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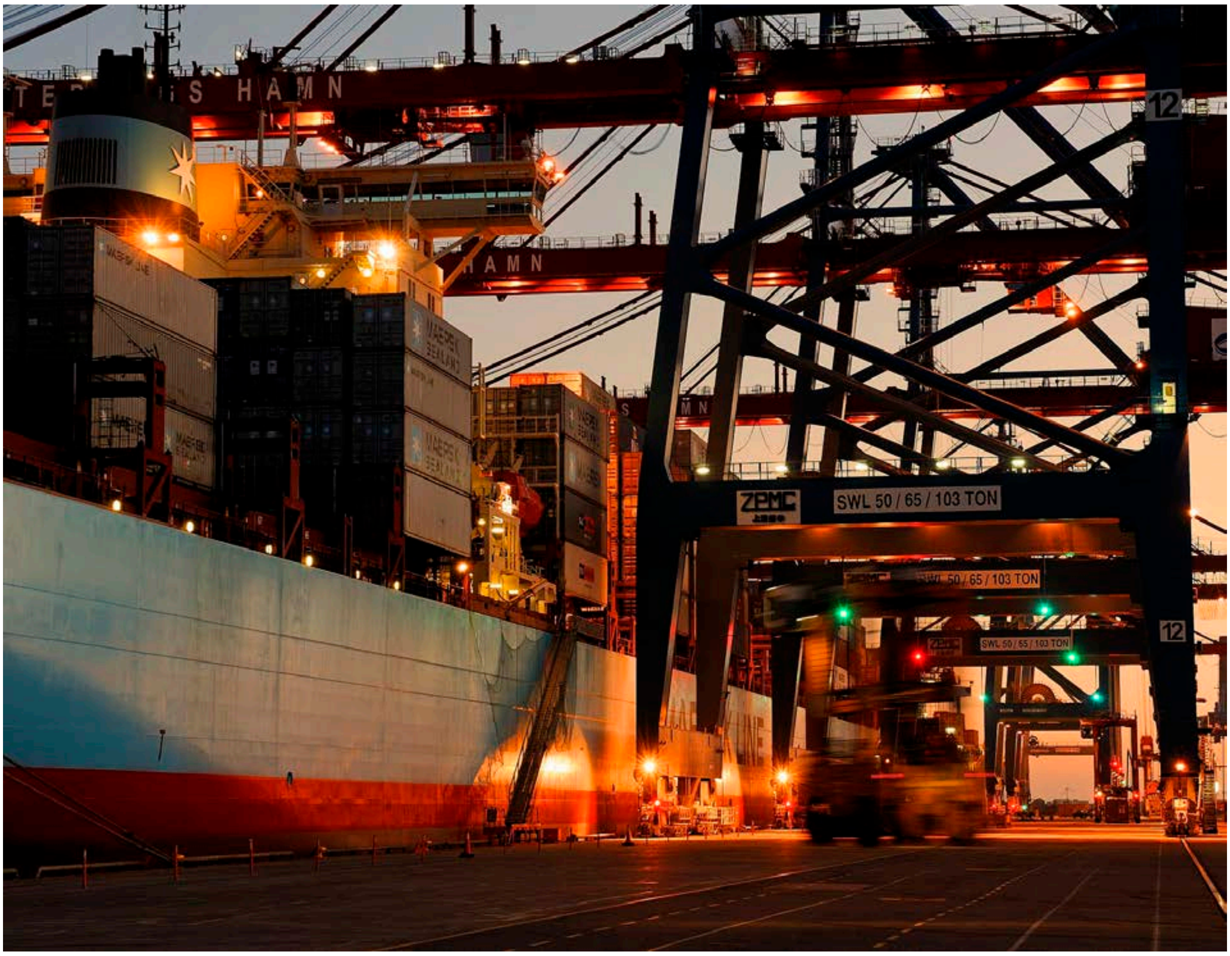

Negative impacts on crane productivity

A case study in APM Terminals Gothenburg

Bachelor thesis in the Shipping and Logistics Programme

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Gothenburg, Sweden 2016

REPORT NO. SoL-16/168

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Cover:
Cargo operations in APM Terminals Gothenburg

Printed by Chalmers
Gothenburg, Sweden, 2016

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Abstract

The increased amount of cargo transported by container vessels require port terminals to have efficient cargo handling. A port terminal needs to be efficient in order to attract and keep customers, hence the productivity in the terminal is important. Loading and discharging operations on container vessels are performed with cranes and the working pace of the cranes are referred to as crane productivity. This thesis investigates what factors a crane operator experiences as difficult and time consuming during cargo operations. The results are that obstructed view are considered as the major issue. The crane operators need to operate behind stacks of containers on board, referred to as Manhattan Stowage. Crane operators consider this as a factor lowering the crane productivity. This is strengthened by the vessel planners who agree and according to them, this issue can be dealt with by taking this into consideration when making the stowage plan at the shipping line. If crane operators can work with unobstructed view, the crane productivity would increase and loading Layer-by-Layer would be an alternative. However, the interviewed shipping line argued that doing so will have negative consequences as a result which makes it not likely to implement. Alternative solutions could be to leave an empty row behind the stack to help the crane operators since they agree on leaving an empty row would give them better conditions.

Keywords: Container, vessel, port terminal, crane operator, crane productivity

Sammanfattning

Den ökade mängden gods som transporteras på containerfartyg ställer ökade krav på de hamnar som hanterar dessa fartyg gällande effektiv godshantering. En hamn måste vara effektiv för att attrahera och behålla kunder och därför är produktiviteten i terminalen viktig. Lastning och lossning av containerfartyg utförs med kranar och takten dessa arbetar i omnämns som kranproduktivitet. Kranproduktiviteten är en av de viktigaste faktorerna för en hamn och därför är det av vikt att hålla denna på en hög nivå. Denna rapport undersöker vilka faktorer som kranförare upplever som svåra och tidskrävande. Resultatet är att skymd sikt betraktas som det största problemet. Kranförarna måste arbeta bakom staplar av containrar ombord, också kallade "Manhattan Stowage" som syftar till stuvning av gods i form av skyskrapor. Kranförarna anser att dessa arbetsförhållanden sänker kranproduktiviteten. Fartygsplanerare bekräftar dessa åsikter och enligt dem så kan problemen avhjälpas genom att ta hänsyn till kranförarnas sikt vid planeringen av lastplanerna som rederierna gör. Om kranförarna kan arbeta med ohindrad sikt, skulle kranproduktiviteten öka och ett sätt skulle vara att istället lasta lager-på-lager. Dock anser det intervjuade rederiet att det sättet att lasta skulle medföra negativa konsekvenser och därmed inte är troligt att införa. En alternativ lösning kan vara att lämna en tom rad bakom stapeln för att hjälpa kranförarna, då de anser att det skulle vara underlättande.

Rapporten är skriven på engelska.

Nyckelord: Container, fartyg, hamnterminal, kranförare, kranproduktivitet

Acknowledgments

The authors would like to thank all who contributed with their time and knowledge during the working process. A special thanks to APM Terminals Gothenburg and Daniel Eliasson, for organizing the interviews and to all crane operators and vessel planners who participated and shared their views on this subject.

Tomas Olsson Neptun, thank you for your assistance and guidance throughout the process.

Lina Skerdén, thank you for your illustrations.

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Definitions

In this section the key expressions used throughout the thesis are explained. These are expressions that could be applicable on more than one area thus, a description on how they are used is necessary.

Cargo operations
This expression is used to define the loading and discharging procedures on container vessels at the quayside.

Cargo planner
This expression is used to signify the title of a person at a shipping line responsible for making the container stowage plan.

Container
A container in the context of this thesis is a standardized ISO-container used to transport general cargo. TEU, twenty-foot-equivalent, is the container size that is used to measure capacity on container vessels. However, the most frequently shipped container is the FEU, forty-foot-equivalent.

Crane
The word crane in the scope of this thesis signifies a crane situated on the quay, used for discharging and loading containers on container vessels.

Crane operator
The person operating, or driving, the crane.

Port operator
When referring to a port operator it signifies the organization in charge of the operational management in a container port terminal.

Port terminal
A port terminal in this context signifies a seaport container terminal. This is a docking, discharging and loading area within a port designed to suit container vessels.

Turnaround time
The time needed to perform cargo operations in a port terminal.

Vessel
A vessel in this context is referred to as a vessel purely designed to carry containers.

1 Introduction

The importance of logistics for companies worldwide has grown since the beginning of the 1960's. Manufacturing companies as well as service providers have shifted from only manufacturing goods or providing one service to integrate the whole logistical flow in its organization, this to ensure a competitive advantage (Lee & Song, 2015). International trade agreements and deregulations of trading limits enabled globalization and created opportunities for companies to expand to markets beyond their own countries.

In addition, the introduction of standardized containers in the 1960's provided an easier and cheaper way of transporting cargo. The risk for thefts and weather damage reduced with the container compared to transporting cargo as bulk. In combination with the possibility to use multimodal transports without restowing cargo and vessels designed purely for carrying containers the containerization changed world trade (Levinson, 2008). Shipping liner companies, hereafter referred to as shipping lines, established liner services on pre-scheduled routes offering possibilities to transport cargo for delivery at a more certain arrival time which allowed companies to plan their transport flows more detailed (Institute of Chartered Shipbrokers, 2013b).

According to UNCTAD, United Nations Conference on Trade and Development (2015), the international seaborne trade carried out by container vessels recorded 1,631 million tons cargo being transported in 2014. Compared to 1980 this is an increase of transported cargo by 1600%. Also, the vessels have been growing from a capacity of 4800 TEU in 1980, to being able to carry more than 19000 TEU in 2015 (World Shipping Council, 2016). With larger vessels, economy-of-scale could be achieved and made transports by sea the most cost efficient mean of transport in comparison with rail, road and air (Lumsden, 2006). By increasing the size of container vessels more cargo could be transported on one voyage which not only decreased cost for each transported container but also the environmental impact.

As container vessels, hereafter referred to as vessels, increased in size the handling of them became more complex. Even though smaller vessels might be equipped with cranes these equipment are decreasing and new-built vessels tend to lack cranes (Stopford, 2009). Seaport container terminals, hereafter referred to as port terminals, are the interface between ocean carriage and land distribution of cargo. Productivity and efficiency in a port terminal need to meet the growing container volumes. Equipment, infrastructure, organization and information systems are essential functions of a port terminal. When managing a port terminal it is of importance that the equipment is utilized and coordinated in a way to ensure high productivity (Institute of Chartered Shipbrokers, 2013a).

In combination with the privatization of port terminals worldwide the competition has increased. The identified main competitive factor for a port terminal is the total turnaround time for vessels. In addition, port terminals need to offer low rates for cargo operations and also availability to access other transportation networks.

The total turnaround time will be shorter with a high crane productivity. Among technical and operational interference, human factors have a major impact on crane productivity (Steenken, Voß, and Stahlbock, 2004).

1.1 Purpose

The purpose of this thesis is to investigate what lowers the pace in the crane productivity while performing cargo operations on a container vessel. Time consuming factors are to be further investigated in order to find possible solutions to improve the crane productivity.

1.2 Questions

What factors are a crane operator experiencing as difficult and time consuming?

- How are these factors affecting the crane productivity during cargo operations?
- Can these factors be addressed in order to improve crane productivity?

1.3 Delimitations

The thesis takes into consideration the cargo operations on container vessels purely carrying containers. Other vessels able to carry containers are usually equipped with cranes and equipment thus, productivity of the quay cranes in port are not of the same importance as of pure container carrying vessels. All terminals are not using the same equipment, thus this thesis is further limited to one terminal, APM Terminals Gothenburg. The theory presented involves the type of cranes, equipment and conditions found at APM Terminals Gothenburg.

During the process, several factors lowering the crane productivity have been observed but limitations have been made to only include cargo operations on a vessel and not surrounding work such as container yard performances. Also, special cargoes, including over dimensioned goods requiring special handling have been excluded.

2 Background

This chapter explains the development of Maritime Logistics. In the first section the concept of Maritime Logistics and involved actors are presented. Secondly, information in regards of how port terminals compete are introduced. Finally, the last section presents key performance indicators measuring the port terminal productivity.

2.1 Maritime Logistics and actors involved

Transportation on sea plays a vital role to support globalization, hence many of the required transportation will be conjured by transports on sea. Thus, this make maritime transportation an important function for the success of the logistical flow (Lee & Song, 2015). It is of essence that development of this system is keeping up to and is integrated in all other logistical functions. This demand of integration of maritime transportation has conjured in the concept, Maritime Logistics (Panayides, 2006). Maritime Logistics consists of three key parts: freight forwarding, shipping and port terminal operation. Maritime transports are considered cost effective and environmentally friendly in regards of other means of transports. Transportation costs such as fuel and personnel required to move a vessel, handling fees in ports and other “under way costs” are spread between more cargoes. Thus, each cargo generate a lower cost per tonne kilometers in comparison with other means of transport such as rail, road and air (Lumsden, 2006). Customers of Maritime Logistics are demanding low-costing, quick and reliable transport solutions. According to Lee and Song (2015) focus should then be to reduce lead-time, reduce business costs as well as to improve service quality. The involved actors and their relation to above mentioned areas of focus are further explained in the following section.

2.1.1 Freight forwarder

Freight forwarders are intermediaries between cargo owners in need of a transport and carriers that provides transport services. Freight forwarders can be specialized in a particular commodity of cargo or only operate between particular destinations (Institute of Chartered Shipbrokers, 2013b). Larger freight forwarders can supply their customers with solutions for any type of shipment. Besides arranging transports freight forwarders can provide additional services for their customers. Examples of additional services are: arranging payments of freight and other charges on the shipper's behalf; customs clearance; issuing documents; warehousing; packing and inlands transportation (Institute of Chartered Shipbrokers, 2013b). Freight forwarders are customers to both port terminals and shipping lines. Freight forwarders agree on a rate for the transport with the shipping line and is to present the cargo and necessary documents to the port terminal. Freight forwarders seek short transit times, low port and cargo handling fees and accessibility to a shipping network (Wijnholst & Wergeland, 1997). Value is perceived when a transport is completed within the agreed upon time and within agreed upon rate. Delays that occur during and a transport such as a container that miss a vessel call generate costs that decreases the perceived value (Institute of Chartered Shipbrokers, 2013b).

2.1.2 Shipping lines

Shipping lines are carriers operating vessels that provide transport between continents, ocean traffic, as well as in between ports of the same country, feeder traffic. Shipping lines can offer a wide variety of trade routes on regular schedules (Lee & Song, 2015). Networks are created by complementing the route by connecting smaller ports with feeder vessels. Competition in between companies is fierce and companies compete by offering more flexible services and lower prices (Lee & Song, 2015). In the price-sensitive container industry the ability to keep costs at a low level is necessary for shipping lines to achieve profitability. As vessels grow in size the demand on port terminals, regarding both capacity and efficiency, increases (Institute of Chartered Shipbrokers, 2013a). A reduced lead-time for shipping lines signifies short turnaround times for vessels in port. Short turnaround times in the ports derives from an increased crane productivity in the port. In this way vessels are allowed to do more trips per year which increases their revenue due to the extra amount of containers shipped (Meisel, 2009). This does as well affect the possibility for shipping lines to improve the service quality to customers by providing shorter transit times and more frequent departures.

2.1.3 Port terminals

Ports are the interface between land and sea. Port terminals includes particular equipment needed to perform cargo operations (Alderton, 2009). It is of importance that port terminals can support shipping lines with the cargo handling services needed in a reliable and flexible way and at a low cost (Panayides, 2006). Activities of a port terminal includes: supporting systems for port entry; stevedoring; transit; storage and inland transport connection. As well as vessels grow larger and amounts of cargo to be handled increases so must also port terminals develop to support the trade (Institute of Chartered Shipbrokers, 2013a). To be able to compete a port terminal needs to apply strategies to create operational effectiveness and service effectiveness. Port terminals compete by advancements in technical, logistical and operational management (Steenken et al. 2004).

2.2 Port operators

Port terminals have traditionally been state-owned but during the last three decades private sector companies have emerged as port operators. The largest privatized port operators of today are Hutchison Port Holdings, APM Terminals and China Merchants Holdings International. The largest state-owned port operators are PSA International and DP World (Lloyd's List Intelligence, 2016). Together these five operators handled 41% of the world's total container flows of 2014 according to Arabian Supply Chain, 2015. Regardless if run by a private sector company or state-owned the main objective for the port operators are to generate profit (Cheon, 2007). Income for port terminals is mainly generated by the number of containers handled. Thus, it is of interest for port terminals to execute fast port calls as this generate opportunities to cater for additional vessel calls. Prior to a vessel calling the port terminal the rate of which the cargo operations will be handled is agreed upon. Failing to complete cargo operations in time can lead to disruptions of the logistical function, cause dissatisfaction among its customers and thereby decrease the perceived value (Lee & Song, 2015).

2.2.1 Port performance measurement

Port operators continuously work on saving time and a focus lies in streamlining loading and discharging operations. Ng and Mak (2005) argues that the total turnaround time is the key one and that a large portion of the terminal turnaround time consists of loading and discharging activities. Le-Griffin & Murphy (2006) argues that increased container handling productivity depends on the number of cranes used during the cargo operation, but also on the crane productivity. The crane operator's efficiency affects the productivity of the entire terminal. To concretize productivity performance indicators can be used. There are a number of indicators for measuring a port's performance. According to the Institute of Chartered Shipbrokers (2013a), vessel output indicators deal with the port's capacity to handle cargo operations on a vessel. One of these indicators are Working Vessel Output, presented below.

$$\textbf{Working Vessel Output} = \frac{\text{Total tonnage handled}}{\text{Total hours worked}} \text{ (tonnes/vessel hour worked)}$$

The total handled tonnage are divided by the numbers of hours for cargo operations. Although, this indicator does not take into consideration that containers can differ in weight.

APM Terminals (2016) define productivity as an average of number of gross moves per hour for each vessel call. A move is considered to be a lift of a container either for loading, discharging or repositioning. The gross moves are explained as the sum of these three types of moves per hour on a vessel call. Gross Moves Per Hour, GMPH, are the gross moves handled divided by the hours for cargo operation as presented below.

$$\textbf{Gross Moves per Hour} = \frac{\text{Gross moves}}{\text{Total hours worked}}$$

This indicator does not deal with the factor several cranes can be used and therefore alter the result which can double if using two cranes instead of one. The indicator Crane Productivity takes this into consideration as presented below.

$$\textbf{Crane productivity} = \frac{\text{Number of containers handled by one crane}}{\text{Total hours worked with the crane}}$$

3 Theory

This chapter describes the planning and execution of a vessel call. The first section describes a vessels construction and its limitations. Secondly, the procedure of making a stowage plan follows. The third section describes the procedures in a port terminal for executing cargo operations. Finally, common port equipment for cargo operations is described.

3.1 Vessel construction

A vessel primarily for containers is constructed with box-shaped holds where containers are loaded vertically in cells, resting on each other. The cells prevent movement of loaded containers during transport. The holds are usually fitted with hatch covers to protect the cargo below deck from sea and weather. Containers can be loaded on these hatch covers, also vertically, resting on each other joined by twist locks. Containers loaded on hatch covers are hereby referred to containers loaded on deck. The hatch covers usually have to be lifted off the vessel with a crane but some vessels have mechanically driven hatch cover which remain on board. To secure containers on deck lashing materials are used due to lack of cells. Lashing materials in use are wires, metal rods and bars (Stopford, 2009).

Locating a container on a vessel

The position of a container loaded on a vessel and when stacked in a yard is given by a numerical coordinate system referred to as the Bay-Row-Tier system (Container Handbook, 2016.) A vessel is divided into sections lengthwise called bays that are numbered from the bow to the aft of a vessel. Each bay is divided into rows which gives the container its position amidships. Finally, every container stack on a vessel is divided into tiers giving the position in relation to on what height it is placed in a stack (Lumsden, 2006).

Twist locks

Twist locks are equipment belonging to the vessel and are used to secure containers on deck, as seen in figure 1. They are also used to join containers stacked on each other, as seen in figure 2. The twist lock contains a movable part which is inserted in the corner casting of a container. Corner castings consists of a steel corner with a hole on each of its four sides, as seen in figure 3. Once the twist lock is inserted the movable part is twisted and locks the container. A manually operated twist lock needs to have the movable part locked and open by a person on board. Automatically operated twist locks will lock from the pressure of two containers put against each other.

Figure 1 manually locked twist lock on deck (Wikipedia, 2016)

Figure 2 manually locked twist lock between containers (Göteborgs Hamn Bildbank, 2016)

Figure 3 corner castings on a container (Chassis King, 2016)

Cell guides

Cell guides are metal frames acting as a securing feature to keep containers in place when loaded below deck. Cell guides are anchored in the bottom of the holds and reaches up to the hatch cover. Some cell guides have insertion guides as can be seen in figure 4 which function as guidance for crane operators to easier get the container into the cell guides (Institute of Chartered Shipbrokers, 2013b).

Figure 4 cell guides with insertion guides (Johansson. N, 2015)

3.2 Stowage planning

Containers planned for transport with a vessel need to be planned and have an assigned slot on board. Every vessel will have a stowage plan made by a central cargo planner, hereafter referred to as cargo planner. A stowage plan is made for the entire route of the vessel and consists of all containers to be loaded and discharged in each port (Institute of Chartered Shipbrokers, 2013b). Prior to a vessel's arrival, the port terminal will receive a plan where import containers to be discharged are marked, and also assigned slots for exports containers to be loaded. Available space are allocated and shown as groups of what type and size of container can be assigned to a location. This procedure is further explained in section 3.3.3. Creating a stowage plan is a difficult process and is usually referred to as the Master Bay Plan Problem (Ambrosino, Sciomachen & Tanfani, 2004). A stowage plan is usually made by a human planner with help from optimization programs thus, many parameters such as vessel structure and container properties need to be taken in consideration (Fan et. al, 2010).

Vessel restriction

The minimum stability requirements for vessels are regulated by The International Maritime Organization (IMO, 2002). Stability issues can cause accidents and cargo can be left behind as a result of wrong calculations prior to the final cargo operations are completed. To increase stability in a vessel one way is to try to focus the heavier cargo in the bottom of the holds and putting the lighter on the higher locations (Ambrosino et al. 2004). Weight distribution when stowing containers on a vessel need to consider the equilibrium of the vessel. Wrong distribution of weights can cause stress on the hull structure resulting in bending moments, shearing and torsion. Weight distribution also needs to be considered from bow to stern so that unwanted trim or heel does not occur. This also affects the scheduling of cranes, the crane split, to work on the vessel while loading and discharging (Institute of Chartered Shipbrokers, 2013). When making a stowage plan the cargo planner need to consider what weight each stack can endure. This applies both under deck and on deck for vessels with hatch covers. Height restrictions under deck is limited by the height available under deck up to the hatch cover. The height restrictions are limiting the amount of containers that can be stored under the hatch covers. Furthermore, the stack height on board is limited by the visibility required from the bridge to ensure safe navigation on the sea. The minimum requirements are regulated in SOLAS, Safety of Life at Sea (IMO, 2014). Furthermore, a vessel cannot be stowed with cargo over the allowed dead weight. In addition, some port terminals have draught restrictions that can further limits the total amount of cargo that can be stowed. It is a complex process for the cargo planner to create a stowage plan that allows for as much cargo on board as possible without making the vessel unseaworthy.

Container restrictions

To ensure efficient cargo operations in the port the cargo planner needs to consider the destination of each container. It is of importance to minimize shiftings due to containers being placed underneath a units planned for a later destination (Institute of Chartered Shipbrokers, 2013b). Hence the variety of containers abled to be carried by a container vessel the process of stowage planning will become more complex (Ambrosino et al. 2004). Reefer containers are constructed to enable transport of cargo that require a certain temperature during the transport. They require electricity thus, pose a limitation on how many reefer containers that can be carried on a vessel. Reefer containers can only have access to electricity on board on certain slots (Ambrosino et al. 2004). The international carriage of dangerous cargo is regulated in the IMDG-Code and states the requirements on how and where to stow dangerous cargo. When making a stowage plan this poses limitation on where the container can be stowed and how the cargo should be handled during cargo operations (Institute of Chartered of Shipbrokers, 2013b). Hazardous cargo need to be reported to all parties involved and the exact location of the cargo need to be known at all times (Ambrosino et al. 2004). Dangerous cargo is classified in nine different classes and the IMDG-Code provides details on how to safely handle and transport the cargo.

Manhattan Stowage and Layer-by-Layer

The stowage plan can be made in many different ways. The two most frequently used on deck are Manhattan Stowage and Layer-by-Layer. An explanation of both follows below.

As seen in figure 5, Layer-by-layer, containers for discharge in two ports are shown in two different colors. The white containers for discharge in the first port are placed on top of the grey containers remaining on board for discharge in a later port.

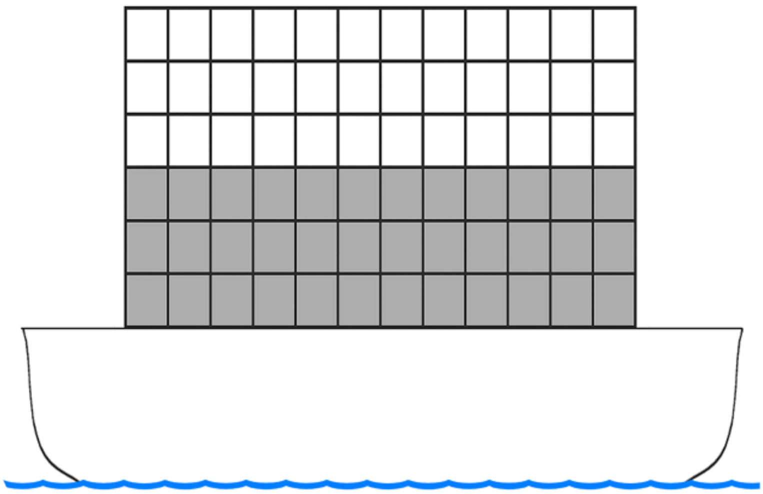

Figure 5 Layer-by-Layer (Skerdén. L, 2016)

As seen in figure 6, Manhattan Stowage, the containers have been placed in stacks and are accessible regardless of which port are called first. The reason for not loading all containers for discharge in one port on the same side is that doing so would affect the stability too much. The weight is equally divided on each side and some cargo operations will be made between these stacks.

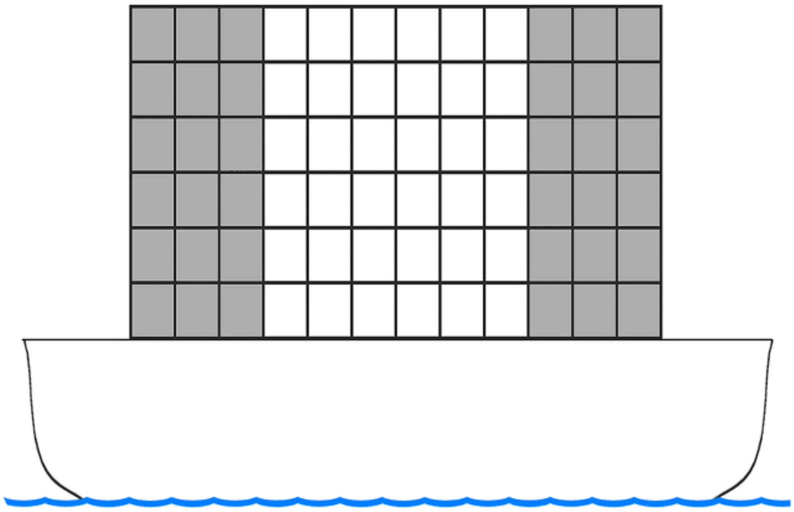

Figure 6 Manhattan Stowage (Skerdén. L, 2016)

3.3 Cargo operation planning

Böse (2011) divides the port terminal operational areas in: Quayside operations; Yard operations and Landside operations. Quayside operations handles the transfer of containers between the quay and a vessel and also the transshipment between the quay and yard. Yard operations handles storing and stacking of containers in the yard area and the transfer of containers between the yard and landside area. Landside operations handle discharging and loading containers on and off trucks and trains and involves controlling containers entering the port (Steenken et al. 2004).

Planning a vessel call

When a vessel arrives to the port terminal the cargo operation starts with cranes discharging import containers. The import containers are moved to the container yard for storage until further transports by truck, train or another vessel. Export containers enter the port terminal by truck, train or a vessel and are usually stored in the container yard until loaded on board the planned vessel (Steenken et al. 2004). To ensure efficient dispatch and schedule of the terminal equipment, the planning process is a crucial activity for the port operators. Prior to a vessel's arrival the port operators need to decide on what berth to allocate to the vessel. Thereafter they will process the stowage plan received from the shipping line and plan in what order the cargo operation will be executed. Finally, a decision on how to schedule the cranes are made. How many cranes that will be used and also the crane split. These three processes are further explained in the following sections.

First phase - Berth allocation

The first phase of planning cargo operations on a vessel is to allocate a berth. Factors to take into consideration are the draught and length of the vessel. In addition, the width of the vessel can limit the options if the cranes do not reach out to all containers on board. That is why larger vessels are operated with larger cranes (Steenken et al. 2004).

Second phase - Stowage planning

Secondly, the initial stowage plan from the shipping line will need to be processed to become a plan on how to execute the loading and discharging operation on the vessel. The initial stowage plan made by the shipping line is usually transferred to the port terminal by Electronic Data Interchange, EDI (Steenken et al. 2004). The stowage plan will have assigned slots on the vessel for each group of containers. It is for the vessel planner in the port terminal to assign a certain container to a certain slot. Containers with the same attributes such as size, weight and destination are considered equal. This enables the possibility to change an allocation of a similar container if the loading sequence need to be rearranged (Steenken et al. 2004). Containers carrying dangerous cargo will have been given an assigned slot due to segregation requirements and should not be changed. The port terminals finished stowage plan contains what containers that are to be loaded on the vessel and the assigned slot. It is of importance for the terminal operator to ensure as few restows of containers as possible. A restow will occur if a container that is to be handled before another is placed underneath the later (Steenken et al. 2004).

Third phase - Crane split

The final process to prepare prior to a vessel's arrival is the crane split. The number of cranes that will perform the cargo operation depend on the vessel’s size, the availability of cranes at berth and technical standards of the cranes and vessel. In addition to the number of cranes allocated to the vessel the crane split will determine how the vessel will be discharged and loaded as it will schedule in what bays the cranes will work (Steenken et al. 2004). The equipment is expensive and it is of importance when managing a port terminal that equipment is utilized and coordinated in a way to ensure productivity.

Cargo operation

Once the vessel has arrived, the discharging and loading operation commences and gangs are assigned to support the cranes. Transportation work are generated for straddle-carriers picking up and dropping off containers under the crane, and also yard cranes used to move containers to and from the yard if used by the port terminal. Communication between the vessel planner and vehicles as well as between vehicles are usually made through radio or wireless internet (Steenken et al. 2004). Terminal operators also need to communicate externally when changes in container status occur to several actors such as shipping lines, freight forwarders, hauliers, customs and coast guards (Steenken et al. 2004).

3.4 Equipment of a port terminal

Quay gantry cranes are used to load and discharge containers on vessels. There are several kind of cranes and the names of them vary. Further in this thesis, crane will be used to refer to the crane performing cargo operations on vessels. This type of crane will be further explained later in this chapter. Trucks and trailers can be used within the whole port terminal for horizontal transfers of containers between the quay, yard and landside areas (Steenken et al. 2004). Straddle carriers are special container handling vehicles that straddles a container and enables loading or discharging of a truck or trailer as well as stacking containers in the yard (Liebherr, 2016b). Straddle carriers are commonly used to support the cranes by provide or remove containers in connection with loading and discharging activities.

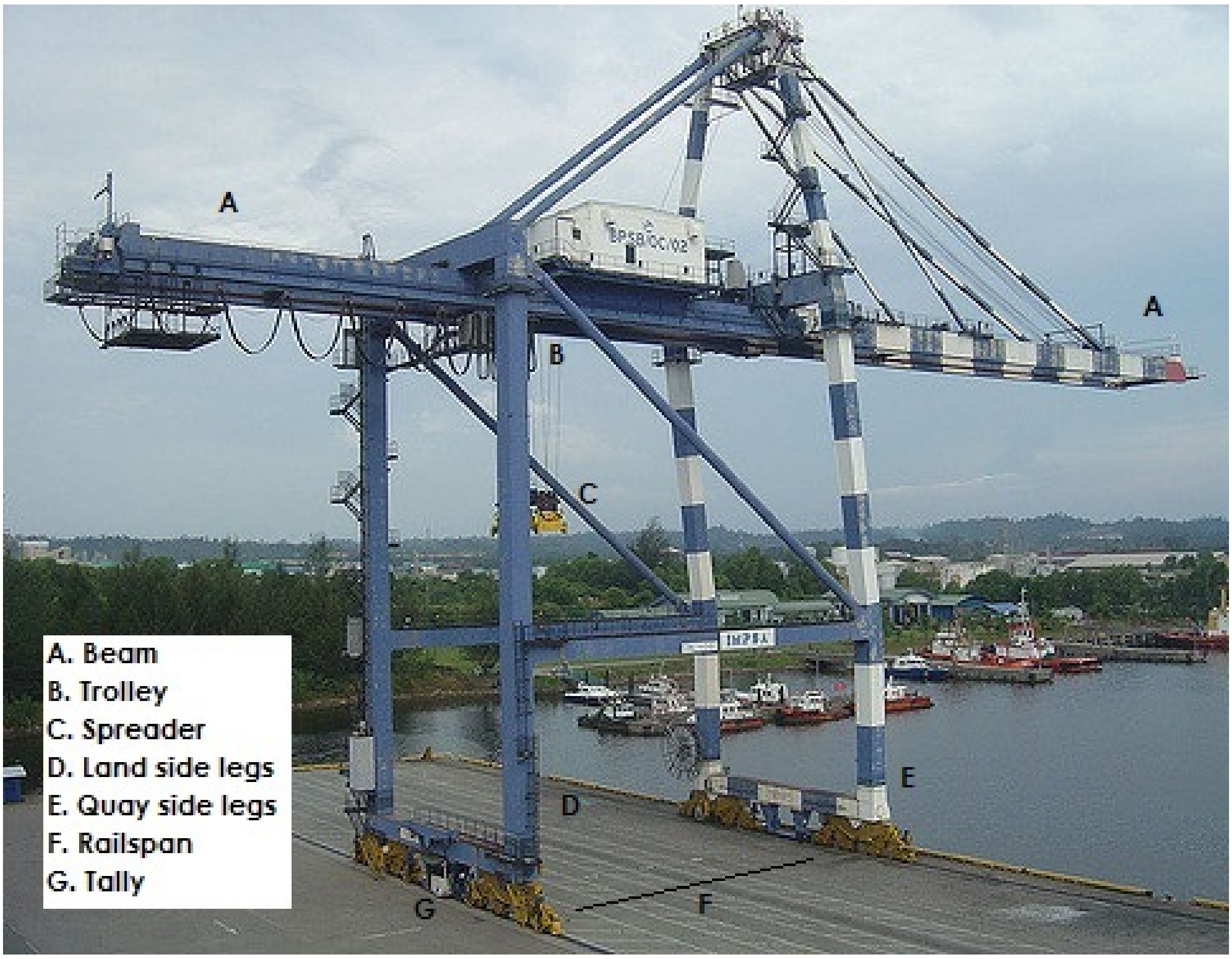

Figure 7 quay crane (Bintulu, 2007)

Quay gantry cranes

A quay gantry crane, or crane, are usually electrically driven and consists of four legs mounted on rails to enable it to be positioned at different locations alongside the vessel on the quay. As seen in figure 7, the structure supports a beam or arm with a moveable trolley on which a spreader is mounted and acts as a connector to lift the container. Cranes can be manual, semi-automatic or automatic (Liebherr, 2016a). The distance between the quayside legs and the yard legs are referred to as the rail span. In between the legs is the portal in which containers are transferred to or from the quay, trucks or trailers. This area is called the back reach area and in this area eventual hatch covers and twist locks will be placed during cargo operations. The legs support a beam which reaches from the quayside outwards over the quay edge. (Institute of Chartered Shipbrokers, 2013a). The beam need to reach across the vessel to handle containers at the far end of the seaside of a vessel as well as it needs to be high enough to handle the containers at the top tier of a vessel (Institute of Chartered Shipbrokers, 2013b). On the beam one, single-trolley crane, or two, dual-trolley cranes, trolleys are attached. The single-trolley crane is more frequently used in the port terminals. The trolley is moving along a rail system on the beam and has a spreader attached which by locking to the container with twist locks enables the pick-up of the container (Steenken et al. 2004). Cranes can be equipped with one or more cameras to help the crane operator to see. Cameras can be placed to enable back reach vision, latch view vision, drive direction vision and rear view visions (Pleora Technology Inc., 2016). The crane operator is situated in the cabin below the beam, just behind the trolley as seen in figure 7 and 8. When loading a container, the crane operator will see the container in front of the cabin and when placing it on board the view will be from above as seen in figure 8.

Optimal moves per hour

Cranes have technical specifications which states how many moves per hour it can perform. A larger crane, such as the Super Post Panamax crane as shown in figure 7 can have a specification of 50 moves per hour while it in reality only reaches 25 moves per hour (Steenken et al. 2004). The number of moves per hour depends on several factors, one of them is the cycle time or frame time. It is the time it takes to perform a lift, and will increase if the container is at the end of the beam compared to closer to the quay.

Spreader

A spreader is the device in use to connect the container with the crane and can move across the beam from the quay to the outmost end of the beam. It is connected to the trolley with steel cables as can be seen in figure 8. The spreader is usually telescopic and can be extended to handle containers in different sizes. The spreader is equipped with a twist lock in each corner and when inserted in the corner casting of the container it locks and ensures that a lift of the container is possible. In every corner of the spreader, above the twist locks, there are metal legs called seeker attached. They can be tilted downwards and be used to find the corners on a container that should be attached to spreader. There are spreaders that can lift two containers at the same time, this is referred to as twin (Institute of Chartered Shipbrokers, 2013b).

Figure 8 crane cabin and spreader (Johansson. N, 2015)

4 Method

In every scientific research it is important to find a method or strategy to use as a framework for how the research is to be executed (Denscombe, 2000). The researcher should evaluate different methods to find the most suitable way to address the problem and choose the framework accordingly. Thereafter it is possible to select suitable methods on how to answer the research questions. This research have been constituted as a case study with semi-structured and e-mail interviews as data collecting methods. A thorough literature review throughout the working process have been made to explain the results. The strategy and the methods in use are discussed in chapter 6. This chapter explains within what framework this research have been conducted, divided in three sections. The first section describes the working process and time frame of this research. The second section explains how data was collected and handled. Finally the third section explains how the ethical aspect of this research have been achieved.

4.1 Working process

The idea to this research came from observations made in APM Terminals Gothenburg. Some crane operations during cargo handling on vessels seemed to be more time-consuming than others. The first researches regarding cargo operations in a port terminal, several factors were mentioned as time-consuming such as restows. Thus, the early focus of this report was to find out if any cargo operations were experienced as more time-consuming. However, no research could be found regarding experiences from a crane operator's perspective. This led to a meeting with APM Terminals Gothenburg in January 2016 where it was discussed how to further investigate these observations. The most suitable persons to answer this question was found to be the crane operators, who perform cargo operations on a daily basis. Semi-structured interviews were held with crane operators which identified several factors as time-consuming. To proceed with these observations and to gain deeper understanding on why these occur, vessel planners in APM Terminals Gothenburg were interviewed. These interviews pointed out time-consuming factors, how these affect cargo operations and also possible solutions. To proceed with the possible solutions, contact with shipping lines had to be made. Requests to several shipping lines were made. However, only one shipping line chose to participate.

4.2 Semi-structured interviews

Interviews with the crane operators were held in February 2016 during a full day in APM Terminals Gothenburg. To enable the participants to feel comfortable the interviews were held in their own working environment. Ten of the asked crane operators chose to participate. The interviews consisted of 12 questions and was held with one participant at a time. The questions are provided in appendix 1.

According to Bryman & Nilsson (2011) the use of semi-structured interviews enables a possibility to adapt the interview and to ask follow-up questions. Furthermore, it enables an opportunity for the interviewed person to talk more freely and gain a holistic view on the issue. This was important since the focus was to allow the participants to elaborate their thoughts regarding their experiences. The results from the crane operators' interviews are presented in chapter 5. The interviews were on approval recorded. To ensure the participants anonymity all transcriptions were given a code. All recordings were deleted after transcription and the participants were offered to receive the transcriptions to verify them. The participants were also offered to receive the completed thesis. The interviews were held in Swedish thus translations have been made to the authors' best ability. The results from these interviews were after transcription color coded and sorted to enable a valid analysis.

4.3 E-mail interviews

To see the problematics that occur from a different angle e-mail interviews were made with vessel planners at APM Terminals Gothenburg. Three vessel planners were chosen by Daniel Eliasson, Planning Manager, APM Terminals Gothenburg. The interviews consisted of 13 questions. The questions are provided in appendix 2. Also these interviews were handled anonymously by giving the answers a code. The participants were offered to receive the completed thesis. E-mail interviews are to be considered as a valid way to conduct interviews and enables for the participants to answer the questions at a time of their choosing (Bryman & Nilsson, 2011). This enabled us to send out the interviews in March and receive the answer when the participants had time. The results from these interviews were after transcription color coded and sorted to enable a valid analysis.

Another set of interviews were prepared by e-mailing several shipping lines, followed by phone calls trying to reach the cargo planners who usually makes the stowage plans. Contact was made with representatives from eight shipping lines, both smaller and larger, with vessels calling APM Terminals Gothenburg. The initial contact was made in March. However, despite several kindly reminders only one shipping line responded. The results are presented in chapter 5. The questions are provided in appendix 3.

4.4 Ethics

When doing a scientific research it is of importance to ensure that an ethical approach have been followed (Bryman & Nilsson, 2011). To maintain high ethics in research projects and to protect the participants' integrity it is of importance to percerve high standards in the research society (Denscombe, 2000). To ensure that all participants have been treated with respect and honesty, all participants were informed why they were asked to participate and that all information was to be handled anonymously. The purpose of the research have been explained and all participants were asked prior to the interviews if they wished to participate. Furthermore, all recordings made have been approved by the participants and all participants have been asked if they would want to receive the transcriptions afterwards as well as if they wished to receive the final thesis once completed.

5 Results

This chapter is divided in three different sections that are further discussed in the following chapter. The first section presents the results from personal interviews with ten crane operators at APM Terminals in Gothenburg. Crane operators are referred to with CO 1-10 when quoted. The second section presents the results from e-mail interviews with three vessel planners at APM Terminals in Gothenburg. Vessel planners are referred to with VP 1-3 when quoted. The third section presents the result from e-mail interview of a Shipping line. All interview questions are attached in appendix 1-3.

5.1 Results from interviews with the crane operators

The crane operators were asked if they experienced that some cargo operations were more difficult than others, thus perceived to take longer time than they could. They were asked to not consider external factors such as the cargo activities involved with transporting containers to and from the crane. They were only to focus on the lifting process of loading or discharging the container. Furthermore, the crane operators were asked if possible to identify on what vessel calls had more time-consuming cargo operations. Finally, the participants were encouraged to discuss possible solutions to increase the crane productivity. The average working experience as crane operator by the participants was 11,2 years.

All ten participants addressed obstructed view as the most difficult and time-consuming factor during cargo operations. This is further explained in the following section. Other factors that were addressed are presented in section 5.1.3. The crane operators also identified differences between vessel calls and provided their point of view on how to address the issues which is presented in section 5.1.4, Results that does not fall under the scope of this research are presented in section 5.1.5.

5.1.1 Obstructed view

All ten crane operators claimed that when they cannot see where they are going to place the container it is both difficult and time consuming. In order to keep a high pace the crane operator need to see the area where the containers is to be loaded. The difficulties are addressed as stacks of containers that blocks the view for where the next container is to be placed. An illustration of obstructed view is presented in figure 9. This is a result of how the stowage plan from the shipping line is conducted and that the stacks blocking the view are containers destined for a later port. This type of stowing are referred to as Manhattan Stowage and is explained in section 3.2.

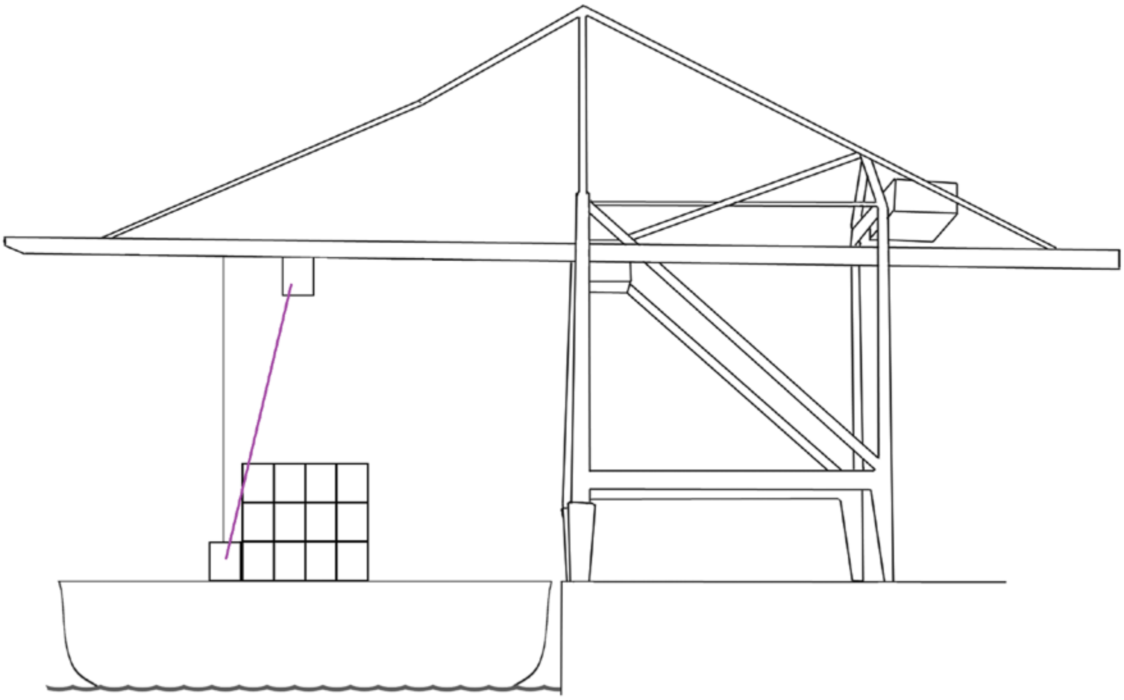

Figure 9 obstructed view (Skerdén. L, 2016)

The crane operators were asked to elaborate how “Manhattan Stowage” affects them during cargo operations. The overall opinion among the crane operators were that the pace of the cargo operations was reduced. Reasons mentioned are that they have to concentrate much more and put down the container blindly. In addition, lifting a container over a high stack extends the time needed to perform the lift thus, increasing the frame time of the crane. To clarify when the crane operators are experiencing difficulties, they were asked how many containers that can be stacked on board in front of the area where they are working without contributing to an obstructed view.

Scenario 1

The first scenario is when the crane operator was to load containers directly behind a stack, as shown in figure 10. The result is presented in table 1.

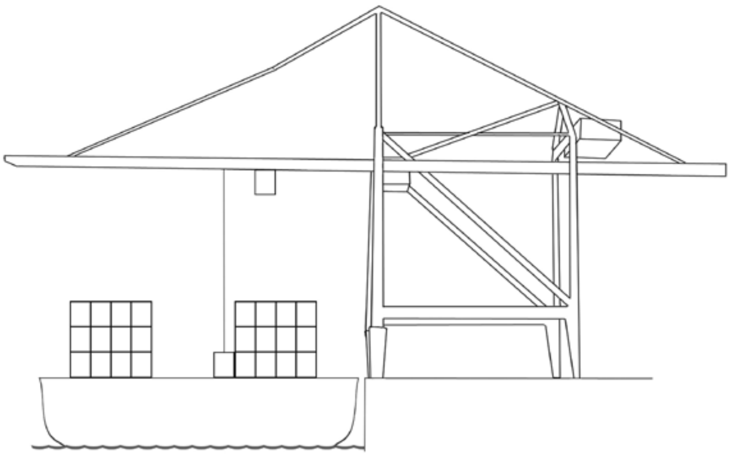

Figure 10 loading directly behind a stack (Skerdén. L, 2016)

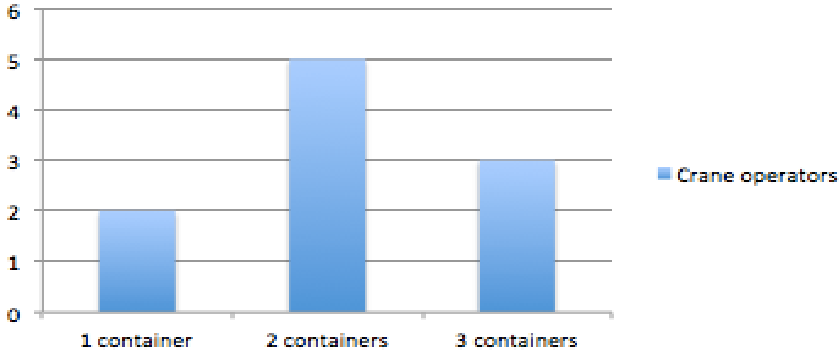

Table 1 number of containers considered to obstruct the view. Scenario 1 (Johansson. N, 2016)

Two crane operators claimed that one containers were a maximum in stack height in order to see properly and not affect the working pace. According to them it is not possible to see the twist locks where the container is to be loaded and even with help from a signalman on board, they have to go by instinct. They claimed that in an ideal situation there should not be even one container blocking the view to be completely sure.

Five crane operators claimed that two containers were a maximum in stack height in order to see properly and not affect the working pace. Two of them pointed out that this is affected by the distance between the containers. With this they mean that if two containers were loaded next to each other and there is a space in between this signifies that they cannot use the already loaded container as a guidance for placements behind. It was mentioned that larger vessels usually have smaller spaces in between containers which then would enable the possibility to actually use a stack as guidance.

Three crane operators claimed that three containers were a maximum in stack height in order to see properly and not affect the working pace. Two of them pointed out that if the twist locks on deck are automatically, they can lift the container when it is loaded and if there is resistance, be sure it is locked by the twist locks and therefore feel that it is in position.

Scenario 2

In the second scenario the crane operators were to load containers behind a stack but leave one row empty behind the stack, as shown in figure 11. The result is presented in table 2.

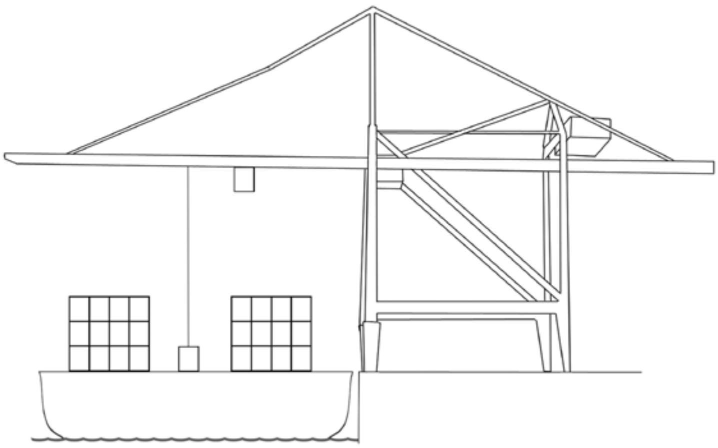

Figure 11 loading behind a stack with one empty row (Skerdén. L, 2016)

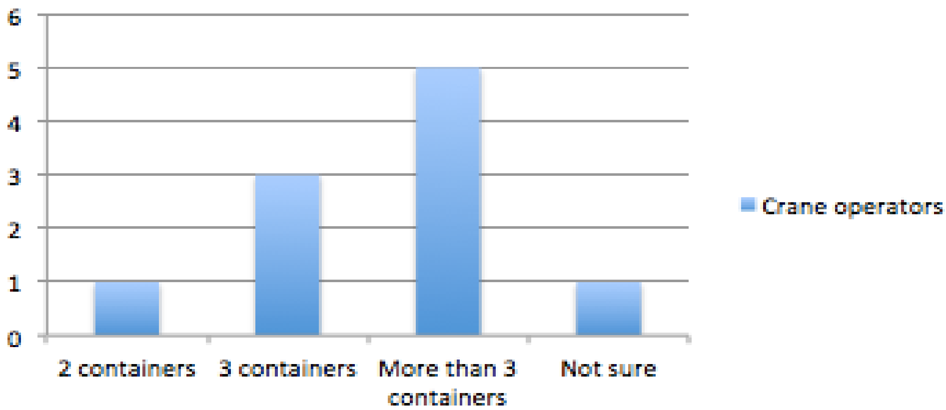

Table 2 number of containers considered to obstruct the view. Scenario 2 (Johansson. N, 2016)

One crane operator claimed that two containers set the limit during these conditions. Three crane operators claimed that three containers set the limit during these conditions. Five crane operators claimed that three containers set the limit during these conditions and one crane operator was not sure. In addition to reducing crane productivity the crane operators argued that the risk of damage on cargo and spreader is increased when the view is obstructed. One crane operator, CO2, expresses this by:

> “Like the other day. Start with 40’ and finish with 20’ behind a stack of five containers in the bay. I am going down and there is a shelf where the spreader can get stuck… There is a risk of damage because I don’t see where I load”

5.1.2 Equipment in use to assist during obstructed views

When confronted with obstructed view the crane operators can use assistance from cameras and or signalman on board. Crane operators can use cameras for help where the view is obstructed to help the crane operator to see behind a stack. According to three of the crane operators these are not very helpful due not being able to use when the stack is not too high. Another option to aid a crane operator is to place a signalman on board the vessel to be the crane operator's eyes. A signalman can be placed on board during cargo operations when a crane operator needs guidance. Equipped with a two way radio the signalman communicates with the crane operator and gives instructions and directions. The overall opinion on the use of a signalman among the crane operators are that it is helpful. The problem of synchronizing the eyes of the signalman and the maneuvering of the crane operator, CO7, is expressed by:

> “The time difference is quite big, because there are more reactions that affect how well it goes. The signalman has to tell when I should do a maneuver and if he don’t time the instruction it is too late”

5.1.3 Other factors

Among other factors mentioned by the crane operators were cell guides, twist locks and obstructing equipment on board each elaborated in this section.

Five crane operators pointed out that the condition and function of the twist locks can affect the cargo operations. Twist locks are explained in section 3.1. Twist locks that are not well working makes it difficult to feel safe during loading of containers. In addition, they argue that vessels with several different types of twist locks makes cargo operations more time consuming. When the person attaching twist locks on the containers have more than one type of twist lock to choose between, uncertainties arises if clear instructions have not been received in advance. Figuring out what type of twist lock to use is time consuming according to three crane operators. Automatic twist locks are considered the best type.

Four crane operators pointed out that the construction and placement of the cell guides of a vessel are creating difficulties when executing cargo operations. The cell guides are explained in section 3.1. With even the crane operators mean that all cell guides are of the same height. When cell guides differ in height there is a possibility to use the higher ones for guidance to get the container into position during cargo operations in cells. If cell guides are not tight enough, there is a risk of getting the container misaligned, which can lead to the container or spreader getting stuck in the cell. One of the crane operators, CO4, expresses it likes this:

"The larger vessels have closer between the containers which makes it easier to load because you can put the container against the stack and use it as guidance"

Two crane operators point out that cranes and other equipment of the vessel causes disturbances during cargo operations thus, decrease the working pace. Furthermore, one crane operator pointed out that hatch covers placed on board the vessel during cargo operations obstructs the cargo operations.

5.1.4 The crane operator's view on how to achieve high crane productivity

All crane operators point out that working behind a stack is more time-consuming than other factors. Thus, the crane operators were asked to if they could identify what vessel calls were more likely to have these type of stowage. Responses are presented below:

Identified causes of differences between vessel calls:

- Carrier
- The size of the vessel
- Equipment
- Amount of export containers
- Placement on the route

When asked to identify differences between port calls all participants mentioned that there were differences in between carriers. Especially port calls by one carrier were perceived as better planned than others. The smaller vessels of feeder type were perceived as worse planned than the larger ocean vessels. Other identified reasons were the condition of the cell guides, the amount of containers to be loaded and in what order on the route the port was. In addition, they were asked to discuss if they saw any possibilities on how to address these stowage plans. The responses are presented below:

Suggested solutions to increase crane productivity:

- Layer-by-layer
- Better cargo operation planning
- Better communication
- Restow containers
- Higher cranes

Some of the suggested solutions to increase crane productivity were to stow the vessels layer-by-layer instead of Manhattan Stowage. Layer-by-layer is explained in section 3.2. In this way the cargo operation is executed from one side of the vessel to another without containers obstructing the view. Furthermore, they point out that when making the cargo operation planning in the port to enable for dual and twin operations. Thus, the opinion is that the less shifting of the position of the crane the higher the crane productivity. Furthermore, it is mentioned that the communication between the cargo planner, vessel planner and the crane operator could benefit the crane productivity. By gaining knowledge of what is time consuming one crane operator argues that improvements could be made. Finally, solutions such as higher cranes and restowing of containers could enable an increase in productivity.

5.1.5 Excluded results

Some of the participants pointed out that cargo operations including containers with out of gauge measurements affected the crane productivity. These do not fall under the scope of this research thus, these have been excluded from the results. In addition, answers from participants in regards of the flow of containers from the yard to the crane are not taken into consideration.

5.2 Results from interviews with the vessel planners

To further investigate the results from the crane operators' interviews were held with three vessel planners. They were asked how they perceive difficult and time-consuming factors during cargo operations. In addition, they were asked to discuss Manhattan Stowage and how that affects the cargo operations. Finally, they were asked to discuss how and if the stowage plan provided from the shipping line can be improved. The average working experience of the vessel planners were 13 years.

All vessel planners were identifying Manhattan Stowage as a problematic factor which negatively affect the cargo operations. Other factors that were experienced as time-consuming were not being able to utilize the crane as possible and opening hatch-covers to access a few amounts of containers.

5.2.1 Manhattan Stowage

All three vessel planners mention Manhattan Stowage as a problematic factor when they were asked what affects cargo operations negatively. The responses further strengthens the results from the interviews with the crane operators. Crane productivity decreases during cargo operations where the view is obstructed. Another aspect that is mentioned is how the crane operator is negatively affected by these kind of operations. Thus, they know that they will never achieve a higher crane productivity no matter how fast they operate. One vessel planner, VP1, addresses the effect on the crane productivity like this:

> "Incredibly much since the crane operator's view deteriorates. The crane operator has to be very careful and use help from the signalman. This leads automatically to a lower GMPH"

When asked to define Manhattan Stowage the opinions between the vessel planners differ. One participant defines anytime when the view is obstructed and a lift is required. Another participant identifies Manhattan Stowage as a stack of three to four containers.

5.2.2 Possible reasons for Manhattan Stowage

When asked to further discuss what causes this type of stacks on board the vessel planners mentioned that it is an enormous puzzle. A vessel's stability has to be kept in order to follow all regulations and to have a safe sea voyage.

> "In some cases it depends on the vessel's construction and sometimes you have to load in a certain way due to the total weight of the vessel" (VP 3)

> "Stability has a role in this because they often load seaside and landside and then we get to discharge and load the middle of the vessel. This has only to do with stability, because the previous port can not load all containers on the seaside so that we can avoid cargo operations behind stacks" (VP 1)

One vessel planner argues that there are several reasons, also how capable the central planner is to include all loops with as few lift behind stacks as possible.

> "Many central cargo planners don't have much choice. They want the vessel to be finished as soon as possible. The formulation of a stowage plan depends on the vessel's stability and to allow the vessel to sail as economical as possible (eco-speed), because that is where the money is" (VP 2)

> "The central planner is supposed to try to make all actors satisfied: the terminal who wants large holds and no Manhattan, the mate who wants the best stability possible and the shipping line who wants the vessel to be stowed for eco-speed and departure on time" (VP 2)

Two vessel planners mention change of rotation as a possible reason. If a vessel needs to call the ports in another order than planned, the containers should be accessible without restows.

> "It is also important that all vessels shall be able to call different ports without having to shift containers. We see this very often on the larger vessels where we might have a very tricky cargo operation but this is because the vessel shall be able to skip ports and be able to discharge containers without having to shift full decks of containers" (VP 1)

> "It would be unfortunately if the shipping lines have not already taken these factors into consideration since they do not want to be berthed here for too long. If you have a large window, long laytime, then the vessel probably is planned to benefit the vessel's stability. With a short window I think you can avoid Manhattan Stowage and similar time consuming factors" (VP 2)

5.2.3 Possible actions to reduce Manhattan Stowage

After receiving the stowage plan, all three vessel planners says they can see where there is going to be a reduction in the crane productivity due to stacks of containers to operate behind. One vessel planners claims that small adjustments can be made, but that these requires approval from the shipping line.

One vessel planners argues that it is sometimes better to discharge the top containers in a stack and thereby reducing the stack height during cargo operations, and then reload the containers back on board.

Two vessel planners argues that a cooperation with the shipping lines could lead to a reduction of Manhattan Stowage.

> "If one could show how time consuming it is, the shipping companies might abandon Manhattan Stowage. It all depends on weighing the figures against each other" (VP 2)

One vessel planner argues that a development of vessels that are easier to discharge and load would result in a higher GMPH, even if it means less capacity in number of containers that can be loaded on the vessel.

Small amounts of containers spread out over the vessel are time consuming according to two vessel planners.

A lot of lateral movements on the crane track results in a lower tempo since it is hard to get a flow according to one vessel planner.

A lot of containers on deck takes longer time to load because of the need of twist locks, especially with manual twist locks. Also, opening a hatch cover for a small amount of containers below deck is mentioned as unnecessary by two planners.

5.2.4 Good conditions for cargo operations

All three vessel planners consider discharging full holds and loading the holds fully as optimally. Two of them mention the reason is to be able to do dual cycling, to increase the utilization of the crane and handle more containers per hour. By doing so, it means less lifts for the crane operators, less handling with an empty spreader and a better GMPH.

5.2.5 Excluded results

Some of the participants pointed out that cargo operations including containers with out of gauge measurements affected the crane productivity. These do not fall under the scope of this research thus, these have been excluded from the results. In addition, answers from participants in regards of the flow of containers from the yard to the crane are not taken into consideration.

5.3 Interviews with shipping lines

The interviews were being held individually by e-mail. Eight shipping lines were contacted and one shipping line chose to provide a power point presentation of their stowage planning procedure. The participating shipping line is anonymous. The questions asked are presented in appendix 3.

5.3.1 How a stowage plan is made at the shipping line

The shipping line identifies the considerations taken when conducting a stowage plan is those of safety, flexibility and productivity. When addressing safety they mean the vessel restrictions and cargo restrictions. When addressing flexibility they mention following factors affected by the port, the ability to offer services and the way the crane split can be conducted. Finally when addressing productivity they consider the capacity of the particular port terminal and how to increase movements by optimizing crane split. It is also mentioned that the plan is to try to reduce restows, operations in low bays and hatch cover moves. It should on the other hand try to increase the possibility to operate with twin- and dual operations and crane split.

5.3.2 Manhattan Stowage

According to the shipping line the basic rule for stowage are to avoid that containers for a later port goes on top of container that are to be discharged in an earlier port. This is avoided by dividing containers for loading and discharging equally over a number of bays. They mention Manhattan Stowage and claims it slows down the crane productivity, or results in restows of containers in order to lower the towers. Manhattan Stowage are defined as stacks of containers on the vessel that a terminal has to operate over in order to load or discharge containers. The reason for not avoiding Manhattan Stowage are that doing so would result in more restows. Reducing these towers on board are possible, but doing so results in the cargo have to be spread out over the vessel. An effect of this is a loss of space in the bottom of the holds and, eventually, an increase in restows. According to them, this loss of flexibility is the reason this method of stowage is not going to be changed. They also claim it works when seen in the context of an overall voyage.

6 Discussion

This chapter starts with a discussion of the result presented in chapter 5. The chapter is divided into three sections. The first section discusses cargo operations that were considered as difficult and time-consuming. The second section discusses Manhattan Stowage. Finally the third section discusses possibilities to address these factors.

6.1 Cargo operations that affect crane productivity

According to the results in chapter 5.1, all of the participating crane operators find obstructed view as the most difficult and time-consuming factor. In order to keep a high pace during cargo operations they need to see what they do. When the view is obstructed they have to be more careful, concentrate much more and sometimes putting the container down blindly. This is verified by the vessel planners who state that the cargo operations performed behind stacks, Manhattan Stowage, are lowering the overall GMPH. Other factors that were discussed are the type of twist lock used and also its condition. It was perceived as if the automatic type of twist locks were in use all the time this would not be as time-consuming. This likely depends on the possibility to lift the container once it is loaded to see if it has been locked by the twist locks. The loading operation is probably not going faster, but the insecurity regarding if it is loaded correctly reduces the time needed for checking. How the cell guides are constructed was also a factor that the crane operators experienced as affecting the pace of the crane productivity. It was considered that they should be uneven and solid so that they could be used as to guide the container into position. Both twist locks and cell guides are part of the equipment of the vessel as mentioned in section 3.1.

As mentioned in chapter 2, a reduction of lead-time and business costs as well as improved service quality are the key factors for port competition and profitability. Port performance indicators are measurements of a port's productivity and an important tool for port management to organize and improve operations in the port. As mentioned in the introduction, it is of importance to have a high efficiency in a port in order to meet the customer's requirements and be competitive. In order to achieve desired efficiency crane operators have to be able to maximize the number of containers handled. Abilities for crane operators to maximize the number of containers handled per hour increases with better planning in the terminal as well as increased resources in form of straddle carriers. However, it is always the crane operators' tempo that determines the crane productivity. Optimizing other processes in the port terminal such as yard performance are important and gives the crane operator better conditions for keeping a high pace. However, difficult conditions on board will not be improved by these processes. Thus, the total GMPH are decided by the crane operators' ability to keep a high pace during cargo operations. As mentioned, when crane operators are experiencing difficulties, the GMPH will decrease regardless of other optimized processes. Following section discusses the most frequently mentioned time-consuming factor.

6.2 Manhattan Stowage

According to the crane operators and vessels planners, the pace would increase during cargo operations if Manhattan Stowage could be avoided. As seen in figure 9, the view is obstructed when loading behind a stack of containers. The crane operators mention that performing cargo operations under these conditions lowers the pace, are more difficult and requires more concentration. Also, the risk of damage on both the spreader and containers are discussed. This, except for being more time-consuming, reduces the flow in the cargo operation and feels strenuous for the crane operators.

The shipping line confirms Manhattan Stowage as more time-consuming but argues it is necessary to avoid other negative aspects. Without having access to the exact cost of performing cargo operations under different conditions, it is hard to determine what way is the most profitable. However, keeping a high pace and have a high GMPH would probably favor both the port terminal and the shipping lines. An assumption is that the shipping lines making stowage plans with Manhattan Stowage are not aware of how time-consuming this kind of cargo operation actually is.

6.3 How can Manhattan Stowage be addressed?

Following section discusses possible solutions to avoid the difficulties that Manhattan Stowage entails.

Layer-by-layer

Several crane operators mentioned that the cargo operations could be performed in a higher pace if the cargo was stowed Layer-by-Layer, as explained in section 3.2. The overall opinion among the crane operators and vessel planners is that Layer-by-Layer gives better conditions for the crane operators. The view is not obstructed and they can achieve a flow in the cargo operations. A possible reason for not using this Layer-by-Layer is mentioned by one of the vessel planners who says a change of rotation would result in the cargo for discharge are inaccessible. These will then have to be removed first in order to complete the discharge operation, and then loaded back on board which results in unnecessary restows. This type of restowing activity is costly. To skip a port is probably an event that needs to be taken into consideration and is done by loading the containers in stacks instead of layers.

Leave one row empty

The crane operators argued that if they could have an empty row between the stack and the assigned slot for the container to be loaded, it could be a higher stack without obstructing their view. 50% of the crane operators could load a container even if the stack were three containers high, compared to the situation where loading directly behind a stack where none of the crane operators could without having their view obstructed. Leaving one row empty results in a loss of capacity but it might be profitable when comparing the figures. A faster cargo operation results in a shorter port call which allows for more voyages. This might be more profitable than loading all slots on the vessel.

Restowing

Restowing containers that obstructs the view are one possible way to solve this issue according to the crane operators. By discharging the top containers in a stack prior to the cargo operation behind the stack makes it possible for the crane operators to see properly. However, these containers are handled twice, once for discharging and once for loading them back on board. Even the vessel planners mention it but points out that these type of container moves are to be avoided if possible and that they need to receive an approval from the shipping line prior to a restow. The shipping line do not seem to consider this a good solution mentioning that the amount of restows are to be reduced. According to Steenken et al. (2004) restows should be avoided if necessary since they are moves done that decreases rather than increases the crane productivity.

Better equipment

Cameras or a signalman on board can in some cases be helpful for the crane operators, as explained in section 3.4, but there are opinions among the crane operators that neither cameras or a signalman on board are very useful. The cameras are not always working as the crane operators want them to. This is a factor that can be discussed whether it is a faulty camera or if the crane operator do not feel comfortable with the "eyes" being replaced with the ones from a camera. This is a factor that should be addressed by the port terminal thus, cameras are equipment of the port terminal as addressed in section 3.4. In regards of the use of a signalman on board the thoughts on how effectual this is differs. Some crane operators find it useful to have someone working as extended eyes but some argues that the communication has to be perfect in order to make it work. When being guided on a two-way radio sometimes it takes longer time to receive the message than that of that the container have moved. The signalman has to be able to time the orders perfectly or else the crane operator's maneuvers are delayed. This is as well a factor for the port terminal to address thus, if the cargo operations could be performed more efficiently with better tools for communication this could be of interest for the port terminal.

6.4 Method discussion

This section discuss the choice of research strategy and methods. Furthermore, validity and selection of participants in this thesis are addressed.

Choice of case study as research strategy

To choose case study as the framework for this research were taken because this strategy is based on investigating naturally occurring events. It is based on activities that can be observed and involves social relations and processes (Denscombe, 2000). This suited the questions of this research well since it focuses on getting a holistic view of a particular problem. For this research it was important to enable investigation of processes of which the researcher had no control. A case study also allows for possibilities to see how external factors are affecting the investigated area, especially since the boundaries are not clearly evident. In addition, case studies allow the use of more than one method. Thus, creating flexibility in the decision on how to proceed ones results are generated. When comparing with a survey type of research strategy this was deemed unsuitable due to being of a more general approach. It is hard to extract details and gain deeper knowledge using this type of strategy. When deciding to use semi-structured interviews this was also affected by the opportunity the researcher gained to actually interview the crane operator in their own environment. If not enabling this access it would likely result in receiving the same type of response are validated as less.

Validation of data collection

When validating a qualitative method it is of importance to validate if the same results were to be perceived if the research would be done the same way by another researcher (Denscombe, 2000). By holding these interviews with a larger amount of crane operators it was possible to receive a good picture of what they experience as problematic and time consuming. What can be discussed is if the result would differ if interviews were held at another port terminal or if the questions would have been sent beforehand. As some participants commented when asked how certain operations affected them they argued that it would have been easier to answer if sitting in the crane when thinking about the question. The results were clear on that obstructed view was the most time-consuming factor which was further strengthened by the vessel planners. Thus, this is considered a valid result and that further interviews, within the same terminal and with another terminal, would not generate a different result.

The results from the crane operators and the vessel planners generated answers on what the time-consuming factors were and how they occurred. To further analyze how to address these problems the shipping lines would need to be involved. The participation from the shipping lines were well under what was expected. Thus, to create another angle towards this research it could be discussed what results would have shown if all or more would have responded. The only respondent from the shipping line can only lead to speculations when discussing their response. Most possible reasons for only one cargo planners performing an answer is believed to be due to the fact that they are situated in offices around the world and that they might not have time to participate in these kind of researches. This is further strengthened by that one shipping line returned with the response that participation was not possible from their side.

Selecting participants

The participants of the first interviews were selected in regards of their expertise within this area. This was a decision made after consulting Daniel Eliasson, Planning Manager, APM Terminals Gothenburg. Furthermore, the interviews with the vessel planners were decided on after receiving the results from the crane operator. At this time it was also decided to enable contact with cargo planners at shipping lines. The shipping lines asked to participate were chosen due to having vessels calling the port terminal. The persons contacted were the ones in charge of making the stowage plan.

7 Conclusion

This chapter summarize the conclusions based on the questions on which this research have been focused on.

Factors impacting crane productivity

This report concludes that crane productivity in a port terminal could increase if the crane operators were to perform cargo operations with unobstructed view. Obstructed view in connection with cargo operations behind stacks are lowering the overall crane productivity. Despite equipment such as cameras to aid the crane operator to see the pace is still perceived as decreased. Signalman on board is a necessity when the view is obstructed due to safety but the cargo operations are still not increased. Cargo operations behind stacks are defined as Manhattan Stowage. This affects the amount of containers being handled, thus lowering the key performance indicator, GMPH, in the port terminal. The Manhattan Stowage is a result of the way the stowage plan is constructed at the shipping line. The crane operators and the vessel planners of the port terminal of Gothenburg sees possibilities to adapt these stowage plans to consider limitations on crane operators productivity.

Possibilities to increase crane productivity

A vessels stowage plan is made by the cargo planner at the shipping line in control of the vessel. Since the stowing is determined prior to the port call modifications will need to take place at the shipping line. The vessel planners of the port terminal see a possibility to reduce the amounts of Manhattan Stowage by better communication. They think this would be of more importance for the shipping line if one could present cost comparisons weighing slower paced cargo operations against shorter time spent in the port. To further investigate how and if possible to adapt stowage plans accordingly further collaboration between port terminals and shipping lines need to take place. The shipping line participating in this thesis is aware of the problem of more time-consuming cargo operations in connection with Manhattan Stowage in comparison with stowing Layer-by-Layer. To reduce the amounts of Manhattan Stowage is not prioritized as it is considered to increase the amount of restows.

Further research

To further investigate how to create possibilities to adapt the stowage plan and consider the pace of the crane operator a quantitative analysis is needed. If a comparative calculation on how much time can be saved at a vessel call is made, it could be possible to influence the shipping lines.

Another area to investigate is if computer optimized stowage plans could include how a crane operators pace is affected by different scenarios.

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Appendix

Appendix 1 - Interview questions to the crane operators.

1. How many years have you been working as a crane operator?

2. If you would identify good conditions for crane operations in regards of the initial stowage plan provided by the shipping company, how would it look like for you to be able to work as efficiently as possible?

3. If you would identify bad conditions for crane operations in regards of the initial stowage plan provided by the shipping company, how would it look like for you to be able to work as efficiently as possible?

4. How do you experience crane operations behind stacks of containers already loaded on board?

5. Can you describe the problems involved with such crane operations?

6. Are these problems only limited to crane operations on deck or is it as well a problem when operating below deck?

7. How many containers can be already stowed on deck before problems such as lowered vision occur?

8. How many containers already stowed on deck can there be before your crane operations are negatively affected? If you are to place the container directly after the already stowed container/containers?

9. How many containers already stowed on deck can there be before your crane operations are negatively affected? If you are to place a container behind the already stowed container/containers with one row as a space between?

10. Do you have an opinion on what port of calls that in general have good conditions for you to operate on?

11. Do you have an opinion on what port of calls that in general have bad conditions for you to operate on?

12. Do you see any possible improvements to be made on the initial stowage plan provided from the shipping company for you to be able to work as efficiently as possible? The optimal stowage plan.

Appendix 2 - Interview questions to vessel planners, APM Terminals Gothenburg

1. How widespread are the problems with crane operations behind stacks of containers already loaded on board?

2. Is it more common on some shipping companies than others? Does it occur more than one time during the same port call?

3. Does it occur both during discharging and loading a vessel?

4. Do you have a definition on when the stack height becomes problematic?

5. Can you do anything to avoid this?

6. Why do you think these kind of stack height occur?

7. For long have you been working as a vessel planner?

8. Has it always looked like this or has the occurrence of these kind of conditions increased or decreased?

9. Do you have any suggestions how to avoid these kind of conditions?

10. Do you know if any attempts have been made to decrease these kind of conditions? Improved communication between port operator and shipping company or such?

11. How does an optimal stowage plan look like to enable an efficient crane operation as possible?

12. Are there any shipping companies in which the communication of improvements are better or worse?

13. Do you get the feeling that all shipping companies have the same knowledge in regards of what affects the efficiency in port? Are there room for improvement at any or more than one shipping company?

Appendix 3 - Survey questions to shipping companies' cargo planners

1. How many years have you been working as a cargo planner?

2. How many cargo planners in charge of vessels calling Gothenburg are working at your company?

3. How many port calls do you have to Gothenburg per month?

4. How do you conduct a stowage plan?

5. What are your priorities when doing the cargo stowage plan on a vessel?

6. What sets your limitations?

7. Do you use any stowage models on how to plan the cargo on a vessel? Tools?

7. Do you know how long time your stowage plan takes to execute in port, in an optimal scenario?

6. If yes, how often is that assessment correct?

7. If it differs, how does it differ?

8. Do you think that it would be possible to execute your stowage plan faster than it is being executed today?

9. Do you keep any statistics of how the initial stowage plan differs from how the actual stowage operations was?

10. If yes, what is your opinion on how it could be executed faster?

11. Do you consider the effect on the crane operators when planning where the cargo is being placed when planning a vessel?

12. Would you be able to moderate your stowage plan if you knew it would create an opportunity to execute the cargo handling operations in port in regards to how the crane operators need to work?

13. How is the communication between APM Terminals and you today in regards of stowage plans and the execution of it?

14. What knowledge or information sharing do you believe would benefit the both of you?