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OPTIMIZATION OF CONTAINER PROCESSES

Terminal Management

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Abstract

The thesis outlines the possibilities of optimization in a maritime container terminal. The focus was on maximizing the system output and optimizing the terminal capacity. The aim was to find operations required for optimizing the terminal and means to achieve full utilization of the terminal handling equipment.

Based on the related theory, a review of different operations in a container terminal was compiled in order to understand the terms applied in the maritime industries. Those included container terminal, terminal management, containers, and communication technology to name a few.

With regard to the data collected, the discharging and loading process of a containership were discussed, and the cycle time of the transfer equipment were analyzed. The means of communicating among parties and the requisition of operating equipment were also discussed. Container inspection in the terminal and its process at the gate were discussed as well.

The results of the thesis suggested means to achieve a shorter transshipment time. This included modification of the current means of data transfer and the introduction of smart card technology at the gate. Moreover, some actions that permit better utilization of the transfer and handling equipment which do not require external investment were proposed. A full utilization of the terminal equipment is possible with the application of a cycle time reduction strategy for the transfer trucks.

Keywords
Terminal Management, Container Terminal, Communication Technology, Cycle time

Miscellaneous

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1 INTRODUCTION

In 2013, the total container traffic recorded for developing countries grew from 5.2 percent to 7.2 percent from the previous year representing 466.1 million TEU. Moreover, an estimated rise of 5.6 percent recorded in 2013 representing 651.1 million shows how the world container traffic has grown. (UNCTAD 2014, 66). The changes in growth call for the need for container terminal operators to stay competitive and make use of the highest technologies in order to be able to handle these challenges (bigger vessels). See Appendix 1 for details.

African economy relies solely on the abundance of natural resources that the continent possess. Turning these resources into usable end products has left the continent no option, but to export some and in return import machinery and equipment to increase productivity. In addition, the continent struggles with the common facilities of the infrastructure such as medicine and food items, which makes the continent a regular importer from developed countries ("Africa Trade, Exports and Imports | Economy Watch" 2010). This transaction is only possible by using containerization.

In general, containers represent about half of the total volume of importation in the Sub-Saharan African Countries. Percentagewise, Abidjan (La Cote d'voir), Tema (Ghana,) Logos (Nigeria) and Dakar (Senegal) receive more than two-thirds of the total container traffic in West and Central Africa. (Raballand, Refas, Beuran, & Isik 2012). In order to house for this massive container demand, terminals have to respond with larger storage yards and good technology so as to facilitate the handling process and ease the congestion at the terminals.

The two commercial ports in Ghana (Tema and Takoradi) recorded unusual high demand and overwhelming increase in container traffic following the crisis in Abijan which happens to be the largest port in the region. However, Tema port is experiencing lower demand and storage difficulties as a result of congestion and longer waiting time. The challenge then compels importers and container vessels to change or redirect their traffic to other destinations. Unlike Tema port, Takoradi port is expected to undergo renovation in the coming year, otherwise it still face the same challenges (Oxford Business Group 2013, 188-190).

1.1 Research Aim and Objectives

Apart from the country's (Ghana) importation, the attention of foreign companies has shifted to the country's economy and other sub-Saharan countries in order to set up businesses as a result of oil discovery in the region. The importation of oil refinery equipment and heavy-duty machinery has caused dramatic increase in container traffic at Ports container terminals.

According to statistics, container traffic increased by 7.5% from 2011 to 2012 and by 7.9% between 2012 and 2013 at the two main harbors in the country (UNCTAD 2014, 65). The difference in percentages shows how container traffic has risen over the past few years. See Appendix 1 for details.

During the author's training at the company, the following issues were identified:

1. Long container process for intermodal transfer.
2. Underutilization of terminal equipment.

The goal of the study was to find possible solutions that can be applied in order to increase the efficiency of the container processes. The thesis aimed to answer the following questions:

- What should be done to minimize the transhipment time and to achieve the continuity of an intermodal freight transport chain?
- What should be done to achieve full utilization of the operating equipment?

Areas of optimization were, for example;

- reducing travelling time/distance of the pickers
- finding the right allocation for the containers to be stacked

- improve the communication between the parties involved

1.2 Research Methodology

1.2.1 Qualitative Research

Qualitative research is a way to explore on individuals' thoughts or a group's adjustment to communal or human challenges. This type of research deals with emerging questions and practices, records gatherings from the partaker's settings, performs data analysis inductively by building from the fundamentals towards common themes. (Creswell 2013, 4). According to Merriam (2014, 14), qualitative research is the determination to understand situations in their natural state as a part of a particular setting.

On the other hand, Lapan, Quartraroli, and Reimer (2011, chapter 4) state that all qualitative research types take on emic perspective, focus on studies and try to understand the viewpoint of the locals and specialists. This is based on people's knowledge and understanding of the context, without any doubt or disbelief from the researcher's point of view. Qualitative inquiries involves direct or indirect communications, the important part of the inquiry is the knowledge that the participants contribute to their actions and deeds. The paper further elaborate collecting of qualitative data into four-cell matrix (See Table 1).

TABLE 1. Classes of data gathering at individuals and community (Lapan et al 2011, Chapter 4)

	Observation	Interviewers
Cultural Level	Community maps, stroll, crusade,	Open-minded in depth interviews with

	games and festivals, seminars, rallies, and markets.	key members (leader of a group, and those who have a deep understanding on the topic)
Individual Level	Daily activities of peoples, visits to education centers, hospitals,	The partaker's own viewpoint on the events,

1.3 Company Background

The Port of Takoradi is located in the western part of Ghana. It was established in 1928 as the first commercial port for the purpose of handling major export and import commodities from and to the country. The coordinates of the Port are 225 km to the west of the capital city of Ghana, Accra at latitude 4°53'N, 1°45'W and 300 km east of La Cote d'voire.

Takoradi port's interconnection to the hinterland makes it the desired port for cargo that needs further transportation to its final destination in the central and northern parts of the country as well as the neighbouring countries in the north. All vessels calling to the port are directed to six different berths which have a depth ranges from 9.5 meters to 10.4 meters with additional three berths reserved for bauxite, manganese, and oil. The length of the berths falls between 120–183 meters which is long enough to accommodate a bigger vessel. The port has storage capacity of 5000 TEUs and about 100 outlets for refrigerated containers. Altogether the port has a covered area of 140000m^2 and an open stacking area of 250000m^2 making it possible to store different types of containers. (Ghana Port & Harbours Authority: Takoradi Port 2015),

Port Services

Below are some of the services at the port;

- Pilotage
- Ship Repair Facility
- Towage
- Mooring/Unmooring/Berthing
- Stevedoring
- Shore Handling
- Storage and Warehousing
- Clearing and Forward Agencies, etc.

Meanwhile, the port has varieties of resources in terms of equipment for all kind of operations to ensure better services to other private stevedoring companies in the terminal, and it is also well-equipped so as to work on vessels efficiently.
About 80% of the vessels calling at the port carry imported containers from the developed countries which are delivered and in return loaded with export goods or empty containers to the destination of origin.(“Ghana Ports & Harbours Authority : Takoradi Port” 2015).

1.4 Containerization

Containerization is a system of freight transport using universal standard dimensional shipping containers that can be loaded/unloaded, secured and loaded onto trucks, trains, ships, and planes, and they can be transferred from one transport mode to another. The system was first developed after World War II in April 27, 1956. (Wood, Anthony, Barone, Murphy, & Wardlow 2002, 207).

The idea behind this innovation was to cut down freight transport’s operational costs by reducing the cargo handling costs. Moreover, containers require less product packaging, help reduce defect, and they result in greater efficiency during the handling process. This counteracts the labour intensive manner in which every item is loaded/unloaded onto or from the mode of transport between nodes (Levinson 2010, 3).

Challenges and Opportunity for Improvement

Seaports are numerous, and container terminal capacity has increased over the years and does not show any signs of slowing down. Bigger container ports around the world such as Singapore, Hong Kong and Los Angeles / Long Beach have thriven thanks to the quick loading-equipment.(Knowles & O’Rourke, 2006).

Modern ports are planning to introduce high technology services into container terminal and redesign the layout of the terminal in order to maximize the terminal capacity, reduce the vessel turnaround time, and reduce the number of container reshuffles massively. For instance, the initial capacity TEU design for Patrick’s Corporation container terminal at Port Botany in Sydney, Australia, was 700,000 TEU (twenty-foot equivalent unit) per year. However, by introducing high technology system it shot up to 800,000 TEU in 2005 (Froyland, Koch, Megow, Duane, & Wren 2007, 54).

2 CONTAINER TERMINAL

The term container terminal is defined as an open area on the berth where vessels are anchored to allow containers to be loaded/unloaded and transported to a storage yard (Steenken, Voß, & Stahlbock 2004, 6-8). Again, according to the paper, the arrangement of the handling equipment at the terminal explained briefly, means a terminal that uses pure straddle carrier systems and a terminal that uses gantry cranes system for container storage. The chosen system type depends on several factors, such as space availability. The economic and historic background of the port also has great impact on the decision making for the preferred system. Furthermore, there is a third system of terminal called an on-chassis system practiced normally in Europe, Asia and some part of North America. Space restrictions affect the third system making it less practicable. (Steenken, et al 2004, 6-8).

According to Lee and Meng (2015, 4), a container terminal generally concentrates on gateway events that involve the exchange of containers between a containership and different inland transport modes. A containership discharges imported, empty or loaded containers to the arrival port and in return loads export containers from the local manufacturers to another destination. There are several activities that happen at a container terminal from the arrival of containership to its departure. Figure 1 below shows the sequential flow of containers at the container terminal in four different phases

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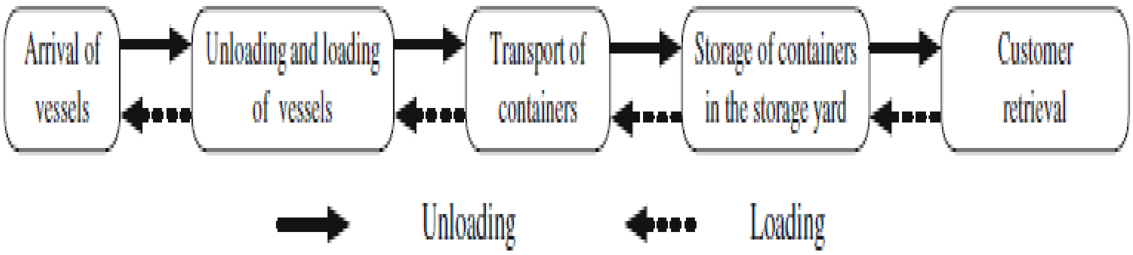

FIGURE 1. The main subsystem in a container terminal (*Lee, Chew, Tan & Han 2006, 542*)

Function of a Container Terminal

The basic functions of a container terminal can be grouped into two main parts. The terminal provide transshipment from containerships to trucks, rails, feeders, etc., and it also serves as a storage location for empty and full containers for a period of time before they are transported.

According to Henesey (2006), all the activities that happen at a container terminal can be categorized into four main subsystems. These are:

1. *Ship-to-shore*, this describes the transfer of containers from an arriving vessel to the berth. The loading and unloading task is performed by a quay crane assigned specifically to the vessel.

2. *Transfer,* the horizontal movement of containers from one point to another within the container terminal, mostly from the berth to the storage yard and from the gate to the storage yard. Trucks, Automated Guided Vehicles or Straddle Carriers are the equipment used in this operation.

3. *Storage*, a predefined area reserved for imported and exported received containers. Storage yards are often marked with strips for easy identification and differentiation from vehicle routes.

4. *Delivery/Receipt*, containers from the hinterland are received at the gate before transporting to the storage yard, and this happens in the reversed order with imported containers. It often involves different transportation modes, such as rail or truck. The subsystems are interrelated because the performance of one subsystem affects the other, thus creating continuity or bottlenecks in the terminal processes. (Henesey 2006, 5 – 6).

2.1 Terminal Management

The management of container terminal operations comes with several decision problems: these involve policies guiding the storage block with regard to container features such as weight, sizes, country of destination, import and export container dispatch, type of goods in the container, etc. They also involve arrangement and scheduling of yard cranes and planning for re-marshalling laws for export containers. (Vacca, Salani, & Bierlaire 2010, 4-5).

Vis and de Koster (2003) also present an insight on how terminal planning and operations should be involved. According to the paper, management must emphasize the loading and unloading of the ship, the arrival of the ship, transferring of containers from the ship to the storage yard and container transfer within the terminal. The author suggested that the overall understanding of the situation is very important before an analytical solution can be decided on. Therefore it is worth breaking the original operation into minor phases.

Nonetheless, the author mentioned that the whole process of developing and validating models for these problems would takes plenty of time and therefore attention should be focused on various types of equipment in the terminal if two or more equipment are to be combined. Figure 2 shows an overview of a container terminal system.

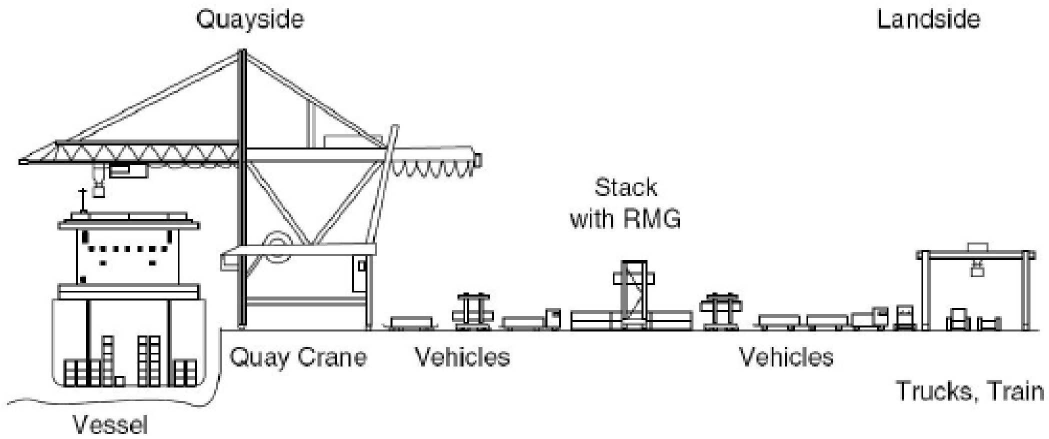

FIGURE 2. *Schematic view of container terminal system (Steenken et al 2004)*

On the other hand, the paper summarizes the common decision problems facing container terminal planners, such as Berth Allocation (BAP), Stowage Planning, Quay Crane Allocation, and Transfer Operation. This is explained briefly in the next chapter.

2.1.1 Berth Allocation

Berth allocation is the process of assigning and scheduling a ship to the berth or to quay cranes in a sequential order over of a given time. All vessels that have reported for a call are programmed to accommodate a placement in the terminal within a specified time. The berths' scheduling in the terminal planning create higher costs when compared to other costs factors. A typical berth allocation must consider factors, such as berth depth, the length of the crane the jib, the ship's length, etc. This has to be considered a few days before the arrival of the ship. (Barnhart & Laporte 2006 501).

2.1.2 Stowage Planning

Stowage planning determines in each bay the category of outbound and inbound containers to be stacked (Barnhart et al. 508). The plan preparation is governed by the stowage instruction of the shipping line in the inverse of the port to be visited by the ship. However, a good planning will result in high productivity of the crane. The planners must see that the right container is transported in the right time and stacked according to the stowage plan or instruction of the shipping line or carrier. This eliminates crane waiting time or vehicle queuing time and thereby increases crane productivity and minimises the ship's berthing time.

Considering terminals where manually driven systems are used, the driver's skill and route selection affect the operating performance where as technical distractions of the crane operation leads to alterations in the order of loading sequence. Transportation time therefore cannot be totalled accurately even if the planners choose to operate automated guided vehicles. For the stated reasons it can, therefore, be concluded that the pre-terminal stowage plan is below standard. (Steenken et al. 2004, 18-19).

Online Stowage Plan

An online storage plan is prepared by the shipping line which generates containers to be loaded simultaneously based on their loading method. Its application by both the terminal managers and shipping lines eliminate or minimize the above stated problems in the sense that containers of the same features are considered equal with regard to the stowage plan of the shipping line. The containers to be transported are selected according to the features allocated to the ship position in the stowage plan of the shipping line. In addition, the online stowage describes the order in which the containers arrive at the quayside for loading. (Steenken et al 2004, 19)

2.1.3 Quay Crane Allocation

According to Vacca et al. (2010, 4), the quay crane allocation is the arrangement of quay cranes to mooring vessels for an operation for a specified time. The authors also indicate that the resources provided for working on the vessels must be adequate enough so as to complete the work in the given time period as requested by the vessels line. During the crane scheduling, planners must take into account crane interferences as this constitute loss of productivity. Therefore, a crane must be specifically assigned by the planners to the actual task to be performed or details given to each crane for loading and unloading.(Barnhart et al 517).

2.1.4 Transfer Operations

This covers the activities regarding the movement of containers between the storage yard and the berth side by means of internal trucks, straddle carriers and Automatic Guided Vehicles (AGV). Vehicle routing and dispatching policies are the likely challenges facing the transfer operations. Implementing a better strategy by the terminal planners will reduce the distance travelled to finish a given task, as well as the vehicle fleet volume, the fleet operating cost or the total operation delay time. (Vacca et al 2010, 4)

2.2 Terminal Handling Equipment

Most terminal handling equipment at the port is provided mainly to facilitate the transfer of cargo between a ship and the storage yard, road vehicles and railway wagons. In the early days of container shipping the cargo handling at the ship's side was performed by on-board crane or lifting equipment. As larger containerships are being constructed for marine cargo transport, container terminals are also being modernized with regard to their terminal facilities so that they meet the ship berthing times. Therefore the idea of on-board lifting equipment is no more beneficial. For instance, operation such as loading/discharging containerships can be performed at the same time. (UNCTAD 2014, 70-71).

Container terminal operators face challenges with the aim to minimize the operational cost while trying to maintain service quality and to maximize operational effectiveness. The construction of larger containerships and the increase in container traffic challenge ports operators to increase their operational output of the terminal equipment. In order to overcome the above challenge, the total logistics capacity and the container hub must correspond with each other. Moreover, faster crane and horizontal transport equipment should be at the highest operational level, and the decision for selecting the right operation system must also contribute to a positive outcome.

Factors that are to be considered during the decision making about the right operating system are:

- vessel capacity
- annual volume container traffic
- land availability
- allowed dwell time of received containers in yard
- Percentage of containers (empty, full load, less load, reefer, etc.)
- Capital
- Cost structures (taxes, wages, financial facility) etc.

The list above can also be made a great deal longer. However, there are a few items of equipment that can be considered when making decisions.

Examples of these are cranes (conventional quay cranes, mobile harbor crane, ship-to-ship crane, rubber-tire crane, rail-mounted) reachstackers, terminal tractors with trailers, automated guided vehicles. (Böse 2011, 29).

2.2.1 Quay Crane

Quay cranes are of two different types: the single-trolleys and double trolley cranes. With the single-trolley type, a spreader is attached to the trolley that allows it to move across the crane arm for container picking. It is a man-operated crane and it works by moving the containers from the vessel to the quay or by placing them on a waiting truck to be transported to the storage yard, and the same cycle is for loading the vessel. The double-trolley crane is unlike the single-trolley type, because two trolleys operate at the same time for loading and discharging. One of its trolleys is automatically driven, and the second one is driven manually. These cranes can be of the rail mounted gantry type (RGM), or rubber tired gantries (RTG) or overhead bridge cranes (OBC). (Steenken et al. 2004, 8) See Figure 3.

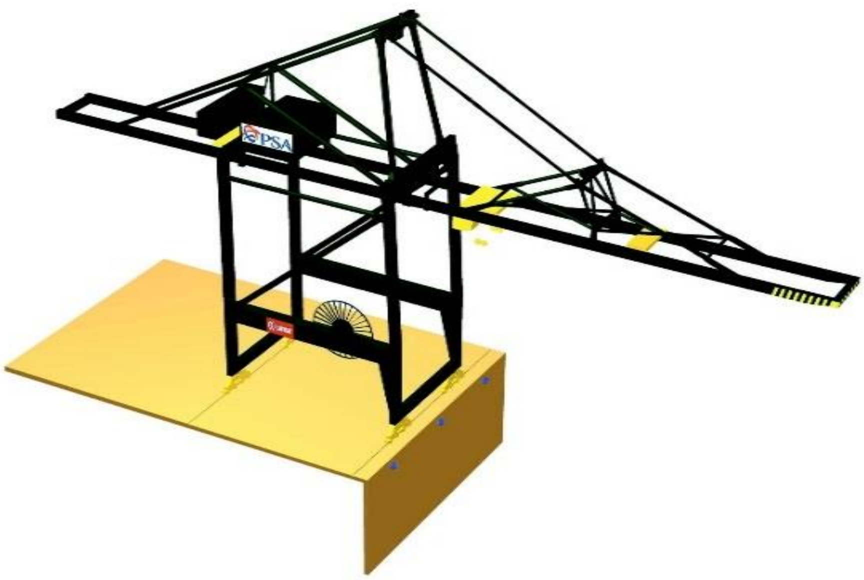

FIGURE 3. Eight Kalmar ship to shore crane (*Marshal consultant logistics*)

2.2.2 Horizontal Transport Equipment

This is a moving equipment that conveys cargo between quayside, storage yard and landside operation. This equipments is defined by their means of operation; that is passive or active. Automated guided vehicles (AGV), and trucks with trailers are considered being the passive type because of the loading processes in which they have to be loaded by another item of equipment or a vehicle. The active type means those that can lift containers by themselves and transport them to next point. The vehicles that belong to the active type are the reach-stackers, straddle carriers and forklifts.(Steenken et al. 2004, 9) See figure 4 for details.

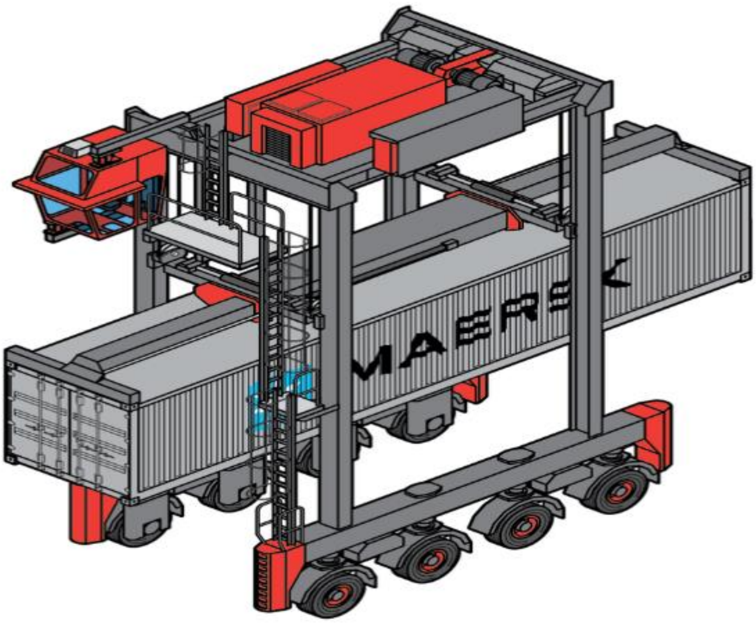

FIGURE 4. Straddle Carrier (*Behance*)

2.2.3 Equipment Productivity and Cycle Time

Cycle time is the total time including the actual processing time and waiting time for completing a particular task. The calculation of a cycle time depends on the exact definition. A reduction in the terminal equipment cycle time will minimize the vessel turnaround time and, thus, improve terminal throughput.
The importance of reducing cycle time in an operation is based on the following factors:

- Saving capital by reducing WIP (Work In Progress)
- Maximizing yield
- More savings through incremental improvements:
- Enhanced employee output.
- Better equipment utilization
- Minimizing non-productive methods of performance measures.

Yard Truck Single Cycle

The yard truck single cycle time for discharging begins from the storage yard to the berth side for loading. The quay cranes load the truck if a container is already discharged to the ground. Otherwise the truck wait until the container is ready. In the storage yard, the yard crane unloads the truck or the truck waits for the crane to be ready. If the truck waits for the crane, the waiting time is then added to the actual operating time. The process continues until all imported containers in the vessel are emptied. The single cycle loading also goes through the same process until the last container in the storage yard is dispatched to the berth side. In both operations a number of trucks are needed to maintain the cranes in a steady operation. A mathematical representation of the operation is as follows:

$$Ts = w1 + \left(\frac{dx1}{dv2}\right) + w2 + \left(\frac{dx2}{dv1}\right) + \sum ly + \sum lb$$

Ts denotes the yard truck unloading and loading (for single) cycle time
w1, and w2 denote container unloading and loading time by the quay crane and yard crane.

x1, and x2 denote the distances between the storage yard and quay side for empty and loaded trucks.

v1 and v2 denote truck speed when loaded and truck speed when empty.

ly, and lb denote the truck waiting time at the yard area and the quay side.

(Ahmed, Zayed, & Alkas 2014)

Yard Truck Double Cycle

The double cycle time involves two yard cranes and two quay cranes, one of each at the storage yard and the berth side. A single truck begins the cycle before the second begins. A transfer truck is loaded with an export container by the first yard crane which dispatches it to the berth side. At the berth, the first quay crane discharges the truck, and the second crane loads it with an imported container to return to the storage yard. The second yard crane then discharges the arriving truck. The truck moves to the first yard crane for an export container to begin a new cycle. A graphical representation of this operation is shown in Figure 5. In the case of crane delay, the time is added to the actual operation time. A required number of transfer trucks is needed to complete the operation. The double cycle time is calculated by the formula below:

$$TD = 2 * (w1 + w2) + \left(\frac{dx1 + dx3}{dv1}\right) + \left(\frac{dx2 + dx4}{dv2}\right) + \sum ly + \sum lb$$

TD denotes the yard truck unloading and loading (for double) cycle time

w1 denotes container loading/unloading time by quay cranes

w2 denotes container unloading/loading time by yard crane respectively.

x1, and x3 denote the travel path between the storage yard and quay side for loaded trucks and vice versa.

x2 denotes the travel distance for an empty truck between loading and unloading quay cranes

x4 denotes the travel distance for an empty truck between loading and unloading yard cranes

v1 and v2 denote truck speed when loaded and truck speed when empty.

ly, lb denote truck waiting time at the yard area and the quay side.

(Ahmed, et al 2014)

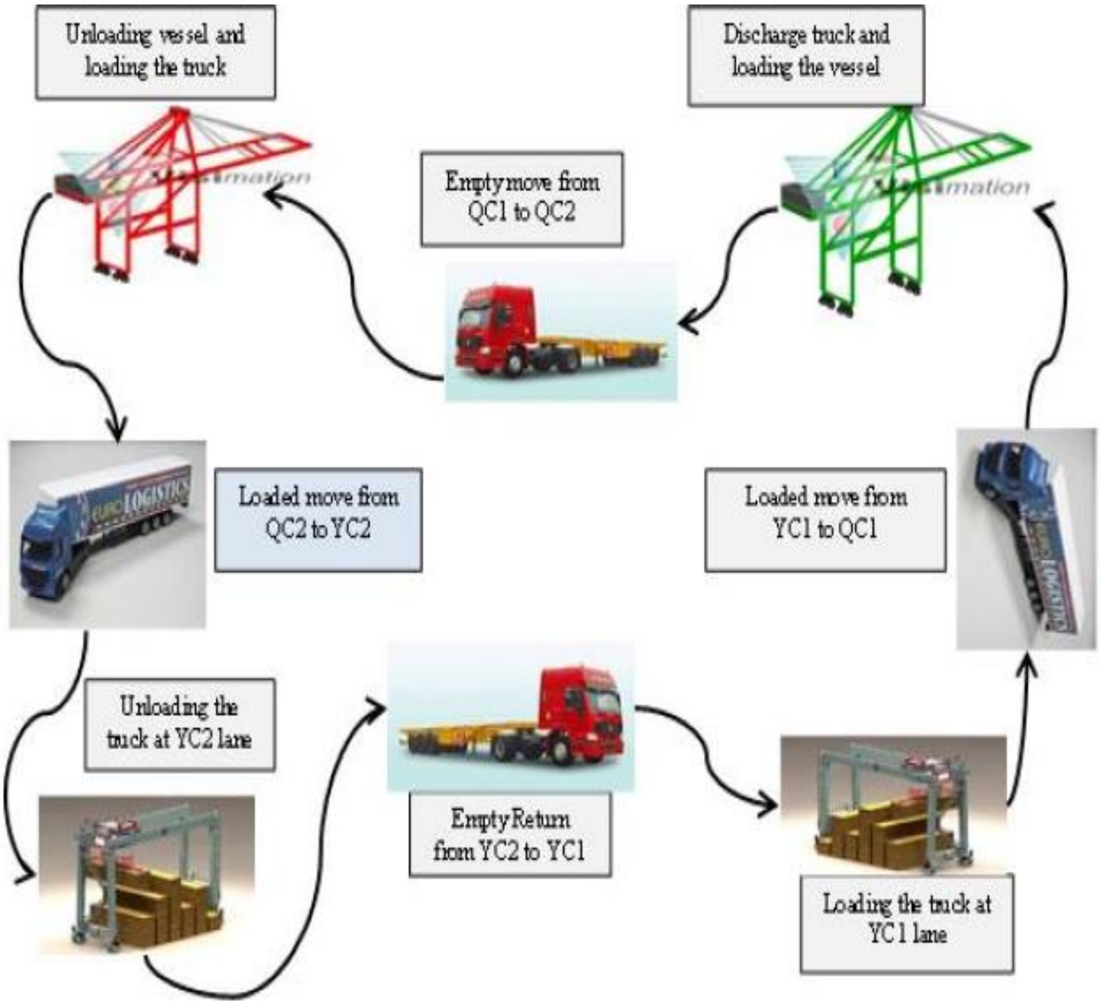

FIGURE 5. Yard truck double cycling operation (*ASARC 2014*)

2.3 Containers

Container is a box simply defined according to the term of its use. These boxes are of different forms but have an identical rectangular shape, a standard outer leaf that has the ability to resist and protect what it's inside. (Customs Convention on Containers, 1972)

Generally, two sizes of container are widely used for transporting freight – 20 foot equivalent unit (TEU) and 40 foot equivalent unit (TEU) container. Table 2 illustrates a container type and dimension:

TABLE 2. Dimensions of 20ft and 40ft dry container (*Port container Services*)

GENERAL PURPOSE CONTAINER SPECIFICATIONS

Specifications	10' Container	20' Container	40' Container
Inside Cubic Capacity	15.4 m3	33.2 m3	67 m3
Max Gross Weight	non payload	30,480 kg	30,480 kg
Tare Weight	1,500 kg	2,360 kg	3,980 kg

Dimensions	Length	Width	Height
10' External	3.10 m (10')	2.44 m (8')	2.59 m (8'6")
10' Internal	2.98 m	2.35 m	2.38 m
20' External	6.05 m (20')	2.44 m (8')	2.59 m (8'6")
20' Internal	5.90 m	2.35 m	2.38 m
40' External	12.19 m (40')	2.44 m (8')	2.59 m (8'6")
40' Internal	12.01 m	2.35 m	2.38 m
Door Size		2.34 m	2.28 m

Material and Security

The manufacturing material of a container must be of a high standard to meet the expected life span during it usage on both land and marine transportation. Example of these materials are aluminium with steel reinforcement, steel, plastic and wood with fibreglass reinforcement. The selected material depends on the purpose of it use.

For every container to be accepted by the international organization, there must be a security information on the leaf which can easily be interpret and access. Such information includes:

- A container number
- Manufacturing data
- The weight and its test data
- Country name of approval.

2.3.1 Types of Containers

CMA-CGM is the third largest shipping company which operates in the maritime industry. The company give a brief distinction of freight containers according to it usage with regard to the international standard organization under the ISO/TC 104.

Dry Container

Dry Container is the most commonly used container for transporting all kinds of general goods. It is sometimes called general purpose container, with steel as the most used material. It is used to carry commodities packed in boxes, cases, pallets, bundles etc. (CMACGM Containers).

FIGURE 6. Dry Container (*Seaco*)

Reefer Container

Reefer or refrigerator container is a thermal container installed with an electric appliance (mechanical compressor), for the purpose of controlling the temperature within the container. It is used for transporting chilled and frozen cargos which are described as perishable products. Meats, fruits, vegetables, etc., are typical examples of perishable products. (CMACGM Containers).

Figure 7. Reefer Container (*Seaco*)

Open Top Container

An open top container is similar to dry container but without a rigid top cover. The container is roofed with tarpaulin which makes it easier for loading/unloading. It is used to carry high height and heavy cargos that are difficult to handle or load through normal container doors. (CMACGM Containers).

FIGURE 8. Open Top Container (*The container traders*)

Flat Rack Container

As the name implies, flat container have no side walls. It has end walls that can be fold or erect depending on the size of the load. It is used to transport heavy and oversize loads which cannot be handle by general containers. The design allows for both top and side loading because it does not have side walls. (CMACGM Containers).

FIGURE 9. Flat Rack Container (*Seaco*)

Tank Container

Tank container is a freight container typically designed for the transportation of hazardous or non-hazardous liquids. Two basic elements are involve in its design, a tank and a frame for stability. (CMACGM Containers).

FIGURE 10. Tank Container (*Seaco*)

2.3.2 Loading and Unloading Containership

All containerships are designed to allow for loading and offloading. Therefore, the loading method applied is very important in the terminal planning. During the loading process, planners consider the objective to ensure the vessel stability and to minimize the handling effort of the loading crane and other yard equipment.

Principles of Loading

The loading principles guides load planners to achieve the objectives stated above. Few loading principles are as follows:

- Containers must be separated and not be put together in the same bay when they are of different groups. This allows containers of the same features to be close to each other in the cell of a bay during the loading operation.
- Yard blocks housing export containers should be located adjacent to each other in the direction of the crane movement. The reason for this principle is that, the travel time of the loading crane is reduce during the loading operations. (Kim, Park, & Ryu 2000, 90-91).

Loading Restrictions

E-CFR Data (2015) gives a brief clarification of the regulations guiding terminal intermodal handling containers or roll-on roll-off operations. The paper point out that, a container must remain in it position unless the following information is clear and aware by the equipment operator.

a) weight of the empty container in pounds,
b) maximum weights a container is design to carry in pounds,
c) total weights of container and load in pounds,
d) type of container, whether empty, half or full load,

2.3.3 Stacking

Container stacking is a process of allocating received containers to a temporary storage yards where it awaits for further transportation by either a vessel, truck, or train. In traditional storage yards, cranes are used for stacking containers side by side with another on top of the bottom ones in a rectangular area termed as block. The block is demarcated in rows and bays which defines the positions and the number of containers in length and width. Containers are stacked 3 – 8 high, the stacking height is referred to as ties. The capacity of a container terminal determine how big a size of a block can be.

Port planners with good stacking method utilizes ground space when containers are stacked with higher ties. However, the higher the ties the more likely reshuffles are require to retrieved bottom containers. (De Castilho & Daganzo 1993, 151).

Method of Stacking Container.

Vis et al. (2003, 8) reported two distinctive ways for stacking container: "*storing on a chassis and stacking on the ground"*. The paper state that, containers that are stacked on the ground provides less accessibility to the more containers because it is crowdedly stacked. Storing on a chassis is the opposite of stacking on the ground. However, the most practice method used by port's operators is the stacking on the ground because it accommodate less storage space.

A decision at the strategy level influences a stacking method. For example, the type of handling equipment to be used for stacking and retrieving of containers. The necessity of efficient stacking is to ensure that other remaining operations can be carried out successfully. Factors such as height of stacking and planning strategy for received containers can also affects the efficiency of stacking. (Vis et al. 2003, 8).

Container Lifting Methods

Powers, Scott, and Mackey (2010) lists and describe four possible ways a container can be lift onto a train, a truck and a containership. Namely, "*the Top Lift Spreader Method, the Top Lift Sling Method, the Bottom Lift Sling Method and the Fork Lift method"*. Moreover, the paper explained that in order to achieve a high container (empty or loaded) throughput, the selected method is of important.

Top Lift Spreader Method

This method uses a spreader designed to fits at the top holes of the four corners of the container. After it is securely lock, a vertical force is applied to lift the container onto the transporting units or to a desirable height. In this method there is nothing like normal hooks in the lifting process as a result of special device fitted to the spreader. See Figure 11 for details.

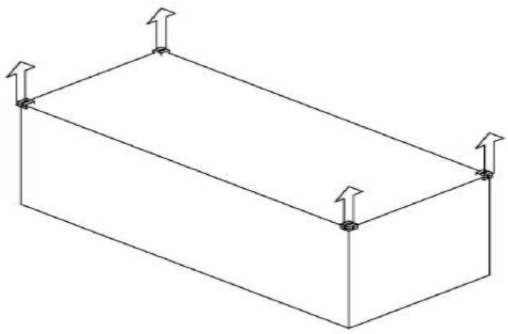

FIGURE 11. Top Lift Spreader Layout (Powers et al 2010)

The Bottom Lift Sling Method

Both empty and loaded containers can be lift by the Bottom Lift Sling method. Its lifting is similar to that of the Top Lift Sling method but the only difference is that, the container is lifted from the sides of the four bottom ends. See Figure 12 for details.

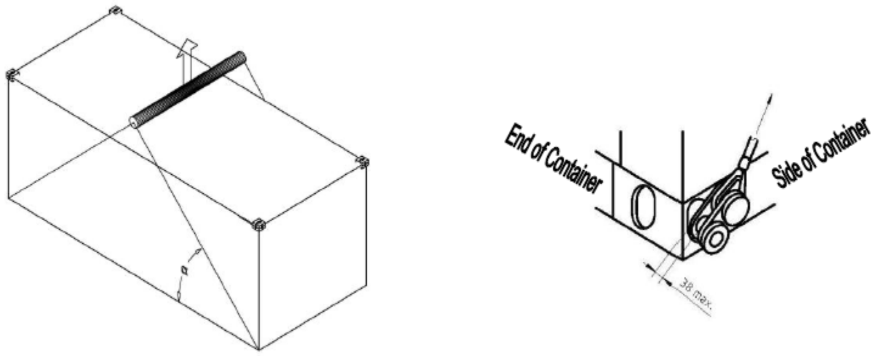

FIGURE12. Bottom Lift Sling Layout (Powers et al 2010)

Top Lift Sling Method

This method is normally applicable to empty containers of 10 foot long owning to a vertical lifting angle, α 60°. The lifting is done with four hooks connecting the sling which is positioned in an inward to outward direction at the corners of the container. See Figure 13 for details.

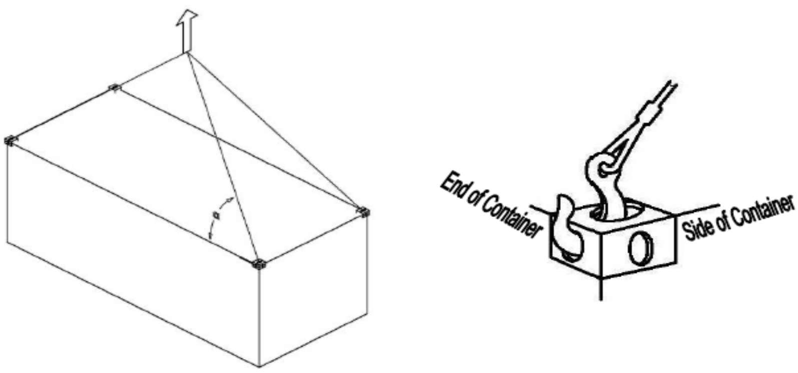

FIGURE 13. Top Lift Sling Layout (Powers et al 2010)

Fork Lift Method

This only applies to 10 and 20 foot long container types, whether empty or loaded. Such containers are provided with forklift pockets. The forks of the forklift machine is slot to the pockets of the container as shown in figure 14 before it is lifted onto the transporting units. (pp. 3-7).

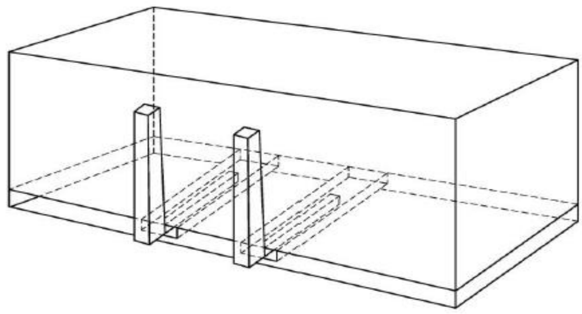

FIGURE 14. Fork Lift loading Layout (Powers et al 2010)

2.4 Information and Communication Technology

"*Data becomes information only when they are timely and relevant*". This implies that, the flow of information must be accurate. The relevancy of information becomes meaningless if it cannot be understood or be interpret. Logistics is define as the transfer of information between nodes, therefore, it is very important to be aware of the information type, what it carries and its final destination. (Grant 2012, 136).

The introduction of IT in the field of logistics has result in major advantages in a company performance, especially when management make the right decision. The direct use of IT for logistics activities consists of:

- duplication of transaction;
- building processes planning system such as ERP;
- carrying out shipment and item tracking and tracing, with the use of RFID;
- supporting the strategy decision making process; etc. (Grant 2012, 136)

2.4.1 Information Technology in Container Terminal

The global movement of freight container involves multiple parties for information transfer in all routes or destinations where the cargo requires change of transport mode. In intermodal transportation, container requires two or more different modes of transport before it get to the finally destination. As a result of this, early planning is a vital part of the decision making on the container type to be used and the nature of the transport. Almost all container types requires different approach in terms transshipment, some cargo are kept under reasonable temperature while others may be stacked in the open storage yards without any source of power connection. (Tiffin & Kissling 2007, 171)

The utilization of storage space in the terminal has result in more reshuffles of empty containers in storage yards at any point of time. With timely or relevant information sharing at the terminal, container transfer, loading and unloading process will improve and reduce the number of reshuffles. This will further cut the turnaround time at transshipment point and speed up the logistics chain.(Tiffin et al 2007, 171)

2.4.2 Benefits of Information Technology application in Container Terminal

The implementation of a computerized container controls system enhance timely information flow, reduces paper works, and increase the overall operating efficiency at the terminal. Below are the benefits of computer application in container hubs:

- speed up the unloading and loading of containers;
- Maximize output through quicker turnaround of containership;
- Provide a good checks and options on the storage of containers thereby creating storage capacity;
- Flexibility in documentation;
- Information becomes more easily accessible by other parties;

- Timely and good utilization of terminal facilities. (UNCTAD 1993, 10)

Kia, Shayan and Ghotb (2000, 340-343) conducted a study on two terminal, one equipped with IT system and the other without IT system. See Table 3 for details. The authors' concluded that the presence of information technology in container terminal reduces man work, enable fast information flow, and improve terminal service qualities.

TABLE 3. Simulation output of terminal with and without IT (Kia 2000).

Description	terminal without IT	Terminal with IT	Differences
Crane service time (2 no.)	182.50 hrs	144.74 hrs	-26.08%
Ship time at berth	93.20hr	74.37 hrs	-25.31%
Ship cost at berth	$174,000	$139,000	-$35,000
Straddle servie time (16 no.)	1,518 hrs	1,214 hrs	-25.04%
Saving time in human resources	1,972hrs	1,580 hrs	-24.81%
Ocuppancy of stacking area	63%	44%	-43.18%

Information technology application in container terminal can be group under these headings;

- *Technology for loading*: these includes computerize system for stacking containers in storage yards with an automated crane, crane with built-in ship-loading technology.
- *Tracking equipment technologies*: those require for data capturing and inventory planning as RFID, GPS, etc.
- *Horizontal transport technologies*: these are used in intermodal activities, for example when combining trailers system or automated guided vehicles (AGV).

2.4.3 Technology Application System

Technology for loading

GPS is a space-based satellite system that was developed in the early 1970s by the United State Department of Defence, to provide navigations, positions and timing information for users. It was made purposely for military use, however it is currently accessible and usable by civilians. (El-Rabbany 2002, 1). Integrating this technology in a container terminal will provide monitoring to the movement and location of straddle carriers, cranes and other terminal equipment. Moreover, its application assist operators to locate the positions of all containers in the terminal as well as those entering and leaving the terminal. (Haefner and Bieschke 1998, 131).

In addition, the technology can be applied to regulate the port and terminal operations, to enhance the performance, facilitate the communication between transhipment terminals, and help data exchange (EDI or Internet based) among port users and operators. (Giannopoulos 2004, 314).

Entrance or Scanning Technology

Trucks entering the terminal carry container to the storage yard and in return take imported container out. The implementation of scanning technology in a terminal will speed up the gates process by allowing trucks to enter without any manned work or paper work. For instance, the port of Thessaloniki (Greece), use smart card technology, series of Data Base Management and Geological information system (GIS) technologies for entrance control and quicker loading processes. This have resulted in a time saving of about 83%. (Giannopoulos 2004, 314)

Again, port of Rotterdam (Netherland) which is the busiest port in Europe also use the same technology as well as the following; port of Felixstowe (United Kingdom), port of Antwerp (Belgium), port of Hamburg (Germany), and port of

Helsinki. At the gate, the system recognizes the driver and register the moving cargo which sends the information to each check point and also direct the driver along the way. *(“IRU POSITION ON THE INTEROPERABILITY OF PORT ACCESS CARD” 2006*).

Horizontal Transport Technologies

These are technologies installed in moving vehicles to maneuver in the terminal without driver. A typical example is the (AGV), a driverless vehicle equipped with infrared used for internal transportation of cargo in a container terminal. (Vis et al 2003, 6).

According to Haefner et al. (1998, 132), AGV system consist of a vehicle, navigation system and directional path, automated inputs, obstacle detection system, and better means of connection with other terminal operating systems. The self-propelled vehicle retrieve and stack container by using automated controls (it includes traffic management technology to monitor transfers, storages, and vehicle status). There is high performance in terminal operations as a result of it continuous operating possibility. Terminals that have implemented the system benefit from high container throughput at a low labor cost, high level of accident free, and greater level of flexibilities.

3 CURRENT SITUATION AND ANALYSIS

Situation Approach

The main research method applied in this thesis was based on qualitative approach. Even though few numerical data were gathered, it cannot be describe as quantitative research because it cannot adequately define the current challenges. The author uses interviews and general observation during training at the company. With the qualitative approach, it was promising to collect data from different levels, beginning from colleagues to senior supervisor of the company. Also the authors participatory in most of the activities helped to obtain a clear and complete picture of the situation.

After the author’s three months training at the company where part of the data was collected, the research was finalized in Finland. There were different approached which the author’s used during the report writing, these involved telephone and internet interviews of company’s employees, importers and exporters, and senior supervisors. In addition, published fact on company’s website were also used to support already gathered data. Telephone and internet interviews were the best option with regard to the distance involved. However, there were few difficulties to get the interviewees’ as a results of their daily schedules. Altogether with the author’s own writing note contributed to this thesis. See Appendix 2 for details.

3.1 Terminal Management

When a vessel arrives at the port, it is directed to the assigned berth or placed in a queue outside the berth zone for sometimes until a berth is vacant. After a berth becomes available, the vessel is directed by a pilot and a tugboat to the berth available. With primary documentations and requisitions of cranes finalized, the cranes begins operation immediately after the berthing to discharge the vessel and reload afterwards.

Handling Equipment/Transfer Vehicles

There are different types and sizes of handling equipment owned by the port and other stevedoring companies operating at the terminal. These are available to operate at any given time when a vessel is berthed. For this reason, it is hardly or unusual for private stevedores to hire additional equipment outside the port. Some of these equipment are Forklift, Load-all, Reachstackers, Ro on Ro of Tractor and Mobile Cranes. (See Figure 15).

FIGURE 15. Different tonnage of handling equipment

3.2 Crane Operation/Vessel Discharging Process

There are a number of mobile cranes used for any related terminal operations. There are HLB-550 crane and 80, 100, 130, 180, 220 tones Groove mobile cranes used at the storage yards and quayside operations. The HLB-550 crane is the only crane used at quayside for vessel discharging and loading operations, the rest are used for other terminal operations. The 220 tone is used to assist vessel discharging/loading operation in peaked days otherwise only the HLB-550 crane operate at the berth.

The crane operator load/unload the vessel according to the discharging plan received from the Stevedore's department. During this operation, an assistance normally signal/direct the crane operator on the exact container to be pick or the exact slot to place container in the hull of the vessel. Currently, the crane can discharge 18 – 25 containers in an hour which is fast enough to meet vessels that report to the port. When the container is release to the ground, the crane returns empty to the vessel hull for another loaded container.

In addition, personnel or banksman records the discharged container number on a tally sheet to confirm the parking list received prior to the vessel arrival. After the recording, the imported containers are carried away by terminal horizontal transport equipment/vehicles to the New Container Yard (NCY) (the allocated yard for import containers) in the terminal. The process continue until the last container is discharge.

Analysis

Benefits

a) Flexibility in Operation

As the saying goes “two hands are faster than one”, the communication between the crane operator and the signalman makes the discharging and loading operation very flexible. With the presence of the signal man, the crane hourly output is within range for some of the vessels calling at the port which does not interfere the berthing or staying time. This is because the discharging and loading operations can be complete within the allowed berthing time of the vessel.

b) Availability of trucks

The longer stay of the spreader in the vessel hull also allow transfer trucks to be readily available always for the discharged container. Furthermore, the availability of the transfer truck solve the problem of berth congestion. Because once the discharged container is released to the ground, it is load onto the truck for dispatching.

Drawbacks

a) Long Operating hours

The crane jib/spreader spend much time in the vessel hull as the operator await for signal from the signalman in search of the right container in the hull, this reduced the crane productivity (throughput). The employment of the signalman in the vessel hull call for extra safety during the discharging and loading operations. This provide additional labor and insurance cost to the company.

b) Truck Queue

Even though container congestion is minimized at the berth, the number of trucks waiting for containers are queued causing roadblock. This implies that, the two handling equipment operating at both the berth and the New Container Yard for lifting and dropping containers from the transfer trucks remains idle thereby making these equipment underutilize.

3.3 Data Transmission in the Port Terminal

Currently, almost all of the basic operations are still paperwork. All applications for port services are receives through fax, phone-to-phone, and personnel delivery for terminal operation task. A practice which is not different from managerial task and customs declarations. Even though the port's uses Enterprise Resources Planning (ERP), it is only accessible at the managerial level. The port of Takoradi operate together with 5 private stevedoring companies in its terminal for cargo handling operations. However, the most used quay crane for discharging and loading containership solely owned by the mother company. This implies that, all private Stevedores/Agents working in the port terminal have to put in crane requisition for loading or discharging before a vessel arrived.

Before a vessel arrive, the agents representing the shipping line passed on the information to the stevedores. This information contains the necessary details, such as the total number, type or group of containers as well as berthing time for the vessel. With these information's, stevedores place request for the type and number of cranes that will be used for the discharging and loading operations. Stevedore or private agents with limited communication access or cannot communicate to the shipping agent, rely on the importer for such information to place equipment requisition for the discharging or loading operations. This helps to commence operation immediately the vessel arrive without any vessel waiting time.

During the operation, if the stevedore or private agents realized that the operating hours booked for the crane cannot complete the task within the allowed berthing time for the vessel, additional equipment or extra operating hours is requested. With this approach, private stevedore or private agent ensures that they execute the task within the vessel berthing time.

Analysis

Benefit

a) On time services

Berthing time is one of the costs factor in the shipping industry which container carriers try to reduce drastically. Stevedores and shipping agent are compelled to apply the necessary mechanism to help reduce this cost factor. With the limited information given by the importer on behalf of the incoming vessel, stevedores or Agent are able to allocate the cranes and truck to start operation as require by the shipping line to avoid vessel waiting time. This work out perfectly between all parties without any huge impact or work interference on the terminal operations.

Drawbacks

a) Extra Charges and Vessel Delay

Stevedores or private agent trying to eliminate preliminary vessel waiting time ends up delaying the vessel or inquire higher operating cost. In peak working days the requisition for additional equipment is questionable, because the rest of the terminal equipment will be busy working on other task as well. Therefore vessel delay is an option but requires extra berthing charges. Higher charge in peak times for extending equipment operating hours if the equipment in question have been booked for different task, this requires jobs cancellation and compensation to the affected hiring party.

b) Congestion and Wrong Impressions

An increase in the equipment operating cost will reflects on importer's container clearance since agent cannot take the extra charges alone, but distribute equally. The price increment compels importer with insufficient financial background to leave container in the care of the port for some days, to search for additional fund for the clearance. This also create wrong impression about port charges. Furthermore, the un-cleared containers turns to create congestion after container free stay time in the terminal, leading to extra rearrangement in terms of container sorting.

3.4 Internal Transfer

About 98% of container transfer at the port are by trucks. This shows that, the railway connection between the terminal and the hinterland is underutilize. After the crane drops the container from the vessel to the ground and container number written, the reachstackers' or groove crane lift and place the container on transport vehicles (MAFI). The MAFI dispatches all discharged containers to the storage yard (NCP) other than special containers (reefer, chemical, etc.) that needs special storage yard.

At the storage yard, the container is again dropped by reachstackers or yard crane before finally stack or slot at the designated block. The truck return without export container to the quayside for another container. This continue till the vessel is fully discharged before reload with export containers. Basically, two reachstackers or similar handling equipment are required, one each at the quay area and the storage yard to lift and drop container from the MAFI.

The above operation normally requires 3 - 5 transfer trucks (MAFI). Trucks are loaded when container is on the ground or wait until container or crane is ready. Discharged containers are move from the quayside as quick as possible to relieve the problem of congestion while the yard crane also drops off container from the trucks to avoid truck queue in the lane.

FIGURE 16. Trucks waiting to be unloaded at export container yard.

Analysis

Benefit

a) Reduction in Operating Cost

The use of a single truck cycle in the transfer operation keeps the transfer operating cost minimum. The extra savings on two or more cranes can be invest or add to the company’s capital.

Drawback

a) Longer Cycle Time

The result of one crane can be seen in long truck cycle. Once again, this requires both handling equipment to stays idle making these equipment underutilize.

3.5 Inspection and Gate Process

Imports containers spend days at the terminal depending on the container traffic at the time. Once the inspection and all the documentation are finalized, the container is cleared for the next transshipment by truck to the hinterland. Some containers require de-stuffing during inspection while others do not.

FIGURE 17. Inspection of imported containers

Inspected and documented containers are moved out from the terminal to ease space for another container. As previously stated, the transportation is only by truck to hinterland. When the trucks reaches the final exit/entrance, subsequent inspections are carried out by customs and security officers.

The driver or cargo owner is required to provide a clearance documents first to the customs, then to a security officer at the gate. It is required that, all outgoing containers should be thoroughly examine and document before a security declaration is issue and gate open to exit the port. The customs check at the gate takes up to 30 minutes and 5 - 10 minutes for the security check. Some gate inspections requires the container to be de-stuffed while others may not. All containers moving out from the terminal without the required approval are not allowed

Analysis

Benefit

a) High security

The multiple inspection at the port explains the importance of cargo documentation in the port terminal. Clearances documents bearing all stamp from checkpoint prove safe and cleared. In addition the final security checks at the gate provide extra value on inspection to the previously customs inspection.

Drawback

a) Road blockage

The final check at the gate requires a driver to pull over for the inspection before proceeding. The mandatory stops forces trucks exiting the port with cargo to wait at gate for both clearance from customs and the security. These trucks end up in a queue at the final gate causing road block to other road users. Furthermore, the number of stops and the time spend at the gate for inspection also increases the transshipment time for the cargo which decrease the product value in the case of perishable products.

3.6 Storage Platform

There are two distinctive storage yards in the terminal used for housing all containers from both vessels and trucks before they are transport to the next destination. Namely the New Container Platform (NCP) and the Export Container Yard (ECY). Imports containers are sent to the NCP and exports containers are received at the ECY.

These Platforms are divided into blocks with floor markings that differentiate the stacking area from running path of the moving equipment and pedestrian path. Meanwhile, there are no demarcations within the blocks that illustrates the rows and bays for container positions. With long term experience and line of sight application, operators are able to stacked containers without exceeding the block markings.

FIGURE 18. Storage yard for export containers

3.6.1 Stacking and Picking Process

The most used equipment in the storage yards for container stacking are the reachstackers, groove crane, and the forklift. The method of stacking follows the terminal stowage plan prepared by terminal operators based on the information received from the shipping line.

In the storage yard, the reachstackers or yard cranes drops the container in the designated block. The containers are stacked based on the order of arrival of the trucks, in other words the method of stacking container follows traditional method (first come first serve). The discharged containers from the arrival vessel are grouped together in the same block, provided there are space in the block otherwise containers are stacked on top of others from different vessel carrier. The stacking is normally of 4 - 5 ties higher.

The clearance of containers by importers follows randomly pattern because of different financial background of importers. This follows that, a container that will be picked for delivery could be at the bottom of 4 or 5 containers with tens of others surrounding it.

Analysis

Benefit

a) Reduction in search time

From the process of stacking, it was understood that stacking container from one vessel in the same block reduces container search in the yard when a container is to be pick. With the name of the carrier vessel, the block in which the containers were stacked can easily be locate within the yard.

Again, queuing of the transfer trucks along the storage yard are reduced, because containers are stacked in the same block without segregation of container characteristics which could result in long truck waiting time. Finally the reachstackers travelling distance for stacking is reduced since containers are possibly stacked in the same block.

Drawback

a) More Reshuffles

Even though containers from one carrier vessel are grouped in the same block thus reduced the search of containers in the yard, picking of the right container in the block requires additional search since container were not group according their characteristics. Meanwhile the randomly clearance of container does not guarantee when a container will be picked. It is therefore follows that, before the right container can be pick for delivery tens of containers stacked on top and around have to be reshuffled.

b) Long Operating Hours

More reshuffles in the terminal extends the equipment operating time. In addition to that, more fuel is required to keep the equipment running. Unplanned container reshuffles requires operator to exceed the normal working hours. In answer to that, more equipment or operators are therefore needed at the terminal to work or few employees would be entitled to overtime payment which will increase the terminal running cost.

Furthermore, the absence of rows and bay demarcations in the yard blocks requires operators to use more time to stacked containers in the yard blocks.

4 SUGGESTIONS FOR IMPROVEMENT

4.1 Suggestions for Minimizing the Transshipment Time of Intermodal Freight Transport

The approach to achieve continues intermodal transport with a minimum transshipment time is to invest in terminal information system. It is therefore recommended that, a reform in the existing IT system will result in a speedy transshipment process.

4.1.1 Data Transmission

Information transfer between parties can be improve with the implementation of Electronic Data Interchange (EDI). The system allows container information to be available to all the various parties and decrease the need for manual data transfer from mode to mode. The EDI permits all port users to access and retrieve all the necessary information's on container such as weight, location, and identification number electronically. In addition, EDI system support automatic billing, internal movement, bill of lading, and vessel arrival time. It eradicate unproductivity container transfer (reshuffles), improves yard and equipment utilization, thus reflect in reduction in harbor charges

With the implementation of the EDI, all private stevedores/Agent will improve their performance by eliminating the requisition of extra operating hours, vessel delays and facilitate communication with shippers. Moreover, importers will get their container from origin to destination on time with ease of information accessibility. Furthermore, the system will decrease the need for human resources in the terminal thereby reducing labor cost. See Figure 19 for details.

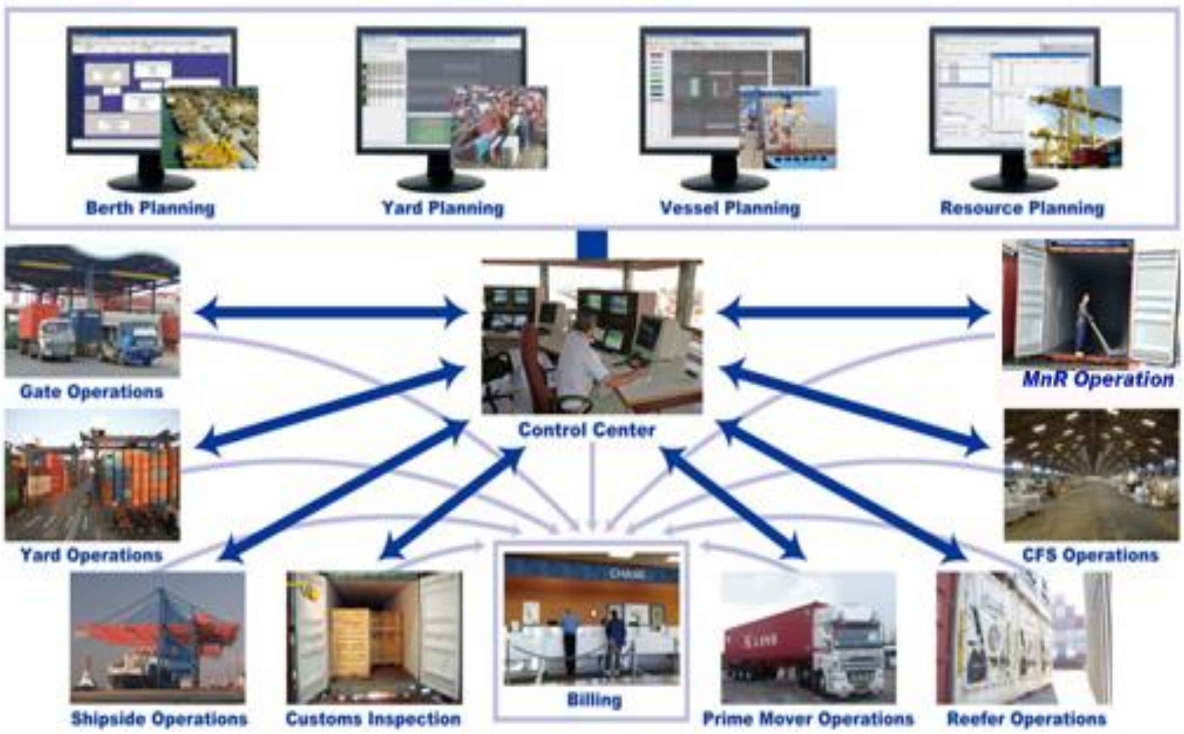

FIGURE 19. Overview of EDI System in VICT port (“VICT - Information Technology” 2015).

4.1.2 Gate Process

A proposed means to speed the gate checking process is to use smart card and truck recognition system. The card works together with a face recognition system and offers all outgoing and incoming drivers with a different electronic identity. Any movement or activity within the terminal by the driver is programme on the card. The driver uses the card at any check point such as customs, exit, loading and unloading point, etc., until the cargo is outside or deliver to the internal transfer trucks.

With the smart card system, the arriving trucks that queue at the gate will be eliminated, the system will facilitates the gate process, reduce bottleneck in the terminal and permit a quicker throughput. The number of customs or security officers at the gate will be reduce or totally eliminated since the system is self-service technology, therefore savings in labor cost. Finally, high security with gate data recovery in the case of any theft or wrong container dispatch. (See Figure 20)

FIGURE 20. Automated entrance at Port of Southampton (United Kingdom)

Kia et al. (2000) simulation results cited in the literature clearly illustrate that, the introduction of electronic devices in a container terminal decreases handling operation and the ship berthing time. It was noted that the manual work in the terminal resulted in 24.81% reduction. Only 44% of stacking area were used in the IT terminal for the stacking of 2000 containers as compare to 63% of terminal without IT system. The presence of the IT system made saving of 35,000 USD in the port charges for the ship at the time of the research.

Again, from the literature the port of Thessaloniki (Greece) reported 83% of time saving after the introduction of smart card technology for gate control. Furthermore, an annual increase of 100,000 TEU at Port Botany in Sydney, Australia were noticed after the implementation of a high technology system.

4.2 Suggestions for Achieving Higher Utilization of Operating Equipment

4.2.1 Reduction in Truck Cycle Time

In order to achieve full equipment utilization during discharging/loading, dispatching, and stacking container processes. It is recommended that, a reduction in the cycle time of the transfer trucks will speed the discharging/loading process thereby eliminating the idle time of both cranes at the point of loading and discharging transfer trucks (MAFI). Moreover, the queuing of transfer trucks that have to wait without any activity for discharge containers will be alleviate. A possible means to achieve a minimum cycle time is by the introduction of a second crane at quayside and the storage yards. This will reduce the cycle time of transfer trucks, a shorter turnaround time of trucks will keep both the yard and quay crane busy all the time. As a result, the ship berthing time will reduce making way for another queuing vessel to visit the berth for discharging or loading operation. A simulation of single and double yard truck cycle prove the above recommendation.

Comparison of Yard Truck Cycling

Consider a vessel with 2000 TEUs capacity that has to be discharge and load afterwards with empty containers. The containers are assumed to be evenly distributed on the vessel. The operation is to be performed by single truck cycle and a double truck cycle. In single truck cycle, one quay crane and one yard crane each at the berth and the storage yard for loading and unloading. For double cycle, two yard cranes and two quay cranes. One for loading and the other for unloading at both end of the operation. Same number of truck are to be used in both operation.

Additional information to satisfy the simulation were recorded during the author training at the company, below are briefly described.

1. Yard crane and quay crane unloading/unloading cycle time are 2 minute and 4 minutes respectively.
2. Loaded truck travel distance from the export yard to the berth is 500 meters and from the berth to the import yard is 700 meters.
3. Empty truck travel distance between loading and unloading crane at the berth is 100 meters and between export yard and import yard is 200 meters.
4. Loaded truck speed is 30 km per hour and 40 km per hour for empty truck speed.
5. Truck waiting time at the storage yard and at the berth are 30 seconds each.

TABLE 4. Transfer Truck Single and Double Cycle Simulation Inputs

	Number of Resources				
Strategy	**Loaded container TEUs**	**Unloaded container TEUs**	**Quay cranes**	**Yard cranes**	**Yard Trucks**
Single cycling	2000	2000	1	1	4
Double cycling	2000	2000	2	2	4

From the theory, single truck cycle can be calculate from;

$$Ts = w1 + (dx1 \div dv2) + w2 + (dx2/dv1) + \sum ly + \sum lb$$

Double truck cycle can be calculate from;

$$TD = 2 * (w1 + w2) + \left(\frac{dx1 + dx3}{dv1}\right) + \left(\frac{dx2 + dx4}{dv2}\right) + \sum ly + \sum lb$$

TABLE 5. Transfer Truck Single and Double Cycle Simulation Output

	Single cycle	Double cycle	Difference	Percentage
Productivity rate (TEU/Hour)	24.88	28.49	3.61	14.51%
Total hours	160.72	140.40	20.32	12.64%

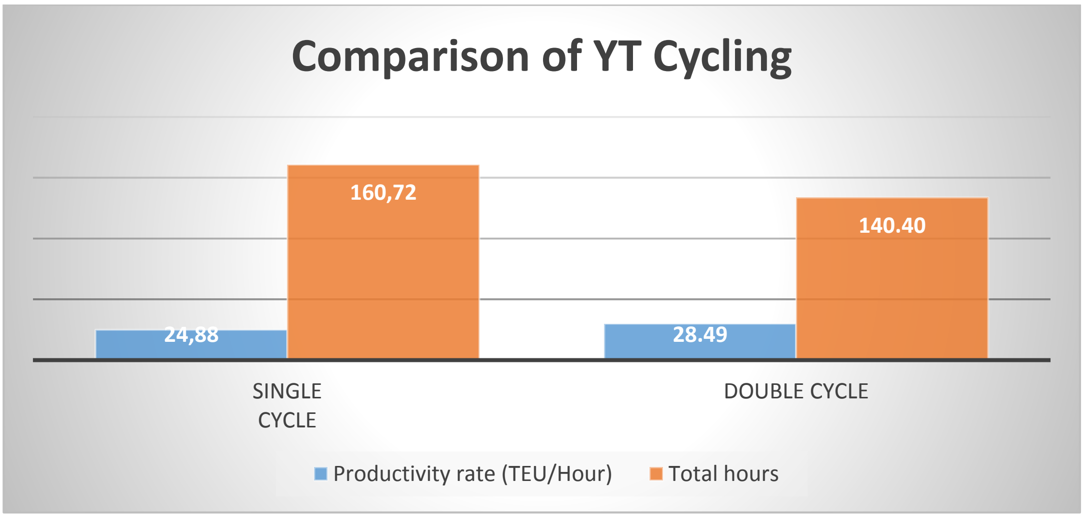

FIGURE 21. Graphical representation of simulation output.

The result show an increase in double truck cycle over the single truck cycle that demonstrate an improvement in terminal productivity. Reasonable savings in operating hours were achieved. See Table 5 for details.

5 CONCLUSION AND RECOMMENDATION FOR FUTURE RESEARCH

This thesis was to look for possible means for optimizing the current terminal activities at the said company. Although the current terminal strategy is quite efficient to meet the demand for smaller vessels that calls at the port. It is expected that, the discovery of oil in the region will impart the terminal throughput. The presence of larger ship-tankers and cargo vessels requires a better performance in terminal information technology as well as shorter vessel turnaround time.

In order to meet the future challenge, suggestions were made. The introduction of IT system in the terminal will certainly improve the productivity, this was clarified by a simulation result and other related researches on the field of container terminal.

A second mathematical results also prove that, terminal equipment will best be utilize with a cycle time reduction strategy. The result shows 7.26% in productivity (TEU/hr/QC), about 12.64% time savings in operation which can be directed to different terminal activity.

The application of the suggested IT system might require a total overhaul of the existence practices, a huge investment in addition to cost of personnel training. However, the long benefits outweighs the drawbacks with respect to ports that have already applied the technology.

Reliability

The entire findings, its analysis and conclusion are very connected to the fact that data collected from interviewees' were consistence, thus proven reliable. Typical reference to United Nation Conference of Trade and Development 2014, the challenge facing port operators as a result of rise in container traffic in developing countries. Honestly, every method used to acquire data for the thesis were very credible. From the visit to the seen, planning of the interviews, and execution were very huge task, but the early preparation and self-motivation made all things achievable. Some personal point of view and other company’s information were considered as confidential that were not allowed to be used in the thesis. Since the port is undergoing expansion, few changes may apply in the coming years if the same findings are to be used for references, otherwise the main objectives will remains the same together with interviewees’ opinion.

Generalizability

The implementation of the suggested improvement could be further study by another students to inquire the overall effort and investment needed to accomplish this improvement. I believe the thesis gives a clear insight to other ports operators on the introduction of modern technology in container terminal, especially to the Sub-Saharan countries struggling to contain larger containerships and other terminal difficulties. Terminals in developed countries that have started using modern technologies have seen improvement in productivity, time savings, less paperwork, and finally maximized annual profits.

Hence, IT system is not static but dynamic that requires improvement of previously acquire knowledge to correspond with it revolution. Therefore other terminals facing similar challenges can based on this idea to stay competitive in the industry.

Directions/recommendation for Future Research

The study only covered areas of improvement, it involves discharging and loading operation, truck transfer process, etc. However, the expected amount to invest in the implementation and the percentage of returns on investment (ROI) can be further studied. Again, a research about the usage of rail system and truck in the terminal can be compare, as this can reduce the number of transport modes used during the transhipment.

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APPENDICES

Appendix 1: Container Throughput for Developing Countries.

Table 4.1. Container port throughput for 80 developing countries/economies and economies in transition for years 2011, 2012 and 2013 (TEUs)

Country/economy	2011	2012	Preliminary figures for 2013 [a]	Percentage change 2012/2011	Percentage change 2013/2012
China	144 641 878	160 058 524	174 080 330	10.66	8.76
Singapore	30 727 702	32 498 652	33 516 343	5.76	3.13
Republic of Korea	20 833 508	21 609 746	22 582 700	3.73	4.50
China, Hong Kong SAR	24 384 000	23 117 000	22 352 000	-5.20	-3.31
Malaysia	20 139 382	20 897 779	21 426 791	3.77	2.53
United Arab Emirates	17 548 086	18 120 915	19 336 427	3.26	6.71
China, Taiwan Province of	14 076 069	14 976 356	15 353 404	6.40	2.52
India	10 284 885	10 290 265	10 653 343	0.05	3.53
Indonesia	8 966 146	9 638 607	10 790 450	*7.50*	11.95
Brazil	8 714 406	9 322 769	10 176 613	6.98	9.16
Thailand	7 171 394	7 468 900	7 702 476	4.15	3.13
Panama	6 911 325	7 217 794	7 447 695	4.43	3.19
Turkey	5 990 103	6 736 347	7 284 207	12.46	*8.13*
Egypt	7 737 183	7 356 172	7 143 083	-4.92	-2.90
Viet Nam	6 929 645	2 937 119	8 121 019	-57.62	176.50
Saudi Arabia	5 694 538	6 563 844	6 742 397	15.27	2.72
Philippines	5 288 643	5 686 179	5 860 226	7.52	3.06
Mexico	4 228 873	4 799 368	4 900 268	13.49	2.10
South Africa	4 392 975	4 320 604	4 595 000	-1.65	6.35
Sri Lanka	4 262 887	4 180 000	4 306 000	-1.94	3.01
Russian Federation	3 954 849	3 930 515	3 968 186	-0.62	0.96
Oman	3 632 940	4 167 044	3 930 261	14.70	-5.68
Chile	3 450 401	3 606 093	3 784 386	4.51	4.94
Islamic Republic of Iran	2 740 296	2 945 818	3 178 538	*7.50*	*7.90*
Colombia	2 584 201	2 804 041	2 718 138	8.51	-3.06
Morocco	2 083 000	1 800 000	2 500 000	-13.59	*38.89*
Pakistan	2 193 403	2 375 158	2 562 796	8.29	*7.90*
Jamaica	1 999 601	2 149 571	2 319 387	*7.50*	*7.90*
Peru	1 814 743	2 031 134	2 191 594	11.92	*7.90*
Argentina	2 159 110	1 986 480	2 143 412	-8.00	*7.90*
Costa Rica	1 233 468	1 329 679	1 880 513	7.80	41.43
Dominican Republic	1 461 492	1 583 047	1 708 108	8.32	*7.90*
Bangladesh	1 431 851	1 435 599	1 571 461	0.26	9.46
Bahamas	1 189 125	1 278 309	1 379 296	*7.50*	*7.90*
Bolivarian Republic of Venezuela	1 162 326	1 249 500	1 348 211	*7.50*	*7.90*
Guatemala	1 163 100	1 158 400	1 211 600	-0.40	4.59
Ecuador	1 081 169	1 117 047	1 205 294	3.32	*7.90*
Kuwait	1 048 063	1 126 668	1 215 675	*7.50*	*7.90*
Lebanon	1 034 249	882 922	1 117 000	-14.63	26.51
Nigeria	839 907	877 679	1 010 836	4.50	15.17
Angola	676 493	750 000	913 000	10.87	21.73
Uruguay	861 164	753 000	861 000	-12.56	14.34
Kenya	735 672	790 847	853 324	*7.50*	*7.90*
Yemen	707 155	760 192	820 247	*7.50*	*7.90*
Ukraine	696 641	748 889	808 051	*7.50*	*7.90*
Syrian Arab Republic	685 998	737 448	795 707	*7.50*	*7.90*

Table 4.1. Container port throughput for 80 developing countries/economies and economies in transition for years 2011, 2012 and 2013 (TEUs) *(continued)*

Country/economy	2011	2012	Preliminary figures for 2013 [a]	Percentage change 2012/2011	Percentage change 2013/2012
Ghana	683 934	*735 229*	*793 312*	*7.50*	*7.90*
Jordan	654 283	*703 354*	*758 919*	*7.50*	*7.90*
Côte d'Ivoire	642 371	*690 548*	*745 102*	*7.50*	*7.90*
Djibouti	634 200	*681 765*	*735 624*	*7.50*	*7.90*
Honduras	662 432	665 354	670 726	0.44	0.81
Trinidad and Tobago	605 890	*651 332*	*702 787*	*7.50*	*7.90*
Mauritius	462 747	576 383	*621 917*	24.56	*7.90*
Tunisia	492 983	*529 956*	*571 823*	*7.50*	*7.90*
Sudan	464 129	*498 938*	*538 354*	*7.50*	*7.90*
United Republic of Tanzania	453 754	*487 786*	*526 321*	*7.50*	*7.90*
Libyan Arab Jamahiriya	195 106	369 739	434 608	89.51	17.54
Senegal	369 137	*396 822*	*428 171*	*7.50*	*7.90*
Qatar	365 722	*393 151*	*424 210*	*7.50*	*7.90*
Congo	358 234	*385 102*	*415 525*	*7.50*	*7.90*
Benin	334 798	*359 908*	*388 341*	*7.50*	*7.90*
Papua New Guinea	313 598	*337 118*	*363 750*	*7.50*	*7.90*
Bahrain	306 483	*329 470*	*355 498*	*7.50*	*7.90*
Cameroon	301 319	*323 917*	*349 507*	*7.50*	*7.90*
Algeria	295 733	*317 913*	*343 028*	*7.50*	*7.90*
Mozambique	269 219	*289 411*	*312 274*	*7.50*	*7.90*
Cuba	246 773	*265 281*	*286 238*	*7.50*	*7.90*
Georgia	239 004	*256 929*	*277 226*	*7.50*	*7.90*
Cambodia	236 986	*254 760*	*274 886*	*7.50*	*7.90*
Myanmar	200 879	*215 945*	*233 005*	*7.50*	*7.90*
Guam	193 657	*208 181*	*224 628*	*7.50*	*7.90*
El Salvador	161 200	161 000	180 600	-0.12	12.17
Gabon	162 415	*174 597*	*188 390*	*7.50*	*7.90*
Madagascar	149 135	*160 320*	*172 986*	*7.50*	*7.90*
Croatia	144 860	*155 724*	*168 026*	*7.50*	*7.90*
Aruba	137 410	*147 716*	*159 385*	*7.50*	*7.90*
Namibia	107 606	*115 676*	*124 815*	*7.50*	*7.90*
Brunei Darussalam	105 018	*112 894*	*121 813*	*7.50*	*7.90*
New Caledonia	95 277	*102 423*	*110 514*	*7.50*	*7.90*
Albania	91 827	*98 714*	*106 512*	*7.50*	*7.90*
Subtotal	**412 682 164**	**434 325 380**	**465 475 613**	**5.24**	**7.17**
Other reported [b]	**562 723**	**590 637**	**630 276**	**4.96**	**6.71**
Total reported	**413 244 887**	**434 916 017**	**466 105 889**	**5.24**	**7.17**
World Total	**587 484 148**	**616 675 181**	**651 099 413**	**4.97**	**5.58**

Sources: UNCTAD secretariat, derived from various sources including Dynamar B.V. publications and information obtained by the UNCTAD secretariat directly from terminal and port authorities.

[a] In this list, Singapore includes the port of Jurong.

[b] The term "other reported" refers to countries for which fewer than 100,000 TEU per year were reported.

Note: Many figures for 2012 and 2013 are UNCTAD estimates (these figures are indicated in italics). Country totals may conceal the fact that minor ports may not be included; therefore, in some cases, the actual figures may be different than those given.

Appendix 2: Interviewees Questions

1) Which information system is the terminal using?
2) Could you describe the terminal communication means that you are using?
3) Do you know some other communication means?
4) How long does it takes to make one truck cycle?
5) How many TEUs do you discharges in an hour?
6) How many checks point do have to stop for inspection?
7) Could you describe the discharging/loading process of a containership?
8) What are the procedure for inspection?
9) Would you like to improve the current situation?
10) Have you heard any complaints from the terminal user?