SUMMARY

Containers have become the standard for unitised cargo transport. In the past two decades, the emergence of the global economy has caused a boom in the volume of containers transported by sea.

Maritime container transport can be divided into a global network of major shipping routes and numerous regional, short-sea services. In ports, container terminals link the different shipping lines and provide the intermodal connection between the maritime and continental transportation networks.

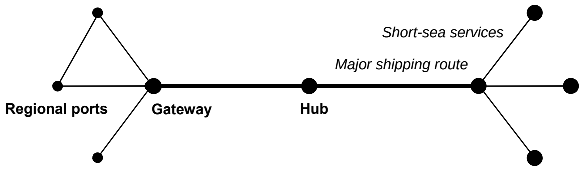

Figure 1 Schematisation of the maritme network

On the major shipping routes, very large container ships operate the intercontinental services. Container terminals in gateway and hub ports, along these routes, annually handle throughputs of over 500,000 TEU. The majority of these terminals is owned and operated by so called global terminal operators (GTO) that own and operate many terminals worldwide.

Regional and short-sea services between regional and minor ports in the periphery of the network are operated by smaller vessels. For the majority of terminals in these ports, annual throughput is much less. Local, single terminal operators (STO) generally operate these container terminals. Public sector involvement is often large.

Shipping lines are pressuring both larger and smaller terminals, to increase the level of services offered and, at the same time, reduce handling costs. Labour expenses take up a large part of those handling costs. For large terminals automated container handling has proven itself as a reliable and effective way to reduce operational costs.

Especially in Europe, small and medium sized terminals face heavy competition. The number of ports that compete for the same hinterland is increasing. To stay ahead of the competition, terminals are forced to offer a very high level of services. Meanwhile, flexible routes of regional services makes business development forecasts uncertain. Investment risks are therefore high in this capital intensive industry. As a result conservativeness is considered a virtue among small and medium sized terminal operators, and scepticism towards innovative technology is widespread.

The goal of this study is to inventory “off-the-shelf” automated container handling equipment and study the feasibility of automated container handling in small and medium sized terminals.

Container terminal analysis
A container terminal consists of 3 elements: a quay for serving ships, a yard for storing containers and a gate and transfer area for serving road vehicles and/or trains. The framework of a terminal designed is formed design requirements. These are based on external and site specific (boundary) conditions on one side. On the other side they are derived the demand for port services and service level requirement established by market analysis.

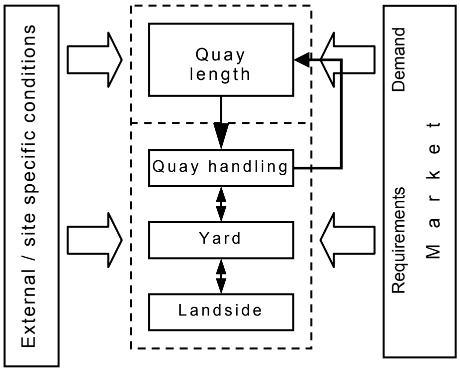

Figure 2 Overview of the influencing aspect on the functional design

Terminal performance can be evaluated on the basis of performance indicators. Key performance indicators are used to index the use of equipment and terminal infrastructure.

At container terminals, the term automation applies to information systems, automated vehicle processing at the terminal gate, and equipment automation. The unmanned operation of terminal equipment complicates a number of aspects of day to day terminal processes.

For automated container handling the following equipment is available:

Table 1 Overview automated eqiopment

	Function	Development status	Advantages	Disadvantages
Automated Guided Vehicle (AGV)	Internal transport quay ←→ yard	Fully operational; In operation since 1993	• Proven technology • Reliability	• Required equipment numbers
Automated Shuttle carrier (SHC)	Internal transport	Prototype (production ready); Technically equal to Autostrad	• Decoupling of quay and yard operations	• Operating costs of equipment (maintenance requirements)
Automated straddle carrier (Autostrad)	Internal transport, stacking and landside transfers	Fully operational; In operation since 2006	• Operational flexibility • Decoupling of quay and yard operations	• Operating costs • Large area requirements
Automated RMG / Automated Stacking Crane (ASC)	Yard handling; waterside transfers, housekeeping, landside vehicle transfers	Fully operational; In different variations operated since 1993	• High productivity • Proven technology	• Low flexibility • Crane rail required
Overhead Bridge Crane (OBC)	Yard handling	Prototype (production ready); Remote controlled operation since 1996, automated prototype fully tested	• High yard density • Well adaptable for unfavourable soil conditions$	• High construction costs of overhead bridge • Low accessibility of stored containers

Case study

Within the Risavika Havn port development project in Norway, an area has been reserved for a modern container terminal. A preliminary design is made of an automated container terminal based on the following design parameters

- Annual throughput : 200,000 TEU
- Transhipment ratio : 20%
- Mixing (Dry : IMO : RF : MT) : 60 : 10 : 5 : 25

- Storage demand avg : 3,871 TEU
  peak : 5,033 TEU
- Vessel size LOA max : 195 m
  avg : 140 m
- Calling rate : 12 – 14 $^{calls}/_{wk}$
- Max. average waiting time : 15% of service time

The quay length is set to 250 m, based on the design vessel and the queuing theory ($E_2/E_2/n$ system). To meet the waiting time requirement, a minimal quay handling capacity of 49,8$^{mvs}/_{hr}$ is required. Five concepts for automated container handling are compared. The different concepts are compared by a multi criteria analysis. The proven concept of AGVs and RMGs is selected. In the MCA, this concept scores marginally better than the Autostrad concept which has only just come onto the market.

A layout is made of the terminal for two alternative arrangements of the container stacks. The queuing theory is applied on a model of the container handling process to get an indication of the terminal's handling system. Equipment cycle times and equipment numbers are calculated. The resulting estimate of 3 STS cranes, 15 AGVs and 6 RMGs is verified in a simulation study. Within Royal Haskoning the terminal simulation package Posport CT has been developed. Due to assumptions in the modelling for the purpose of the study, the results produced by Posport CT can be questioned. The package is very useful for an indication of equipment quantities and productivities. Based on the results of the simulation study, the handling system is reduced to 2 STS cranes, 12 AGVs and 6 RMGs.

A detailed layout of the terminal is given appendix V. On a concept level, the civil works of the terminal are discussed. The following costs estimate is made.

- Fixed terminal structures and installations
  - Quay wall : € 11,281,250.00
  - Terminal infrastructure : € 6,517,000.00
  - Terminal buildings : € 2,833,000.00
  - Terminal facilities : € 7,800,000.00
- Terminal equipment:
  - Quay cranes(+ spreaders) : € 14,200,000.00
  - Yard cranes (+ spreaders) : € 16,120,000.00
  - AGVs : € 4,800,000.00
  - Other equipment : € 1,195,000.00

Including preliminary cost (15%) and contingency (15%) the total cost of the terminals structures and installations are estimated at 37,732,578.13 Euro. The total cost of terminal equipment, including contingency (20%), is estimated at 39,042,000.00 Euro.

The commercial feasibility of the project is evaluated using the discounted cash flow model. The Net Present Value (NPV) and Internal Rate of Return (IRR) are calculated for three investment scenarios. Each scenario is compared with a basic cost estimate of a conventional terminal design.

Table 2 Overview of results of DCF-model

Investment structure	NPV		IRR	
	Automated	Conventional	Auto	Conv.
• Land leased from PA in ready for building state • No foreign capital	-5,457,314.28	-21,678,434.03	7%	3%
• Quay wall included in lease • No foreign capital	2,253,254,07	-15,505,979.35	8%	3%
• Land leased from PA in ready for building state • 50% foreign capital (6% interest)	3,769,430.12	-15,504,769.26	9%	1%

Conclusions and recommendations

The NPV calculations show that the additional investment costs of automation are recovered in 6 to 8 years. From the discounted cash flow calculations it can be concluded that the project, in its proposed form, would not be feasible as a commercial investment. Public sector involvement is required in the form of, either (partial) ownership of the terminal infrastructure and / or equipment, or through financial support in the form of low cost financing or financial guarantees. Considering the influence of ports on regional economies it is not unthinkable a regional or national government will provide this support.

Due to the long life of the project, the investment risk is high. Confirmation of the forecast throughput development and terminal income is therefore recommended. The Autostrad concept was not selected for the case study on the grounds of area requirements, reliability and maintenance costs. To confirm the grounds on which the Autostrad was not selected, further study of this concept is recommended.