# TERMINAL CONTAINER D'ALTURA DI VENEZIA

Relazione Tecnica VOL. 02

Venezia, 22 marzo 2012

AUTORITÀ PORTUALE DI VENEZIA

DIREZIONE PIANIFICAZIONE STRATEGICA E SVILUPPO

Il cuore dell'intero progetto, nonché la chiave per il suo successo, risiede nell'efficienza del sistema di connessione tra terminale d'altura e terminali di terra (area Montesyndial). Il sistema deve lavorare all'unisono ottimizzando ogni fase di trasferimento. Tali necessarie sinergie costituiscono il fattore determinante per la l'intera progettazione, sia delle opere civili che sistemi di movimentazione.

Il presente studio, svolto in collaborazione con le società Halcrow Lts ed Idroesse Infrastrutture, descrive dettagliatamente le fasi che hanno portato al dimensionamento del modello d'esercizio per il trasferimento dei contenitori da/per i terminal d'altura nonché l'identificazione del layout relativo alle opere civili in altura e nel principale terminal di terra localizzato nell'area di Marghera.

L'analisi ed il dimensionamento sono stati condotti in diversi scenari di crescita del mercato, prevedendo dapprima la realizzazione di un modulo in grado di gestire in altura fino ad 1 milione di contenitori, ma prevedendo anche una suo futura espansione fino ad una capacità massima di 3 milioni di contenitori.

Lo studio si completa con la descrizione degli impatti in termini di addetti suddivisi per terminali, ruoli e competenze.

# TECHNICAL STUDY REPORT
# VENICE CONTAINER TERMINAL AND LOGISTICS STUDY

Venice Newport Container and Logistics S.p.A.

Venezia, 15 February 2012

VENICE NEWPORT CONTAINER AND LOGISTICS

VENICE PORT AUTHORITY

AUTORITA' PORTUALE DI VENEZIA

Halcrow

idroesse infrastrutture

HALCROW GROUP LIMITED HALCROW

This report has been produced with the advice and support of:

Venice Port Authority

Strategic Planning and Development  Department

# CONTENTS


1. Executive summary ........ 10
2. Introduction ........ 12
   Background ........ 12
3. Project Requirements ........ 16
   Introduction ........ 16
   Throughput ........ 17
      Average and Peak Throughput ........ 21
4. Project Site Description ........ 25
   Location ........ 25
   Climate ........ 28
   Wave Climate ........ 29
5. Concept Development ........ 30
   Introduction ........ 30
   Options considered ........ 30
      Option 1 - Independent Offshore Terminal ........ 30
      Option 2 - Offshore/ Onshore Terminal ........ 33

Combinations ... 40
SWOT analysis ... 40
6. Preferred option – waterway ... 42
Local environmental conditions ... 42
Operational considerations ... 42
Economic considerations ... 43
Flexibility ... 44
Waterway Options Considered ... 44
Conventional barge systems ... 45
Conventional roll on-roll off systems ... 46
Special cranes systems ... 47
Buffer Storage and it's implication for cranes ... 47
Bridge cranes ... 49
Special berth alignments ... 50
Special waterway transfer systems ... 51
LASH vessels ... 51
SEABEE vessels ... 52
BACO liner vessels ... 52

CONDOCK vessels....52
Preferred Waterway Transport System....53
7. Definition of movement system and overall dimensions....55
Introduction....55
Characteristic Dimensions....55
Feasible mama vessel and barge combinations....57
Barge Stability....59
Barge Dimension....59
Tugs and Manoeuvring....59
Mama Vessel....60
Operational characteristics of transfer system....61
Traffic restrictions on mama vessel....61
Fuel consumption....63
8. Logistic Simulation Modelling....64
Introduction....64
General approach....64
Traffic Simulation Software....65
Model development....67

Model Description ........ 67
Model philosophy ........ 67
Model logic ........ 69
Simulation length and replications ........ 75
Verification and validation ........ 75
Scenarios ........ 76
Throughput Scenarios ........ 76
Results ........ 81
Initial Screening ........ 81
Discussion of results ........ 85
Scenarios E+ ........ 86
Sensitivity Tests ........ 88
9. Layout offshore ........ 93
Introduction ........ 93
Key considerations ........ 93
Schematic Layout ........ 94
Main infrastructure ........ 95
Quay length ........ 95

Deep-sea berth quayside apron ........ 95
Buffer container storage ........ 96
Refrigerated container stacks ........ 98
Space demand for non-container handling purposes ........ 98
Marine Services ........ 99
Barge Operation ........ 99
Buildings ........ 100
Equipment ........ 101
Power requirements ........ 107
Phasing of terminal ........ 108
10. Layout at Monte/Syndial ........ 109
Introduction ........ 109
Key considerations ........ 109
Conventional Operations ........ 110
Quay ........ 110
Yard ........ 110
Workshop ........ 113
Inspection Area ........ 113

Rail ........ 113
Gates ........ 114
Automated barge operation for second phase ........ 115
Out of Gauge/non-container traffic ........ 118
Traffic Circulation ........ 118
Office Building ........ 118
Equipment ........ 119
RTG ........ 119
Tractor Trailer ........ 120
Reachstackers ........ 120
Empty Container Handlers ........ 120
Scenario 1 – onshore equipment ........ 121
Rail Mounted Gantry Cranes (RMG) ........ 121
Bridge Cranes ........ 121
Multi-trailer ........ 122
Power requirements ........ 124
11. Organisation structure ........ 125
Introduction ........ 125

Key considerations ........................................................................................................................................................126

Schematic of organisation structure ...............................................................................................................138

Software concept ..............................................................................................................................................................141

# 1. EXECUTIVE SUMMARY

Venice Port Authority (VPA) appointed Halcrow/ Idroesse to undertake a concept and logistics study for an offshore container terminal that is to be linked to an onshore container terminal located at a defined site in Monte/Syndial as well as others. The offshore terminal location was established prior to this study and is approximately 150minutes by waterway routes from the proposed Monte/Syndial terminal location.

The study was carried out in close cooperation with VPA and involved determining :

- a transport link that facilitates the transfer of containerized cargo between the offshore and onshore terminals
- the layouts for the offshore and onshore terminal at Monte/Syndial
- an organization structure for management of terminals
- capital and operating cost estimates

This report presents the key considerations, assumptions and parameters utilized in the development. All cost estimates are presented in volume 2 of the report.

The throughput scenarios for the offshore and various onshore terminals were provided by VPA, ranging from scenario 0 to 3. The offshore terminal is to be designed to handle a throughput up to 3 million TEU with a transfer of up to 2.2 million TEU to onshore terminals, and 0.8 million TEU as transhipment to other locations via the offshore terminal.

## Assessment of transfer link

An assessment of different transfer mechanisms ranging from fixed infrastructure links to waterway based systems was carried out. Based on the relative merits of each option against the evaluation criteria a waterway transfer link was chosen to be most appropriate system.

## Waterway Transport Link

A waterway transport link between the offshore and onshore terminals has been developed due to its ability to offer the flexibility to route to several different locations, the ability to be phased in line with stages of the development as well as likely environmental and cost benefits.

A lighter transport ship, referred to as mama vessel in this report, carrying unpowered barges has been selected as a transport mechanism.

The main key advantages of this system are that:

- it removes the need for a large number of powered, seaworthy and manoeuvrable barges
- thus potentially reduces the overall staffing required
- fits the restricted waterway system at the terminal
- and can be turned around fast in line with service level expectations of mainline customers

The preferred barge dimensions are approximately 58m long and 26.5m wide with an operating draft of 3.75m and with a capacity to carry 216 TEU.

The preferred mama vessel dimensions are approximatly 150m long with a beam of 31m and an operating transit draft of 5.5m and a undocking draft of 6.25m. The vessel will have a capacity to carry two fully loaded barges i.e. 432 TEU.

The number of barges and mama vessels required for each scenario has been determined through a series of operation simulations to optimize the container transfer process. A starting fleet of 10 barges and 3 mama vessels growing to 20 barges and 6 mama vessels in the full build out (excluding spares) is envisaged.

## Layout of offshore terminal

The offshore terminal layout has been envisaged as an automated terminal where possible to reduce number of staff located offshore and thus labour cost. Further, it has been planned with high productivity and competitive turnaround speeds in mind. It will comprise of:

- Conventional ship to shore cranes (18 no) serving the mainline vessels with a productivity of 1500 TEU per m quay per annum
- Four mainline berths phased in line with growth i.e.
    - 2 berths in scenario 1,
    - 3 berths in scenario 2 and
    - 4 berths in scenario 3
- Automated mini-straddles (shuttle carriers) operating in the backreach of the crane (separated from manual labour) and serving the stack
- Automated overhead bridge cranes that serve a buffer stack and have a cantilevered section that can load the waterway barges at high speed with an average turn around speed for loading of 270min (in total exchange 432 TEU this comprises of 216 TEU load off and 216 TEU load on)

The offshore container terminal must have a container buffer storage for operational reasons, estimated to be around 5,000 TEU per berth.

## Layout of onshore terminal

The layout of the onshore terminal is divided into two parts:

- a conventional RTG container terminal which starts operation in scenario 0 and
- a special barge terminal that starts operating from scenario 1 onwards.

The RTG container terminal will have a berth length of 600m with a target productivity of 1,000 TEU per m quay per annum. It will be served by 4 mainline ship to shore cranes in a conventional RTG layout with tractor trailers operating between the quay crane rails. The stack is envisaged to comprise of 12 number 7 over 5 high RTG cranes with a block length of approximately 40.

The barge container terminal is expected to comprise of at least 5 barge berths with overhead bridge crane modules similar to the ones offshore. However, there is space for 6 barge berths which would enable an increased throughput.

The overhead bridge cranes onshore have a longer stack length than those offshore which requires two bridge crane spreaders. At the landside, safety considerations require that containers be turned through 90° in order to be loaded/unloaded to/from road vehicles in a semi-automated operation. A rail interface is provided that enables a throughput volume in scenario 0 of 0.2m TEU and 0.4m TEU in the following scenarios. The remainder of cargo will be handled by trucks.

## Organisation Structure

A single management hierarchy is envisaged with operations integrated to the greatest extent possible, resulting in a requirement for approx. 65 employees.

At the onshore terminal a 6-hour shift pattern is proposed, whereas at the offshore terminal a 12-hour shifts pattern is envisaged as staff will have to remain offshore for a period of days, similar to the way in which the off-shore oil industry operates. The onshore terminal starts with approximately 450 staff growing to 600 in the full build out, whereas the offshore terminal starts with approximately 450 staff growing to nearly 700. The waterway link will start with 80 staff growing to 140.

# 2. INTRODUCTION

## Background

Venice has a long tradition in international sea trade and has over the past centuries exploited its strategic geographic position enabling trade between Europe and the East.

The hinterland of Venice is Italy's most important economic and industrial area. It is also an area that experiences a high level of international trade. In addition to its natural hinterland, Venice is ideally placed to take advantage of the European Commission's efforts to promote the mobility of passengers and freight within the EU via the Trans European Networks - Transport (TEN-T) initiative. Located on land corridor 5 (Lyon-Budapest-Ukraine) and close to land corridor 1 (Berlin-Palermo), Venice is strategically placed to facilitate intermodal services and provide a gateway to the EU Motorways of the Sea initiative. Please refer to Figure 2-1.


**Figure 2-1 Location of Venice in the Trans European network and within the region**



In pursuit of its commercial objectives, Venice Port Authority (VPA) commissioned MDS Transmodal to investigate market demand further, revealing a shortage between supply and demand in the region.

Expansion at the industrial port of Venice (Porto Marghera) is limited by the disposition of the existing infrastructure which consists of relatively narrow canals and relatively shallow water depths. Development of the port to accommodate the ever increasing size of commercial vessels (and especially container ships) would necessitate extensive deepening and widening of the canals and widespread reconstruction of the quays and wharves.

The unique nature of the lagoon and the old city (which is a UNESCO world heritage site) means that regulations are in place to protect the environment from damage, in particular flooding.  Dredging of the canals is restricted to prevent enlargement of the tidal prism and a flood barrier system (the MOSE) is being installed at all entrances to the lagoon to protect the

city from tidal surges that can occur in the Adriatic.

Hence, VPA has proposed an offshore island to be located some 8 nautical miles (15km) from the Malamocco inlet, to facilitate a future growth of traffic. It is anticipated that transhipment facilities will be provided for containers, with possible future development for other cargo. It is expected that trade to and from the mainland will be maintained by a system of shuttle barges or lighters, but a fixed link has not been entirely ruled out at this stage.

## Terms of Reference

Halcrow Group Ltd and Idroesse Infrastrutture were commissioned on the 8th September 2011 to study the concept of an offshore deep-sea container terminal in combination with a land based terminal and their operating model, lay-out and link. The work scope for delivery included:

A1) conceptual configuration and schematic lay-out of the system comprising the deep water terminal and the coastal terminals;

A2) Infrastructure, layout of structures and the best facilities for the deep-sea container terminal planned at the mouth of the Malamocco;

A3) Infrastructure, structure, layout and best facilities for the container terminal in the former Montefibre/ Syndial AS area;

A4) definition of the type of movement facilities and their overall dimensions;

A5) definition of an operating model and calculation of the movement times in the various phases of the logistical chain relating to the various lay-out and facilities scenarios;

A6) identification of main infrastructure needed at the deep-water terminal and at the Montefibre/ Syndial terminal;

A7) identification of the organisation structure required to manage the deep-water terminal, Montefibre/ Syndial terminal and the links;

A8) evaluation of the parameters for the construction costs of the structures and civil engineering infrastructure;

A9) assessment of critical points and nodes that could affect flow of goods within the entire cycle;

A10) evaluation of the cost of facilities;

A11) identification of overall costs to produce a software package that can manage the entire cycle;

A12) evaluation of the costs of the individual operations in the transfer cycle.

Further, a particular requirement was that *"The study must be carried out in close collaboration with the Customer and with the Venice Port Authority, through meetings planned to agree the most suitable technical solution to adopt"*.

Studies by others concerning an offshore bulk liquid facility and breakwater layout are ongoing. Hence, liaison with VPA on these matters was an integral part of the project to enable a coherent and coordinated approach.

However, these elements are outside the scope of this study relevant indicative information has been presented to provide context for the reader.

## Approach

Given the strategic nature of the project and the need to quickly confirm decisions and assumptions, a step by step collaborative approach with VPA was developed.

This meant that Halcrow and Idroesse worked through the project scope and then presented their interim findings to VPA at a number of workshops to share context and progress.

Thus decision making was a team effort and assumptions, priorities and outcomes were provided and endorsed early to ensure the derivation of an accepted, suitable solution in the stipulated timeframe.

The following workshops and the decisions agreed therein provided direction to the study and the development of the scheme:-

- **Workshop 1,** 6 Oct 2011, Definition of Concept & SWOT Analysis

  Waterway transfer option was confirmed as the preferred modus operandi.

- **Workshop 2,** 18 Oct 2011, Definition of Waterway System

  Waterway transfer mechanisms were considered and the use of barges to be transported by LASH vessels were confirmed

- **Workshop 3,** 27 Oct 2011, Definition of Simulation System

  Endorsed the concept for the fast unloading and loading system that would be provided to minimise barge time at berth. The scope of the simulation model was also agreed together with the range of scenarios to be tested.

- **Workshop 4,** 17 Nov 2011, Interim Results of Simulation System, outline layout and concept for costing

  Discussed the preliminary findings of the simulation modelling studies relating to feasible solutions, and identified those configurations of barge and ship to be tested as part of the study

- **Workshop 5,** 12 Dec 2011, Interim Results of costing and refined layout

  The interim results of the costing were presented as well as a refined layout for both Montefibre/ Syndial and the Offshore terminal. The approach was endorsed by VPA.

- **Workshop 6**, 22 Dec 2011 – Results of Study

  Presentation of all results and handover of first draft report

## Purpose and Structure of Report

The aim of this report is to serve as a point of reference concerning client requirements and to act as a baseline for future work. The report provides a brief explanation of the rationale of the concept developed to date and presents the main parameters on which it has been based. It is understood that the report contents may be issued to users of differing interest in either technical or commercial aspects and hence it has been split into three volumes:

- Volume 1 – Technical Study Report
- Volume 2 – Financial (Costs) Analysis Report
- Volume 3 – Financial (Viability) Analysis Report

This volume is Volume 1 of this study and covers  scope element A1 to A7, as well as A9.

# 3. PROJECT REQUIREMENTS

## Introduction

Port development typically takes place over an extended period of time with port users' requirements and cargo handling technology evolving during its life. The scheme concept has been created with the intention of allowing the port to adapt to changing circumstances whilst maintaining a state of the art facility. A modular terminal concept has been employed to allow flexible demand driven expansion. These terminal modules can readily be constructed on a "just in time" basis, in phases to accommodate the growth in traffic and varied to suit new technologies.

The stated key requirements by VPA for the concept are as follows:

- Utilise an offshore terminal to enable deep drafted container vessels to call and to link with several other terminals including Montefibre/Syndial, Chioggia, Levante and potentially others
- Utilise the available land at Monte/Syndial for a container terminal
- Offshore: Include Maersk EEE class vessels or similar, Exclude MalaccaMax/ Post-Suez Max vessels with a draft of 21m
- Onshore: Limit dredging requirements where possible to reduce environmental impact on the lagoon
- Meet the throughout demand identified by VPA
- Modern innovative infrastructure and state of the art IT/communications infrastructure
- Rapid turnaround times and minimum transit times
- Excellent safety and security
- Competitive cost structure
- Provide for containerised cargo

In terms of technological choices, the concept has been prepared to incorporate a number of the most advanced cargo handling equipment, IT/communication and security systems etc to ensure a state of the art facility.


**Figure 3-1 Maersk E – Class vessel at berth**

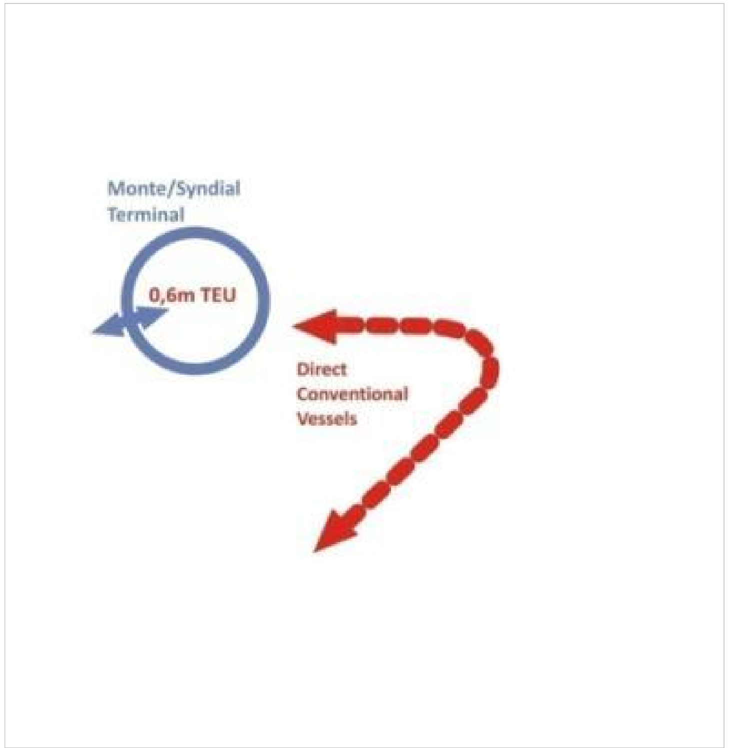



**Figure 3-2 Scenario 0 annual throughput**

Estimated costs relating to the innovative concepts, such as the bridge cranes and mama vessels, have been estimated based on the available information to date. Further detailed studies should be undertaken to further refine the cost estimate, feasibility and acceptability to industry.

## Throughput

During workshop 1, on the 6th Oct. 2011, the annual throughput scenarios to be assumed in the option development were refined by VPA. A key stated requirement is the ability for phased development and to enable traffic to be sent to a variety of destinations including Monte/Syndial, Porto Levante, Chioggia Port as well as others.

### Scenario 0:

This scenario comprises an initial terminal for direct calls at Monte/Syndial to enable an early start up of operations. It is assumed that at this stage the offshore terminal is not yet operational, but is under construction.

Key assumptions:

- No offshore terminal
- Montefibre/Syndial 0.6m TEU[1] throughput on 600 meters of quay

[1] TEU is a twenty foot equivalent unit or one standard container with dimensions 20 feet long by 8 feet wide by 8.5 feet high

### Scenario 1:

This scenario comprises the first phase of the offshore terminal which serves mainline vessels and directs this containerised cargo traffic to the Monte/Syndial terminal.

Key assumptions:

- 1 million TEU offshore terminal plus 0.6million TEU at Monte/Syndial by direct vessels
- 0.8 million TEU offshore-onshore to Monte/Syndial (i.e. total 1.4million TEU at Monte/Syndial)
- remaining 0.2 million TEU in tran-shipment (0.1 million TEU off plus 0.1 million TEU on)

Please refer to Figure 3-3 for a con-cept image of the throughput traffic for this scenario.

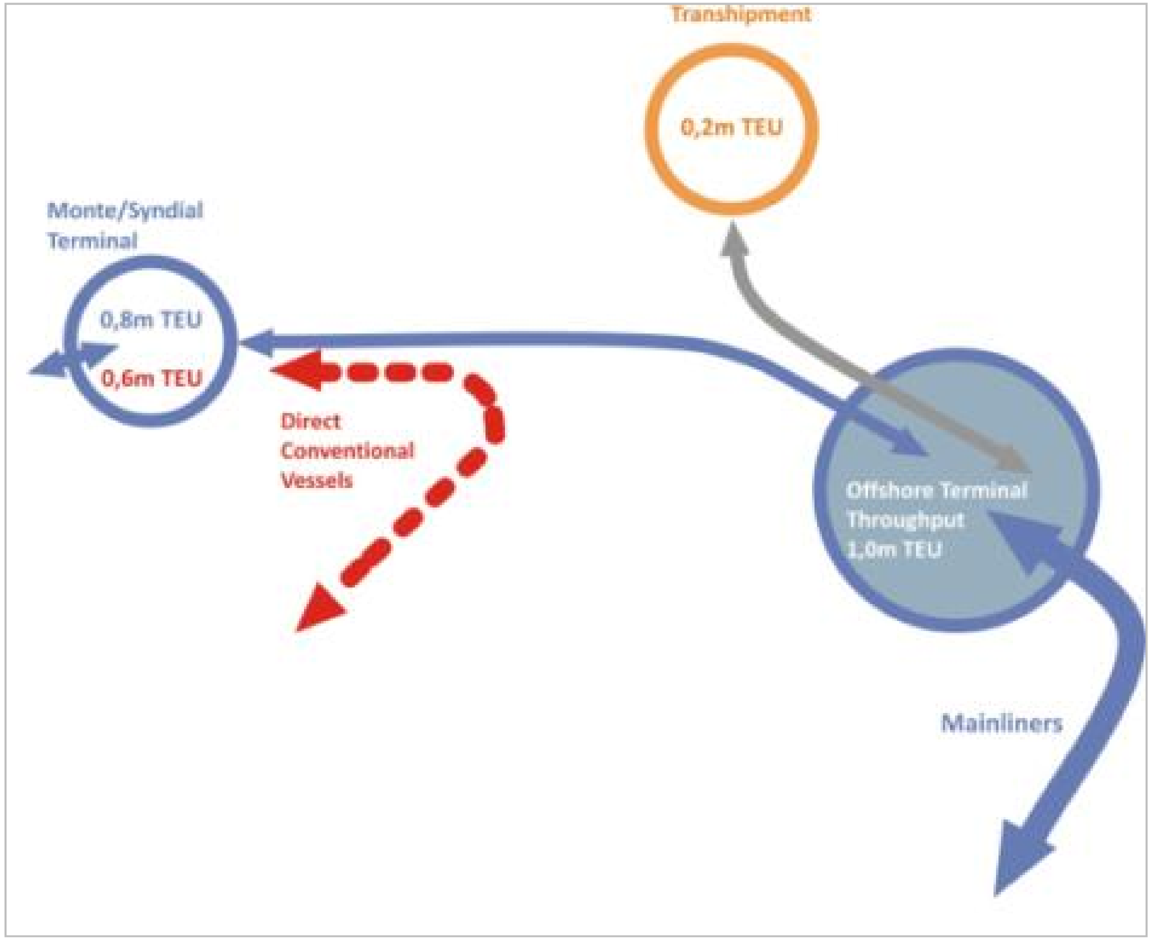



**Figure 3-3 Scenario 1 annual throughput**

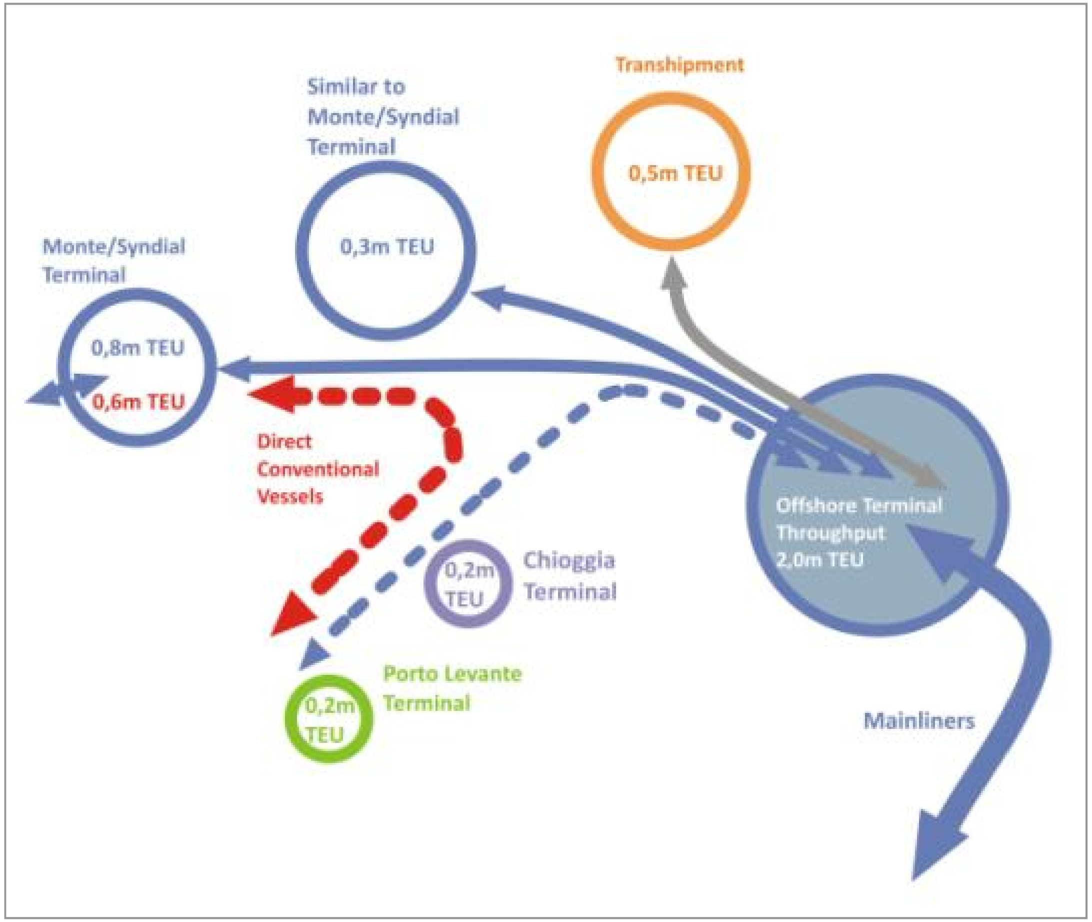



Figure 3-4 **Scenario 2 annual throughput**

### Scenario 2:

This scenario assumes the extension of the offshore terminal to enable a larger annual throughput volume to be handled. This additional through-put is shared between Chioggia Port, Levante Port and another terminal with similar characteristics to Monte/Syndial as well as a tranship-ment component to other ports.

Key assumptions:

- 2 million TEU offshore terminal plus 0.6million TEU at Monte/Syndial direct
- 0.8 million TEU offshore-onshore to Monte/Syndial (i.e. total 1.4 mil-lion TEU at Monte/Syndial)
- 0.2 million TEU offshore-onshore to Chioggia Port
- 0.2 million TEU offshore-onshore to Porto Levante
- 0.3 million TEU to another terminal similar and close to Monte/Syndial
- 0.5 million TEU transshipment (0.25m off plus 0.25m on)

### Scenario 3:

This scenario assumes the extension of the offshore terminal to its full envisaged build out to facilitate the handling of 3 million TEU throughput. The additional throughput is shared between Chioggia Port, Levante Port and another terminal with similar characteristics to Monte/Syndial as well as a transhipment component to other ports.

Key assumptions:

- 3 million TEU offshore terminal plus 0.6 million TEU at Monte/Syndial direct
- 0.8 million TEU offshore-onshore to Monte/Syndial
- 0.2 million TEU offshore-onshore to Chioggia Port
- 0.2 million TEU offshore-onshore to Porto Levante
- 1.0 million TEU to another terminal similar and close to Monte/Syndial
- 0.8 million TEU transshipment (0.4m TEU off plus 0.4m TEU on)

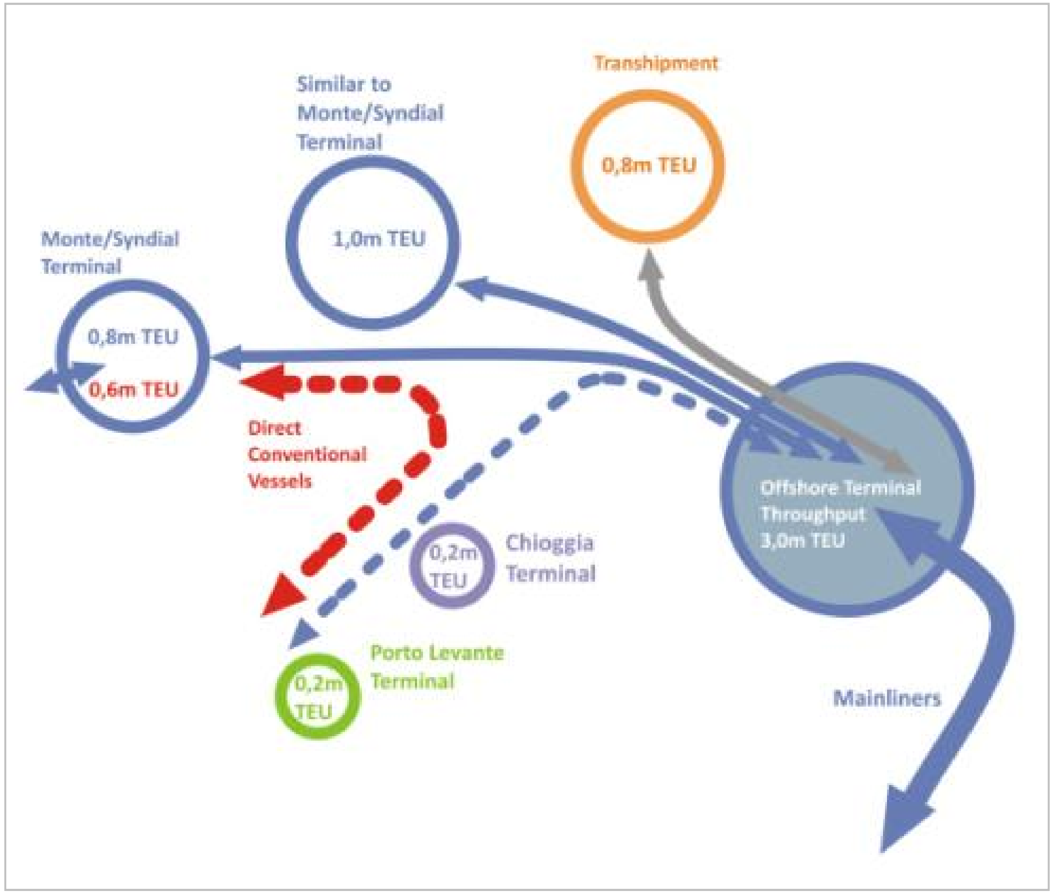



**Figure 3-5 Scenario 3 annual throughput**

**Figure 3-6 Typical river push-tow barge system**

## Transfer mechanism

The waterway characteristics at the onshore terminals differ significantly, resulting in differing requirements for vessels seeking access. It has been assumed that one type of transfer mechanism will operate between Monte/Syndial and similar onshore terminals and the offshore terminal whereas a similar or different transfer mechanism may operate at Porto Levante and Chioggia.

Key assumptions:

- Total barge transfer load for consideration 0.8 million TEU (Monte/ Syndial) plus 1 million TEU (similar to Monte/ Syndial)
- A waterway system (to be defined) is to transfer 0.2million
- TEU to Chioggia plus 0.2million TEU to Porto Levante

## Average and Peak Throughput

In order to meet the stated annual throughput capacity, any proposed system should be able to cope with the average throughput traffic as well as with peak traffic.

Potential weekly vessel call schedules, container exchange volume and target productivity have been examined to establish the number of berths required offshore, the typical average daily throughput values as well as daily peak throughput values based on the stated scenarios and assumptions provided by VPA as well as experience. Please refer to the Table 3-1 for a summary of throughput by scenario and berth for annual, daily average and daily peak volume.

At the offshore terminal the following number of berths are required per scenario:

- Scenario 1 – 2 Mainline Berths
- Scenario 2 – 3 Mainline Berths
- Scenario 3 – 4 Mainline Berths

A potential weekly vessel call schedule for the offshore terminal in scenario 3 is presented in Figure 3-7.

| Description | Scenario 0 | | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|---|---|
| | (TEU) | (boxes) | (TEU) | (boxes) | (TEU) | (boxes) | (TEU) | (boxes) |
| Annual Throughput Offshore Deepsea Berths | 0 | 0 | 1,000,000 | 655,000 | 2,000,000 | 1,310,000 | 3,000,000 | 1,965,000 |
| Annual Throughput Offshore Barge Berths | 0 | 0 | 800,000 | 524,000 | 1,100,000 | 720,500 | 1,800,000 | 1,179,000 |
| Annual Throughput M/S Barge Berths | 0 | 0 | 800,000 | 524,000 | 800,000 | 524,000 | 800,000 | 524,000 |
| Annual Throughput M/S Mainline Berths | 600,000 | 393,000 | 600,000 | 393,000 | 600,000 | 393,000 | 600,000 | 393,000 |
| Average daily throughput Offshore Deepsea Berths | 0 | 0 | 2,800 | 1,800 | 5,500 | 3,600 | 8,300 | 5,400 |
| Average daily throughput Offshore Barge Berths | 0 | 0 | 2,200 | 1,400 | 3,000 | 2,000 | 5,000 | 3,200 |
| Average daily throughput M/S Barge Berths | 0 | 0 | 2,200 | 1,400 | 2,200 | 1,400 | 2,200 | 1,400 |
| Average daily throughput M/S Mainline Berths | 1,700 | 1,100 | 1,700 | 1,100 | 1,700 | 1,100 | 1,700 | 1,100 |
| Peak daily throughput Offshore Deepsea Berths | 0 | 0 | 5,600 | 3,700 | 11,200 | 7,300 | 15,900 | 10,400 |
| Peak daily throughput Offshore Barge Berths | 0 | 0 | 4,500 | 2,900 | 6,200 | 4,000 | 9,500 | 6,200 |
| Peak daily throughput M/S Barge Berths | 0 | 0 | 4,500 | 2,900 | 4,500 | 2,900 | 4,200 | 2,800 |
| Peak daily throughput M/S Mainline Berths | 4,400 | 2,900 | 4,400 | 2,900 | 4,400 | 2,900 | 4,400 | 2,900 |

**Table 3-1 Summary of throughput by scenario and berth for annual, daily average and daily peak volume**

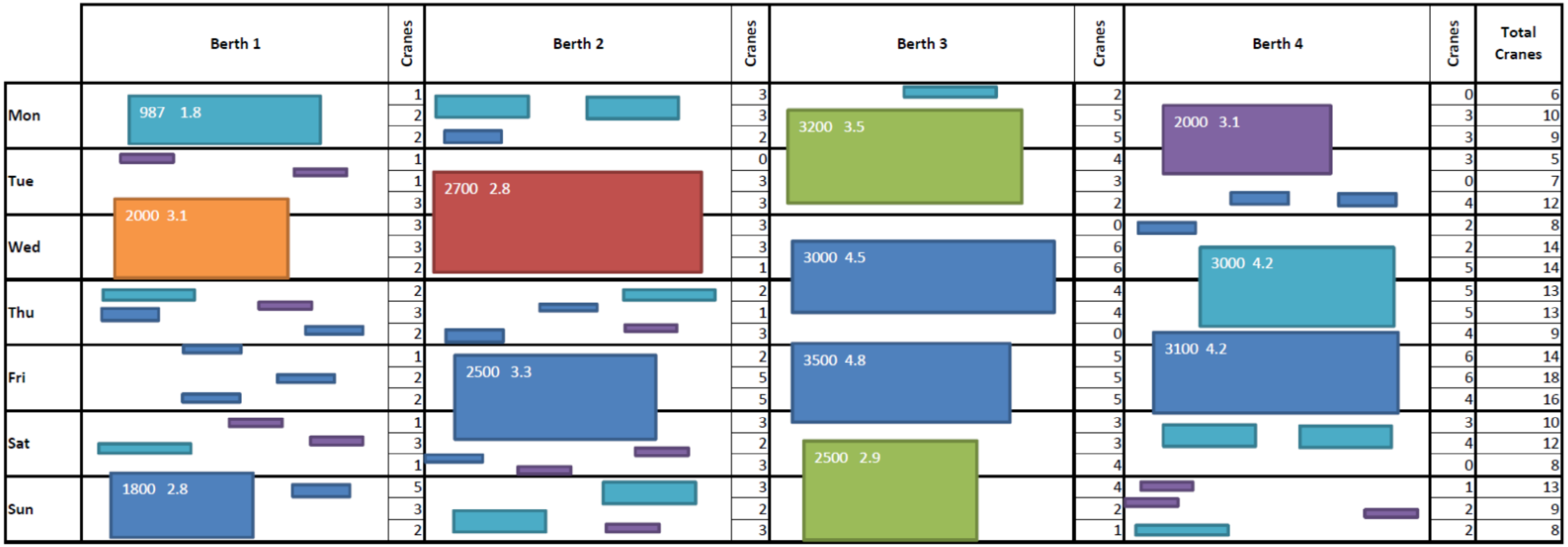



**Figure 3-7 Potential berth plan at offshore terminal main berths for scenario 3 based on average weekly throughput**

Notes:

Each shaded box represents a vessel, each vessel with numbers in the box represents a mainline vessel, those without a number represent a feeder vessel

The first number in the shaded box represents the number of moves per vessel (assumed single cycle i.e. 1 box = 1 move)

The second number in the shaded box represents the crane split, this is governed by the largest indivisable parcel of boxes which have to be served by a crane for example if a vessel exchanges 2500 boxes and 600 are in an area that can be accessed by one crane only then the crane split is 2500/600=4.1 . This "long" or "heavy" crane determines the overall loading time as other cranes may finish earlier.

### Methodology of deriving peak throughput

Considering the berth plan, it is evident that there are days when 3 mainline vessels will be present at the berths at the same time, possibly with a feeder vessel berthed as well in the scenario 3.

Further, it is clear that there will be times when mainline vessels will be berthed one after each other on the same berth. This requires continuity of service with no "pile ups due to delays" as the opportunity to catch up with old boxes on the terminal whilst new ones are handled will be limited and carry risk of delay to the mainline vessel.

Thus, the peak scenario has been calculated considering the target productivity at the mainline berths as the shore side equipment, storage and waterway transfer system would need to be able to cope with the main ship to shore crane productivity to avoid delay.

The mainline ship to shore crane productivity is purposefully maximised by terminal operators to achieve fast turn-around times for mainline vessel which is desired by customers.

Table 3-2 provides an overview of the methodology used with the example of scenario 3, other scenario peaks have been determined the same methodology considering a 24 hour period.

The peak scenario for the waterway system is lower as some cargo is transhipped and hence stays at the offshore terminal.

| Description | | |
|---|---|---|
| | | Units |
| Crane productivity | 30 | mph |
| Assumed no of cranes on mainline berth | 5 | no |
| Crane utilisation | 85 | % |
| Mainline productivity | 127.5 | mph |
| Feeder productivity | 25.5 | mph |
| Mainline in operation at peak | 3 | no |
| Feeder cranes in operation at peak | 2 | no |
| Hourly throughput | 434 | mph |
| In a peak 24 hour period | ~10,400 | moves |
| In a peak 24 hour period | ~15,900 | TEU |

**Table 3-2 Derivation of peak throughput for scenario 3 for offshore deepsea berths**

Note:

mph - moves per hour

no - number

# 4. PROJECT SITE DESCRIPTION

## Location

The proposed scheme is located along a number of key sites, an offshore terminal site, an onshore terminal site at Montefibre/ Syndial and other onshore terminals in the region such as Porto Levante and Chioggia, Figure 4-1.


**Figure 4-1 Location of offshore terminal**

## Location of the offshore terminal

The suggested location for the off-shore terminal is some 8 nautical miles east of the Porto di Malamocco. For the purposes of the study this position has been taken to be 45°27' N, 12°30' E. The depth of water at this

location is about 20 metres below Chart Datum (CD) as shown on British Admiralty Chart 1483 "Approaches to Chioggia, Malamocco, Venezia and Marghera".

The location is near to the Gulf of Venice Traffic Separation Scheme, so some amendment to that scheme may be required should the project be realised.

## Location of the onshore terminal at Monte/ Syndial

The proposed location for the onshore terminal at Monte/Syndial is on the south bank of the Canale Industriale Ovest. The boundaries of the site under consideration are presented in Figure 4-5 .


**Figure 4-3 Location of onshore Terminal at Monte/Syndial in relation to Venice**

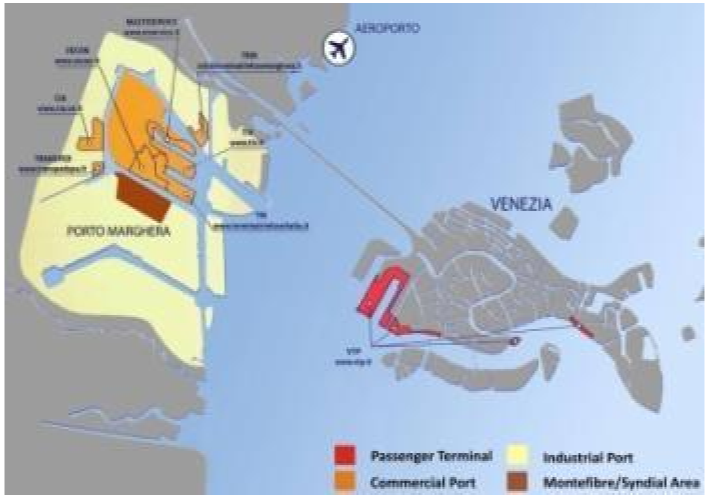



Figure 4-4 **Offshore Terminal and connections to other ports**


Figure 4-2 **Monte/Syndial Terminal Site**

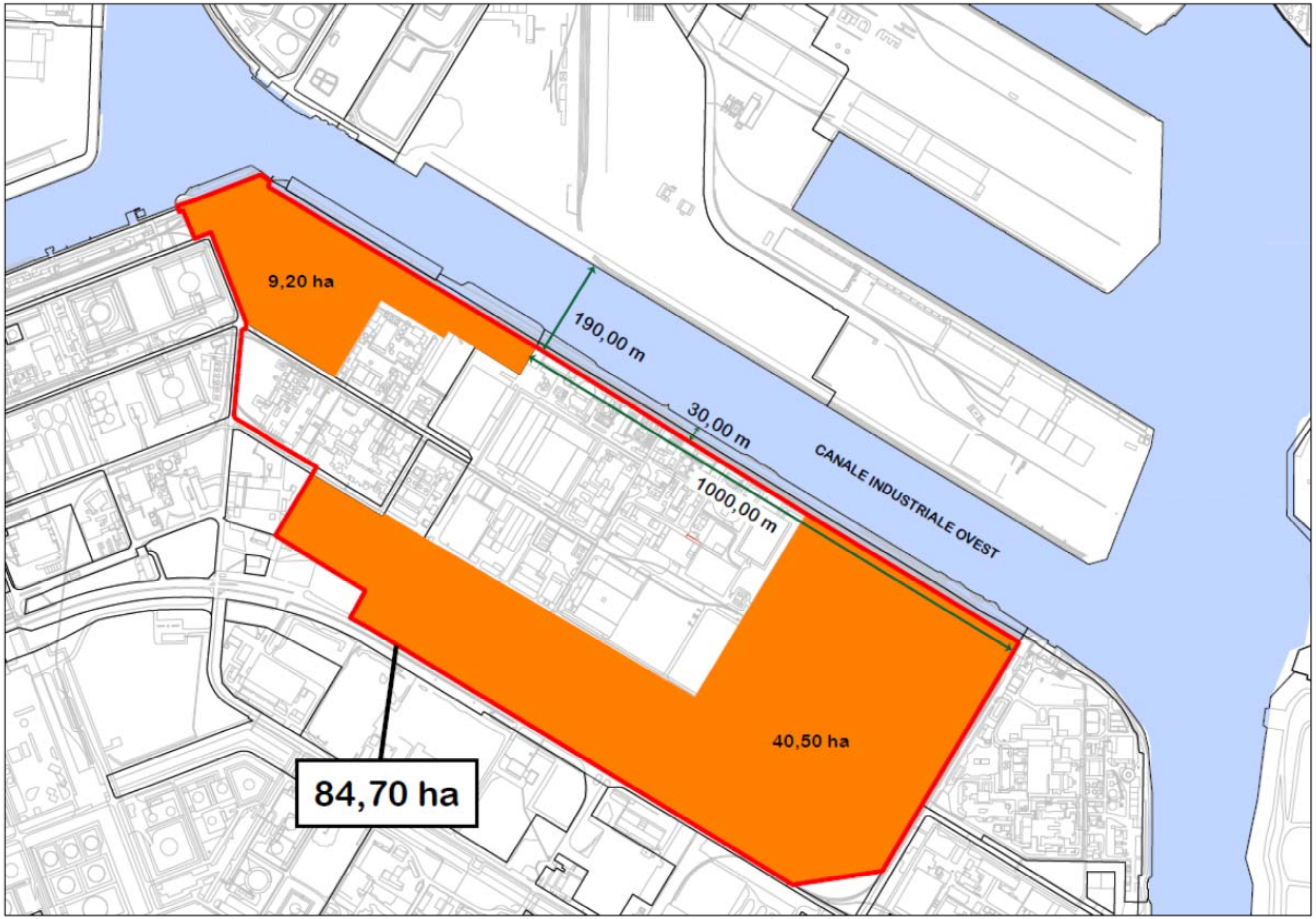



**Figure 4-5 Boundaries of the available land for the inland Terminal at Monte/Syndial (red line)**

## Climate

There is a strong seasonal variation in the climate; with summers being hot and mostly dry and winters, by comparison, cold and wet. The northern Adriatic is susceptible to winter fog.

In winter months, the location can be affected by the Bora which is a cold dry wind emanating from the mountains to the north-east. It can frequently reach gale force.

In summer months, the area can be affected by the Sirocco, which is a south easterly or southerly wind emanating from the deserts of North Africa or Arabia. Typically hot and humid, the Sirocco is generally light to moderate in strength, although it can reach gale force. Visibility can be restricted at times.

The Medatlas (Istituto di Scienze Marine [ISMAR] et al) contains wind and wave statistics for fixed points covering the whole Mediterranean Sea. The nearest points to the proposed site are 45°N, 13°E (latitude, longitude) and 45.5°N, 13°E, approximately 51km south-east and 44km north-east of the site respectively, see Figure 4-6. Whilst the more exposed southerly point (right plot) shows a more general distribution of winds less than 5m/s, both points show a clear dominance of the 30-75 degree sector for all winds greater than 5m/s.

## Tides and water level

British Admiralty Tide Tables Volume 2 for 2010 (NP 202-10) give tide levels for Venice as presented in Table 4-1.

| | |
|---|---|
| LAT | -0.2 |
| MLWS | +0.1 |
| MLWN | +0.4 |
| MSL | +0.5 |
| MHWN | +0.6 |
| MHWS | +0.9 |
| HAT | +1.1 |

**Table 4-1 Tide levels for Venice**

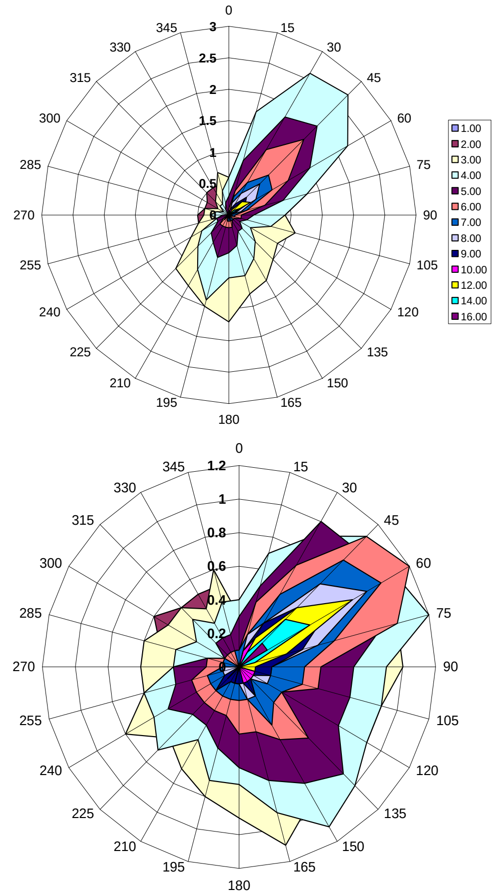



**Figure 4-6 Wind Rose Medatlas points 45.5°N,13°E (top) and 45°N,13°E (bottom). % wind (vertical axis) by max speed (m/s) with direction (deg).**

## Wave Climate

Wave climate was assessed using the data presented in “Relazione Tecnica”, an analytical report for the positioning and orientation of a previously proposed oil terminal, which was to be located outside the lagoon and in almost the same location as that being considered for this project. The wave data was directly sourced from the ISMAR monitoring platform located adjacent to the site, and covered the period October 1987 to December 2000.

Figure 4- displays the monitoring data graphically. Figure 4- shows a wide spread of wave direction for waves less than 0.5m (purple shading).

Figure 4- only shows waves greater than 0.75m, considered to be waves that would restrict the operation of large container vessels. This shows a clear predominance of larger waves between 045 and 135 degrees (from true North), a 90 degree sector that represents only 25% of all possible directions. Therefore the outer breakwaters at the offshore terminal need to protect this sector to provide a safe and efficient harbour. The configuration of the inner harbour structures should be designed to protect vessels and berths vulnerable to waves less than 0.75m in height.

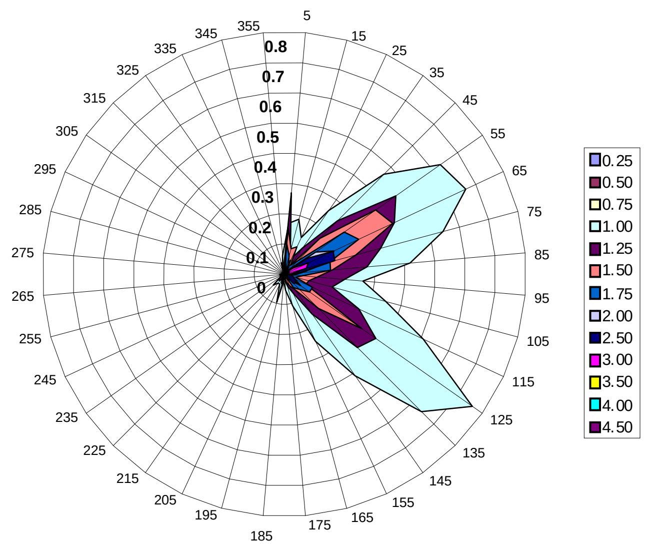



**Figure 4-7 Percentage waves >0.75m by max height (m) with direction (deg).**

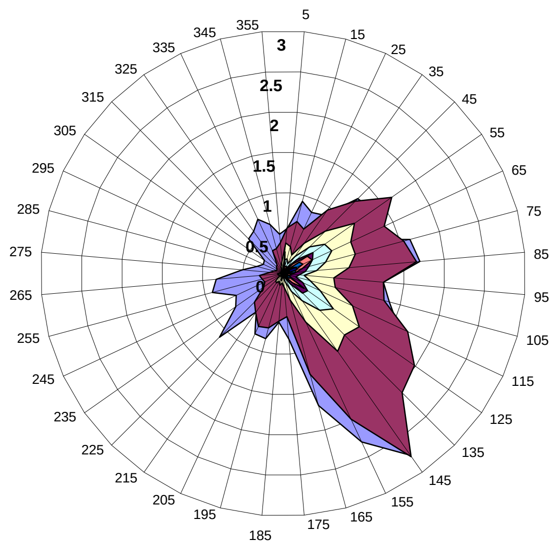



**Figure 4-8 Percentage of all waves by max height (m) with direction (deg). +4% calm**

# 5. CONCEPT DEVELOPMENT

## Introduction

The project scope includes a high level concept development for various possible options for a container transfer system for the offshore terminal and the strengths, weaknesses, opportunities and threats (SWOT) analysis of these options. This is presented in the following chapter (Scope element A1).

## Options considered

Two principal operational options were considered; the first comprised of an independent offshore terminal and the second comprised of an offshore/onshore terminal concept. Both of these concepts are elaborated in more detail in the following sections.

## Option 1 - Independent Offshore Terminal

The independent offshore terminal was envisaged to be operating independently with all main activities carried out offshore:

- All cargo is received on the offshore island
- All cargo is sorted/ inspected on the offshore island
- All cargo is placed on final transport mode for onward transport inland
- Process works vice versa for export

Refer to Figure 5-1 for an explanatory sketch of this conceptual model. A prerequisite for this model is the presence of onward transport modes offshore i.e. a rail and/or road connection for the transport of containers inland. The consequence of this is the need to connect the offshore terminal located approximately 30km offshore by a

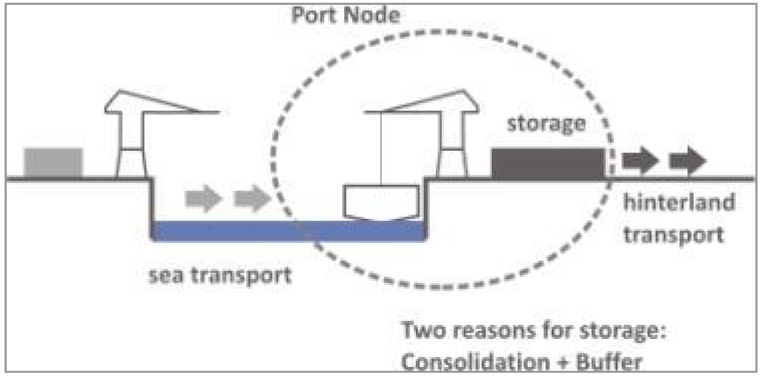



**Figure 5-1 Concept of an independent offshore terminal as a transport node**

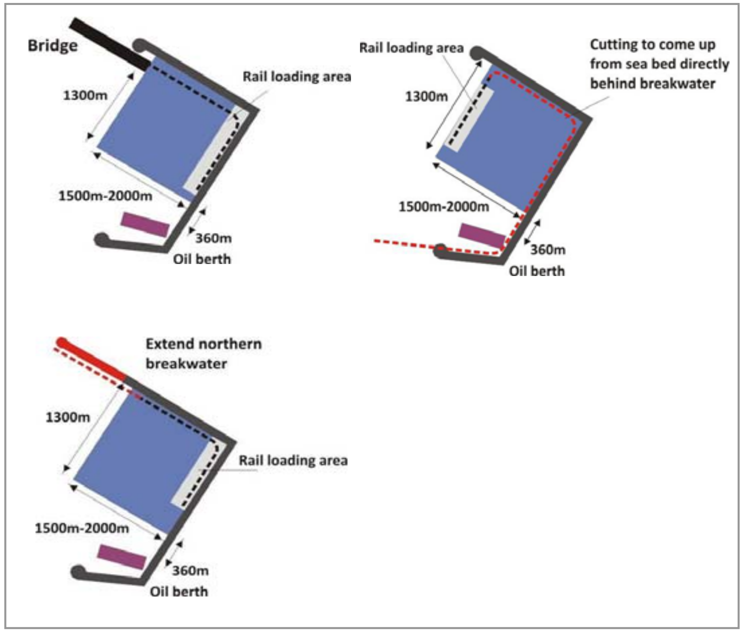



**Figure 5-2 Potential concept layouts for option 1**

fixed infrastructure link to the mainland.

The infrastructure connection could comprise of a tunnel, a bridge or any combination of the two.

Key disadvantages of this concept are:

1. The fixed infrastructure link cannot be phased, it has to be available from day one of operations to enable the port to function
2. The cost of the fixed link may be large and is uncertain given the significant length of the link, the potential ground condition risks and environmental protection requirements
3. The nature of the fixed infrastructure link makes it difficult to route containerized cargo to several other hinterland terminals at a number of diverse locations efficiently

Key advantages of such a concept are:

1. Double handling of containers is minimized and hence operational cost are reduced
2. There is a lower operational risk as the offshore operation could be largely based on existing best practice worldwide with no significant deviations making this potentially more attractive to operators
3. The turnaround time of containers could be very fast

Please refer to Figure 5-3 which provides an overview of the key strength, weaknesses, opportunities and threats for this option.

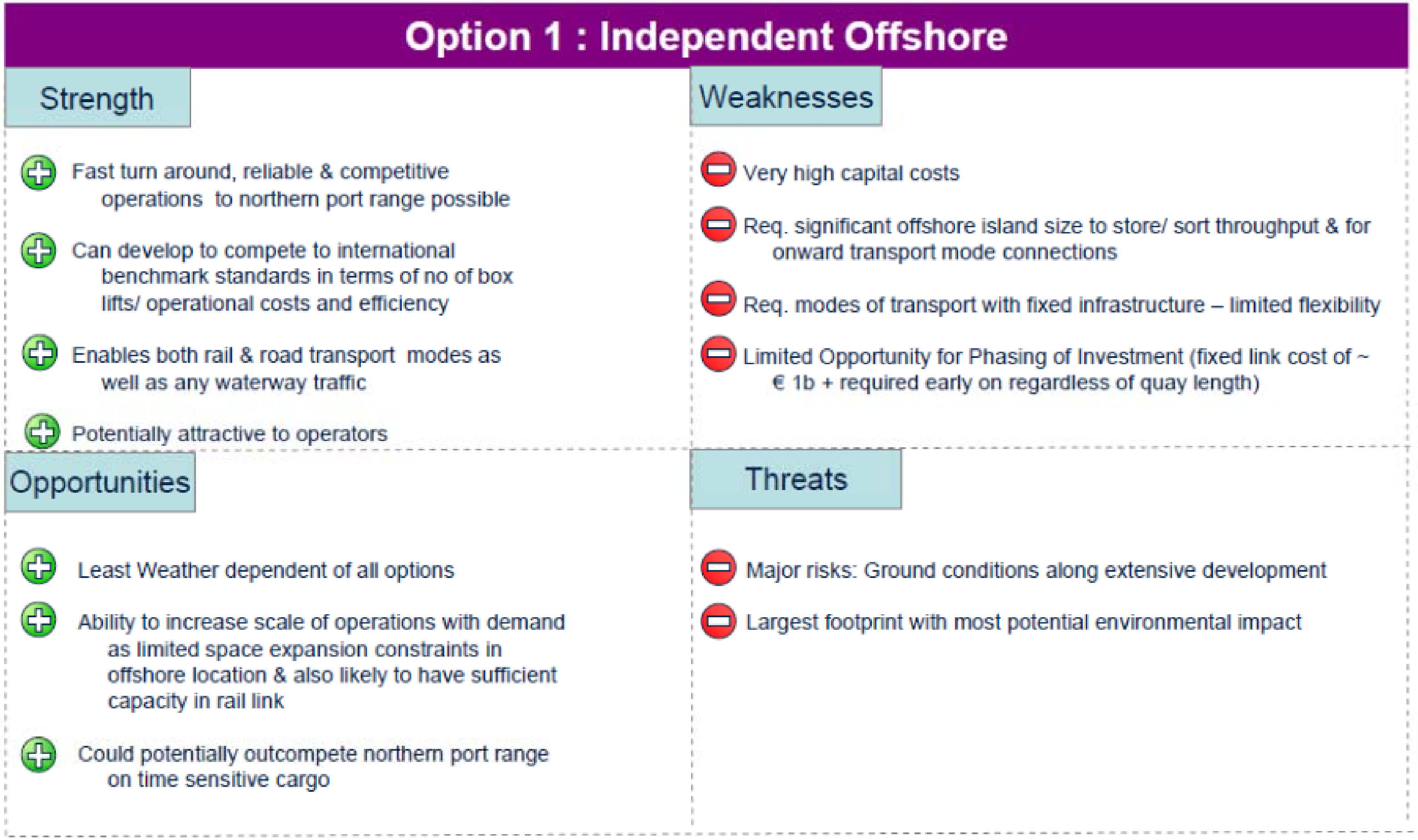



**Figure 5-3 SWOT diagram for the option 1 – independent offshore terminal**

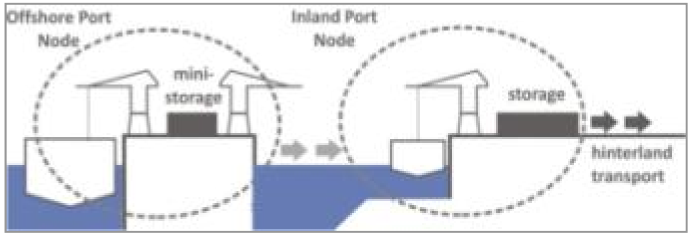



**Figure 5-4 Concept of an offshore/ onshore terminal with a waterway link as a transport node**

## Option 2 - Offshore/ Onshore Terminal

The offshore/ onshore terminal concept has been envisaged to function in a symbiosis where activities are split between the offshore and onshore terminals based on a pragmatic approach to requirements:

- All cargo is received at the off-shore island to enable large post-Panamax vessels to call
- All cargo is transported to on-shore terminals where it is sorted and then placed on the final transport mode for inland distri-bution
- The process works vice versa for export

A prerequisite for this mode of operation is the seamless integration of the offshore and onshore terminals, requiring a high degree of planning, reliability and cooperation. There are several transportation modes possible to connect the offshore to the inland terminals: waterway, rail and road.

## Option 2A – Offshore/ onshore terminal with a Waterway link

The concept option 2A comprises of a waterway link that transfers containers from the offshore terminal to the onshore terminal using barges or other types of water craft. Please refer to Figure 5-4 which provides a sketch of this operational concept.

Key disadvantages of this concept are:

1. The relative weather/ wave climate dependence that could affect operational reliability
2. It is potentially less attractive to operators due to its complexity, operational cost, risk and novelty of operation
3. The scheme increases the congestion and traffic on the already busy routes between the Malamocco lagoon inlet and Marghera

Key advantages of this option are:

1. The relative low impact on the environment due to smaller footprint of infrastructure, especially within the protected lagoon
2. The flexibility in terms of routing and allowing additional inland terminals to participate in the onward transport chain
3. The flexibility in terms of phasing of investment

Please refer to Figure 5-5 which provides an overview plan for two possible concept layouts for the offshore terminal. Figure 5-6 provides an overview of the key strength, weaknesses, opportunities and threats for this option.

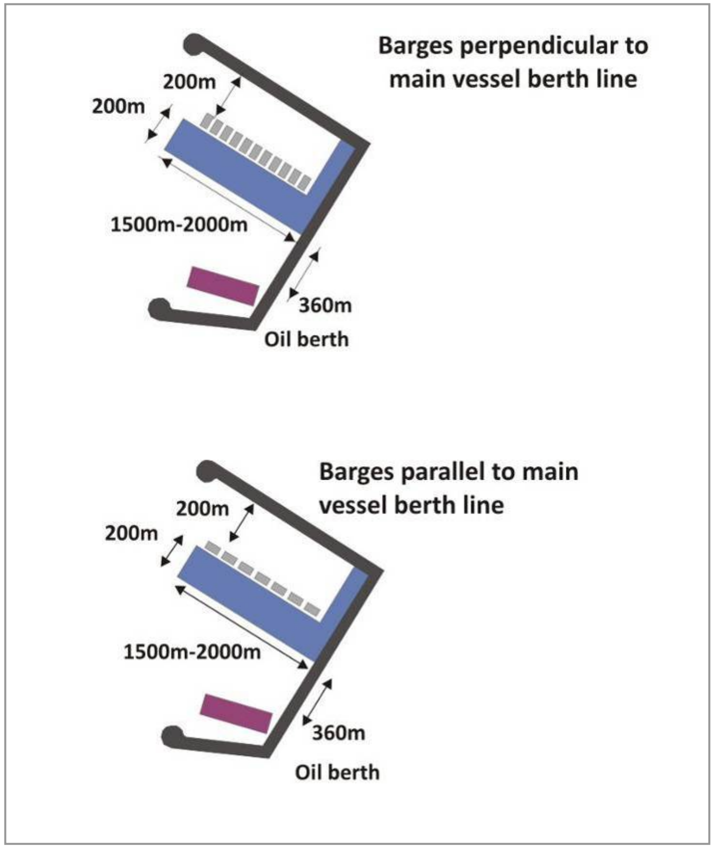



Figure 5-5 Potential concept layouts option 2A

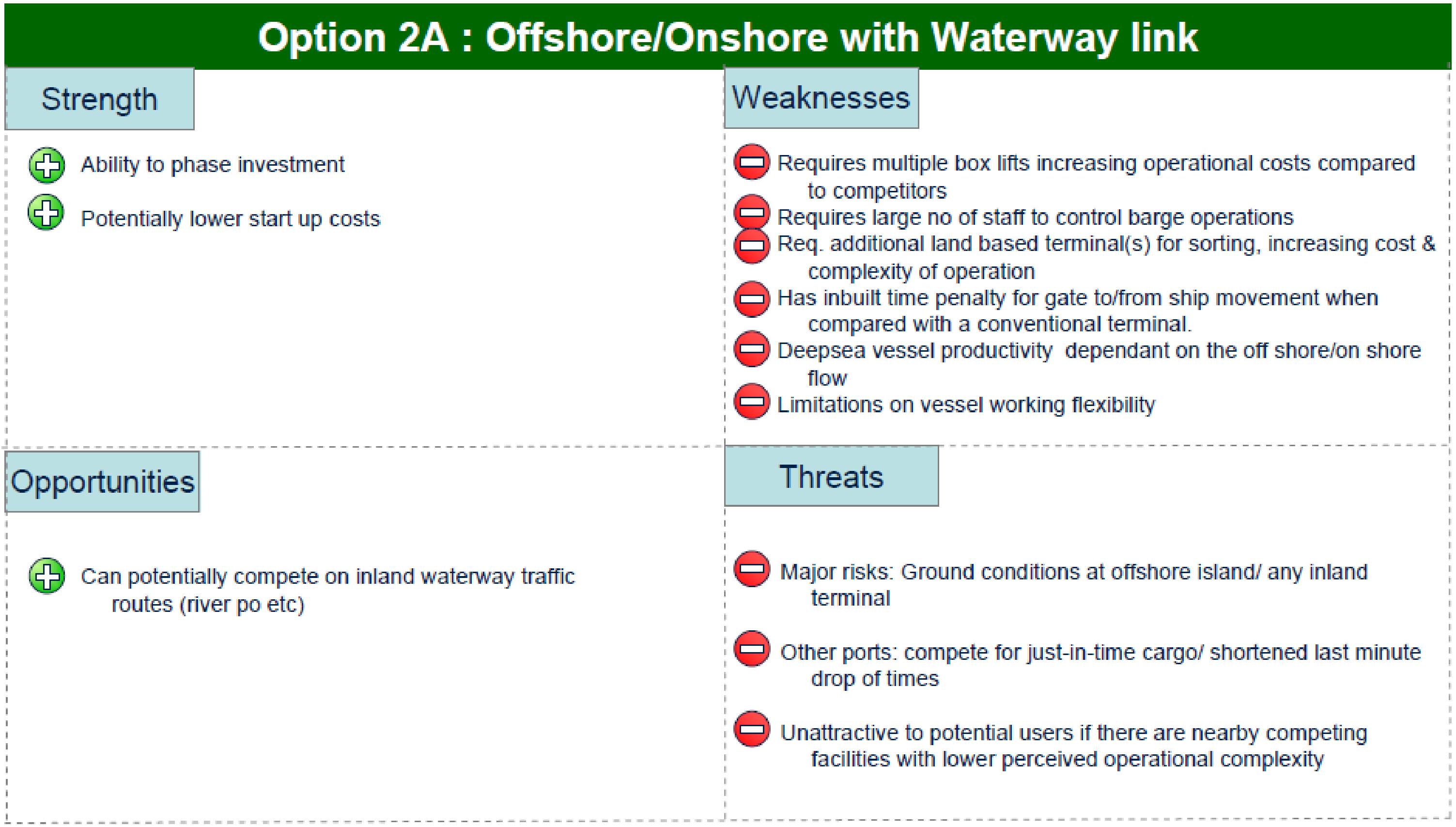



**Figure 5-6 SWOT diagram for the option 2A – offshore onshore terminal with waterway link**

### Option 2B – Offshore/ onshore terminal with a Rail link

Option 2B comprises of an offshore/ onshore terminal with a rail link between to permit the transfer of containers to inland terminals for processing.

A prerequisite of this option is the need for infrastructure to support the rail track connection. This would require tunnels and/ or bridges to connect the mainland to the offshore terminal.

Key disadvantages of this concept are:

1. The limited ability to phase the upfront cost as a connection to the mainland is required for operation regardless of the throughput levels achieved
2. Double handling of containers makes this operationally more expensive than conventional container operations
3. It is potentially less attractive to operators due to its complexity, operational cost, risk and novelty of operation

Key advantages of this concept are:

1. Fast and reliable connection from the offshore terminal to the mainland reducing potential reliability risks

Please refer to Figure 5-7 which provides an overview plan of two possible concept layouts for the offshore terminal. Figure 5-8 provides an overview of the key strength, weaknesses, opportunities and threats for this option.

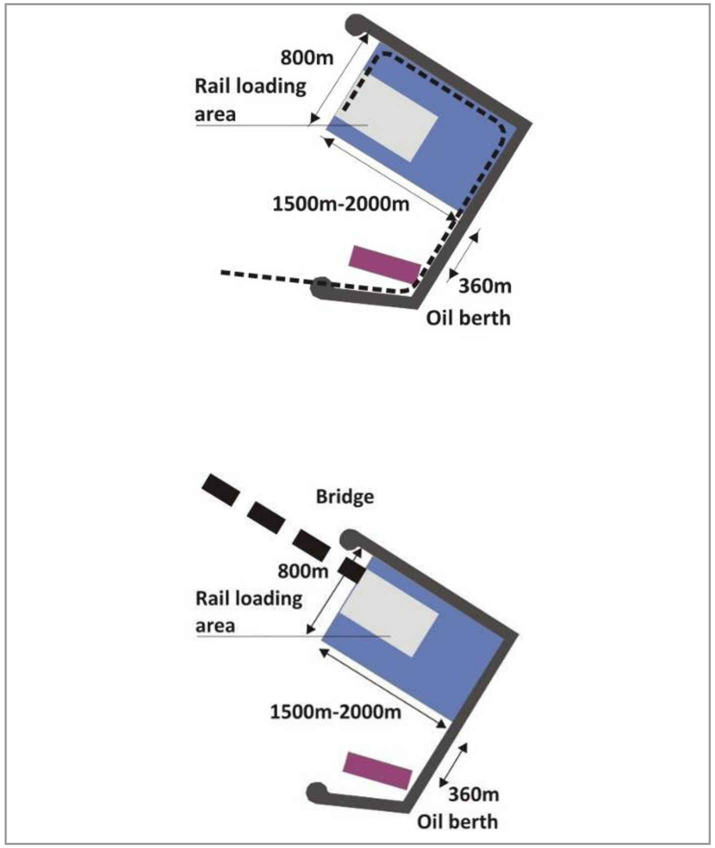



**Figure 5-7 Potential concept layouts for option 2B**

## Option 2B Offshore/Onshore with Rail link

### Strength

- Fast & reliable offshore/onshore connection

### Weaknesses

- Very high initial capital costs
- Req. significant offshore island size for onward transport mode connection
- Req. modes of transport with fixed infrastructure – limited flexibility
- Limited Phasing
- Requires multiple box lifts increasing operational costs compared to competitors
- Req. additional land based terminal(s) for sorting, increasing cost & complexity of operation (difficult to sort by vessel bay for optimised loading)

### Opportunities

- Least Weather dependent of all options
- Ability to increase scale of operations with demand as limited space expansion constraints in offshore location & also likely to have sufficient capacity in rail link

### Threats

- Major risks: Ground conditions along extensive development
- Large footprint with significant potential environmental impact
- Other ports: compete for just-in-time cargo/ shortened last minute drop of times

**Figure 5-8 High-level SWOT diagram for the option 2B - Offshore/Onshore system with a rail link**

### Option 2C – Offshore/ onshore terminal with a Road link

Option 2C comprises of an offshore/onshore terminal that is connected with a road link between to enable the transfer of containers. Similar to the rail link option, a prerequisite for this option is the need for infrastructure to support the road such as tunnels and/ or bridges.

However, in addition to this requirement, a road link requires trailer trucks or similar to move containers backwards and forwards between the offshore terminal and the inland terminals. A consequence of this requirement and the low carrying capacity of transfer units is that this option is less fuel efficient and relatively labour intensive.

Key disadvantages of this concept are:

1. The limited ability to phase the upfront cost as a connection to the mainland is required for operation regardless of the throughput levels achieved
2. Double handling of containers makes this operationally more expensive than conventional container operations
3. It is potentially less attractive to operators due to its complexity, operational cost, risk and novelty of operation

Key advantages of this concept are:

1. Fast and reliable connection from the offshore terminal to the mainland reducing potential reliability risks

Please refer to Figure 5-9 which provides an overview plan of two possible concept layouts for the offshore terminal. Figure 5-10 provides an overview of the key strength, weaknesses, opportunities and threats for this option.

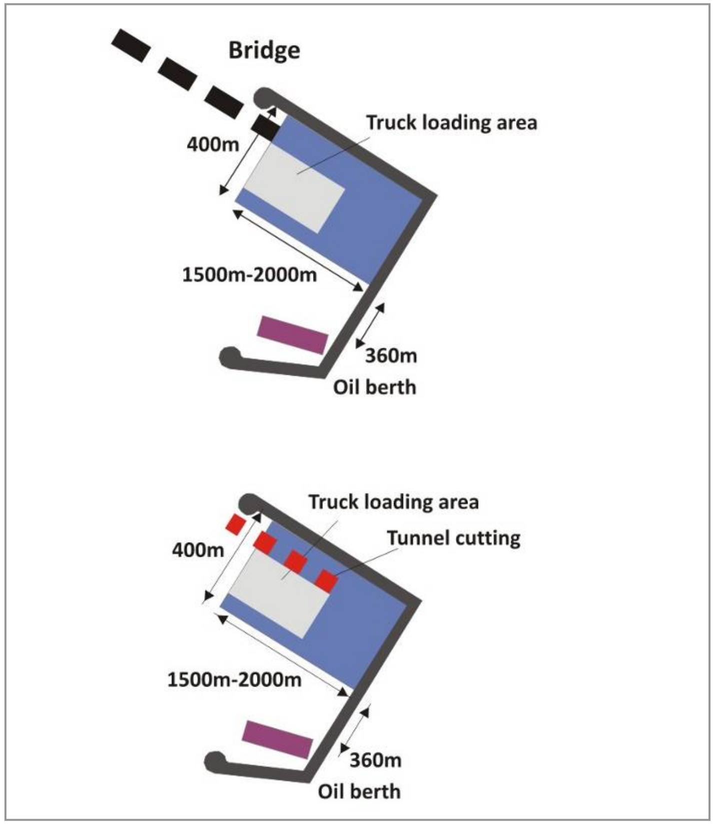



**Figure 5-9 Potential concept layouts offshore for option 2C**

## Option 2 C: Offshore/Onshore with Truck link

### Strength

- Fast and reliable operations
- Reduced offshore island size reducing cost & impact

### Weaknesses

- Very high initial capital costs
- Req. modes of transport with fixed infrastructure – limited flexibility
- Limited Phasing
- Requires multiple box lifts increasing operational costs compared to competitors
- Req. additional land based terminal(s) for sorting, increasing cost & complexity of operation (difficult to sort by vessel bay for optimised loading)

### Opportunities

- Dependent on fixed infrastructure choice can be resistant to weather dependency

### Threats

- Major risks: Ground conditions along extensive development
- Large footprint with significant potential environmental impact
- Other ports: compete for just-in-time cargo/ shortened last minute drop of times

**Figure 5-10 High-level SWOT diagram for the option 2C - Offshore/Onshore system with a road link**

## Combinations

In addition to the options 2A, B and C a variety of combinations of options are possible such as the combined rail and road link to the mainland with an offshore/ onshore terminal. These combinations have not been considered further as the relative advantages and cost in comparison with option 1, the independent offshore terminal, appeared to be marginal.

## SWOT analysis

High level indicative costing has been undertaken to establish which options are most likely to be feasible and which would therefore merit further investigation. The costing undertaken utilizes simplified high level unit costs that are meant to enable indicative relative comparison of options rather than absolute costs.

This analysis reveals that both the independent offshore terminal and the onshore/offshore system with a waterway link are likely to be more viable than the road or rail fixed link options. The independent offshore terminal is likely to have the lowest operating cost, whereas the offshore/ onshore system with a waterway link is likely to have the lowest capital infrastructure costs, refer to Figure 5-11.

After considering the relative merits of each scheme it was agreed with VPA to further investigate a waterway based option as it has the least environmental impact and enables phased development (refer to Figure 5-12).

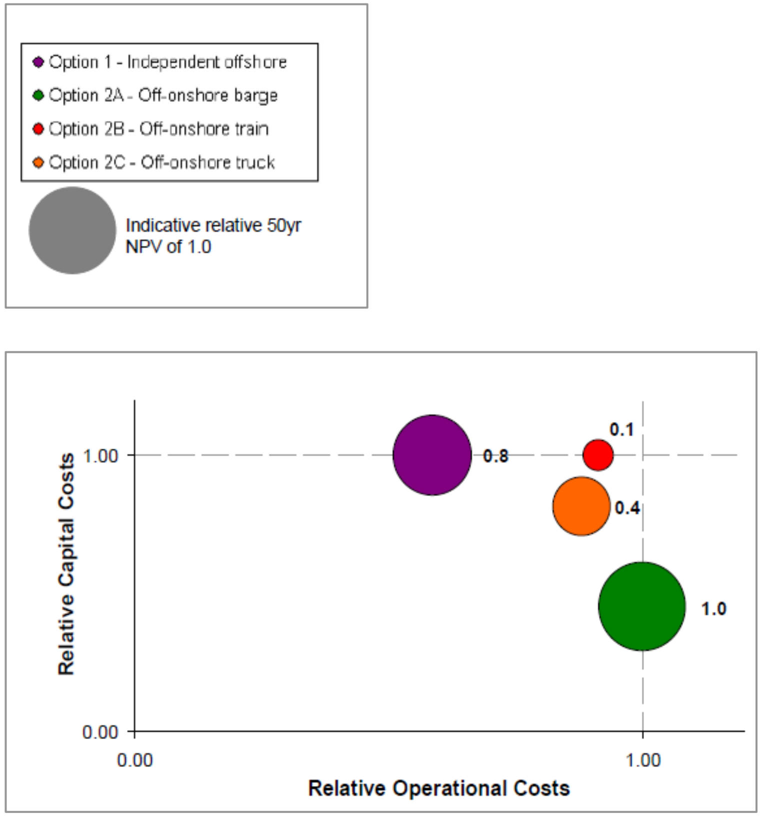



**Figure 5-11 Relative indicative costs of options**

| | Option 1 Independent Offshore | Option 2 Offshore/ Onshore system: A - Waterway | B - Rail | C - Truck |
|---|---|---|---|---|
| Costs | (−) Very High initial capital costs<br>(−) Limited Phasing<br>(+) Low operating costs | (−) High operating costs<br>(+) Potentially lower start up costs<br>(+) Phasing possible | (−) Very High initial capital costs<br>(−) Limited phasing | (−) High initial capital costs<br>(−) Limited Phasing |
| Space | (−) Req. significant offshore island size for throughput<br>(+) Co-location enables synergies | (+) Minimises space on offshore island<br>(−) Req. other terminals | (−) Req. significant offshore island size for terminal in addition to land based terminals | (−) Req. terminal on offshore location in addition to land based terminals |
| Operations | (+) Competitive ops possible<br>(+) Int. Benchmark standard<br>(+) Potentially attractive to operators | (−) Req. multiple box handling<br>(−) Req. Seamless chain<br>(−) Limitations on flexibility | (−) Req. multiple box handling<br>(−) Req. Seamless chain | (−) Req. multiple box handling<br>(−) Req. Seamless chain<br>(−) Req. large no of trucks/ trailors |
| Environment | (−) Largest footprint with most potential impact<br>(−) Req. modes of transport with fixed infrastructure | (+) Least footprint<br>(+) Flexible infrastructure | (−) Req. fixed infrastructure | (−) Req. fixed infrastructure |
| Other | (−) Major risks: Ground conditions along extensive development<br>(+) Can scale up ops Least Weather dependent | (−) Inbuilt time penalty<br>(−) Weather dependent Complex<br>(+) Compete on river routes | (−) Major risks: Ground conditions along extensive development Inbuilt time penalty<br>(+) Can scale up ops<br>(+) Less Weather depend. | (−) Major risks: Ground conditions<br>(−) Scale up of ops limited Weather dependent |

Score Legend: Low High

**Figure 5-12 High-level comparison of key features of options**

# 6. PREFERRED OPTION – WATERWAY

In order to define a possible waterway system suitable for the offshore/ on-shore concept at Venice, the following perceived key issues were considered:

- Local environmental conditions
- Operational considerations
- Economic considerations
- Flexibility

## Local environmental conditions

Any proposed waterway transport system must cope with the local wave climate offshore and remain reliable. This means coping with waves that are higher than typical river barge systems permit (>1.5m to 2m) for a short section of transport between the offshore terminal and the entrance of the lagoon.

Further, there are strong cross currents in the approach of about 5knots, with an allowable speed in the channel in the lagoon of 10knots.

In addition, the channel width and depth within the lagoon is constrained limiting the size and frequency of any waterway vessel system.

## Operational considerations

Any proposed system should enable operators to meet customer expectations. These typically include but are not limited to the following:

- No terminal imposed delays to mainline vessels
- No terminal imposed delays on the landside interface
- Approximately 15% of cargo should be available for pick up 24hrs after discharge is complete
- Drop off times of up to 12-24hrs before departure from mainland must be allowed for a percentage of cargo

- The majority of export cargo is likely to be dropped off at the terminal in the period of 7 days to 1 day before expected ship arrival,

In addition to these requirements, any system would need to provide the ability to cope with unexpected events and constraints that are outside the operators control such as:

- Unreliable estimated time of arrival for mainline or feeder vessels
- Various combinations of vessel size/ container exchange/ discharge only/ load only / optional loading calls
- A variety of receiving and redelivery times
- Late planning information

## Economic considerations

Any proposed system should be able to transport a large volume of containers to achieve economies of scale, but be capable of meeting the service levels expectations of customers (see section 0. Operational considerations) and fit within the river/ channel system. (see section 0.Local environmental conditions)

Further, any proposed system should minimise double handling (as this introduces cost) and minimise equipment and manpower requirements.

In particular, given the distance of the offshore terminal to the shore, the usage of staff offshore should be limited as much as possible as travel time will be significant.

## Flexibility

Any proposed system should be flexible such that it could be scaled in size to handle changes in throughput or enable different hinterland waterway terminals to be served.

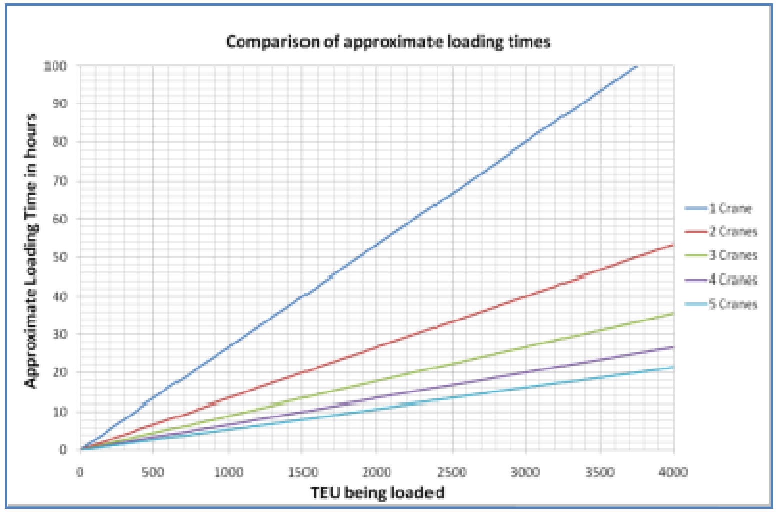
This means that it should facilitate waterway transfer vessels to call at several inland terminal locations with varying degrees of waterway accessibility, having implications for the maximum draft, beam and length of vessels to be used.

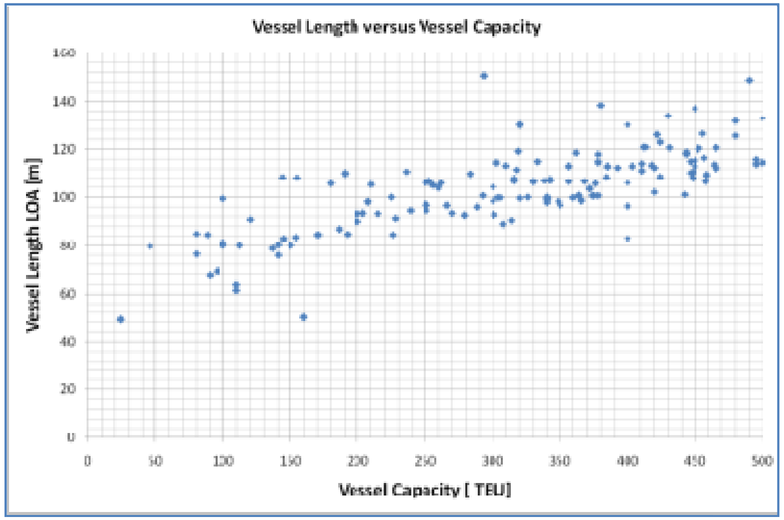
## Waterway Options Considered

A number of waterway based systems were considered at a strategic level in relation to requirements including:

- Conventional barge systems
- Conventional roll on –roll off systems
- Special equipment such as “fast-net” cranes or “bridge cranes” to increase turnaround times
- Special berthing alignment
- Special waterway vessels

It should be noted that the choice of waterway transfer mechanism impacts the possible methods of operating the terminals.




after 1980

## Conventional barge systems

Conventional barge systems are well established for river or short sea transport; however they are typically designed for relatively long distances compared to the waterway system required at Venice.

The travelling time for a barge from the offshore terminal to the terminal at Monte/Syndial is estimated to be approximately 150 minutes or about 2.5 hours.

A typical crane capacity for containerised cargo is approximately 20 to 30 moves per hour with conventional cranes. Each move represents on average approximately 1.5 TEU being lifted if single cycles are being used i.e. one box is lifted or discharged per cycle with a TEU to Box ratio of 1.5. This leads to a loading capacity per typical crane of about 30 to 45 TEU per hour excluding hatch cover moves.

Typically, mainline vessels are served by 4 to 5 cranes working simultaneously to enable the mainline vessel to complete the call and be turned around in 16- to 24hours.

In the offshore/onshore concept after the discharge of the mainline vessel, the cargo needs to be loaded onto a waterway vessel and discharged at a hinterland terminal such as Monte/Syndial. Thus the cargo needs to be both loaded and discharged multiple times requiring more time than a conventional container terminal to complete the process.

Considering the serviceability requirements, the likely drop off times in the terminal and the need to load and discharge the cargo multiple times, it becomes clear that barge capacities of more than 1000 TEU and probably more than 500 TEU are likely to be not feasible (see also Figure 6-1).

Further, it should be noted that vessels of that capacity are significantly shorter than mainline vessels. See the Figure 6-2 which indicates a vessel length of about 80 to 150m. Hence, the number of cranes working these on a conventional berth is lower than a mainline vessel with a length of 300 to 400m as too closely spaced cranes start interfering with each other. With this length 2 to 3 cranes may operate, resulting in a lower productivity and slower turnaround time.

Further, typically seaworthy barge systems or coasters have hatch covers to provide stability and increased storage and lashing systems holding the containers in position. However, the removal and subsequent re-stowing of hatch covers as well as the lashing and unlashing of containers uses valuable time which means the serviceability criteria of customers requiring late drop off or early pick up of cargo are further negatively affected.

Some river systems avoid the need for lashing or hatch-covers such as push-tow barge systems. However, these would not be suitable as a reliable transport means for the short section of transport between offshore terminal and the lagoon due to the wave climate exceeding permissible river barge systems for significant periods of time.

## Conventional roll on-roll off systems

Conventional roll on and roll of systems are used in short sea journeys such as between Ireland and UK. An advantage of these systems is the relative speed of discharge and loading at either end. Containers would be loaded onto a cassette or chassis and placed with tractors which connect to these.

However, a key disadvantage of these systems is the need for drivers to move each of the containers in and out of the vessel increasing staff costs offshore.

Further these kind of systems require a large amount of marshalling space and storage to store containers ready to be loaded on the waterway system as stacking is not possible. Given the proposed throughput volume in the full built out, this is a major drawback.

**Figure 6-3 Ipswich Ro-Ro**


**Figure 6-4 Cassette units, image reproduced from TTS marine.com**

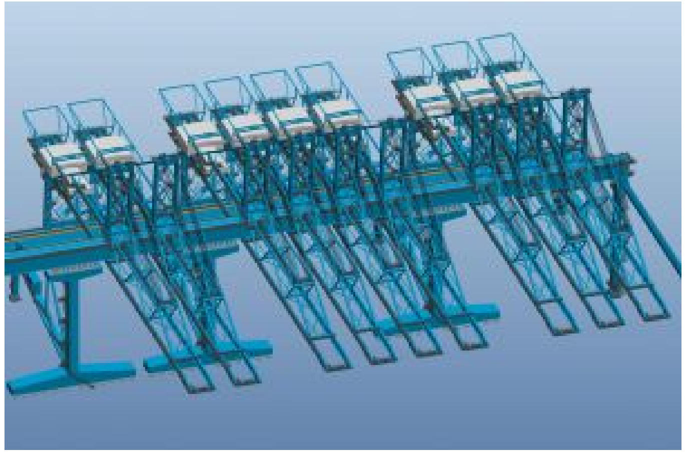


Figure 6-5 Fastnet cranes as developed by APM Terminals

Figure 6-6 Typical Standard Ship to Shore Crane serving mainline vessel

## Special cranes systems

Special cranes may be utilised in combination with various waterway systems to improve productivity and hence turnaround speed and efficiency.

"Fastnet" cranes, a crane concept developed by APM Terminals provide the ability to space cranes closer together. This results in overall increased productivity and hence reduces turn around speeds and the number of vessels required to provide the offshore/ onshore terminal service link. Refer to Figure 6-5 showing "fastnet cranes" and compare this to Figure 6-6 a typical standard ship to shore crane layout.

The "fastnet" cranes are not yet in service and are hence not tried and tested. Further, they are relatively costly compared with standard cranes due to the increased steel requirement.

Finally, this method of loading is similar to conventional cranes in terms of transfer equipment required: the cranes must have containers that are ready to be loaded or can be received for discharge underneath the crane beam and hence another mechanism that transfers these into the buffer stack is required such as straddle carriers or automated guided vehicles. Since there are more cranes in operation than with a conventional system, more transfer equipment is required to keep up with the increased pace of operation increasing cost.

## Buffer Storage and it's implication for cranes

It should be noted that for operational reasons a buffer storage is essential on the offshore terminal as containers have to be loaded in specific holds and by weight in the mainline vessel (dependent on the following ports of call and stability) resulting in an optimised loading sequence for each mainline ship to shore crane for productivity.

Customers expect to be able to inform the terminal operator approximately 24 hours before estimated ship arrival of the number of containers to be exchanged and only 12 hours before arrival to confirm the ship plan.

Thus the load and discharge sequence is only finalised at this late stage. However, due to the time delay imposed by the offshore/ onshore concept due to travelling time and multiple loading, buffer storage is essential as this will enable sequencing of containers as required for each crane and ensure the majority of containers are present by the time the mainline vessel calls to ensure a smooth and continuous container exchange.

In effect, the multiple loading of containers in the offshore/ onshore concept can be utilised to direct containers to the buffer stacks near the allocated mainline berth which is typically allocated 48 hours before ETA. This then reduces the distance travelled on the terminal by the container increasing efficiency.

The buffer storage could be serviced by conventional rail mounted gantry cranes or by rubber tyre gantry cranes. However, both of these systems require an interim connection between the waterway crane and the stack, often provided by straddle carriers or other transport vehicles such as tractor trailers or automated guided vehicles.

An alternative to this is the combination of the stack crane with the waterway crane to reduce double handling and to remove the need for a transfer mechanism between the two via straddle carriers or similar. This concept is referred to as a bridge crane in this report. See Figure 6-11 and Figure 6-9 for a concept overview of both a conventional crane system serving a buffer stack offshore and the bridge crane system serving the offshore terminal.


**Figure 6-7 Typical rubber tyre gantry crane serving a stack**

**Figure 6-8 Transfer between ship to shore cranes to stack crane, here performed by tractor trailer units**

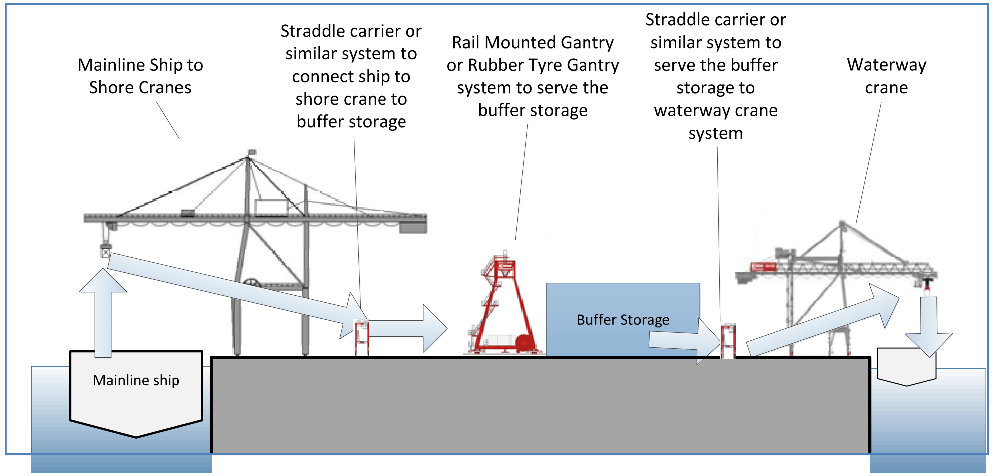



**Figure 6-9 Concept sketch of a offshore/onshore terminal with bridge crane**

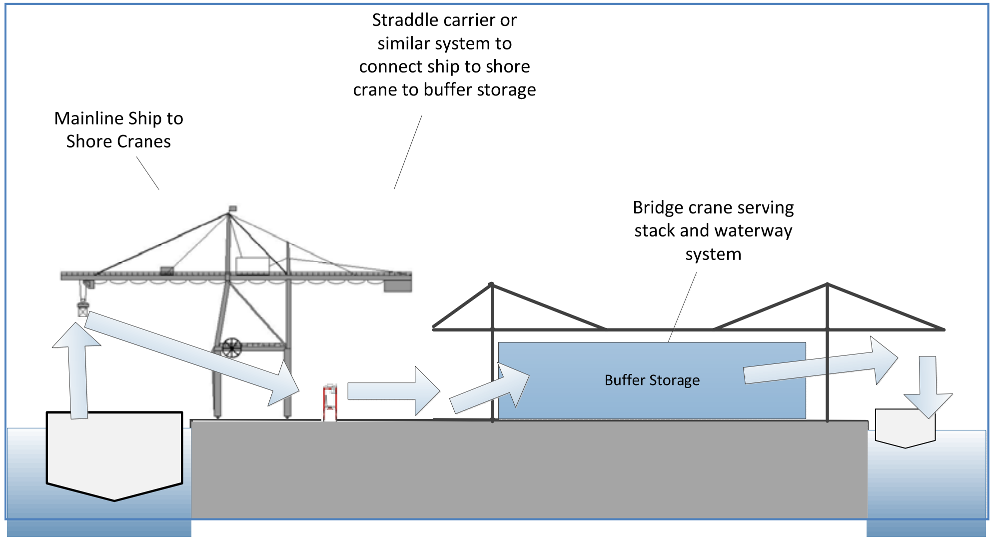



**Figure 6-11 Concept sketch of a offshore/onshore terminal with conventional equipment**

## Bridge cranes

The bridge crane concept referred to in this report is the combination of an overhead stacking crane for the offshore buffer with the loading crane for the waterway system. It is noteworthy that Singapore's Pasir Panjang Container Terminal operates an automated overhead bridge crane serving the yard (Figure 6-12). How-ever this crane does not connect to barges as it is proposed here.

This combination removes the requirement for an interim transfer mechanism, thus reducing the number of different equipment required offshore and reducing the space requirement.

Automation of this sequence of transport may be possible reducing the personal requirements offshore, with an automated straddle carrier or similar picking up/ dropping containers at the mainline ship to shore crane (controlled by personal) transferring this to a position underneath an automated bridge crane, the automated bridge crane picking up the container and storing in the temporary buffer until further loading onto the waterway transfer system.

Rotation of the container by 90 degrees during the buffer storage process can be avoided whilst enabling parallel stowage in the barge increasing productivity and enabling flexibility.

It should be noted that whilst this concept builds on established principles and technologies and is likely to result in a fast turnaround of waterway vessels, it is not a tried and tested concept and thus carries innovation risks.

## Special berth alignments

Special berth alignments may be used to improve productivity such as perpendicular berth faces rather than the standard parallel berths. An example of such a berth interface is the “indented berth” in Amsterdam which is capable of supporting 9 cranes working on a single vessel increasing productivity.

At the offshore terminal, the concept of indented berths is possible for the waterway transfer system to increase turnaround speed. In particular, a crane system could be devised that may serve both the waterway transfer system as well as the stack subject to the size (beam and length) of the waterway system.

However, a significant drawback of this kind of solution is the limited ability to replicate this “indented” berth alignment at the onshore terminals such as Monte/Syndial.

The channel width at the proposed Monte/Syndial terminal site is limited to 190m whilst requiring two side basin usage. The terminal width

**Figure 6-12 Automated overhead bridge cranes at Pasir Panjang Container Terminal Singapore (note these do no have a barge crane end and only serve the yard)**


**Figure 6-13 Indented berth at Amsterdam Container Terminal, Image from Google Earth Pro**

**Figure 6-14 LASH vessel**


**Figure 6-15 SEABEE vessel**

available is approximately 600m. Hence, the space for turning vessels, berthing these and providing space for storage and other standard terminal operations is likely to be insufficient.

## Special waterway transfer systems

A special waterway transfer system that may be useful in the offshore/ onshore terminal concept is that of a barge-carrying ship. These vessel transport other vessels such as unpowered river barges across the open sea to sheltered areas.

This has the advantage of removing the need for a large number of powered, seaworthy and manoevrable barges in the waterway transfer system and thus potentially reducing the overall staffing required. The main vessel would transfer barges between the offshore and onshore terminal, loading pre-assembled barges at each end. However, it is an essential requirement that barges could be loaded fast and that the main carrier vessel should fit the waterway. There are four main types of barge carrying vessels :

1. LASH vessels
2. SEABEE vessels
3. BACO liner vessels
4. CONDOCK vessels

These vessels are sometimes referred to generically as LASH vessels, kangaroo vessels, barge carriers or lighter transport ships.

## LASH vessels

The LASH concept, the Lighter aboard ship system (LASH), was developed in 1968 and included cranes on the LASH barge to load river barges. However, due to the advent of containerised shipping, removing the need to move entire barges, but enabling the transfer of bundled cargo in the form of containers, this system did not flourish.

## SEABEE vessels

The Seabee vessels carries lighter barges on its deck and lifts these up with a platform at the stern that acts like an elevator. These vessels are typically larger than LASH vessels and have a carry capacity for 38 barges.

## BACO liner vessels

The BACO liner vessel operates like a floating dock with water ballasting. Barges are floated through bow doors into the carrier when the main vessel is lowered, once the doors have been closed the BACO liner is de-ballasted and can voyage to its destination. Several tiers of containers onboard the barges can be carried by this system.

## CONDOCK vessels

The CONtainer DOCKing vessel (CONDOCK vessel) has a large hold which can be loaded from above using its own lifting gear, external cranes or via stern ramps. Containers can be carried in three tiers on deck. Ballast tanks can be used to turn the vessel into a floating dock and take on board floating cargoes such as loaded barges. Sometimes these vessels are referred to as float on float off vessels.


**Figure 6-16 BACO Liner**

**Figure 6-17 CONDOCK vessel**

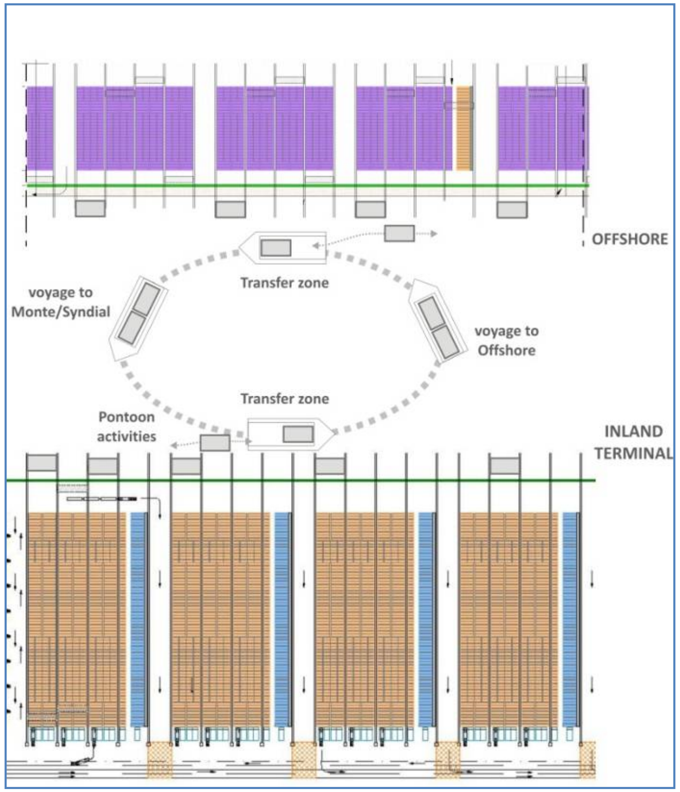



**Figure 6-18 Schematic of offshore/ onshore terminal in a waterway link based on preferred option of a lighter transport vessels ("mama" vessel) carrying unpowered barges combined with bridge cranes**

## Preferred Waterway Transport System

The merits of the various systems in relation to the requirements were discussed with VPA during workshop 3. It was agreed to investigate a waterway transport system based on:

- ship to shore cranes,
- automated straddle carriers
- bridge cranes combined
- with a barge carrying vessel of the CONDOCK type but without its own cranes.

Refer also to Figure 6-18.The main reasons for this choice were:

1. The service level provision to mainliners should be excellent/ competitive and hence Ship to Shore cranes combined with straddles which drop the boxes or pick them up decouple the types of equipment resulting in delays in one not affecting the other and thus continuity of transfer with potentially very high productivity

2. Straddles that are automated to reduce the number of staff required offshore
3. Bridge cranes that are automated to replace conventional systems to achieve high productivity to meet customer service expectation, to reduce the number of types of equipment and to reduce the amount of staff required offshore
4. CONDOCK type vessels (float on float off) with unpowered barges to reduce the amount of staff required to drive vessels, to provide sea worthiness without extensive lashing, to enable maneuvering in the restricted channel and lagoon, to provide flexibility of serving other destinations and other barge sizes, and to increase turn around speed in the loading process

In the remainder of this report the main vessel carrying the barges is referred to as “Mama vessel” for simplicity.

# 7. DEFINITION OF MOVEMENT SYSTEM AND OVERALL DIMENSIONS

## Introduction

In chapter 5 and 6 the concept of the offshore terminal and transfer mechanism to onshore terminals was defined. In this section, the dimensions and key characteristics of the system are considered (scope element A4)

## Characteristic Dimensions

The current disposition of the various canals and berths within the Porto Marghera complex, where the onshore terminal is to be located, impose restrictions on the size of vessels that may navigate and moor. Constraints are also imposed by the main navigation channel, the "Canale Litoraneo" between the San Leonardo Oil Refinery and Porto Marghera. A particular constraint is the limitation on dredging that is designed to protect the old city of Venice by restricting any changes to the tidal prism.


**Figure 7-1 Overiew of waterways near terminal**

The characteristic limiting dimensions of the waterways are shown in Table 7-1. While the present width of the Canal Industrial West varies from about 110m opposite the Banchina Emilia to about 100m at the western turning basin, it is proposed that the Canal be widened to 190m in connection with the development of the Montefibre-Syndial Container

Terminal to permit ships and barges to berth without impacting operations on the Banchina Emilia.

The size of any mama vessel is therefore limited by these dimensions.

Typically Panamax class ships are permitted to use the canal under one-way traffic rules, which indicates a maximum beam dimension of about 32.3m.

The length of the mama vessel is limited by the diameter of the turning basins as well as the acceptable levels of ship induced wave generation. Typically, a ratio of 1.5 to 2 times the vessel length provides a good indicator of required turning basin diameter subject to vessel manoeuvrability and environmental conditions.

Hence, in Turning Basin number 3 a vessel with a maximum length of 240m could be accommodated, but a more ideal length of 180m is considered desirable for the mama vessel. The turning area in the Canal Industrial West is smaller, reducing the allowable vessel length there to a range of 160m to 120m.

On the assumption that mama vessels will turn in Turning Basin Number 3 and proceed astern to the barge berths the limiting characteristic dimensions for the mama vessel are:

- Maximum Length - 180m to 240m
- Maximum Beam - 32.3m
- Maximum Draught - 11.5m

| Location | Location ID on Figure 7-1 | Width*1 | Depth*1 | Expected Depth*2 |
|---|---|---|---|---|
| Turning Basin in Canal Industrial West | 1 | 240m diameter | 8.5m | 10.5m |
| Canal Industrial West (proposed) | 2 | 190m | 11.5m | 12.0m |
| Turning Basin Number 3 | 3 | 360m diameter | 11.5m | 12.0m |
| Canal Litoraneo (San Leonardo to Marghera) | 4 | 80m (min 57m) | 11.5m | 12.0m |

**Table 7-1 Characteristic Limiting Dimensions for Navigation**

Sources:

*1 British Admiralty Chart 1449, Edition No 2, dated 11th Feb 2010

*2 Venice Port Authority, plans for end 2012

However, to improve flexibility of operations and to limit ship induced wave generation, a smaller overall vessel length in the range of 120 to 160m would be preferable. This would enable the second basin to be utilised for turning.

## Feasible mama vessel and barge combinations

In consultation with VPA a number of possible mama vessel and barge dimensions have been developed for further consideration.

The barge dimensions have been developed based on possible terminal stack layouts to optimise container transfer between the stack and the barge.

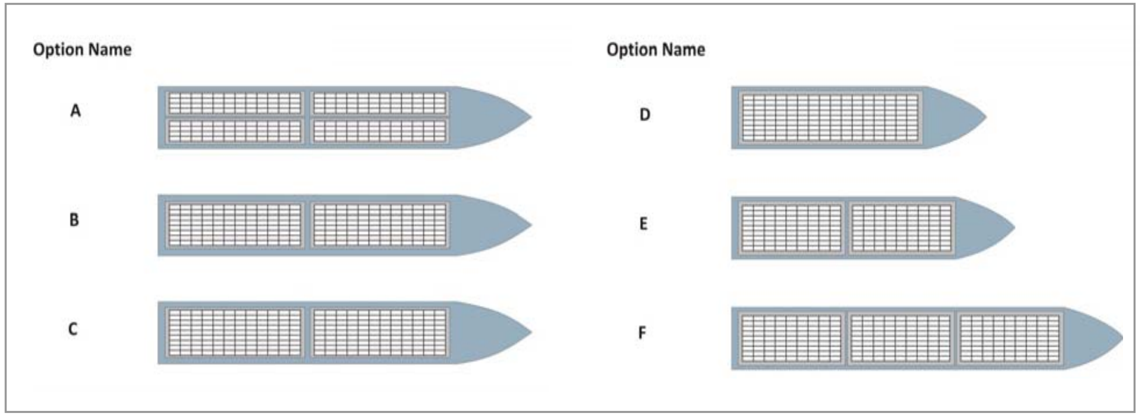



**Figure 7-2 Possible mama vessel and barge vessel configurations considered**

Multiples of two 40ft long containers for barge length have been utilised as this is equivalent to the perceived ideal width of one barge bridge crane module. Barge bridge cranes that are wider than two 40ft units would have significant spans to cover increasing bending moments induced and hence the structural requirements and cost. Shorter crane spans would increase the number of cranes required thus cost.

Unit widths of 4, 8 and 9 containers wide have been considered for the barge beam dimension. Stability of barges under loading is a key consideration, generally the wider and longer the barge the more stable it is. Further a certain length to width ratio is advantageous to improve stability and manoeuvrability.

A summary of all mama vessel and barge combinations that have been considered are presented in Table 7-1 and Figure 7-2.

| Barge variant | Height | Width | Length | Barge capacity | Indicative Barge Dimensions | Buffer stack arrangement | No of barges on mama vessel* | Mama vessel | |
|---|---|---|---|---|---|---|---|---|---|
| | (TEU) | (TEU) | (TEU) | (TEU) | (m x m x m) | | (no) | Capacity (TEU) | Indicative dimensions (m x m) |
| A | 3 | 4 | 12 | 144 | 11 x 90 x 5.75 | 5 x 3 | 4 (S+L) | 576 | 28.5 x 200 x 7.5 |
| B | 3 | 8 | 12 | 288 | 24 x 90 x 5.75 | 5 x 3 | 2 (L) | 576 | 28.5 x 200 x7.5 |
| C | 3 | 9 | 12 | 324 | 26.5 x90 x 6.3 | 5 x 3 | 2 (L) | 648 | 31 x 200 x 7.5 |
| D | 3 | 9 | 16 | 432 | 26.5 x 120 | 4 x 4 | 1 | 432 | 31 x 140 x 7.5 |
| E | 3 | 9 | 8 | 216 | 26.5 x 58x5.75 | (2 + 2) x 4 | 2 (L) | 432 | 31 x 150 x 7.5 |
| F | 3 | 9 | 8 | 216 | 26.5 x 58x5.75 | (2 + 2) x 4 | 3 (L) | 648 | 31 x 210 x 7.5 |

**Table 7-2 Possible mama vessel and barge vessel dimensions**

Note: * S denotes barge placement side by side along the width of the vessel, L denotes barge placement longitudinal along the length of the vessel – see also Figure 7-2

## Barge Stability

An outline assessment of barge stability has been undertaken by a naval architect based on the project requirements. The summary results are:

Type A – Likely to be unstable given the fast paced cargo loading operations intended; therefore not recommended.

Type B – Less stability issues than type A however length of barge will require two tugs for manoeuvring into position, also will not be as stable as the following types.

Type C & D – probably the most stable of all barges due to their size; however the length is a greater concern when manoeuvring and will require two tugs for manoeuvring into position.

Type E & F – considered to be the most versatile of all barge types and will have adequate stability for the required operations. In addition, they can be operated by a single tug in all but the windiest conditions.

## Barge Dimension

In summary, the most versatile of the barges is Type E/F, being 58m in length, 26.5m beam and 5.75m deep. The loaded operating draft of the barge, based on an average TEU weights of 20 tonne, will be 3.75m approximately. Lower average TEU weight of 15t may be considered and would result in a reduction of draft.

## Tugs and Manoeuvring

For manoeuvring of the barges, a standard Daman Shipyards (Gorinchem, Netherlands) type STANTUG, or similar, would be more than adequate for manoeuvring the barges in and out of the dock of the mama vessel. Consideration could be given to utilising a wired system dependent on wind conditions.

The dock walls would be provided with winches to hold the barges in position whilst ballasting operations are undertaken onboard the mama vessel.

## Mama Vessel

The vessel design will be a combination of a lighter transport vessel and an offshore supply vessel, it will have an open dock accessed through the stern which will accommodate the requisite number of barges.

The vessel will be capable of ballasting down to deep draught to load and offload barges and then de-ballasting to a transit draught where approx 50% of the weight of cargo barge will be taken on the specially strengthened tank top of the mama vessel.

The vessel transit draught is about 5.5m and the loading draught is about 6.25m. The tank top of the vessel is at 3m above base. This gives 3.25m depth of water over the stern of the dock. If an allowance of 15 tonnes per TEU is made the operating draft of the barge will be 2.85m, giving a clearance of 0.4m over the stern of the dock.

The propulsion engines (diesel electric) will be accommodated in an engine room forward, beneath the accommodation.

Additional manoeuvrability would be provided by fitting an azimuth jet thruster forward.

Given the restriction on ship length imposed by the diameter of available turning basins and given the barge stability and manoeuvrability issues, barge type E appears to be the best solution from all the barge arrangements considered.

The Figure 7-3 provides an indicative layout of typical mama vessel for option E.

The estimated steelweight for the mama vessel suitable for two Type E/F barges, would be circa 5,500 tonnes; the required propulsive power for 15 knots being circa 6mW.

## Operational characteristics of transfer system

The loading programme for the transport vessel would be as follows:

1. Arrival at offshore port with barges at approximately 5.5m transit draft
2. Ballast vessel down to undocking draft of 6.25m
3. Discharge barges
4. Load full barges with containers
5. De-ballast vessel to transit draft of approximately 5.5m.
6. Transit to Venice Lagoon and terminal
7. Arrive at terminal
8. Ballast down to 6.25m
9. Discharge barges
10. Load barges
11. De-ballast to transit draft of 5.5m

In the transit condition, the barges will be 'grounded' in the dock of the transport vessel and will be further secured in position by tirfors. The barges will remain grounded throughout the transit due to negative buoyancy and will become afloat again when the transport vessel is ballasted down.

At all times, both the transport vessel and barges have more than adequate stability reserves to ensure safe transit.

## Traffic restrictions on mama vessel

The proposed widening of the Canal Industrial West at the new Montefibre-Syndial container terminal to 190m will provide sufficient clearance for mama vessels to pass other moored vessels at both the Banchina Emilia and the new terminal.

The beam of the mama vessel indicates that it might be subject to one-way-traffic rules in the Canal Litoraneo.

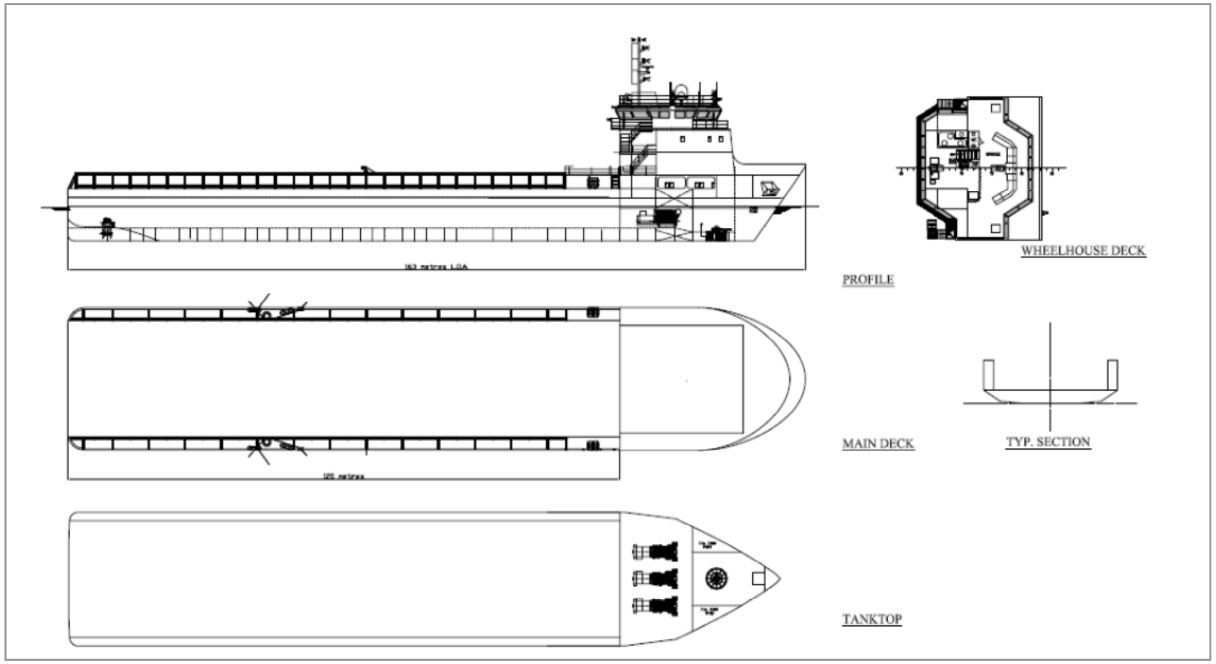



**Figure 7-3 Typical indicative mama vessel layout**

## Fuel consumption

Due to the similarity in beam of all mama vessels, the fuel consumption will be comparable across all sizes. The shorter mama vessels may use up to 10% more fuel due to the increased length/breadth ratio. On the basis of required power of about 5,000kW, fuel consumption is likely to be of the order of around 1,000 litres per hour at full load at 15knots transit speed.

For sections in the lagoon where the transit speed is reduced, fuel savings of approxiumatly 25% could be achieved.

# 8. LOGISTIC SIMULATION MODELLING

## Introduction

This section of the report responds to the following scope elements of the project:-

**A5) definition of an operating model and calculation of the movement times** in the various phases of the logistical chain relating to the various lay-out and facilities scenarios. The operating model must include transfers to and from the Monte/ Syndial terminal and to and from other shore-based terminals as agreed during the study.

**A9) assessment of** critical points and nodes that could affect flow of goods within the entire cycle, from the ship to land transport, and actions to optimise this cycle;

This chapter of the report provides description of the model, assumptions, scenarios tested, findings, results of the sensitivity tests and recommendations concerning the most promising barge/ship configurations.

## General approach

It was agreed that the simulation modelling would evaluate the logistics cycle for the transfer of containers between the offshore terminal and the proposed Monte/ Syndial container terminal and another similar onshore terminal. Containers are moved by dumb (i.e. non-powered) barges that are loaded and unloaded by specially designed bridge cranes that can service both the barge berths (via outreach booms) and the adjacent stack located at both the island and the mainland. Barges are manoeuvred by tugs onto semi-submersible “mama” vessels which then transfer the barges between the offshore terminal and the onshore terminals and vice versa.


**Figure 8-1 ARENA simulation model**

## Traffic Simulation Software

The traffic simulation model was developed using the traffic simulation software Arena version 9 from Rockwell Software of the U.S.A.

Arena provides a comprehensive set of tools for the development and analysis of bespoke simulation models including:

- Statistical analysis of input data.
- An extensive collection of model building logic modules.
- Animation of the modelled process.
- Tools to analyse the output from models.

The main advantage of Arena is that it allows a model to be constructed to represent the unique issues associated with the (anticipated) real life operation.

Arena has a graphical user interface that allows the analyst to drag-and-drop logic modules to create flowcharts representing the logical process or system to be represented. Once the logic has been defined, further modules may be used to define the spatial relationship between the various logical processes that comprise the model.

In Arena, operations are modelled by considering the entities that pass through the system, and the processes through which the entities pass as they proceed. The generic term entity is used to denote any person, object or thing, either real or imaginary, whose movement through the system causes changes in state of the system. In this model barges and mama vessels are entities.

The term process denotes the sequence of logical activities or operations through which the entity moves. Processes are activated by entities. In this model, processes would include voyages between the island and the mainland, manoeuvring and berthing operations etc. In addition, resources may be required to undertake particular processes, such as manoeuvring, berthing.

In general, simulation models provide output or results for a system with a given input. Simulation models are run rather than solved and therefore cannot generate an optimal solution on their own; they can only serve as tools for the analysis of system behaviour under a given set of conditions.

Figure 8-2 shows how the "flow-chart" style of the graphical interface in Arena can be used to build simulation models.

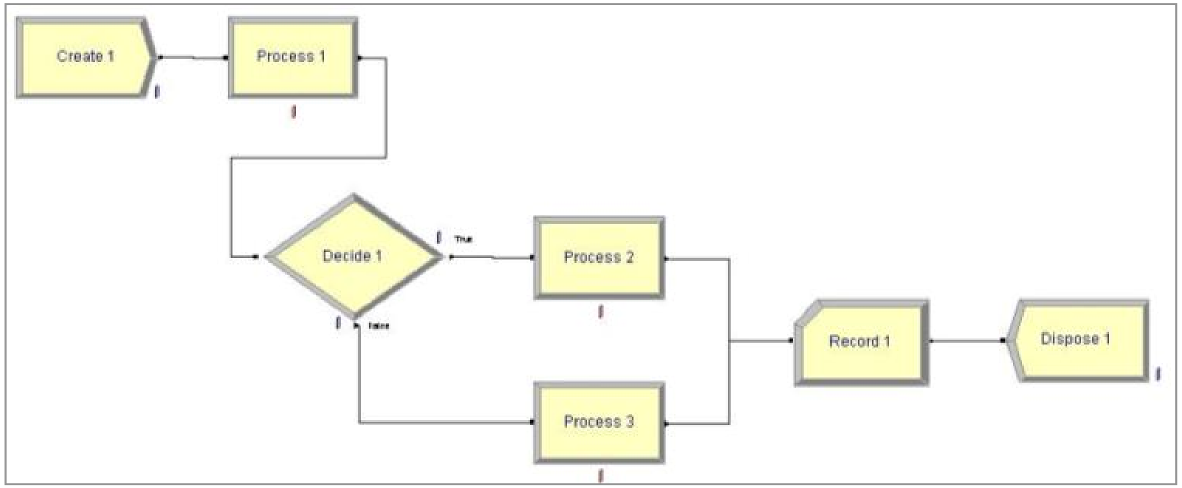



**Figure 8-2 Typical elements in an ARENA simulation model**

## Model development

Development of the model has been undertaken using a "prototyping" approach whereby a basic model is set up and then continuously refined to replicate the desired operation. Data analysis, model development, verification and validation are therefore concurrent activities, although they must be reported here in a sequential form for clarity.

Once the basic model has been set up, verified and validated, alternative scenarios were set up. These included runs that investigated the effect on throughput when additional mama vessel or barges are introduced, the impact of Mose barrier closure, or the impact of varying the barge crane speeds. The impacts of these changes may then be quantified by comparing the results with those of the basic model case.

## Model Description

### Model philosophy

The model has been designed to represent the movement of container barges between the barge berths at the offshore island and the barge berths at the landside terminal, for both import and export directions.

The limits of the model are the barge berths at the island and the barge berths at the mainland. Refer to Figure 8-3 for an overview.

The model consists of two independent model entities; namely barges and mama vessels that undergo their own separate sequences of activities. However, there is interaction between the two entity types during barge loading, vessel voyage and barge unloading operations

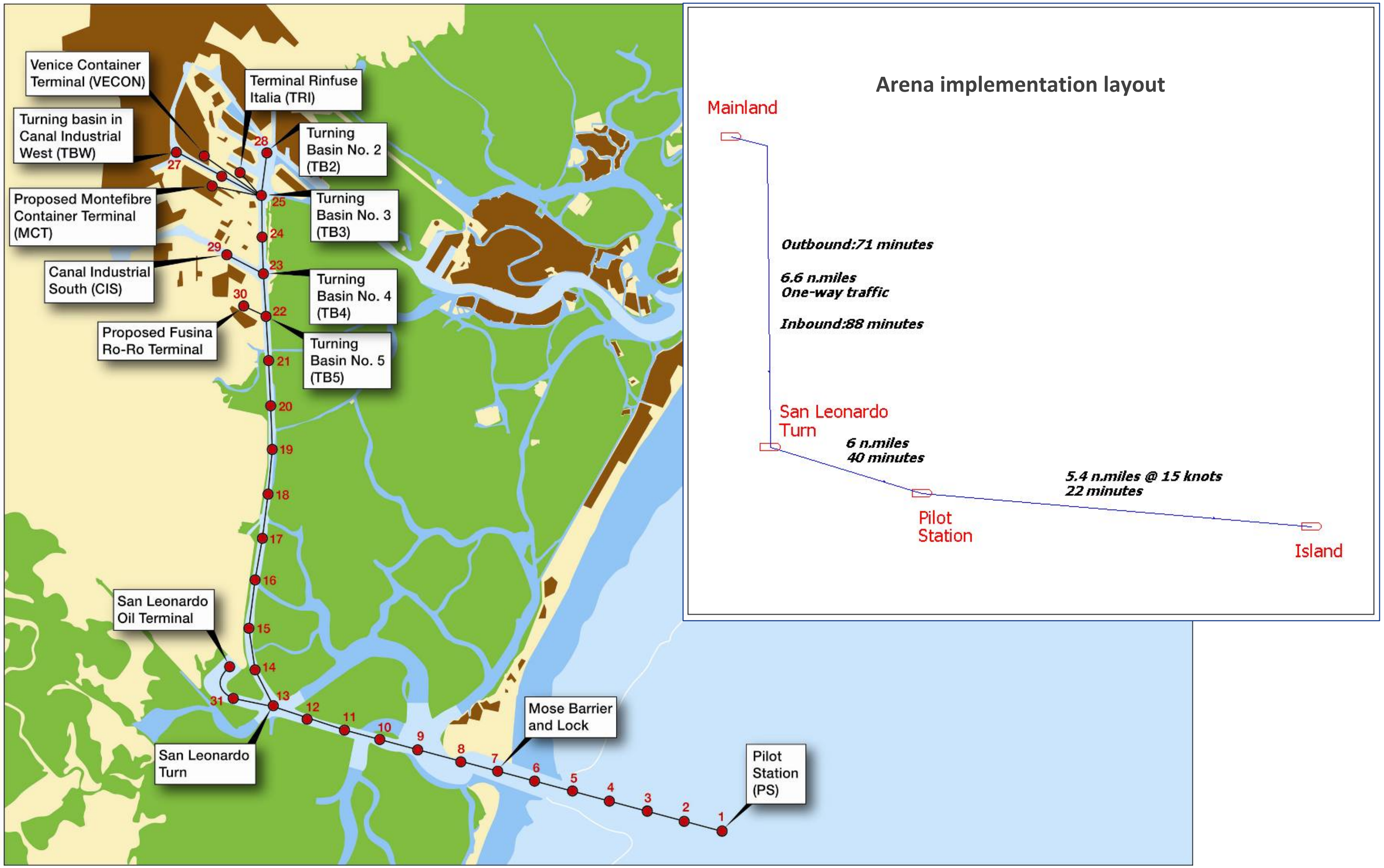



**Figure 8-3 Simulation model concept and implementation overview in Arena**

Both the mama vessel and barge entities require resources to undertake particular activities. From the results, preliminary resource estimates can be deduced; alternatively, resources can be used to limit the number of activities that can be carried out simultaneously.

The primary objective of the model is to demonstrate that the desired throughput levels for the various development stages of the offshore terminal can be achieved by particular combinations of barges and mama vessels.

## Model logic

### Ship cycle

Each mama vessel undertakes the following sequence of activities in a continuous loop:-

1. Voyage to offshore terminal
2. Arrive at offshore terminal - manoeuvre
3. Flood ballast tanks - float barges
4. Unload barges. This activity is dependent on the number and type of barges.
5. Load barges. This activity is dependent on the number, type and readiness of fully loaded barges for loading on the mama vessel. Hence this activity may be delayed by the mama vessel having to wait for barges to become ready.
6. Empty ballast tanks - ground barges on deck
7. Depart from offshore terminal - manoeuvre
8. Voyage to onshore terminals
9. Arrive at onshore terminal - manoeuvre
10. Flood ballast tanks - float barges
11. Unload barges. This activity is dependent on the number and type of barges.
12. Load barges. This activity is dependent on the number, type and readiness of fully loaded barges for loading on the mama vessel. Hence

this activity may be delayed by the mama vessel having to wait for barges to become ready.

13. Empty ballast tanks - ground barges on deck
14. Depart from onshore terminal-manoeuvre

For further details on the time durations and the resource requirements for these activities, please refer to the Appendix C.

### Barge cycle

Each barge undertakes the following sequence of activities in a continuous loop:-

1. Voyage to offshore terminal. This activity duration is dependent on the mama vessel.
2. Unload from mama vessel
3. Manoeuvre into berth
4. Exchange containers with offshore terminal stack
5. Wait for a mama vessel
6. Manoeuvre out of berth
7. Load onto mama vessel
8. Voyage to onshore terminal. This activity duration is dependent on the mama vessel.
9. Unload from mama vessel
10. Manoeuvre into berth
11. Exchange containers with onshore terminal stack
12. Wait for mama vessel
13. Manoeuvre out of berth
14. Load onto mama vessel

For further details on the time durations and the resource requirements for these activities, please refer to Appendix C.

### Signalling between mama vessels and barges

The interaction between mama vessels and barges is controlled by a system of signals within the model. It is anticipated that in the real world this would be controlled by the terminal operating system and the port control tower. The following description applies to the barge transit from the island to the onshore terminals but is equally valid for the return transit to the offshore island terminal.

When a barge is ready to load onto a mama vessel, it waits in a queue at the offshore island terminal for a mama vessel to arrive. When a mama vessel is ready to load, it issues a signal to the barge to commence its loading sequence. This is repeated until all barges are loaded.

On completion of loading, the mama vessel then empties its ballast tanks, departs from the island and completes its voyage to the mainland. During this time, the barge(s) in transit are waiting for a signal from the mama vessel to indicate that it has arrived and unloading may start.

On completion of the voyage and flooding of the ballast tanks, the mama vessel then sends a signal to the barges on board that they may start unloading; whereupon the barges are unloaded sequentially from the mama vessel and manoeuvred into their berths at the mainland.

Once all barges have been unloaded, the mama vessel is then deemed to be ready to load a new set of barges for transport back to the island and the mama vessel issues a signal to waiting barges accordingly. Thus the mama vessel sequence repeats.

At the same time, the transfer of containers between the original barges and stack in both directions (i.e. unloading and loading) takes place at the barge berths. On completion of the container transfer, the barge is then considered to be ready to load and waits for a signal from the next mama vessel. Thus the barge sequence repeats.

### Barge Transfer Times

Container transfer times onto and off barges have been derived from crane productivity assumptions (moves per hour), the number of cranes that can work an individual barge and the width of the barge (bearing in mind that barge stability may be an issue when narrow barges are being loaded or unloaded). It is assumed that dual cycling takes place whenever possible and all barges are transported with a full consignment of containers.

In deriving the transfer times, it has been assumed that:

- times at both the offshore terminal and onshore terminals are achieved at all times and there are no yard/stack delays due to insufficient landing space in the stack or shortage of containers for transfer;
- there are no weather delays or breakdowns
- dual cycling is not realistic on the four-wide barges (barge type A).
- same transfer times apply to both island and mainland stacks. Whilst the mainland stacks have two bridge cranes, stack length will be much longer so productivity will be similar.

For further details on the time durations and their derivation, please refer to Appendix C.

### Resources

Both mama vessel and barge entities require resources to undertake particular activities. From the results, preliminary resource estimates can be deduced; alternatively, resources can be used to limit the number of activities that can be carried out simultaneously by entities. The following resources are used within the model:

- **Berths:** Berths are provided at the island and the mainland for the use of barges; the number provided depends on the throughput scenario and the type of barge. Each barge requires the use of one berth while manoeuvring into the berth, container transfer, waiting for a mama vessel and manoeuvring out of the berth.
- **Tugs:** Each barge requires one tug unit to assist with manoeuvres between the mama vessel and the berth and vice versa at both the island and the mainland. So that operations are not unduly restricted and recognising that more than one barge may be permitted to manoeuvre concurrently, ten tug

units are provided at each location. Tug utilisation therefore indicates the number of tug units that might be required. Consideration could be given to utilising a wired system dependent on wind conditions.

- **Mama vessel ship deck:** One "deck" resource is provided for each mama vessel. To ensure that all barges are loaded or unloaded sequentially, each barge must take control of the deck for loading or unloading, after which it is released for the next barge.

- **Transfer zone:** Due to the restricted width of the Canal Industrial West at the location of the proposed mainland terminal (Monte/ Syndial), it has been assumed that there is only sufficient space for one mama vessel to unload, load and manoeuvre barges at any time. To model this restriction, one "transfer zone" resource has been provided at the mainland. Whilst there are no space restrictions at the island, this restriction has also been introduced there to prevent bunching of mama vessels on the island-mainland-island cycle. Mama vessels must take control of each transfer zone before they are permitted to unload and load barges.

### Basic assumptions

The following assumptions apply to the model and its operation:-

- All mama vessels travel with a full consignment of barges.

- All barges are transported with a full consignment of containers.

- There are no weather (i.e. wind, tide, visibility etc) delays or night movement restrictions on mama vessel or barge operations.

- Throughput estimates from the model are based on the stated barge TEU capacities and 24-hour x 7-day operation for 363 days per year.

- Container transfer times at both the island and mainland are achieved at all times and there are no yard/stack delays due to insufficient landing space in the stack or shortage of containers for transfer.

- Except in certain specific cases, it is assumed that only one mama vessel is permitted to load and unload barges in the Canal Industrial West at any time due to space considerations in the canal.

- Mama vessel speeds on voyage between the onshore terminal and the offshore terminal (and vice versa) are derived from ship speeds reported by the MV Hyundai Supreme during entry passage on 30th June 2010 and departure passage on 2nd July 2010; more fully reported in the "Port of Venice Traffic and Terminal Study; Report on Traffic Simulation Study", Halcrow, 28 January 2011.

- Mama vessels are likely to be subject to one-way traffic restrictions in the Canale Litoraneo between the San Leonardo Oil Terminal and Monte/ Syndial. Movements would also be affected by convoys of existing traffic. Since a full traffic simulation of the channel is beyond the scope of this study an assumed mama vessel delay was applied in the model. The results of the 2010 traffic simulation study (Halcrow) indicated that, in 2009, the channel was occupied for 70% of the time by one or more vessels.

On this basis, it was assumed that the channel would be occupied for 70% of the time, but because this figure included traffic in both directions, it was assumed that a mama vessel proceeding in one direction would have a 1 in 2 chance of meeting opposing traffic.

Hence the probability of delay to a mama vessel was assumed to be 35%. The assumed delay time was half the transit time between San Leonardo and Monte/ Syndial as this is the likely average time for a ship to clear the channel.

On this basis the average delay was assumed to be 30 minutes.

## Simulation length and replications

All simulation runs are for a period of 363 days (i.e. one year of 365 days less 2 days for the Xmas holiday), starting on the 1st January 2012 at 00:00. The dates are immaterial, but a value is required by Arena.

Before statistics collection starts, each model is run for a warm-up period of 5 days, during which time no statistics are collected. This is to ensure that the chosen starting conditions (i.e. disposition of the mama vessel and barges) do not affect the statistics. The model runs therefore start on 27 Dec 2011 at 00:00, and the results for the first 5 days are ignored.

All test scenarios are run for 100 replications (or repeat runs) to obtain an average result for the different sequences of arrivals and departures that are generated by the software for each individual run.

## Verification and validation

The model represents an operation which does not yet exist; thus there is no data that could be used to benchmark and validate the model. Validation is thus limited to ensuring that the results reflect the input data, are reasonable and that any specific anomalies can be explained.

The model has been designed to report the following parameters to allow comparison with the input assumptions and to confirm validity.

**Throughput:** the barge capacity in TEU is an input to the model; hence the throughput achieved by the various combinations of barges and mama vessels can be calculated (in the model) from the number of cycles*1 achieved and reported.

**Reported activity times:** reported activity times can be used for comparison with the input data, bearing in mind that the input data is likely to represent the minimum value because it does not include any queuing time or resource related delays.

# Scenarios

## Throughput Scenarios

VPA has provided annual traffic throughput scenarios to be considered for the development. Any proposed system would need to be able to cope with the resulting average and peak traffic flows and hence the model assesses these.

Table 8-1 is a summary of the annual, daily average and daily peak for each scenario that the waterway system would need to handle.

| Description | Scenario 0 (TEU) | Scenario 1 (TEU) | Scenario 2 (TEU) | Scenario 3 (TEU) |
|---|---|---|---|---|
| Annual Throughput Offshore Barge Berths | 0 | 800,000 | 1,100,000 | 1,800,000 |
| Annual Throughput M/S Barge Berths | 0 | 800,000 | 800,000 | 800,000 |
| Average daily throughput Offshore Barge Berths | 0 | 2,200 | 3,000 | 5,000 |
| Average daily throughput M/S Barge Berths | 0 | 2,200 | 2,200 | 2,200 |
| Peak daily throughput Offshore Barge Berths | 0 | 4,500 | 6,200 | 9,500 |
| Peak daily throughput M/S Barge Berths | 0 | 4,500 | 4,500 | 4,200 |
| Annualised Peak* Offshore Barge Berths | 0 | 1,600,000 | 2,300,000 | 3,500,000 |
| Annualised Peak* M/S Barge Berths | 0 | 1,600,000 | 1,600,000 | 1,500,000 |

**Table 8-1: Summary of throughput by scenario for waterway system for annual, daily average and daily peak volume**

***The ARENA simulation has the number of barges and mama vessels as a constant input over the simulation and hence each combination run is assessed over a year (363 days) as the model is to determine whether a throughput volume has been achieve**d. Thus a measure of success is if the required theoretical annualised peak can be met in the model with the provided combination of barges and mama vessels. Each annual run is repeated for 100 times to obtain an average result for the different sequences of arrivals and departures that are generated by the software for each individual run.

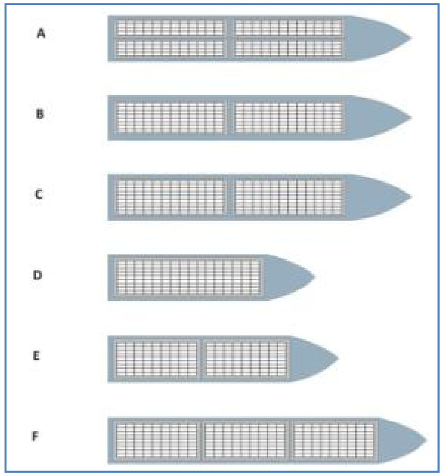



Figure 8-4 Overview of barge and mama vessels

### Barge Scenarios

In collaboration with VPA the barge scenarios to be tested with the model were defined. A summary list of these and their key characteristics is presented in Table 8-2A and Figure 8-4

### Scenarios Tested

It was agreed that the barge and throughput scenarios presented in Table 8-2B were to be tested initially.

Depending on the results of the initial screening tests, it was further agreed that sensitivity tests would be carried out for selected barge configurations for average throughputs.

| Barge Type | Height | Width | Length | Barge capacity | Barges on mama vessel | Mama vessel | |
|---|---|---|---|---|---|---|---|
| | (TEU) | (TEU) | (TEU) | (TEU) | (no) | Capacity (TEU) | Indicative dimensions (m x m) |
| A | 3 | 4 | 12 | 144 | 4 (S+L) | 576 | 28.5 x 200 x 7.5 |
| B | 3 | 8 | 12 | 288 | 2 (L) | 576 | 28.5 x 200 x 7.5 |
| C | 3 | 9 | 12 | 324 | 2 (L) | 648 | 31 x 200 x 7.5 |
| D | 3 | 9 | 16 | 432 | 1 | 432 | 31 x 140 x 7.5 |
| E | 3 | 9 | 8 | 216 | 2 (L) | 432 | 31 x 150 x 7.5 |
| F | 3 | 9 | 8 | 216 | 3 (L) | 648 | 31 x 210 x 7.5 |

Table 8-2A Barge characteristics

| Barge Type | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| | average | peak | average | peak | average | peak |
| A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| D | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| F | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Table 8-2B Initial barge scenarios tested

### Barge turn around speeds

The barge width of barge type A is assumed to have a negative impact on crane productivity and hence turn around speed of the barge due to the lower stability of the barge resulting in listing which impacts possible loading speeds.

Other barge turn around speeds were based on the capacity of the barge, the number of cranes that can serve the barge and the productivity of the cranes.

An analysis of crane acceleration and distances has determined that each bridge crane may be able to achieve single cycling speeds of up to 37 moves per hour and dual cycling speed of approximately 22 moves per hour. However, productivity will not always be at peak speeds and overall turn around speed will depend on distribution of cargo and allocation space in the stack.

A distribution of crane productivity and lifts has been assumed based on these figures and experience, resulting in Table 8-3.

| Barge Type | Height | Width | Length | Barge capacity | Containers | Containers Exchanged | Cranes | Heavy Crane, no of containers | Distribution of turn around productivity achieved | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 2.5% | 10.0% | 42.5% | 42.5% | 2.5% |
| | (TEU) | (TEU) | (TEU) | (TEU) | (no) | (no) | (no) | (no) | (min) | (min) | (min) | (min) | (min) |
| A | 3 | 4 | 12 | 144 | 95 | 190 | 3 | 63 | 238 | 211 | 173 | 152 | 141 |
| B | 3 | 8 | 12 | 288 | 189 | 378 | 3 | 126 | 315 | 270 | 252 | 216 | 204 |
| C | 3 | 9 | 12 | 324 | 213 | 426 | 3 | 142 | 355 | 304 | 284 | 243 | 230 |
| D | 3 | 9 | 16 | 432 | 284 | 568 | 4 | 142 | 355 | 304 | 284 | 243 | 230 |
| E | 3 | 9 | 8 | 216 | 142 | 284 | 2 | 142 | 355 | 304 | 284 | 243 | 230 |
| F | 3 | 9 | 8 | 216 | 142 | 284 | 2 | 142 | 355 | 304 | 284 | 243 | 230 |

**Table 8-3 Barge turn around speeds**

| Description | scenario 1 average | scenario 1 peak | scenario 2 average | scenario 2 peak | scenario 3 average | scenario 3 peak |
|---|---|---|---|---|---|---|
| Deep-sea berths | 2 | 2 | 3 | 3 | 4 | 4 |
| Deep-sea quay | 1,000m | 1,000m | 1,500m | 1,500m | 2,000m | 2,000m |
| Barge Type | | | Barge Berths Required | | | |
| A | 10 | 10 | 15 | 15 | 20 | 20 |
| B | 10 | 10 | 15 | 15 | 20 | 20 |
| C | 10 | 10 | 15 | 15 | 20 | 20 |
| D | 8 | 8 | 12 | 12 | 16 | 16 |
| E | 16 | 16 | 24 | 24 | 32 | 32 |
| F | 16 | 16 | 24 | 24 | 32 | 32 |

**Table 8-4 Berths Required**

## Berths required

The number of barge berths provided for each barge and throughput scenario is dependent on the length of the barge (TEU equivalent) and the number of buffer stacks and overhead travelling bridge cranes that would be used to transfer containers onto and off the barges. The total number of stacks for each deep-sea berth, and hence the number of barge berths are limited by the length of the deep-sea berth.

Table 8-4 shows the number of deep-sea berths and barge berths to be provided for each barge type and throughput scenario.

## Sensitivity tests

### Mose barrier closure

It was agreed that a sensitivity test would be run for selected barge types and throughputs whereby the speed of the mama vessel would be reduced on passage to mimic the effect of closing the Mose flood barrier. For the purposes of the test, the speed reduction would apply to the simulation period to give an indication of the impact of a long term closure.

Mama vessel speed assumptions for voyages between the mainland and the pilot boarding point off the Malamocco Entrance to the lagoon (and vice versa) during Mose flood barrier closure are derived from speeds reported by the MV Hyundai Supreme during entry passage on 30th June 2010 and departure passage on 2nd July 2010; more fully reported in the *"Port of Venice Traffic and Terminal Study; Report on Traffic Simulation Study"*, Halcrow, 28 January 2011 (see Chapter 5).

Speed reduction assumptions are given in Appendix C.

It should be noted that the Halcrow Report *"Port of Venice Traffic and Terminal Study; Report on Traffic Simulation Study"* (Section 9.6) found that flood events of short duration did not have a major impact on the movement of ships. Therefore applying the speed reduction to the whole of the simulation period will provide an estimation of the likely effect of a long term closure.

The scenarios to be tested were confirmed at the workshop following the initial screening phase when the results were reviewed.

### Crane speeds

It was also agreed that a sensitivity test would be run for selected barge types and throughputs whereby the crane speeds would be varied. Crane speeds have a direct impact on the container exchange times for barges at both the island and the mainland berths, increasing crane speeds would reduce the time for the container exchange, whereas reducing the speeds would increase the exchange time.

For the purposes of sensitivity testing, crane speeds would be varied by plus or minus 15%; this would apply to both the island and mainland terminals. Speed variation assumptions are presented in Appendix C.

Again, the scenarios to be tested were confirmed with VPA at the workshop.

## Results

### Initial Screening

All the scenarios shown in Table 8-2 were executed. In order to determine the required number of mama vessels and barges necessary to achieve the desired throughput level, each barge and throughput scenario was run with different combinations of barges and mama vessels. Not all combinations of mama vessels and barges were executed because the objective was to determine a mama vessel-barge combination that would achieve the desired throughput.

The results are shown in the tables Table 8-6 to Table 8-11.

**Tables of Throughput achieved for barge and mama vessel combinations, all values are in TEU x 1 million)**

| Number of Barges provided | Number of Mama Vessels provided | | | | | | |
|---|---|---|---|---|---|---|---|
| **Type A** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 8 | 0.63 | | | | | | |
| 12 | 0.74 | 1.26 | | | | | |
| 16 | 0.74 | 1.48 | 1.81 | | | | |
| 18 | | | 2.00 | | | | |
| 20 | | 1.48 | 2.20 | 1.82 | | | |
| 24 | | | 2.20 | 2.87 | 1.82 | | |
| 28 | | | 2.20 | 2.87 | 3.07 | | |
| 32 | | | | | 3.07 | | |
| 36 | | | | | | 3.08 | |

**Table 8-6: Barge Type A**

| Number of Barges provided | Number of Mama Vessels provided | | | | | | |
|---|---|---|---|---|---|---|---|
| **Type C** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 4 | 0.73 | 1.14 | | | | | |
| 6 | 1.03 | 1.46 | 1.68 | | | | |
| 7 | | 1.53 | | | | | |
| 8 | | 2.04 | 1.78 | | | | |
| 10 | | 2.04 | 2.79 | | | | |
| 12 | | 2.05 | | 3.33 | | | |
| 14 | | | | 3.49 | | | |
| 16 | | 2.05 | | 3.96 | | | |

**Table 8-8: Barge Type C**

| Number of Barges provided | Number of Mama Vessels provided | | | | | | |
|---|---|---|---|---|---|---|---|
| **Type E** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 4 | | 0.76 | | | | | |
| 6 | 0.68 | 0.97 | | | | | |
| 8 | | 1.36 | 1.19 | | | | |
| 10 | | 1.36 | 1.86 | | | | |
| 12 | | | 1.93 | 2.22 | | | |
| 14 | | | | 2.33 | 2.34 | 1.19 | |
| 16 | | | | | | 2.35 | |
| 18 | | | | | | 2.36 | |

**Table 8-10: Barge Type E**

| Number of Barges provided | Number of Mama Vessels provided | | | | | | |
|---|---|---|---|---|---|---|---|
| **Type B** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 4 | 0.68 | 1.07 | | | | | |
| 6 | 0.91 | 1.34 | | | | | |
| 7 | | 1.41 | | | | | |
| 8 | 0.91 | 1.82 | 1.72 | | | | |
| 10 | | 1.82 | 2.59 | | | | |
| 12 | | | | 3.14 | | | |
| 14 | | | | 3.28 | | | |
| 16 | | | | 3.60 | | | |

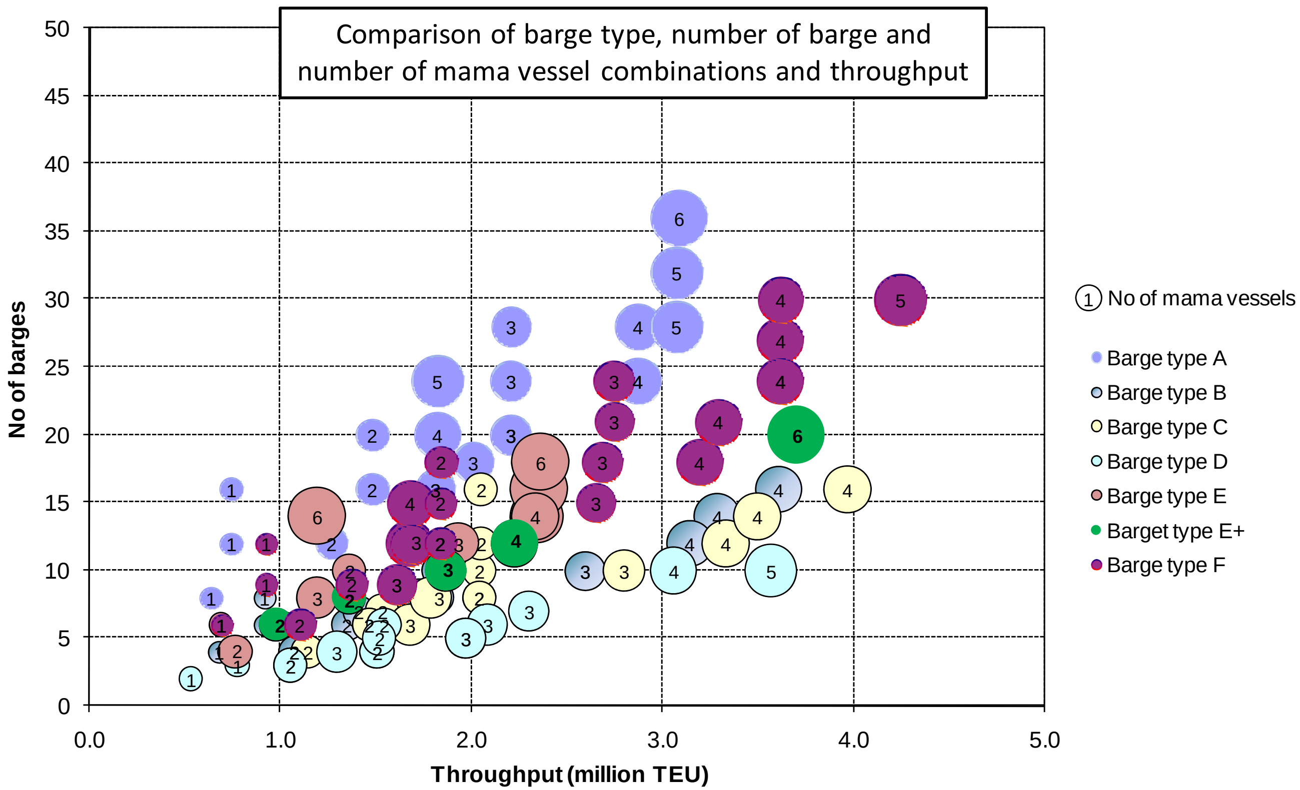
**Table 8-7: Barge Type B**

| Number of Barges provided | Number of Mama Vessels provided | | | | | | |
|---|---|---|---|---|---|---|---|
| **Type D** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 2 | 0.53 | | | | | | |
| 3 | 0.77 | 1.05 | | | | | |
| 4 | 0.77 | 1.50 | 1.29 | | | | |
| 5 | | 1.52 | 1.97 | | | | |
| 6 | | 1.54 | 2.08 | | | | |
| 7 | | | 2.30 | | | | |
| 10 | | | | 3.06 | 3.56 | | |

**Table 8-9 Barge Type D**

| Number of Barges provided | Number of Mama Vessels provided | | | | | | |
|---|---|---|---|---|---|---|---|
| **Type F** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 6 | 0.69 | 1.10 | | | | | |
| 9 | 0.92 | 1.37 | 1.61 | | | | |
| 12 | 0.92 | 1.83 | 1.67 | 1.67 | | | |
| 15 | | 1.83 | 2.65 | 1.67 | | | |
| 18 | | 1.84 | 2.68 | 3.19 | | | |
| 21 | | | 2.74 | 3.28 | | | |
| 24 | | | 2.74 | 3.61 | | | |
| 27 | | | | 3.61 | | | |
| 30 | | | | 3.61 | 4.24 | | |

**Table 8-11: Barge Type F**




The tables indicate that (for certain scenarios) the maximum throughput is related to the number of mama vessels and that there is an optimum number of barges that are required to achieve that throughput. Increasing the number of barges beyond that level is seen to have no material effect on the throughput achieved.

All the results are summarised in the "bubble chart" in Figure 8-5. In the chart, the number of mama vessels is indicated by the diameter of the circle and the number within.

**Figure 8-5 Summary overview of barge and mama vessel number combinations in relation to throughput**

Note:

Barge type E+ is a variation on the barge type E, but allowing two mama vessels att eh Monte/Syndial terminal area at the same time – see also the section on Scenario E+

Table 8-13 shows the results for the full offshore development scenario 3, for both the average annual throughput of 1.8 million TEU and the annualised peak throughput of 3.5 million TEU.

The table indicates an inability of barge types A and E to achieve a peak throughput of 3.5 million TEU required in the full build out of the offshore terminal, scenario 3.

Further inspection of the results indicates that for these scenarios, there is a bottleneck at the transfer areas where barges are loaded and offloaded from the mama vessels.

In the model one transfer area is provided at both the island and the mainland in scenarios A and E. In these scenarios the transfer areas are experiencing utilisation rates of around 100% resulting in congestion and delay.

| Barge type **and scenario i.e. average or peak** | **Capacity (TEU)** | **No of mama vessels** | **No of Barges** | **Annual Throughput (mTEU)** | | **Mama vessel cycle time *1 (hours)** | **Average mama vessel interval *2 (hours)** |
|---|---|---|---|---|---|---|---|
| | | | | **Achieved** | **Target** | | |
| A (average) | 144 | 3 | 16 | 1.81 | 1.8 | 16.7 | 5.6 |
| A (peak) | 144 | 4 | 24 | 2.87 | 3.5 | 14.0 | 3.5 |
| A (peak) | 144 | 5 | 28 | 3.07 | 3.5 | 16.4 | 3.3 |
| B (average) | 288 | 2 | 8 | 1.82 | 1.8 | 11.1 | 5.5 |
| B (peak) | 288 | 4 | 16 | 3.60 | 3.5 | 11.1 | 2.8 |
| C (average) | 324 | 2 | 8 | 2.04 | 1.8 | 11.1 | 5.5 |
| C (peak) | 324 | 4 | 16 | 3.96 | 3.5 | 11.4 | 2.8 |
| D (average) | 432 | 3 | 5 | 1.97 | 1.8 | 11.5 | 3.8 |
| D (peak) | 432 | 5 | 10 | 3.56 | 3.5 | 10.6 | 2.1 |
| E (average) | 216 | 3 | 10 | 1.86 | 1.8 | 12.1 | 4.0 |
| E (peak) | 216 | 5 | 14 | 2.34 | 3.5 | 16.1 | 3.2 |
| E (peak) | 216 | 6 | 18 | 2.36 | 3.5 | 19.2 | 3.2 |
| F (average) | 216 | 2 | 12 | 1.83 | 1.8 | 12.3 | 6.2 |
| F (peak) | 216 | 4 | 24 | 3.61 | 3.5 | 12.5 | 3.1 |

**Table 8-13 Summary results for full offshore development scenario 3**

**Note**s:

*1 Mama vessel cycle times represent the average time for one ship to make a complete round trip i.e. from the offshore terminal to the onshore terminal and back

*2 The average mama vessel interval is the cycle time divided by the number of ships

## Discussion of results

The results from the initial screening of scenarios were presented to VPA at Workshop Number 4, held on the 17th November 2011 in Venice.

During the ensuing discussion it was agreed that barge types A and D would not be investigated further. Type A was dismissed on account of its narrow width resulting in stability concerns and slow loading rates. Type D was dismissed as it is unlikely to be cost efficient as each mama vessel carries only one barge resulting in limited benefits from the mama vessel/ barge concept and due to the lack of flexibility that such a system would provide.

It was agreed that barge types B and C should be investigated further. In addition, it was agreed that barge type E should be tested with a model modification referred to as E+.

In the initial model runs it was assumed that only one mama vessel can unload barges at a given time at Monte/ Syndial due to space constraints in the Canal Industrial West.

This assumption limits the throughput that can be achieved with any system that requires a large number of mama vessels to achieve the desired throughput such as barge type E.

After further discussion, it was agreed that a variation on model E should be tested such that two mama vessels are allowed to operate simultaneously in the canals at Montefibre-Syndial to establish whether the required peak capacity can be reached. This scenario is referred to as E+.

Doubts were raised on the viability of option F due to the length of the associated mama vessel and the likely impact on manoeuvring and manoeuvring times.

It was agreed that this option would therefore only to be considered as a possible future expansion of scheme E+ and would not be considered further in this part of the study.

## Scenarios E+

### Assumptions

The agreed assumption is that two mama vessels would be permitted to pass at any given time in the Industrial Canal West. It should be noted that barge type E is smaller than the other barge types tested and its mama vessel might be able to pass other vessels and wait in the turning basin beyond the berth.

### Results

Scenario E for the annualised peak throughput case was rerun with multiple transfer zones provided at both the island and the mainland. Table 8-14 shows the results.

The results indicate how the number of barges and the number of mama vessels influence the achievable throughput.

Further they demonstrate that an annualised peak throughput of 3.5 million TEU can be achieved using barge type E, but only if two mama vessels can be handled at the same time in the Canal Industrial West.

Further, it is assumed that there is effectively no restriction on the number of mama vessels that can be handled simultaneously at the offshore terminal.

The combination of 6 mama vessels and 20 barges with 2 transfer zones appears to offer the optimal solution and to achieve the desired annualised peak throughput.

| Barge type | Number of mama vessels | Number of Barges | Number of Transfer zones | Throughput (million TEU) | | Mama Vessel cycle time *1 | Average mama vessel interval *2 |
|---|---|---|---|---|---|---|---|
| | | | | Achieved | Target | (hours) | (hours) |
| E | 5 | 14 | 1 | 2.34 | 3.5 | 16.1 | 3.2 |
| E+ | 5 | 14 | 2 | 2.51 | 3.5 | 15.0 | 3.0 |
| E | 6 | 18 | 1 | 2.36 | 3.5 | 19.1 | 3.2 |
| E+ | 6 | 18 | 2 | 3.11 | 3.5 | 14.5 | 2.4 |
| E+ | 6 | 18 | 3 | 3.20 | 3.5 | 14.1 | 2.4 |
| E | 6 | 20 | 1 | 3.40 | 3.5 | 13.3 | 2.2 |
| E+ | 6 | 20 | 2 | 3.70 | 3.5 | 12.2 | 2.0 |

**Table 8-14 Summary results for the peak scenario 3 for E**

Notes:

*1 Mama vessel cycle times represent the average time for one ship to make a complete round trip i.e. from the offshore terminal to the onshore terminal and back

*2 The average mama vessel interval is the cycle time divided by the number of ships

## Preferred Scenarios & Movement Times

The following tables provide a summary of the results of the modelling for barge types B, C and E and show the preferred combination of barges and mama vessels as indicated by the simulations executed.

**Notes**:

*1 Mama vessel cycle time represent the average time for one ship to make a complete round trip i.e. from the off-shore terminal to the onshore terminal and back

*2 The average mama vessel interval is the cycle time divided by the number of ships

| Type B | Scenario | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 1 | 2 | 2 | 3 | 3 |
| | Average | Peak | Average | Peak | Average | Peak |
| Target (mTEU) | 0.8 | 1.6 | 1.1 | 2.2 | 1.8 | 3.5 |
| Achieved (mTEU) | 0.91 | 1.82 | 1.34 | 2.59 | 1.82 | 3.60 |
| Barges | 6 | 8 | 6 | 10 | 8 | 16 |
| Mama vessels | 1 | 2 | 2 | 3 | 2 | 4 |
| Barge cycle (hours) | 33.0 | 22.1 | 22.4 | 19.4 | 22.1 | 22.3 |
| Mama vessel cycle*1 (hours) | 11.0 | 11.1 | 14.9 | 11.6 | 11.1 | 11.1 |
| Mama vessel interval*2 (hours) | 11.0 | 5.5 | 7.5 | 3.9 | 5.5 | 2.8 |

**Table 8-15:Barge type B - preferred configurations**

| Type C | Scenario | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 1 | 2 | 2 | 3 | 3 |
| | Average | Peak | Average | Peak | Average | Peak |
| Target (mTEU) | 0.8 | 1.6 | 1.1 | 2.2 | 1.8 | 3.5 |
| Achieved (mTEU) | 1.03 | 2.04 | 1.14 | 2.79 | 2.04 | 3.96 |
| Barges | 6 | 8 | 4 | 10 | 8 | 16 |
| Mama vessels | 1 | 2 | 2 | 3 | 2 | 4 |
| Barge cycle (hours) | 33.0 | 22.2 | 19.8 | 20.2 | 22.2 | 22.8 |
| Mama vessel cycle*1 (hours) | 11.0 | 11.1 | 19.8 | 12.1 | 11.1 | 11.4 |
| Mama vessel interval*2 (hours) | 11.0 | 5.5 | 9.9 | 4.0 | 5.5 | 2.8 |

**Table 8-16: Barge type C - preferred configurations**

| Type E/E+ | Scenario | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 1 | 2 | 2 | 3 | 3 |
| | Average | Peak | Average | Peak | Average | Peak |
| Target (mTEU) | 0.8 | 1.6 | 1.1 | 2.2 | 1.8 | 3.5 |
| Achieved (mTEU) | 0.97 | 1.86 | 1.36 | 2.22 | 1.86 | 3.70 |
| Barges | 6 | 10 | 8 | 12 | 10 | 20 |
| Mama vessels | 2 | 3 | 2 | 4 | 3 | 6 |
| Barge cycle (hours) | 23.2 | 20.2 | 22.2 | 20.3 | 20.2 | 20.4 |
| Mama vessel cycle*1 (hours) | 15.5 | 12.1 | 11.1 | 13.5 | 12.1 | 12.2 |
| Mama vessel interval*2 (hours) | 7.7 | 4.0 | 5.5 | 3.4 | 4.0 | 2.0 |

**Table 8-17: Barge type E - preferred configurations**

## Sensitivity Tests

### Mose Barrier Closure

Tests with barge types B, C and E under the annual average throughput scenarios were repeated with slower mama vessel transit times as described in the Section "Sensitivity Tests".

With the Mose barrier closed, mama vessel voyage times (and hence round trip times) are increased. As a result, the arrival interval between mama vessels is increased and the number of barge transfers is reduced.

The need for additional mama vessels or barges to meet the required throughput demand depends on the capacity of the system for the non-Mose case and the surplus capacity that the system offers.

When systems have a relatively high surplus capacity (e.g. barge type E for scenario 2, with a target of 1.1m TEU) there is sufficient latent capacity to cater for Mose closure and no more mama vessels or barges are required.

Alternatively, if there is little surplus capacity, then more barges or mama vessels are required e.g. barge type E for scenario 3, with a target of 1.8m TEU.

**Tables comparing Mose Barrier closure effects on the waterway transfer system**

| Throughput Scenario | Barge type | Mose Barrier | Number of Mama vessels | Number of Barges | Throughput (million TEU) Achieved | Target | Mama vessel cycle time*1 hours) | Average mama vessel interval*2 (hours) |
|---|---|---|---|---|---|---|---|---|
| 1 | B | Open | 1 | 6 | 0.91 | 0.8 | 11.0 | 11.0 |
| 1 | B | Closed | 2 | 4 | 0.96 | 0.8 | 20.8 | 10.4 |
| 2 | B | Open | 2 | 6 | 1.34 | 1.1 | 14.9 | 7.5 |
| 2 | B | Closed | 2 | 6 | 1.18 | 1.1 | 17.0 | 8.5 |
| 3 | B | Open | 2 | 8 | 1.82 | 1.8 | 11.1 | 5.5 |
| 3 | B | Closed | 3 | 9 | 1.82 | 1.8 | 13.1 | 6.5 |

**Table 8-14 Mose Barrier Closure - Barge Type B**

| Throughput Scenario | Barge type | Mose Barrier | Number of Mama vessels | Number of Barges | Throughput (million TEU) Achieved | Target | Mama vessel cycle time*1 (hours) | Average mama vessel interval*2 (hours) |
|---|---|---|---|---|---|---|---|---|
| 1 | C | Open | 1 | 6 | 1.03 | 0.8 | 11.0 | 11.0 |
| 1 | C | Closed | 1 | 6 | 0.86 | 0.8 | 13.0 | 13.0 |
| 2 | C | Open | 2 | 4 | 1.14 | 1.1 | 19.8 | 9.9 |
| 2 | C | Closed | 2 | 6 | 1.29 | 1.1 | 17.5 | 8.7 |
| 3 | C | Open | 2 | 8 | 2.04 | 1.8 | 11.1 | 5.5 |
| 3 | C | Closed | 3 | 9 | 1.96 | 1.8 | 17.3 | 5.8 |

**Table 8-15 Mose Barrier Closure - Barge Type C**

| Throughput Scenario | Barge type | Mose Barrier | Number of Mama vessels | Number of Barges | Throughput (million TEU) achieved | target | Mama vessel cycle time*1 (hours) | Average mama vessel interval*2 (hours) |
|---|---|---|---|---|---|---|---|---|
| 1 | E | Open | 2 | 6 | 0.97 | 0.8 | 15.5 | 7.7 |
| 1 | E | Closed | 2 | 6 | 0.86 | 0.8 | 17.5 | 8.7 |
| 2 | E | Open | 2 | 8 | 1.36 | 1.1 | 11.1 | 5.5 |
| 2 | E | Closed | 2 | 8 | 1.15 | 1.1 | 13.1 | 6.5 |
| 3 | E | Open | 3 | 10 | 1.86 | 1.8 | 12.1 | 4.0 |
| 3 | E | Closed | 4 | 12 | 2.02 | 1.8 | 14.8 | 3.7 |

**Table 8-16 Mose Barrier Closure - Barge Type E**

Notes:

*1 Mama vessel cycle time represent the average time for one ship to make a complete round trip i.e. from the offshore terminal to the onshore terminal and back

*2 The average mama vessel interval is the cycle time divided by the number of ships

### Crane Speed tests

For the crane speed tests the barge types B, C and E runs were repeated under the average annual throughput scenario but with slower mama vessel transit times as described in the Section "Sensitivity Tests".

With faster crane times, barge loading times will be reduced. However, the effect on the average mama vessel cycle times will depend on which element of the transfer chain controls the throughput.

If barges are waiting for mama vessels (i.e. the throughput achieved is dependent on the number of mama vessels), then any variation in the barge transfer times will only affect the waiting time for the barge. In this case, the throughput will remain relatively constant (e.g. barge type E with scenario 2).

Alternatively, if mama vessels are waiting for barges, then any variation in barge transfer times will have an impact on mama vessel cycle times.

Slower barge transfer will increase mama vessel cycle times and reduce the achievable throughput, whereas increasing crane speeds reduce mama vessel cycle times and increase the throughput (e.g. barge type E with scenario 3).

In some cases, the use of slower cranes means that the target throughput cannot be achieved; in this case, additional mama vessels or barges (or both) may be required. On the other hand, the use of faster cranes might mean that the number of mama vessels or barges could be reduced.

**Tables comparing crane speed increase and decrease by 15% on the waterway transfer system**

| Throughput Scenario | Barge type | Crane speed | mama vessels (no) | No of Barges (no) | Throughput (million TEU) achieved | Throughput (million TEU) target | Mama vessel cycle time *1 (hours) | Average mama vessel interval *2 (hours) |
|---|---|---|---|---|---|---|---|---|
| 1 | B | Normal | 1 | 6 | 0.91 | 0.8 | 11.0 | 11.0 |
| 1 | B | Slow | 1 | 6 | 0.91 | 0.8 | 11.0 | 11.0 |
| 1 | B | Fast | 1 | 6 | 0.91 | 0.8 | 11.0 | 11.0 |
| 2 | B | Normal | 2 | 6 | 1.34 | 1.1 | 14.9 | 7.5 |
| 2 | B | Slow | 2 | 6 | 1.28 | 1.1 | 15.7 | 7.8 |
| 2 | B | Fast | 2 | 6 | 1.40 | 1.1 | 14.4 | 7.2 |
| 3 | B | Normal | 2 | 8 | 1.82 | 1.8 | 11.1 | 5.5 |
| 3 | B | Slow | 2 | 8 | 1.80 | 1.8 | 11.1 | 5.6 |
| 3 | B | Fast | 2 | 8 | 1.82 | 1.8 | 11.0 | 5.5 |

**Table 8-17 Crane Speed Test - Barge Type B**

| Throughput Scenario | Barge type | Crane speed | mama vessels (no) | No of Barges (no) | Throughput (million TEU) achieved | Throughput (million TEU) target | Mama vessel cycle time *1 (hours) | Average mama vessel interval *2 (hours) |
|---|---|---|---|---|---|---|---|---|
| 1 | C | Normal | 1 | 6 | 1.03 | 0.8 | 11.0 | 11.0 |
| 1 | C | Slow | 1 | 6 | 1.03 | 0.8 | 11.0 | 11.0 |
| 1 | C | Fast | 1 | 6 | 1.03 | 0.8 | 11.0 | 11.0 |
| 2 | C | Normal | 2 | 4 | 1.14 | 1.1 | 19.8 | 9.9 |
| 2 | C | Slow | 2 | 4 | 1.05 | 1.1 | 21.4 | 10.7 |
| 2 | C | Fast | 2 | 4 | 1.21 | 1.1 | 18.6 | 9.3 |
| 3 | C | Normal | 2 | 8 | 2.04 | 1.8 | 11.1 | 5.5 |
| 3 | C | Slow | 2 | 8 | 2.00 | 1.8 | 11.3 | 5.7 |
| 3 | C | Fast | 2 | 8 | 2.04 | 1.8 | 11.1 | 5.5 |

**Table 8-18 Crane Speed Test - Barge Type C**

| Throughput Scenario | Barge type | Crane speed | mama vessels (no) | No of Barges (no) | Throughput (million TEU) achieved | Throughput (million TEU) target | Mama vessel cycle time *1 (hours) | Average mama vessel interval *2 (hours) |
|---|---|---|---|---|---|---|---|---|
| 1 | E | Normal | 2 | 6 | 0.97 | 0.8 | 15.5 | 7.7 |
| 1 | E | Slow | 2 | 6 | 0.92 | 0.8 | 16.3 | 8.2 |
| 1 | E | Fast | 2 | 6 | 1.01 | 0.8 | 14.8 | 7.4 |
| 2 | E | Normal | 2 | 8 | 1.36 | 1.1 | 11.1 | 5.5 |
| 2 | E | Slow | 2 | 8 | 1.33 | 1.1 | 11.3 | 5.7 |
| 2 | E | Fast | 2 | 8 | 1.36 | 1.1 | 11.1 | 5.5 |
| 3 | E | Normal | 3 | 10 | 1.86 | 1.8 | 12.1 | 4.0 |
| 3 | E | Slow | 3 | 10 | 1.73 | 1.8 | 13.0 | 4.3 |
| 3 | E | Fast | 3 | 10 | 1.96 | 1.8 | 11.5 | 3.8 |

**Table 8-19 Crane Speed Test - Barge Type E**

Notes:

*1 Mama vessel cycle time represent the average time for one ship to make a complete round trip i.e. from the offshore terminal to the onshore terminal and back

*2 The average mama vessel interval is the cycle time divided by the number of ships

# 9. LAYOUT OFFSHORE

## Introduction

It is a fundamental requirement that the combined offshore and onshore terminal will provide a service to shipping lines equal to or better than competing terminals and with service levels comparable at an international level. Being situated in deep-water, marine access to the offshore terminal will be as good as any other deep-sea terminal and better than most. There is no reason main line load and discharge operations cannot be equivalent to, or better than other modern facilities. The particular layout considerations that must be addressed when compared with onshore terminals are caused by the need to minimise the impact of barge link with the mainland.

## Key considerations

The main factors in determining the layout of the offshore terminal are:

- The length of quay necessary to handle the planned volumes, bearing in mind the probable size of main line vessels.
- Space for handling hatch covers, fitting and removing twistlocks.
- Maximisation of the opportunity to introduce automated handling
- The need to design separate automated machinery from human activity
- The required size of buffer storage
- The necessity to handle non- containerised or out of gauge units

- Barge berthing with minimum container movement distance between barge and buffer stack
- Provision of maintenance, accommodation, and control office buildings with ready access to operating areas
- Provision of machinery fuelling station, inspection facilities, leaking container facilities, waste storage, and berthing of service vessels (tugs, personnel ferry, fuelling vessel, water disposal vessel.

## Schematic Layout

A schematic of the offshore terminal is presented in Figure 9-1.

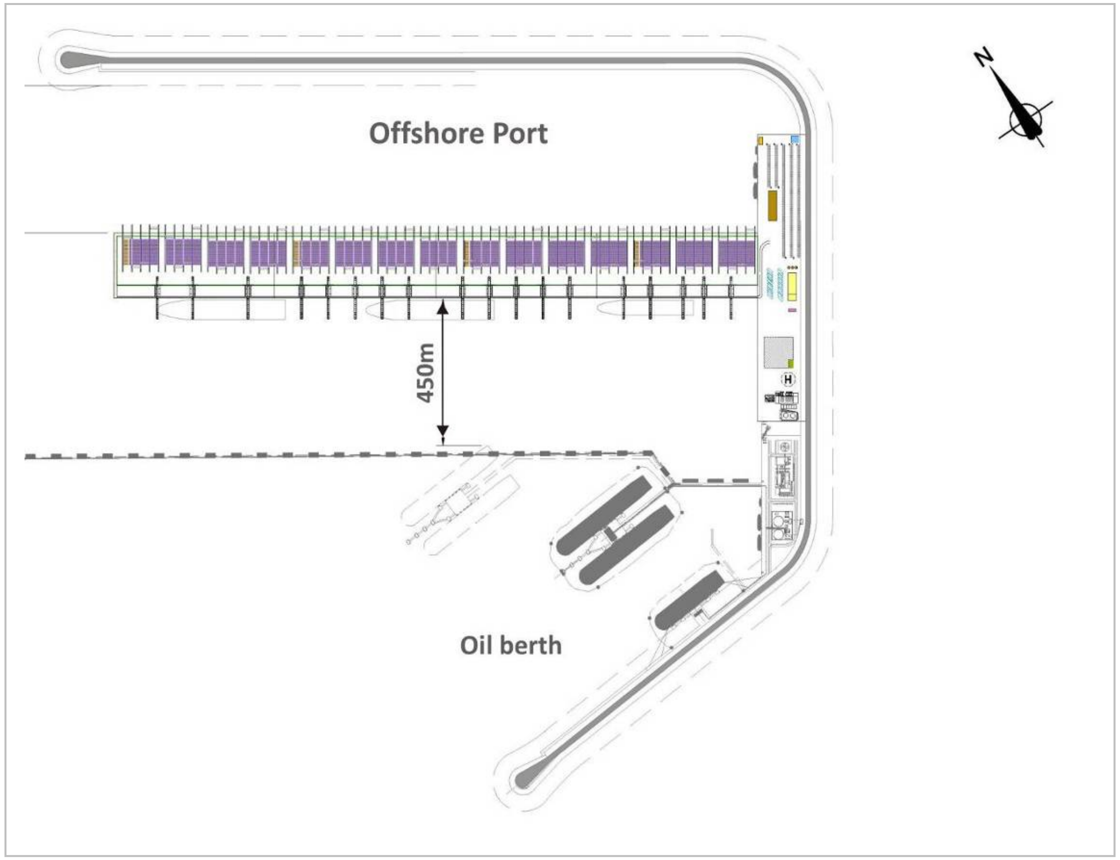



**Figure 9-1 Schematic layout of the offshore terminal**

**Figure 9-2 Automated shuttle carrier operation in the crane back reach, source Kalmar shuttle carrier catalogue**

## Main infrastructure

### Quay length

The minimum quay length proposed is 2000m. This quay length represents four berths for the largest vessel that are now on order. At design capacity, 2000m of quay results in a ratio of 1500 TEU per metre of quay per year. This is a very aggressive figure that in Europe is reached by very few terminals. Such terminals that reach this figure are in general, single user terminals where berthing clashes can be more readily avoided when compared with multi user terminals.

With high planned productivity and large container exchanges, it might be considered that quay utilisation is low but competitive pressure from other ports and low tolerance of lines to accept berthing delays (especially with new, larger and more costly ships), it would be unwise to plan for the planned volume on a lower quay length

### Deep-sea berth quayside apron

Cranes for handling the largest vessels will require an outreach spanning at least 24 containers. Such cranes are normally built on rails having a span of 35 metres. This area between the crane legs is sufficient for all operations where the presence of workers is required (Hatch covers, OOG, twist lock operations, checking,) and the transfer operation between ship to shore crane and automated transfer equipment is planned to take place in the crane backreach (refer to Figure 9-2).

The method of separating automated equipment from manual labour operations with lanes in the backreach has distinct safety advantages and been adopted in at other automated container terminals such as London Gateway. Travelling lanes in the backreach are also utilised when straddle carriers get to high so that they do not fit between the crane legs such as with 4-1 straddles.

The transfer machines proposed (so-called mini straddles or automated shuttle carriers by Kalmar) require sufficient space for manoeuvring under the crane backreach travelling in defined lanes parallel to the quay line and then manoeuvring under the assigned bridge crane. 25m has been allowed for the back reach, 15m for a travelling zone and 21m for the bridge crane transfer area.

## Buffer container storage

The layout has been designed in such a way that the rotation of containers from barge to main line vessel is avoided. Refer to Figure 9-3 which shows one offshore mainline vessel berth section with associated terminal to transfer containers into the stack and onto the barges.

Rotation of containers during the handling and transfer process requires time, space and has additional complexity from the point of view of automation. Bridge crane and buffer stacks are therefore arranged for container storage with container alignment parallel to the quay line (i.e. aligned with both barge and main line vessel stowage). This alignment also allows the design of barges and the bridge crane stacks to be matched, in order that shifting of barges during the load and discharge process is avoided. It also allows for possibility of more automation in the barge operation cycle. Bridge crane stacks are therefore laid out according to barge length and distributed over the full length of the quay in such a way that the required buffer capacity is met. This results in the need for a buffer stack length of approx. 80m.

The bridge cranes could also accommodate barges of class V, but this would be operationally inefficient due to the requirement to align the bridge crane with the containers on the barge.

Besides the limits on the height of stacked boxes to define the allowable stacking density, other principle characteristics determining the size of the storage yard are:

- Average dwell time of the containers in the offshore terminal;

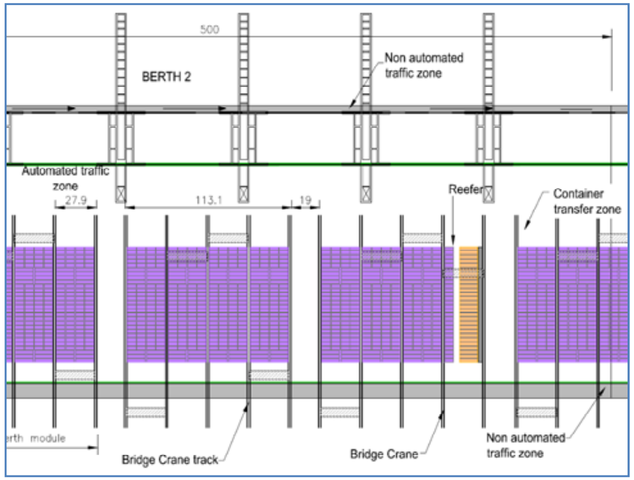



**Figure 9-3 Concept plan overview at offshore terminal for a single mainline vessel berth (annotated Berth 2) with ship to shore cranes, bridge crane modules serving the temporary buffer storage (highlighted in purple) and associated barge berths**

| Description | | |
|---|---|---|
| Split of loaded to empty cargo | 80-20 | |
| TEU Ratio '20:40 | 1.53 | |
| Reefers | 8% | of loaded cargo |
| Out of gauge | 3% | of loaded cargo |
| Mainline avergae container | 4000 | TEU |
| Peak container exchange | 5000 | TEU |
| Average dwell time offshore for containers bound to Chioggia/Levante or transshiped | 4 | days |

**Table 9-1 Extract of key assumptions concerning buffer storage provided by VPA**

| Description | | | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|---|
| Chiogga /Levante | | TEU | 0 | 400,000 | 400,000 |
| Transhipment | | TEU | 200,000 | 500,000 | 800,000 |
| MonteSyndial and | | TEU | 800,000 | 1,100,000 | 1,800,000 |
| Chiogga /Levante | 4 | Dwell days | 0 | 4,384 | 4,384 |
| Transhipment | 4 | Dwell days | 1,096 | 2,740 | 4,384 |
| MonteSyndial and | 1.5 | Dwell days | 3,288 | 4,521 | 7,397 |
| minus reefer days | | Dwell days | -263 | -526 | -789 |
| minus oog days | | Dwell days | -99 | -197 | -296 |
| Sub Total | | Dwell days | 4,022 | 10,921 | 15,079 |
| occupancy rate | 0.85 | | | | |
| peak factor | 1.1 | | | | |
| Total required buffer storage for TEU | | | 5,200 | 14,100 | 19,500 |
| Per Berth this a storage requirement of | | TEU | 2,600 | 4,700 | 4,875 |
| Space available on offshore terminal | | TEU | 12,852 | 19,278 | 25,704 |
| Space available on offshore terminal per berth* | | TEU | 6,426 | 6,426 | 6,426 |

**Table 9-2 Buffer storage requirement**

Notes: Storage is calculated based on average dwell time of cargo in the stack

$$storage\ req = \frac{av. dwell\ time * throughput * peak\ factor}{365 * acceptable\ occupancy}$$

*The storage available at each berth enables the maximum TEU exchange of 5,000 to be stored should this be a load only call, plus a small amount of transhipment or Chiogga/ Levante traffic

- Quay productivity/throughput; and
- Modal split between cargo and the cargo split itself.

The required buffer stack capacity was reached by taking into consideration the overall throughput volume per annum, the presence of transhipment containers, an average offshore dwell time of non-transhipment traffic of 1.5 days, the expected ratio between 20 and 40 feet containers, an operating occupation level of 85% and a peak day requirement of 10%. Refer also to Table 9-2.

Reefer traffic volumes were also considered and special provision for them is made during each phases of terminal growth.

Operating constraints will determine that in normal circumstances, discharge and loading operations take place via the buffer stack.

However, provision is made between modules of four bridge crane stacks for an access lane between the deep-sea berth side of the bridge crane stack and the barge berth. This lane provides the opportunity to move containers between the main line vessels and the barges without transit through the buffer stack.

However, this would provide considerable challenges for automated equipment and operational circumstances would rarely be such that this could be done without considerable negative impact on productivity.

However, these lanes will be required for the access of maintenance vehicles, movement of personnel, and the movement of out of gauge (OOG) units by means of manually operated mini straddle carriers. The inter module spacing is also required to provide unhindered space for automated mini straddles to turn into the transfer area of each module at the deep-sea berth.

## Refrigerated container stacks

Reefer stack capacity was calculated as above and using the expected volume of reefer traffic. Purpose built bridge crane reefer stacks, distributed along the length of the quay will use the same bridge crane width as other stacks. These could also be used for dry containers but each reefer stack will be fitted with a gantry structure running the length of the stack for human access up to five tiers for the purpose of plugging, unplugging and monitoring of reefer containers.

As far as possible, there is provision for non-container handling vehicular traffic to circulate using a 5m lane between the berth face and the seaside crane rail or seaside bridge crane transfer area. A transfer lane between main line berth and the barge berth for this traffic is envisaged every 500m. This, of course, will need to be carefully controlled to avoid the potential of mixing automated traffic with vehicular traffic but is necessary to avoid the need for all vehicles to circulate the entire terminal.

## Space demand for non-container handling purposes

The above considerations result in an overall 200m terminal width. With the entire 2000m by 200m area being dedicated to container handling operations. Further space is required for supporting, but essential non-operating purposes and for the storage of cargo that cannot be accommodated within the bridge crane stacks. For this purpose, use has been made of an area of 875m by 150m lying inside the breakwater. A large accommodation and office building is required. Positioning of this building takes into account the need to have easy access to the terminal traffic circulation and easy access to the berthing area allocated for personnel ferries and supply vessels.

A separate maintenance building is required for the servicing of mobile machinery and as a store and centre for the maintenance of ship to shore

| Description | | | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|---|
| Import and export reefers throughput per annum | | TEU | 64,000 | 128,000 | 192,000 |
| Reefer dwell time | 1.5 | Dwell days | 263 | 526 | 789 |
| Occupancy | 0.85 | | | | |
| Peak Factor | 1.1 | | | | |
| Space requirement of | | TEU | 340 | 681 | 1,021 |
| Provide space for | | TEU | 506 | 759 | 1,012 |
| Provide space at each berth for | | TEU | 253 | 253 | 253 |

**Table 9-3 Reefer requirements**

| **Description** | | | **Scenario 1** | **Scenario 2** | **Scenario 3** |
|---|---|---|---|---|---|
| Import and export oog throughput per annum | | TEU | 24,000 | 48,000 | 72,000 |
| oog dwell time | 1.5 | Dwell days | 99 | 197 | 296 |
| Occupancy | 0.85 | | | | |
| Peak Factor | 1.1 | | | | |
| Space requirement of | | TEU | 128 | 255 | 383 |

**Table 9-4 Out of gauge unit requirements**

and bridge cranes. Easy access to this building for mini straddles is essential and a parking area is required for machinery not in use, or waiting servicing.

A large area for out of gauge cargo has been provided based on expected traffic levels as advised by VPA. It is expected that this area will be served by manned machinery and its location enables the loading of such cargo to/from barge by means of mobile crane thus avoiding the usage of bridge cranes.

Storage of fuel, water and waste will be required and these have been positioned close to the workshop. It is expected that there will be the need to provide examination facilities for the use of authorities even though it is expected that most non-transhipment containers will be examined on-shore.

Emergency facilities will be needed offshore. A specially constructed site for leaking containers will be provided away from other buildings. A helicopter pad should be provided, however this facility may be shared with the oil terminal.

## Marine Services

It has been assumed that tugs for main line vessels will be arranged directly, and paid for, by the line from third party tug operators. Therefore, neither costs nor facilities for such services have been taken into account. No provision has been made for the bunkering of main line vessels but in the unlikely event that this was required, bunkering could be performed by lighter. Provision has not been made for the installation of "cold ironing" power supply for main line vessels.

## Barge Operation

The barge operation will take place on the more sheltered side of the container terminal. Barge carrying mama vessels will perform the floating on and off of barges within this area and at least in good weather, without the need to go alongside the quay.

Tugs will manoeuvre the barges with exports to pre designated barge berths principally dependant on the proximity of the planned main line berth for which the majority of the barges exports are planned. Relatively low barge numbers compared to barge berths will allow a large degree of freedom in selecting the optimum berth and at the same time leave the majority of bridge cranes free for working mama vessel load/discharge operations.

Bridge crane layout is designed with barge dimensions in mind. Container stowage on barges will exactly match the spacing of bridge crane stacks thereby avoiding the need to shift barges. Barge mooring will need to be a fixed and rigid system allowing for rise and fall in tide as well as displacement changes as the barges are loaded and discharged. This is an important feature and key to ensuring high barge productivity and the possibility of a high level of automation of barge handling.

Two tugs have been assumed off shore. When not engaged in manoeuvring barges on and off mama vessels, they will be used for the marshalling of completed barges in readiness for mama vessel arrival.

Tugs will require offshore fuelling facilities and this is planned to be available on the same non-container handling berth that will be used by personnel ferries and supply vessels. A small store has also been provided for tugs adjacent to the fuelling berth. Major tug maintenance will be carried out at shore based facilities.

## Buildings

Buildings will be required for offices, operations control, living accommodation, storage, machinery maintenance and covered cargo inspection. Office accommodation will be required not only for terminal staff but also for customs, port health authority, harbour master, pilots etc.

A single multifunction building is proposed to house as much of the above requirements as possible. Accommodation and catering needs will be quite large in that two complete operational teams must be accommodated in addition to maintenance staff, indirect terminal staff plus line agencies, customs and other authorities. Several floors will be required enabling the top floor to be used for terminal control purposes. The office building requires good access for vehicular traffic to the terminal and easy access to ferry traffic from the shore.

A separate maintenance building will be required with sufficient height to enable at least four mini straddle carriers to be serviced under cover. Within the maintenance building, workshops will be required for electrical, electronic, and mechanical maintenance. The maintenance building should also incorporate the spare parts stores.

Separate buildings will be required to provide covered container inspection, stores for barge tugs. Facilities will also be required for the storage of fuel, liquid and solid waste. A leaking container site will be required fitted with confined drainage to prevent pollution. A similar facility will also be required, near the maintenance building for the steam cleaning of machinery.

## Equipment

### Ship to Shore Cranes

It is assumed that ship to shore cranes will be of dimensions that are compatible with the handling of the largest ships expected to enter service. Even if the largest vessels now on order are not expected to make north Adriatic calls, it would be unwise not to foresee the future possibility and provision of such cranes, would create possibilities of attracting potential lines when they are considering changes in their liner services.

Such cranes will be capable of handling vessels with 24 rows of containers and stack heights on deck of nine high. Such cranes are normally built on crane rails of 35m span. The complication of double trolleys and lashing platforms can be avoided in order to minimise maintenance.

Twistlock and hatch storage operations are planned to take place between the crane legs with automated operations taking place in an extended (25m) back reach.

Given typical operating speeds for cranes of this size, it is unlikely that crane cycle time will be the limiting factor in overall productivity. It is assumed that crane specification will be such that maximum use is made of twin and tandem lift spreaders in order that productivity is maximised and crane cycles minimised.

Such cranes are normally expected to handle volumes of at least 120,000 moves per years. A move is the complete cycle of a crane spreader, from the ship to the shore and back and may carry several container boxes dependent on a single or dual lift as well a tandem or multiple lift arrangements and TEU box ratio.

The productivity figure of 120,000 moves would imply the requirement for 16 cranes. However, given the large turnaround figures and large vessel expected, 16 cranes (average four per berth) may result in lower than possible crane deployment especially at peak times. Such considerations can be seen at other terminals where planning results in ratios close to one crane per 100m of quay. Eighteen cranes are therefore planed for scenario 3 when terminal capacity is reached.

It would be expected that cranes of this type would continue operations in winds of up to 20m $sec^{-1}$. This is an important factor to take into account when considering wind effects on other parts of the twin terminal operations.

### Mini – Straddle

The equipment planned for the transfer from ship to shore to buffer stack is an automated mini-straddle carrier. Mini-Straddle carriers are a relatively new concept within modern container terminal operations although straddle carriers have been in operation since the earliest days of containerisation.

The mini straddle concept is just the same as that of a normal straddle carrier but they have been designed for the purpose of operating in conjunction with automated yard stacking systems. The term "mini" is used as these machines are lower than conventional straddles, which also perform container stacking within the yard. Designs are typically one


**Figure 9-4 Straddle carrier, source KALMAR straddle carrier catalogue**

over one (i.e. capable of lifting a con-container to the height sufficient to carry it over another grounded container).

As yet, there is no terminal that has automated these machines but active consideration is being given to this by both terminal operators and the manufacturers. Manually operated machines have been produced by two of the main straddle suppliers and one of these suppliers has, for several years, been developing the automation of straddles to the point where real operations are now being carried out. The principles of automating a mini-straddle would be little different, and perhaps simpler as there is no need for them to perform yard stacking.

Automated Guided Vehicles have been in operation for a number of years and these would be an alternative. However, the mini straddle provides the opportunity of realising the best features of a straddle operation with the dense stacking advantages of automated stacking cranes. The main advantage is simply that the operation of both ship to shore cranes and yard stacking cranes is disconnected from the operations of the mini straddles.

It is not necessary for either crane to await the presence of a mini straddle (as would be the case with an AGV) and this has large advantages in the realisation of high productivity and minimising the number of machines required. It is expected that a ratio of three machines per ship to shore cranes would easily be capable of reaching high productivity figures given a highly sophisticated yard planning computer system managed by well-trained and competent planners.

Two manually driven mini straddles have been included. These machines are mainly planned for the handling of out of gauge traffic or special functions (e.g. moving containers in out of the inspection area, handling leaking or damaged containers)

### Bridge Cranes

Bridge cranes have been in operation for many years. Singapore has a terminal using remotely controlled bridge cranes and prototype auto-automatic bridge cranes were developed in Belgium several years ago. Bridge cranes have not been more extensively used due to the cost of the overhead structure and the proven ability to automated rail mounted gantry cranes.

However, in the case of the offshore terminal, the bridge crane with tracks extended to barge width over the quay, provide the opportunity to discharge and load barges in a single move directly to the buffer stack location. At the point of load or discharge to/from ship to shore crane, the same bridge crane can perform a single move from buffer stack to transfer area ready for the mini straddle carrier.

Barge stability and the adequacy of the barge mooring system will determine the extent to which the bridge crane cycle can be automated. If manual intervention is required, only the last few centimetres of spreader lowering/ lifting at the barge end will require human intervention. In this case, remote control can be carried out from an office using CCTV or by an operator on site, using a hand held control and in both cases, it is reasonable to assume that a single operator can control more than one bridge crane.

Bridge crane dimensions have been kept to the minimum possible, not only to save yard space but also to avoid wasting space on the barge design as to avoid complication, barge stowage needs to be aligned with bridge crane stack geometry.

The bridge stacks are designed to store containers parallel to the quay (i.e. same alignment as the barges) to ensure high barge crane productivity and therefore minimise barge numbers. This also avoids the need to have rotating bridge crane spreaders which would add cost and complication. However, this does require that at the deep-sea end of the buffer stack, mini straddles will have to access the transfer area parallel to the quay face rather than the more usual means with automated stacks of entering the transfer area perpendicular to the quay face.

**Figure 9-5 Reach stacker handling out of gauge cargo, source ConTraiLo "Linde Reach Stacker"**

**Figure 9-6 Mobile harbour crane to handle out of gauge cargo, photo shows Model 7, G HMK 7408 B four-rope crane handling wind turbine components at Socarpor, Portugal – Source http://www.setcorp.ru**

In both the deep-sea and barge opera-operation, it is envisaged that maximum use will be made of dual cycling. (Combined loading and discharging) in order that the number of bridge crane cycles made without a load are minimised.

### Other Handling Equipment

A quantity of other non-automatic equipment will be required to support operations. Out of gauge container traffic or the occasional piece of non-container traffic will be handled and stored outside the automated operation. Reachstackers are very flexible machines and the most effective pieces of equipment for the OOG storage area. These machines may also be required in the examination area or for the handling of damaged containers.

Tractor-trailers will similarly be required for the handling of exceptions such as damaged containers or traffic that cannot be easily grounded and must be kept on trailers.

Two mobile harbour cranes have been included for the handling of the large quantities of out of gauge traffic or non-container traffic, the addition of a mobile harbour cranes positioned adjacent to the OOG area will avoid considerable disruption that would be caused by the handling of this traffic within the main container handling area.

| Offshore equipment | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| Description | Total numbers | Change | Total numbers | Change | Total numbers | Change |
| Bridge crane and special bridge crane frames*1 | 32 | | 48 | 16 | 60 | 12 |
| Mobile crane | 1 | | 1 | | 2 | 1 |
| Ship to shore crane | 7 | | 12 | 5 | 18 | 6 |
| Auto mini straddle | 20 | | 35 | 15 | 52 | 17 |
| Manual mini straddle | 2 | | 2 | | 2 | 0 |
| Terminal tractor | 2 | | 2 | | 3 | 1 |
| Trailer | 10 | | 15 | 5 | 20 | 5 |
| Reachstacker | 1 | | 1 | | 2 | 1 |
| Spare spreader | 2 | | 3 | 1 | 4 | 1 |
| Spare bridge crane spreader | 2 | | 3 | 1 | 4 | 1 |

**Table 9-5 Summary of key equipment requirements offshore**

Note:

*1 Bridge cranes need a supporting frame to work , in this concept study this frame has been assumed to be made of steel due to the slenderness of the structure and the forces involved. In the example of Pasir Panjang terminal this was made out of concrete. Further, each frame has been developed based on a modular approach where a frame can support 4 bridge cranes, thus 32 bridge cranes require 8 modular frames as support. A more detailed study is required to devlop this design concept.

## Power requirements

Venice Offshore Terminal will be developed progressively over 3 phases. To provide the power for the fully developed Port it is anticipated a power plant of approximately 36MWe would be required; the average load for a fully operational Port is estimated to be approximately 70% of this value.

An assessment of electrical load has been carried out based on anticipated loads and diversity factors for the Port operations. Transient loads have also been reviewed to determine the required “spinning reserve” and is included in the power plant value.

The first phase of the Port would require approximately 24MW, the plant would be designed for the fully developed Port but in the first Phase not all generator and auxiliaries would be installed. The remaining generators would be added later following a review of the actual Port operation..

Just as important as it is to meet the Port peak power demand the plant needs to be capable of prolonged operation at low load satisfying the Port’s minimum demand. For generators it is as important to consider the minimum load as it is the maximum and would dictate the minimum unit size. If necessary the need to include a ‘low load’ unit may be required and as the plant would require a black start capability this ‘low load’ unit could be used to satisfy this requirement.

VPA has advised that power requirement at the offshore terminal will be accommodated by a cable to be provided by others. However, a power station will be provided as a backup in case of failure of the cable.

### Phasing of terminal

Possible phasing of the offshore terminal in line with the stated project throughput requirements identified in chapter 2 are presented in Figure 9-7.

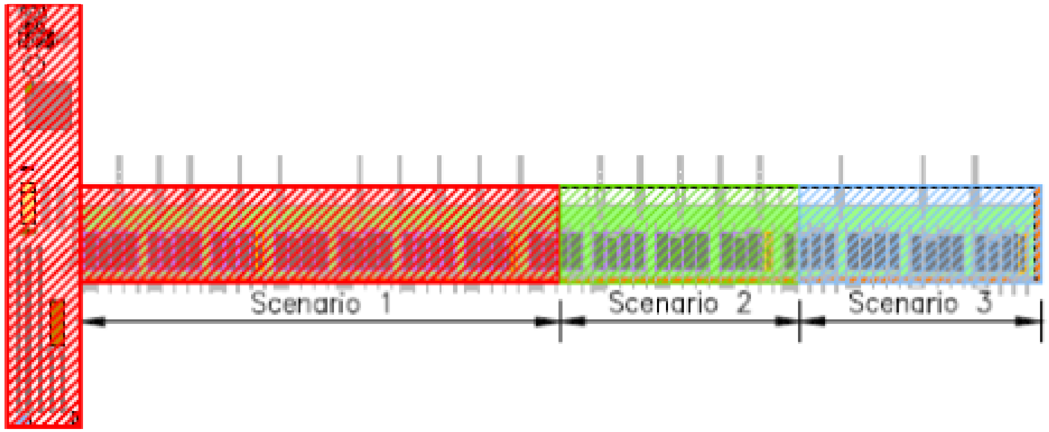



**Figure 9-7 Phasing by scenario for the offshore terminal**

# 10. LAYOUT AT MONTE/SYNDIAL

## Introduction

The first part of the development is an onshore terminal for handling container vessels up to the maximum size that will meet the size constraints of entering the Venice lagoon. Generally speaking, these vessels are up to panamax dimensions. Volumes for this type of traffic are assumed to reach 600,000 TEU per annum after which growth in deep-sea traffic will be accommodated offshore with the potential to berth much larger, in fact, the largest vessels in service.

Many regional ports can handle panamax size vessels and services on which such ships are used are increasingly regional rather than oceanic. It therefore seems appropriate to configure the start up onshore terminal with the flexibility to handle a variety of traffic with the ability to adapt, rather than invest large sums in automated operations that are targeted at one particular traffic type, are inflexible and which require long amortisation periods.

A conventional RTG operation is therefore planned for the initial stages with automated development following the opening of the offshore terminal when high levels of productivity and intensity of operations will be required.

## Key considerations

- The initial development must operate as a standalone terminal, capable of offering as good or better service levels as similar regional terminals operating similar traffic.
- Service levels must also be comparable with the best that are available internationally to line operators in the services on which their vessel are deployed.
- Development of the conventional onshore terminal must take into consideration the need to expand services to accommodate the additional traffic that will result from

the opening of the offshore ter-terminal. (e.g. Gate and rail expansion)

- As far as possible, the design must avoid duplication of facilities for the conventional and offshore op-erations

## Conventional Operations

### Quay

600m of quay is provided for the initial operations described as Scenario 0. Please refer to Figure 10-2 for an overview of the terminal layout at Montefibre/ Syndial for this phase. 600,000 TEU is the required capacity and with a ratio of 1,000 TEU per metre of quay per year, this should easily be accommodated providing there are reasonable productivity levels and no major delays to vessels arriving or departing because of navigational restrictions. A conventional RTG operation is planned with tractor-trailers operating between the 30m span quay crane rails with hatch cover storage in the back reach.

### Yard

Based on expected dwell times, 20:40 ratio, the traffic split and making allowances for occasional traffic peaks, 12 RTG blocks will provide sufficient storage to operate at around 70% occupation, refer also to Table 10-5. Note that for RTG opera-tions 70% is generally accepted as an optimum occupation level.

In addition to the RTG storage of dry containers, a further block is provided for reefer containers. Capacity of this has been determined by expected reefer traffic volumes and dwell time. An access gantry within the reefer stack will be provided for staff charged with unplugging, plugging and monitoring of the containers.

**Figure 10-1 Conventional terminal with similar layout to that proposed at the conventional area at Monte/Syndial**

| Description | Dwell days | Scenario 0 to 3 Annual TEU | Dwell days |
|---|---|---|---|
| Full Export | 5 | 192,000 | 1,841 |
| Full Import | 7 | 288,000 | 4,340 |
| Empty Export | 18 | 30,000 | 1,356 |
| Empty Import | 18 | 90,000 | 4,068 |
| Reefer Import | 4 | 23,040 | 158 |
| Reefer Export | 4 | 15,360 | 105 |
| OOG Import | 7 | 8,640 | 130 |
| OOG Export | 5 | 5,760 | 55 |
| standard TEU in stack, unfactored | | | 11,605 |
| remove import empties after duration in stack | | | -3,082 |
| remove export empties after duration in stack | | | -1,027 |
| standard TEU in stack after removal of empties | | | 7,496 |
| Occupancy rate | 0.7 | | |
| Peak factor | 1.1 | | |
| Storage required | | TEU | 11,800 |
| Provide RTG 7x5 = 35 – shuffle factor*1 of 4 = 31 TEU capacity, 40 TEU long, 12 no blocks =31*40*12=14,888 *2 | | TEU | 14,888 |

**Table 10-1 Storage requirement for containers at standard RTG terminal**

Note

*1 A shuffle factor is a reduction factor in the capacity of a stack due to the need to shuffle boxes to get to the one wanted i.e. the box near the bottom, in order to reach it the crane needs to remove boxes on top and place these somewhere thus reducing overall storage capacity:

*2 Dependant on the stack layout chosen and lane alignment, a longer block may be possible – the layout should be optimised in a detailed masterplanning study

RTG configuration planned is seven wide plus transfer lane, one over five stacking height.

The lengthy dwell time for empty container storage makes the provision of separate empty storage a more cost effective option and the layout assumes that empty stacks will be serviced using empty container handlers fitted with face frames. The area is situated at the rear of the terminal. The empty container area is also designed to support the additional empty volumes that will flow following the opening of the offshore terminal.

| Description | Scenario 0 to 3 in TEU |
|---|---|
| Longterm storage for empties required | 6,000 |
| Storage for oog required | 300 |
| Storage for reefers required | 400 |

**Table 10-2 Storage required for empties, oog and reefers for RTG terminal**

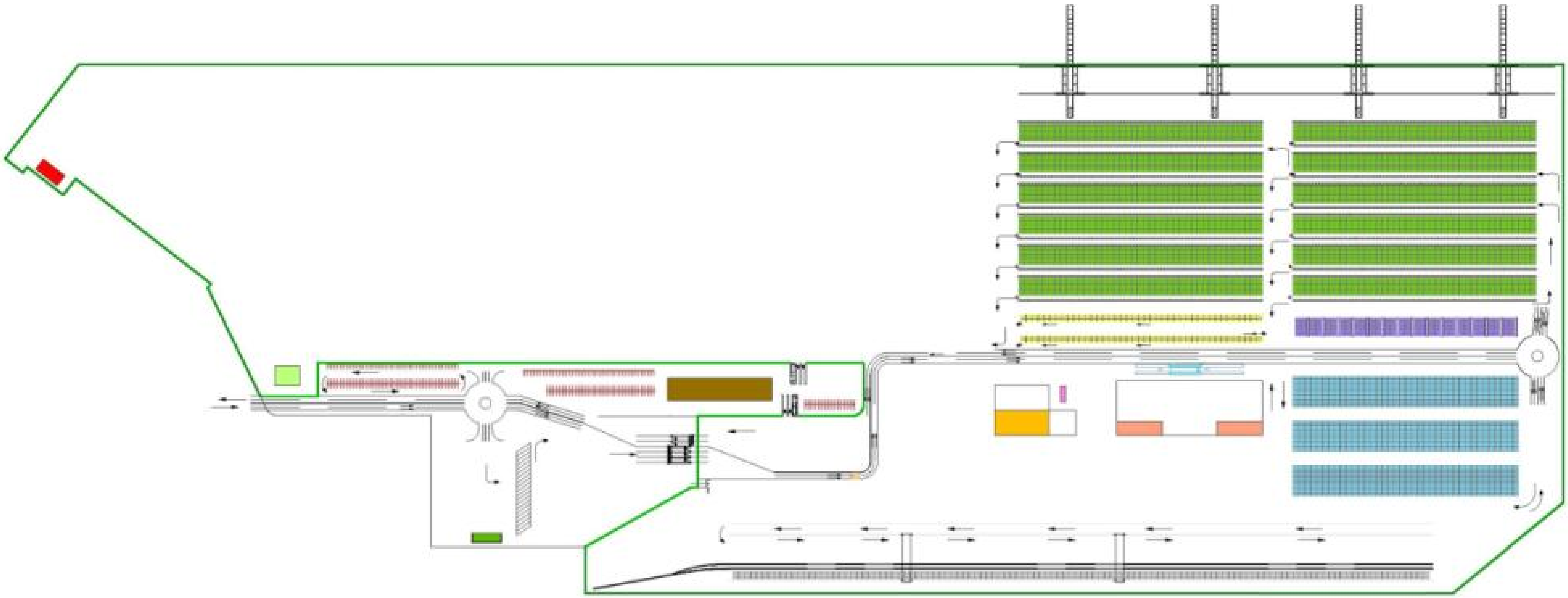



**Figure 10-2 Overview layout plan for the onshore terminal at Montefibre/ Syndial in phase 1**

## Workshop

The workshop for machinery maintenance is positioned as close as possible to the RTG area, such that RTGs will be able to directly access a maintenance parking area in front of the workshop. Being positioned at the western end of the conventional area, the maintenance workshop is also positioned to support the future barge operating area.

## Inspection Area

Similarly the inspection area is positioned to support both the conventional and barge area. Covered inspection facilities will be required for both customs and food health authorities. Space is also provided adjacent to this area for X-Ray inspection. Containers will be moved to and from the area by internal tractor trailer and either left on trailer or grounded using reachstackers depending on the type of inspection required.

## Rail

The rail tracks at the rear of the terminal will also be required in the first phase of conventional operations but built to accommodate full capacity following the commencement of offshore operations. The rail terminal has tracks of 775m, this is to accommodate the longest expected future trailing length of 750m plus allow space of 25m for loco. Further, a turnout of 150m length is provided.

It is planned that the terminal would be served by wide span Rail Mounted Gantry Cranes.

A span of 50m is provided which is far wider than would be required in the initial stages of operation and would also provide substantial growth for the extra traffic to/from barge and the potential for future growth. It is anticipated that initially 2 rail sidings may be required to be served with 2 RMG cranes, increasing to potentially 6 sidings and 3 cranes.

The space not required for rail tracks in the early stages can usefully be used for the temporary positioning of export and import containers thereby enabling continuous train operations with the gantry cranes regardless of any disruption in the circulation of traffic carrying containers to and from the container stacks.

The concentration of inland train movement during the night time hours will require external train marshalling yards. This provision has been assumed in the design as otherwise, capacity of the on-terminal rail facility will be severely limited. It has therefore been assumed that trains will be pushed on to the terminal and a locomotive escape track has not been provided although there is space to provide such a track if required.

## Gates

As with other facilities, gates have been designed to allow a limited facility to be provided to support the conventional operations with the possibility to expand to support the full operation when the barge facility opens. Gate lane numbers have been calculated based on expected volumes, typical traffic peaks, and estimated service times. A two-stage gate entry process is assumed – this is quite common in container terminals generally including other Italian terminals.

The process assumes the pre-advice of collection and delivery of containers by electronic means and then registration and completion of missing information when the vehicle arrives at the gate pre-entry office. This can be carried out using self-service computer terminals, ideally, but not essentially, with the added benefit of vehicle driver machine-readable identity cards.

The second stage of the process is gate entry for automatic inspection of containers by means of CCTV, and a check (automatic) that information has been pre-entered leaving only seal check and recording of seal number to be completed manually.

For conventional terminal traffic, yard location will be advised to the driver, at this stage. In the case of the barge operation, the transfer bay will be advised or if the required bay is occupied, the driver will be directed to the internal parking area for subsequent transfer-bay advice when the bay becomes vacant. For this reason, an internal parking area has been provided for use when the barge area becomes operational.

## Automated barge operation for second phase

During the second phase of operations the terminal is expanded to be able to handle containerised traffic from the offshore terminal via barges. Please refer to Figure 10-3 for an overview of the terminal layout at Montefibre/ Syndial for this second phase

The barge berths have been designed such that the marine interface will be identical to that of the offshore barge berths. However, in that the larger part of both export and import dwell time will be absorbed ashore, (to minimise the size of the offshore buffer stack), the bridge crane bays are much longer and due to this, and the constant demand for serve at the landside, two bridge cranes per stack will be required.

As with the offshore terminal, container storage will be parallel to the quay line to facilitate rapid barge handling (one over five high stacking). At the landside, safety considerations require that containers be turned through 90° in order to load/unload to/from road vehicle.

Loading vehicles with parallel alignment would require that containers would pass over the top of parked road vehicles and/or leave tractor cabs and drivers vulnerable to containers being moved by bridge crane. The landside bridge cranes will therefore be fitted with rotating spreaders. Perpendicular alignment at the landward end of the barge stacks also allows vehicles to be reversed into the transfer area leaving the cab of the tractor-trailer unit clear of the bridge crane operating area. Nevertheless, small kiosks are planned in order that driver must clear the transfer area before loading or discharging of vehicles takes place.

In the same way as with the conventional berth, it is not cost effective to allocate bridge crane space to accommodate the lengthy dwell times of the empty traffic. Therefore, empty containers would be moved in and out of the bridge crane stacks as soon as possible in the case of imports and as late as possible in the case of exports.

Extra empty stacks have been planned to support the barge berths and in combination with the conventional berths, over 13,500 TEU of empty stacking space has been planned. The large movement of empty containers and rail traffic would imply a significant quantity of internal tractor-trailers that would constantly be in conflict with the service demand of external traffic. For this reason, the use of multi-trailer units being handled under the bridge cranes at the quayside is foreseen. The flow of barge traffic being spread over several barge berths will allow quite a lot of bridge crane availability when stacks are not required for barge operation, and enable better overall bridge crane utilisation.

Calculation of space requirements shows that the expected volumes can be managed by 5 units of four bridge crane stacks but space exists to create a sixth module which would either create the opportunity for higher volume or provide greater comfort at peak times should dwell times be in excess of those predicted.

Note

*1 stack capacity in TEU is derived from cross sectional capacity =20 TEU - 4 TEU shuffle factor to get to boxes = 16 TEU capacity, space in stack for 69 boxes long, each has hence capacity for 1104 TEU

Each berth comprises of three standard stacks as well as one special stack that can accomodate 40ft or 20ft reefers and a 20ft dry container

| Description | Dwell days | Scenario 0 to 3 Annual TEU | Dwell days |
|---|---|---|---|
| Full Export | 3.5 | 256,000 | 2,455 |
| Full Import | 5.5 | 384,000 | 5,786 |
| Empty Export | 16.5 | 40,000 | 1,808 |
| Empty Import | 16.5 | 120,000 | 5,425 |
| Reefer Import | 2.5 | 30,720 | 210 |
| Reefer Export | 2.5 | 20,480 | 140 |
| OOG Import | 5.5 | 11,520 | 174 |
| OOG Export | 3.5 | 7,680 | 74 |
| standard TEU in stack, unfactored | | | 15,474 |
| remove import empties after duration in stack | | | -4,110 |
| remove export empties after duration in stack | | | -1,370 |
| standard TEU in stack after removal of empties | | | 9,995 |
| Occupancy rate | 0.7 | | |
| Peak factor | 1.1 | | |
| Storage required | | | 15,700 |
| Provide Bridge cranes, stack capacity in TEU, 16 TEU, X 69 boxes long = 1104 TEU, with 5 berths and three stacks each this leads to ~16,500 TEU with 6 berth this is ~20,000 TEU*1 | | | 16,500<br>20,000 |

**Table 10-3 Storage in bridge crane stack required**

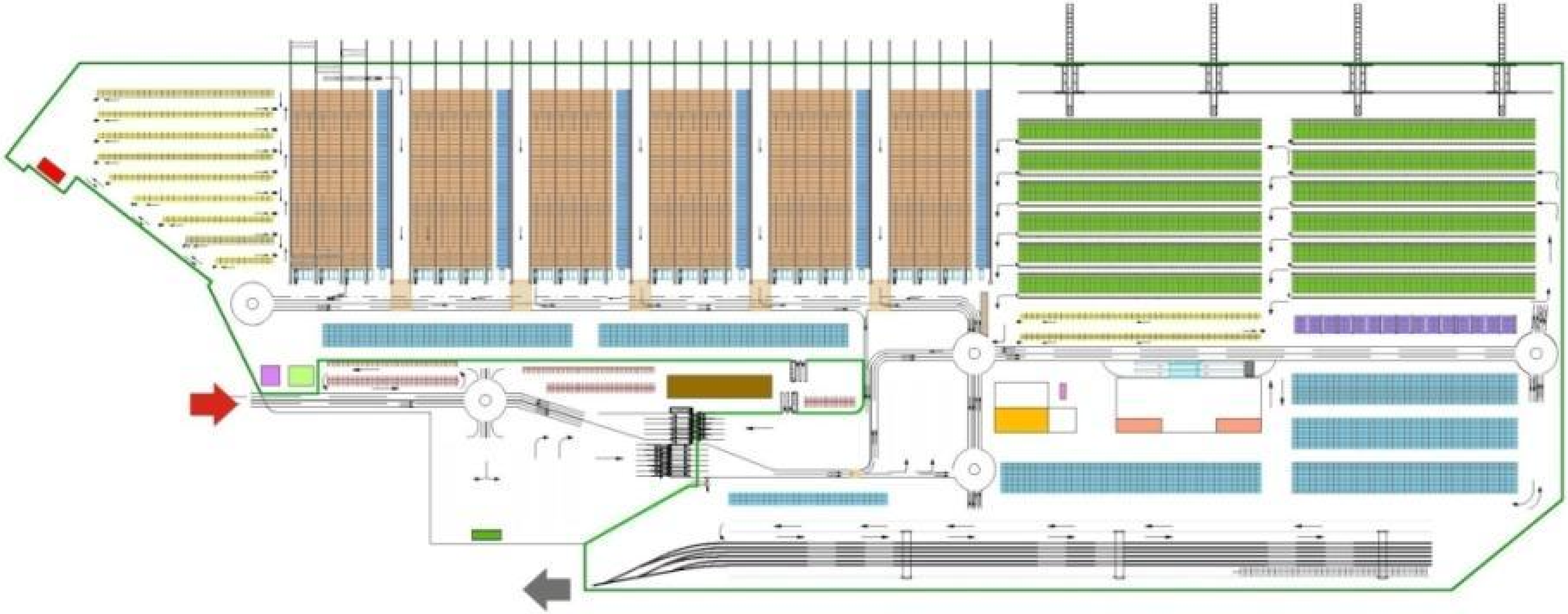



**Figure 10-3 Overview layout plan for the onshore terminal at Montefibre/ Syndial in phase 2**

## Out of Gauge/non-container traffic

The area to the extreme west of the quayside, where there is insufficient depth of terminal to create a bridge crane stack has been allocated for storage of out of gauge traffic that can be handled using reach-stackers. As in the case of the offshore terminal, handling to/from barge can take place using the seaside bridge crane from the quay apron or if volumes justify, there is sufficient quay space available for a mobile crane.

OOG and non –container traffic can be handled to/from barges by means of a mobile harbour crane. Handling of such cargo can also be performed by means of the seaside bridge crane from the quayside apron.

## Traffic Circulation

Traffic circulation has been designed with flexibility in mind enabling external vehicles to perform export moves within the conventional RTG areas, and collection form the barge area or vice versa.

## Office Building

A single multi-floor terminal office building is planned adjacent to the terminal gate complex. This location avoids the need for non-operational vehicle traffic to enter the terminal and from a security point of view, the building can be considered to be outside the secure fencing. Vehicles for the transport of personnel, supervisors will be able to enter the terminal by means of barrier control. The building would be required to accommodate management offices for the combined offshore/onshore terminals, planning functions for both, and control office for the onshore functions. In addition there will be a need for onshore workforce locker/changing rooms, offices for authorities and agents etc.

| Description | Scenario 0 to 3 in TEU |
|---|---|
| Longterm storage for empties required | 7,500 |
| Storage for oog required | 350 |
| Storage for reefers required | 600 |

**Table 10-4 Required storage for barge terminal operations**

## Equipment

Four ship to shore cranes are planned for the initial onshore start-up operations. The forecast volume of 600,000 TEU (400,000 moves) could be handled providing there are no particular delays after completing vessels due to, for example, night-time sailing restrictions. Modern cranes are normally considered capable of handling in excess of 120,000 moves.

Cranes for this terminal would need to be suitable for the maximum size of ship that is likely to enter the lagoon (panamax dimension). Built on a 30 m rail span, crane design would be typical of the modern cranes of this size. Hatch cover storage would take place in the backreach with the majority of all other operations taking place between crane legs.

## RTG

RTGs operating in stacks of seven containers wide and with lifting height of one container over five are planned. There are several ratios used for planning RTG numbers and to a certain extent, the most appropriate ratio depends on factors such as dwell time, terminal layout and productivity expectations. In this case, there are no particular constraints imposed by yard layout and dwell time falls within typical European levels and therefore to achieve high productivity levels it is considered best to look at the ratio between total storage TEU and number of machines. Productive terminals of this type in a European context will typically have a ratio of around 1000 TEU of total RTG storage space per machine. Sixteen machines are therefore considered appropriate. This also results in a good ratio of RTG to ship to shore crane and is in line with typical RTG ratio in terms of moves/year.

## Tractor Trailer

In conventional RTG operations, the number of tractor / trailer units is crucial to the level of productivity that can be achieved and except with very large numbers, when efficiency decreases, the number deployed is generally the main constraint in determining the cycle time. Many terminals in Europe deploy three units per crane but this number is too low to maintain good productivity. Four units per crane have been assumed but it is important that scheduling software is used that allows logical deployment of tractor-trailer units between all quay cranes such that there are no instances of quay cranes waiting for tractor-trailer units whilst other are queued under adjacent cranes. Conventional elevating fifth wheel tractors are assumed with cornerless purpose-designed trailers for easy removal and fitting of twistlocks.

## Reachstackers

Reachstackers will be required for the handling of OOG containers, servicing the inspection area.

## Empty Container Handlers

These machines will be required for managing the empty container storage area. The use of these machines is much more cost effective than RTG storage for the management of empty containers and direct stack to ship via tractor-trailer is normally equally as productive as with RTG. It is envisaged that machines deployed will be capable of stacking at least seven high.

### Scenario 1 – onshore equipment

Reach stackers and empty container handlers, also used in Scenario 0 will be required in increased numbers to support the handling of OOG and examination movements when the offshore terminal commences operations. To a lesser extent, extra tractor-trailer units will also be required to support movements for examinations.

### Rail Mounted Gantry Cranes (RMG)

Wide span RMG are provided for the rail terminal. Numbers can be increased as required by traffic levels. Rail span at 50m is more than may be considered necessary for the number of tracks required but space beneath the gantry is not wasted as this enables trains to be discharged without waiting for tractor-trailer units or import containers to be pre-positioned in advance of train arrival. In order to maximise the space available between the rails, a cantilever is suggested on the seaside of the tracks for load/discharge from trailer.

### Bridge Cranes

As noted earlier, each bridge crane stack will require two bridge cranes. This is due to the greater length of the stack when compared with offshore buffer storage and due to the constant need to service external road vehicles delivering or collecting containers and internal vehicles serving the empty stacks, rail terminal, and the examination area.

Due to the need to avoid risk of contact between automated bridge crane operations and external vehicles, it is necessary to turn containers through 90° before loading to external vehicle. In this way the vehicles cab unit is always outside the bridge crane operating area (only the trailer unit is positioned within the transfer zone). Landside bridge cranes will therefore be fitted with a rotating spreader.

Both seaside and landside bridge cranes will be driverless and operate fully automatically within the stack. t For safety reasons, the last part of the spreader lifting or lowering at landside and seaside barge or transfer area, will be controlled either remotely using CCTV or by an operator with a handheld control. In both cases, operators will control more than one bridge crane.

## Multi-trailer

Barge handling will not occupy all berths, all of the time and this will leave a number of seaside bridge cranes available for other purposes. There is a need to move significant quantities of empty containers in and out of the bridge stacks to avoid stack congestion. The use of conventional internal tractor-trailers for this purpose will require a large number of resources. The use of multi trailer trains operating on the quayside barge- berth apron will avoid congesting the landside end and significantly reduce the number of men and machines to be used in the container transfer. The same means can be used for the transfer of containers to/from the railhead.

Purpose designed multi trailer tractors have the ability to tow five or six 40' twin axle chassis. Some terminals use automatic coupling/decoupling mechanisms in order that several trailer trains can be managed by a single tractor thereby decoupling the transfer operation from the empty container handler or rail terminal RMG operation. (Decoupling would not be possible at the bridge crane).

| Onshore terminal equipment | Scenario 0 | | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|---|---|
| **Description** | **Total numbers** | **Change** | **Total numbers** | **Change** | **Total numbers** | **Change** | **Total numbers** | **Change** |
| Ship to shore crane | 4 | | 4 | | 4 | | 4 | |
| RTG | 16 | | 16 | | 16 | | 16 | |
| Tractor | 20 | | 20 | | 20 | | 20 | |
| Trailor | 24 | | 26 | 2 | 26 | | 26 | |
| Spare Spreader | 1 | | 1 | | 1 | | 1 | |
| Special lift frames*1 | 3 | | 3 | | 3 | | 3 | |
| Empty Handler | 2 | | 5 | 3 | 5 | | 5 | |
| Reachstacker | 1 | | 3 | 2 | 3 | | 3 | |
| RMG | 1 | | 3 | 2 | 3 | | 3 | |
| Bridge cranes, bridge crane frames and spreaders for barge berths | | | 24 | 24 | 24 | | 24 | |
| Bridge crane rotating spreader | | | 24 | 24 | 24 | | 24 | |
| Mobile harbour crane | | | 1 | 1 | 1 | | 1 | |
| Multi trailer tractor | | | 5 | 5 | 5 | | 5 | |
| Multi trailer chassis | | | 22 | 22 | 22 | | 22 | |

**Table 10-5 Overview onshore equipment**

**Note: *1 Special lift frames are frames than are used for out of gauge cargo / project cargo that may require chains**/ wires etc for lifting

## Power requirements

The Monte/ Syndial Terminal is dominated by the bridge crane loads rather than the quayside cranes. This results in a much more stable Port load. To provide power for the fully developed Port it is anticipated a HV substation of approximately 20MWe will be required.

To provide security of power for the Port at least 2 independent HV power supplies should brought to the Port. Consideration needs to be given to provision of emergency generation for essential services in the event of a double supply failure.

# 11. ORGANISATION STRUCTURE

## Introduction

The initial conventional operations at the on-shore facility require an organization structure typical of similar terminals in Italy. Following the commencement of operations off-shore, it is considered that evolution of the on-shore structure, to manage off-shore operations and the on-shore barge facility, will be the most cost effective and least disruptive means of managing the transition period and subsequent growth of the combined operation.

Inevitably, there are particular and unavoidable costs in placing workers at a terminal some distance off-shore and an overriding consideration of the development of the organisational structure has been to minimise the number of off-shore personnel and carry out as much work as possible within the on-shore structure. For example, staff responsible for berth planning in the on-shore only stage can be used, with some extra manning, to also carry out berth planning for the offshore terminal as this activity can be done remotely from an on-shore location. It is envisaged that most non-operating functions such as finance, personnel etc. will be entirely shore based whereas some, such as the Safety and Security function can be managed from the on-shore terminal but with 24 hour presence of departmental staff at the off-shore site. Therefore, the structure proposed is one with a single management hierarchy with operations integrated within it, to the greatest extent possible.

The nature of any terminal operation is one in which the operator has little or no control over the demand for operations. Whilst fixed weekly berthing plans may provide some indication of the level of activity, these are constantly changing and there will be frequent exceptions caused by vessels being off schedule, bad weather, seasonal traffic variation and exceptional factors such as strikes or disruption at other ports. Flexibility within the workforce is therefore a key consideration and all possible means of varying the deployment of the workforce to meet actual demand, as late as possible in the planning cycle, will be required in order to maximise efficiency and minimise the number of employees required. This flexibility should also extend to the ability to call upon shore-based workers to cover exceptional off shore needs and vice versa. Similarly, and particularly at the off shore site, workers will need to be multi-disciplinary, i.e. workers trained to carry out a variety of functions in order that unexpected absence or particular demands do not cause problems due to lack of available skills.

## Key considerations

### Onshore Terminal – Scenario 0

Management organisation of the terminal is based upon a commonly seen structure for terminals of similar size. As mentioned above, it is envisaged that this basic structure would remain, albeit expanded for the future off-shore terminal and on-shore barge facility.

Six-hour shifts have proved popular with workforces in a number of Italian terminals. Six-hour shifts also have advantages from a terminal management perspective. Whilst inappropriate for the offshore site (as is discussed later) at the onshore site, a six hour shift work system has been assumed.

The advantages are that continuous working of vessels can be carried out without the need to have extra men within the shift team to provide relief cover for breaks. Also, the shorter the length of the working period, the easier it is to apply working effort to the varying level of demand. Inevitably, longer shift work periods generally result in lower efficiency in the use of manpower resources. Given the restrictions of the 48-hour working time directive, 6 hour shifts also provide the opportunity for workers to carry out a double shift, or more readily change shifts without contravening statutory rest periods etc.

Four shift teams are envisaged. Each team will comprise of extra men to cover holiday absence (11%), other

| Management organisation | No. of Employees |
|---|---|
| **General Management** | |
| General Manager | 1 |
| Administration | 3 |
| Sales and Marketing Manager | 1 |
| Sales and Marketing Staff | 5 |
| H&S and Security | 1 |
| Finance Manager | 1 |
| Finance Staff | 14 |
| HR Manager | 1 |
| HR Staff | 24 |
| Management Accountant | 1 |
| Accounts Staff | 7 |
| | |
| **Operations Management** | |
| Operations Director | 1 |
| IT Manager | 1 |
| Marine Manager | 1 |
| Marine Clerks | 3 |
| **Total** | **65** |

**Table 11-1 Summary of Management organisation**

| Shift | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **time** | **01to 07** | **07 to 13** | **13 to 19** | **19 to 24** |
| cranes manned | 2 | 4 | 4 | 2 |

**Table 11-2 Crane manning onshore**

absence (e.g. sickness, 10%) and to provide rest day cover (15%) in line with the European regulation of working time.

A high degree of multi task training is envisaged in order that these numbers can be maintained at lowest possible levels. Crane manning at the on-shore facility, when full volume is reached has been set at the level in indicated in Table 11-2

The concentration of higher "normal" manning in the two middle shifts results in lower unsocial hours costs, it is usually more popular with workers and may better suit Venice night time navigational restrictions should they still exist when operations commence.

Nevertheless, it is assumed that by means of double shifts and overtime, all cranes can be manned when required by demand. This level of manning given reasonable levels of productivity is sufficient to meet the terminal capacity of 600,000 TEU.

Exceptionally flexible working arrangements may provide the opportunity to reduce the number of crane teams from the daily 12 teams to 10 or 11.

Standard crane manning assumed is:

- 1 crane driver
- 1deckman
- 1 checker
- 4 tractor drivers
- 3 lashing/securing

Whilst crane driver, deckman and checker are tied to a particular crane, it is assumed that tractor drivers and lashers will be pooled across all working cranes in order to meet priority and maximise efficiency.

It may well prove, in the event, that it is more cost effective to sub-contract some of this work, particularly lashing, to third parties but for the purposes of this study it is assumed that all work is carried out by direct employees.

Yard, gate and rail manning headcount numbers have been estimated based upon the demands of ship-working, expected variability in gate demand over each shift and each day of the week, and that rail activity will proceed throughout the day regardless of the actual arrival and departure of trains to/from the terminal. The yard team, who will carry out most of the housekeeping activity, OOG handling and customs work has a concentration of manpower during shift 2 when it is expected most of the examination work will take place.

Manning in the equipment maintenance area has been based upon levels of similar sized operations. However, it must be noted that this assumes a high level of external support for carrying out specialised maintenance and routine servicing of non-specialised plant.

Please refer to Table 11-3 for a summary of direct Operations and Maintenance Staff for Scenario 0.

| Direct Operations and Maintenance Staff- Scenario 0 | No. of Employees |
|---|---|
| **Supervision** | |
| Onshore Operations Director | 1 |
| Berth Supv | 11 |
| Yard Supervisor | 5 |
| Planning Manager | 1 |
| **Quay Operations** | |
| Crane Drivers | 16 |
| Checker | 16 |
| Deckmen | 16 |
| Lashing | 49 |
| Tractor | 65 |
| **Control and Planning** | |
| Control Room Head | 1 |
| Controllers | 8 |
| Berth Planning Head | 1 |
| Berth Planning | 3 |
| Ship Planning Head | 1 |
| Ship Planners | 8 |
| Ship Planning Clerk | 4 |
| Yard Planning Head | 1 |
| Yard Planners | 5 |
| Gate Supervisor | 1 |
| Gate Clerks | 24 |
| **Yard / Rail** | |
| Yard Team | 39 |
| RTG | 54 |
| Rail Team | 42 |

| Direct Operations and Maintenance Staff- Scenario 0 | No. of Employees |
|---|---|
| **Maintenance** | |
| Maint Manager | 1 |
| Maint Foreman | 5 |
| Mechanical | 24 |
| Electrical | 8 |
| Electronic | 3 |
| Stores | 3 |
| Clerical | 3 |
| IT | 5 |
| Safety | 5 |
| Security | 16 |
| **Total** | **445** |

**Table 11-3 Direct Operations and Maintenance Staff for Scenario 0**

| Onshore terminal direct staff by shift | 1 | 2 | 3 | 4 | Total (incl absence cover) |
|---|---|---|---|---|---|
| **Time** | **01 to 07** | **07 to 13** | **13 to 19** | **19 to 24** | |
| **Supervision** | | | | | |
| Onshore Operations | | 1 | | | 1 |
| Berth Supv | 2 | 2 | 2 | 2 | 11 |
| Yard Supervisor | 1 | 1 | 1 | 1 | 5 |
| Planning Manager | | 1 | | | 1 |
| **Quay Operations** | | | | | |
| Crane Drivers | 2 | 4 | 4 | 2 | 16 |
| Checker | 2 | 4 | 4 | 2 | 16 |
| Deckmen | 2 | 4 | 4 | 2 | 16 |
| Lashing | 6 | 12 | 12 | 6 | 49 |
| Tractor | 8 | 16 | 16 | 8 | 65 |
| **Control and Planning** | | | | | |
| Control Room Head | | 1 | | | 1 |
| Controllers | 1 | 2 | 2 | 1 | 8 |
| Berth Planing Head | | 1 | | | 1 |
| Berth Planning | | 2 | 1 | | 3 |
| Ship Planning Head | | 1 | | | 1 |
| Ship Planners | 1 | 2 | 2 | 1 | 8 |
| Ship Planning Clerk | | 3 | 2 | | 4 |
| Yard Planning Head | | 1 | | | 1 |
| Yard Planners | | 2 | 1 | 1 | 5 |
| Gate Supervisor | | 1 | | | 1 |
| Gate Clerks | 3 | 5 | 5 | 4 | 24 |
| **Yard / Rail** | | | | | |
| Yard Team | 5 | 9 | 7 | 6 | 39 |
| RTG | 6 | 12 | 12 | 10 | 54 |
| Rail Team | 6 | 12 | 6 | 5 | 42 |
| **Barge Berth** | | | | | |
| Barge Berth Supervisors | | | | | 0 |
| Bridge Crane Operators | | | | | 0 |
| Multi-Trailer | | | | | 0 |
| **Maintenance** | | | | | |
| Maintenance Manager | | 1 | | | 1 |
| Maint Foreman | 1 | 1 | 1 | 1 | 5 |
| Mechanical | 3 | 6 | 6 | 3 | 24 |
| Electrical | 1 | 2 | 2 | 1 | 8 |
| Electronic | | 1 | 1 | | 3 |
| Stores | | 3 | | | 3 |
| Clerical | | 3 | | | 3 |
| IT | 1 | 1 | 1 | 1 | 5 |
| Tug Crew | | | | | |
| Safety | 1 | 1 | 1 | 1 | 5 |
| Security | 2 | 4 | 4 | 2 | 16 |
| **Total** | **54** | **122** | **97** | **60** | **445** |

**Table 11-4 Direct Onshore Operations and Maintenance Staff for Scenario 0 by shift**

## Onshore Terminal – Scenario 1, 2 and 3

With the commencement of off-shore operations, the onshore barge terminal will be opened and it is expected that the offshore volume in Scenario 1 will fill the in-shore terminal barge berth capacity, with subsequent off-shore growth utilising capacity at other third party in-shore berths. Therefore, onshore growth in head-count for scenario 2 and 3 will only be in those areas required to support off-shore functions (e.g. planning).

The offshore traffic flowing through the Onshore barge berth will require increases in the strength of the teams operating the rail terminal, empty storage, examinations and , the in/out gate. Container handling on barges will be carried out semi automatically by bridge cranes in the same way as the offshore terminal with bridge crane operators manually controlling only the lifting and dropping on the barge itself. A separate bridge with rotating spreader will directly serve external traffic and this also, will be semi-automatic with remote operators controlling the last part of the lifting or lowering operation. In both cases, operators will control more than one bridge crane.

Multi trailer systems have been planned to reduce the manning requirement for the bulk movement of containers from the bridge crane stacks to/from the rail terminal and to/from the empty stacks.. These will be loaded and discharged on the quayside, adjacent to the barge berth by the same operators that control the barge loading/discharge.

Please refer to Table 11-5 for a summary overview of the in-shore direct labour headcount for Scenario 1, 2 and 3

| Onshore terminal direct labour headcount for scenario 1,2 and 3 | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| | No of employees | Change | No of employees | Change | No of employees | Change |
| **Supervision** | | | | | | |
| Onshore Operations Director | 1 | | 1 | | 1 | |
| Berth Supv | 11 | | 11 | | 11 | |
| Yard Supervisor | 5 | | 5 | | 5 | |
| Planning Manager | 1 | | 1 | | 1 | |
| **Quay Operations** | | | | | | |
| Crane Drivers | 16 | | 16 | | 16 | |
| Checker | 16 | | 16 | | 16 | |
| Deckmen | 16 | | 16 | | 16 | |
| Lashing | 49 | | 49 | | 49 | |
| Tractor | 65 | | 65 | | 65 | |
| **Control and Planning** | | | | | | |
| Control Room Head | 1 | | 1 | | 1 | |
| Controllers | 11 | 3 | 11 | | 11 | |
| Berth Planing Head | 1 | | 1 | | 1 | |
| Berth Planning | 3 | | 3 | | 3 | |
| Ship Planning Head | 1 | | 1 | | 1 | |
| Ship Planners | 15 | 7 | 15 | | 15 | |
| Ship Planning Clerk | 8 | 4 | 8 | | 8 | |
| Yard Planning Head | 1 | | 1 | | 1 | |
| Yard Planners | 5 | | 5 | | 5 | |
| Gate Supervisor | 1 | | 1 | | 1 | |
| Gate Clerks | 31 | 7 | 31 | | 31 | |

| Onshore terminal direct labour headcount increase for scenario 1,2 and 3 | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| | No of employees | Change | No of employees | Change | No of employees | Change |
| **Yard / Rail** | | | | | | |
| Yard Team | 60 | 21 | 60 | | 60 | |
| RTG | 54 | | 54 | | 54 | |
| Rail Team | 63 | 21 | 63 | | 63 | |
| **Barge Berth** | | | | | | |
| Barge Berth Supervisors | 5 | 5 | 5 | | 5 | |
| Bridge Crane Operators | 30 | 30 | 30 | | 30 | |
| Multi-Trailer | 22 | 22 | 22 | | 22 | |
| **Maintenance** | | | | | | |
| Maintenance Manager | 1 | | 1 | | 1 | |
| Maint Foreman | 5 | | 5 | | 5 | |
| Mechanical | 24 | | 24 | | 24 | |
| Electrical | 11 | 3 | 11 | | 11 | |
| Electronic | 5 | 2 | 5 | | 5 | |
| Stores | 3 | | 3 | | 3 | |
| Clerical | 3 | | 3 | | 3 | |
| IT | 6 | 1 | 6 | | 6 | |
| Tug Crew | 16 | 16 | 16 | | 16 | |
| Safety | 8 | 3 | 8 | | 8 | |
| Security | 16 | | 16 | | 16 | |
| **Total** | **590** | | **590** | | **590** | |

**Table 11-5 Summary overview of the onshore direct labour head-count for Scenario 1, 2 and 3**

| Onshore terminal direct staff by shift for scenario 1 | 1 | 2 | 3 | 4 | Total (incl absence cover) |
|---|---|---|---|---|---|
| Time | 01 to 07 | 07 to 13 | 13 to 19 | 19 to 24 | |
| **Supervision** | | | | | |
| Onshore Operations Director | | 1 | | | 1 |
| Berth Supv | 2 | 2 | 2 | 2 | 11 |
| Yard Supervisor | 1 | 1 | 1 | 1 | 5 |
| Planning Manager | | 1 | | | 1 |
| **Quay Operations** | | | | | |
| Crane Drivers | 2 | 4 | 4 | 2 | 16 |
| Checker | 2 | 4 | 4 | 2 | 16 |
| Deckmen | 2 | 4 | 4 | 2 | 16 |
| Lashing | 6 | 12 | 12 | 6 | 49 |
| Tractor | 8 | 16 | 16 | 8 | 65 |
| **Control and Planning** | | | | | |
| Control Room Head | | 1 | | | 1 |
| Controllers | 1 | 2 | 2 | 1 | 11 |
| Berth Planing Head | | 1 | | | 1 |
| Berth Planning | | 2 | 1 | | 3 |
| Ship Planning Head | | 1 | | | 1 |
| Ship Planners | 2 | 3 | 3 | 2 | 15 |
| Ship Planning Clerk | | 3 | 2 | | 8 |
| Yard Planning Head | | 1 | | | 1 |
| Yard Planners | | 2 | 1 | 1 | 5 |
| Gate Supervisor | | 1 | | | 1 |
| Gate Clerks | 4 | 7 | 7 | 5 | 31 |

| Onshore terminal direct staff by shift for scenario 1 | 1 | 2 | 3 | 4 | Total (incl absence cover) |
|---|---|---|---|---|---|
| Time | 01 to 07 | 07 to 13 | 13 to 19 | 19 to 24 | |
| **Yard / Rail** | | | | | |
| Yard Team | 6 | 10 | 7 | 6 | 60 |
| RTG | 6 | 12 | 12 | 10 | 54 |
| Rail Team | 6 | 13 | 6 | 6 | 63 |
| **Barge Berth** | | | | | |
| Barge Berth Supervisors | 1 | 1 | 1 | 1 | 5 |
| Bridge Crane Operators | 5 | 6 | 6 | 5 | 30 |
| Multi-Trailer | 4 | 4 | 4 | 4 | 22 |
| **Maintenance** | | | | | |
| Maintenance Manager | | 1 | | | 1 |
| Maint Foreman | 1 | 1 | 1 | 1 | 5 |
| Mechanical | 3 | 6 | 6 | 3 | 24 |
| Electrical | 2 | 2 | 2 | 2 | 11 |
| Electronic | | 2 | 2 | | 5 |
| Stores | | 3 | | | 3 |
| Clerical | | 3 | | | 3 |
| IT | 1 | 1 | 1 | 1 | 6 |
| Tug Crew | 2 | 3 | 3 | 2 | 16 |
| Safety | 1 | 3 | 1 | 1 | 8 |
| Security | 2 | 4 | 4 | 2 | 16 |
| **Total** | **70** | **144** | **115** | **76** | **590** |

**Table 11-6 Direct Onshore Operations and Maintenance Staff for Scenario 1 onwards by shift**

## Off-Shore Operations – Scenario 1, 2 and 3

It is assumed that operations are carried out by workers who remain offshore for a period of days, similar to the way in which the off-shore oil industry operates. Time taken for travel, if workers were to travel home at the end of each shift would be costly, very inflexible and prevent even small amounts of overtime being worked. Furthermore, bad weather would, from time to time, leave workers stranded offshore, with reliefs being unable to travel.

The basic outline of working envisaged is that there will be four offshore teams, two teams on rest and two offshore with rotation on a five day basis. This means that working periods off shore will be of 12 hours duration and therefore each of the job categories, essential for continuous operation has extra workers within the team to provide relief for breaks. Under such arrangements, it is essential that a very high degree of multi training is established in order that machinery operators do not have to operate machines for the full 12 hours even though relieved for breaks. (e.g. a crane driver could drive his crane for 6 hours (with a break) and carry out the function of deckman for the remaining 6 hours.)

In order to provide the degree of flexibility necessary, and to vary supply of labour with demand, very flexible working arrangements would be required of the offshore teams. As in any case, offshore teams are in place for a period of five days, it is expected that variable start times, overlapping shifts, split shifts and such overtime as working laws allow, would provide the degree of flexibility required. It is assumed that similar flexible working arrangements would enable the use of men not engaged in their primary task to cover miscellaneous tasks such as mooring and unmooring of vessels, fuelling vehicles, cleaning machinery, offices etc.

Offshore periods of several days also require that there are full catering, accommodation and leisure time facilities.

As stated earlier, it is assumed that only staff essential to the operation of the offshore terminal will be working offshore. Whilst it is expected that there will be a manager off shore in overall charge, other management staff will be shore based and will visit the offshore terminal on a routine and "needs must" basis. The presence of sophisticated terminal operating computer systems will mean that the majority of planning activity can be carried out ashore. However, there will be a need for a small satellite office offshore to deal with the planning needs of ship's officers, the printing and delivery of paperwork and the communication and handling of exceptions with the main shore based planning office.

A very high degree of systems planning and control of the loading and discharging of barges is assumed in the operation of the inter-terminal barge link. However, it is assumed that the shore side planning office will be the one in control.

A very high degree of automation is assumed. The mini-straddle link between ship to shore cranes and the buffer stack will be driverless. Bridge cranes are assumed to be fully automatic in the operation of the deep sea side and partially automatic with some manual assistance for the last few metres of lowering and lifting in the barge operation. In this case, it is assumed that operators would be remote, and control more than one bridge crane using CCTV and/or handset with data link.

Barges will be cellular and therefore no provision has been made for lashing / securing personnel though a minimum number of staff have been allowed for mooring of barges as this will be a much more of a continuous task when compared with the arrival / departure of deep-sea vessels.

Break relief staff have been included for crane drivers, checkers and deckmen. Other staff will have sufficient time to be able to take breaks without affecting the continuity of work. Four complete cycles have been allowed as annual leave and extra staff (11%) have been included in each of the four teams to allow for this purpose.

| Headcount planned for each shift and total (4teams) | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| | On shift | Total incl hols etc | On shift | Total incl hols etc | On shift | Total incl hols etc |
| **Operations Supervision** | | | | | | |
| Berth Supv | 2 | 10 | 3 | 15 | 4 | 19 |
| Lashing | 1 | 5 | 1 | 5 | 1 | 5 |
| Control | 1 | 5 | 1 | 5 | 1 | 5 |
| **Operations** | | | | | | |
| Control Planning | 2 | 10 | 3 | 15 | 3 | 15 |
| Control Barges | 1 | 5 | 2 | 10 | 2 | 10 |
| Crane Drivers | 10 | 48 | 14 | 68 | 17 | 82 |
| Barge Cranes | 6 | 29 | 8 | 39 | 10 | 48 |
| Checker/Deckmen | 20 | 97 | 28 | 136 | 34 | 165 |
| Lashing | 10 | 48 | 15 | 73 | 20 | 97 |
| Barge controllers | 2 | 10 | 2 | 10 | 2 | 10 |
| Tractor | 1 | 5 | 2 | 10 | 2 | 10 |
| Reachstacker | 1 | 5 | 1 | 5 | 1 | 5 |
| Straddle | 2 | 10 | 2 | 10 | 2 | 10 |
| **Maintenance** | | | | | | |
| Maint Foreman | 1 | 5 | 2 | 10 | 2 | 10 |
| Mechanical | 6 | 29 | 7 | 34 | 10 | 48 |
| Electrical | 6 | 29 | 7 | 34 | 10 | 48 |
| Electronic | 2 | 10 | 3 | 15 | 3 | 15 |
| **Marine** | | | | | | |
| Tug Crew | 6 | 29 | 6 | 29 | 6 | 29 |
| **H&S** | | | | | | |
| Safety/Security | 1 | 5 | 1 | 5 | 2 | 10 |
| **Catering** | 4 | 19 | 4 | 19 | 5 | 24 |

| Headcount planned for each shift and total (4teams) | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|
| | On shift | Total incl hols etc | On shift | Total incl hols etc | On shift | Total incl hols etc |
| **Day Work (Not Shift)** | | | | | | |
| Offshore Terminal Manager | 1 | 2 | 1 | 2 | 1 | 2 |
| Maintenance Supervisor | 1 | 2 | 1 | 2 | 1 | 2 |
| Stores | 1 | 5 | 2 | 5 | 2 | 5 |
| Clerical | 1 | 2 | 2 | 5 | 2 | 5 |
| IT | 1 | 1 | 2 | 2 | 2 | 4 |
| Paramed | 1 | 2 | 1 | 2 | 1 | 2 |
| Catering Manager | 1 | 2 | 1 | 2 | 1 | 2 |
| Accomodation (Cleaning, etc.) | 6 | 15 | 7 | 17 | 8 | 19 |
| | | | | | | |
| **Power Plant (emergency only)** | | | | | | |
| Plant Manager | 1 | 1 | 1 | 1 | 1 | 1 |
| Operator (shift) | 1 | 4 | 1 | 4 | 1 | 4 |
| Assistant operator (shift) | 1 | 4 | 1 | 4 | 1 | 4 |
| Mechanical (shift) | 1 | 2 | 1 | 2 | 1 | 2 |
| Electrical (shift) | 1 | 2 | 1 | 2 | 1 | 2 |
| | | | | | | |
| Total | | 457 | | 597 | | 719 |

**Table 11-8 summary head count for the offshore terminal staff by shift**

### Waterway link staffing

For the waterway link, the mama vessels require to be staffed. Each vessel is expected to have :

- 1 captain
- 1 co captain
- 1 mechanical
- 1 assistant mechanical
- 2 deckhands

Four shift teams are envisaged. Each team will comprise of extra men to cover holiday absence (11%), other absence (e.g. sickness, 10%) and to provide rest day cover (15%) in line with the European regulation of working time. Thus each mama vessel will require approximately 33 staff.

However, peak staff will not have to be employed continuously, for the staffing it is assumed that some staff will be flexible and can use overtime resulting in a requirement for 100% of staff at the average time and an additional incremental 40% to cover for peak time. The resulting overall staff requirements are presented in Table 11-9.

| | Scenario 0 | | Scenario 1 | | Scenario 2 | | Scenario 3 | |
|---|---|---|---|---|---|---|---|---|
| Description | Average | Peak | Average | Peak | Average | Peak | Average | Peak |
| Number of mama vessels suitable for type E required without spares etc | 0 | 0 | 2 | 3 | 2 | 4 | 3 | 6 |
| Staffing required on mama vessels | 0 | 0 | 67 | 101 | 67 | 135 | 101 | 202 |
| Staff employed | 0 | | 81 | | 94 | | 141 | |

**Table 11-9 Waterway link staffing**

## Summary of Staff

A summary overview of staffing is presented in Table 11-10

| Description | Scenario 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| General and operations management employed | 65 | 65 | 65 | 65 |
| Onshore terminal labour employed | 445 | 590 | 590 | 590 |
| Offshore terminal labour employed | 0 | 457 | 597 | 719 |
| Waterway transfer system employed | 0 | 81 | 94 | 141 |
| **Total employees** | **510** | **1,193** | **1,346** | **1,515** |
| Max. typical staff onshore present at a given moment in time,<br><br>most staff preset during day shift =<br><br>day shift staff for Monte/Syndial termina + general; management staff for both terminals | 187 | 209 | 209 | 209 |
| Max. typical staff offshore present at a given moment in time,<br><br>most staff present during day shift offshore, but night shift resting offshore = offshore single shift x 2 | 0 | 210 | 271 | 323 |
| Waterway transfer staff present during a single maximum shift | | 18 | 24 | 36 |

**Table 11-10 Summary of staffing required**

## Schematic of organisation structure

The following organizational charts reflect the structure that is proposed for the management and operation of the combined offshore and onshore development under Scenario 3.

A single management structure is foreseen in order to avoid duplication of effort and that the two terminal develop in a well-coordinated and mutually supporting manner. The off-shore terminal is essentially an "operating only" facility under the 24x7 control of a terminal manger reporting to the combined terminal head of operations. Offshore staff in non-operations functions will report to the offshore manager but with indirect reporting to the function head ashore.

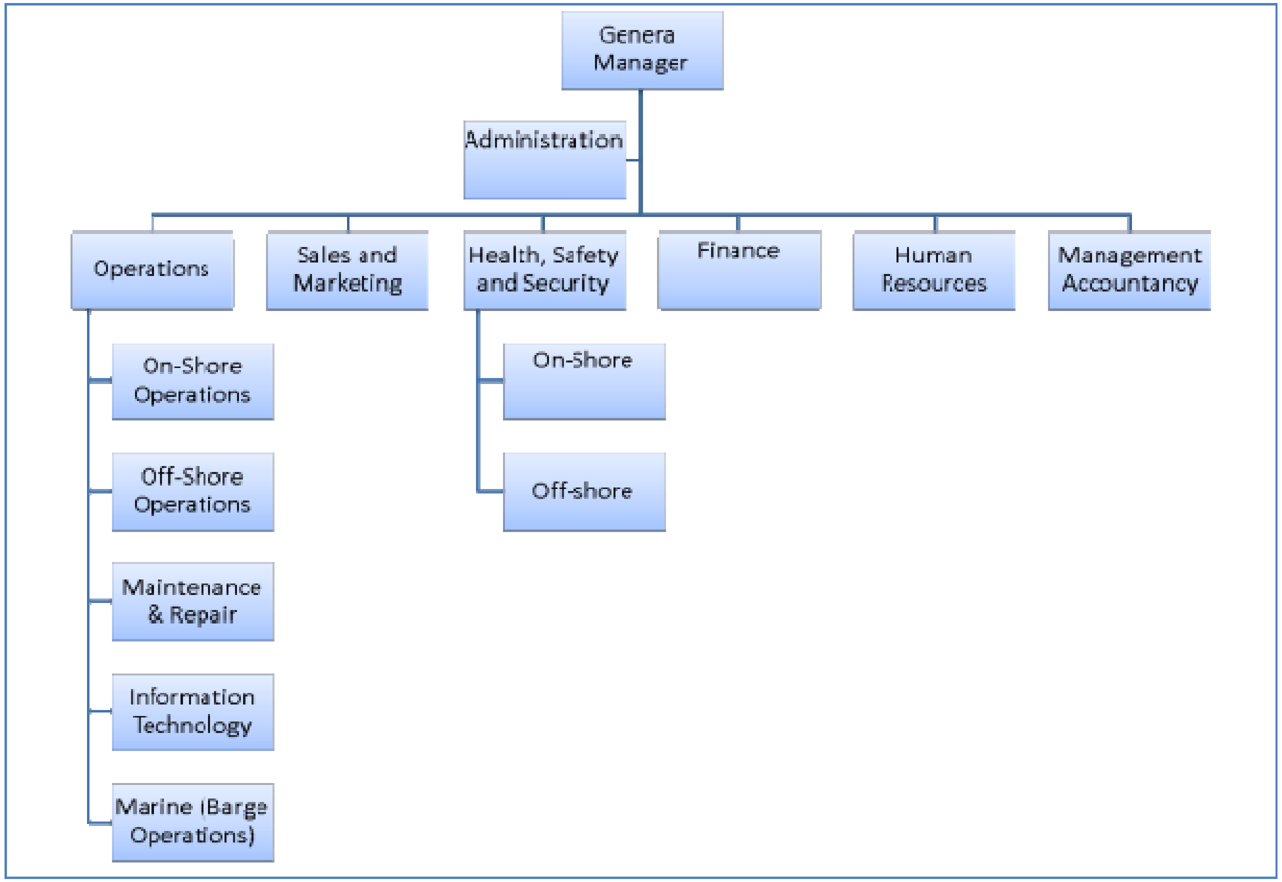



**Figure 11-1 Management organogram**

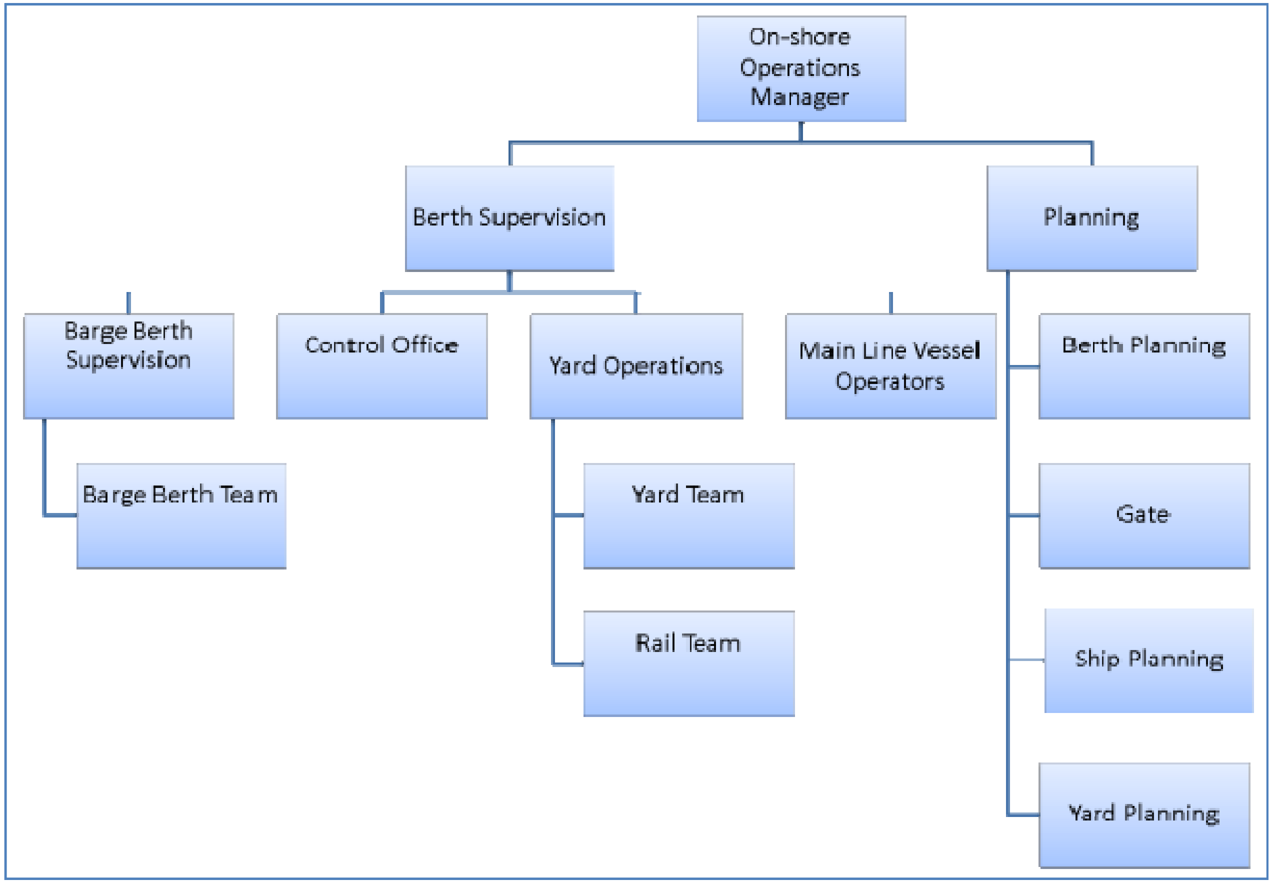



**Figure 11-2 Onshore operations management structure**

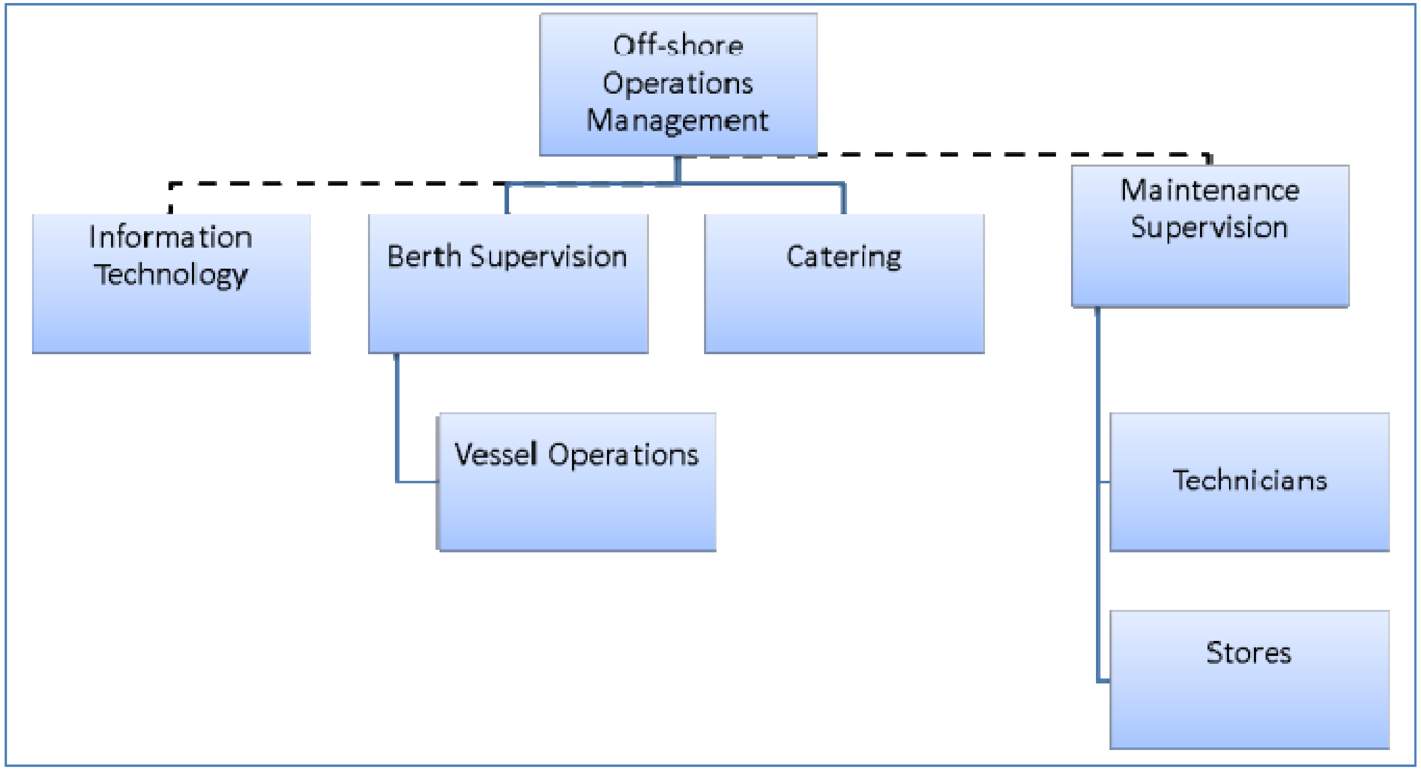



**Figure 11-3 Offshore operations management structure**

## Software concept

To achieve high productivity in both terminals a best-of-class approach is essential. As systems for the efficient control of such a complex environment is not yet part of the standard software packages available, an approach similar to that used in industry and airport logistics is suggested, i.e. the use of two different layers. One layer, for all administrative features such as booking, billing, customer data, external interfaces etc.,, where standard solutions are available, A second layer for the operational logistics control which has to be adapted to geographical needs, processes, type of vehicles and cranes etc. A number of modern terminals have already adopted this software design.

Existing suppliers offer a broad range of standard systems which can be used for the first software layer. These systems form only part of the overall Terminal Operating System (TOS) solution. The following fields can be covered by standard systems:

1. Administrative TOS (booking, billing, external interfaces, customer data etc.)

2. Ship Planning (vessel planning, berth planning, crane split, work instructions)

3. Appointment system (web slot booking, slot planning and optimisation)

4. Autotest environment

5. Roster Control

For standard systems, minor adaptations are assumed to cover the possibility of special customer requirements. The critical part of the proposed solution is the logistical control of the terminal itself – which is called the Terminal Control System (TCS). And it contains all necessary control components for the operation of the two terminals. Some of them such as "Bridge Crane Control" will be used in both terminals, and others are only needed for one terminal such as the "RMG Rail ".

Software components, which are required in more than one application, require only a single installation as they can run two separate operations running from one central platform. This should be a stated requirement when RFPs are sent out. The cost calculation takes this assumption as otherwise, there would probably be issues concerning licence fees and additional procurement costs.

The control part of the terminal software, Terminal Control System TCS, is not a part of the aforementioned TOS solutions and there are sound reasons for this. The control solution has to be adapted to the logistics requirement of each terminal to achieve the required high productivity. However, components exist on the market, which can be used, but these would need to be modified. A completely new development for the TCS would also be an option but this would lead to higher costs, a longer time frame and more risks would be involved. Totally new development is therefore not recommended.

Rail planning is seen as an available component which would need some modification. Some TOS suppliers are offering the rail module as a standard package, but these solutions need additional development to maximise efficiency. For this reason, rail planning has been considered "not-yet-standard" and the costs for further development were calculated accordingly.

A barge module with the functionality required for the new terminal concept does not exist on the market and therefore has to be developed. It is suggested that this module would be developed by the supplier of the rail planning software, as this would lead to a more homogenous software environment. The supplier of the ship planning system could be an alternative developer but such suppliers normally focus on standard software packages and not on bespoke software development.

Several interfaces between the different systems, modules and components will have to be developed; these interfaces have been identified on the basis of three types:

1. Simple interface – small effort

2. Medium complexity – medium effort
3. Complex interface – high effort

## Specific requirements

Within the software solution, there are specific requirements for:

1. Terminal Link, Synchronisation
2. Auto Straddles
3. Auto Bridge Cranes
4. Auto Yard
5. Open architecture

The Terminal Link requires a special synchronisation functionality, which forms part of the Process Control component. The process control must generate processes covering the whole transport chain for containers entering the offshore terminal from mainline vessels and leaving the onshore terminal via truck, train or vessel – and vice versa. The module should not just cover the container flow itself but should comprise an optimisation component to synchronise the different transport steps, taking into account priorities and deadlines for each container. Advanced optimisation for such a synchronisation effort is essential.

To optimise automatic equipment is more complex than the control of manually driven ones. In addition to an intelligent optimiser, the interface with such equipment is highly complex and some experience of this is required on the part of the supplier.

For an automatic yard, well known stacking strategies apply. Nevertheless, an optimiser working with soft goals delivers better results as a segregation model – which is also helpful for the RTG yard. Additionally, intelligent housekeeping software should be part of the automatic yard as it allows strategies such as “placing a container in a convenient location during peak operation and subsequent shifting to the appropriate slot later when cranes are available”. This strategy leads to an increase of peak throughput.

Because of the complex software environment, all software systems, modules and components should sup-support an open architecture. Extensive interfacing capabilities are required to exchange data easily between all elements.

## Operational aspects

All systems, modules, and components should as a minimum, comprise the following functionalities:

1. Installation for production but also for testing and training. As close as possible to down-time free update capability.
2. Roll-back functionality
3. Fast recovery mode, initialisation process
4. Hot stand by solution
5. 24/7 hotline support
6. Mandatory capability
7. Manual overwrite
8. Real time optimisation
9. Easy to use database editor

For a smooth operation of the terminal the software should be installed in three forms: production, test and training. In this way, operations can run unaffected while a new version is tested. In parallel, employees can be trained using the training environment – regardless of which software version is used. A further requirement is that with no additional effort, a scenario in one environment can be copied to another one – especially the test to the production environment. Base data such as terminal layout, equipment, yard strategies etc. are to be taken from the production environment automatically. Installation of new versions should be as nearly down-time free as possible. This is especially important for the production environment. At most 15 to 30 minutes should be allowed.

In the case that the installation of a new version fails or still contains bugs which were not detected in the tests, a roll-back to the earlier version has to carried out. The software needs to have the capability to do so with minimum effort and in reasonable time.

The software should be as stable as possible If a component is down, a fast recovery mode is necessary to have the system up and running again in very short time. An initialisation process is needed to synchronise the status of the automatic equipment and the TCS after such a breakdown.

To avoid breakdown time due to hardware failure the software systems should support a hot stand-by concept. Software systems and components should be able to run on different hardware environments at the same time – switching automatically to another server when the current one is dropping out. It will be a requirement that the switch is carried out within seconds and all interface partners receive the necessary information instantaneously.

A 24/7 hotline with a remote connection should be available to help in cases of a failure. The remote connection should also be active 24/7. At the very least, this is essential for all operational software such as TCS, planning modules, appointment system and also for the administrative TOS. Modules such as Roster Control and the Autotest Environment are not as critical.

As mentioned above, some modules are used in more than one instance.. Therefore, the software should be capable of being installed on one central platform and being capable of running several different mandators from the centre. The software needs to be configurable to achieve this.

All decision assignments to equipment, yard, block and slot will be carried out automatically within the TCS. However, the system needs to have a manual override mode for exception handling. The dispatchers and the drivers must be able to override the system's decisions. This facilitates efficient terminal operation. On the other hand management have to ensure that dispatchers and drivers use this functionality only in urgent cases and for exception handling. Otherwise the power of the optimisation components will not be used. Decisions by dispatchers and drivers have to be taken into consid-consideration within optimisation runs.

Advanced optimisation can be divided into planning and real time optimisation. Planning applies to Ship Planning, Barge Planning and Rail Planning. For this kind of functionality some time taken is acceptable in order to fulfil the planning calculations (a few minutes). For assignments to equipment, yard, block and slot, decisions in real time are essential. Results close to the optimum in one to three seconds, the faster the better, are required. Only in this way, with all new information taken into account can the optimiser run every few seconds. This leads to a higher productivity and to more satisfaction of the drivers.

For the independently produced software, an easy-to-use database editor for usage by the client is needed. The client should be able to add equipment, change the yard layout etc. without help from the supplier. If the editor comes with software import and export functionality, this will help to facilitate terminal operation.

### Features

The standard terminal features must be covered by the various software packages. The scope of the study does not cover the listing all these features.

A special feature for this combined terminal is the waterway link. The process control component must be capable of constructing a process over the two terminals taking into account several transport and storage steps. Furthermore, this component must have the ability to communicate all transport and storage steps to the optimising components (with all updates, which are usually seen in logistical undertakings).

The Hinterland Manager coordinates all transport orders at the inland side whereas the Waterside Manager will be doing the same for the waterside. These components list all transport orders, with starting location, destination, container number, deadline, priority etc. Within these components, all transport orders can be stopped, re-activated, changed, and deleted by the dispatcher.

In order to run the terminals with high productivity, not only deadlines but also priorities should be part of the optimisation run. When an external truck and a waterside vehicle are expecting to receive a container from the same crane at, for example, 10:00 then the single calculation of deadline is not helpful – priorities have to be taken into account, to decide whether or not it is better to serve the waterside vehicle first and have the external truck wait for some minutes or vice versa. These two elements – deadline and priorities – are overlapping which results in more complexity but with advanced optimisation this can be solved.

The software solution should comprise advanced optimisation within the following components:

1. Ship planning (autostow, berth planning and crane split)
2. Barge planning (autostow and berth planning)
3. Rail planning (train planning)
4. Appointment system (slot planning and optimisation)
5. Process Control (synchronisation)
6. RMG Rail (transport assignment, dynamic crane split)
7. Manual vehicles (transport assignment, pooling)
8. External trucks (routing optimisation)
9. RTG Control (transport assignments, block assignments)
10. Bridge Cranes (transport assignments, synchronisation)
11. Trailer Tractors (transport assignment, pooling)
12. Auto Straddles (transport assignment, pooling)
13. Yards (yard allocation, block allocation, slot optimisation, housekeeping)

### Remarks

A rough estimation of a completely new development of all non-standard components and modules would lead to a factor of 2.5 in the number of man days needed to develop the solution.

Several TOS suppliers claim that they have the TCS functionality already within their TOS system. However, this would not be the case for this level of terminal complexity. Also, some hardware suppliers are planning to offer parts of the TCS - e.g. crane suppliers are offering the logistical crane control. However, hardware suppliers do not usually have much know how in advanced optimisation. Even if such solutions are working properly, the synchronisation of the processes suffers if part of the logistical control is given to a hardware supplier. The synchronisation of different transport steps within a process is critical for such a complex terminal - even though the Auto Straddle solution partially reduces the efforts for synchronisation. It is suggested to keep all logistical control components within the TCS.