaded from vessel = The unit is unloaded from the vessel but cannot be collected.
2) Unit unloaded from vessel = The unit is unloaded from the vessel and can be collected.

For the customer it is confusing as they cannot tell if the event message is (1) or (2). This means that the customer sees the event message (1) and sends a driver to the terminal for collection but fails to do so as the unit is not ready for collection. Couple of hours later the unit is ready for collection but the event message will still state the same “Unit Unloaded From Vessel”. However, it is now ready for collection, something which negatively contributes to uncertainties as mentioned above.

Furthermore, freight forwarders believe there is a lack of information and there is a need to have information from one source and not several. In addition, the information must be reliable and come in an early stage so that decisions can be made upon those with confidence.

Respondent 7 describes that time is of essence when it comes to transport and logistics and linked with time is money. Thus, planning is very important and uncertainties to the planning is unwelcomed. Not knowing when a unit can be collected from the terminal is an uncertainty in the planning and therefore it is an issue that the respondent wants to eliminate:

“When you have uncertainty in your planning, which this would be like, to not have any clue which time your units can be collected, that's something that's definitely an issue that you want to eliminate.” According to respondent 7.

In addition, respondent 7 claims the information received from the terminal regarding when the unit can be collected is poor. The information is so poor that it creates more uncertainty rather than clarity. Due to this it is easier for the respondent to plan a collection of the unit for the next day instead, since they cannot rely or depend on the information received:

“We have to plan, like, one day after the unit has arrived at the terminal, if that makes sense. You have a vessel coming in today. You know it's going to be unloaded sometimes during the day, but since we don't know when and when it will be available, it's much easier for us to plan a collection tomorrow.” According to respondent 7.

Furthermore, the information itself is unclear as the respondent claims it is difficult to act on the received information. For example, when the unit has been unloaded from the vessel it doesn’t necessarily mean that the unit can be collected. However, when the unit can be collected the status information is the same, “unit has been unloaded from the vessel”. Respondent 7 cites:

“Yeah, it's off the vessel, but is it really available for pickup? You don't really have more information than that. And again, to avoid actually having to contact the terminal, you'd kind of want another status code there saying available for pickup or not.” According to respondent 7.

Lastly, respondents 7 discusses the importance of not only receiving adequate information but also the value of this being reliable and useful for them. The information should also come at an early stage and not last second update. This is important as it allows them to re-plan their operations and reduce negative impacts on their business:

"That's like a freight forward dream to have certain information early and with certain information, I mean, like secure, you can even know it's going to happen. So it's not unsecure information that you can't act on, if that makes sense, because that's an issue as well. If you receive a lot of information and a lot of contradictory information, you kind of don't know what to act on…
… you don't want an overload of information. You want the correct information at an early stage, like as early as possible." According to respondent 7.

While discussing challenges between the terminal and truck drivers, respondent 8 has a similar response to respondent 7. Respondent 8 expresses that the larger companies are not communicating to the smaller hollier companies about pickup times.

"I think the whole thing is really this with communication between the small the small holiers and the large companies. I talked with one company that driving to Borosa and Ulricham earlier today and asked them if the driver could do a test next week. And he said, well, we don't know how much we have to do next week yet. We know that tomorrow maybe. So they don't know where the boats are coming. They don't know what transport it's very short." According to respondent 8.

4.1.5 The challenges & benefits of providing a more precise collection time.

The challenges and benefits that were found from the interviews are presented in Table 2 below. All factors are described thoroughly in this section and also why they impact the collection time.

Table 2: Showing the challenges and benefits of providing a more precise collection time

Challenges	Benefits
Standardised handling of cargo	Optimised production
Amount of lifting units	Prioritisation
Location onboard	Resources/Operation
Prioritisation	
Amount of actors involved	
Resource peaks	

The interviews provided a result indicating that there are several challenges involved in predicting a more accurate ETA of collection of goods. However, it was also found that benefits are to be achieved by predicting a more accurate ETA of collection of goods. The main challenges cited by the respondents were standardising cargo handling, controlling the large number of lifting units, locating the cargo onboard, knowing which units to prioritise, the amount of actors involved in handling the containerised units, and lastly, the peak in resources caused by vessels arriving. The optimization of facilities, equipment, stevedores, and locations are among the benefits of offering a more precise collecting time. Prioritisation of units can also be advantageous, but it necessitates information sharing and access to those units. Furthermore, with a more precise collection time, customers can optimise their production chains, and the terminal can prioritise units efficiently.

Respondent number 3 claims that a major challenge for a RoRo terminal to provide a more precise collection time for containerised units is to standardise the way of handling cargo. By having a standard sequence of action it would be easier to have a system predict when the unit loaded onto the vessel will be discharged. Furthermore, it would be possible to know exactly how long it takes for the discharged unit to reach the different stages in the terminal. Calculations can then be done to provide a more accurate timing on when the unit is available for collection by customer:

"A more standardised way of handling the cargo. So we know that it always takes a certain amount of time after it has been discharged on the carrier from the vessel." According to respondent 3.

Respondent number 4 on the other hand suggests it is the amount of lifting units arriving on the vessels that is the major challenge. With the high amount of lift units arriving on Thursdays and with the limited number of machines and stevedores to handle those units. It becomes challenging to get all lift units available for collection in reasonable time:

"It's the amount of lifting units being handled for one specific call. I think if we take like Thursdays, we have roughly from 70 to 100 lift units arriving with the same ship and the customer wants to collect them at the same time, more or less. We have a limited number of machines and stevedores to handle these units. And that's a challenge to get it collectible in time." According to respondent 64.

The location of the cargo onboard is a factor which impacts the discharge time of a unit, this is because of how the vessels are unloaded and in what sequence this occurs. According to respondent 5 & 3, containerised goods are usually stored in the middle of the main deck. To access this area all cargo loaded on the starboard- & port side of the upper deck ramp and the building in the middle will have to be discharged first. This means in a perfect scenario that the containerised units loaded on main deck can begin discharging within an hour, as said by respondent 5:

"If we take a happy process example, you probably would be able to start discharging cassettes within an hour. About an hour you probably would be able to access that kind of cargo." According to respondent 5.

All containerised units are not loaded on the main deck, if the cargo is hazardous it will most likely be loaded towards the front up on the weather deck (due to regulations). Cited by respondent 5:

"If there are dangerous goods that are containerized, it's most likely to be present in the front of the weather deck on the starboard side." According to respondent 5.

The discharge time for units placed on the weather deck are not the same as those loaded on the main deck. According to respondent 5 accessing those units on the front of the weather deck probably takes two to three hours into production:

"Accessing stuff on the weather deck is probably two to 3 hours into production, I would say." According to respondent 5.

This means that a general discharge time for containerised units cannot be used since they are not loaded in just one specific area onboard. Instead, they are spread out onboard.

The benefits of providing a more precise collection time enables the terminal to prioritise units which are in the sequence of being collected and helps customers to plan their operations much better. For example, they will not have to arrive at the quay early in the morning and wait hours for the unit to be ready. Instead they will know when the unit is available and can therefore plan their day much better. Respondent number 3 states below when asked about the benefits:

"Yeah, this means that we only have to prioritise those units that are actually going to be picked up or in the sequence of being picked up. It also will create customer value because they don't need to have a driver assigned to that which needs to be waiting until they can actually pick it up. They can do more things so the customer could plan their picking up, so the haulier could plan his missions better throughout the day and week and so on." According to respondent 3.

Respondent number 3 adds to the above that the benefits would enable the terminal to optimise their facilities, machines, stevedores, areas and more. Furthermore, the customer can have a more optimised production chain:

"The benefit is both for us and for the customers collecting and leaving off the units. They can have a more optimised production chain and we can also optimise our facilities, our areas and machines and stevedores and so on. So the more of this we can plan ahead, the better for the operation." According to respondent 3.

At the moment the customers struggle to optimise their production chains as they don't know when the unit is collectable. The information they receive is that the vessel arrives at a certain time in the morning, more than that they do not know. A consequence of this is that the customer does not understand why it's taking so long for the unit to be collectible and was expecting to collect the unit during the early stages of the morning. Respondent 3 states:

"Can't understand why their units have to wait. I mean, we discharged the vessel for several hours and the vessel arrived at eight, now it's 12:00. Where's my unit?" According to respondent 3.

Prioritisation was mentioned above as a benefit resulting from a more precise collection time. However, prioritisation comes with its own challenges such as forwarding this information to everybody taking part in the discharge and import operation. Moreover, access is needed for those units that are prioritised as cited by respondent number 3 below.

"You need to have access to those units that are prioritised. Today we discharge and put it in a block stove outside the vessel and then we move them up to the lift area where we also put them in a block stove. But the challenge is of course to get the correct information from everybody who works for the same target. Because you have someone working on the vessel, discharging it to the quayside, someone shunting it from the quayside to the lift area and at the lift area you have a reach stacker driver." According to respondent 3.

Another challenge of providing a more precise collection time has to do with the RoRo industry itself. Several departures on a daily basis with export and import units arriving and leaving all the time, the operation is focused on keeping the flow of cargo moving and not being built up. When a vessel arrives a big peak in resources is created as cargo must be moved from the vessel to quay and quay to vessel. The terminal struggles to operate efficiently with the high peaks, to solve this the operational tempo is decreased to cut down the peak and have a steady, more consistent tempo throughout the day.

"It's always nice to cut the peaks because then the peak sets the standard of how many people you need to have lifting and also how much machinery you need. Since we are a RoRo business, there's a lot of departures throughout the week." According to respondent 3.

A consequence of not cutting the peak is the requirement of more resources for a shorter period of time. This is not sustainable as when the peaks are completed the machinery, personnel and other resources won't be used optimally, which is why the peaks are cut.

"We don't need so many people, so much machinery, because we use it over a longer time. ... nobody wants to work 3 hours in the morning and then have a really long break throughout the day and return in the afternoon." According to respondent 3.

Cutting the peaks does not necessarily mean that the collection time will be delayed, instead, by knowing which unit to prioritise the resources can be focused on getting the unit available for the customer quicker as cited by respondent 3:

"If we knew which ones that were prioritised, then we could make sure that we still handle the import units for 10 hours. But we take those ones that are necessary in the beginning, those that somebody is waiting for, then we will still cut the peak, but we will gain in customer satisfaction." According to respondent 3.

4.1.6 Truck Appointment System

All respondents thought a "Truck Appointment System" (TAS) would benefit the terminal and how it operates as this would inform which units to prioritise. Something which above was mentioned as one of the challenges to provide a more precise collection time. Cited by respondent 5:

"That is something I would like to see also just because if you do make the slot bookings, we know which units to actually prioritise." According to respondent 5.

Furthermore, respondent 5 adds that it is necessary to know which units the customer wishes to collect so they, the terminal can prioritise. Something a TAS will allow with the slot booking function:

"So there are things we can do to improve the pickup time. It's just a matter of seeing what customers actually want to pick up the units first and those we should of course prioritise." According to respondent 5.

Respondent 3 believed having two queues by the lift area would be the best use of a TAS where one queue would be used for those customers who have not booked a time slot. The second queue would be used for those with a time booked and would be prioritised over queue one:

"So that would be great for such a business as a lift area because in my imagination, you could have two queues. You could have one with booked lifts and one that missed their slot or too early or too late, or just unbooked. So then you work to make sure that the booked ones get their service and then you will service the other ones when there is time." According to respondent 3.

Also, it is not optimal to have all customers coming at the same time and one way to deal with that situation is to introduce a TAS. Or as said by respondent 5:

"You can't just have everyone come at once. You need to make a slot booking for that. So that is something we need anyway. Yeah, I think that is a way forward." According to respondent 5.

Moreover, the TAS would allow customers to make their own appointment when they wish to collect the unit and the terminal would make sure to deliver this request by preparing the unit in advance. Respondent 3 claims that this system would reduce the extra lifts needed and the overall process would go faster because of this:

"We could skip one extra lift with this…
… which means the overall process will go faster because we could skip a lot of lifts." According to respondent 3.

A similar system already exists in the terminal but for other commodities, at introduction it was heavily criticised by the customers as they claim flexibility would be affected negatively. However, at this point in time the customers seem to be content as they don't have to queue and wait for the service. Instead they arrive within their booked time slot, receive the service and get going with their day. Flexibility is not affected negatively as long as communication is held, if the customer is going to be late, a simple phone call can be made to re-arrange the time slot:

"And also if they arrive, if something happens, they normally just could call, say, please, I'm 1 hour late. And we can arrange it anyway because then we know it's 1 hour late." According to respondent 3.

However, another challenge is introduced with the TAS and that applies to the units which share cassettes/carriers with other containers. For example, respondent 3 brings up an example where four units are loaded onto one carrier:

"If you have four units on a carrier, what will you do with the rest of them and stuff like that?" According to respondent 3.

The TAS will need looking into further detail and how you deal with the units which share cassettes/carriers with other containers. However, as mentioned above, all respondents are positive about introducing such a system for the lift units.

Respondent 8 was also positive when asked about the implementation of a TAS; however, did raise a challenge for the system. The challenge suggests that customers will want to pick up their cargo at the same time and therefore book all of the slots for a certain time. That would leave certain periods of the day void.

"I think that's good. But I think everybody would like to pick up their container first

Everybody would like to pick up the container in the morning and go directly to the customer with it. It's really tough this with safe parking, but I think it would be a good system. But I don't know how it will work in the morning." According to respondent 8.

4.1.7 Internal Transport

From the interviews it was learned that the first step in discharging the Immingham vessel is usually to discharge the main deck first so that the rest of the vessel is accessible. E.g. the lower hold of the vessel. As illustrated by respondent 5:

"You will do a rush discharge of the main deck to just rip everything out because you want to open the hatch to the lower hold and continue the discharge from the lower hold." According to respondent 5.

Afterwards, when the units are outside of the vessel, personnel will pull the units to the lift area. Once the unit has been put outside the vessel they change location status in the system to "B1". This creates a work order to have the unit transported from B1 to the lift area. Mentioned by respondent 3 a problem in the past was that personnel did not update the location in the system to B1. This meant that the people transporting the unit to the lift area did not know the unit was ready for transportation, thus leaving the unit in B1.

" We had problems throughout the year that some shifts or some drivers, they didn't never park it on B1, so then the shunt people never saw it." According to respondent 3.

Apparent from the results in section 4.4 this is still a problem and lots of units do not receive the B1 status. More of this can be read under section 4.4.

In order to optimise discharge time the units are firstly discharged to the B1 area. Reason being, it's more efficient to unload the units to B1 first rather than transporting the units directly to LP from the discharge. The next step is to transport the cargo from B1 to LP. As highlighted by Respondent 4 -

“We have units arriving from Immingham, being discharged to B1 and then transported from B1 to LP. It's about 500 metres away and we discharge them to B1 just to get the vessel unloaded as soon as possible…” According to respondent 4.

“... It would take longer to discharge the ship if the crew discharging were to drive the units from the ship all the way to LP, it would take a longer time to discharge the vessel.” According to respondent 4.

Cargo transport between the two areas is ordered by a so-called “work order” in the terminal operating system (GTMS). These so-called “work orders” are managed by the terminal dispatchers, and are also visible for the terminal cargo handlers. These work orders are generated within the terminal system by priority, thus giving the cargo handlers a list of units that are ready for transport.

“For each carrier being discharged from the ship, we have a work order in our system and that work order is visible in our transfer crews computers, and as soon as the carrier is discharged, it becomes active on their list. They see that this unit has to be moved from B1 to LP. And that work order is executed by me and my colleague” According to respondent 4.

A separate information flow is used simultaneously as the work order flow, in order to ensure that the cargo is being moved as directed. These instructions are to firstly unload the cargo from the vessel to B1. The instructions then state when to move the cargo from B1 to LP.

“We give the drivers instructions to when they are discharging the ship, put the units on B1 and then we tell our crew who is transferring goods on the terminal to take it from B1 to LP as soon as it's possible.” According to respondent 4.

4.1.8 Information Sharing Standards

All respondents agreed that a standard terminology is needed for all stakeholders to use. This would enable greater insight and understanding of the actors' different operations and their functionality. Currently, there is a slight confusion as different actors have different understanding and translation of their terminology. The two shipping lines sharing the terminal do not use the same terminology, one of them generalises the different cargo types which causes confusion. In the container industry everything is very standardised, where the unit identification should be written, the different sizes and types of containers. However, in the Ro-Ro business there is a great variance in cargo types as everything with wheels can be loaded, even cargo without wheels. This makes it difficult to standardise a language but it also means it's necessary for the language to be standardised with all stakeholders, as said by respondent 5:

"So, yeah, a standardised way so everyone speaks the same language. That's really important." According to respondent 5.

Respondent 4 added that benefits could be achieved through standardisation such as using the same system and terminology. Moreover, insight to the different actors' operations in the supply chain can be obtained.

"Yeah, I could see a benefit with that if we could all use the same we can use the same system with the same terminology. Yeah, I think that would be of course we would benefit from it. I think we can have more insight in each other's operations." According to respondent 4.

Respondent 3 emphasised the importance of a standard terminology with authorities as they have a big problem with understanding each other. Especially with Brexit related communication which has to do mainly with customs, they don't understand the difference between trailers and containers:

"Yes, because we have a big problem with the authorities that don't understand. Since Brexit we have had customs and then they don't understand the difference between the trailer and the container." According to respondent 3.

4.1.9 Software Systems & Applications

Software systems and applications can be of great help when it comes to predicting a more precise collection time of not only containerised units but all types of units. Respondent 5 mentions that a new application will be introduced on a route operating to and from Vlaardingen where each unit gets a designated spot onboard which is mirrored in the system. To clarify, if a unit is loaded on the main deck in row 20 bay 2 this is shown in the system as well. The benefit of having such an application is that discharge time can be better calculated as information just showcasing which deck the unit is loaded on, is not enough. As mentioned by respondent 5, the location of the unit on the deck plays a big part in the discharge time:

"If it's in the beginning of the deck or in the end of the deck, whichever deck you are on, it can be a huge difference of about two, three hours until the unit is discharged or not." According to respondent 5.

However, by adding the exact position and then collecting statistics on how long it takes for units to be discharged from that very location. A more precise discharge time can be calculated:

"After 100 voyages, after 1000 voyages which actually round up pretty quickly, you will have an average time for all spots on deck. And in that case you will have pretty reliable statistics on when the unit will be discharged." According to respondent 5.

Respondent 3 does not believe it is necessary to know the exact position of a unit onboard the vessel. Instead, they believe it is sufficient to use timestamps from the loading operation done in the other terminal. More precisely, if timestamps are saved during loading of the vessel in the exporting harbour for example, container 3 was loaded onto the vessel two hours after the loading operation commenced. By then reversing the operation (discharging) and applying a standardised sequence, the unit (container 3) should be estimated to be discharged two hours after the discharge operation commenced. This routine is easier to implement as the timestamps are already saved today in the terminal cargo handling system (GTMS). The timestamp is saved when the work order for loading a unit onto the vessel is completed by the tug master. As said by respondent 3:

"Because when you load a unit, you confirm a work order in GTMS, so you know the timestamp of when it was loaded, so you know the sequence of the cargo on each deck. So if you take that timestamp and one easy way would you just take the loading port timestamp for loading and just play it the other way around for discharge." According to respondent 3.

Timestamps can also be used together with a method called "zoning". Respondent 3 describes this method as zoning the vessel into several big areas, where the timestamps that have the same timings are used to divide the zones. This method does not demand any system updates or system implementation. Instead the method can be implemented directly by the terminal dividing the zones. However, the difficult aspect of this method is ensuring that the Immingham terminal also adheres to the method and also agrees to the different zones and what timestamp is included in each zone:

"You could do a zone just start naming zones directly. There's no implementation really into GTMS for that. Just do it. The hard thing is to teach the drivers in all the terminals that from now on we should call this and this" According to respondent 3.

However, as mentioned above in section 4.1.5 the challenge is to standardise the handling of cargo. Even though it might have taken two hours to load the unit as mentioned in the example above, it is not a certainty that the discharge time will be the same. This is due to many factors affecting this time and also why it is difficult to provide a more precise estimation of when cargo can be collected. Respondent 3 mentions that these factors can be discharge crew being taken from one vessel to another due to shortages of staff, or being used for different cargo commodities such as cars which require more personnel. Moreover, equipment needed for one vessel such as machines used for cassette handling can be occupied on a different vessel since several ships are operated on simultaneously in the terminal. Finally, maintenance and or repairs on the vessel can prevent the terminal from discharging in a standardised sequence and instead proceed with a compromised operation. These factors affect the discharge time with timestamps as they were not included in the timestamp saved from the loading operation. Respondent 3 mentions:

"You have to be more clever than just reversing because there are other factors when it comes to vessel calls…
… But every day there's deviations and different demands". According to respondent 3.

Using system application comes with further advantages, as said by respondent 5 this can indicate when a customer is prone to collect their unit. By analysing a customer's collection time through past bookings a pattern can be found and also calculated as to when the customer will collect their unit. The most important data for the terminal is to know which customers are prone to collect their units within the first twelve hours of them being available:

"You can actually see which customers are more prone to pick up the units within the first 12 hours." According to respondent 5.

Those units can then be prioritised and put in a "fast lane" so they are more conveniently placed and handled for quick access. The units which are known to not be collected quickly, can be placed further away in the stacks to give room for those units that are prioritised.

"If the customer knows when the units will be ready, they're probably more prone to pick them up in an earlier state. The customers that are not in a rush to pick up the cargo. Then we can also plan their locations in the yard much better based on statistics as well. I know this customer always picks up after three days. These customers picked up within the first 12 hours. Then we know actually where to put the units in the yard as well." According to respondent 5.

However, this requires a thorough and correct data analysis of the customers, but if done accurately it will provide a great insight to the customers operational behaviour which allows for a completely different planning from the terminal's perspective.

"We can, like I said, see the different customers and see their behaviour and determine by their behaviour. We'll also get the suggestions in the yard that this unit can go further away because it will remain longer in the yard than the rest of the units would probably do. So there are things we can do to improve the pickup time. It's just a matter of seeing what customers actually want to pick up the units first and those we should of course prioritise." According to respondent 5.

When asked if such a system such as “TAS” (mentioned above) can be introduced to the terminal’s current system respondent 5 states that it’s only available for vessel operations and not yard operations:

“Yeah, but that is for vessel operations. Okay, for now. So they haven't done that part just yet on the yard side of things.” According to respondent 5.

By splitting up the terminal system and making a difference between the yard- and vessel operation such a system, more specifically “TAS” can be implemented. They will run on the same information in the background, it’s only how things are handled that will look differently. For the terminal workers operating tug masters, reach stackers. Will have the same equipment installed:

“So it's just how you handle things that will look different.” According to respondent 5.

Respondent 3 & 5 both saw benefits in sharing information with customers regarding what time the units would be collectable. However, both were doubtful in sharing timings which were precise to the hour. The interviewees thought it would be beneficial to provide information stating that the unit is available within two to three hours so the customer can plan their operations much better:

“I think it's good for the customers because it can let the customers plan their activities accordingly. And if they know that, say this unit will be available for pickup in 3 hours and this unit will be available for pickup in 2 hours, then they can actually plan their because they know they got 2 hours before the first unit is ready for pickup. Then they can do something.” According to respondent 3.

Respondent 5 adds that having a system provide a more accurate timing will stop the customer from having to wait at the terminal for hours:

“For the customers I think it is valuable because if they can plan their activities around the information we provide them, it of course is valuable to them because then they know, okay, I can do another mission while I wait. Instead of just spend 2 hours waiting for something which of course is pretty brain dead when you think of it in that sense?” According to respondent 5

Lastly respondent 5 mentions that some information which is beneficial should be shared:

“But the general pickup time, expected pickup time, I think that is beneficial for everyone to have a singular dimension. It adds value to the customer because they can plan their operations after that.” *According to respondent 5.*

Though, reluctancy was forwarded when it came to providing more accurate availability times, more precise, times stating availability on the hour or less. This was seen as a negative factor as too much information could be harmful rather than helpful. If an accurate time is provided to the customer and then not followed by the terminal, dissatisfaction can be a big risk. Therefor, the respondents thought timings stating availability within two to three hours would be better and safer:

"Provide information that's accurate enough to help the customer, but not so accurate that they will get disappointed too much if you miss." According to respondent 5.

Respondent 3 discusses information should not be shared too much so it risks disappointing the customer rather than satisfying. It's more about finding the required level of information to be shared.

"If it's too much, then it's risk for disappointment rather than satisfaction…
…It's finding the sweet spot, what the service actually requires and what's satisfactory and not to give too much." According to respondent 3.

Respondent 5 thought that showcasing live data, where the units exact position is in the terminal would have a negative impact on terminal expectation. Because the customer does not fully understand the terminal's operational flow. One example being if a customer would see their unit unloaded from the vessel, they might believe the container can be collected immediately. However, this is not the case as other internal processes are yet to be completed before the unit can be retrieved:

"Maybe that it has been discharged from the vessel, but that is sensitive because if you tell too much, they will always go yeah, but if it's ready, if it's off the vessel, why can't I pick it up right now? Because they do not understand the inner workings of the terminal in that sense." According to respondent 5.

4.2 Questionnaire Result

The following results are taken from the Questionnaire "titled" that was submitted to the terminal and focused on Standardization within the terminal.

Question 1 Result: *"Yes"*

Question 2 Result*: "Maybe no Standard as in the container business but EDI, Barcodes, RFID chips for specific flows"*

Question 3 Result*: "Vessel Arrival / Vessel Departure"*

Question 4 Result: *"By knowing deck spaces for individual units, one can more accurately estimate availability for collection. Today only the specific day the vessel arrives is stated on the ETA notification, and discharge is yet to be done for these units to be available."*

"Traditionally low incentive from the terminal / Shipping line in Gothenburg to improve this."

4.3 Quantitative Result

The case study's quantitative results are presented in categories, as well as summaries for each table. From the data it was found that the terminal operations maintain a relatively even pace when discharging cargo; however, it can also be of interest to break the operations up and examine each portion. Therefore, this section has been divided up into the different unloading phases, which take place throughout the entire operation. The first section 4.3.1, Discharge Times, considers the overall operation and how long it took for the containers to be discharged from the time the vessel arrived. Section 4.3.2, Internal Transport Times, breaks down the different stages of the operation and examines those respective times. The next section is 4.3.3, Available for Collection Times, focuses on the time it took for the cargo to be ready for collection. The final section is 4.3.4, Collection Times, and gives an overall view of how long containers were in the terminal before customers collected their cargo. Each section presents the results in a variety of formats in order to improve the discussion portion of the paper.

As represented in Table 3, there were 359 containers moved during the 8 weeks with a cumulative time spent in the terminal of 807 days. The average time for those containers to be collected was 2.25 days.

Table 3: Monthly container times showing the average time a unit was available for collection

Total Amount of Container Units	**Total Amount of Days The Units Were In The Terminal**	**Average Days In Terminal Per Unit**
359	807	2.25

4.3.1 Discharge Times

This section presents results for the average time it took to discharge vessels on the Immingham to Gothenburg route. Table 4 presents the times by week (1-4 and 9-12) and then by day. The table also presents the weekly average. The greyed out days on the table were days when no containers were moved. The fastest times to discharge the vessel were during Week 9 on

Wednesday at 22 minutes and Week 1 on Thursday at 58 minutes. The two slowest times to discharge the vessel were during Week 2 at 4 hours and 4 minutes and during Week 9 at 3 hours and 3 minutes. The fastest weekly average was Week 10 with an average of 1 hour and 44 minutes. The slowest average was Week 4 with an average of 2 hours and 30 minutes. Figure 8 presents the averages from Table 4 in a graph form, which presents another perspective to compare. Figure 9 is a pie graph that presents the weekly averages from Table 4. Table 5 takes all of the discharge times for every day and presents those averages. It takes all the discharge times for a given day and presents that average. The fastest time on Table 5 was on Wednesday with a time of 1 hour 42 minutes and the slowest time was on Thursday with a time of 2 hours and 33 minutes. Figure 10 displays the averages from Table 5 in a pie chart.

Table 4: Monthly container times showing the average time it took to discharge the vessel

Time to Discharge Summary						
	Tuesday	Wednesday	Thursday	Friday	Saturday	Weekly Average
Week 1	2:12		0:58	2:30		1:53
Week 2	1:57		4:04	1:39	1:38	2:19
Week 3	1:20	1:54	1:45	2:40	1:20	1:48
Week 4	3:25	2:06	1:59	2:37	2:24	2:30
Week 9		0:22	3:03	2:42	2:04	2:03
Week 10	2:00	1:11	1:29	1:26	2:36	1:44
Week 11	1:11	1:54	2:43	2:48	1:44	2:04
Week 12	1:06	2:01	1:38	1:47	2:45	1:51
Note: Discharge LP - Vessel Arrival Time = Time to discharge (hours)						

Figure 8: Monthly container times showing the average times it took to discharge the vessels by week and day

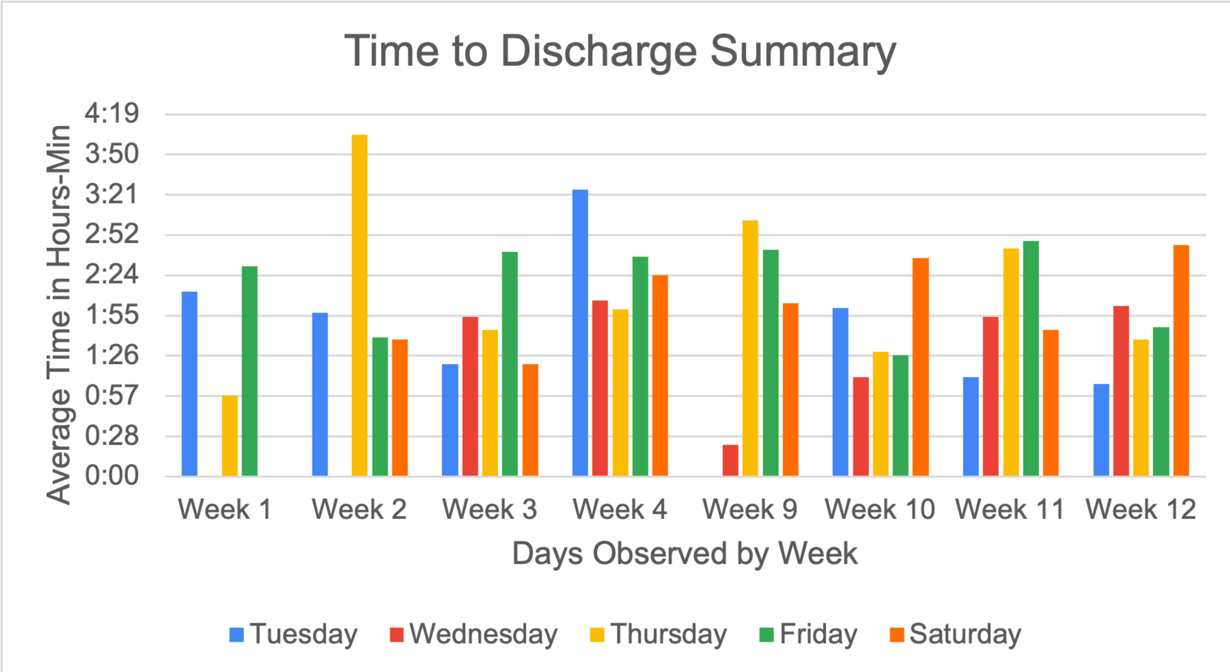


Figure 9: Monthly container times showing the weekly average time to discharge the vessel

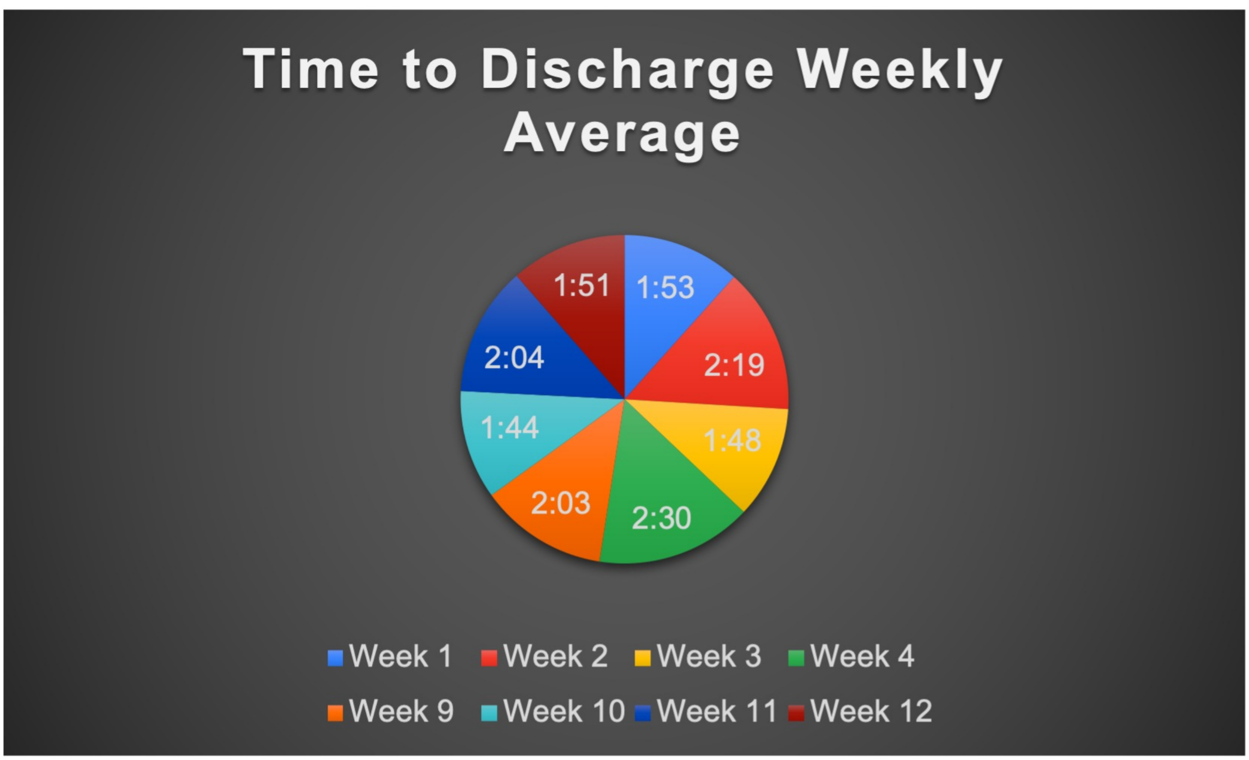
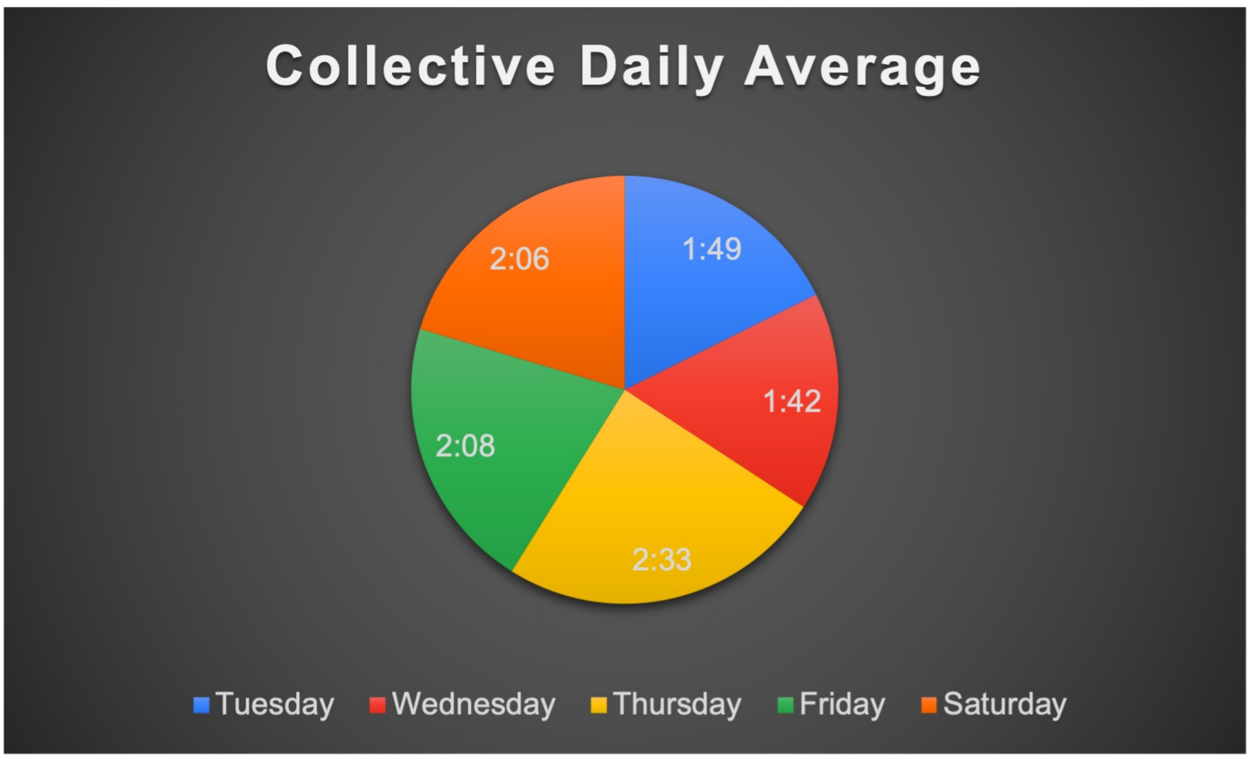


Table 5: Monthly container times showing the collective daily averages to discharge the vessel

Time to Discharge Daily Average Summary					
	Tuesday	Wednesday	Thursday	Friday	Saturday
Total Average	1:49	1:42	2:33	2:08	2:06
n	50	72	84	76	77

Figure 10: Monthly container times showing the collective daily averages to discharge the vessel



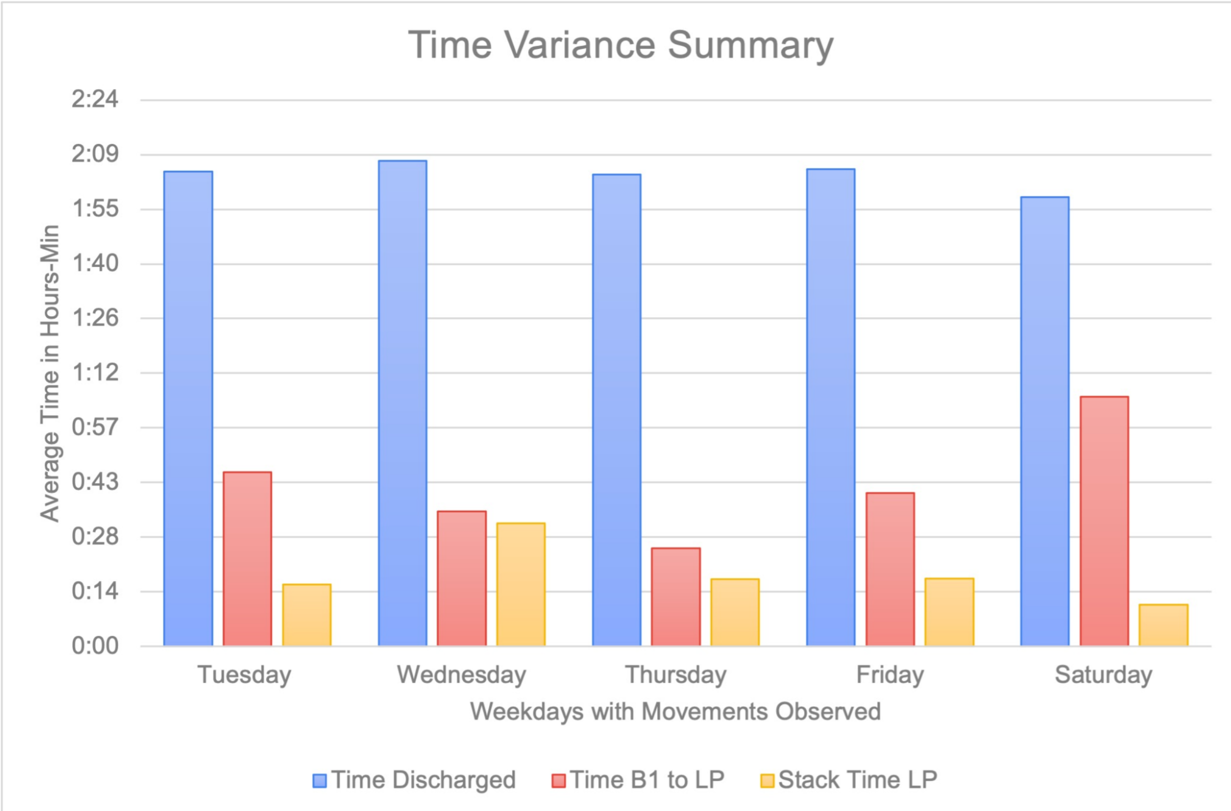
4.3.2 Internal Transport Times

This section presents the results found from the various internal terminal movement times. Table 6 is a summary of the average daily variance from three main event reporting times. The first time is "Time Discharged," which is the difference between when the vessel arrived to the container was discharged to the offloading location (B1). The second time, "Time B1 to LP," is the difference between when the container arrived at B1 and when it arrived at LP. The final time, “Stack Time LP,” is the difference between when the container was discharged to LP and when the container was made available for pick up. It is of note that the times on Table 6 are all averages from the containers handled on the respective day. Each day shows the total amount of containers handled that day, which amount to 359 containers handled in total. Figure 11 depicts the results from TAble 6 in a bar graph. The slowest discharge average was on Wednesdays with a time of 2 hours and 8 minutes. and the fastest was on Saturday with a time of 1 hour 58 minutes. The variance between the fastest and slowest is 10 minutes. The slowest time for B1 to LP was on Saturdays with a time of 1 hour and 5 minutes. The fastest time for B1 to LP was on Thursdays with a time of 25 minutes. The variance between the fastest and slowest times was 40 minutes. Looking at the third category, the fastest time for Stack Time LP was 11 minutes on Saturdays and the slowest time was on Wednesday with a time of 32 minutes. The variance between the fastest and slowest times was 21 minutes.

Table 6: Monthly container times showing the average daily variance for three event reporting times

Time Variance Summary				
	Time Discharged	Time B1 to LP	Stack Time LP	n
Tuesday	2:05	0:45	0:16	50
Wednesday	2:08	0:35	0:32	72
Thursday	2:04	0:25	0:17	84
Friday	2:05	0:40	0:17	76
Saturday	1:58	1:05	0:11	77
				359

Figure 11: Monthly container times showing the collective daily time variance for internal movements



4.3.3 Available For Collection Times

The following results present the average time that it took for a container to be made ready for collection. Table 7 shows the 8 weeks of collected data and indicates the corresponding average. Table 7 also gives the weekly average for each week, additionally any greyed out days were days where no containers were moved. The three fastest times on Table 7 are on Week 9 - Wednesday at 1 hour 5 minutes, Week 1 - Thursday at 1 hour 9 minutes, and Week 12 - Thursday at 1 hour 59 minutes. The three slowest times on Figure 13 are Week 11 - Friday at 5 hours and 16 minutes, Week 4 - Tuesday at 5 hours 6 minutes, and Week 2 - Thursday at 4 hours 51 minutes. The fastest Weekly Average was Week 2 at 2 hours 54 minutes. The slowest Weekly Average was Week 11 at 3 hours 49 minutes. The second figure, Figure 12, is a bar graph that takes the data from Table 7 and gives a comparison between the weeks. Figure 13 is a pie chart that displays the weekly averages from Table 7. The next portion of these results takes the collective daily average and displays the data in Table 8. On Table 8 the fastest average was Tuesday with an average of 2 hours 38 minutes and the slowest average was Saturday with an average of 3 hours 40 minutes. Lastly, Figure 14 takes the results from Table 8 and presents them as a pie chart.

Table 7: Monthly container times showing the average time it took for a container to be ready for collection

Available for Collection Summary						
	Tuesday	Wednesday	Thursday	Friday	Saturday	Weekly Average
Week 1	4:00		1:09	4:25		3:11
Week 2	2:02		4:51	2:26	2:18	2:54
Week 3	3:06	2:53	2:31	3:02	3:06	2:55
Week 4	5:06	2:40	2:35	2:37	3:09	3:13
Week 9		1:05	4:14	4:57	4:11	3:37
Week 10	2:15	2:37	4:05	2:36	4:38	3:14
Week 11	2:42	2:16	4:02	5:16	4:49	3:49
Week 12	3:16	3:26	1:59	2:20	3:32	2:55
Note: Available for collection time - vessel arrival time = Time from arrival to available collection						

Figure 12: Monthly container times showing the comparison between weeks of the average time it took for a container to be made ready for collection

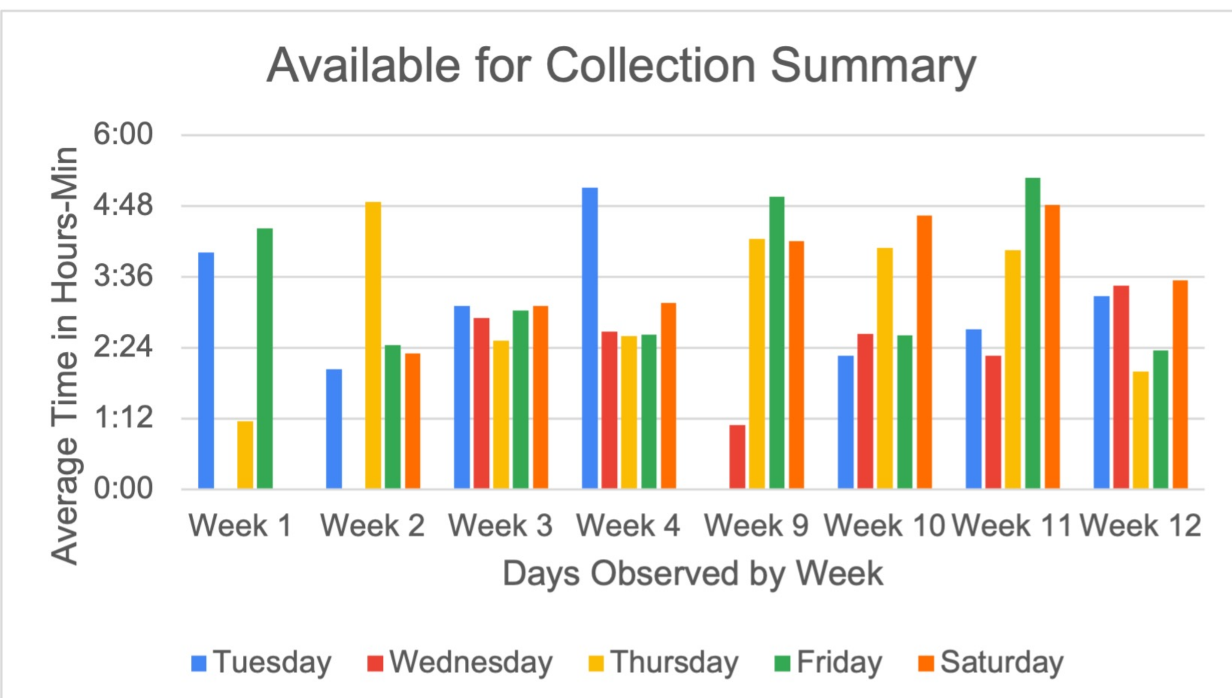


Figure 13: Monthly container times showing the comparison between the weekly averages for the time it took for a container to be made ready for collection

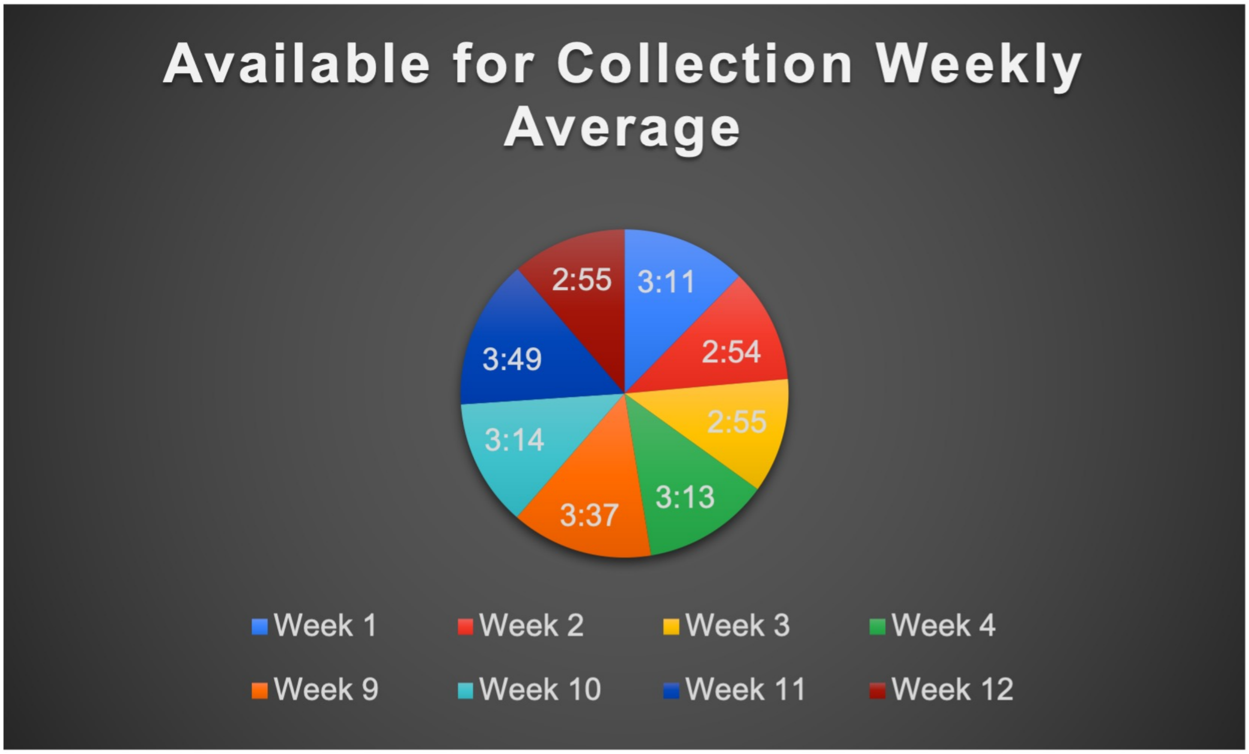
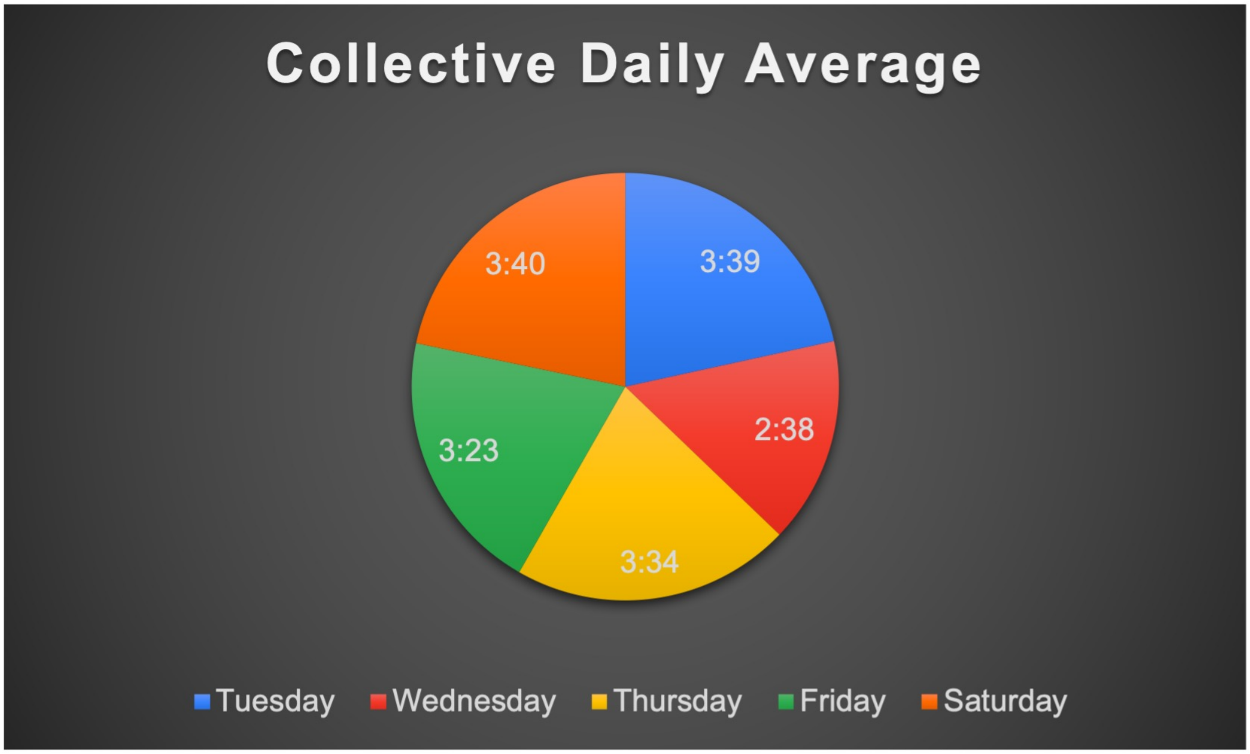


Table 8: Monthly container times showing the collective daily average for a container to be made ready for collection

Daily Total Average Summary					
	Tuesday	Wednesday	Thursday	Friday	Saturday
Total Average	3:39	2:38	3:34	3:23	3:40
n (containers)	50	72	84	76	77

Figure 14: Monthly container times showing the collective daily average for a container to be made ready for collection



4.3.4 Collection Times

This section presents the various pickup times for containers. The authors set the parameters as follows: any container picked up the same day as it was marked ready for pickup, any container picked up 1 day after the container was marked as available for pickup, any container picked up 2 days after the container was marked as available for pickup, any container picked up 4 days after the container was marked as available for pickup, any container picked up 5 days after the container was marked as available for pickup, and lastly any container picked up after 5 days from the time the container was marked as available for pickup. The amount of cargo that was picked up on the same day it arrived was 62 containers or 17% of the cargo. The amount of cargo that was picked up one day after it arrived was 92 containers or 25% of the cargo. Between same day pick up and one day after arrival pickup the percentage of cargo picked up is 42% of the cargo. Table 9 presents results as the number of containers picked up within each respective category by week. Figure 15 takes the results from Table 9 and presents them as the number of containers moved. Figure 16 displays the collective pick up average in a pie chart, i.e., the average taken from every week.

Table 9: Monthly container times showing the number of days it took for containers to be picked up number of containers

Pick Up Time Summary								
	Same Day	1 Day	2 Days	3 Days	4 Days	5 Days	> 5 Days	n
Week 1	5	7	6	5	4	3	4	34
Week 2	6	13	4	11	4	1	3	42
Week 3	9	21	9	9	8	2	2	60
Week 4	6	10	6	11	2	1	3	39
Week 9	4	10	5	9	2	3	1	34
Week 10	10	5	7	9	5	1	3	40
Week 11	9	11	10	4	3	3	2	42
Week 12	13	14	10	21	5	3	1	67
Total	62	91	57	79	33	17	19	358

Table 10: Monthly container times showing the number of days it took for containers to be picked up by percentage

Pick Up Time Summary %							
	Same Day	1 Day	2 Days	3 Days	4 Days	5 Days	> 5 Days
Week 1	15%	21%	18%	15%	12%	9%	12%
Week 2	14%	31%	10%	26%	10%	2%	7%
Week 3	15%	35%	15%	15%	13%	3%	3%
Week 4	15%	26%	15%	28%	5%	3%	8%
Week 9	12%	29%	15%	26%	6%	9%	3%
Week 10	25%	13%	18%	23%	13%	3%	8%
Week 11	21%	26%	24%	10%	7%	7%	5%
Week 12	19%	21%	15%	31%	7%	4%	1%
Total	17%	25%	16%	22%	9%	5%	5%

Figure 15: Monthly container times showing the time it took for containers to be picked up from terminal in days

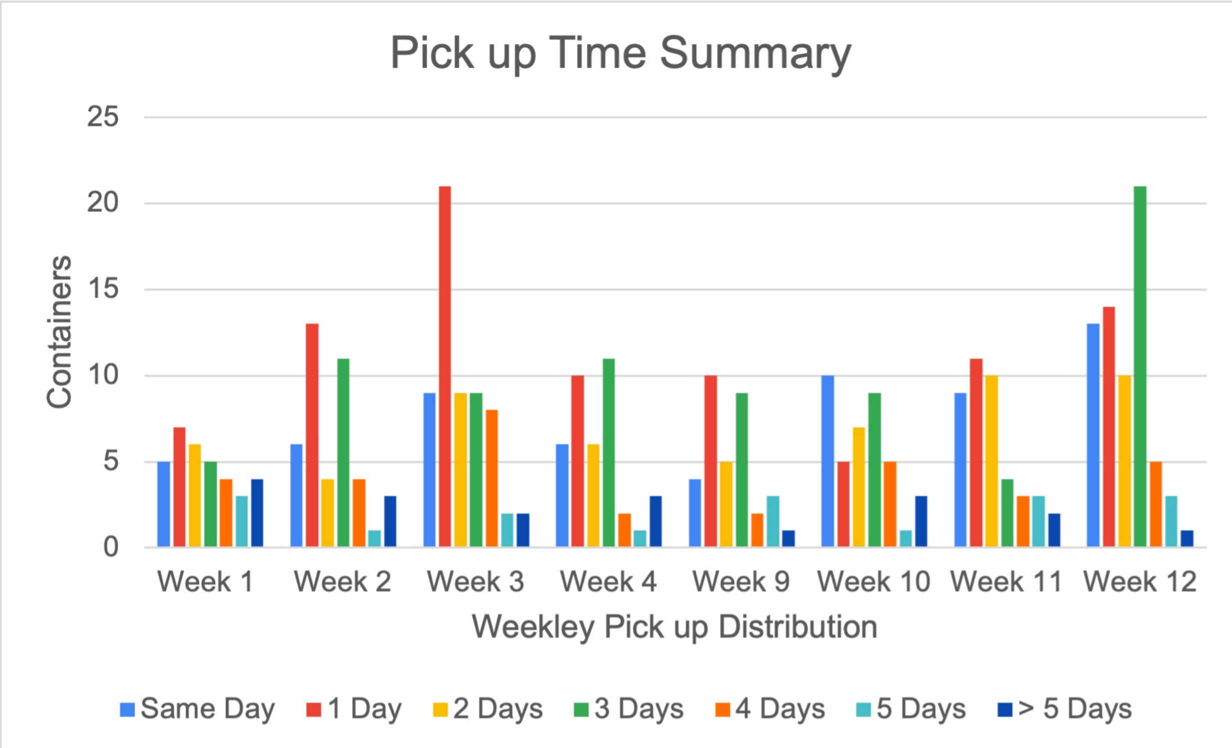
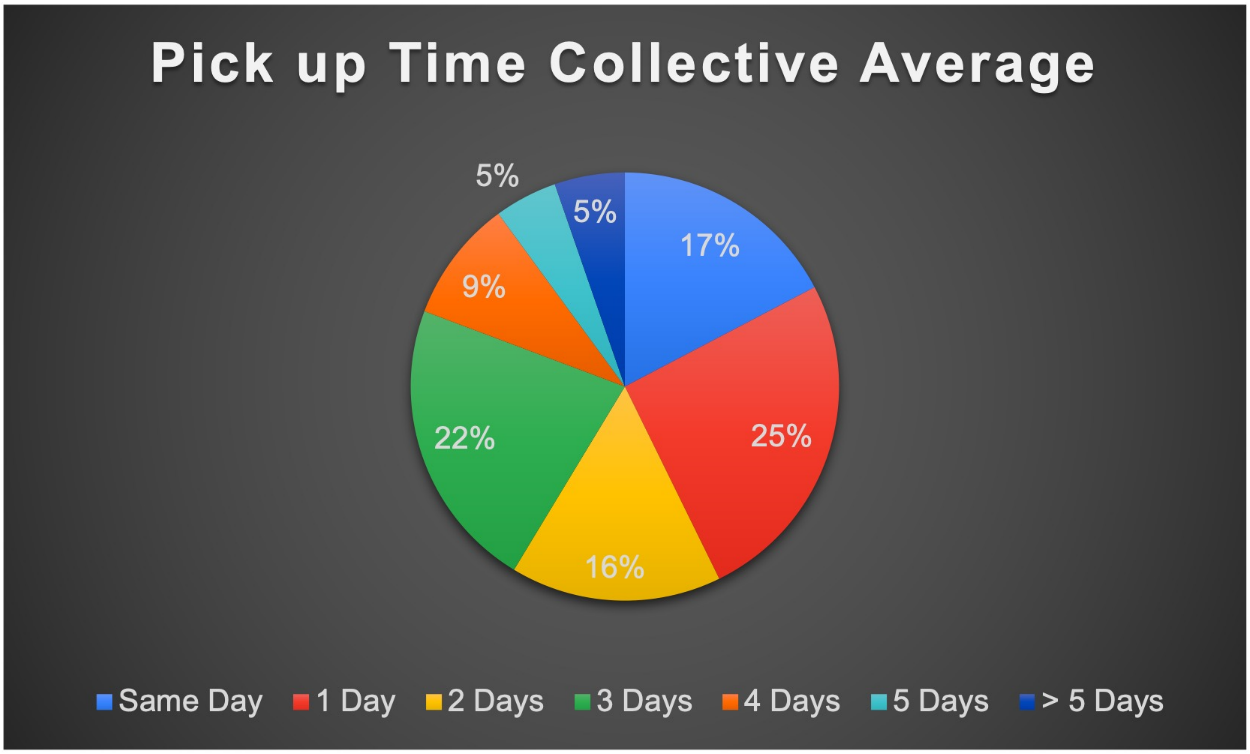


Figure 16: Monthly container times showing the average time it took for containers to be picked up once available for pickup



5 Analysis & Discussion

In this section of the thesis, the results from the interviews, questionnaire and discharge data are discussed and analysed in relation to the theoretical framework. This chapter is divided into eight sections, which address the three research questions in the first six sections (5.1-5.6). The seventh section (5.7) discusses the internal processes of the terminal, whereas the eighth (5.8) and last part of this chapter discusses the methodology used for the thesis.

5.1 Challenges with predicting a more precise ETA

As seen from the results of this study, predicting a more accurate ETA of collection of goods involves a considerable amount of challenges. Alessandrini et al, (2019) argues that some repercussions of an inaccurate ETA for a vessel's arrival are increased challenges for terminal operations to estimate the required resources, leading to undesirable activities and increased costs. This theory was verified during the thesis. In order to provide a more accurate ETA of collection of goods, these challenges must be overcome, which is easier said than done. Even though predicting a more accurate ETA of collections of goods comes with challenges, it also includes benefits for the terminal and their operation. It is important to realise that a greater prediction of a more accurate ETA does not only contribute positively to the customer but also to the terminal and how they operate.

The respondents claim that the amount of lifting units arriving on Thursdays overwhelms the terminal due to the amount of machinery and stevedores available, which creates a challenge in getting all units available for collection at the same time. However, as shown from the discharge data (see section 4.4.4) not all customers collect their units on the same day the vessel arrives. This means that all units arriving do not need to be made available for collection for the same day, instead by knowing which units will be collected on the same day, those units can be prioritised and prepared whilst the other units not being collected can be dealt with at a later stage. Since resources are strained, this would help enable an efficient use of those.
Though, as was also found in the interviews, the challenge with prioritising is to know which unit is prioritised and getting this information to all actors in the operation. Furthermore, accessing the unit can also be a problem since all lift units are discharged in a blockstove. This could then prevent terminal operators from reaching the unit for further handling and preparation for collection. This means that the information of which unit to prioritise will have to reach the terminal in a timely manner so that they can handle the unit accordingly.

From the interview with respondent 3 it was found out that the terminal can handle units quickly and get them ready in time, as long as they know which units are to be prioritised. This suggests that a system which can provide information of which unit to prioritise is necessary, this is further discussed in section 5.2.

Under section 4.1.1 & 4.1.2 stowplans showed to have a great impact on the discharge time of a vessel, more specifically the clarity and accuracy of the stowplan itself, as they provide essential information for the terminal and how they are going to discharge the vessel most efficiently. Respondent 5 mentioned the importance of knowing where onboard the vessel a unit is located and how this is necessary to determine how long it will take to discharge the unit.

Worth discussing is how the stowplan can be used to also provide information where the unit is loaded onboard and by doing so positively affecting the discharge time. Firstly, the clarity of the stowplan will provide the terminal with information of how the vessel is loaded, thus enabling them to make an optimal discharge plan. Secondly, if the stowplan is so accurate that it shows exactly where onboard the lift units are located it could be used to estimate the discharge time for that specific unit much better. However, this cannot be confirmed as this study did not conduct any experiments or observations with clear stowplans compared to non-clear stowplans. Therefore, this can only be used and seen as a possibility.

5.2 Benefits of predicting a more precise ETA

The main challenges cited by the respondents were standardising cargo handling, controlling the large number of lifting units, locating the cargo onboard, knowing which units to prioritise, the amount of actors involved in handling the containerised units, and lastly, the peak in resources caused by vessels arriving. The optimization of facilities, equipment, stevedores, and locations are among the benefits of offering a more precise collecting time. Prioritisation of units can also be advantageous, but it necessitates information sharing and access to those units. This verifies Hathikal et al, (2020) theory. Furthermore, with a more precise collection time, customers can optimise their production chains, and the terminal can prioritise units efficiently. This benefit is aligned with Harmelink & Veenstra (2021), who argued that ETA plays a crucial role in determining cargo delivery and reducing costs associated with logistical activities.

5.3 Enhancing the accuracy of the ETA collection time

Similar to the previous research question, the results of this study show that enhancing the accuracy of the ETA collection time is a complex task. Padolak & Khan, (1979) interpretation that a Ro-Ro terminal should be seen as a system consisting of subsystems was verified. Additionally, Morales-Fusco & Sauri, (2009) theory that the subsystems must be optimised in order to increase the performance of the entire system was supported. In order for the accuracy of the ETA collection time to improve various obstacles need to be addressed and overcome. The factors that the results highlight are both verified and new findings. Although there were multiple factors that were verified by this study, the introduction of a Truck Appointment System (TAS) stood out.

Considering the introduction of a TAS, all respondents throughout the interview process responded positively to the system. The first factor that was identified was the ability for the terminal to be able to prioritise bookings with the use of a TAS. During the interviews, respondent 5 emphasised how important it is for the terminal to know which containers customers intend to collect. This is important since the terminal would in turn know which units to focus on first. The TAS would operate with a so-called slot booking system, which would enable the terminal to prioritise units.

Another area It was found/verified during the interviews that the RoRo industry has a hard time predicting collection times due to its nature, i.e., operating with multiple departures on a daily basis with both import and export units coming and going simultaneously. Therefore, the terminal focuses on keeping a continuous flow throughout the terminal and not allowing build ups. Respondent 3 mentioned that when a vessel arrives the terminal is susceptible to big peaks in resources as cargo needs to be discharged from the vessel to the quay and quay to vessel. When this happens the terminal can encounter problems and as a result will slow down its operational tempo in order to cut down the high peak and have a more consistent tempo. Conversely, when the terminal is not able to cut down peaks, a much higher demand on cargo handling resources is made. The high demand on resources causes a disruption within the terminal, i.e., personnel, machinery, and other resources. Respondent 3 said, "*If we knew which ones that were prioritised, then we could make sure that we still handle the import units for 10 hours. But we take those ones that are necessary in the beginning, those that somebody is waiting for, then we will still cut the peak, but we will gain in customer satisfaction."* Considering this, it does not mean with certainty that the collection time will be delayed; however, by using a TAS and prioritising cargo terminal resources can be better managed. Van Asperen et al. (2013) confirms this theory that by knowing the collection date a terminal will have the possibility to make unproductive moves during off-peak hours, thus increasing preparation work and better preparing for when a vessel arrives. Furthermore, (Davies & Principal, 2009) reinforces the theory that a TAS would aid in eliminating peaks and enable an improvement in the predictability of truck processing transactions.

Another factor that was brought up during the interviews was the implementation of a new queueing system. Respondent 3 suggested that implementing a queuing system with two lanes, one for booked time slots and another for unbooked or missed slots, would be an optimal utilisation of the TAS. Since the lane for booked slots would be prioritised a higher level of efficiency would be possible. The TAS would inherently help manage the previous situation with one lane where all customers could arrive simultaneously, as respondent 5 highlighted. The use of two lanes can therefore impact the time cargo spends at the terminal and increase the terminals competitiveness (Morales-Fusco, Sauri & Lago, 2012).Through the use of a slot booking system the terminal could better regulate customer arrivals, thus reducing congestion and optimising resource allocation.

Nonetheless, respondent 8 brought to light a potential challenge with implementing a TAS. Since customers would be empowered to book pick up slots, it could create a struggle between customers as they may want to book during the same time. The respondent brought up the example of the majority of trucks wanting to pick up their cargo during the morning in order to better facilitate the rest of their day. This however can be discussed further in the following section 5.5, discharge data, as not all customers pick up their cargo at the same time.

A final consideration is the implementation of a TAS would empower customers to schedule their own appointment for unit collection, which would also allow the terminal to prepare the units in advance. Respondent 3 mentioned the advance of this being the terminal could reduce the need for additional lifts and as a result expedite the overall process. Therefore, giving the TAS the potential to improve both operational efficiency and customer satisfaction. Similarly, Morales-Fusco & Sauri, 2010 suggest that a RoRo terminal operates with the highest performances when turnaround times are reduced.

5.4 Zoning and timestamp influence

The application of real time data from a RoRo terminal has potential benefits, which include the prediction of ETA collection. The interviews made this clear through a couple of instances to include: zoning and timestamping. Upon additional analysis of the discharge data, patterns were identified, which further strengthen the potential benefits of using real time data. However, the use of real time data in the terminal settings also presents challenges.

The first approach discussed during the interviews involves utilising timestamps from the loading operation in the exporting harbour. This approach aims to reverse the operation and apply a standard sequence, thereby allowing for an estimate to be made for when the unit will be discharged. This method relies on the pre-existing timestamps that were saved in the terminal cargo handling system (GTMS) during the loading process. Respondent 3 advocates for this approach, even suggesting that it can eliminate the need to know the exact position of the unit onboard the vessel.

As argued by Leggate et al. (2004) Information Communication Technologies have the potential to enhance coordination between carriers, shippers and their supply chain partners. This was verified with a potential solution in zoning. The second approach was also discussed during the interviews. This approach can be combined with the first method. One of the approaches discussed during the interviews was that of “zoning.” This practice divides a vessel into several large areas based on the timestamps that the units receive. The units are grouped with other units with similar timings. Unlike timestamps, this approach does not require system updates though. It is much more dependent on cooperation between terminals to agree on the zones and the inclusion of specific timestamps in each zone. Respondent 3 mentioned some challenges for this

approach being standardised cargo handling, deviations, and differences in demand. These are considered challenges because they can all affect the discharge time.
Both of these approaches are in line with Balan, 2018 that the implementation of technology will reduce cost and improve quality since both approaches can improve terminal efficiency and customer satisfaction.

5.5 Discharge data

It is advantageous to consider the quantitative data collected and analyse what it represents. Firstly, the results from the discharge data reinforce the potential of prioritising certain cargo, which will allow for more efficient discharging of the vessel. In addition it would make room for more efficient cargo handling once the cargo is discharged. Lastly, by analysing the discharge data several challenges and questions are raised.

From the analysis of the discharge data collected from the terminal several patterns were identified. The first pattern comes from Figure 8, which shows the two fastest vessel discharge times as 22 minutes during Week 9 on Wednesday and 58 minutes during Week 1 on a Thursday. The two slowest discharge times were during Week 2 at 4 hours and 4 minutes on a Thursday and during Week 9 at 3 hours and 3 minutes also on a Thursday. Considering the two fastest times, 8 containers were moved on Wednesday and 3 containers were moved on Thursday. Considering the two slowest times, 22 containers were moved on the Week 2 day and 7 containers were moved on the Week 9 day. This highlights the potential that using real time data creates. Since the fastest day had 8 containers moved and the second slowest day had 7 containers moved, real time discharge data could be used to relay to terminal operators that the ETA will be either positively or negatively affected. It is difficult to tell from the data collected, what may have caused the delay on the slower days as the data collected is only discharge times.

Another result of interest is highlighted on Table 10 and Figure 15. The results show that out of all the containers during the 8 week period 62 containers or 17% were collected on the same day of discharge. Then one day after discharge there were 91 containers or 25% collected. These results confirm the importance of prioritisation of cargo. If the terminal can identify the lower percentage of containers that are picked up on the same day then those units could be prioritised and be made available first and in turn improve cargo handling efficiency within the terminal. This finding is supported by a response from respondent 5, who said that analysing a customer's collection time could offer benefits. *"If the customer knows when the units will be ready, they're probably more prone to pick them up in an earlier state. The customers that are not in a rush to pick up the cargo. Then we can also plan their locations in the yard much better based on statistics as well. I know this customer always picks up after three days. These customers picked up within the first 12 hours. Then we know actually where to put the units in the yard as well."*

Therefore those units can then be prioritised and put in a “fast lane” so they are more conveniently placed and handled for quick access. The units which are known to not be collected quickly, can be placed further away in the stacks to give room for those units that are prioritised.

Referring to Figure 13 and Table 8, another result of interest appears. Similar to the results Figure 8 the averages for available for collection time do not alway follow a logical result, i.e., higher averages resulting from more units moved and lower averages resulting from less units moved. For example the fastest time was on Wednesday in Week 9 with 1 hour and 5 minutes. The slowest time however was during Week 11 on Friday with 5 hours and 16 minutes. A total of 8 containers were moved on the fastest day and a total of 8 containers were moved on the slowest day. This finding can imply that additional data is required in order to determine why or what caused the 4 hour difference in timing. One additional finding from this result is the next two fastest times both occurred on a Thursday (Weeks 1 and 12). This result can imply that certain days of the weeks follow certain operation patterns and thus can be utilised to determine how the operational flow will look for that day.

Lastly, during the discharge data analysis it was noted that 171 times were missing or not reported when a unit arrived at the B1 position. That is when a unit moves from B1 to LP. This was noted and brought up to terminal operators. The general consensus however, was that this lack of reporting was not an issue and had no influence over the operations. This goes against (Lind et al., 2021), and the importance of quality when capturing event related data. Hence, it could be investigated to see if the lack of recorded times is of importance or not. Additionally the use of terminal standards is in question with this case. The results taken from the questionnaire confirm that no Logistics standards, e.g. GS1, are used within the terminal and could therefore be applied in a test environment to see if there are any positive effects.

5.6 Information sharing

As mentioned above IT is about transmitting and understanding information being exchanged. Additionally as highlighted by (Pontrandolfo & Scozzi, 1999), the quality of the shared data must also be reliable. Additionally Dermirbas et al. (2014) underscores the potential that ICT has in greatly improving visibility and communication in information exchange, which in turn enhances the efficiency of logistic operations.

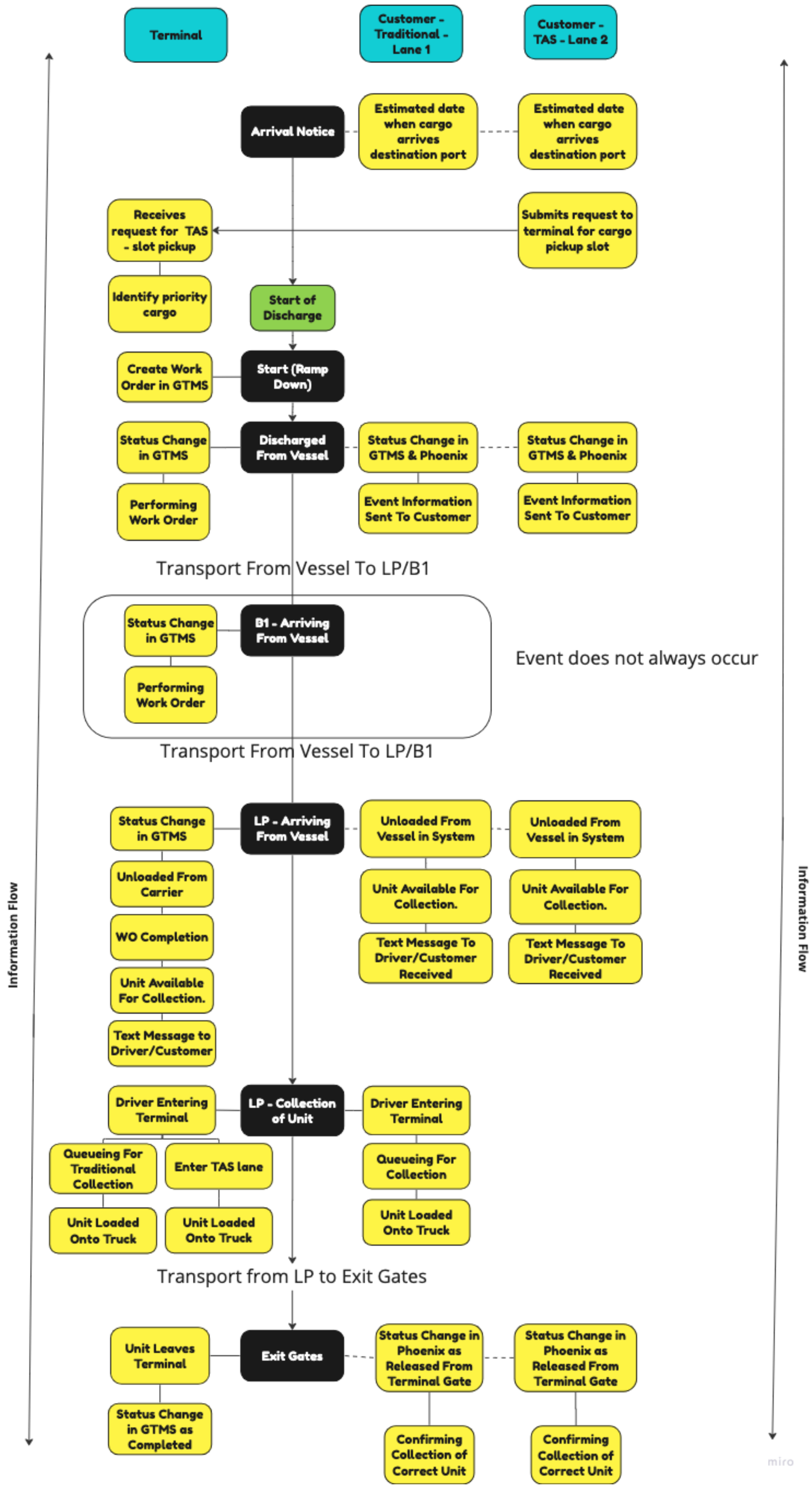
During the interview process, respondents 3 & 5 both saw benefits in sharing information with customers regarding what time the units would be collectable. However, both expressed doubts as to how much data should be shared. For example the interviewees thought it would be beneficial to provide information stating that the unit is available within two to three hours so the customer can plan their operations much better. Respondent 5 also thought that information which is beneficial should be shared with customers, i.e., general pickup time and expected pickup time. Therefore improving internal terminal processes as well as communication and visibility with customers. The interviewees however, did not see all information sharing as positive. Respondents 3 & 5 were doubtful in sharing timings which were precise to the hour. The interviewees only thought it would be beneficial to provide information stating that the unit is available within two to three hours so the customer can plan their operations much better.

Regarding the outside perspective, freight forwarder and trucking company, both expressed the importance of reliable data and communication. Respondent 7 mentioned the importance of reliable data being shared "*If you receive a lot of information and a lot of contradictory information, you kind of don't know what to act on.*" These findings agree with the theory proposed by Pontrandolfo & Scozzi (1999) where it was found that the quality of the shared data must also be reliable. Furthermore, the findings also agree with Lind (2021) and Leggate (2004), who discussed the essence of an organisation being able to rely on a third party's shared data. This is an area that was identified to be lacking, (communication), between the terminal and customer. Thereby increasing the potential for more disruption in the process. Interviewee 8 mentioned the biggest challenge is the lack of information that the truck drivers get when it comes to pickup times. Ringsberg & Lumsdem (2016) and Lind (2021) argue that such an example will negatively impact a port terminal's logistical efficiency. The findings in this project can not verify that though and would need to be further investigated.

5.7 Internal Process Model

The initial systematic mapping of the terminal processes showed the value of breaking down the various interfaces , therefore it was used as a basis for the process model presented in this section.

Figure 17: Showing the Internal Process Model



Note: Completed by authors

The purpose of the model is two fold. First, it is in place to present a systematic interpretation of the terminal's container operations. Secondly, the model is in place to improve the connection between the various actors and processes. As stated in Section 2.4 the method for deriving the initial process map was through the systematic mapping process as described by (James et el. 2016). This led to the initial process laid out in Figure 2, which presents how current terminal operations flow within GRT.

The model presented in this section (See Figure 17) is a continuation of the initial process presented in Section 2.5.3. Therefore, this version is a continuation of the initial systematic mapping, the data gathered from the theoretical framework, and the qualitative data from the interviews. The process model conveys the current terminal operations flow (core processes) within GRT as well as what it would look like with the addition of a TAS. Since the model displays the core processes, it is of note that there are sub processes as well. Those sub processes however were not added since they were not considered to be pertinent results.

Considering the model, the container flow starts from the vessel's arrival and ends with the container departing the terminal via truck. During the entire flow there are three prominent domains. The first domain being the arrival of the vessel, which includes vessel discharge. As well as showing the process for booking a specific time slot associated with a TAS. The second domain being Transport from Vessel to LP/B1. Just as the initial systematic mapping shows, this model indicates that the transportation from vessel to B1 does not always occur. This was found during the authors interviews as well as during the analysis of the discharge data. During the second domain the model also indicates the distinction between customers who choose to use the TAS and those who use the traditional pick up process. The third and final domain is the Transport from LP to Exit Gates.

Another prominent feature of the model is the indication of information flow, which is presented as a two way flow on both sides of the model. This flow is something that is argued by (source) and was verified by interviewees (3,7, and 8). The information flow is something that is fundamental to the model as communication between the various events (core processes) and actors who are involved during said events. The information flow is something that has been verified as a component that can either negatively or positively affect the ETA of the container within a RoRo Terminal. It is important to reiterate how the project defines ETA. ETA refers to the estimated time of arrival of the container to the LP, i.e., when a container is available for pickup.

5.8 Methodological discussion

This MSc thesis project has been conducted based on a mixed methods approach. The project utilised a case study in order to collect data, which combined qualitative and quantitative methods. A benefit to the mixed methods approach is the potential to use conclusion triangulation as described by Deznin (2017). The case study consisted of systematic mapping, interviews, questionnaires, and discharge data collection. By using a mixed methods approach the authors were able to explore the research in a qualitative and quantitative way. The data was analysed using a triangulation approach in order to increase the validity and reliability of the findings. In addition the practice of "Explanation Building" as described by Yin (2014) was employed when analysing data. During the methodological formation the authors also made ethical considerations. All data that was collected during the interviews, observations (process mapping), questionnaires, and discharge data observations was pre-approved by the appropriate authority. For example the shipping company and terminal were asked prior to taking any quantitative data. In addition a Non-Disclosure Agreement (NDA) was signed by all stakeholders, who were directly involved in this thesis. The authors are held to that NDA and did not disclose anything outside of that agreement. When it came to the interviews and questionnaires all participants were made aware of the research being done and that their participation was completely voluntary. All participants were told that they would remain anonymous and the authors received consent prior to recording any of the interviews.

Following the completion of the data collection and results analysis, the authors made note of a couple of improvements that could be made during the methodology execution. First, the use of questionnaires was not as effective as it could have been. The authors issued one questionnaire in order to gain an understanding of how the terminal utilised logistics standards. The results were easily interpreted; however, it could have been improved by getting more recipients. Also, the authors believe that if further research is done where other terminals are observed then this method could be even more useful. The second note that the authors made was regarding the analysis of the discharge data. Since the authors decided to stick to analysing average times due to time restrictions, the analysis was not as thorough as it could have been. Therefore, it is recommended that further analysis be conducted on similar data in order to verify the findings in this project.

6 Conclusions

The purpose of this MSc thesis was to explore how a verified model could be used to improve Estimated Time of Arrival (ETA) at a Ro-Ro terminal. In addition, to analyse the potential benefits of providing real-time information about the estimated times of arrival and departure for containerized maritime shipping of goods. Furthermore, the research aimed to identify ways in which the terminal can provide stakeholders with more accurate timings for the collection of cargo from the quay. Upon reviewing the results from this project, enhancing the accuracy of the ETA collection is proven to be a multifaceted task since the terminal operations process is complex, consisting of multiple factors and stakeholders.

RQ 1: What challenges and benefits exist for a RoRo terminal for predicting a more accurate ETA of collection of goods?

The study found several challenges when it comes to predicting a more accurate ETA of collection of goods, some being more difficult to overcome than others. However, benefits were also discovered with predicting a more accurate ETA of collection of goods.

In conclusion the interviews conducted during this project revealed that predicting a more accurate prediction of collection of goods presents several challenges. The challenges include: determining which units to prioritise, locating cargo onboard vessels, managing the involvement of multiple actors, standardisation of cargo handling and efficient control of a large number of lifting units. In addition the standardisation of stowage plans can be considered a challenge; however, as mentioned in the discussion no experiments were conducted to test this hypothesis.

Despite these challenges it was evident that there are also significant benefits to be gained from predicting a more precise ETA. One of the key benefits that was discovered from this study is the optimisation of facilities, i.e., cargo handling equipment, stevedores, and cargo handling areas. By accurately predicting the collection time, terminals can allocate said resources more accurately, which can result in higher efficiency. Another key benefit that was identified was prioritising, which would help enable the terminal to know which units to focus on and which units to handle at a later stage. However, prioritisation necessitates effective information sharing and access to relevant units.

Moreover, a more accurate collection time (ETA) enables customers to optimise their production chains, by receiving knowledge of when their goods will be collected they can plan their supply chain processes more efficiently. This in turn leads to better resource utilisation, as well as reduced downtime for their operations. Simultaneously the terminal can leverage the precise collection time to prioritise units effectively and by doing so further enhance operational efficiency.

While there are challenges to overcome, the benefits of predicting a more accurate collection of goods are substantial for both the terminal and customers. By addressing these challenges and implementing effective solutions, terminals can unlock improved resource utilisation, streamlined operations, and enhanced customer satisfaction.

RQ 2: What can a RoRo terminal do to enhance the accuracy of the ETA collection time?

Upon analysis of a Truck Appointment System (TAS) it was found that such a system through slot bookings, would benefit the terminal to determine which units to prioritise for handling and by doing so provide a more precise collection time. This is possible since the terminal would be aware of which units would be collected at what time. Therefore, allowing the terminal to deliver an improved service for their customers. The introduction of a TAS would allow for a two lane queuing system, where one would serve the slot booking customers and the other would serve the traditional customers who have not booked a slot. This system would once again help with prioritisation of units to handle and as such enhance the unit collection time. Since customers would now be able to book a slot in advance, the terminal could identify priority units and then allocate resources for cargo handling more effectively. This practice can reduce the number of lifts made during a traditional cargo handling process and thus reduce the time spent on moving units.

Overall, the use of a TAS emerges as a promising solution for enhancing the effectiveness and efficiency of lift unit handling at the terminal and the accuracy of ETA collection time. This reflects its potential to address challenges related to unit prioritisation and collection time accuracy. The benefits from such a system would include: streamlined operations, optimised resource allocation, improved customer satisfaction, and flexibility through effective communication.

However since this project did not conduct any field experiments, it is difficult to make claims that a TAS would be the best option for enhancing the accuracy of the ETA collection time. This would require trials and testing before being implemented.

RQ 3: How can current real time data from the RoRo terminal be used to predict an ETA collection time?

Software systems and applications using real time data have the potential to enhance the accuracy of predicting ETA collection time. I.e, an application assigning a designated spot onboard a vessel for each cargo unit, the application provides a more comprehensive understanding of the discharge time by considering the precise location of the unit onboard. The location onboard significantly affects the time required for the unit's discharge. Moreover, utilising timestamps from the loading operation in the exporting harbour is another approach, by reversing the operation and applying a standardised sequence, an estimate can be made for when the unit will be discharged.

Furthermore, timestamps can be combined with the “zoning” method, this method is preferred as it does not require system updates or implementations, but rather cooperation between terminals to agree on the zones and the inclusion of specific timestamps in each zone. However, as discussed, standardising cargo handling remains a challenge and deviations and different demands can affect the discharge time. Thus, it also affected the prediction of ETA for collection. Further advantages can be made from utilising software systems, such as predicting customer collection times based on past bookings and operational patterns. This allows for prioritising units and placing them in a “fast lane” for quick access, units known to be collected quickly can be strategically located closer to improve efficiency.

While sharing information with customers about the availability of units is beneficial, the interviewees expressed hesitancy about providing precise timings down to the hour. Instead, they suggested offering estimated availability within a two- to three-hour timeframe, allowing customers to plan their operations accordingly. Dissatisfaction can be a consequence of providing too much information if the terminal fails to meet precise time commitments.

Sharing live data that reveals the exact position of units in the terminal was also cautioned against. Reason behind that was the fact that customers may not fully understand the internal operational processes that must be completed before a unit can be retrieved. This may lead to unrealistic expectations and potential dissatisfaction.

Using real time data in the form of collection times, it was found that the majority of units aren’t collected the same day that the vessel arrives. This gives an indication to the terminal of the patterns of the different customers who use the terminal. These patterns can be a starting point for further observation and understanding of customer behaviour to further enhance terminal resources.

6.1 Managerial implications

Upon completion of this study several conclusions can be drawn, which apply to the various stakeholders in the Ro-Ro segment. These conclusions stem from the challenges and benefits that were verified while exploring this thesis.

Firstly, the acknowledgement and understanding of the challenges that are present in predicting a more accurate ETA is important for managers. By acknowledging the challenges associated with unit prioritisation, cargo location onboard, involvement of multiple actors, standardisation of cargo handling, and efficient control of lifting units more appropriate strategies can be made to further improve the accuracy of ETA predictions.

The second conclusion that can be made is the importance of effective communication and information sharing. Managers should ensure effective communication and information sharing with the various customers in this segment. One example is through providing estimated availability within a two-to-three hour timeframe, which can help customers plan their operations accordingly. In addition it can help to avoid potential dissatisfaction caused by precise time commitments that may not always be met. However, care should be taken when sharing so called live data as it can have the opposite effect and cause unrealistic expectations resulting in customer dissatisfaction.

Lastly, the study has shown that there are potential tools for terminals to take advantage of, which can help address the challenges aforementioned. The implementation of a TAS or software systems that share real-time data through a timestamp function can lead to more improved prediction of ETA. The use of these systems can impact operations by optimising resource allocation and in turn streamline terminal operations. The findings and verifications from this study show that managers need to proactively acknowledge and address the challenges, leverage benefits, and explore innovative solutions to enhance the accuracy of ETA collection time.

6.2 Suggestions for future research

Following the completion of this thesis, there can be a couple of suggestions made for future research. The first suggestion for further research would be to conduct experiments on applying a TAS in a Ro-Ro terminal to receive greater knowledge on how that impacts the terminal operations and customer satisfaction.

The second suggestion is to make a multiple case study and analyse two or three RoRo terminals. The aim of a multiple case study would be collecting data from various terminals, and verification of the findings of this project. Additionally a multiple case study would allow for further data analysis. Since this study has not looked at specific containers, i.e., what cargo was picked up the same day and what cargo was picked up after 5 days. The authors recommend this as something that can be done in future research as looking into specific cargo trends and pick up times. This type of research can make a stronger case for a Truck Appointment System and timestamp and zoning methods.

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Appendix

A – Interview guide, Validity questions (introduction part)

My name is Chris Lucero Hampus Hammond. We will be conducting an interview today for our Master's Thesis project, Impact of RoRo terminal logistics operations on Estimated Time of Arrival and Estimation Time of Departure of containerized goods, which will be 30-40 minutes long.

The project focuses on terminal operations in a Roll on roll off terminal and how the operations affect the estimated time of arrival of containerized goods. The participation is voluntary, interviewee can stop taking part whenever he/she wants, the information from the interview is used for this research project only and the interviewee will remain anonymous.

We would like to record this interview but want to get your consent before recording. (wait for consent)

The structure of the interview will be semi-structured, meaning we have a set of questions, but can deviate a little from those questions depending on the answers that you give. There are no right or wrong answers, we're interested in your experiences, thoughts and perceptions. Since we have a limited amount of time, I might interrupt your story or move to another topic. I want you to know that it's not because what you say is not interesting, it's because we have some topics where I want your opinion and we need to cover that within the time frame for this interview. I hope you think that is, ok?

B – Interview guide, Interview Questions

Interview Captain (Respondent 2) semi-structured interview

Example Questions:

1) How is ETA reported?
2) When, what, where, who, why?
3) Same procedure for arriving IMM & GOT or do they differ?
4) Different compared to other shipping lines/vessels?
5) Who do you report the ETA to? Dispatcher, DFDS Office etc.
6) How do you define ETA? Quay, lighthouse etc.

Terminal Operator (Respondent 3) semi-structured interview

Example Questions:

1) What do you think is the main challenge for providing a more precise collection time for containerised units?
2) Conversely, what do you think are the biggest benefits of providing a more specific ETA (Collection time)? It sounded like that last
3) Would it be possible to prioritize certain units for collection and what would the challenges be to do so?
4) What's the terminal's perspective on more precise collection times? Feasibility etc.
5) Does the terminal believe it's necessary or even a competitive advantage to be able to provide this information to the customer?
6) What's your personal opinion of the topic?
7) How do you think a truck appointment system (TAS) would affect this situation?
8) What can the customer do to contribute?
9) Who informs terminal workers that a unit can be transported from B1 to LP?
10) How is that information shared internally?
11) Who has access to that information?
12) What standards does the terminal use? Have you heard of GS1 or EPCIS?
13) Do you think there is a need to have a standard terminology for all stakeholders (Terminal, customers, shipping line, ect.)?

Terminal Operator (Respondent 1) semi-structured interview

Example Questions:

1) What do you think is the main challenge for providing a more precise collection time for containerised units?
2) Conversely, what do you think are the biggest benefits of providing a more specific ETA (Collection time)?

3) Would it be possible to prioritise certain units for collection and what would the challenges be to do so?
4) What's the terminal's perspective on more precise collection times? Feasibility etc.
5) Does the terminal believe it's necessary or even a competitive advantage to be able to provide this information to the customer?
6) What's your personal opinion of the topic?
7) How do you think a truck appointment system (TAS) would affect this situation?
8) What can the customer do to contribute?
9) Who informs terminal workers that a unit can be transported from B1 to LP?
10) How is that information shared internally?
11) Who has access to that information?
12) What standards does the terminal use? Have you heard of GS1 or EPCIS?
13) Do you think there is a need to have a standard terminology for all stakeholders (Terminal, customers, shipping line, ect.)?

Freight forwarders (Respondent 7) semi-structured interview

Example Questions:

1) Is it an issue for your operations to not have a more precise collection time for your units?
2) If so, please elaborate as to why it's an issue and how it affects your operations.
3) If the collection time was more precise how would that affect your operations?
4) How's the overall information being received when it comes to your units in the terminal?
5) Is the information adequate or poor?
6) What information would you want to receive and how would you want it to be received?
7) Is the information received from GRT & the shipping lines confusing?
8) How do you think a truck appointment system (TAS) would affect this situation?
9) Any other solution ideas?
10) How often do your drivers have to wait at the terminal before they can enter due to units not being ready for collection?
11) Does it happen often that your drivers spend an entire morning at the terminal waiting?
12) What standards do you use? Have you heard of GS1 or EPCIS?
13) Do you think there is a need to have a standard terminology for all stakeholders (Terminal, customers, shipping line, ect.)?

Volvo Trucks (Respondent 8) semi-structure interview

Example Questions:

1) Is it an issue for your operations to not have a more precise collection time for your units?
2) If so, please elaborate as to why it's an issue and how it affects your operations.
3) If the collection time was more precise, how would that affect your operations?
4) How's the overall information being received when it comes to your units in the terminal?
5) Is the information adequate or poor?
6) What information would you want to receive and how would you want it to be received?
7) Is the information received from GRT & the shipping lines confusing?
8) How do you think a truck appointment system (TAS) would affect this situation?
9) Any other solution ideas?
10) How often do your drivers have to wait at the terminal before they can enter due to units not being ready for collection?
11) Does it happen often that your drivers spend an entire morning at the terminal waiting?
12) What standards do you use? Have you heard of GS1 or EPCIS?
13) Do you think there is a need to have a standard terminology for all stakeholders (Terminal, customers, shipping line, ect.)?

IT Manager (Respondent 5) semi-structured interview

Example Questions:

1) As a former dispatcher what would you say impacts the discharge time most?
2) How do you think using software systems and better information exchange can help develop a more precise collection time for customers to collect their units?
3) What do you think is the main challenge for providing a more precise collection time for containerised units?
4) How do you think a truck appointment system (TAS) would benefit a more precise collection time?
5) Can you briefly describe GTMS? Have you used similar systems? How do they compare?
6) How do you think that would work with GTMS?
7) Do you think there is a need to have a standard terminology for all stakeholders (Terminal, customers, shipping line, ect.)?
8) Do you think stowplans affect the discharge time? Is it a big issue?
9) Do you believe designating each unit onboard a vessel with a specific position will impact the discharge estimations? Or what do you believe will contribute most to a more precise discharge estimation?

10) Do you think the customers who are collecting import units from the terminal receive enough information/updates regarding when their units can be collected?
11) Adding to above, do you think real time data can impact the collection time and do you think it's feasible with the terminal systems to implement such data? Example, "Unit X is currently at B1, estimated time for collection is 2h."
12) If not, what factors impact this?

Terminal Operator (Respondent 4) semi-structured interview Interview #2

Example questions:

1) You mentioned in the previous interview that the way to predict a more precise collection time is to standardise the way of handling cargo. Can you elaborate that a bit more?
2) From the 439 container bookings we examined, we noticed a lot of them never received the "B1" status. Instead they changed status directly to LP. Do you think that's a problem? Does that impact the internal transport? For example, will the people hunting the units from B1 to LP overlook the unit because of this?
3) Some of the respondents in the previous interview said that dividing the vessel into zones would enable a more precise collection time. Also, giving them an exact position onboard. What do you think about that?

C. Questionnaire Guide - Port Terminology Survey

This survey is a voluntary survey designed for a Master's Thesis that is conducted by two students in the Maritime Management MSc Program at Chalmers University of Technology in Gothenburg Sweden. The thesis is exploring the use of ETA/ETD in port terminal operations. The answers provided may be used in the report and all participants will remain anonymous.

1. Does the terminal use a set of standard operational (port and transportation) terminology? Y/N
2. If yes, what is the standard that the terminal uses? Example: GS1 Standard
3. If no, how does the terminal define its operational processes? Example: computer program. Please clarify the name of the program used
4. How does the terminal define ETA/ETD (Estimated Time Arrival/Estimated Time Departure)?
5. How do you think (if) semantic (information) interoperability can be improved? (that IT systems define ETA/ETD exactly the same or near the same) Or does it not need to be improved you think?