GREEN EFFORTS

Green and Effective Operations at Terminals and in Ports

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[Container Terminal Processes]

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Container Terminal Processes

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2	Updated version	19/09	
3	Updated version	28/02	

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
FL	Forklift
OOG	Out-of-gauge cargo
PM	Prime Mover
PTKL	Port and Terminal Knowledge Landscape
QC	Quay Crane
RMG	Rail-Mounted Gantry Crane
RTG	Rubber-Tired Gantry Crane
TEU	Twenty-Equivalent Unit
VC	Van Carrier

Executive summary

A transparent picture of processes provides a common basis to foster discussions with the industry, administrations, policy makers and the public, most of them not being familiar with the processes on a container terminal.

With regard to the main aim of the project "reduction and optimisation of energy consumption and carbon footprint" deliverable D 3.2 provides content to the overall picture to be shown within the "Port and Terminal Knowledge Landscape (PTKL)" (see D 3.1 "Project Topology, Methodology and Tools" chapter 3.2.1). It aims to map relevant container terminal processes following the methodology provided in D.3.1. The mapped processes are suitable to base management of operations, modelling and simulation on and to contribute to the aims of the PTKL.

Even if container terminal processes are rather uniform all over the world, terminals are individually depending on layout, equipment and hinterland connections. Therefore a generic reference terminal is designed to allow for application of various solutions to reduce energy consumption and carbon footprint for comparison of results.

Additional contribution to the PTKL will be provided e.g. within the further deliverables in WP 3 aiming at mapping relevant RoRo (D 3.3) and inland terminal (D 3.4) processes and defining respective reference terminals.

1 Introduction

The main objective of work package 3 is to identify relevant terminal domains and processes by developing a terminal process map with regard to reduction and optimisation of energy consumption and carbon footprint applicable to container, RoRo and inland waterway terminals.

To achieve desired results a wide scope of scientific disciplines and practitioners must contribute, only a few being familiar with terminal processes. Therefore a "Port and Terminal Knowledge Landscape (PTKL)" will be generated to provide an unambiguous reference for multi-disciplinary research work and to support exchange of ideas with practitioners.

This Port and Terminal Knowledge Landscape technically in the first step is an industrial process map organized into domains (area of responsibility). Later it will serve to link all relevant information independent of the data types and format to a visualized terminal layout of reference terminals for container, RoRo and Inland Navigation at the same time allowing to identify and explain terminal-port links.

A process map is fundamental for the development and implementation of the simulation tool as defined in WP 5. However, it also serves as a basis for carbon footprint calculation and load shedding.

Business process modelling meanwhile is well established and there are various methodologies, conventions and tools available, however, in the port and terminal industry, the approach is currently no so common and usually not covering energy supply and consumption aspects even if some bigger terminal operation companies do apply process management tools for this purpose.

This deliverable aims to map relevant processes that are suitable to base management of operations, modelling and simulation upon allowing for a wide scope of measurements to reduce energy consumption.

The proposed solution aims at to:

- provide a transparent picture of processes and related organisation(s), responsibilities, equipment, scheduling, resources and other relevant facts
- allow for performance measurement by appropriate key performance indicators that can be added to a terminal's management system
- generate the Consortium-Coordination Platform (CCP) to base investigation, development, applications and training upon and to allow focussed work by maintaining the overall terminal and port coherence
- allow for selection of most appropriate methodologies and tools to implement and manage energy supply and consumption
- elucidate and visualize port and terminal processes to foster discussions with the industry, administrations, policy makers and the public (to support dissemination).

Process mapping is based on the process capturing and management methodology developed within the EU-funded project EFFORTS in the year 2009.

Even if container terminal processes are rather uniform all over the world, terminals are individual depending on layout, equipment and hinterland connections. Therefore a generic reference terminal is designed to allow for application of various solutions to reduce energy consumption and carbon footprint for comparison of results.

The main objective of this deliverable is to provide a common basis for all project partners, especially for the partners who are not familiar with container terminal entities and processes. Therefore, chapter 2 discusses a model of a container terminal based on the methodology developed in D 3.1. Chapter 3 develops data and layout of a generic reference terminal.

2 Model of a Container Terminal

Objective of a container terminal is to handle containers and move them from one means of transport to another means of transport. This could either imply (see Figure 1)

- import (container comes in by vessel and leaves by truck, train or barge)
- export (container comes in by truck, train or barge and leaves by vessel) or
- transhipment (container comes in by vessel and leaves by vessel).

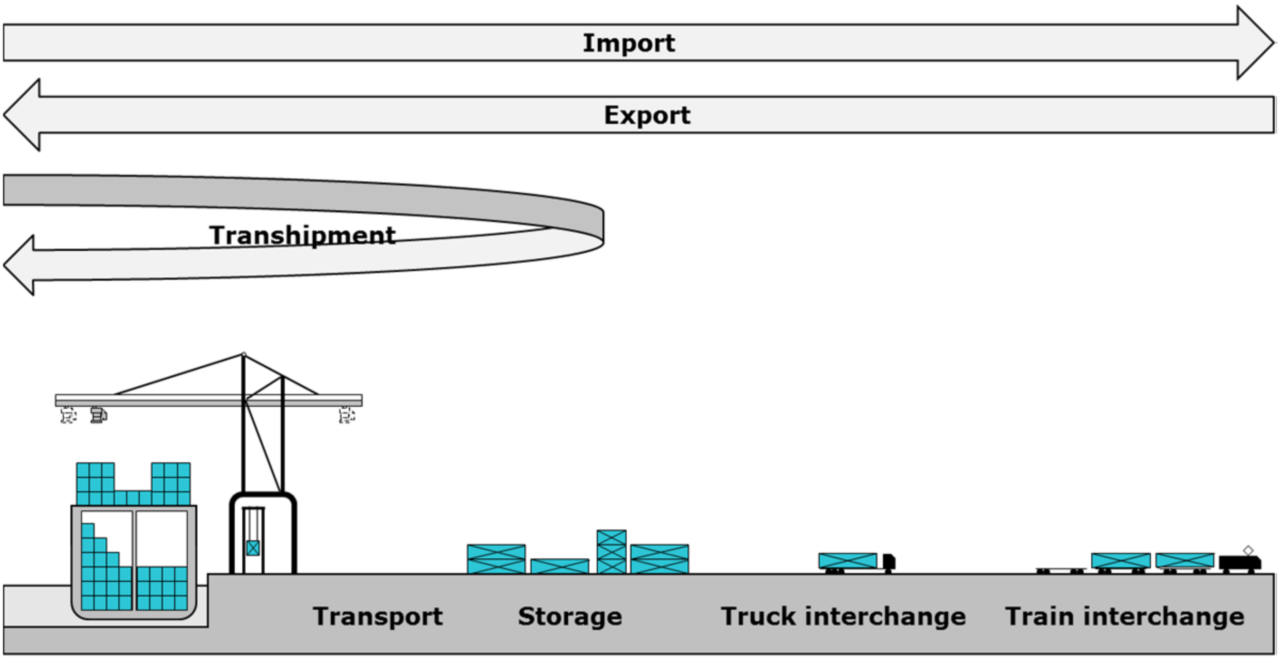

Figure 1: Schematic side view of a container terminal (Adapted from Jahn 2010)

Very roughly, the logistics processes for container handling are as follows:

For import, containers are lifted from the ship and transported to the stacking area. After a certain dwell time, they are removed from the stacking area and lifted on a means for Hinterland transportation. For export and transhipment, the processes are very similar.

Depending on the type of terminal, also other handling operations are possible. For example, if the train interchange is not directly on the container terminal but nearby and separated by a fence (“near-dock terminal” instead of “on-dock terminal”), it is possible that containers are moved from train to truck and vice versa. In the case of “on-dock terminals” this happens on rare occasions.

If two or more container terminals are close-by inter-terminal transfers are possible. This would be the case if a train is loaded with containers for different terminals and if the train is not shunted before entering one of the terminals. Then the train would be unloaded at one terminal and the containers destined for another terminal close-by would be transported e.g. by truck to the other terminal.

2.1 Entities on a Container Terminal

2.1.1 Handling Equipment

Different kinds of equipment are used on container terminals for container handling. Equipment can be used for vertical (hoisting, lowering) and / or horizontal movements. For GREEN EFFORTS, especially measures such as utilisation profile, speed, acceleration and consumption are relevant. This section focuses on describing the handling equipment on container terminals to provide a common basis for all project partners, especially for the partners who are not familiar with container terminal entities and processes.

Equipment is mainly required for the following container handling tasks:

- Lift a container on / off a ship
- Horizontal transport between quay and stacking area
- Stack containers in the stacking area
- Horizontal transport between stacking area and gate
- Lift a container on / off a truck / train

The process descriptions in section 2.2 indicate where the equipment is usually used.

The following equipment list is not exhaustive. However, it provides a basis for future discussions on container terminal equipment. For every type of equipment, its use is explained as well as advantages and disadvantages.

2.1.1.1 Quay Cranes

Quay cranes (QC), or ship-to-shore cranes, are installed on the quay in order to load and discharge containers on respectively from a vessel. There are three common sizes for QC:

- Panamax QC: can serve a vessel up to 13 containers wide that can pass the Panama Canal
- Post Panamax QC: can serve a vessel up to 18 containers wide, being too wide to pass the Panama Canal
- Super-Post Panamax QC: can serve a vessel up to 22 and more containers wide.

Apart from different sizes, QCs have different kind of spreaders: standard spreaders are twin-spreaders that can carry either one 40’ or two 20’ containers at the same time. Some QCs are equipped with tandem- or triple-spreaders that can carry two respectively three 40’-containers in parallel at the same time.

2.1.1.2 Van Carrier

Van Carrier (VC) are also called Straddle Carrier. VC can lift containers and transport them horizontally. They can stack containers up to 4 high. Therefore, a container terminal can be operated by only using VC. VC can be equipped with twin-spreaders; this option is only used when carrying empty containers.

2.1.1.3 Prime Mover / Chassis system / AGV

Prime movers (PM) are intended for horizontal transport on a container terminal. Therefore, another kind of equipment is needed for lifting containers on and off a PM.

2.1.1.4 Rubber-Tired Gantry Crane

Rubber-Tired Gantry Cranes (RTG) are used for stacking operations, thus vertical transport, on a container terminal. They can straddle several rows of containers and can change blocks in which they operate. RTGs always operate in combination either with a type of prime mover or with van carriers for horizontal transport.

2.1.1.5 Rail-Mounted Gantry Crane

Rail-Mounted Gantry Cranes (RMGs) are used for stacking operations as well. They are very similar to RTGs except that they have steel-wheels and are mounted to rail tracks. Therefore, RMGs cannot change blocks easily. RMGs are often used for train operations.

2.1.1.6 Reach Stacker

Reach Stackers (RS) are designed to stack and restack containers in the stacking area as well as to load and discharge trucks and trains. RS are vehicles with a spreader at the front. They are usually used in small and medium terminals and for stacking empty containers.

2.1.1.7 Forklift

Forklifts (FL) are designed to stack and restack especially empty containers. They can be used in a similar way like RS. There are also smaller FLs in use e.g. in the marshalling area to move twist locks boxes and lashing equipment.

2.1.1.8 Bus / Cars

Buses and cars on a terminal are used as shuttle for employees to change places (e.g. from the buildings to the quay side and back at the beginning and end of shifts) more quickly and safely. These vehicles are also useful for visitors, ship crews, agents, maintenance crews.

2.1.2 Containers

Containers are categorised by type and attributes.

There are different types of containers. Depending on the type, certain additional processes are necessary (e.g. cooling down temperature-controlled containers). Most relevant are:

- Standard (20’, 40’, 45’), of a height of 8’ up to 9’6” (high cube)
- Temperature-controlled, also called reefer
- Tank
- Flat rack
- Open top

To save yard space empty containers (“empties”) are stowed in a dedicated area, sometimes remote from the main terminal area.

Containers containing hazardous cargo (ref. to "International Maritime Dangerous Goods Code") need special treatment and stowage following IMDG and local laws of security and operation.

"Out of gauge cargo" (OOG) refers to cargo not matching a container slot ("high and heavy") like e.g. machinery, project cargo and pleasure craft. OOG is usually transported on flats racks or open tops. Terminals often do seaworthy packing and lashing on a flat in a dedicated area.

2.1.3 External Vehicles and Modes of Transport

External vehicles are all vehicles that do not belong to the terminal, but that interact with the terminal by delivering or picking up containers. External vehicles are usually vessels, trucks and trains. Vessels can be large deep sea vessels, feeder vessels or barges for inland waterway transportation. Other external vehicles on the terminal are possibly employees' cars, cars of external service providers (e. g. snow removing vehicles), customers, or customs.

2.1.4 Terminal Area

The terminal area comprises a quay, streets, a storage yard for the different types of containers, a rail area including tracks, a truck area including truck transfer area, a gate area, parking space to cars and equipment, a rain water sewage system, an area for maintenance, a transformer station, space for utility vehicles and leaking / smelling / smoking containers, lighting and buildings. Depending on the general layout, different requirements exist due to different sizes and strains on the ground.

2.1.5 Building

Terminal buildings are e.g. for administration, staff services (canteen, showers, changing rooms, break rooms), client offices, and maintenance and repair. If a container terminal is part of a larger corporation, the head quarter as central function might be located somewhere else. This would affect e.g. the number of employees on the terminal and the size of office buildings.

2.1.6 Employees

Employees play a very important role on a terminal. Although some terminals increase the degree of automation by implementing respective equipment such as AGVs, most terminal operations rely on manpower. As important part within the system the skills and behaviour of employees while performing processes and using equipment affects the terminal operations and therefore have an impact on the overall efficiency and performance of the terminal. In WP 11 "Qualification and Incentives" solutions will be developed to reduce the contributions to the energy consumption of the terminal due to the employees´ skills and behaviour.

2.1.7 Stakeholder

Different stakeholders are involved in a container terminal. These include the respective port authority, shipping & trucking companies, customs, energy supplier, residents, equipment manufacturers etc.

2.2 Processes on a Container Terminal

As mentioned in D 3.1, a process is understood as a workflow with specified begin and termination covering a phase of a production. Thereby, production can also imply providing a service.

The processes to import, export or tranship containers are discussed in this deliverable to provide a basis for further research in GREEN EFFORTS. As described in D 3.1, a process map will be developed, explaining

- Process objective(s)
- Main operations and its sequence
- Operational site(s)
- Time-dependency
- Resources
- Responsible parties.

The processes are structured according to domains which represent physical areas on the terminal. The container terminal domains are introduced in D 3.1 and displayed in Figure 2. The following subsections discuss the details of the container terminal processes for each domain based on the process mapping approach developed in D 3.1. Each table represents one process within a certain domain. The processes are described as generic as possible to ensure comparability. If necessary, they will be described more detailed within the course of the project.

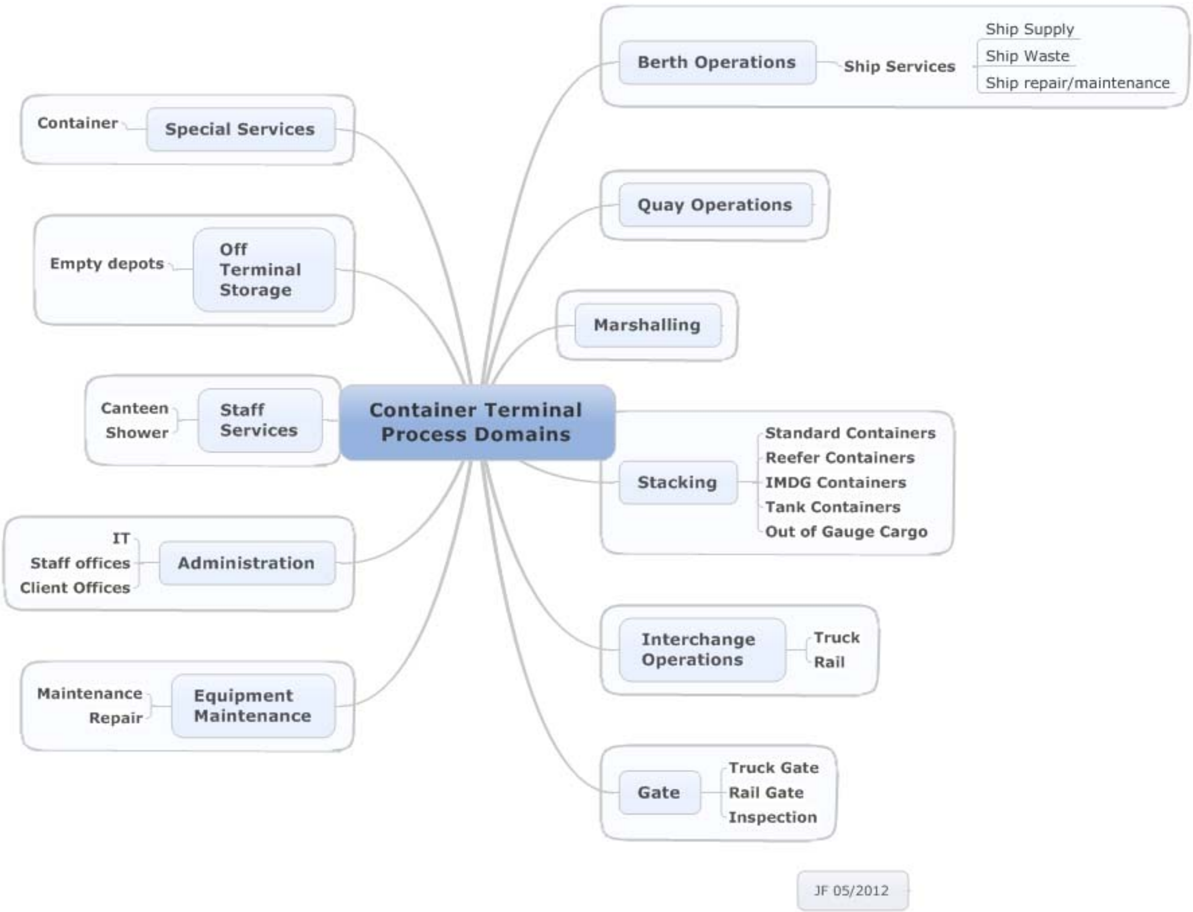

Figure 2: GREEN EFFORTS Container Terminal Process Domains and Meta-processes (Cf. GREEN EFFORTS D 3.1 / Froese 2012)

2.2.1 Berth Operations

As described in D 3.1, the berth domain associates to processes related to ships while they are berthed (water side). This includes ship services as e.g. administrative services, ship supply (water, food, fuel...), ship waste, ship repair/maintenance.

Process name	**Administrative services**
Process number	1.1
Process objective(s)	Conduct necessary administrative processes related to the ship
Main operations and its sequence	• Obtaining port clearance • Arrival briefing on operations • Government controls • …
Operational site(s)	Berth
Time dependency	While ship is approaching resp. berthed, before unloading starts
Resources	(Car)
Responsible parties	

Process name	**Ship supply**
Process number	1.2
Process objective(s)	Deliver units of supply (fresh water, food, fuel…) to the ship
Main operations and its sequence	• Depends on type of supply
Operational site(s)	Berth
Time dependency	While ship is berthed
Resources	Truck, bunkering barge
Responsible parties	Supply contractor

Process name	**Ship waste**
Process number	1.3
Process objective(s)	Collect units of waste from the ship
Main operations and its sequence	• Depends on type of waste
Operational site(s)	Berth
Time dependency	While ship is berthed
Resources	Truck, barge
Responsible parties	Waste disposal contractor

Process name	**Ship repair / maintenance**
Process number	1.4
Process objective(s)	Conduct ship maintenance, repair broken parts
Main operations and its sequence	• Depends on type of ship, maintenance plan and defects
Operational site(s)	Berth
Time dependency	While ship is berthed
Resources	Truck, barge
Responsible parties	Repair & maintenance contractor

2.2.2 Quay Operations

The quay domain comprises processes also involving the ships but related to the land side. This implies mainly loading and discharging containers, but also moving hatch covers and shuffling on board a ship.

Handling Out-of-gauge-(OOG)-cargo requires a few additional operations that have to be done before or after moving the container. These additional operations take place when (un)loading a container off/on a ship, truck, train or barge, and also when the OOG-container is moved within the terminal area for any reason. In order to avoid unnecessary complexity, the additional operations are described in this domain but belong to all domains referring to moving containers.

In the case of OOG-cargo, handling depends on the dimensions of the cargo. First, if the cargo is longer than a standard 40'-container it is stored in a special designated area, but normal handling equipment can usually be used. Second, if the cargo is higher than a standard container a special frame is required to make sure that the spreader of a VC or QC can pick the cargo. To bring the frame to the cargo and take it back, additional moves are necessary. Third, if the cargo is wider than a standard container, certain equipment as e.g. a VC cannot be used for handling. These additional operations have to be considered when calculating energy consumption.

Process name	**Lashing**
Process number	2.1
Process objective(s)	Lash and unlash containers on the ship
Main operations and its sequence	• Move lashing crew to containers to be (un)lashed, if necessary by lashing cage • (Un)Lash containers • Move lashing equipment • Move lashing crew back to quay side respectively to other containers on the ship to be (un)lashed
Operational site(s)	Quay
Time dependency	While ship is berthed, before discharging containers and after loading containers
Resources	Quay crane, lashing cage
Responsible parties	Quay crane operator, lashing crew

Process name	**Move Twist Lock Boxes**
Process number	2.2
Process objective(s)	Move boxes containing twist locks on/from/within the ship and on the quay side
Main operations and its sequence	• Discharge container with twist lock boxes (QC) • Move container to a specified position (VC) • Move twist lock box out of container to specified position (FL)
Operational site(s)	Quay
Time dependency	While ship is berthed
Resources	Quay crane, van carrier, forklift, twist lock box
Responsible parties	Equipment operators

Process name	**Discharge a container**
Process number	2.3

Process objective(s)	Move container from ship to quay side
Main operations and its sequence	• Lower down and position spreader • Hoist container • Move container to the quay side • Lower down container • Position container on PM / put container on the quay side • Hoist spreader
Operational site(s)	Quay
Time dependency	While ship is berthed, usually before loading containers
Resources	Quay crane
Responsible parties	Quay crane operator

Process name	**Load a container**
Process number	2.4
Process objective(s)	Move container from quay side to ship
Main operations and its sequence	• Lower down and position spreader • Hoist container • Move container to the ship • Lower down container • Position container in bay • Hoist spreader
Operational site(s)	Quay
Time dependency	While ship is berthed, usually after discharging containers
Resources	Quay crane
Responsible parties	Quay crane operator

Process name	**Move hatch cover**
Process number	2.5
Process objective(s)	Move hatch cover from ship to quay side (and back to ship)
Main operations and its sequence	• Lower down and position spreader • Hoist hatch cover • Move hatch cover to the quay side / ship • Lower down hatch cover • Position hatch cover on quay side / ship • Hoist spreader
Operational site(s)	Quay
Time dependency	While ship is berthed, while discharging and loading containers
Resources	Quay crane
Responsible parties	Quay crane operator

Process name	**Housekeeping on the ship**
Process number	2.6
Process objective(s)	Move container within to ship
Main operations and its sequence	• Lower down and position spreader • Hoist container • Move container to another position on the ship • Lower down container • Position container in bay • Hoist spreader
Operational site(s)	Quay
Time dependency	While ship is berthed and if reasonable
Resources	Quay crane
Responsible parties	Quay crane operator

2.2.3 Marshalling

The marshalling domain comprises processes linked to work and circulation areas (occasionally called “apron area”). This area does not necessarily exist on every terminal depending on the space available.

Process name	**Horizontal transport**
Process number	3.1
Process objective(s)	Move container from quay side to stacking area or from stacking area to quay side
Main operations and its sequence	• Lift container (in case of VC or Lift-AGV) • Drive to stacking area respectively to quay side
Operational site(s)	Marshalling
Time dependency	While unloading resp. discharging a ship
Resources	Equipment (VC, PM, AGV…)
Responsible parties	Equipment operator

2.2.4 Stacking

Container stacking encompasses processes occurring during stacking of containers (e.g. including pre-stowing and shuffling of containers and any processes required by different types of containers).

Process name	**Stack**
Process number	4.1
Process objective(s)	Place container into stacking area
Main operations and its sequence	• Lower down and position spreader • Hoist container • Move container to the stacking position • Lower down container • Hoist spreader
Operational site(s)	Stacking area
Time dependency	After horizontal transport or truck/train discharging
Resources	Equipment (VC, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Process name	**Remove from stack**
Process number	4.2
Process objective(s)	Remove container from stacking area
Main operations and its sequence	• Lower down and position spreader • Hoist container (end of process in case of VC) • Move container to a PM • Lower down container • Hoist spreader
Operational site(s)	Stacking area
Time dependency	Before horizontal transport to ship or loading truck/train
Resources	Equipment (VC, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Process name	**Shuffling**
Process number	4.3
Process objective(s)	Change a container's position to provide access to another container which is located below the first container
Main operations and its sequence	• Lower down and position spreader • Hoist container • Move container to another stacking position • Lower down container • Hoist spreader
Operational site(s)	Stacking area
Time dependency	At least before loading the second container, but possibly earlier
Resources	Equipment (VC, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Process name	**Temperature-controlled storage**
Process number	4.4
Process objective(s)	Keep the temperature of a temperature-controlled container at the temperature specified by the customer
Main operations and its sequence	• Check temperature of temperature-controlled container (either manually or automatically) • Adjust to specified temperature • Temperature-controlled shuffling (see process number 4.3) additionally needs a person to (un)plug the power supply
Operational site(s)	Stacking area
Time dependency	Temperature has to checked in certain intervals, temperature has to be adjusted if the upper temperature limit is reached
Resources	None
Responsible parties	Container owner, operator

Process name	**Pre-stowing**
Process number	4.5
Process objective(s)	Optimise area where containers to be loaded are stacked
Main operations and its sequence	• Identify containers for the process • Remove from stacking area (see process number 4.2) • Horizontal transport to quay side (see process number 3.1) • Place in specified area for pre-stowing
Operational site(s)	Stacking area, marshalling, quay
Time dependency	Before loading, can be omitted
Resources	Equipment (VC, PM, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Pre-stowing (process number 4.5) has certain limits such as time, feasibility and resources available. Temperature-controlled and OOG containers are not pre-stowed.

2.2.5 Interchange Operations

The interchange domain links to processes in relation to handling of containers for hinterland transport modes.

Process name	**Truck loading**
Process number	5.1
Process objective(s)	Move container from stacking area to truck
Main operations and its sequence	• Remove from stacking area (see process number 4.2) • (Horizontal transport to truck interchange) • Place on truck
Operational site(s)	Stacking area, interchange
Time dependency	After truck arrival
Resources	Equipment (VC, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Import containers of some major customers can be stacked in a lot. If these customers agree to get any container of this lot and not a special container as the containers have the same content, the containers on top of the stack can be loaded and reshuffling moves can be avoided.

Process name	**Truck discharging**
Process number	**5.2**
Process objective(s)	Move container from truck to stacking area
Main operations and its sequence	• Remove container from truck • (Horizontal transport to stacking area) • Place into stacking area (see process number 4.1)
Operational site(s)	Stacking area, interchange
Time dependency	After truck arrival
Resources	Equipment (VC, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Process name	**Train loading**
Process number	**5.3**
Process objective(s)	Move container from stacking area to train
Main operations and its sequence	• Remove from stacking area (see process number 4.2) • (Horizontal transport to train interchange) • (Pre-stowing train area) • Place on train
Operational site(s)	Stacking area, interchange
Time dependency	After train arrival
Resources	Equipment (VC, PM, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Usually, a list of containers to be loaded is pre-announced in advance. This offers the possibility to pre-stow containers in the train area.

Process name	**Train discharging**
Process number	**5.4**
Process objective(s)	Move container from train to stacking area
Main operations and its sequence	• Remove container from train • (Horizontal transport to stacking area) • Place into stacking area (see process number 4.1)
Operational site(s)	Stacking area, interchange
Time dependency	After train arrival
Resources	Equipment (VC, PM, RTG, RMG, RS, FL)
Responsible parties	Equipment operator

Before a train is discharged a pre-check takes place whether the containers are delivered as announced beforehand and seal-numbers are checked.

2.2.6 Gate

The gate domain includes processes to dispatch containers from/to the hinterland (interface between container terminal and hinterland). The gate domain therefore comprises e.g. check-in and check-out processes, trucks waiting for loading/discharging, security and entrance checks.

Process name	**Check in**
Process number	**6.1**
Process objective(s)	Check driver (trucker card), truck, chassis number and container number against (pre-announced) data in the system
Main operations and its sequence	• Pre-gate operation: identity check driver (either by trucker card or personally in an office); check truck and container (licence plate, chassis number, damages to the container) • take picture of truck, driver, container (may include OCR-Systems) • Gate operation: check if seal, truck, container fits together
Operational site(s)	(Pre-)Gate
Time dependency	Before loaded truck enters terminal
Resources	None
Responsible parties	Gate operator

Process name	**Check out**
Process number	**6.2**
Process objective(s)	Register and check container collected by truck
Main operations and its sequence	• Checking container number • Remove container from the system • Security check
Operational site(s)	Gate
Time dependency	Before loaded truck leaves terminal
Resources	None
Responsible parties	Gate operator

2.2.7 Equipment Maintenance

The equipment maintenance domain includes processes related to support handling equipment functionality and availability. This refers to regular maintenance processes and equipment repair.

Process name	**Maintenance**
Process number	**7.1**
Process objective(s)	Keep equipment in good working condition
Main operations and its sequence	• Maintaining equipment • Cleaning
Operational site(s)	Workshop
Time dependency	In regular intervals
Resources	Spare parts
Responsible parties	Equipment manager

Process name	**Fuelling**
Process number	**7.2**
Process objective(s)	Refuel container handling equipment
Main operations and its sequence	• Refuel at the fuel station • Refuel at the VC parking area using a fuel truck
Operational site(s)	Workshop
Time dependency	During operation if necessary, otherwise after shift end
Resources	Fuel truck, fuel station
Responsible parties	Equipment manager

Process name	**Repair**
Process number	**7.3**
Process objective(s)	Bring equipment in good working condition
Main operations and its sequence	• Fix broken equipment (flat tire, motor break down, spreader problem...)
Operational site(s)	Workshop, terminal area
Time dependency	As soon as necessary
Resources	Spare parts, bus (for emergency maintenance crew)
Responsible parties	Equipment manager, emergency maintenance crew (mechanics, electronics)

2.2.8 Administration

The administration domain includes processes to manage the whole terminal and all client processes. This refers e.g. to IT or staff offices (e.g. planning department, financial department).

Process name	**Administration**
Process number	**8.1**
Process objective(s)	Organise container handling
Main operations and its sequence	• Operations planning • Finance • IT • Security • Personnel • Utility (cleaning etc.) • ...
Operational site(s)	Terminal area, mostly buildings
Time dependency	Depending on the process step
Resources	Computers, car(s), utility equipment (e.g. snow removal trucks)
Responsible parties	Respective department

2.2.9 Staff Services

The service domain associates to all processes for staff. These include e.g. a canteen, showers, changing rooms and break rooms.

Process name	**Staff services**
Process number	**9.1**
Process objective(s)	Support staff
Main operations and its sequence	• Provide food in a canteen • Provide shower, change and locker facilities • Provide break rooms for rest
Operational site(s)	Buildings
Time dependency	Depending on shifts
Resources	Kitchen, sanitary facilities
Responsible parties	Respective department

2.2.10 Off-Terminal Storage

The off-terminal storage domain includes processes to move and store containers outside the terminal operation area (e.g. empties, to-be-repaired containers).

Process name	**Off-Terminal Storage**
Process number	**10.1**
Process objective(s)	Store containers on a site outside the terminal area
Main operations and its sequence	• Load container on truck or train (see processes number 5.1 and 5.3) • Check container at gate to be transported to off-terminal site • Transport container • Check container as arrived at off-terminal site • Place container on position • Retrieve the container • Option: container repair
Operational site(s)	Off-Terminal site
Time dependency	Depending on truck/train arrival
Resources	Equipment, external vehicles
Responsible parties	Equipment operator, transport contractor

2.2.11 Special Services

The special services domain includes all service processes which are not part of the terminal operation, however can be offered by terminals as additional value-added services to their client.

Process name	**Special services**
Process number	**11.1**
Process objective(s)	Providing value-added services
Main operations and its sequence	• Container repair • Labelling • Stuffing • Stripping • Client / customs check
Operational site(s)	Respective buildings
Time dependency	Depending on customer requests
Resources	Equipment
Responsible parties	Equipment operator

2.3 Overview container handling processes

The following figure shows the interdependencies between the main handling processes during container import. For container export, the processes take place the reversely.

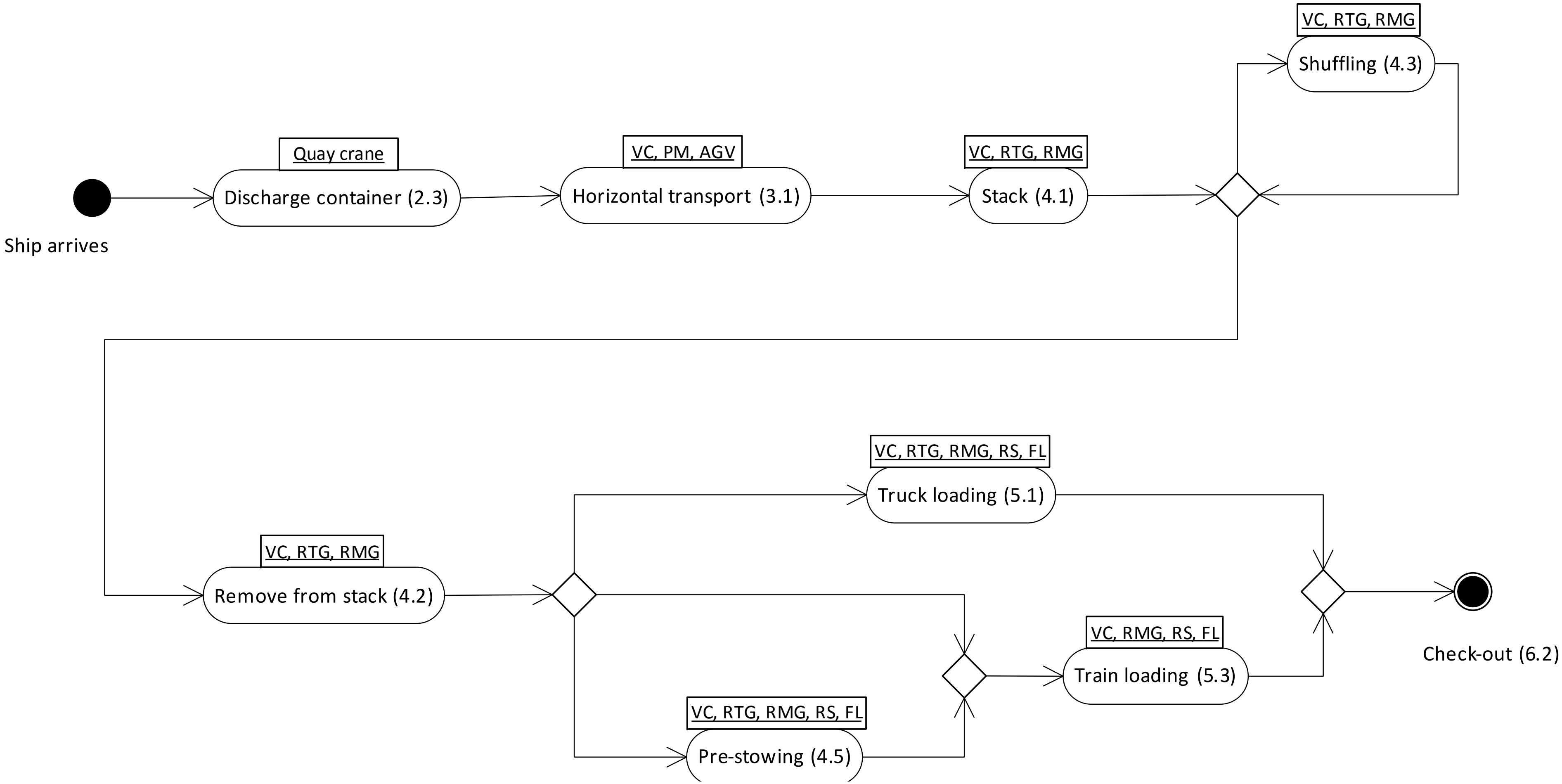

Figure 3: Main container handling processes during import

3 Reference Terminal

The reference terminals serve as exemplary cases for all carbon footprint calculations and simulations which will be conducted within GREEN EFFORTS. Figure 4 shows a generic view of a container terminal and the main logistics processes. The capacities and dimensions of the particular areas are specified in the following.

For the container terminal, three different variations will be considered during the course of the project: first, a pure van-carrier terminal, second, a tractor-terminal which uses tractor/chassis-systems for horizontal transportation and RTGs for stacking operations, third, an AGV-terminal which uses AGVs for horizontal transportation and RMGs for stacking operations.

This deliverable focuses on the first variation, the pure van-carrier terminal.

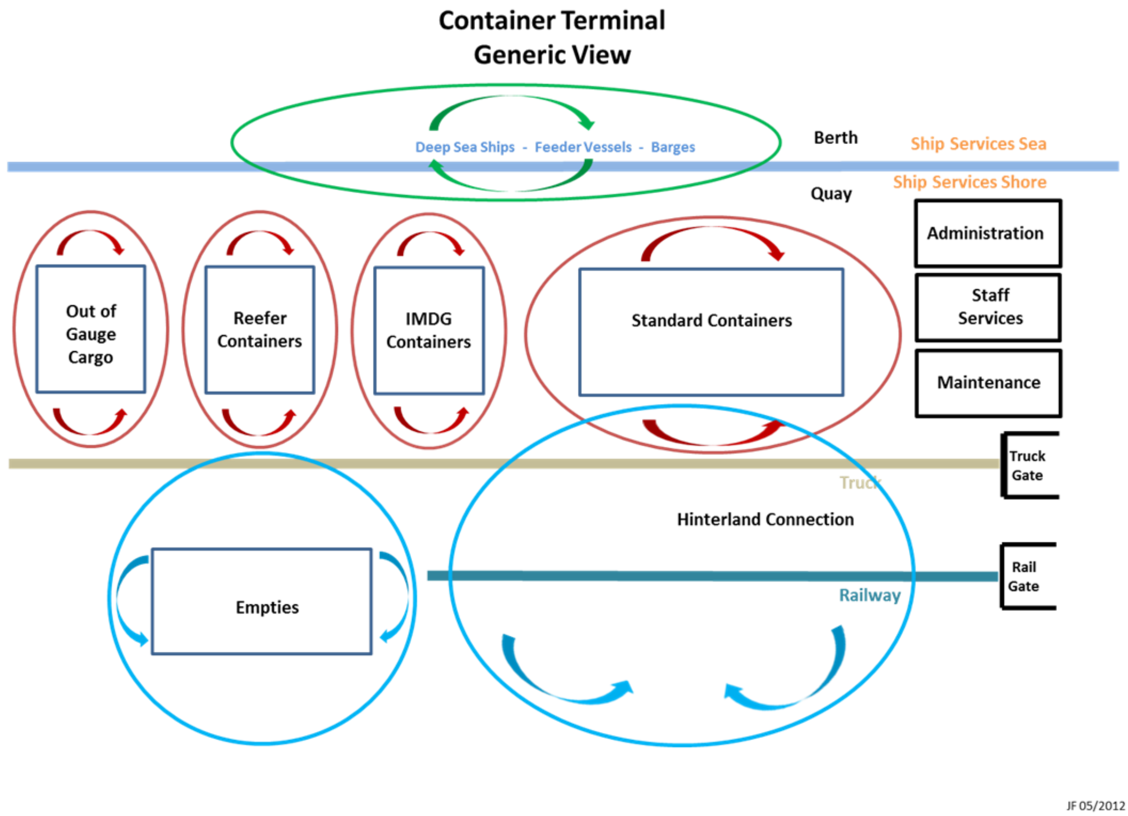

Figure 4: Generic View of a Container Terminal – Main Logistics Processes (Cf. GREEN EFFORTS D 3.1/Froese 2012)

3.1 Assumptions

The reference terminal is a stand-alone, common user terminal. It is designed as a van carrier terminal. Only for container handling in the train area RMGs are used. The quay length is 1310m which is sufficient for 3 deep sea vessels (14,000 TEU, length 370m). There is no dedicated barge area, barges are served by normal quay cranes.

Operation hours of the terminals are 360 days per year, 24 hours per day and therefore 8640 hours per year if nothing else is mentioned in the following sections regarding certain areas.

Data for the reference terminal calculations and the calculations were verified by several experts in the field of terminal operations. The calculations in this section refer amongst others to (Böse 2011) and (Brinkmann 2005).

Geographical position of the reference terminal is defined to be within the Hamburg-Antwerp-Range which implies certain climatic conditions.

3.1.1 Modal Split

Regarding modal split, 75% domestic containers are assumed of which 65% are transported by trucks, 30% by train and 5% by inland waterway barges. The remaining 25% containers are transhipped either by feeder or deep sea vessel (see Figure 5). Furthermore, 0.5% containers are assumed to be transhipped between feeder and hinterland transportation. These numbers are an average of the ports within the Hamburg-Antwerp-Range.

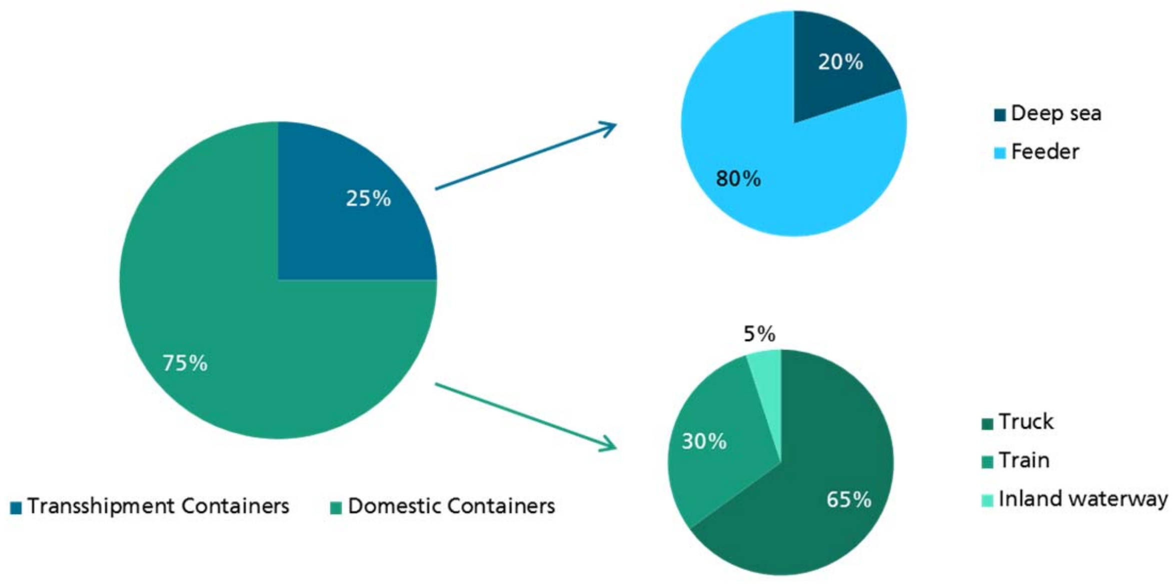

Figure 5: Modal split of the reference terminal

3.1.2 Container Type Mix

Regarding the mix of containers (see Figure 6), it is assumed that 80% of all containers are full standard containers, 15% are empty and 4% temperature-controlled containers. In 1% of the containers are dangerous goods. The TEU factor is 1.6, indicating that 60% of all containers are 40ft-containers.

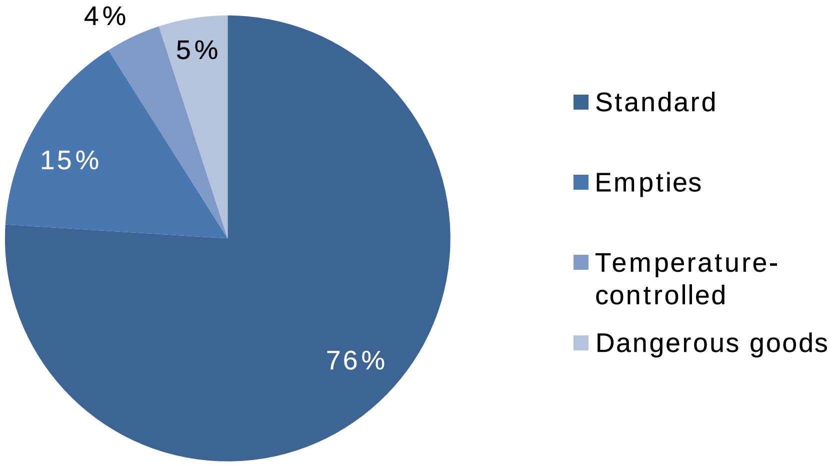

Figure 6: Container type mix

The dwell time has a direct impact on the required storage space. For the reference terminal, 4 days dwell time is assumed for all container types except for empty containers, where 11 days are assumed.

3.1.3 Equipment Productivity VC Terminal

The equipment productivity refers to the number of containers handled by one unit of equipment within one hour. The quay cranes are all Super-Post Panamax, 22 rows outreach, one trolley, and equipped with twin-lift spreaders. It is assumed that 22% of all QC container moves are in twin-lift operation. Quay cranes are presumed to perform 24 moves / hour on a deep sea vessel, 20 moves / hour on a feeder vessel and 16 moves / hour on a barge. Applying the assumption of 22% twin-lift operation, productivity is 29.3 boxes / hour on a deep sea vessel, 24.4 boxes / hour on a feeder vessel and 19.5 boxes / hour on a barge.

A van carrier is presumed to operate 6.5 moves / hour and a RMG in the train area to operate 20 moves / hour.

Table 1 below summarises developed assumptions in a table form to provide better overview on the reference terminal data.

3.1.4 Throughput per ship

Two types of deep sea ships are assumed with a throughput of 1000 respectively 2000 moves per arrival. For feeder ships a throughput of 125 moves and for barges 50 moves are assumed.

Table 1: Summary of Reference Terminal Assumptions

Quay length	1,310 m
Nr. berth	3 (max vessel length: 370 m each)
Operating hours/year	8640 hours (360 days X 24 hours)
Container Destination	75% Domestic (Hinterland) 25% Transhipment
Modal Split for Domestic/Hinterland Transport	65% Truck 30% Train 5% Barge
Type of container	76% Standard 15% Empty 4% Temperature-controlled 5% Dangerous Goods
Container size	60% 40ft container
TEU Factor	1.6
Dwell time	4 days for all types of containers 11 days for empty containers
Equipment productivity	
Quay crane	24 moves/hour resp. 29.3 boxes/hour (deep sea vessel) 20 moves/hour resp. 24.4 boxes/hour (feeder vessel) 16 moves/hour resp. 189.5 boxes/hour (barge)
Van Carrier	6.5 moves/hour
RMG	20 moves/hour

Throughput per ship	
Deep sea	1000 resp. 2000 containers
Feeder	125 containers
Barge	50 containers

3.2 Calculations

3.2.1 Volumes

The container terminal has a capacity of 2,000,000 TEU. However, this number is only realistic if no interruptions occur. Therefore, it is assumed, that on average 1,600,000 TEU are handled. Table 2 shows how the volume distributes on the modal split. For example, 200,000 TEU are transhipped from a deep sea vessel on a feeder vessel.

Table 2: Modal split average volumes [TEU]

	Deep sea vessel	**Feeder vessel**	**Truck**	**Train**	**Barge**
Deep sea vessel	800,000	160,000	388,050	179,100	29,850
Feeder vessel	160,000	0	1,950	900	150
Truck	388,050	1,950	0	0	0
Train	179,100	900	0	0	0
Barge	29,850	150	0	0	0

3.2.2 Terminal Capacity

Providing 4 quay cranes per berth, 12 quay cranes are required for the reference terminal. This implies a distance of 109m between quay cranes.

Considering the modal split volumes in Table 2, 877,594 containers are handled by QC on a deep sea vessel, 103,656 containers are handled by QC on a feeder vessel and 18,750 containers are handled by QC on a barge.

Taking the QC productivity (see 3.1.3) into account, one QC operates on average 2933 hours/year which equals a utilization of 34%. Throughput per QC is 83,333 boxes/year, and quay capacity is 1221 TEU/m/year.

3.2.3 Berth Occupancy

Assuming the throughput per vessel as shown in Table 1, 585 deep sea vessels per year arrive at the terminal of which 50% (un)load 1000 containers and 50% (un)load 2000 containers. 829 feeder vessels arrive and 375 barges arrive.

On a deep sea vessel 3 respectively 5 QC operate, 2 on a feeder vessel and 1 on a barge. Including a processing time of 3 hours for deep sea vessels, 2 hours for feeder vessels and 1 hour for barges, the berth occupancy is 4735 hours/year or 55%. Thereby, processing time includes the time when a berth is occupied by a vessel by no (un)loading operations take place (e.g. manoeuvring, administrative services, unlashing and lashing).

3.2.4 Stacking Area Dimensions

The number of required storage positions for each type of container is composed of the average occupancy and a buffer. The average occupancy is based on the container mix, the estimated maximum volumes and the assumed dwell times. The buffer is calculated with a peak factor of 1.2.

This results in the following numbers:

Table 3: Required number of container positions

Container type	Required positions [TEU]	Required positions [Container]
Standard	17,116	10,697
Empty	9,290	5,806
Temperature-controlled	901	563
Dangerous goods	1,126	704
Total	**28,433**	**17,770**

The number of containers per block depends on the type as well. The following dimensions (width x length x stacking height) are assumed:

- Standard and dangerous goods container: 30 TEU x 16 TEU x 2.5 TEU = 1200 TEU per block
- Empty container: 46 TEU x 22 TEU x 5 TEU = 5060 TEU per block
- Temperature-controlled container: 43 Container x 2 Container x 3.5 Container = 301 Container per block

For the case of temperature-controlled containers, the number of containers has to be considered instead of TEU as this equals the number of required plugs.

Considering the number of required positions for the container yard and the number of containers per block, 16 blocks for standard containers are necessary, 2 for empty containers and 2 for temperature-controlled containers.

The blocks' sizes are determined by the size of a TEU and a clearance between containers for stacking and van carrier movements. This results in the following dimension for one block depending on the container type:

- Standard and dangerous goods container: 12,600m²
- Empty container: 16,200m²

- Temperature-controlled container: 4,800m²

Therefore, at least 243,162 m² are required for the stacking area. However, this does not include space for streets between blocks which needs to be added once the positioning of the blocks is decided. As a general rule, 20m width for streets is sufficient.

Following International Maritime Dangerous Goods (IMDG) Code and local laws of security in operation higher area requirements exist for dangerous goods. This can include a special fenced area, camera surveillance, leakage-proof soil, or specific admin warning in the system. Usually, not all DG containers are put in one stack but rows with DG alternate with standard containers as barrier in case of leakage and as the danger of propagation of fire is too high.

3.2.5 Hinterland Capacity

3.2.5.1 Truck Interchange Area and Gate

The truck interchange area is considered to operate 360 days/year and 18 hours/day, therefore 6480 hours/year. Total truck volume is 485,063 containers, thereof 50% import and 50% export. Assuming that 20% of arriving loaded trucks also leave loaded 1213 trucks arrive per day. Figure 7 shows an assumed distribution of trucks arriving at the gate during the day.

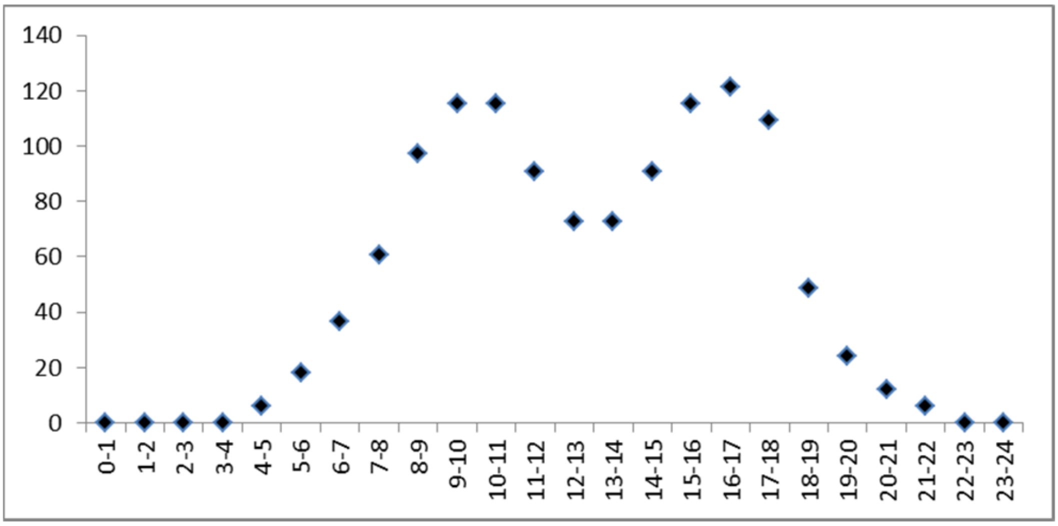

Figure 7: Number of loaded and empty trucks arriving at the gate hourly

Check-in time and check-out time for loaded trucks at the gate is assumed to be 3 minutes and 1 minute for empty trucks. Time for interchange operations is assumed to be 15 minutes and a maximum of one hour waiting time is considered acceptable.

Based on these assumptions, 4 gates each for check-in and check-out are required of which 1 is reserved for empty trucks. 25 interchange bays are necessary.

3.2.5.2 Train Interchange Area

The train interchange area is considered to operate 360 days/year and 24 hours/day, thus 8640 hours/year. Total train volume is 358,200 TEU. Presuming a maximum number of 90 TEU/train, an average service time of 4 hours and an average train utilisation of 65%, a minimum of 2 tracks is required. Depending on the train schedules, it could be reasonable to build more tracks to increase flexibility and to be more independent from train schedules. Therefore, the reference terminal is planned to have 3 tracks.

3.2.6 Equipment

3.2.6.1 Van Carrier

Presuming that 20% of throughput is shifted additionally (so called "unpaid moves"), and that VC productivity is 6.5 moves/hour and 24 operating hours/day, 69 VCs are necessary for quayside operation, shiftings, truck interchange and transfer to train interchange. Including 12% VC for maintenance and repair results in a total minimum number of 77 VC.

3.2.6.2 RMG

Throughput of the train area is presumed to be 223,875 containers, operating hours 8640 hours/year and productivity of a RMG 20 moves/hour. This results in a minimum number of 2 RMGs which are necessary for the reference terminal.

3.3 Data Sheet of the Reference Terminal

The following table summarises the core data of the reference terminal.

Table 4: Data sheet reference terminal

Length quay side	1310	m
Number of quay cranes	12	
Terminal capacity	2,000,000	TEU
	1,250,000	Container
Yard capacity	32,600	TEU
	20,400	Container
Area	80	ha
Number of train tracks	3	
Number of truck lanes at gate	4+4	

4 Conclusions

To provide a starting point for analysing energy consumption, supply and management and carbon emissions a reference is required. Therefore, first a model of a container terminal has been described containing all relevant entities and processes in order to allow determining a reference terminal as basis for application of various solutions and comparison of impacts at a later stage of the project.

This deliverable additionally contributes to the overall picture to be shown within the Port and Terminal Knowledge Landscape aiming at providing a basis for a comprehensive understanding of all relevant aspects, elucidating of processes and relevant context including the terminal-port relation and allowing development of tailor-made solutions for individual terminals.

References

Böse, Jürgen W. (Hg.) (2011): Handbook of Terminal Planning: Springer New York (Operations Research/Computer Science Interfaces Series, 49).

Brinkmann, Birgitt (2005): Seehäfen. Planung und Entwurf. Berlin: Springer.