1. Introduction

International sea-freight container transportation has grown dramatically over the last years and world container trade keeps growing presently. In these circumstances container terminals represent nowadays a key actor in the global shipping network. There is an increasing need for container terminal operators to stay competitive and make use of the highest technologies so as to cope with the existing demand (ESPO 2007).

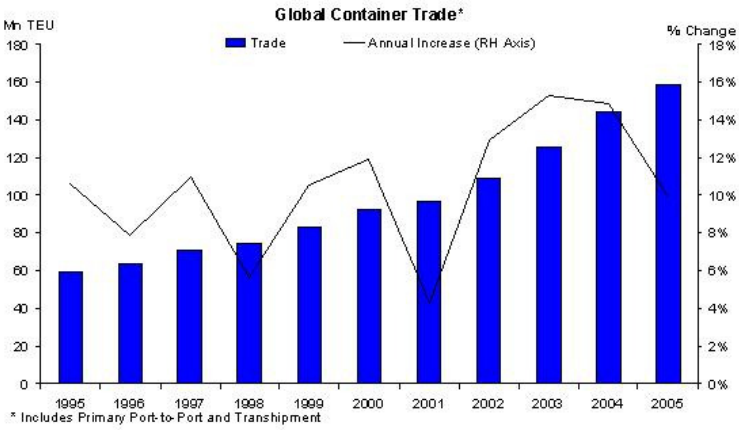


Figure 1-1 Container Trade Evolution. (Source Drewry/MSI)

It is of great importance in a container terminal to speed up operations in order to keep the delivery times as short as possible from/to ships, trucks and trains (Maione 2005). Terminal managers have to face with an increasing competitiveness among terminals, which require more and more efficiency in container operations both along the quayside and within the yard. Moreover the minimization of operational costs directly requires the achievement of competitive terminal fares, thus increasing the attractiveness for new customers (Vacca and Bierlaire 2007).

In line with this objective, terminal operation processes and methods need to given a special consideration and process standardization comes out as a suitable solution. When processes are standardized the company may benefit in such ways as cost reduction and more predictability (Team 2002).
Given the complex environment that terminal operators have to face currently, a set of standardized and optimized operational processes will facilitate the business.

2. Thesis Goal and Context

The aim of this thesis work is the understanding, critical observation and subsequent standardization of the processes taking place within container terminals operation. A complete and utilizable standard model for the processes taking place in the terminal is desirable as it will signify a more effective operation as well as facilitation for the information flows within the company and outside if needed (Sorenson & Wiechmann, 1975). In order to make the first steps and guidelines for this goal, the research questions that are tackled during this thesis report are the following:

- What are the fundamental **processes** that take place in the container flow operations within a container terminal? What are the key **factors** influencing these processes and in what way do they do so?

- How can these processes be **standardized** so that they can be implemented in different terminals structuring a global terminal concept? What are the **criteria** for such standardization?

- How do these processes perform in **reality** in a specific terminal and what are their main issues and risks? What are possible solutions for them? Are they valid as **standards** or best practices?

This work is partly a result of a 6 months internship experience within APM Terminals organization which currently works in collaboration with the TU Delft University in The Netherlands. The internship was performed at the Headquarters of the company in The Hague. The work developed for the company consists for the most part in the building of a process model for the standardization of processes. This model will be used in the consideration of future automated terminals and it is performed in cooperation with another exchange student from TUDelft at the Innovation department of APM Terminals.

<u>APM terminals</u>

As part of the A.P.Moller Group, APM Terminals is one of the world's leading container terminals operating companies. It presently aims to expand and improve the global terminal infrastructure. With a total of 50 container port facilities it provides service to 60 shipping lines among 35 different countries. A main goal within the company core policy is to build a global terminal network and this requires a high degree of innovation and the ability to cope with the existing dynamic environment of the global container trade.

Automation could be the way to cope with the complex environment that terminal operators need to work with and APM Terminals has already started a path through automation with its new terminal in Portsmouth, Virginia. Opened in 2007, this semi-automated facility can be the first one of a large number of terminals including automated services. About 160 APM terminal facilities are planned to be constructed in the near future and therefore enlarge the global network that the company intends to have (APM Terminals 2007). In this objective standardization of processes has a key role. Standardization of processes will benefit the company in many aspects: it allows a simplified and better decision making and it implies a cost reduction and an increase in efficiency. Besides, it can be a good tool for information sharing within the company and outside if it is needed.

More information about APM Terminals can be found in annex 1 at the end of the report.

3. Methodology

In order to answer the research questions the methodology followed has mainly four phases involving three different locations these being the university, the company office and the terminal facility. Each location serves to obtain different inputs for the process model and gives varied perspectives which are mentioned in Figure 3-1.

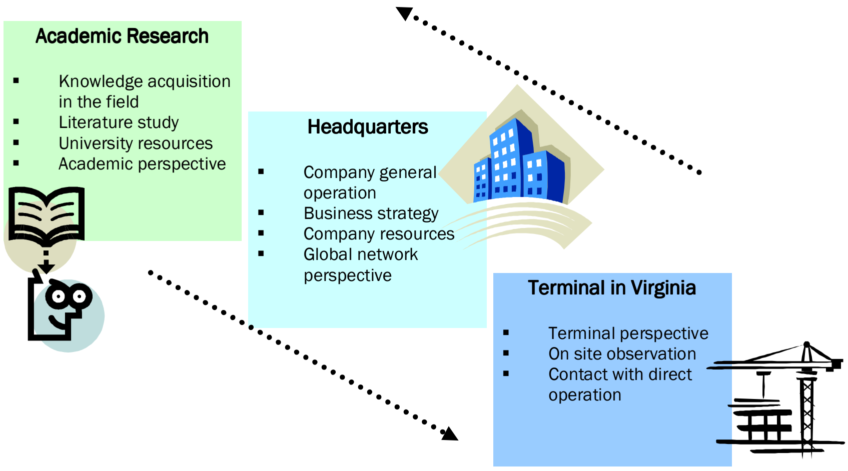


Figure 3-1 Thesis different approaches

The three first working phases are therefore defined by the location where the work is performed and the fourth phase is a recapitulation phase involving the three former ones. The methodology phases are explained in more detail below and shown in Figure 3-2.

1) <u>Academic Research</u>: The first step for the research work is the study of literature. Several books and reports regarding topics related to container terminal operations are considered and studied. As the familiarization with the field increases, the goals of the research are settled and a first version of the project plan is presented.

2) <u>Company Learning</u>: As a second stage in the documentation study, company documentation obtained in the headquarters is searched and read. Company documentation comprises:

- General data collections about the existing terminals within the company. This includes broad data, performance indicators and operational specifications for different terminals.
- Conceptual information such as theoretical reports and simulation studies.

- Operational Specifications handbooks for different terminals within the company. Also existing process maps from different terminal.
- Data related to the specific terminal relevant for the project that serves as the case study mentioned below.

Besides documentation study, several interviews and experts opinions are used for selective identification of the relevant operation processes and their comprehension.
When all relevant data is processed, the first inputs for the project model are introduced and elaboration of process maps starts. At the same time, the initial project plan is reviewed and the research questions are determined with a more specific approach.

In addition to the study of available documentation, participation in an organized workshop on automated terminals provides useful input for the elaboration of the processes deliberation and the subsequent process list. This workshop hold up at the TU Delft consists on a brainstorming session among relevant matter experts within the company.

A visit to APM Rotterdam terminal in the Netherlands is performed in order to see a real case example of operation. First real operation issues and processes are observed at this stage and incorporated to the report as well as experts opinions.
Feedbacks obtained in the former experiences and from the continuous consulting of documents are introduced in the process model building. First process maps are revised by experts within the company Headquarters.

3) <u>On-site approach</u>: The following step in the research is the visit to APM Virginia terminal. The three-week visit includes onsite observation, collection of terminal available data and interviews with several people within the terminal workforce and management. Operation observation is agreed and supervised by the facility in-charge employees and includes all operation areas and processes resulting in a complete observation of each of the main terminal operation areas. This embraces all the processes presented in this work and meetings with responsible operations managers for each of them.

Process maps are revised and validated by relevant experts in the terminal and the consequent obtained feedback is updated to each of them. Several process maps are developed in this stage of the project and the process model is again revised and pertinent modifications are upgraded due to enhanced comprehension in the general operation.

Attendance to re-design meetings for the terminal rail operations area serves as useful input for the surveillance of the facility internal organization and procedures.

4) <u>Recapitulation</u>: Back to the company headquarters, the following step comprises the assembly of all the information obtained at the terminal and the stages before. The process model is finished and the report writing has a main priority in this stage including fresh data obtained from the visit to the terminal and several literature selected pieces from the academic research phase. At the same time the list of processes is finally presented and each one of the process maps developed are to present in the form according to the process model.

As a final step that is included in the recapitulation phase, a survey is created in order to know the judgment and usability of the model below different opinions and points of view. In order to test the model, experts opinion is therefore the criteria used.

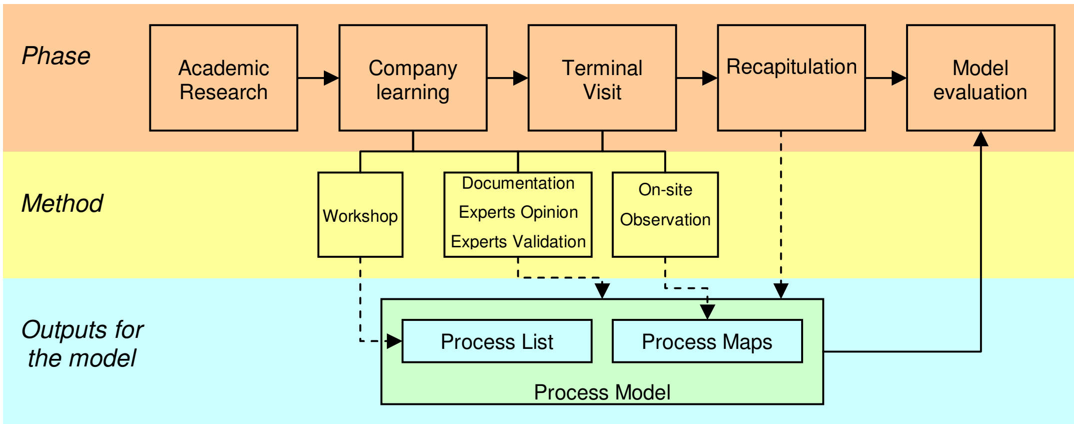


Figure 3-2 Thesis Methodology

4. The Container Terminal

The initiative of this work is to have a view of a container terminal as a bunch of processes. In order to answer the first thesis research question all the factors involved in how to support these processes as well as the factors depending on them are relevant for this approach. In the present chapter the relevant characteristics of a container terminal are presented as well as the way that each of them is related to the processes and how can it affect the operation aspects studied along this report.

In order to conceive a new container terminal, the first decisions to be made are the ones concerning the operational specifications and services that the terminal aims to have. From these, the processes taking place will be defined. The process can contain various methods and techniques that have to be chosen matching with a supportive layout and its suitable handling system. The layout is the arrangement of the different areas of the terminal and the handling system represents the way in which the containers will be handled and both are meant to meet the process needs. The relations for the decision components mentioned are shown in Figure 4-1 and are explained in more detail along this chapter.

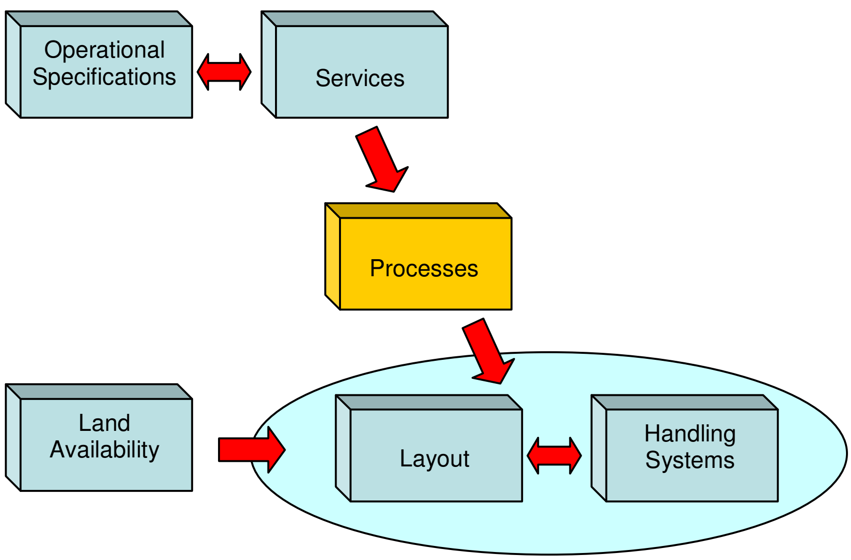


Figure 4-1 Components sequence for the terminal conception

A part from these influences, there also needs to be consideration of external factors such as organization and circumstantial and local facts of the terminal subjected to study.

In order to be familiar with the existence and performance of the processes in container operations, their context needs to be established. Why a terminal is built and what needs to be decided for its operation methods sets the context for the processes studied along this work. The contextualization starts by defining the main functions of a container terminal.

4.1. The Functions of a Container Terminal

A container terminal is a facility where containers are transhipped between different transport modes. In the case of a marine container terminal these transport modes are ships and land vehicles (mainly trains and trucks). The basic elements that structure the container terminal are summarized in the scheme illustrated in figure 4-2 below.

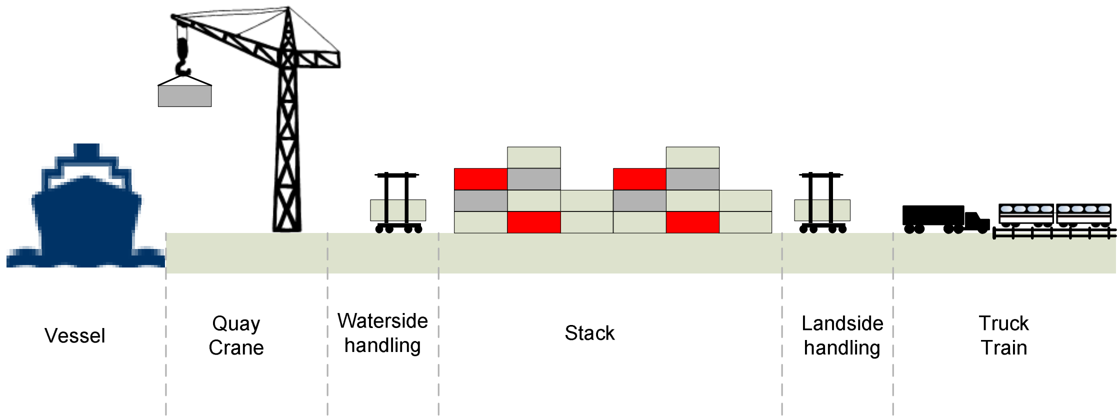


Figure 4-2 Basic elements of a container terminal

The functions of a container terminal can be summarized in two main parts or groups. Firstly, terminals essentially provide high-speed transhipment from deep sea vessels to feeders, barges, rail and trucks and vice versa. Besides, they provide a location where containers, full and empty, can be stored during a longer period (Saanen 2004) in the element denoted by stack in Figure 4-2.

The first function group can be easily explained by the container flows and their related modal split present in the terminal observed in Figure 4-3 which contains the modes of transport considered for the general scheme, as well as the barge transport.

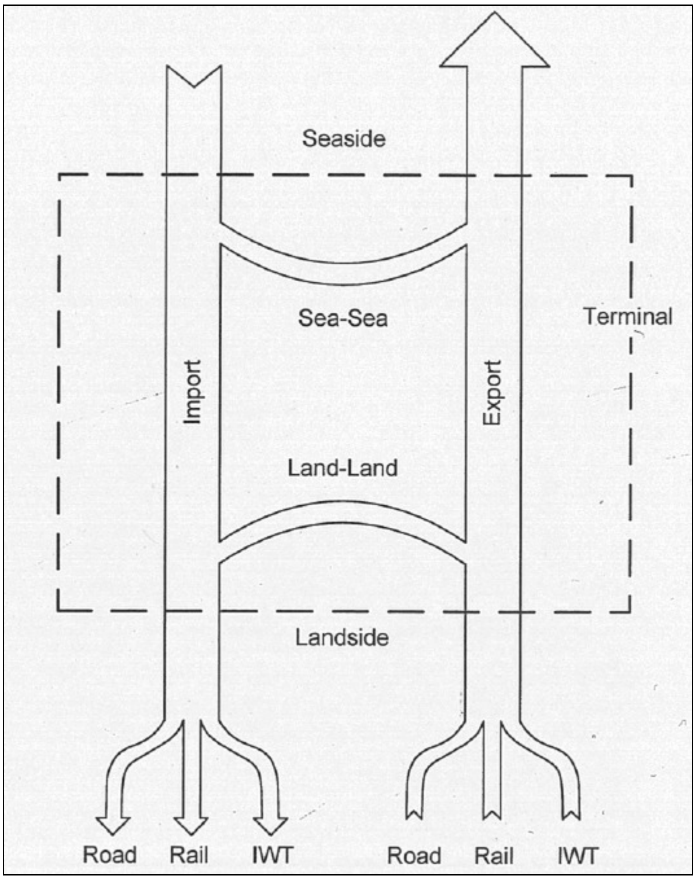


Figure 4-3 Container flows and modal split (Ligteringen 2007)

Depending on the origin and destination of a container within the terminal, it can be classified in three different types or flows:

A **transhipment** container is the one which is discharged from the ship, stored in the yard and transported to another vessel.
Import flow comprises all containers entering the terminal from sea vessel and exiting it by inland transportation, either road or rail.
Export containers are those containers coming by inland transportation and leaving the terminal by vessel.

The percentage of transhipment containers is an important factor related to the terminal design and operation as the higher it is the more importance lies on the marine handling. Instead, if it is the case of an import/export terminal, the rail and road operations will have a big impact in the terminal performance and therefore different contemplation in the design process. Therefore, the kind of terminal and its specifications are predominantly defined by the volume of containers corresponding to each of these flows.

When planning a container terminal both land availability and volume are key determinant features. The starting points for considering the terminal design are:
-The existing **land area** and the availability for future expansion
-The present **cargo volume** plus anticipated future increases (Atkins 1983)

Other features like equipment and infrastructure cost and performance need to be considered but these are mainly determined as well by the above mentioned factors.

The total capacity of the terminal can be represented by the terminal **throughput.** The throughput is measured as all the productive moves made by QC on sea going vessels. This corresponds to the number of containers that are loaded to the ship in one year (Saanen 2004). As one of the main **operational specifications** for a terminal**,** the throughput will be the starting point for the consideration of the terminal design parameters and directly related to other specifications like berth dimensions or number of quay cranes.

4.2. Land Availability and Handling Systems

Space constraints are a factor to take into account when considering a new terminal as they mean one of the main limitations for the operation in a container terminal. Whether there is space or not affects on the existence of empty areas, reefer areas, chassis availability, etc.

Land availability also has an effect on the determination of the layout and handling system chosen and therefore on the equipment. For instance, the existence in some places of the chassis system is due mainly to space ease of use. The **Chassis** system operates on the premise that there is a chassis or trailer for each container in the terminal (Atkins 1983). This system is simple and fast and clearly simplifies the operation and thus the processes but it needs a big yard. Other systems like the Straddle Carrier system and the Gantry crane system are the main solutions for terminal systems. The **Straddle Carrier** system is usually used in terminals with the little throughput. It relies on a single piece of equipment for operations within the terminal and for serving the ships (Coltof 1999). A straddle carrier is a motorized member equipment that runs on rubber tires. It can straddle a single row of containers and is primarily used to move containers around the terminal, but also to transport containers to and from the transtainer and load/unload them from truck chassis. The main difference with the chassis system is that the containers are stacked two or three-high in the yard which has a big influence in the operation. The SC system can also be presented as the forklift system which consists in a very similar operation with equipment differences.

Figure 4-4 Chassis, Straddle Carrier and Gantry crane

The **Gantry Crane** system is very significant for the terminal with the very big container volume in addition to relatively small stacking yard. The operation of stacking is done by a transtainer having ability to stack four or five containers vertically. The horizontal transportation of containers is carried out by additional handling systems on the different sides of the stack in order to take them to the transport destinations (rail, gate, vessel).

Most terminals use one of these three systems or a combination of them. A good example of space significance is the difference between the handling systems used in spacious countries like USA and the ones used in more overcrowded countries like European ones. For example, in the APM Pier 400 terminal in Los Angeles, land availability enables the use of chassis as observed in Figure 4-5.

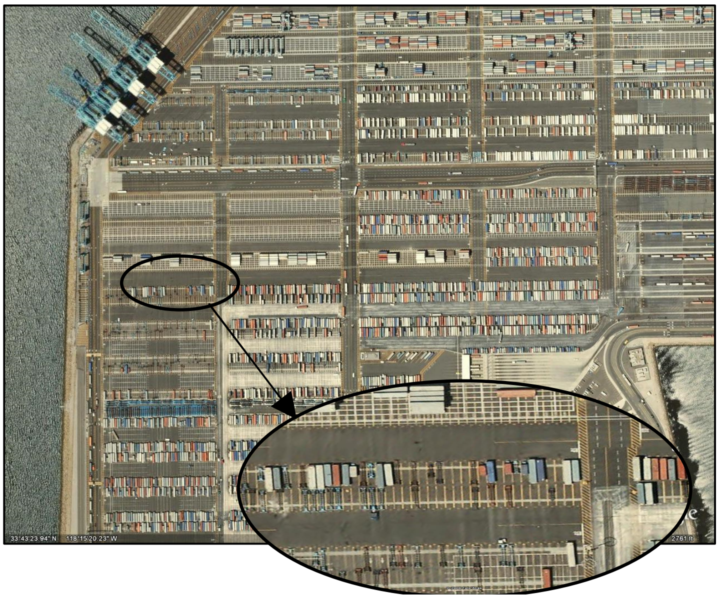


Figure 4-5 APM terminal Pier 400 in Los Angeles

Nevertheless, in the restricted space areas as many terminals existing in Europe there is the need to utilise every ground spot at the maximum capacity. This can mean the need to stack higher which has a repercussion in the operation. A Yard Gantry Crane system or a Straddle Carrier system (Figure 4-6) are more appropriate in these cases.

Figure 4-6 APM terminal in Rotterdam

4.3. Services and Processes

Different services offered by the terminal need to be defined as well as the operational specifications and are the initial point when considering the processes carried out within the terminal. The services that the terminal aims to provide will define the number of processes that need to take place and this is explained in more detail in chapter 9 when describing the procedures to create the generic process list. The kind of cargo, whether the terminal handles OOG (out of gage) material, whether it handles refrigerated containers or not are some of the services that have to be chosen when conceiving the terminal.

Given the mentioned functions:

- Discharging external equipment including vessels, trucks, and rail.
- Loading external equipment; including vessels, trucks, and rail.
- Container shifting (housekeeping) for pre loading consolidation or to access import containers for loading on trucks.
- Stacking of containers: vessel, road or rail.

Besides central terminal services, most container terminals offer a number of other services that are closely related to container handling. Specific services that can be offered by a terminal are:

- Reefer monitoring, plugging and unplugging
- Empty containers handling
- Break-bulk/OOG handling
- Tank containers handling
- (Custom) document handling
- Maintenance and repair of containers and equipment
- Container inspections

Table 4-1 shows a selected list of general specifications and services for 4 terminals from APM Terminals including the case study for this thesis.

Specification	**Definition**	**Rotterdam**	**Pier400 LA**	**Douala**	**Virginia**
Terminal Capacity	Terminal volume in terms of T.E.U*.	2700000	1600000	600000	1000000
Terminal Area	Terminal total surface in hectares	100	195		93
Yard Slots	Total number of slots in T.E.U.	10792	5400	10314	12600
- Wheeled	Slots on wheels - chassis	0	8000	0	350
-Grounded	Normal slots	10792	46000	10314	??
Berth length	Dimensions of berth in meters	1600	2192	660	977
Quay Cranes	Number of QC for vessel load/discharge	11	14	2	6
Reefer plugs	Number of plugs for refrigerated containers	1750	2000	120	424
Handling System	Type of handling equipment concept	SC	Chassis	Forklift	RMG
Yard Planning System	Software for yard operations	COSMOS	NAVIS	ICARE	NAVIS
Vessel Planning System	Software for vessel operations	COSMOS	NAVIS	ICARE	

Table 4-1 Terminal Operational Specifications and services (Source APM Terminals)
*T.E.U.:twenty-foot equivalent unit based on the volume of a 20-foot long shipping container, a standard-sized

The processes consideration comes after defining all functions and services aimed to offer by the terminal.

4.4. Layout Parameters and Handling Systems

Given the services and operational specifications to be present in a terminal and their subsequent required processes a supportive layout has to be used. The layout of each operation area of the terminal needs separate and singular consideration depending on the processes held.

As seen in section 4.2, the **handling systems** are determined in a general way by the land constraints but they have to be also implemented to a fitting layout that will facilitate its operational efficiency. Both waterside and landside handling need to be studied separately and regarded as a whole. Therefore, depending on the area of operation, each of the layout parameters has different approach in order to apply a handling system or another and to support the processes taking place in that area.

4.4.1. Parameters for the stack

The first issue to determine is stack dimension and this will mainly depend on terminal volumes. Stack dimensions: height, length, with are depending on the terminal throughput.

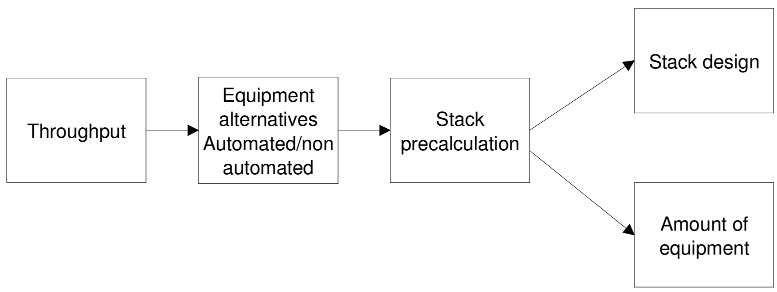


Figure 4-7 Stack design steps (source APM Terminals)

If the system used is a straddle carrier system or a chassis system the stack can have variable layouts which are not studied in this work. In the case of the SC system the shape of the stack depends on the SC used and their conditions (dimensions, capacity, stack interaction). If it is a chassis system the layout can be very variable also.

The stack layout for a gantry crane system has mainly two options. It can be parallel or perpendicular to the quay depending on the modes of operation and layout of the terminal site (Busk, Uglvigm & Lombardero, 2004).

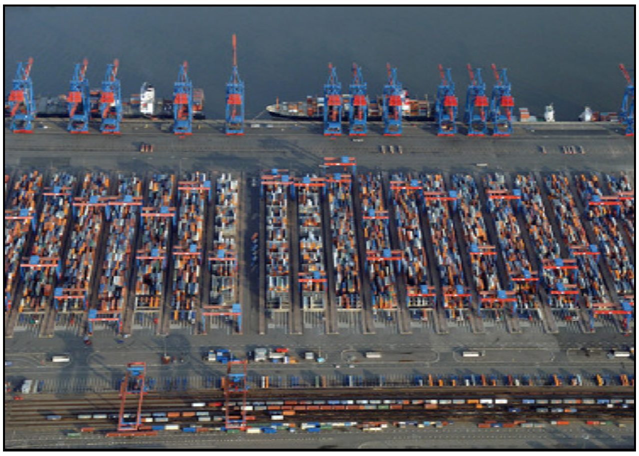


Figure 4-8 Perpendicular stack layout in Hamburg terminal (source Port of Hamburg)

4.4.1.1. The Automated RMG Module stack

As container volumes keep increasing, new container terminals are being built and existing terminals – in particular those that cannot easily expand their area – aim at increasing the density of the stacking yard (Saanen and Valkengoed 2005). The **Automated Rail Mounted Gantry (RMG) module** is one of the Yard Gantry Crane handling systems that can be chosen to support stack operations. The RMG automated (or semi-automated) version comes as a good solution for the actual global needs. These cranes consist on three separate motions for transportation of material. The first motion is the hoist, which raises and lowers the material. The second one is the trolley gear, which allows the hoist to be positioned directly above the material for placement. The third is the gantry, which allows the entire crane along the working area via a railway. Some of the aspects that make the RMG a preferred technology to use are shown in Table 4-2 below. Also a table comparing the RMG technology to the Rubber Tyred Gantry (RTG) one is included in annex 2 at the end of this thesis.

Electrically powered
Efficient operation
Land utilization
Less travel distance for street trucks at terminals
Deployment: Semi-automated or automated
Environmentally friendly
Regenerate power back to the network – cost savings in energy consumption
No diesel engine and related maintenance requirements
Accurate movements - Locate container in any given time, no GPS required
RMG can be manned but can be easily fully automated if required or permitted

Table 4-2 Advantages of RMG module over other cranes and handling systems (Lazic, 2006)

RMG operations lend themselves very well for yard automation, which is interesting from a cost perspective. ECT in Rotterdam and CTA in Hamburg shown in Figure 4-8 are two examples of stacking yard automation in Europe, proving the feasibility of the concept (Saanen and Valkengoed 2005).

Those are the main reasons why this type of Yard Gantry Crane system is the centre of the processes standardization model presented in this thesis. Particularly the semi-automated version is studied later in the case study for the Virginia terminal.

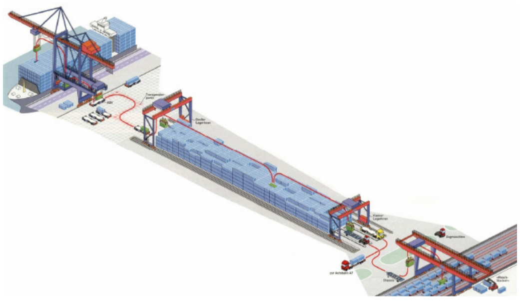


Figure 4-9 RMG module scheme (source ABB)

The stacking yard consists on several modules built perpendicular to the quay with two automated stacking cranes (ASC, used for generalization of equipment in the model as RTG operation is also possible) per each module.

Figure 4-10 Automated RMG stack layout

One of them is working at the waterside part of the stack and therefore having interaction with the waterside modes of operation and the other crane is working at the landside and interacting with those used for the inland operation. While the waterside is a fully automated operation there is action of a remote operator for the landside interaction due to safety reasons. The operator has a punctual intervention in the interaction waterside processes and takes over the control of the crane in order to place the container above the truck that is waiting in the transfer point.

The RMG module operation can be understood by considering the different moves that are performed by each of the two the cranes. These are:

- **Productive** move: any move that signifies that a container is brought into or out of the stack. For instance, loading a truck in the landside transfer point is a productive move.
- **Shuffle** move: any move that is a direct support to make the productive move. Shuffles are done when the container that has to be moved is blocked by other containers and therefore the containers above it have to be moved too. It could be considered part of a productive move because it is needed for the productive move. The fuller the stack, the more shuffles have to be made.
- **Housekeeping** move: any move performed in order to improve the position of the box (not urgent, just when time allows it)
- **Pre-positioning** move: anticipating move in order to place container in optimal position. You know exactly where you are going to put it, not as housekeeping that you can put it wherever you want. These are for the export flows, to put them in a quick place for charging the vessel.

More information about the RMG module stack is attached in Annex 2.

4.4.1.2. Operation Modes for the interactions of the RMG module

Both landside and waterside of the RMG module can be served by different modes of operation. These consist in the vehicles employed as horizontal transportation of containers bringing them to the QC at the waterside and bringing them to either gates or rail at the landside. Once the RMG module is chosen as the handling system the modes of operation need to be considered according to its operation and the terminal layout. For the RMG module presented in the above section and later on in the process standardization chapter, there are different modes from both the landside and waterside interactions that can be studied in the yard operations processes.

- **Shuttle truck (ST):** It is Variation of the straddle carrier being lighter and therefore quicker designed to carry different sizes of containers.

- **Automated Guided Vehicle (AGV):** These transports can hold different sizes of containers. Thanks to computer control, they fulfill their travel orders on-schedule, working almost silently at high speed with position accuracy of within +/- 3 degrees. They travel forwards, in reverse, sideways and can even overtake each other. Even refueling takes place automatically. They are controlled and supplied with data and orders by navigation software, and so-called transponders, i.e. electro-magnetic route markers embedded into the ground of the terminal.

- **Road truck:** Conventional trucks to go over the road and are mainly external to the terminal.

- **Utility tractor (UTR):** A truck or lorry consisting of a towing engine and a semi-trailer (plus possible additional trailers) that carries the freight. Differently to the road truck, it is used just for internal transport within the terminal in order to for handle terminal trailers or chassis.

Figure 4-11 Modes for the horizontal transportation of containers: Shuttle Truck, Automated Guided Vehicle, Road Truck and Utility Tractor.

4.4.2. Parameters for the rail

Decide type of crane → Layout of rail → Type of operation

Figure 4-12 Rail parameters relation (APM Terminals)

To support the rail operation two types of Type of crane are mainly available:

-RMG/RTG
-Reachstackers

Having selected the type of rail cranes used and the layout of the terminal, the type of operations or logistics on the railhead will be defined (Busk and Uglvigm 2004).

4.4.3. Parameters for the gates

The gate is the facility within the container terminal where the external vehicles enter and leave the terminal with the pertinent loads. Depending on area constraints the gate can have several layouts. The first distinction that can be done is between the one-step gate and the multi-step gate:

- One-step gate: all the expensive high resolution image technology (license plate, hazardous placard reader, and container number, damage check, etc.) is installed in every truck lane. Additionally, a relatively large number of truck lanes are required since all processes are done in one step

- Multi-step gate: the different required technologies can be spread over more steps in less lanes. Moreover, a minimum number of truck lanes are required, because the time consuming processes are done serial.

The obvious advantages of the multi-step gate versus the one-step gate are lower installation and maintenance costs and lower cost to provide redundancy.
(Busk, Uglvigm & Lombardero, 2004)

4.5. Terminal Environment and Organization

Having standardization as a goal, it is important to create a framework for the issue that wants to be standardized. Therefore this has to be done for the terminal operation processes and it is done in a high level in this section.

Until now, a set of physical factors affecting the terminal operation have been mentioned yet institutional factors are more difficult to define as they appear in a higher level and therefore need to be studied with a broader perspective. These can have effect on the operation as much as physical ones can. Institutional factors are such things as union work rules, stow of arriving vessels, customs regulations, intermodal train scheduling, safety rules, and requirements imposed on the terminal operator by the carrier (Institute 2007).

In order to get a structured view of this idea the institutional framework for a container terminal can be divided in two elements/parts:

- External relations: main actors with which a container terminal operator deals.

- Internal Structure: specific policy followed by the terminal operator regarding investments, quality, etc.(Wiegmans 2003)

The second element will at all times be subjected to the first one as the operator adapts to the external factors in order to keep on the good track.

As willing to operate a global network around the world, an operating company as APM terminals needs to consider all the external relations in order to proceed and expand in a successful way.

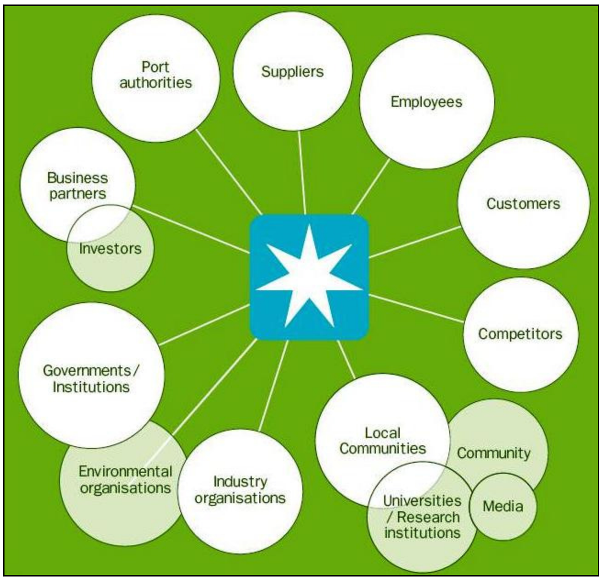


Figure 4-13 Stakeholders in a Container terminal (source APM Terminals)

Adding complexity to the operation, these stakeholders can mean several restrictions with different degree of influence depending on the country/region where the terminal is settled. The general operation therefore needs to take them all into account.

4.6. The Influence of Automation

Automation is the use of control systems such as computers to control industrial machinery and processes, reducing the need for human intervention. The chose of the RMG module has been the way to open the path to automation in terminal operations. It has been chosen for the study due to its significance within the company. Just implemented in one terminal until now, automation appears as a solution for the actual need of expansion and the need to cope with the several restrictions such as complexity and space restriction. Automation of the staking crane allows for a better preparation of the yard and therefore a better timing and land utilization. Therefore it can be a solution for restricted space terminals (Saanen and Valkengoed 2005)

Generally, an automated system operates more accurately and faster so terminals counting with those should be more efficient. However, high capital investments are necessary and the development and application are complex(Wiegmans 2003).

5. Processes Standardization in Terminal Operations

As commented in chapter 1 of this thesis work, standardization of processes comes out as a good solution in order to cope with the complexity of the environment. For the purpose of standardization, the understanding of what a process is and how it can be presented are the key features in this section.

A process is a series of activities that have to be carried out by actors to reach a common goal. It can be a combination of physical, communication and control activities that take place in a certain time sequence. As explained in the former chapter, a container terminal is a facility that has several functions and these have to be performed by means of the adequate processes.

The study and consideration of all services and activities that comprise the terminal operation and their cataloguing into several processes gives as an output the generic process list: the list of processes for the generic terminal.
The process model comes then as a way to locate each process in the list given a certain order and present it in a generic way, in a consistent and understandable language.

5.1. Building a Process Model

The aim of this section is to create a generic model for the processes occurring in an automated container terminal. The goals of a process model are in line with the terminal operator needs and thus are:

- Descriptive: Track what actually happens during a process from an external observer point of view searching for rooms for improvement.
- Prescriptive: Comprise guidelines, and behaviour patterns which, if followed, would lead to the desired process performance.
- Explanatory: Explore and evaluate the several possible courses of action based on rational arguments.

Following the model, processes are represented in the form of process maps and complemented with a process description discussing remarkable aspects or events. Each process included in the generic process list has the same treatment, so do the sub-processes and therefore a standard is created in order to present each of the processes of a generic terminal.

The intention of the model is to show how the process should develop for an efficient implementation, in contrast with the process that happens in reality in many terminals. The process under consideration can be obtained through an analysis done in several steps. The challenge is finally to obtain a generic solution than can be implemented in future terminals around the world. The approach followed is schematized in 5-1.

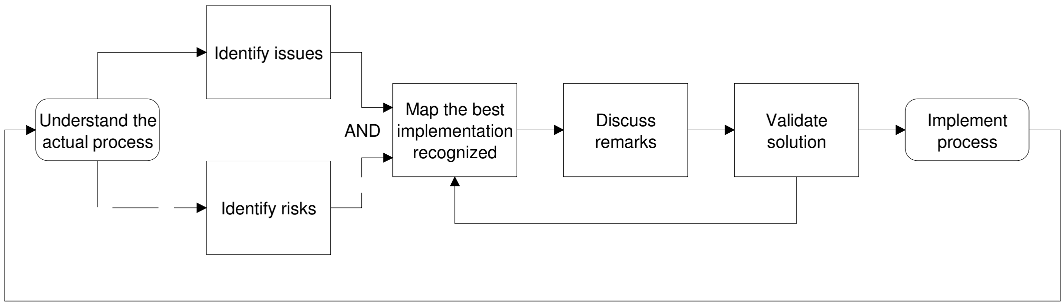


Figure 5-1 Process model approach steps

The first step consists on studying the process in the way that it is taking place currently focusing on the comprehension of what goes on in reality. A critical view of the activities to be realized, their need, their sequence or the actors involved, among others things, can help to recognize points of inefficiency and potential risks in order to identify opportunities for improvement. This serves as a basis for the mapping of what should always happen. It is crucial though not to miss the information of the real case so explanations are included for discussing remarkable aspects, assessing uncertainties or even giving alternative solutions. The solution obtained is validated by different experts in the sector and the feedback incorporated to the final solution. In order to cope with new issues and remain up-to-date with technology developments a feedback loop should be included in the process for future revisions.

5.1.1. Process Maps

According to R. T. Kreutzer there are some conditions that must be fulfilled in order for a process to be standardized: *"The process steps and activities have to be visible, it has to be possible to fix the single steps and the process steps and activities have to be repetitive and predictable, because when activities are very variable, standardized procedures may show dysfunctional effects"* (Kreutzer, 1986).

The tool chosen in this approach that serves as the model core is the process map. A process map is a graphical representation of a process. These maps are used to replicate the processes taking place during the operation of a container terminal. The focus is on the container flows for the different cargo including the relevant physical procedures as well as communication and control activities. The map can help in identifying duplicated or unnecessary steps and allow a simple analysis of alternatives. The results obtained have to be included in a revision of the map and tested or assessed by different sources. Better maps will be developed after several rounds and serving as a basis for future implementations.

It is important to be clear about what to map out. The start and end points of the process should be clear as well as all input and outputs involved. Several relevant people should be consulted in order to get a detailed perspective of the process. A critical analysis of the situation with the main goal in mind should be done to decide which events should be considered and branched out and which ones should be ignored or just commented. Finally, a great effort and time has to be placed on analyzing the map and developing an action plan to test improvements when possible. The results are presented to the different actors involved in the process as well as the rest of operational areas to get external points of view and better assess the impact on the whole system. The final solution should be compiled incorporating the value added by feedback and the process should be revised once and again in an iterative process until the expected usability level has been reached.

Process maps can depict many levels of detail. Several rounds can be made to expand the most interesting activities. However, it should be done without loosing track of the big picture as too much detail can consume time and effort with no results. Determining an appropriate level for the map following it consistently is vital.

Figure 5-2 is an overview of the steps followed for developing a process map.

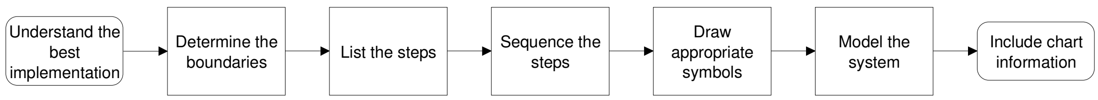


Figure 5-2 Process mapping steps

The general notation for the symbols and flows that appear in the process maps is schematically represented in 5-3.

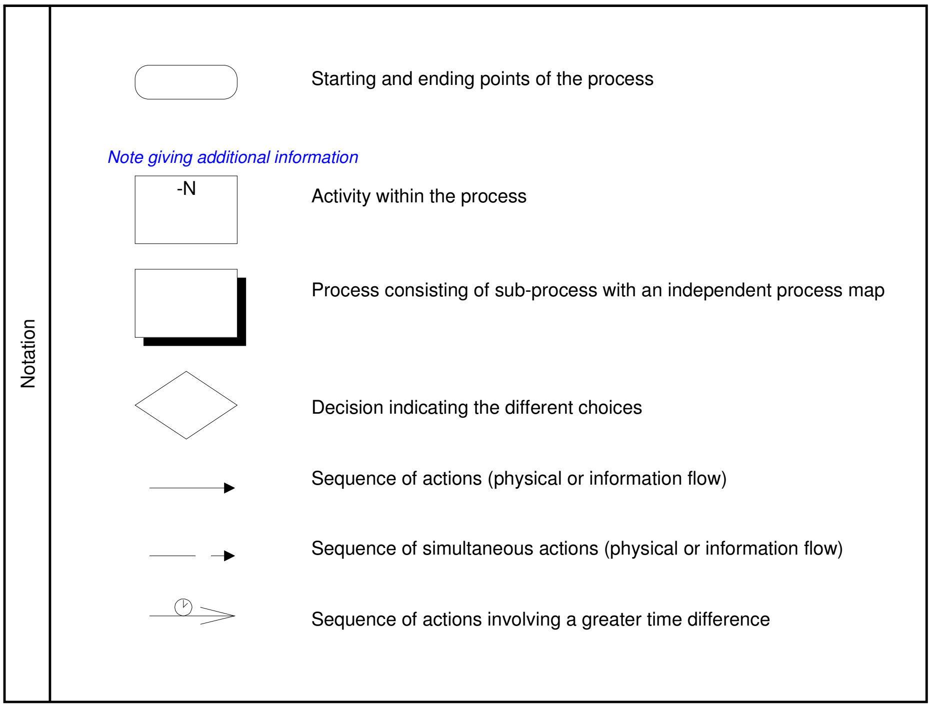


Figure 5-3 Graphical Notation for the Process Maps

5.1.1.1. Actors, Actions and Interrelations

The process map includes such information as process complexity, the actors involved, actions and interrelations between them.

The actors carrying out the actions are indicated on the left side of the process map with the possibility of adding different hierarchical levels. There is a distinction between departments, significant personnel, information and control systems and equipment. The different possibilities are explained below.

On the right side of the process map the actions are expressed using activity boxes and indicating their order and interrelations by means of connection lines. The activities representing the start and finish points of the process are showed with round-coin rectangles. Activities are expressed by rectangular shapes. A shadow on the shape means that it consists of sub-process including a set of activities detailed in an independent process map. Rhombus shapes have a decision behaviour and are used for case differentiation. Notes are included when necessary for giving additional information, changes of state in the system or any important comment.

The interrelations between activities are expressed by means of connector lines that can be inputs or outputs of the activity depending on the arrow direction. Slashed lines indicate additional or parallel events. The basic Boolean logic on one or more logic inputs are indicated by means of the AND and OR operators between the inputs involved. AND will be used if all input paths are necessary required to be completed in order to execute the activity that they are pointing out and OR if the completion of any of them is enough to perform the next activity pointed out by the connector lines.

5.1.1.2. Mapping Example

Figure 5-4 is an example of process map showing a general overview of the activities involved in the container flow of the import/export and transhipment handling cycles.

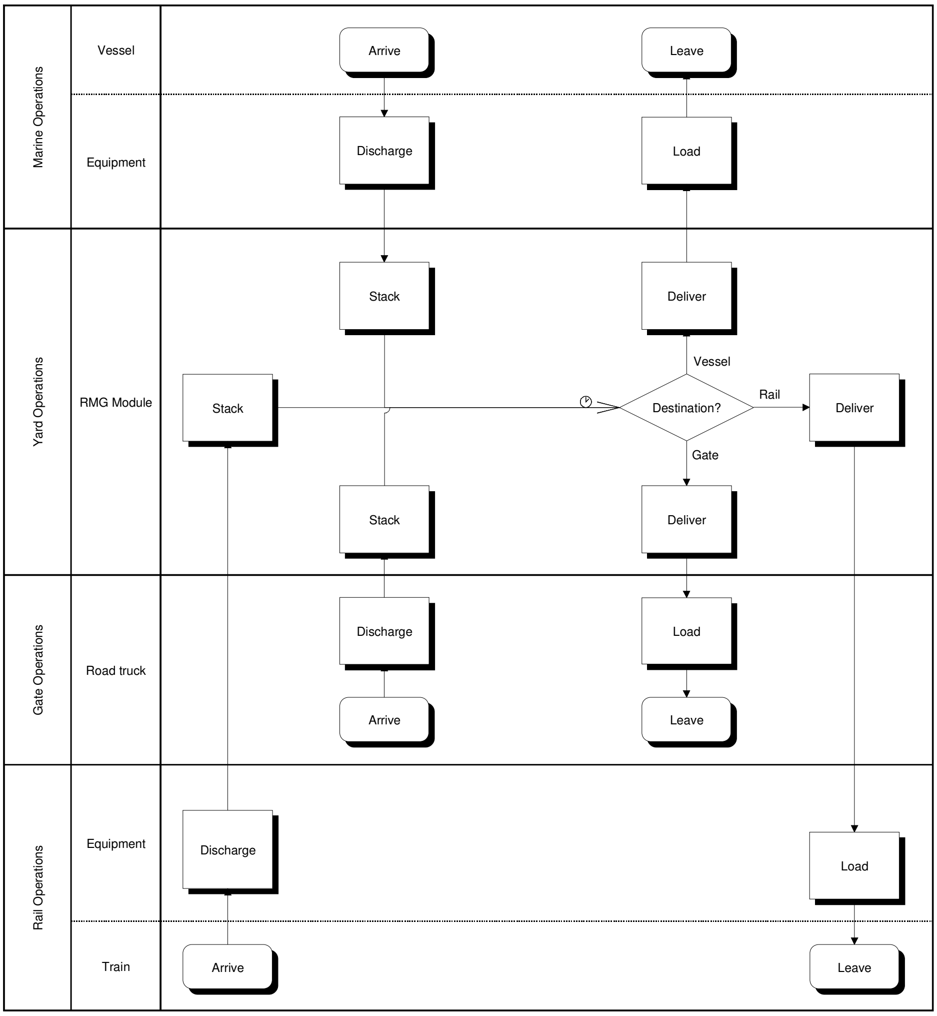


Figure 5-4 General flows: Import – Export – Transhipment

5.1.2. Process Description

Overview and comments: An overview of the process represented in the map is given in the first section of the description. This section gives some comments when needed to clarify the parts that are difficult to express just graphically.

Outstanding events: Special attention is paid on explaining key activities and occurrences of great importance

Risks: There is an emphasis on the risks present in the actual process indicating their probability of occurrence, consequences and management.

Exceptions: Exceptions to the general process mapped are mentioned if existing.

Important concepts for the standardization: Conclusions obtained from the process and directions to be incorporated in the standardization criteria for the global analysis.

5.2. Standardizing the Generic Terminal

Once the tools for the process model are defined more matter-specific criteria used in the model can be introduced.

The second research question presented in chapter 2 aims for the concept of a standard terminal operation that can be implemented worldwide. For that purpose a framework needs to be established and therefore a language and required simplifications necessary to apply the process model are presented in this section.

There are a large number of activities taking place in the operation of a container terminal going from the business specific activities necessary to exploit the terminal to the additional ones aimed to assist the main business. The standard terminal concept developed in this thesis comprises the business specific activities. It is developed paying special attention to the operation procedures. A comprehensible list should be generated covering the whole terminal operation.

5.2.1. Elaborating the Process List

As explained in the methodology, the process list comes as an output of research in different terminals, experts' opinions and a brainstorming workshop. This output though needs structure in order to be presented in the process model. The structure used comprises three factors: process hierarchy, process classification and process priority.

5.2.1.1. Process Hierarchy:

Separated in 4 different levels the processes follow the following hierarchy:

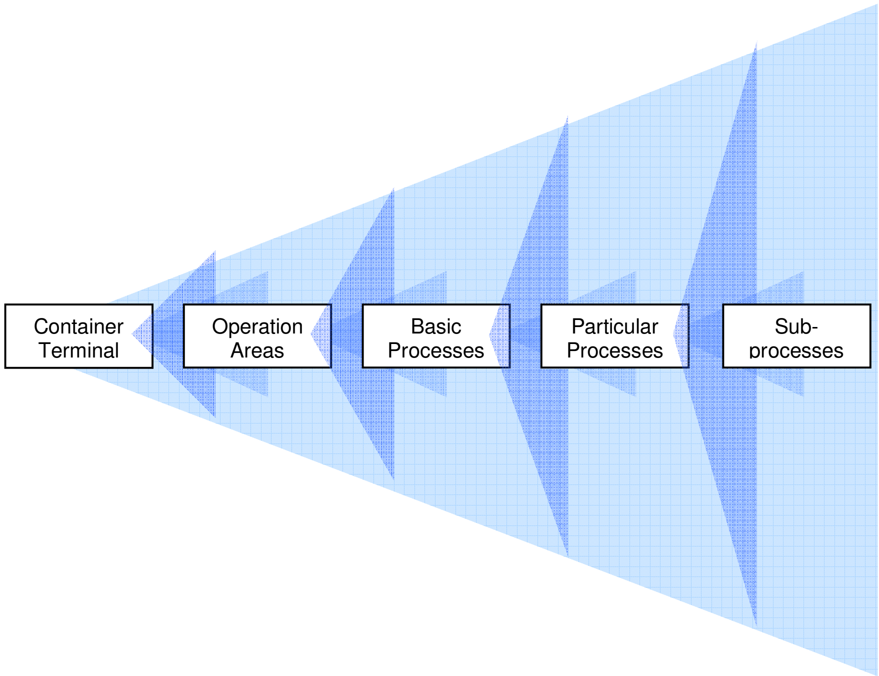


Figure 5-5 Hierarchy levels for the standard container terminal processes

Operation areas: The first level is the most generic one in the hierarchy differentiating the general areas of operation in a container terminal.

Basic processes: The second level specifies the generic basic processes that take place in a container terminal. This set of basic processes is equivalent in the different operation areas of the terminal.

Particular processes: The third level identifies the type of cargo and handling equipment used for vertical and horizontal transportation. It is included to differentiate the options available to operate the generic processes in each operation area setting all possibilities for particularizing cases.

Sub-processes: A forth level is used for bringing in a higher level of detail for a specific activity whenever it is relevant for a better understanding of the process.
The method followed starts by generating a list of processes for each operation area defined. This way each level will be developed considering all possibilities of cargo and vertical and horizontal handling equipment.

5.2.1.2. Process Classification:

A criterion in order to select the activities that are going to be considered for the study must be defined to narrow the possibilities. A widely used approach has been adapted to the container trade industry in order to identify common groups of activities, processes or procedures in the container terminal operation in terms of volume and regularity of their service. The processes have been classified in three groups as explained below.

The first category includes processes that take place on a continuous basis and represent the largest part of operation volume in any given period.

The second group comprises the processes that occur regularly to meet customer requirements or to satisfy a recurring demand.

The third category refers to the processes that are run in rare occasions to cover odd situations or specific customer requirements with random occurrence.
These three categories are commonly referred to as runners, repeaters and strangers. Their main characteristics are summarized in Table 5-1.

Process Type	**Demand**	**Variability**
Runner	High	Low
Repeater	Medium	Medium
Stranger	Low	High

Table 5-1 Process classification by demand and variability

Additionally, this categorization can be used afterwards for developing the different group management strategies. Different categories will follow different strategies and will require specific improvements.

5.2.1.3. Process Priority:

Priorities are used for assigning the processes different levels of importance according to the value they can have for the standard terminal concept. These priorities will certainly depend on the stage of the standardization project varying the focus on each phase of the total duration of the whole project.

In the first stage of the project, the core processes have to be selected and considered for being modelled in the most efficient way as they represent the core capabilities required for any terminal to be in business. Therefore, special attention will be paid on the runner processes on every generic operational area defined in order to identify similarities and differences that can be used afterwards.

A three-tier priority scheme is used for classifying processes. For the starting phase the meaning of these priorities has been set to:

<u>High</u>: The first priority level is basically for top runner processes selected to primarily cover the main movements of regular containers for all activities in every operation area of the terminal. Different container handling equipment has been selected in order to reach a first approach as complete as possible.

<u>Medium</u>: The next priority level includes runner, repeater and stranger processes that contribute to the basic understanding of the terminal operations adding extra features to the high priority processes.

<u>Low</u>: The last priority level is given to any other runners and repeaters already included in the higher categories for any of their particularizations and that do not have remarkable differences as well as nearly all stranger processes in the terminal.

At this point it should be noted that a low priority in the first stage of the project does not mean that the process is not important for the whole project of the standard terminal but it will be in later stages. For instance, the stranger processes will be considered of great importance in the last stage of the project, when all regular processes have been already considered, as these strangers can be an important source competitive advantage allowing the terminal to stand out from their competitors.

The final version of the list contains about 100 processes, 20 for the marine operations, 25 for yard operations, 10 for the gate operations and 20 within rail operations. The list is attached in Annex 3.

5.2.2. Setting Standard Definitions

A higher understanding of the business specifics is required for further simplification. In order to use a consistent and simple terminology for the process model the simplifications made as well as the criteria for those are explained in this section. Along it, the four main factors determined in the terminal processes are schematized and standardized for the generic terminal, these are:

- Operation Areas

- Data Items
- Job Functions
- Information and Control Systems
- Container Handling Equipment

5.2.2.1. Operation Areas

As a broad approach, distinctive areas can be considered to support the different operations performed within the generic terminal. They are strictly related to the functions of the terminal explained at the beginning of this thesis and these are:

- Marine operations area
- Yard operations area
- Gate operations area
- Rail operations area

Figure 5-6 represents them graphically in a generic positioning scheme.

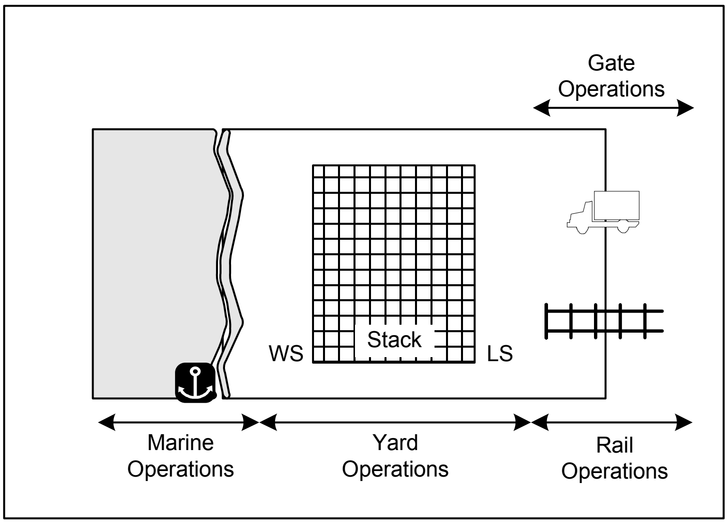


Figure 5-6 Operation areas for the generic terminal

Marine Operations area comprises the processes involving ship load and discharge as well as the horizontal transportation traffic flows related to vessel activities. The Yard Operations area includes not only the containers' stack but also its landside and waterside interactions with the modes of operation. Gate Operations area is the zone where external transport enters and exits the terminal and the same applies for rail transport at the Rail Operations area. In the case of the Rail operations area there is also considered an area called Rail Buffer Area where the containers are kept until they are loaded in the train.

Inside each operation area there are distinctive sub areas defined for their relevance in many of the processes, these are the following:

Transfer Points

Transfer points are geographical -fix or movable- spots in which containers are shifted from one container handling equipment to another. Transfer can be performed from a crane to an internal or external vehicle when the former one has a passive role as it waits for the crane to load the container on top of it. It can otherwise be performed physically on the ground and both crane and vehicle pick up and drop containers.

The considered transfer points within the terminal are:

- QC transfer points limited by several lanes underneath the QC
- Stack WS transfer points limited by several lanes at the end of the stack landside
- Stack LS transfer points limited by several lanes at the end of the stack waterside
- Rail transfer points limited by lanes underneath the rail crane

Transfer Areas

A transfer area is the surface that comprises a group of transfer points used for the same purpose (the same kind of transfer). These are:

- QC transfer area – transfer points
- RMG transfer area at both sides of the RMG stack (WS and LS)
- Rail transfer area

Figure 5-7 represents them graphically in a generic positioning.

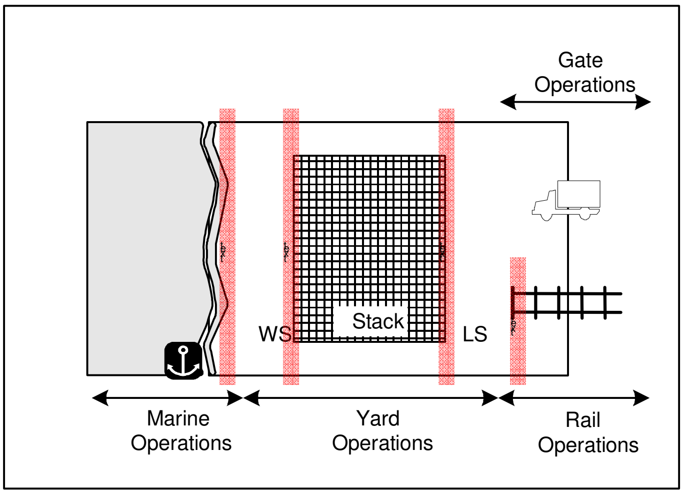


Figure 5-7 Transfer areas

Transfer Zones

The transfer zone includes the transfer area plus the space above it where the cranes lift the containers. This zone is considered mainly for safety reasons all along the terminal transfer processes to avoid any concurrence of crane while lifting a container and human presence. These two actors cannot be in the same transfer zone at the same moment. The transfer zones to be considered within the terminal are:

- QC transfer zone
- RMG WS transfer zone

- RMG LS transfer zone
- Rail transfer zone

5.2.2.2. Information: Data Items

Within any process that takes place in the terminal there is a significant part that consists in collecting information or checking it. This information is uploaded in the course of the operation process to the relevant system in order to create a link between the current state of the process being performed and the terminal general operation.

Information is gathered in the form of data items and these can vary from one terminal to another depending on local regulations, quality standards, company standards and other. The following data items in Table 5-2 apply though for the generic terminal as are known to be required for the operation.

Data Item	Description
Seal check results	Any loaded container entering the terminal is checked to confirm that it remains locked and hasn't been opened during the trip. The same applies for containers leaving the terminal.
Weight	All containers are weighed at entrance of the terminal for safety considerations. Weigh is performed therefore in gate and rail operations areas.
Container number	Digits applied by the respective company are checked so as to enable the identification of a specific container and thus follow its process along the terminal.
Damage Inspection results	Containers must be in good condition at the terminal. Therefore damage inspections are performed in the gate and rail areas.
Empty Inspection results	In the case of an empty container, the inside has to be checked in order to
Truck identification	External vehicles must be identified
Container handling equipment identification	All internal equipment is identified when any action is being performed.
Load type	At any point of some processes there is an update to the system about the load of the container
Driver's personal identification	Any personnel external to the terminal must be identified at the entrance so must the truck drivers coming in and out the gates.
Hazardous placards	Hazardous cargo, when handled, is recognized and distinguished from the rest of the containers as it may need a different treatment or different operation.
Container location	All containers are located inside the terminal.

Table 5-2 Data items

The reasons why a specific data item is placed in a specific process are diverse and can be discussed. In the same way, the motives for placing a data item capture in the

process and the way in which it is performed can vary for different terminals depending on many factors such as technologies usage, labour restrictions and systems.
On purpose of process standardization, information needed is a main factor to consider. Depending on the information required the process can vary. Therefore, a way to identify some of the steps that have to be performed in a specific process is to consider all the information that has to be gathered in the form of data items during that process' execution.

When the different data items are identified, several terminal job functions and systems have to be defined in order to match them with the data items. In many cases, systems and job functions are exchangeable and the same data item can be captured either by a person or a system. The more wish for automation, the more functions are performed by systems instead of people.

5.2.2.3. Job Functions

Information job functions

As said before, some of the functions within the terminal are directly derived from the data items list. For all the data items presented in the former section there has to be both a collection and a checking and thus several functions are defined depending on:

- How many data items can be collected by the same job function. Collection needs to be made on-site so the number of different compilations done by a same job function will depend mainly on the physical possibility for all of them at the same place and time within a safe procedure.
- How many data items can be checked by the same job function. A same job function can receive different data items and therefore there has to be some hierarchy for treating them.

The number of people performing the same job function will depend on volume factors and this is of no interest for this section.
The different functions for the terminal concerning data items collection and checking are presented therefore in the process maps.

Execution job functions

Besides the job functions existing for information purposes, there are other job functions directly related to the main process actions taking part in the process. Container handling equipment drivers such as the crane driver, vehicle driver and truck driver are examples of those. Other functions as lashers and pin men are considered too.

5.2.2.4. Information and Control Systems

Information and Control Systems are also presented in a general structure as showed in Figure 5-8. This generic representation allows using the information concept in the different terminals for representing the data communication regardless the software and systems set up in place.

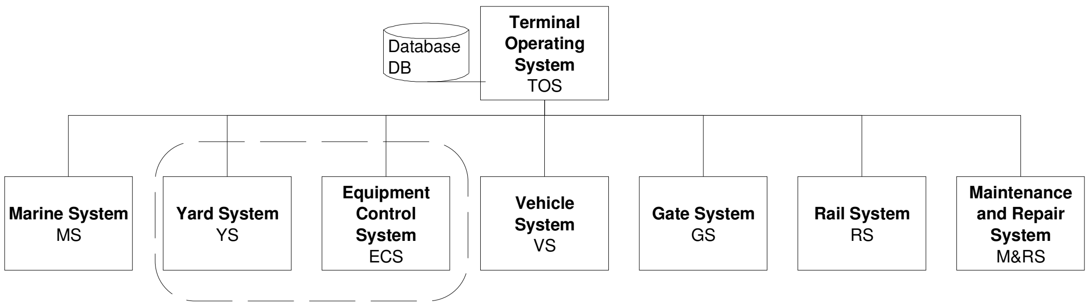


Figure 5-8 Generic information systems organization

The TOS includes the logic and decision making functions keeping an updated database with information of the whole terminal.

Each of the operation areas defined above has its corresponding sub-system being *Marine*, *Yard*, *Gate*, *Rail*. An additional sub-system called *Vehicle System* is considered for managing the internal terminal transport and an *M&R System* for the operations related to damaged material. The function of these sub-systems is to receive work orders from the TOS, manage their execution, collect results and additional information and update the status back in the global database of the TOS.

These subsystems include and manage the information acquired by:

- Sensors as lasers, light curtains or weight mats
- Communication systems such as sound and light alarms, displays, radio systems, cameras, tablet PCs and buttons
- RFID readers, scanners and radiation portals

In order to introduce an extra level of detail in the automated yard, the Equipment Control System for the ASC is differentiated from the Yard System for controlling all crane related system actions. The Yard System will then manage all yard information and control flows but the ASC ones.

5.2.2.5. Container Handling Equipment

The container handling equipment used in the terminal will be differentiated between cranes, vehicles and other container handling equipment as schematized in Figure 5-9.

- Cranes include the different cranes present in the terminal that can be automated including RMG, RTG and QC.
- Vehicles can be external to the terminal as the road trucks or for internal terminal transport used in horizontal transportation. The later can have several options as human driven vehicles or automated ones. In the case of the UTR there are several combinations as UTR-TC (translifter), which can carry a cassette, or UTR-BC.

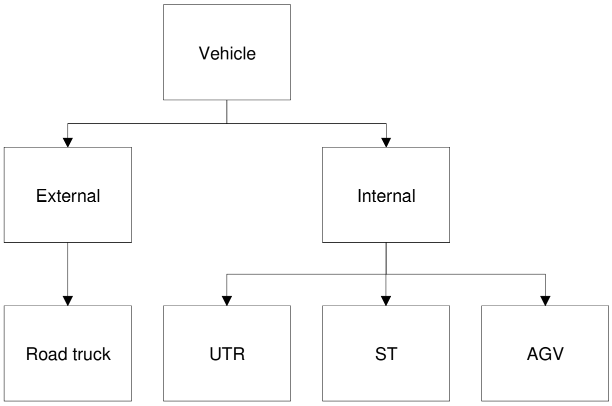


Figure 5-9 Equipment - Vehicles

Other Container Handling Equipment is the group that includes any other equipment not included in the other groups as for instance MTH, RS or fork lifter.

6. Case study: Virginia Terminal

A case study is a research method for investigating a phenomenon within its real-life context. It provides a systematic approach of looking at events, collecting data, analyzing information, and reporting the results. As a result of it the researcher may gain a sharpened understanding of why the instance happened as it did, and what might become important to look at more extensively in future research (Soy 1997).

In this section of the thesis, emphasis is placed on exploration and description and reporting of the relevant information for the general study. The case study in this work will have mainly two functions/purposes:

- Answering research question number 3. Observing and understanding the real operation in order to get the needed comprehension of the processes and their issues and risks. Identifying the ones that affect the possibility of standardization and indicating ways to overcome that.

- Applying the process model presented in chapter 5 in order to test it and to give guidelines about the necessary model improvements.

So as to fulfil as much as possible these functions, there is a procedure followed for each of the processes studied. First the operation must be understood and mapped, and then the issues and singularities of each process are presented and critically discussed in the process description in order to distinguish the best practices. These best practices need to be given a critical look in order to conclude whether they can be used as standards or alternatively they are restricted to the studied case. It is very important to emphasize that the sources of information for all the case study statements are oral interviews and **citations of experts** and data from **past performance** of the terminal. The way in which all this is discussed is explained in further detail in chapter 7-1.

6.1. The Virginia Terminal

An APM Terminals facility in North America serves as the case study for this thesis. In this section the relevance and the description of this terminal are presented.

6.1.1. Relevance of the case

Within APM terminals, Virginia is the first built and operated semi-automated facility. It is also the first one of these characteristics in the United States as strong labour restrictions have delayed the introduction of automation until these days while it is already present for several decades in some European terminals mentioned in chapter 4. This fact has been due to many reasons related to the location (country):

- Little public concern about air emissions until recently
- In the past, land has been plentiful and cheap, so wheeled operations have been possible
- Sophisticated software programs required for automation of the cranes not proven

Therefore, the influence of automation in a non-easy environment is the fact that makes this terminal interesting for the study.

There is a high degree of innovation put into practice in this facility and examples of these are the yard area weight-sensitive booths and remotely controlled cranes which are the first ones of this kind in the United States. The RMG module performance is sensitive to many factors that need to be studied opening this way the path of automation for the operating company. It is interesting to study its processes and the way they are currently being executed in order to set the standards for future implementations.

6.1.2. General Data

APM Terminals Virginia Container terminal is situated in Portsmouth, Virginia. It is fully operated by APM Terminals and considered the largest privately owned terminal in North America. The first phase of the facility started being operational in August 2007 and has a capacity of 1 million TEU. The terminal is designed regarding to future volume increases so a second phase can suitably be implemented in the coming years achieving a throughput of 2 mil TEU (APM Terminals). It is an import/export terminal as can be observed by the container volumes shown in Table 6-1.

Container Capacity	Start of operations		
	Moves	TEU	% of total
Import	564,000	987,000	47
Export	516,000	903,000	43
Transshipment	120,000	210,000	10
Total	1,200,000	2,100,000	100

Table 6-1 Container Volumes for Virginia at the starting operations date

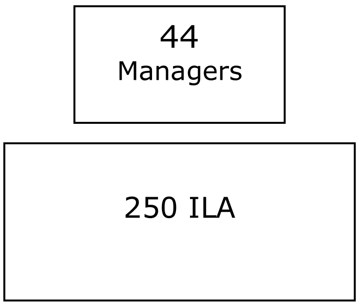
General explanation of the terminal regarding operational specifications and equipment is summarized in table below:

Description General	
Terminal area in hectares	93
Terminal Capacity in TEUs	40,600
Number of Blocks	15
Total Ground slots in TEUs	12,600
Total Reefer receptacles	424

Quay length in m	976,884
Number of terminals	1
Number of berths	3
Quay Crane (QC)	6
Rail Mounted Gantry (RMG) Cranes	30
Water depth alongside in m	16,764
Water depth approach channel in m	15.24
Number of Buffer points for RMG LS	75
Gate Lanes	26
In-Gate Portals	2
In-Gate Pedestals	13
Out-Gate Portals	2
Out-Gate Pedestals	13
Rail Tracks	6
Utility Tractor (UTR)	20
Reach Stacker (RS)	3
Empty Handler (MTL)	2
Rubber Tired Gantry (RTG) Crane	4
Shuttle Trucks (ST)	20
Terminal Chassis/Cassette	350

Table 6-2 General data Virginia Terminal

In Virginia the terminal organization is summarized by the existence of two main groups: The terminal management and the terminal workforce:



Within the managers group there are general managers, managers an assistant operations managers (AOM) who are in charge of managing the labour.

The workforce is formed by people that are part of an association called ILA (International Labor Association). It is a regional association which has a lot of influence in the terminal operation and organization as need constant negotiation from the managers' side.

6.2. Processes Study: Application of the Process Model

In order to gain a general view of the operation along the whole terminal three processes have been picked from the process list created. Each of them is part of a different operation area and contains different issues regarding operation and terminal constraints.

- Marine operations - Marine discharge loaded container-interaction QC-ST
- Yard operations - LS stack deliver container - Interaction ASC-road truck
- Gate operations - Gate entrance for loaded containers

For the rail operations area no process has been selected for this study due to its similarities with the gate operations.

All processes studied during the work are attached in the confidential annex of the thesis as well as the complete process list.

6.2.1. Marine discharge loaded container Interaction QC-ST

Marine operations happen to be the main factor having impact on the terminal's costs and benefits (Vacca and Bierlaire 2007). In Virginia, the process of loading and discharging the vessels is run manually and the interest in its study lies partly on the labor organization constraints and their different effects on operation.

The studied process shows the interaction between the QC and the ST when the QC discharges a container and it is picked up by a ST at the QC transfer area. This process is therefore part of the marine operations area.

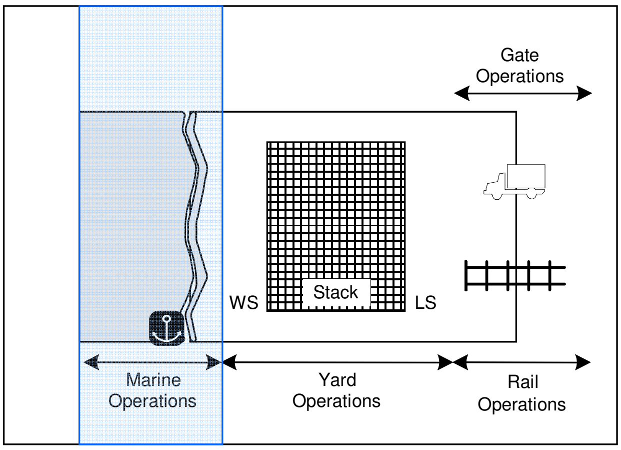


Figure 6-1 Process operations area

Process Map

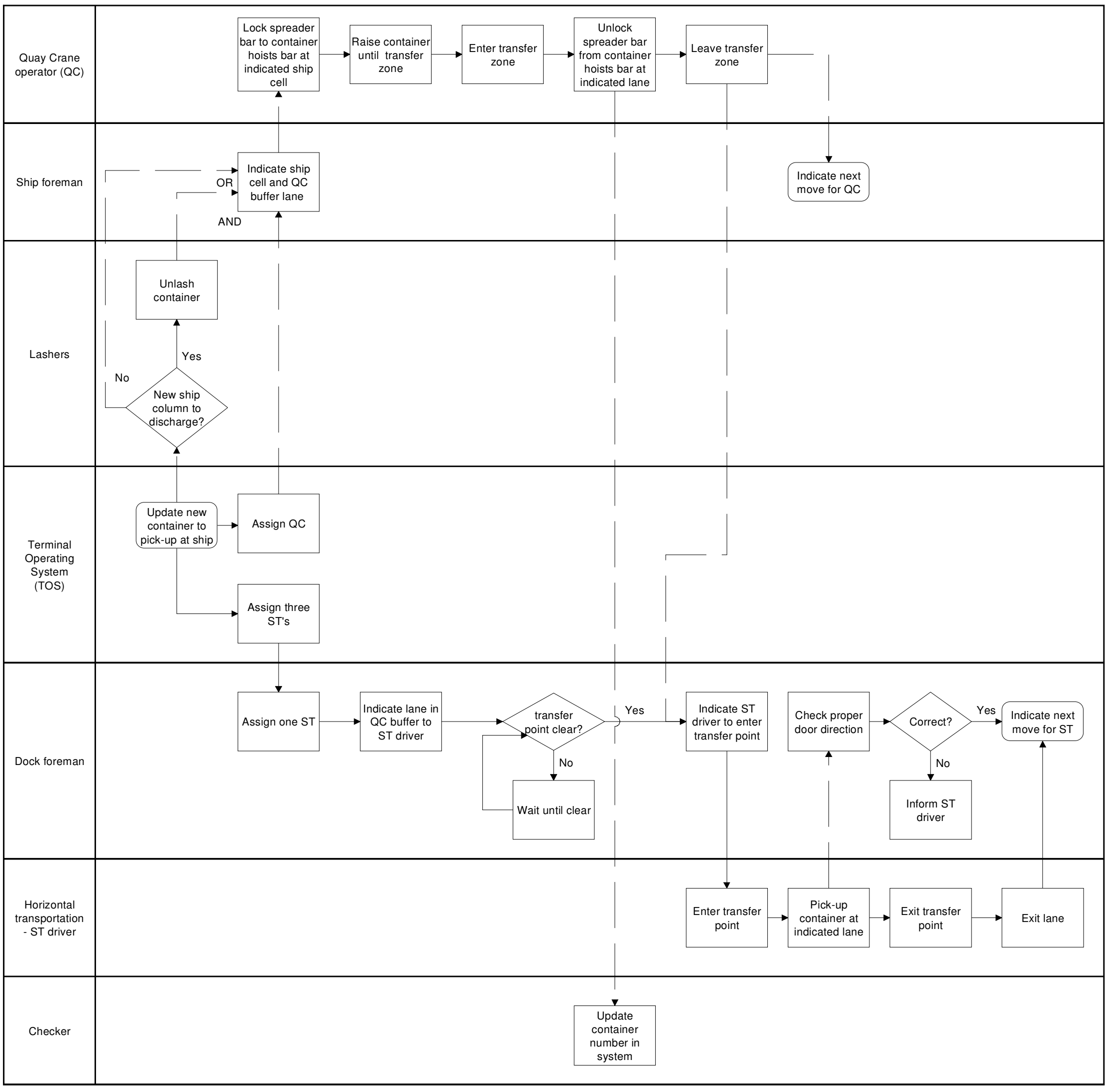


Figure 6-2 Process map for Marine discharge loaded container – Interaction QC-ST *(Process map is for example only and is not based on actual situation or design)*

Process Description

The process map in Figure 10-2 shows the way in which the QC discharges containers on the deck and the interaction between the QC and the ST when the former one picks up the containers from the floor. The loading process is similar but is not presented in the same process map for clearness reasons. When the QC operation takes place, it is important to remark that there are three possibilities which are:
-Discharge only
-Load only
-Both load and discharge at the same time
The last one is known as double cycling and can be very effective when there are elevated volumes and high speed in discharging is needed.

Figure 6-3 QC transfer zone

As shown in Figure 6-3, the dock foreman stays together with the checker inside a truck next to the dock. From that position they will observe the movements of the ST and the containers being discharged and loaded to the ship in order to perform correctly their functions.

Labour organization: Gangs

In Virginia, the process for charging and loading the ships is carried out by the so called gangs. These are groups of people per each crane that work together. When the ship comes, it is assigned a several number of cranes (from one to three depending on the ship volume) and each crane has its corresponding gang. This working group mentality is a consequence of the union regulations and restrictions. The gangs in Virginia comprise several functions as indicated below. It is very important to differentiate which of these functions are operationally essential and which ones are due to union regulations:

1 Dock Foreman 1 Ship Foreman 1 Checker	**Ship Gang (Pin men)** 1 Header *(boss, supposed to be the 4th pin man, but without clear function)* 3 Pin men
2 Crane Operators *(The Union requires the terminal to contract 2 crane operators per quay crane thought the operation could be carried out by one)* **Dock Gang (ST drivers)** 1 Header *(boss in charge of driving the forklift to move Pin baskets around under the crane)* 6 ST Drivers. *Only three of them are needed at a time, but there is the requirement by contract to employ 6 per crane, and they alternate in 2 hour shifts. It is also remarkable that due to union regulations, they are not allowed to type any numbers and therefore they could be doing other functions at the same time as for instance the checker function.*	**Lashing Gang (lashers)** 1 Header *(in some cases the boss works with their gangs, and some doesn't do much)* 6 Lashers *(due to contract regulations as it is the minimum to hire)*

Each gang has its own way of operating and it depends on the agreements made within each group and whether there is double cycling or not. Also, as in many manual processes, there is a high influence of the local labour regulations and therefore a generalization is needed. What the operation essentially requires in terms of functions and therefore the actors in the above process map are:

- Dock Foreman
- Ship Foreman
- Crane Operator
- Checker (can be done by ST driver)
- ST Driver
- Pin men (one for each container corner)
- Lashers (in the needed amount depending on vessel volume)

The process is as showed in Figure 6-2. Main issues to take into account are the traffic patterns for the ST and their interaction with the spreader when it is carrying a container. ST must follow some rules that are agreed between the members of the gang concerning safety procedures. It will always wait until the crane has left the transfer zone to enter the lane. Dock foreman is the one uploading -via the tablet PC- the containers that are being loaded and discharged and he/she should also check that ST are following the correct traffic rules. In practice, the dock foreman tells the ST driver which lane to go and when to enter it.

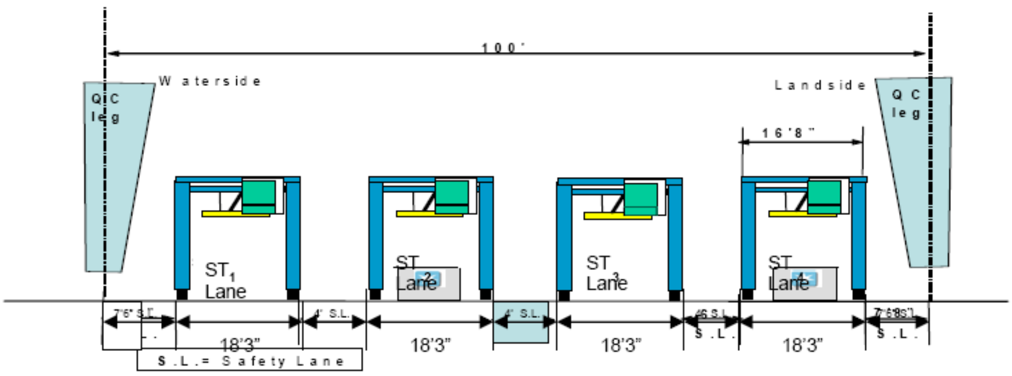


Figure 6-4 QC transfer lanes section

The layout of the QC transfer zone is as showed in Figure 6-4. There are 4 lanes for the ST operation which enable the traffic of these vehicles. The use of the different lanes again depends on the crane operator preferences. In some cases two of the lanes are used for loading and the other two for discharging as this signifies a better intersection of the transfer zones.

ST was selected in Virginia as the mode of waterside handling in stead of the AGV due to 2 reasons:

- Studies showed them to be less productive than the ST in a factor of ½ due to ship configuration
- Due to regulations AGV don't imply any savings but additional costs of equipment.

The risks registered in this process are mainly involving the systems failures.

Foreman PC fails
Foreman PC application or communication fails
Waterside traffic pattern not efficient

Table 6-3 Risk list for Marine discharge container – Interaction QC-ST

6.2.2. LS stack deliver container Interaction ASC-Road truck

As an interesting part of the yard operations the landside interaction of the ASC happens to be a main operation issue due to the interaction between human and automated crane. This process shows the interface between the ASC operation and the road truck driver action when the former one delivers a container to the RMG stack and/or receives it. It is part of the yard operations, taking place at the landside transfer area of the stack.

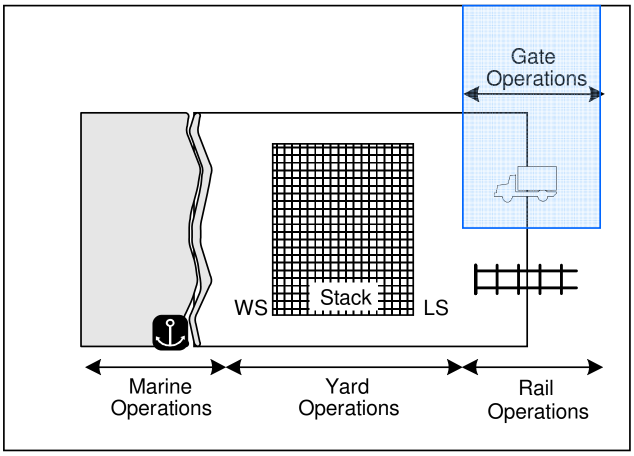


Figure 6-5 Process operations area

The process *LS stack deliver container - Interaction ASC-Road truck* contains the following sub-processes:

2.3.4. Shuffle moves
2.3.2. LS ASC move
2.3.3. Driver safety procedure in transfer zone

Which are included in the confidential version of this report.

Process Map

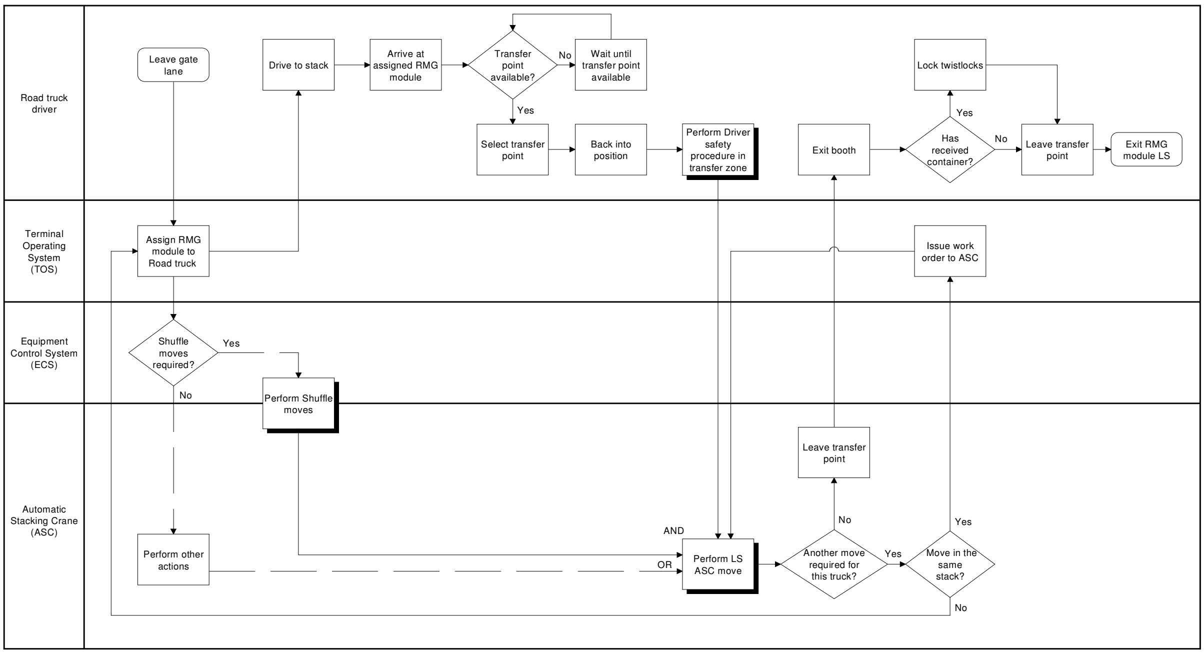


Figure 6-6 Process map for LS stack deliver container *(Process map is for example only and is not based on actual situation or design)*

Process Description

As shown in Figure 6-7, the area where the process takes place enables more than one truck for the same ASC. When arriving at the assigned stack, the driver can pick any buffer point available and wait until receiving the instructions to proceed.

Figure 6-7 Trucks at the transfer lanes at the LS transfer zone

From the truck's perspective the process allows different possibilities:

- 1 Delivery
- 1 Pick-up
- 1 Delivery and 1 pick-up

A truck will probably have two missions for one trip. It will not only deliver a container but also receive another one for which two ASC moves will be needed. When the road truck has already delivered a container in the stack there is the possibility, though not very often, that it has to receive another container in the same stack. In this situation, the TOS will issue another work order to the ASC while the driver remains in the booth until the second move has been finished and the ASC has left the transfer point. If otherwise, the second container is in a different stack, the process is repeated from the beginning at the point when the TOS assigns the module to the truck as indicated in the process map.

In Figure 6-6, both cases for empty and loaded containers are included as the process is the same for the two of them. In the case of a truck receiving a reefer container from the stack, this must be unplugged in advance by a mechanic some time before the truck arrival. When delivering a reefer container, it must be plugged in the reefer rack located in the stack after the process.

Due to the human presence in this process many risks must be taken into consideration. The ability of the truck driver plays an important role on that. The truck can have difficulties when backing into position and damage the infrastructure of the landside transfer area.

Also other communication and operation risks are considered. Below is a list of the main risks that have to be considered within the completion of this process

Road truck has trouble backing up at LS
Road truck damages a booth
One booth or more non operational
All booths in one stack non operational
Container position out of reach of RMG
Reefer not unplugged
Hazardous spill

Table 6-5 Risk list for ASC pick-up/drop container at RMG LS transfer area from/to road truck

6.2.3. Gate entrance for loaded containers

The interest in the study of the gate operation lies in the layout concept as well as in the correct sequence of the data gathering sub processes that compose the overall gate process. An infrastructure that suits the truck volume, the correct layout and the right use of it added to a suitable sub process sequence is what can make it a best practice.
In order to map the process, data items are the main criteria. Once data items needed are identified, the discussion for different functions and systems can be approached. As mentioned before in section 5.4.3, the requirements for the data items depend on local factors but mainly these can be derived from the different services/processes that need to be held in the gate.

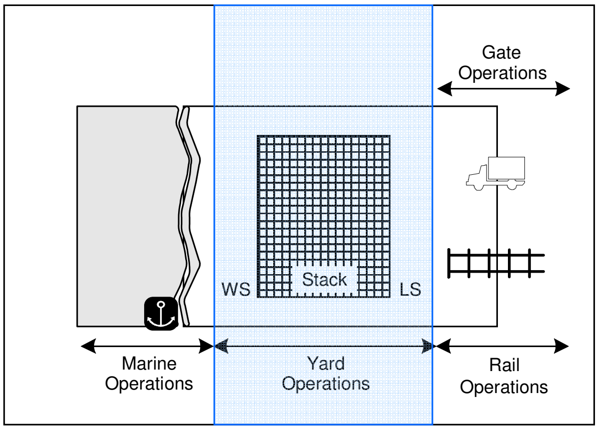


Figure 6-8 Process operations area

Process Map

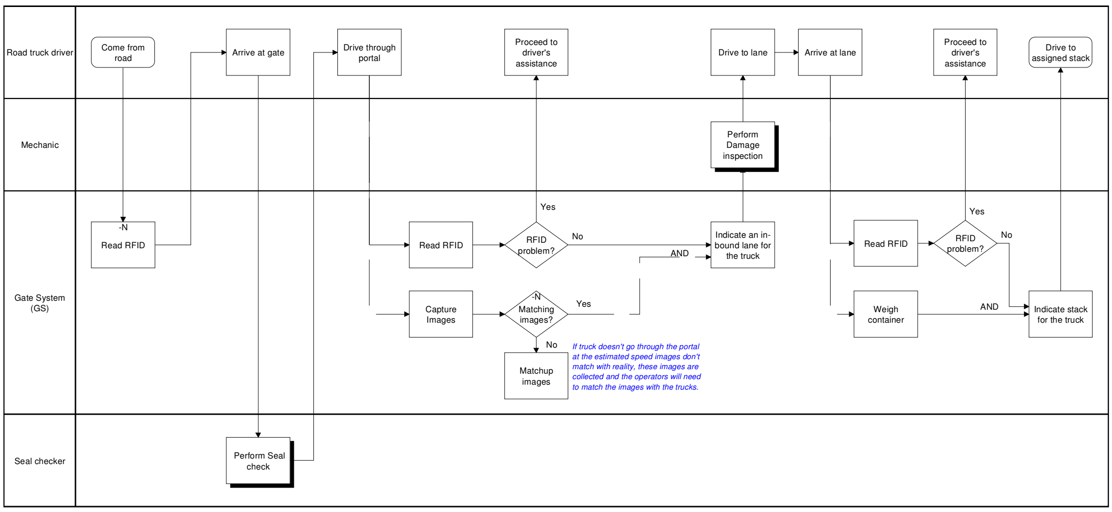


Figure 6-9 - Process map for Gate entrance for loaded containers *(Process map is for example only and is not based on actual situation or design)*

Process Description

Along the process, 3 RFID reads are required: one at the road just before the entrance, one at the portal and one at the lane. The RFID at the road will inform the system whether that truck has an appointment or not. If it does have one, TOS will indicate the corresponding stack to prepare the container for that appointment (start shuffle moves if possible and needed).

The driver will then be submitted to the seal check. Only loaded containers will stop at the entrance of the terminal, before the portals, in order to allow the seal check.

The second RFID read will be performed when the truck goes through the portals at the same time that images will be captured for the consequent damage inspection and data verifications comprising container and chassis numbers, hazardous placards and genset number. Sometimes the truck doesn't go through the portal at the estimated speed so the images don't match with reality as they don't correspond to the correct truck. All these unmatched images are collected and the operators will need to match the images with the corresponding trucks. The third RFID read is used to confirm the truck identity, matching it with the data obtained at the portal.

Figure 6-10 RFID problem indicated by the screen after portal pass

In the gate process data items collection and verification is a key factor. All the activities involve one of these actions. However, the sequence of the different activities is not a main issue as most of them can be performed anytime and in an arbitrary order. For example, damage inspection can be performed at different points of the process and the same applies for empty inspection, seal check, etc.

For an empty container the process will be similar but will have some differences. Seal check is not required and an empty inspection is performed at the lanes to check that the container is in acceptable condition and clean in the inside. In Virginia, the empty inspection in the in-bound lanes is done by a remote clerk who indicates the driver to open the back doors of the container and inspect it remotely. Once the inspection is performed the driver can close the door and go back inside.

The turn time

Truck drivers are an independent entity from outside the terminal so they can choose whether they want to work in the terminal or not. Mostly, their choice depends on the terminal promised turn time. This is the time that passes from the instant a truck enters to the terminal until it leaves through the out gate. In At the beginning of the terminal operation, the terminal romises an average turn time and that is what the drivers expect to have. Turn time is an important indicator of the effectiveness of the gate and stack operations at the terminal.

Gates issue

The seal check has to be performed in all loaded containers that enter the terminal as well as the ones that leave it (the former action is not required by the client but it is currently done because of security reasons).

In the In-gate seal check was formerly performed by 2 seal checkers. They were working just in two lanes so this made of lanes 1 to 4 a bottleneck at the entrance as the load flows are much higher than the empty ones. While the empties had 7 lanes to go through, only 4 lanes where enabled for loaded containers.

For the Out Gate the solution hasn't been found yet thought the problem there is even more significant. While the process is the same as in the In-Gate, the main difference is regarding the little space available before the portals that doesn't allow a seal check to be performed outside the lanes. Consequently the seal check is still performed at the lanes following the union requirements mentioned before and thus slowing down the out-gate process. This issue is highlighted by the fact that between the portals and the lanes the space available is only for about 40 trucks against the more than 200 hundred that fit in the in-gate. An aerial view of the gates shows this difference in Figure 6-11. This fact creates traffic jams at the terminal closing times almost every day.

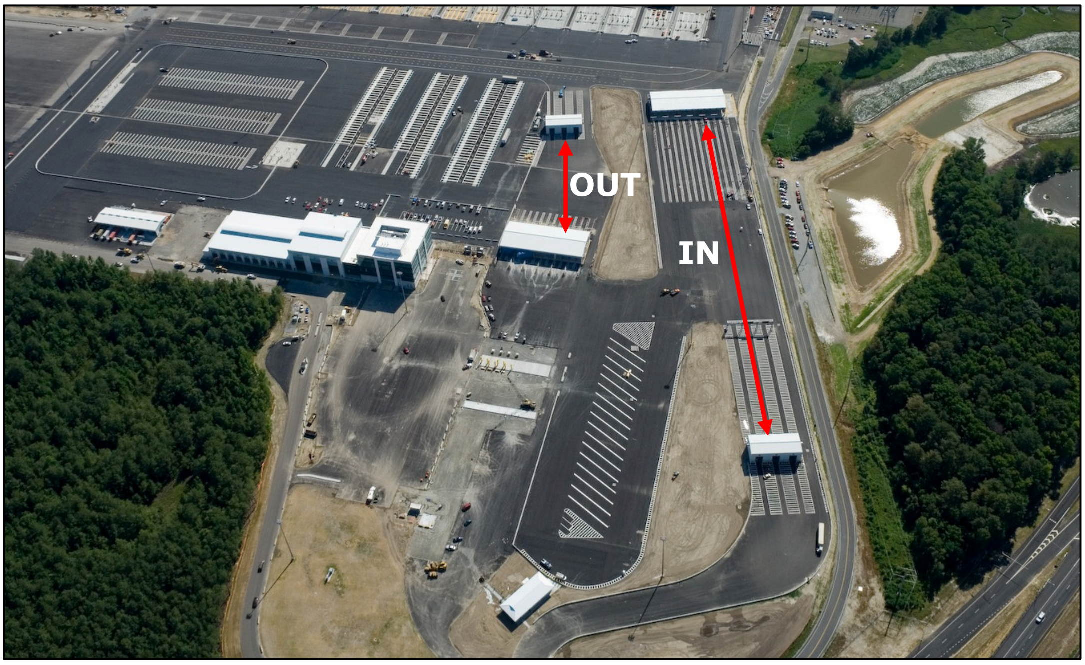


Figure 6-11 Distances from portals to lanes for both in-gates and out-gates

The appointment system

The appointment system is an application which the drivers can access 24 hours before their delivery. In the appointment website the driver includes his/her data and the kind of cargo he/she is carrying.

The main advantage of the appointment system is that it can allow the TOS to find the optimal position within the stack for an export container. It is a way to improve both the export flow smoothness at the gates and the stack. No representative automation general effects can be seen in Virginia gate currently. However, it is noticed that the appointment trucks have shorter turn times in the terminal as there are lanes reserved for them and operation is considerably faster. The appointment process is as showed in Figure 6-12.

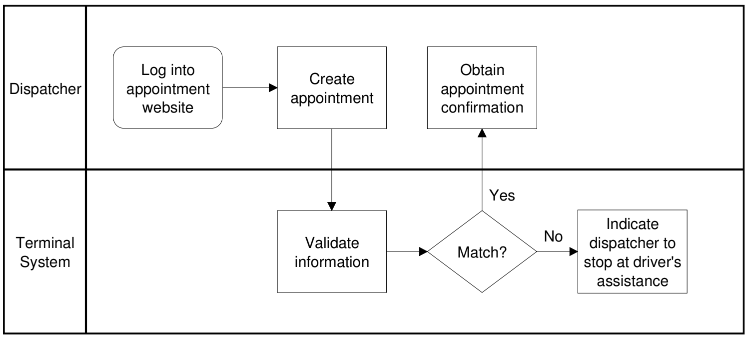


Figure 6-12 Appointment system

7. Case Study Reflections and Model Evaluation

As commented in chapter 6, the case serves basically in two ways:

- To visualize the processes studied in advance
- To recognize the issues of each process and actually observe these issues in reality and their impact and occurrence in the terminal daily performance.

Besides it serves to meet the terminal environment and the related matters for its organization.

Along this chapter several conclusions on the issues observed in the three processes are discussed. First, the case study evaluation method is explained and applied to the relevant issues in order to conclude some operation aspects of the terminal and how the model copes with them. Secondly, an evaluation of the process model regarding usability and performance possibilities is performed.

7.1. Evaluation Method for the Case Study

In order to discuss and analyse in a more systematic way the standardization issues found along the three sample processes studied the results are discussed in the form of a table as a mode of results schematization:

Issues for Standard Operation	**Observed Presence in the Process**	**Influence on the Operation**	**Model Usability**	**Model Performance**
Relevant aspect that can affect the possibility for the process standardization	Level in which the issue is observed during the operation in the terminal	Level of affectation of the issue in the operation	Whether the issue is well reflected in the process model	Whether the issue is managed regarding generalization

Table 7-1 Case Study Results

The first three columns in table 7-1 present the relevant factors affecting the operation and both their presence and influence in the studied process. Given that the processes are very of different kind of operation and placed in diverse areas of the terminal this serves as a way to reflect on and complete the answer to the first research question of this thesis involving the factors presented in chapter 4. Besides these mentioned factors, process complexity is measured in the way the operation sequence is difficult to understand (and therefore reproduce) in the actual process and reality divergence means the level of variance that the process can have in reality compared to the representation. Both aspects can easily lead to standardization hitch and are thus crucial for it.

The two resting columns serve to evaluate both the process maps and the description for the different factors. Firstly, it is done regarding to the model accomplishment in representing and reproducing the best practice and secondly regarding to the success in obtaining a result independent of these issues and therefore useful for standardization. By these, the limitations of the model developed regarding the different issues will be identified.

In order to fill the table presented each process representation is checked regarding the relevant points from a general point of view.

7.2. Case Study Reflections

The Summary tables for the three processes studied allow room for general reflections:

Summary table of results for Marine discharge container – Interaction QC-ST

Issues for Standard Operation	**Observed Presence in the process**	**Influence in the operation**	**Model Usability**	**Model Performance**
Regulations	High	High	Good	Good
Layout	Medium	Medium	Bad	Bad
Equipment	High	High	Good	Bad
Automation Degree	Low	Low	-	Bad
Process Complexity	High	High	-	Good
Reality Divergence	High	Low	Good	Bad

Summary table for ASC pick-up/drop container at RMG LS transfer area from/to road truck

Issues for standard Operation	**Observed Presence in the process**	**Influence in the operation**	**Model Usability**	**Model Performance**
Regulations	Low	High	Bad	Good
Layout	Medium	Medium	Bad	Good
Equipment	High	High	Good	Bad
Automation Degree	High	High	Good	Bad
Process Complexity	Medium	Medium	-	Good
Reality Divergence	Low	Low	Good	-

Summary table Results for Gate entrance for loaded containers

Issues for standard Operation	Observed Presence in the process	Influence in the operation	Model Usability	Model performance
Regulations	High	High	Good	Good
Layout	High	High	Good	Bad
Equipment	Medium	Medium	Good	Bad
Automation Degree	Low	High	Good	Bad
Process Complexity	Medium	Medium	Good	Good
Reality Divergence	High	Medium	Good	Bad

Looking at the result tables several conclusions related to each of the issues for standardization are overseen:

- A high influence of the regulations mainly in form of Union rules is present in the entire terminal operation and according to information gathered this is an issue affecting the whole country. Therefore, there needs to be main criteria for standard processes. These have to be thought independently to the union rules but also applicable to them not to miss the affected countries. The model comes as a good solution as it is suitable both in the way the issue is considered and in the sense that it can separate the process standard part (including it in the process map) from the rest (explained in the process description).

- Both **layout** and **equipment** are in general affecting the operation but they are more difficult to reflect by the process model. It can't be said that it is effective as in the regulations' case. The model is not successful in obtaining a standard for the equipment as it would need different maps and descriptions for different types of equipment. For instance another map and description for the AGV interaction instead of ST would be needed instead of being integrated in the given one.

- **Automation** degree affects the operation in the way that it could be completely different regarding the level of automation. For instance the gate process is influenced by the appointment system and it would vary significantly with a higher percentage of truck appointments. Automation is in general well explained in the process.

- **Process complexity** is indeed an issue for standardization as makes it difficult to unify and to be consistent. Complexity presence is equivalent to its effect on the operation.

- Concerning **reality divergence** it can be concluded form observation that it is quite habitual that the process is not exactly the same always. There are holes in the operation that can't be predicted in the design stages and are mainly due to human behaviour.

From the last two columns of the tables of results some conclusions can be drawn about the process model functionality. It is interesting to remark that when the model seems to be good in terms of usability it is not performing in terms of generalization performance. This can be explained by the fact that the more detail and closer explanations are done about the process, the more difficult it is to present it as a generic and therefore possible applicable standard process.

7.3. Model Evaluation

A more general assessment for the process model developed is given in this chapter regardless of its use in the specific processes and case study presented above but focused on the general possible functions of the model.

In order to evaluate whether the process model built fulfils the initial requirements of being descriptive, prescriptive and explanatory, several experts within the company headquarters and outside are consulted. A survey about a sample of a process included in the process model as an example is presented and some interviews are hold in order to draw conclusions on the process model usability, improvements needed and future possibilities. The survey is attached in annex 5 at the end of this report and a summary about the answers obtained is presented below:

-Number of people inquired: 8

-The inquired people has several backgrounds and experience in different countries and they comprise different levels of experience going from junior staff interns at the headquarters to more than 10 years experts in operation.

-Departments involved: 4

- Technical
- Finance
- IT
- Operations

Summary about the template document (questions 2.1, 2.2, 2.3)

In general the process positioning is clear but some people experienced in operation would request more detail in the figure about operations areas. Also people with high position believes that a reader without details in the industry can benefit from an introduction of the overall workflow
The process hierarchy is in general not clear, especially for people not familiar with process maps who don't realize it intuitively. The legend can help when more attention is paid so everybody can finally understand it. The required information is all included in general.

Summary about the Process Maps (questions 3.1, 3.2, 3.3)

In general the sequence of actions is comprehensible. However, people non-familiar with process maps consider that sequence can occasionally cause confusion (parallel, OR and AND missing, simultaneous lines)
The actors and tasks are completely understandable And the level of detail is In general considered as good for them to understand but they think that this would depend on target.

Summary about the Process Description (questions 4.1, 4.2)

The description helps to understand the process. The majority of the inquired thinks it is not necessary for understanding the process therefore the process map would be enough but also add that other people may need it.

Summary about Process Model (questions 5.1, 5.2, 5.3, 54, 5.5)

The model is considered enough for a clear operation understanding. Everybody except from technical departments people believe the interactions and systems are well illustrated. This can mean that for more technical specific functions the model can be insufficient.
Important missing issues like time are still something that can be improved.
Application for process models would be management positions that don't need a high level of detail about the operation. They give a clear overview of the operation for people related to the business in a high and middle level.

From the answers obtained it seems that indeed the model is in general clear and descriptive. The functionality of the model is depending on its level of detail which is seen as appropriate for a general perspective of the operation. More detail and specification would be needed for specialized and technical positions.

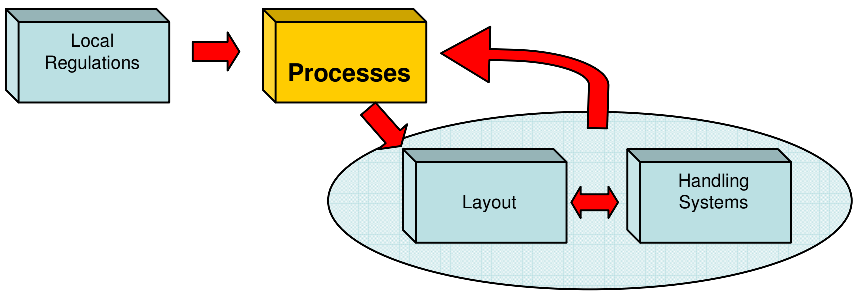
8. Conclusions and Recommendations

8.1. Answers to the research questions

Going back to the research questions introduced at the beginning of this report, answers for them are presented in the form of general conclusions as well as the corresponding future steps to follow.

What are the fundamental **processes** that take place in the container flow operations within a container terminal? What are the key **factors** influencing these processes and in what way do they do so?

The fundamental processes are the ones directly related to terminal functions and are about 100 processes within marine, yard, rail and gate operations as a high level approach. This list of processes is the output of several documentation deep research and expert's opinions and has been validated by the former ones. From the study of the processes selected in this work, the main factors influencing the operation happen to be process area's **layout**, chosen **handling system** supported by suitable **equipment** and the **regulations** due to locality. Given this observation the initial diagram presented in chapter 4 can be resized for the observation approach as:



Terminal conception reports and studies state that depending on the process that is foreseen the layout and handling equipment are applied. However, from real case observation it is verified that there is a difference between the process theoretical approach and the real process performance. Although processes are thought and implemented according to volume, layout and equipment specifications, there is always the need for **readjustments** and even consideration of new and different process. This fact is mainly due to:

- Human behaviour (either independent or influenced from union guidelines) that can't be predicted in both cases of manual processes and automated processes with human interaction.

- Container trade is a dynamic business and implies constant changes in volumes (gates, rail). This makes exact predictions impossible.

How can these processes be **standardized** so that they can be implemented in different terminals structuring a global terminal concept? What are the **criteria** for such standardization?

The process model presented in chapter 5 can be used to **partly** standardize the processes. Generic terminology and simplification of functions, operation areas, equipment and systems within the terminal is needed and suitable to apply in order to represent a generic terminal.

The process model needs to be on the one hand descriptive and therefore precise in the relevant aspects of the terminal in order to obtain best practices from present examples. On the other hand, it also has to be general as to stay useful and valid for standard implementation. The trade-off between generalization and detail level needs main consideration as it is difficult to make the model completely generic without missing relevant detail specially when treating layout and equipment factors.

A solution to this can be performing an improved model with regards to these issues. As in the regulations aspects, where it has been simple to **separate** them **from the mainly operation aspects**, a similar solution has to be obtained for layout and equipment. In this line, process maps are not enough and should be understood as a puzzle separating generic parts from specific (as equipment).

It is important to remark that the model shows to be comprehensive for the people related to the business and could serve as a tool for broad comprehension of the processes.

How do these processes perform in **reality** in a specific terminal and what are their main issues and risks? What are possible solutions for them? Are they valid as **standards** or best practices?

This is answered in detail along the case study and related also to answer of the first research question. The performance of the processes depends on the factors mentioned and on the level of automation, process complexity and variability of it. All these are observed in the terminal causing gaps in the operation: unpredicted facts. All these gaps make difficult the process standardization. Besides, most of the best practices observed in the terminal are subjected to specific procedures (as it is observed in the studied processes descriptions) and therefore need to be given a second real test. There is a need for more case study terminals in order to improve the model.

There is a high risk in using a single case study that serves at the same time for the understanding of processes. This can influence the general conception of processes and factors. In order to avoid this fact, a critical look and expert validation must be given to the process model built before the interaction with the case study terminal.

8.2. Recommendations and Future Steps

In order to give more sense to the generic terminal concept the process model should be completed with the rest of the processes from the list. After the runners focus that has been the decision of this report, **strangers** would be a good second step to consider as they are the processes that can make the quality difference (among competitors) when they are effective. Also they are obtained from reality observation so the case study collected data can serve for this purpose.

As said before the main future step to take is the improvement of the model given its observed limitations. Regarding the process maps, specific ones have to become independent and separated from the general ones but with the possibility to connect them in order to get a complete high process overview.

A part from that, **more case study terminals** need to be used to test the model and therefore allow an iterative rebuilding of it. Yet there has to be considered that the advantage of a single case study is that it is very useful to get a standard with strong guidelines from the example. Therefore, if the case is effective in reality and well-thought (considering standardization issues) it will mean useful guidelines for future implementations.

In order to have Virginia as the main guideline without missing generalization, the following case studies would need to be less intensive (less time period). When applying the model to those, the limitations and weaknesses of the model can be identified and then reconsidered.

Bearing in mind the company terminal network, to study one terminal from each of the continents/regions would be the next logical step due to regulations interest and environment conditions in general.

The model presented here can be used as the answer to requests for a general view of the terminal operation. For example, management positions who are not interested in specific and detailed issues of the processes. A modelled process can also be handed in to operators or terminal workforce who demand for a higher perspective of what they are doing and to suppliers of general terminal devices or software who may need the broad perspective of the operation.

It can be implemented in the design of new terminals with special focus on regulation aspects as the model appears to have a better performance on that.

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10. Annexes

10.1. ANNEX 1: APM Terminals Information

This annex comprises relevant information about the terminal operator for whom the project is performed and pertinent terminals considered in this thesis.

APM Terminals is part of the A.P. Moller - Maersk Group. Started in 1904, the A.P. Moller - Maersk Group has developed into a global company, employing about 117,000 people in around 130 countries.

The A.P. Moller - Maersk Group comprises A.P. Møller - Mærsk A/S and subsidiaries. The group includes Dansk Supermarked Group and other companies within the following main areas:

- Container shipping and related activities,
- Tankers, offshore and other shipping activities
- Oil and gas activities.
- Retail activity
- Shipyards, other industrial companies

A global leader

APM Terminals is one of the world's largest container terminal operating and management companies, with a comprehensive and geographically balanced Global Terminal Network of over 50 integrated facilities in 35 countries and five continents. Providing over 60 shipping lines with world-class service, reliability and efficiency, APM Terminals is also one of the world's fastestgrowing terminal operating companies, with the largest capacity of any terminal operator, and 14 new or expanded facilities currently in development or under construction in Europe, North America, South America, West and Central Asia, Africa and the Far East.

Market Share 2007:

Year:	2004	2005	2006	2007
PSA International	7.9%	8.1%	9.6%	10.3%
Hutchison Port Holdings	8.9%	8.3%	7.0%	7.2%
APM Terminals	5.7%	6.0%	6.4%	6.4%
DP World	2.5%	5.7%	6.2%	5.9%
Top 4 total market share:	25.1%	28.2%	28.9%	30.1%

Redefining the industry

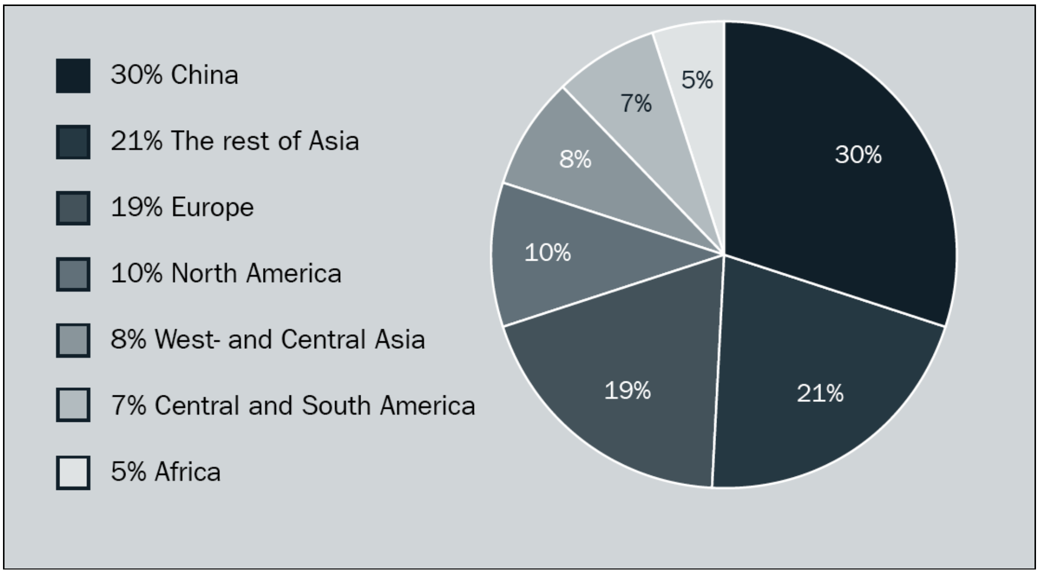
APM Terminals is redefining the container industry by investing
in, expanding and improving terminal and transportation infrastructure world-wide as global container trade continues to increase. Through our Global Terminal Network, APM Terminals offers Liner Operators and the shipping industry innovative and

effective solutions to transportation and logistics challenges. Optimum safety and efficiency in environmentally proactive facilities are our priority, and our policy world-wide. APM Terminals' investment in new facilities and technologies in 2007
exceeded $850 million USD.

Making supply chains more efficient
Customers can realize improved supply chain efficiency, lower operating costs and global synergies through use of APM Terminals' integrated global facilities.

Proud history
With headquarters in The Hague, Netherlands, AP M Terminals was established in 2001 as a separate and independent division of the A.P. Moller-Maersk Group of Denmark. The company's history in terminal operations began half a century ago with a facility in the Port of New York in 1958. Its heritage includes the Port Authority of New York and New Jersey's first dedicated container terminal.

The future
As world trade continues to expand, creating new markets and economic development opportunities, annual global container traffic volumes have been projected to double from the current 400 million TEUs within a decade. APM Terminals is committed to making the investments in the facilities, technology and personnel required to meet the expanding demands of the container transportation industry, and accommodate the needs of a dynamic global economy with the world's only truly Global Terminal Network.
2 June 1, 2008

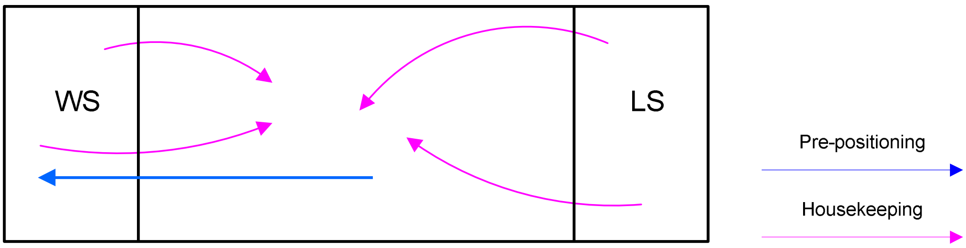


2007 Global container terminal market by region (source APM Terminals)

Sources:
http://about.maersk.com/en/FactsAndFigures/Documents/FastFacts.pdf
http://www.apmterminals.com

10.2. ANNEX 2: RMG data

This annex contains several conclusions for different studies about the RMG stack operation and its advantages and disadvantages compared to other systems.



As seen in the figure above, the RMG module stack can be divided in 3 sections depending on the moves performed by the ASC:

- The waterside (WS), where there will be the interaction with the marine operation.
- The middle part of the stack, where the major part of the volume is.
- The landside (LS), where there will be the interaction with gate and rail operations.

Housekeeping moves tend to be those that place containers from both waterside and landside of the stack to the center of it. As mentioned above, housekeeping is done whenever there's time for it and is useful to get out of the way containers that are not urgent as they are planned to remain in the stack for a while.

Otherwise, containers that are shipping soon will be retrieved form that central part of the stack and placed at the WS or near it by the pre-positioning moves.

Automation of the staking crane allows for a better preparation of the yard and therefore a better timing and land utilization. Therefore it can be a solution for restricted space terminals. The RMG software works with time windows. Its decisions depend on whether it has knowledge about the coming operations in advance and how much in advance, for example, for the WS export:

- If it is known 30 min. in advance- it'll move it OUT of the stack
- If it is known 90 min. in advance- it'll pre-position it (put it in the WS part of the stack)

RMG vs. RTG comparison	
RTG • Diesel Powered • Does not gantry with containers • Cannot be run remotely or automatically • Less capacity and more labor intensive • Cost: $1.0M - $1.5M	RMG • Electrically powered • Does gantry with containers • Can be highly automated • Higher capacity than RTGs • Higher capital costs for machines, runways, and electrical infrastructure. • Cranes doing the work of hostling equipment • Cost: $3.5M - $5.0M depending on size and features

Source:
http://www.intermodal.org/committees_files/resources/OpsCmte_UP_TermEff_May2_07.pdf

10.3. ANNEX 3: Process List

This annex presents the process list developed for the process maps

Section	General Process	#	Process Map	Source - Workshop 26.06.08 - Virginia Doc. - General Doc. - Other				Type	Priority	Approach - Internal Doc. - External Doc. - The Hague Team - Virginia Team - On-site Observations				
				WS	VD	GD	O			ID	ED	HT	VT	OO
0. Terminal Operations	1. General Handling Cycles	1	0.1.1. Terminal general flows - Import-Export-Transhipment											
		2	0.1.2. Terminal import											
		3	0.1.3. Terminal export											
		4	0.1.4. Terminal transhipment											
1. Marine Operations	1. Pre-arrival	5	1.1.1. Marine pre-arrival operations											
	2. Load / Discharge at QC buffer	6	1.2.1. Marine load container - Interaction QC-ST											
		7	1.2.2. Marine load container - Interaction QC-UTR											
		8	1.2.3. Marine load container - Interaction QC-AGV											
		9	1.2.4. Marine discharge container - Interaction QC-ST											
		10	1.2.5. Marine discharge container - Interaction QC-UTR											
		11	1.2.6. Marine discharge container - Interaction QC-AGV											
		12	1.2.7. Marine load discharge empty - Interaction QC-ST											
		13	1.2.8. Marine load discharge empty - Interaction QC-UTR											
		14	1.2.9. Marine load discharge empty - Interaction QC-AGV											
		15	1.2.10. Marine load discharge twin - Interaction QC-ST											
		16	1.2.11. Marine load discharge twin - Interaction QC-UTR											
		17	1.2.12. Marine load discharge twin - Interaction QC-AGV											
		18	1.2.13. Marine load discharge reefer - Interaction QC-ST											
		19	1.2.14. Marine load discharge reefer - Interaction QC-UTR											
		20	1.2.15. Marine load discharge reefer - Interaction QC-AGV											
		21	1.2.16. Marine load discharge OOG											
	3. Horizontal Transport (M <-> Y)	22	1.3.1. WS horizontal transport - Case ST											
		23	1.3.2. WS horizontal transport - Case UTR											
		24	1.3.3. WS horizontal transport - Case AGV											
		25	1.3.4. WS horizontal transport - Interaction ST-UTR											
2. Yard Operations	1. WS Stack / Deliver	26	2.1.1. WS stack deliver container - Interaction ASC-ST											
		27	2.1.2. WS stack deliver container - Interaction ASC-AGV											
		28	2.1.3. WS stack deliver empty - Interaction ASC-ST											
		29	2.1.4. WS stack deliver empty - Interaction ASC-AGV											
		30	2.1.5. WS stack deliver twin - Interaction ASC-ST											
		31	2.1.6. WS stack deliver twin - Interaction ASC-AGV											
		32	2.1.7. WS stack deliver reefer - Interaction ASC-ST											

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		33	2.1.8. WS stack deliver reefer – Interaction ASC-AGV	
	2. LS Stack / Deliver	34	2.2.1. LS stack deliver container – Interaction ASC-road truck	
		35	2.2.2. LS stack deliver container – Interaction ASC-UTR	
		36	2.2.3. LS stack deliver container – Interaction ASC-AGV	
		37	2.2.4. LS stack deliver empty - Interaction ASC-road truck	
		38	2.2.5. LS stack deliver empty - Interaction ASC-UTR	
		39	2.2.6. LS stack deliver empty - Interaction ASC-AGV	
		40	2.2.7. LS stack deliver twin - Interaction ASC-road truck	
		41	2.2.8. LS stack deliver twin - Interaction ASC-UTR	
		42	2.2.9. LS stack deliver twin - Interaction ASC-AGV	
		43	2.2.10. LS stack deliver reefer – Interaction ASC-road truck	
		44	2.2.11. LS stack deliver reefer – Interaction ASC-UTR	
		45	2.2.12. LS stack deliver reefer – Interaction ASC-AGV	
	3. Container Move and Safety	46	2.3.1. WS ASC move	
		47	2.3.2. LS ASC move	
		48	2.3.3. Driver safety procedure in transfer zone	
		49	2.3.4. Shuffle moves	
		50	2.3.5. Swap move	
	4. RMG M&R	51	2.4.1. ASC breakdown	
3. Gate Operations	1. Pre-arrival	52	3.1.1. Gate pre-arrival operations	
	2. Entrance / Exit	53	3.2.1. Gate entrance loaded	
		54	3.2.2. Gate entrance empty	
		55	3.2.3. Gate entrance twin	
		56	3.2.4. Gate entrance reefer	
		57	3.2.5. Gate exit loaded	
		58	3.2.6. Gate exit empty	
		59	3.2.7. Gate exit twin	
		60	3.2.8. Gate exit reefer	
		61	3.2.9. Gate entrance exit OOG	
4. Rail Operations	1. Pre-arrival	62	4.1.1. Rail pre-arrival operations	
	2. Load / Discharge at Rail buffer	63	4.2.1. Rail load discharge container - Interaction RTG-UTR	
		64	4.2.2. Rail load discharge container - Interaction RTG-AGV	
		65	4.2.3. Rail load discharge empty – Interaction RTG-UTR	
		66	4.2.4. Rail load discharge empty – Interaction RTG-AGV	
		67	4.2.5. Rail load discharge twin – Interaction RTG-UTR	
		68	4.2.6. Rail load discharge twin – Interaction RTG-AGV	
		69	4.2.7. Rail load discharge reefer – Interaction RTG-UTR	
		70	4.2.8. Rail load discharge reefer – Interaction RTG-AGV	

		71	4.2.9. Rail load discharge OOG	
	3. Horizontal Transport (Y <-> R)	72	4.3.1. LS horizontal transport loaded to rail - Case UTR	
		73	4.3.2. LS horizontal transport loaded to rail - Case AGV	
		74	4.3.3. LS horizontal transport empty to rail - Case UTR	
		75	4.3.4. LS horizontal transport empty to rail - Case AGV	
		76	4.3.5. LS horizontal transport twin to rail – Case UTR	
		77	4.3.6. LS horizontal transport twin to rail – Case AGV	
		78	4.3.7. LS horizontal transport reefer to rail - Case UTR	
		79	4.3.8. LS horizontal transport reefer to rail - Case AGV	
		80	4.3.9. LS horizontal transport cassette to rail - Case UTR	
		81	4.3.10. LS horizontal transport cassette to rail - Case AGV	
		82	4.3.11. LS horizontal transport loaded from rail - Case UTR	
		83	4.3.12. LS horizontal transport loaded from rail - Case AGV	
		84	4.3.13. LS horizontal transport empty from rail - Case UTR	
		85	4.3.14. LS horizontal transport empty from rail - Case AGV	
		86	4.3.15. LS horizontal transport twin from rail - Case UTR	
		87	4.3.16. LS horizontal transport twin from rail - Case AGV	
		88	4.3.17. LS horizontal transport reefer from rail - Case UTR	
		89	4.3.18. LS horizontal transport reefer from rail - Case AGV	
		90	4.3.19. LS horizontal transport cassette from rail - Case UTR	
		91	4.3.20. LS horizontal transport cassette from rail - Case AGV	
		92	4.3.21. LS horizontal transport OOG	
5. Other	1. Check and Inspection	93	5.1.1. Seal check	
		94	5.1.2. Genset number check	
		95	5.1.3. Damage inspection	
		96	5.1.4. Empty inspection	
		97	5.1.5. Reefer inspection	
	2. Reefer	98	5.2.1. Reefer pre-tripping	
		99	5.2.2. Electrical connection of reefers	
		100	5.2.3. Pick-up/drop reefer in reefer stacking area	
	3. Hazardous	101	5.3.1. Hazardous in/out handling	
	4. OOG	102	5.4.1. Pick-up/drop OOG in stack	
	5. M&R	103	5.5.1. Maintenance procedures for each type of equipment	
		104	5.5.2. Stack maintenance	

10.4. ANNEX 4: Photos Case Study

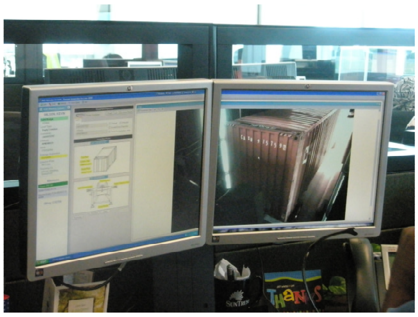
This annex includes photos taken in the Virginia terminal which are relevant for the issues treated in the case study.

Sequence of discharging a container in one of the QC's transfer zone

QC. Transfer lanes below the QC. Container being loaded to the ship by the spreader

Trucks at the LS RMG transfer points. Truck delivery while driver waits in booth

Trucks entering the terminal through lanes. Trucks passing through the out-gate portals



Manual seal check in contrast with OCR damage inspection performed remotely

View of the RMG stack from the QC with the WS transfer zones in first instance. ST's used for waterside handling parked during non operation period

10.5. ANNEX 5: Process Model Survey

This annex includes the survey to the several participants for the process model evaluation

Survey for Process Model Evaluation

Innovation and Design – Automation
APM Terminals The Hague

October 2008

This survey has been developed for evaluating the usability of the model proposed for describing operation processes in a container terminal.

To answer the questions in this survey, respondents may have read the material provided consisting in a process example including maps and description of the significant aspects. In addition, the process maps notation and list of acronyms are included for reference during the examination of the process.

1. Background questions

1.1. What is your experience in the sector?

1.2. What is your department?

1.3. What is your job function?

2. Template document related questions

2.1. Is the process positioning clear in the terminal operations?

2.2. Is the process hierarchy clear for the different processes / sub-processes?

2.3. Does the template document provide all required information?

3. Process map related questions

3.1. Does the process map depict in a comprehensive way the sequence of actions?

3.2. Is it easy to understand the actors and their tasks?

3.3. Is the level of detail of the process maps adequate?

4. Process description related questions

4.1. Does the process description help to understand the process?

4.2. Is the written description of the process necessary to understand the process?

5. General questions

5.1. Do you think this basic model (a process map complemented with a written description) is sufficient for a clear understanding of the operation?

5.2. Are the different interactions between human and systems clearly illustrated?

5.3. Is there any important point missing when studying the process in the way presented?

5.4. What can make the process clearer in your opinion?

5.5. Is there any application you oversee for these process models?

6. Suggestions

6.1. Is there any other interesting feedback or something you would like to highlight?