Barge Hub Terminals: A Perspective For More Efficient Hinterland Container Transport For The Port Rotterdam

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ABSTRACT

The competitive position of the Port of Rotterdam not only depends on its location and ability to service the largest sea going vessels, but more and more on its connections with the hinterland. Barges play an important role in the transport of containers to and from the hinterland and in the accessibility of the port. The current modal split in the hinterland container transport of Rotterdam is approximately 30 % barge, 10% rail and 60 % road. With the increasing container volumes and congestion problems on the roads, barge transport has to play a more prominent role. To enable growth of container barge transport new strategies regarding barge services, operations and container handling processes in the port are required.
This paper presents a perspective, based on the implementation of a so-called Barge Hub Terminal in or near the Port of Rotterdam, which assumes that barge hinterland services are offered via this intermediate terminal. This idea has much in common with the concept of off-dock (near-dock) railterminals used for rail hinterland transport of US ports.
After discussing the current situation in the port of Rotterdam in more detail; the Barge Hub Terminal is presented discussing the general ideas, different type of operations, possible terminal locations and layout. The paper includes the Strengths, Weaknesses, Opportunities and Threats of the Barge Hub Terminal concept and finalizes with the conclusions.

INTRODUCTION

Transport of freight in containers is developing spectacularly. In the period 1985 to 2005 worldwide freight flows in containers grew on average by 10% per year, while the growth of general cargo was just 3,8% annually. Economic growth, globalization and the rise of the Chinese economy have boosted the worldwide growth of freight transport and the development of container transport in particular. Forecasts show that the growth of container transport is likely to continue and the expected pace of growth in the period 2005 to 2015 is still about 7.5% per year (Lempert, 2006).

Increasing container transport volumes also put higher demands on the performance of container ports. Many seaports have started or launched ambitious port terminal expansion plans to handle larger volumes. Increasing container throughput in ports however also raised the issue of capacity and quality of hinterland transport. Shippers and carriers value the attractiveness of a container port not only on its performance in the seaside operations, but also on its ability to offer a wide range of high quality services to the hinterland. Scale economies in the sea transport leg have shifted the attention of shippers and carriers to the inland leg of the chain as a way to control costs, as in many cases hinterland services have the largest share in the total transport bill. As a result hinterland accessibility has become increasingly important for the competitiveness of a seaport.
In view of the current performance of the hinterland transport of Rotterdam and its perspectives in the light of further increasing container throughput, improving the hinterland accessibility has become a strategic issue for this port as well.
Road transport has been and still is the major hinterland transport mode. Its share in the modal split more or less stabilized during the last five years (see table 1), but even in this rather small time span the number of containers transported by road dramatically increased from 1,870,000 units in 2001 to 2,450,000 boxes in 2005 (a growth of 31%). As the expansion of road infrastructure in the port area and the major hinterland corridor, the A15 highway, could not keep up with the persistent traffic growth, container road transport is increasingly faced with congestion problems. Plans to expand the capacity of the road infrastructure exist, but as container throughput in the port of Rotterdam is also expected to grow by 70% to 15.9 million TEU (Gemeente Rotterdam, 2004), problems with congestion as well as air quality are likely to get worse. Hence, in addition to more road infrastructure capacity a vigorous modal shift is inevitable.

Table 1 Modal split in container hinterland transport for the marine container terminals in the port of Rotterdam, 2001 – 2005 (in 1,000 containers and in percentage)

	2001		**2002**		**2003**		**2004**		**2005**	
	cont.	%	cont.	%	cont.	%	cont.	%	cont.	%
Barge	925	30	1,089	32	1,102	31	1,188	31	1,280	31
Rail	258	9	302	9	336	10	358	9	380	9
Road	1,870	61	2,002	59	2,083	59	2,344	60	2,450	60
Total	3,053	100	3,393	100	3,521	100	3,890	100	4,110	100

Source: Port of Rotterdam Authority

So far rail transport has played a modest role in container hinterland traffic for several reasons, currently available capacity being one of them. However, the opening of a new dedicated freight rail line (the Betuwe route) connecting the port of Rotterdam with the German hinterland will increase rail capacity and will offer opportunities for substantial growth of rail transport. On the other hand barge transport has already clearly demonstrated its attractiveness as an alternative hinterland transport mode. The ability to offer cheap and reliable services has attracted the interest of shippers and carriers in barge transport and explains the significant growth of container barge transport since the mid eighties. In the period from 1985 to 1995 barge traffic in the hinterland of Rotterdam grew from 200,000 TEU to about 1 million TEU. In 2005 more than 2 million TEU were transported, corresponding to a market share of 31% (www.portofrotterdam.com). Of course favorable

natural circumstances, such as the presence of the Rhine river and access to an extensive national and international waterway network with good navigable conditions, have also stimulated the strong development of hinterland transport by barge in Rotterdam. These strong assets of barge transport – quality of services and infrastructural capacity – suggest that a more prominent role of barge transport would be desirable to keep the port of Rotterdam accessible.

This modal shift is not a matter of course, but requires a permanent high performance of container barge services to the hinterland. The quality of handling barges in the port greatly influences the performances of these container barge services to the hinterland, and the present way of handling barges is far from optimal. The main cause for this inefficiency is the fact that barges have to call at many terminals in the port when they visit the port of Rotterdam. This involves a lot of time, which could be used more productively, for example for sailing. Moreover, as a result of visiting many terminals the call size is on average relatively small, leading to a relatively long handling time per terminal and hence a lower terminal productivity. In addition, as many barges call at the same terminal this causes congestion and waiting times at terminals. Furthermore, seagoing vessels also call at these terminals and in general these ships have priority over barges in handling and thus the waiting time of barges can increase. An additional problem is that when a delay arises at one terminal the barge may not catch the agreed time window for handling at the next terminal. So barge operators need to include large margins when planning their terminal visits to ensure reliable transport services. Altogether the duration time in the port is relatively long, which has a negative influence on the turn around time and total cost of barge services and hence on the competitiveness of barge transport. As container throughput in the port of Rotterdam will increase more sea-going vessels and barges will visit the port, and added to this the fact that the number of terminals will also increase (as a result of the port expansion plan Maasvlakte 2), the problems described here are likely to increase. Therefore to enable growth of container barge transport new strategies regarding services, operations and container handling processes will be needed.

This paper focuses on one of the possible strategies to overcome this inefficiency in container barge handling by implementing a so-called barge hub terminal (BHT) in or near the port of Rotterdam. This barge hub terminal would function as a collection and distribution point for containers to and from the hinterland.

After discussing the current situation in the port of Rotterdam in more detail; the Barge Hub Terminal is presented discussing the general ideas, different types of operations, possible terminal locations and layout. The paper includes the Strengths, Weaknesses, Opportunities and Threats of the Barge Hub Terminal concept and finalizes with the conclusions.

CURRENT SITUATION IN THE PORT OF ROTTERDAM

As introduced in the previous section, barge transport has a share in the modal split of about 31%, handling about 1.3 million containers or 2.1 million TEU per year between marine and hinterland terminals. In addition, approximately 700.000 TEU per year is transported to and from empty depots and barge terminals in the port area. This section further discusses: the three main trades in barge transport to and from Rotterdam, the number of barge container terminals and calls in the port of Rotterdam, and the different type of barges used.

Main Container Trades in Barge Transport

In the hinterland barge transport to and from Rotterdam, three major markets or trades can be distinguished:

- *Rhine river trade*: transport of containers between the port of Rotterdam and large industrial and consumer areas in Germany and parts of France and Switzerland. In 2004 about 950,000 TEU were transported in this hinterland corridor of Rotterdam:
- *Rotterdam – Antwerp trade*: transport of containers between the port of Rotterdam and Antwerp. This flow is a result of the mainport strategies of deep-sea carriers. Transported volume in this trade was about 950,000 TEU in 2004;
- *Domestic trade*: transport of containers between Rotterdam and inland areas in the Netherlands. In 2004 transport volume in this trade exceeded 880,000 TEU.

In addition to differences in geographical orientation these trades have different supply and demand characteristics that also result to different operational features:

Rhine river trade

- Many barge operators
- Large vessels
- Daily services: several vessels per day
- Customers: shippers and forwarders (merchant haulage) + shipping lines (carrier haulage)
- Many calls in the port of Rotterdam, relative few calls in the hinterland
- A trunk waterway with a few tributaries

Rotterdam – Antwerp trade

- Modest number of barge operators
- Very large vessels
- Daily services: several vessels per day
- Customers: shipping lines (carrier haulage)
- Very modest number of terminal calls (large call sizes)
- One trunk waterway

Domestic trade (in The Netherlands)

- Barge operator is also inland terminal operator
- Small and medium-sized vessels
- (almost) daily services to Rotterdam
- customers: shippers (merchant haulage)
- many calls in the port, just one in the hinterland
- fine-meshed waterway network

From this operational characteristics, it can be concluded that the barge hub terminal concept would be most interesting for the Rhine river and domestic trade, because the problem of many terminal calls and small call sizes is most manifest in these trades. Together these trades represent about 1.8 million TEU in 2005.

An overview of the total container flows in the Netherlands in 2001 is presented in Figure 1.

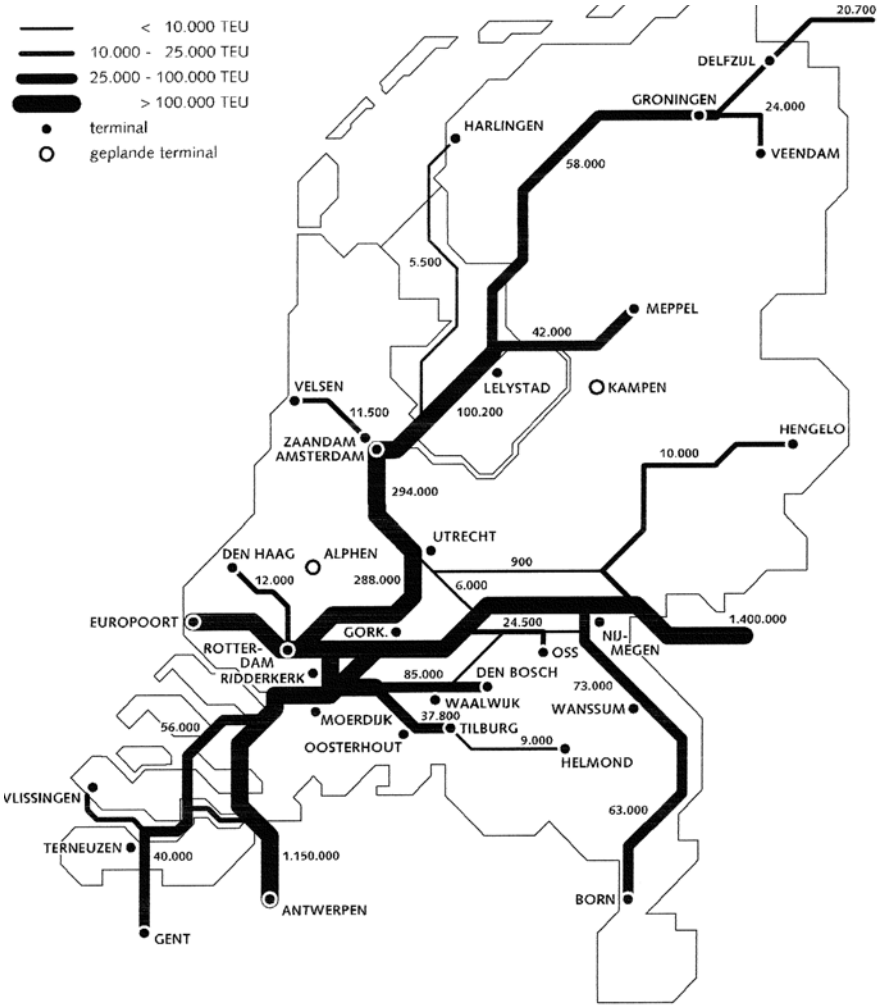


Figure 1 Container flows barge transport in TEU in 2001 (Source AVV)

Number of Barge Container Terminals and Calls in the Port of Rotterdam

The port of Rotterdam has about 30 terminals including empty depots. These terminals are spread over a rather large port area. Clusters of terminals are found in the area of Eem/Waalhaven, Botlek and Maasvlakte (see Figure 2). The distance between Maasvlakte and Eem/Waalhaven is about 40 km, which corresponds to a sailing time of about 2.5 hours.

The Maasvlakte has the largest share in total port transhipment volume (about 65%). The share of the Eem/Waalhaven is also significant, while the number of containers handled in the Botlek area is rather limited.

Selected interviews have shown that the number of calls in the port is on average nine for large and medium-sized vessels (Haskoning, 2003). The call size usually ranges between 1 TEU and 100 TEU. The average call size turned out to be 22 containers (approximately 35 TEU, unloading and loading together). In the Maasvlakte area the call size is generally larger, which is explained by the larger total throughput in this port area. Interviews have also shown that, the average waiting time to visit a terminal is about 1 hour, but larger waiting times up to a whole day also occur. Barge operators try to plan efficient trips in the

port, but because of delays in handling they regularly have to modify their schedule for terminal visits, which results in additional sailings in the port.
Due to the large number of terminals to visit, the waiting times at terminals and rescheduling of tours the port visits are time-consuming. The average port duration time varies from 10 – 16 hours to even 1.5 days, dependent on the vessel size and trade. For instance, in hinterland services to the Lower Rhine region (up to Bonn) and to most domestic destinations vessels make two roundtrips a week. Since these vessels spend about 2 days a week in the port and usually also 2 days at the inland terminal(s), the time spent on sailing is relatively small. Knowing that sailing is the most important business for the barge operator to generate income, this indicates that time savings in the port (and at hinterland terminals) could bring productivity gains.

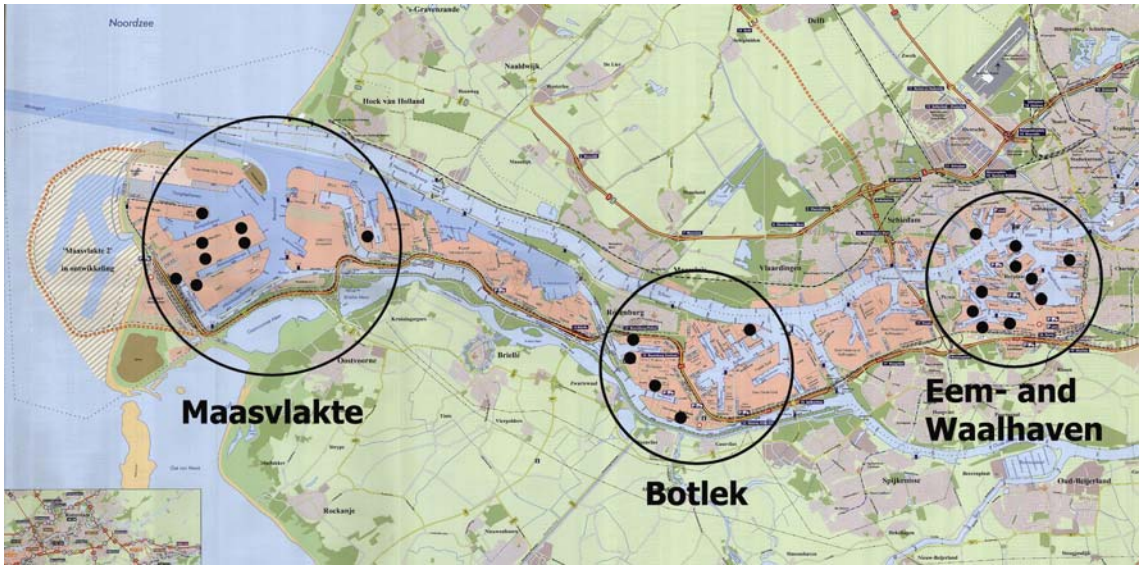


Figure 2 The location of barge terminals in the port of Rotterdam (Source: adapted from Port of Rotterdam Authority)

Type of Barges

In container barge transport different type of vessels are being used: motor vessels, motor vessel/pushbarge combinations and pushboat/pushbarge formations. The container loading capacity of these vessel types can significantly vary: from about 32 TEU for the smallest motor vessel to theoretically 960 TEU for a pushboat-pushbarge formation (with six pushbarges).
In the Rotterdam – Antwerp trade pushboat-pushbarge formations (in most cases 2 barges) are used, while in the Rhine river and domestic trade only motor vessels and vessel/pushbarge combinations are operated.
In Rhine river trade the average size of container vessels has gradually increased due to increased transport volumes and as result possibilities to capture economies of scale. The 208 TEU vessel is still commonly used, but several larger vessel have been introduced (JOWI class) and in particular the motor vessel-push barge formation (having a capacity up to 400 TEU) has contributed to increasing scales of operation.

In domestic trade the size of vessels range from 32 to 200 TEU. In addition to transport demand the size of a vessel is strongly determined by the waterway characteristics, mainly draught and size of locks, but also the height of bridges restrains economies of scale.
Figure 3 presents three of the barge types used for container transport with their main dimensions.

Figure 3 Three types of barges used for inland water transport (Source BVB – www.inlandshipping.com)

THE BARGE HUB TERMINAL

After presenting the current situation for barges in the port of Rotterdam in the previous section, this section focuses on the Barge Hub Terminal. It discusses the general ideas behind the BHT, various possible operations (logistical concepts), alternative Barge Hub Terminal locations and possible layouts, and finalizes with some preliminary findings and assessments.

General Idea

The general idea for the Barge Hub Terminal is to function as a collection/distribution point for (barge) containers transported to and from the hinterland. Barges from the hinterland call at the BHT, where containers are exchanged. The aim is to reduce the number of calls in the port of Rotterdam, and there are several different types of possible operations. The barges could for instance only unload the small call sizes at the BHT and then continue to the port (with a reduced number of calls), or at the other end of the spectrum they could unload all containers at the BHT leaving the distribution in the port to other barges. For the return flow, from the port to the hinterland, the BHT could of course perform the same collection/distribution or exchange function. The different types of operations are further discussed in the next section.

The Barge Hub Terminal could be an economically and environmentally sustainable way to respond to increasing growth of hinterland transport as the following benefits of this network are envisaged:

Performance improvement of barge hinterland operations:

- improvement of the hinterland vessel turnaround time (higher productivity), because of a reduction of the number of calls in the port;
- improvement of the cost and reliability performance of barge hinterland services.

More efficient performance of marine terminals:

- a higher crane/quay productivity, because the average productivity of handling containers in large call sizes is higher;
- a better utilisation of space at marine terminals as the dwell time of containers at marine terminals can be reduced if the barge hub terminal can also facilitate a storage function for (empty) containers.

Improvement of Port Accessibility to and from the hinterland:

- A barge hub terminal may also act as an 'extended gate' for container trucks operating in long-distance hinterland transport. By dropping and picking up their containers at the barge hub terminal instead of visiting the marine terminals trucker may avoid road congestion that particularly occurs in the port terminal areas. Hence they also increase their productivity.
- By reducing the number of calls barges make in the port of Rotterdam, barge traffic and required lay-by berths will also be reduced.

Sustainable environmental and social benefits:

In its role as 'extended gate' for container trucks the barge hub network can contribute to:

- a reduction of traffic congestion in the port and at roads to the marine terminals;
- lower truck fuel consumption;
- air quality improvement (exchange of road kilometres for barge kilometres)

Development of possible new markets

- A barge hub terminal can enable new container barge services between inland terminals for freight that has no relationship with the seaport, i.e. continental cargo. Bundling maritime and continental container freight on vessels sailing to the hub enables services between pairs of inland terminals that have insufficient transport volume to start a direct (shuttle) service.

Type of Operations (logistic concepts)

One of the main goals of the barge hub terminal is a reduction of the number of calls at marine terminals. In other words, the aim is to bundle small container batches and to compose dedicated full-loaded vessels to visit marine terminals. Different types of operations or logistic concepts can be defined (see also Royal Haskoning, 2003; Konings, 2007):

A. Exclusive discharge of small container batches

Hinterland vessels drop their small container batches at the BHT and only visit those marine terminals where large container batches are unloaded and loaded. These marine terminal visits however can still be numerous. In sailing back to the hinterland small container batches are picked up at the BHT. Very small vessels (e.g. Neokemp: 32 TEU capacity) may only be visiting the BHT as their average call size is almost per definition small. In this concept the small container batches are transported by additional vessels exclusively used for collection and distribution of containers between the BHT and marine terminals.

Advantages:

- sorting and handling in BHT relatively simple
- time saving for small hinterland vessels
- decoupling of hinterland and collection/distribution (C/D) transport for small batches: possibilities for floating stack (storage) of containers

Disadvantages:

- Only limited time saving for large hinterland vessels (as still several marine terminals are visited)
- investments in C/D transport equipment

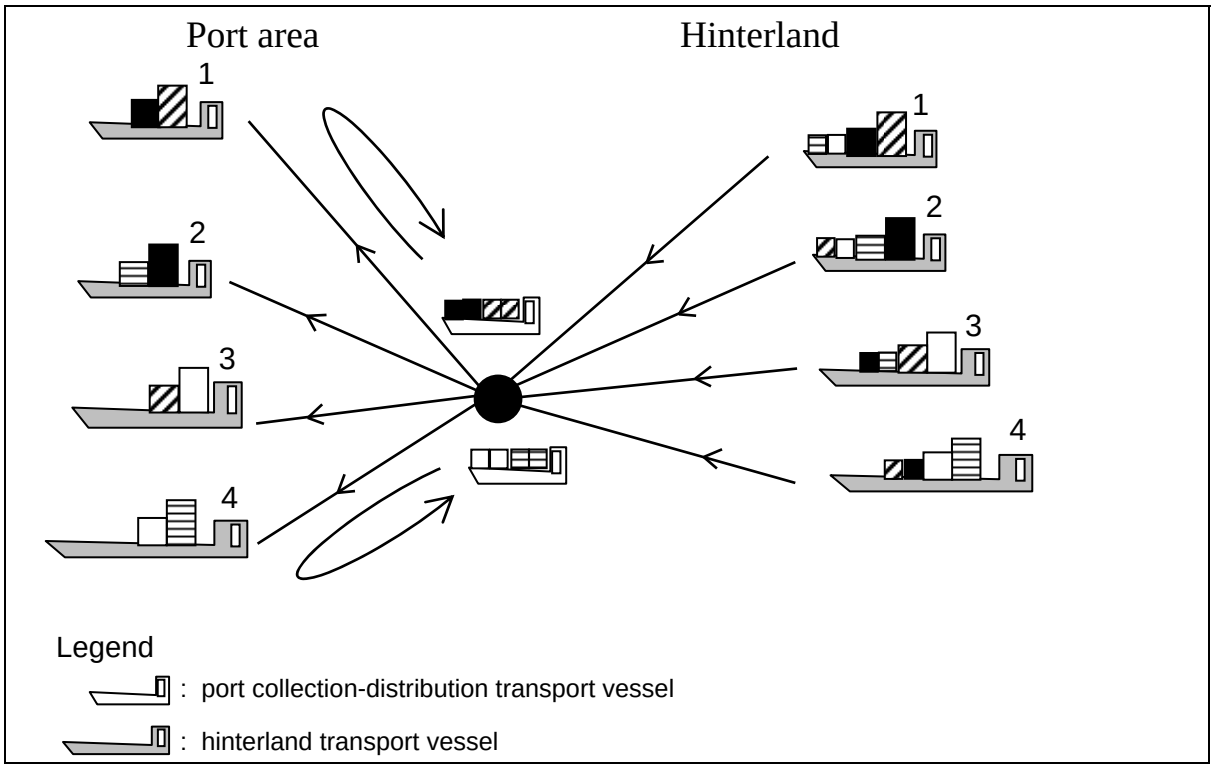


Figure 4 BHT Concept A, with exclusive discharge of small container batches

B. Discharge of all small container batches and loading of small container batches with same destination as large batches

Hinterland vessels drop their small container batches at the BHT and pick up other small batches that have the same marine terminal destination as their large container batches. The marine terminal visits can still be numerous. In sailing back to the hinterland small container batches with the same inland destination are picked up at the BHT.

Advantages:

- more efficient use of hinterland vessel capacity in C/D transport / no need for C/D transport equipment

Disadvantages:

- even more limited time saving for hinterland vessels (as still several marine terminals are visited and additional handling time is introduced for loading containers at the BHT)

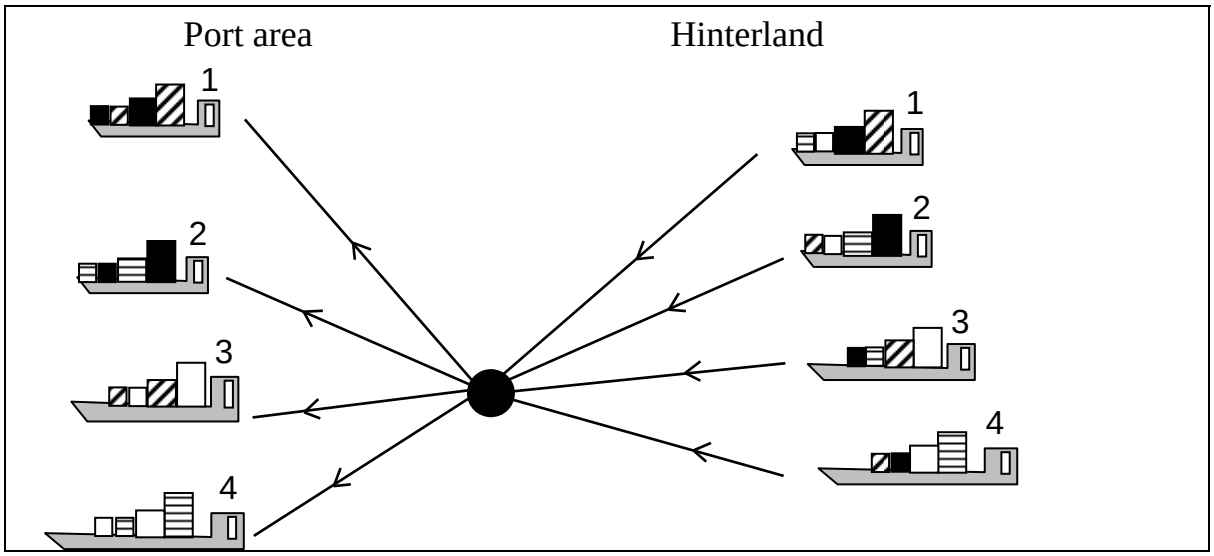


Figure 5 BHT Concept B, with discharge of all small container batches and loading of small container batches with same destination as large batches

C. *Discharge of (almost) all container batches and fill up the largest container batch*
Hinterland vessels drop at the BHT all their container batches except their largest batch and pick up other batches that have the same marine terminal destination as the largest container batch. Only one marine terminal needs to be visited. In sailing back to the hinterland many other batches have to be picked up at the BHT.
Advantages:

- efficient use of hinterland vessel capacity in C/D transport/ no need for C/D transport equipment
- time savings of hinterland vessel due to visit of only one marine terminal

Disadvantages:

- many additional handlings, limiting the time savings and introducing extra costs

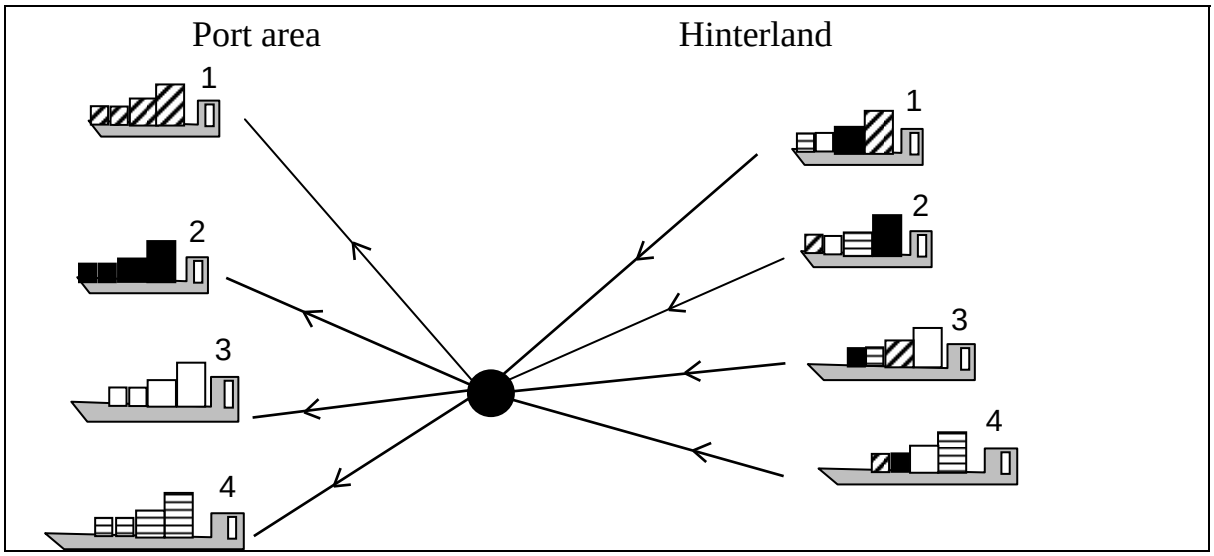


Figure 6 BHT Concept C, with discharge of (almost) all container batches and fill up of the largest container batch

D. *Discharge of all containers*
Hinterland vessels only visit the BHT to unload and load all their containers irrespective of container batch sizes. Vessels exclusively sailing between the BHT and the marine terminals take care of collection and distribution of containers from/to marine terminals. In this concept a more distant location for the BHT (i.e. an inland terminal location) would be a more logical location, because on very short distances the additional handlings would be very difficult to compensate through savings in collection/distribution transport
Advantages:

- maximum time saving of (every type of) hinterland vessel
- most favourable conditions for (un)loading barge vessels at marine terminals (large container batches --> high handling productivity)
- maximum economies of scale in collection/distribution transport
- decoupling of hinterland and collection/distribution transport: possibilities for floating stack (storage) of containers

Disadvantages:

- high additional handling costs (every container is handled two times extra)
- high demands on BHT in terms of capacity and sorting functions
- investments in C/D transport equipment

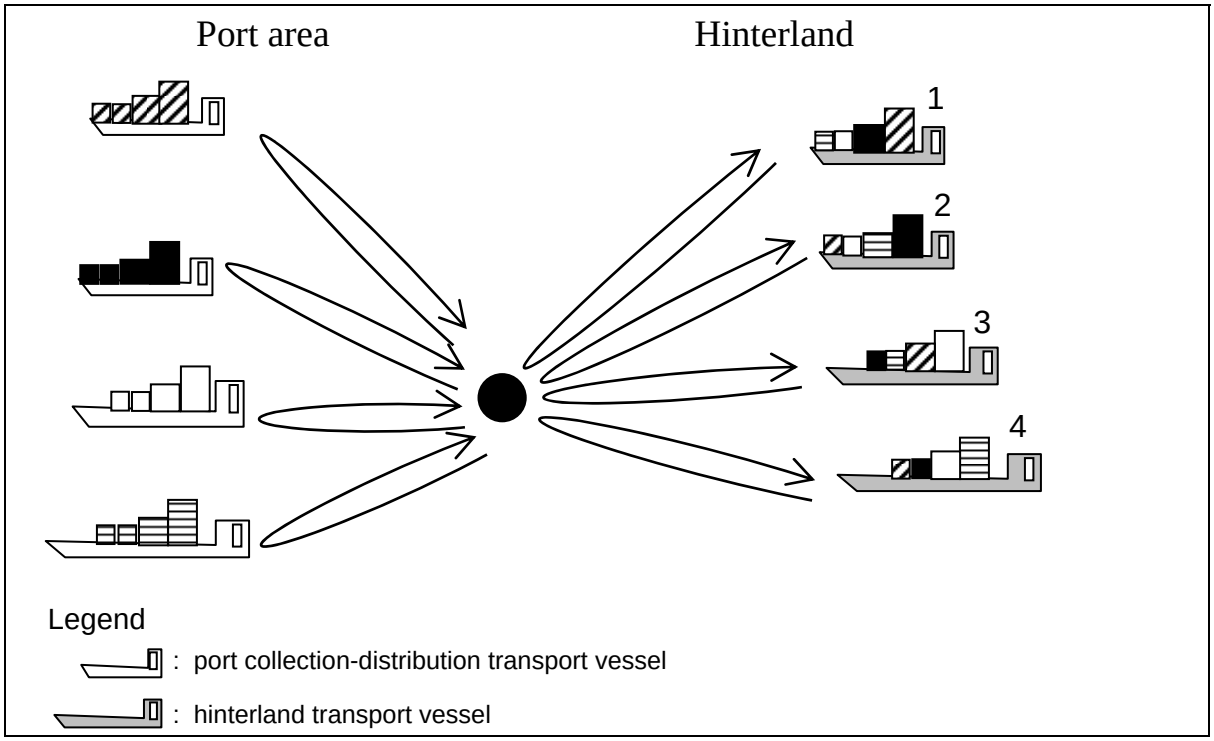


Figure 7 BHT Concept D, with discharge of all containers

Other types of operations, and combinations of the types presented above, are of course also possible. The operations discussed can be considered as basic configurations.

Alternative Barge Hub Terminal Locations

The primary function of the BHT is to improve the efficiency of container barge handling at marine terminals in the port, but such a hub terminal is not necessarily located in or near the port of Rotterdam. The BHT could also be located at more distant locations, i.e. existing inland terminals. The idea to use an inland terminal would have much in common with the role of what Slack (1999) defines as a satellite terminal.
Figure 8 present two possible locations for a BHT: In or near the port of Rotterdam (left), and further inland near Nijmegen (right) where the river Rhine enters the Netherlands.

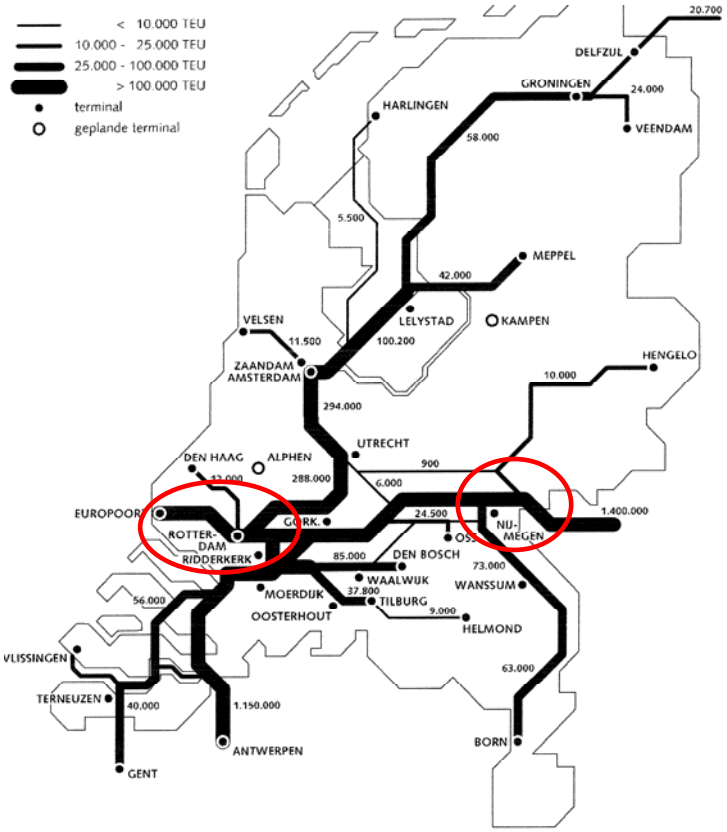


Figure 8. Two possible locations for the BHT (in Container flows 2001 by AVV)

The different locations have their merits and demerits. A BHT in or near the port of Rotterdam will be able to serve a larger market as nearly all flows or trades to and from the hinterland will pass nearby. Furthermore, the BHT will be able to function as a buffer or storage facility for (empty) containers thus servicing the deep sea terminals in peak periods. When positioned near the hinterland entrance to the port, the BHT could also function as container drop of / pick-up point for trucks. However, the land / terminals costs in the port of Rotterdam will be higher compared to inland terminals. A BHT near Nijmegen will require less investments and could further stimulate the modal shift from road to barge by functioning as an extended gateway for trucks. The market is however limited to the Rhine trade and the southeast domestic trade.
Several different locations have been suggested, but no single location has yet been selected as most promising. There does seem to be a preference for locations at the landside entrance of the port.

Type of Barge Terminals

Barges can be handled at different types of terminals. This section presents some of the different types. At the deep sea terminals, barges are often handled by the same quay cranes that handle the large deep sea vessels, or by barge cranes positioned on the deep sea quay (see Figure 9). From a cost and handling capacity point of view, the smaller barge cranes are of course preferred. Such barge cranes can handle 120.000 to 140.000 containers per year, or even more when barge scheduling is controlled by shipping lines and terminals.

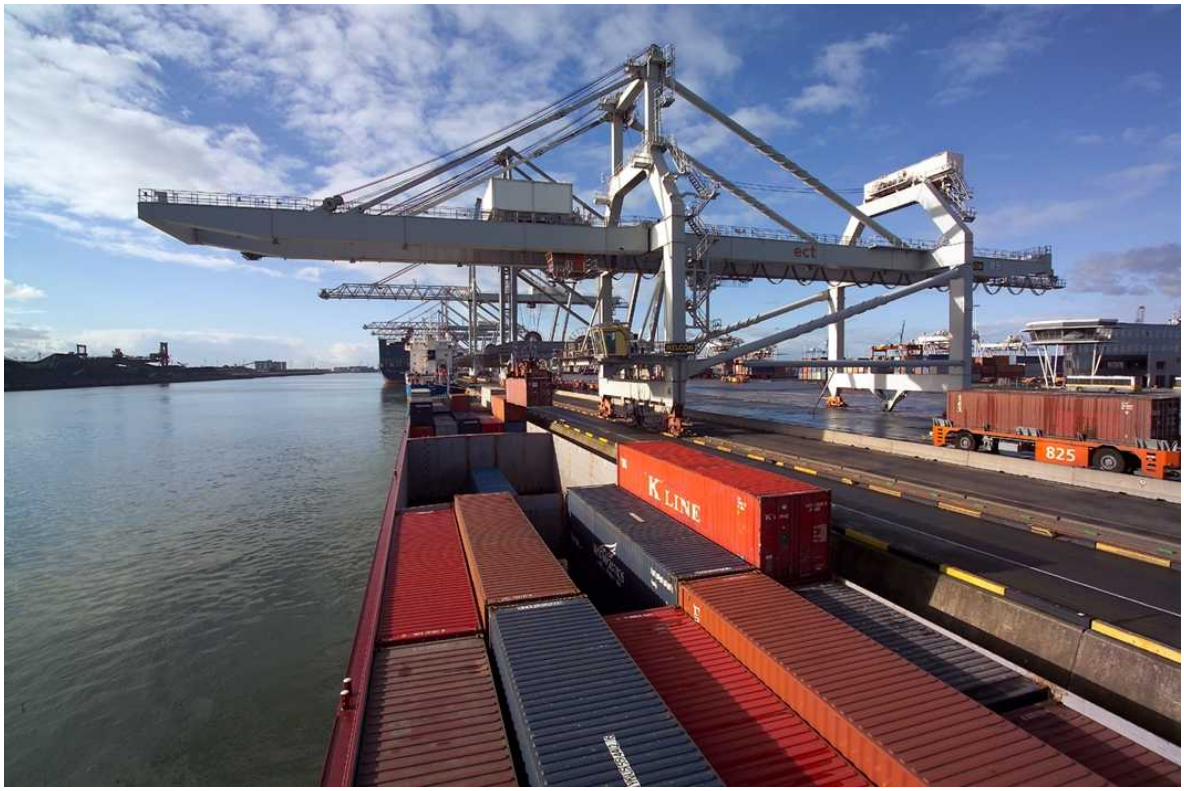
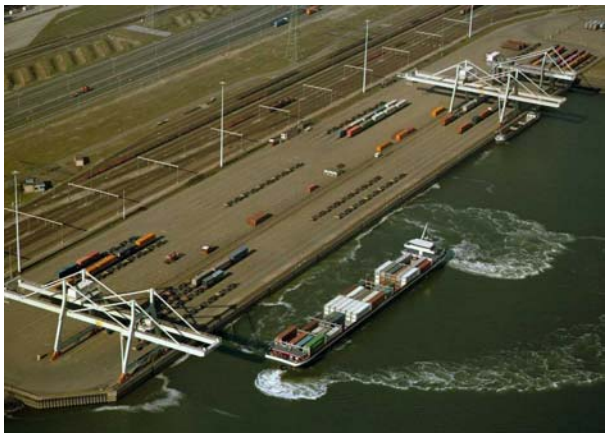


Figure 9 Barge handled at deep sea quay by barge crane at ECT Delta Terminal (Photo: ECT)

Some deep sea terminals also have a dedicated (shallower) quay for handling barges. Figure 10 presents an artist impression of the barge / short sea quay to be built al the head of the Delta Terminal at the Maasvlakte (bottom of photo). The barge and short sea vessels will be handled by Wide Span Gantry cranes which can stack the containers under the crane and load and unload transport vehicles in the back reach. The handling capacity of such a dedicated barge/feeder facility can be 1 million moves or more, depending on scheduling and information quality.

Figure 10 Artist impression of the dedicated barge/ short sea quay at the delta terminal (Source: Port of Rotterdam)

So called Barge Service Centers (BSC) can also be used for loading and unloading barges. A Barge Service Center is also dedicated to handling barges but is not located on or at the deep sea terminal, and requires Inter Terminal Transport. At the Maasvlakte, this ITT is done by Multi Trailer Systems. Figure 11 (left) shows the first Barge Service Center at the Maasvlakte with the multi trailer systems. Figure 11 (right) shows an artists impression of a possible new BSC as developed in the FAMAS studies (FAMAS, 2000). This FAMAS BSC has a higher efficiency and requires less space. The current barge Service Centre can handle more than 200.000 containers per year. The FAMAS terminal was calculated at about 200.000 containers per berth per year, resulting in a potential capacity of over 1 million containers for the terminal shown in Figure 11 (right).



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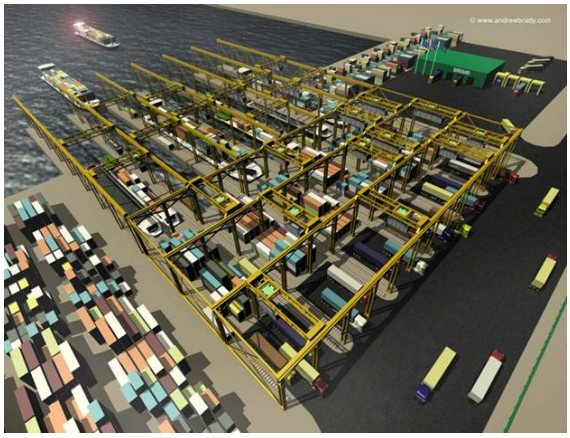

Artists Impression of FAMAS BSC
(Source Port of Rotterdam)

Figure 11 Current Barge Service Center near Delta Terminals (left) & Artists impression of possible future BSC as proposed by FAMAS studies (right)

Inland barge terminals often use wide span gantry cranes. Figure 12 shows the inland terminal “DeCeTe” in Duisburg (Germany). With 4 gantry cranes they handle about 250.000 TEU per year.

Figure 12 Inland barge terminal "DeCeTe" in Duisburg (Germany)

Mobile cranes are also used for loading and unloading barges. Figure 13 shows a mobile crane handling barges berthed side by side. This type of operation can result in a handling capacity of more than 75.000 handlings per crane per year.

Figure 13 Mobile harbor crane handling several barges side by side (Photo: Gottwald)

Which type of terminal is most suited for a BHT of course depends on e.g. the type of operation, desired throughput and location of the terminal. Considering the total potential market (1.8 million TEU) and assuming (as an example) 10% of this market would be handled at the BHT this would result in a BHT with a desired capacity of 180.000 TEU per year (a medium size inland terminal). Such a throughput could be handled by a terminal similar to the current inland barge terminals with wide span gantry cranes. For a more flexible terminal (with other commodities and/or other handling locations) the mobile cranes could prove to be a better alternative. However, for larger throughputs (more than 0.5 million handlings) the FAMAS terminal could prove the better concept. Further research will be needed to better understand the requirements and to develop the most suitable Barge Hub Terminal Concept.

Preliminary Calculations & Assessments

An earlier quick scan (Royal Haskoning, 2003), researching the feasibility of a BHT in Dordrecht (located at the landside entrance of the port) shows that barges can save costs by visiting the BHT. Depending on the type of operation, up to 8 euro per TEU could be saved. Comparing these savings with an estimated 35 euro per TEU additional handling costs at the BHT, their conclusion was that the costs were far greater than the benefits. However, as also indicated in the quick scan, the focus was primarily on the barge operation. The calculations did not include possible savings at the deep sea terminals (due to more efficient handling of barges with larger call size) or possible savings and benefits for the Port of Rotterdam (less investments in quays and improved safety due to a reduction of barge traffic). Furthermore, the type of operations and type of terminals considered could be further diversified and perhaps optimized, possibly resulting in larger savings and reduced costs.

An interesting assessment from the quick scan (Royal Haskoning, 2003) is that operations where all small call sizes are exchanged and the smallest barges only visit the BHT (similar to type B in this paper) have the highest savings per TEU. Discharging of almost all containers as presented in type C of this paper, would not result in savings. The time saved by visiting only one marine terminal in the port would be undone by the time(cost) required for handling nearly all container twice at the BHT. Operations similar to A and D as discussed in this paper were not considered in the quick scan. Nevertheless, a preliminary assessment could be that second handling (almost) all containers at the BHT will probably not be the most feasible solution.

Although further research is required, a BHT located near the landside entrance of the port does seem to have the most benefits. Due to the proximity to the port, it has the largest potential market and can provide several different services for the marine terminals. Furthermore it can function as a container drop-off / pick-up point for trucks.

The type of terminal required for a BHT has not been sufficiently researched. As discussed, the type of terminal most suited greatly depends on the type of operation, throughput and location. However, the type of terminal does greatly determine the handling costs, and as the handling costs seem to be a dominant factor in the cost benefit calculations, the type of terminal should be considered in future research.

STRENGTHS, WEAKNESSES, OPPORTUNITIES & THREATS

Based on our findings to date, the following Strengths, Weaknesses, Opportunities and Threats can be named for the Barge Hub Terminal:

Strengths

- Improvement of barge efficiency in the Port of Rotterdam (by reducing number of visits to marine terminals)
- Improvement of quay efficiency at Marine Terminals (due to larger call sizes barges)
- Improvement of Port Accessibility and Safety (Less barge traffic in the port)

Weaknesses

- Additional handling costs and time at BHT.
- Investments required for BHT concept

Opportunities

- With the ever increasing container volumes, and only limited road and rail capacity, barge transport is expected to grow considerably, requiring a further improvement of barge efficiency
- Possible threshold values for such BHT concepts to work could be reached with the increasing volumes in barge transport.
- With the development of Maasvlakte 2, the number of marine terminals will further increase, also increasing the potential number of visits for barges
- The BHT can provide additional services to Marine Terminals, e.g. MT depot and (floating) stack/storage capacity
- The BHT can function as a container drop-off/pick-up point for trucks (improving port accessibility and truck efficiency and reducing environmental impact)
- The BHT can develop new markets / stimulating the modal shift to Barges
- The BHT could function as a collection distribution point for containers directly transshipped between deep sea vessels and barges. This concept, using floating cranes for the direct transshipment, is currently being researched (see [Pielage & Rijsenbrij, 2005])

Threats

- The number of parties involved (barge operators, marine terminals, port authorities, and others), and the resulting complexity in organizing and realizing such a concept
- The possible imbalance between costs and benefits between parties, and their willingness to evenly share the costs and benefits
- Availability of suitable space for the BHT
- Other (more feasible) concepts for improving barge efficiency.
  One of the possible ideas is to reduce the number of visits in the port by visiting more terminals inland (picking up less container per terminal). The inland vessel loads only those containers in the hinterland that are destined for one or a few terminals in the port. Consequences are yet to be determined.

CONCLUSIONS

The Barge Hub Terminal (BHT) has potential for the Port of Rotterdam. It can improve barge efficiency in the port, quay efficiency at the marine terminals, and will also improve the accessibility and safety of the port. Furthermore, the BHT can provide additional (storage) services to the marine terminals and function as a container drop-off/pick-up point for trucks, further improving port accessibility and truck efficiency.
Of the four types of operation (concepts) discussed for the BHT, concept B seems to have the most potential. In this concept only the small container batches are unloaded at the BHT, which are then loaded onto other (larger) barges carrying large batches with the same destination. According to earlier studies, such a BHT concept could save up to 8 euro/TEU

for the barges (by saving time), but the estimated 35 euro/TEU additional handling costs at the BHT would prove this concept to be financially unattractive. However, as also indicated in the earlier studies, these calculations did not include savings at the marine terminals (due to better quay efficiency) or possible savings / benefits for the Port of Rotterdam (less investments in quays and reduction in barge and possibly truck traffic).
In order to better assess the feasibility of the BHT, more research is needed. The different concepts should be further developed and analyzed, including costs and savings for the many other parties involved. As the handling costs at the BHT are a dominant factor in the cost benefit calculations, the terminal type and location should be considered in more detail in future research. Reducing costs here would greatly improve the feasibility of the BHT.
The BHT has potential, but involves many parties. For a BHT project to succeed, all these parties should be consulted and/or involved. It is important, not only to include the possible costs and benefits of all the parties involved, but also to address the possible imbalance between these cost and benefits and the willingness to share these costs and benefits.
The increasing container volumes and the increasing number of marine terminals in the Port of Rotterdam may accomplish feasible barge hub terminal concepts in the near future.

REFERENCES

FAMAS, 2000, Integrale Rapportage FAMAS – Samenvatting FAMAS onderzoeksprogramma 1997-1999, TRAIL onderzoekschool / Connekt, Delft.

Gemeente Rotterdam, 2004, Havenplan 2020, Ruimte voor kwaliteit, Rotterdam.

Konings, R., 2007, Opportunities to improve container barge handling in the port of Rotterdam from a transport network perspective, in: *Journal of Transport Geography* (forthcoming).

Lempert, B., 2006, Developments and trends in the container shipping market, Presentation at the ERIM Research Seminar 'Developments & trends in Maritime Logistics, 21 February, Erasmus University Rotterdam.

Pielage B.A., and J.C. Rijsenbrij, 2005, Floating cranes for the container terminal of the future. Presented at the International Conference on Port-Maritime Development and Innovation (ICPMDI), Rotterdam.

Royal Haskoning, 2003, Containeruitwisselingsterminal Dordrecht, Quick scan voor een haalbaarheidsanalyse, Rotterdam.

Royal Haskoning, 2005, Maasvlakte 1 en 2 samen klaar voor de Binnenvaart, Projectorganisatie MV2, Rotterdam.

Slack, B., 1999. Satellite terminals: a local solution to hub congestion?. Journal of Transport Geography, 7(4), 241-246.