MALACCA-MAX: CONTAINER SHIPPING NETWORK ECONOMY

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ABSTRACT

Malacca-max container carrier, has become the term for the maximum size of container carriers liable to be built in the future. Previous papers have established that significant savings can be gained by a large increase of ship size. This paper discusses economical and logistical aspects of the container carrier when the ship is considered in the network of port-to-port and door-to-door transport. Great emphasis is put on the routing of the ship, hub port selection, feedering strategy and the competitive position of the ship with regards to transit times of today's carriers.

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1. INTRODUCTION

Fundamental changes are taking place in container shipping, which form the driving forces for the implementation of very large container ships such as the Malacca-max container carrier. These fundamental changes are: Mega mergers, mega volumes, mega ships, mega hubs and mega modal shift. Each of these factors has an influence on the optimal ship size (Wijnolst *et al*, 2000).

Mega mergers

During the 1980s there were three groups of container shipping lines: Many small companies, a fair number of medium-size companies and a very small number of large companies. In the early 1990s companies discovered that the group of medium size companies had to grow in fleet size, or would be forced to merge. This resulted in an increase of small and large companies, and a decrease of medium size companies (Wijnolst, Waals, 1998). There are two factors that force companies to grow, or to stay small: Economies of size of large container ships and dis-economies of scale of the overhead organisation.

Mega volumes

The most promising trade route for the ultra large container carriers is the Europe - Far East route. If, by 2010, the westbound container volume would increase to a level of 7.5 million TEU, then 144,000 TEUs per week have to shipped on this route. This could be done by 64 Malacca-max container ships. If this volume would be shipped with Panamax vessels then an equivalent of 242 ships would be needed. From these tentative calculations it can be concluded that apart from the engineer's technology push, there exists a real demand that will trigger and necessitate a further increase in ship sizes.

Mega ships

The increase in ship sizes started in the oil tanker market during the late 1960s. The supertanker of 100,000 dwt was followed by a rapidly increasing deadweight of over 500,000 tonnes in the mid-1970s. Thereafter the market has returned to the smaller size VLCC of around 300,000 dwt. The limiting factor of the VLCC is the draught, especially the Strait of Malacca which allows a maximum of around 21 metres. A similar development, but less spectacular, can be witnessed in dry bulk shipping, where again the draught is a limiting factor.

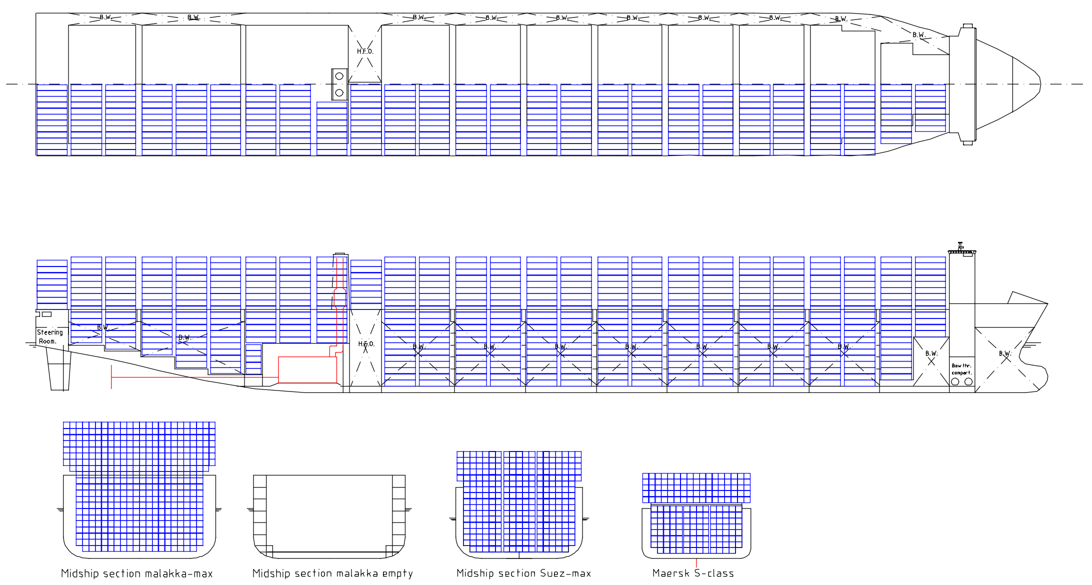
The development of container ships follows a similar pattern as oil tankers and dry bulk carriers, with a time lag of twenty years. The maximum deadweight was limited to 70,000 dwt, which corresponds with the limitation of the Panama Canal locks. Since 1988, the post-Panamax container ships increased rapidly in size to 105,000 dwt in 1999.

A container ship design was made by the Delft University of Technology (Wijnolst *et al*, 1999), based on the same size limitation as the VLCC and the large dry bulk carriers: The draught. The draught was limited to the 21-metre draught of the Strait of Malacca. The parameters of this ship are shown in table 1 and compared with other ship sizes. The general arrangement is shown in figure 1. There are indications that it may not be necessary to have a 21-metre draught to carry the same number of containers, since the required deadweight could be lower.

Table 1: Malacca-max design characteristics

Ship	Malacca-max	Suezmax	Sovereign Maersk
$Length_{oa}$ (m.)	400.00	400.00	348.00
Breadth (m.)	60.00	50.00	42.80
Draught (m.)	21.00	17.04	14.00
Depth (m.)	35.00	30.00	24.10
Displacement (tonnes)	313,371	212,194	142,500
DWT (tonnes)	243,600	157,935	105,000
Light Ship Weight (tonnes)	70,771	54,259	37,500
TEU capacity	18,154	11,989	8,400
V_{ship} (kn.)	25.00	25.00	25.00
P_{engine} (kW.)	116,588	91,537	61,000

Figure 1: Malacca-max container ship design



Mega hubs

The cost of hinterland transportation of containers is a significant part of the total cost of the deepsea container line. Traditionally container ships call at a number of ports before they start crossing the ocean. In the past many ports that had a direct call within a multi-porting loop, lost out to bigger ports. In the latter case a hub-feeder structure has emerged. The hub feeder concept implies large transhipment movements of containers, but at the same time may provide the lines with the opportunity to bring the containers closer to the final destination by ship.

In order to make hub-feeder an option, a number of conditions have to be met:

- The hub-feeder system can only be competitive if there is a substantial percentage of the containers on the deepsea vessel that remain in the main port (Bello, 1999);
- The increase in feeder container flows creates economies of scale in shortsea transportation and a minimum critical mass to feeder containers to many more small ports (Boer, 2000);
- Finally, the cost per container move in the hub-feeder system has to decrease (Wijnolst *et al*, 1999).

A recent P&O Nedlloyd study (Boer, 2000) indicates that it is possible to gain significant savings on their services to the UK, when one hub port is chosen (Rotterdam) and all containers are feedered. The reason for this is that because all containers are concentrated in one hub port, flows become thick enough to add extra feeder ports to their feeder network. Then distances by truck become shorter and costs lower. Another reason is that the expensive main carrier spends less time in port, and so increases productivity.

Mega modal shift

Mega hubs will lead to mega single-user terminals. This will facilitate a modal shift of hinterland transport, as more dedicated and condensed flows can be arranged from one terminal. The mega hub will lead for example to many changes in shortsea shipping, or better in feeder shipping. From a hub more ports can be served, with higher frequency and lower slot costs because of the economy of scale of larger feeder vessels. Shortsea shipping may get a boost from the increase in feeder business.
In inland shipping in Europe an important modal shift is happening. The share of inland shipping to and from Rotterdam has increased to around 37 per cent, which is not only reducing congestion on the roads, but is also a contribution to a healthy environment.

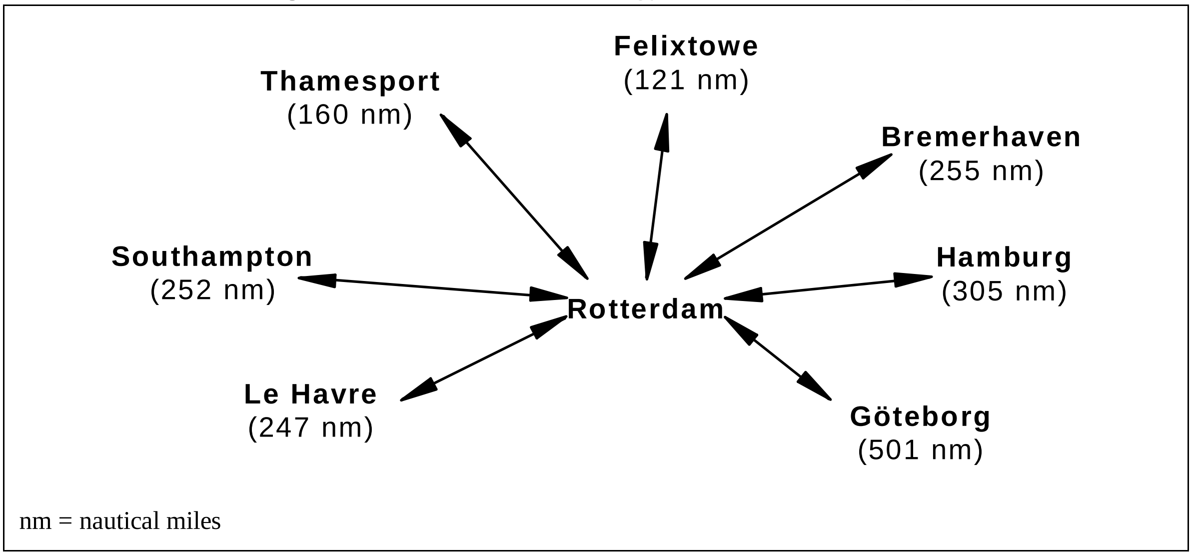
The relevance of this paper is twofold. First it establishes a likely demand for large container vessels and the shape of their network environment. Second, the paper is an example of the possible fruits of the Dutch maritime knowledge infrastructure. It combines marine engineering, maritime business and network economics to build a vision for the future of container shipping.

2. HUB-FEEDER STRATEGIES

The Malacca-max container carrier would be operating in three different areas: Northwest Europe, the Mediterranean and the Far East. In each region two different feedering strategies can be used: Direct feedering and indirect feedering (loop). For each region an analysis has been made of both strategies. The concepts are illustrated here by the case of Northern Europe.
In Northern Europe Rotterdam is the hub port, while the feeder ports are Bremerhaven, Felixstowe, Göteborg, Hamburg, Le Havre, Southampton and Thamesport.

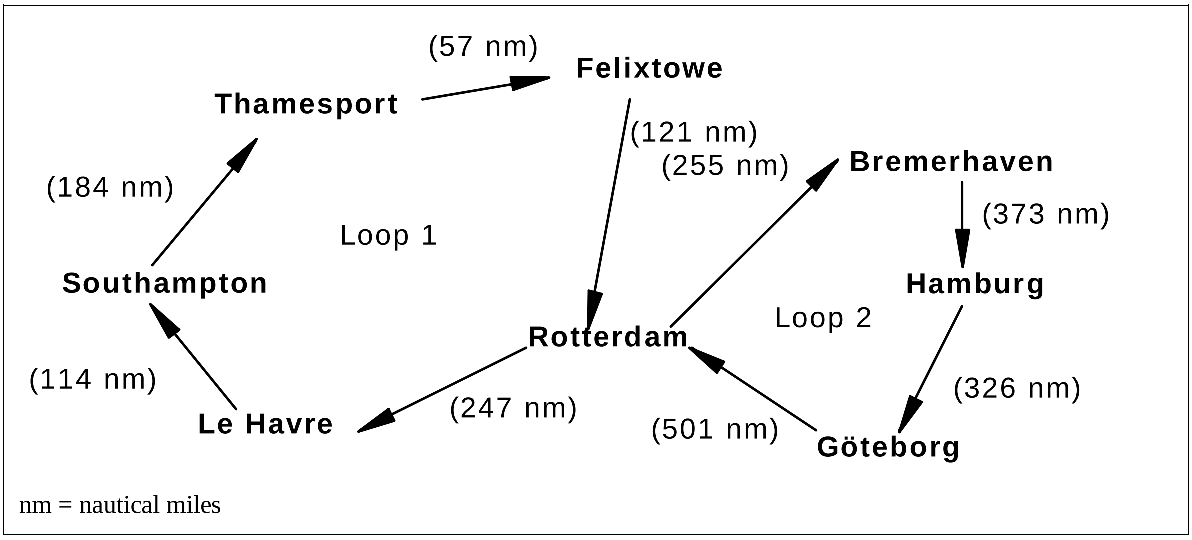
The first feeder strategy is that each port in northern Europe has its own direct feeder connection with Rotterdam. This strategy results in the shortest transit time, but on the other hand requires more feeders and the number of transhipped containers on one leg is smaller. This requires ships with a small capacity and smaller ships have a lower economy of size which will increase the transit costs. Another factor which influences the transit costs is the total transit distance. In this strategy the cumulative feeder distance to and from each of the abovementioned ports is 3,682 nautical miles. Figure 2 visualises this strategy.

Figure 2: Direct feeder strategy for Northern Europe



The second feeder strategy is to serve more than one port during one voyage. The feeder vessel will now sails in a closed loop. Figure 3 illustrates this strategy. This strategy results in a longer transit time, but fewer and larger ships can be used, so that the economy of size increases. Besides, the total transit distance of loop 1 and loop 2 is 1982 nautical miles, which is half the distance of the first strategy.

Figure 3: Indirect feeder strategy for Northern Europe



A calculation was made for the demand for ships in each strategy. The number of containers for each port of (feeder) destination are assumed to be proportional to the ratio of containers handled now. 18,000 TEU is unloaded in Rotterdam for the North European market.
Finally, the turnaround time of each leg or loop is calculated. This calculation is based on an average vessel speed of twenty knots. Entry and exit are three hours per call, and the (un)loading speed is seventy moves per hour per thousand TEUs.
Table 2 shows the transit times between Rotterdam and the feeder ports for the direct feeder strategy. This is for a one way direction and the calculated round-trip times are to and from the mega hub Rotterdam. The last column shows the current transit times. It can be seen that the approximated transit times, which are half of the approximated round-trip times, are in line with current transit times. Table 3 shows the transit times for the loop feeder strategy.

Table 2: Transit times for direct feedering in Northern Europe

Port	Direct feedering distance	Sea Time (hours)	Port entry/exit (hours)	(un)loading Time (hours)	Total round-trip time	Transit from Rotterdam
Bremerhaven	2 x 255 nm	25.5	6	28.6	2 d. 12 h.	---
Felixstowe	2 x 121 nm	12.1	6	28.6	2 d. 0 h.	1-3 days
Göteburg	2 x 501 nm	50.1	6	18.6	3 d. 3 h.	---
Hamburg	2 x 305 nm	30.5	6	28.6	2 d. 17 h.	1-3 days
Le Havre	2 x 247 nm	24.7	6	21.4	2 d. 4 h.	1 day
Southampton	2 x 252 nm	25.2	6	21.4	2 d. 5 h.	1-3 days
Thamesport	2 x 160 nm	16	6	12.9	1 d. 11 h.	---

Table 3: Approximated transit times per loop in North Europe

<table>
<tr><th rowspan="2"></th><th colspan="2">Feedering distance</th><th>Sea time</th><th rowspan="2">Port entry/exit</th><th rowspan="2">(un)loading time</th><th rowspan="2">Round-trip</th></tr>
<tr><th>Loop 1</th><th>Loop 2</th><th>Loop 1</th></tr>
<tr><td>Bremerhaven</td><td rowspan="5">247 nm
114 nm
184 nm
57 nm
121nm</td><td rowspan="5">255 nm
373 nm
326 nm
305 nm</td><td rowspan="3">36,2 h.</td><td rowspan="3">30 h.</td><td rowspan="3">39.3 h.</td><td rowspan="3">4 d. 10 h.</td></tr>
<tr><td>Felixstowe</td></tr>
<tr><td>Göteburg</td></tr>
<tr><td>Hamburg</td><td>Loop 2</td><td></td><td></td><td></td></tr>
<tr><td>Le Havre</td><td rowspan="3">63 h.</td><td rowspan="3">24 h.</td><td rowspan="3">46.4 h.</td><td rowspan="3">5 d. 13 h.</td></tr>
<tr><td>Southampton</td><td>723 nm</td><td>1260 nm</td></tr>
<tr><td>Thamesport</td><td></td><td></td></tr>
</table>

On the basis of Table 2 and Table 3 the total number of container carriers required for a daily feeder service, has been calculated. The feeder ship demand is shown in Table 4. For the direct feedering strategy approximately seventeen carriers are needed and for the loop feeder strategy ten carriers. Besides, the capacity of the carriers of the direct feedering strategy is significantly smaller then the capacity of the carriers in the feedering loops. However, the transit time of the direct feedering strategy is significantly shorter then the transit time of the feedering loops.

Table 4: Number of carriers required for a daily service in Northern Europe

Port	Carrier demand/ day	Round-trip Time	Carrier Demand
Bremerhaven	1 x 2000	2 d. 12 h.	**2.50**
Felixstowe	1 x 3000	2 d. 0 h.	**2.00**
Göteburg	1 x 650	3 d. 3 h.	**3.25**
Hamburg	1 x 4000	2 d. 17 h.	**3.66**
Le Havre	1 x 1500	2 d. 4 h.	**2.25**
Southampton	1 x 1500	2 d. 5 h.	**2.25**
Thamesport	1 x 450	1 d. 11 h.	**1.50**
Loop 1	1 x 5500	4 d. 10 h.	**4.50**
Loop 2	1 x 6500	5 d. 13 h.	**5.50**

3. CHOICE OF THE HUBS

During its journey the Malacca-max container carrier will only visit four or maybe five hub ports. From here containers will be feedered to their final destination. As most important hubs Rotterdam and Singapore are selected. Two extra hubs have been selected: One in the Mediterranean, another one in the Far East.

3.1 Mediterranean hub port selection

The Mediterranean hub was selected on the basis of four criteria:

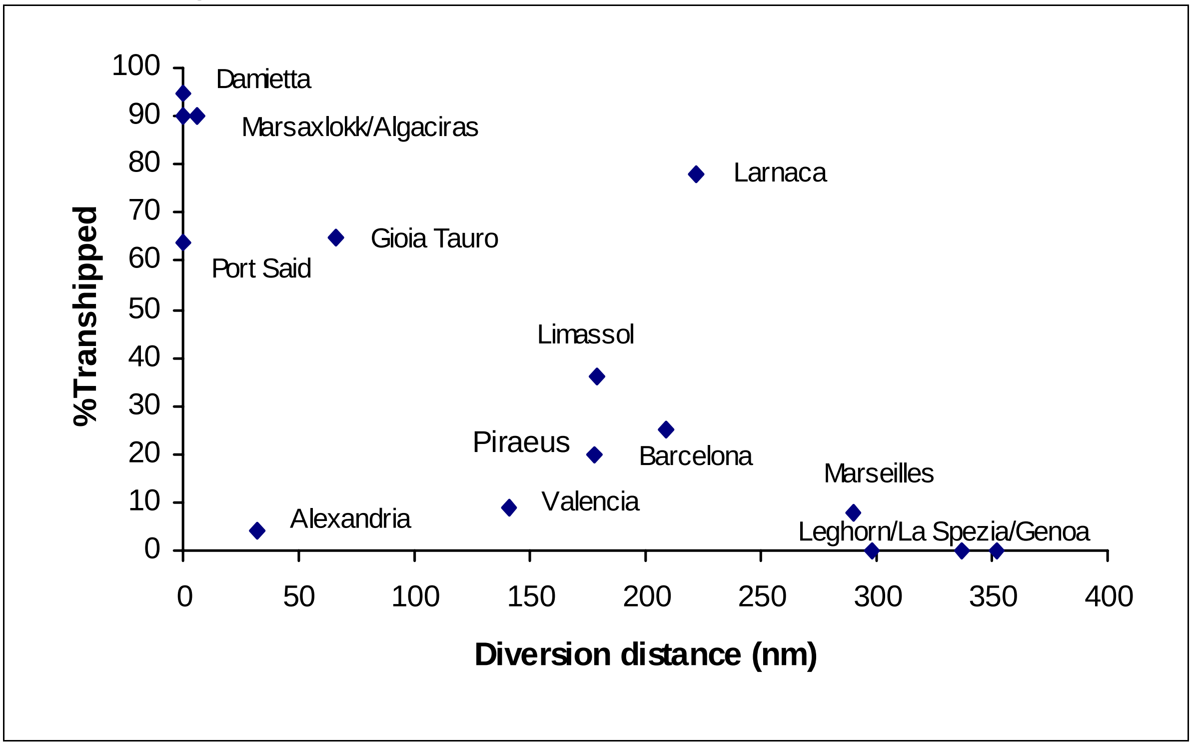
- Deviation from the main route;
- Container throughput;
- Physical restraints of the ports;
- Centre of gravity of container flows.

Starting with an initial number of 15 ports, each criterion is applied until a small number of suitable ports remains

Deviation distance from main route

The Mediterranean region has traditionally been served by way of direct vessel calls. The large number of relatively small ports has resulted in many inefficiencies for these direct call services. The location of a transhipment hub needs to be close to the major shipping routes in order to minimise route deviation and it must be central to those ports that it will serve in order to minimise feeder vessel transit time and expense. Figure 4 plots the various ports between Gibraltar and the Suez Canal as a function of route deviation and transhipment share of the containers handled.

Figure 4: Relationship between transhipment and diversion distance



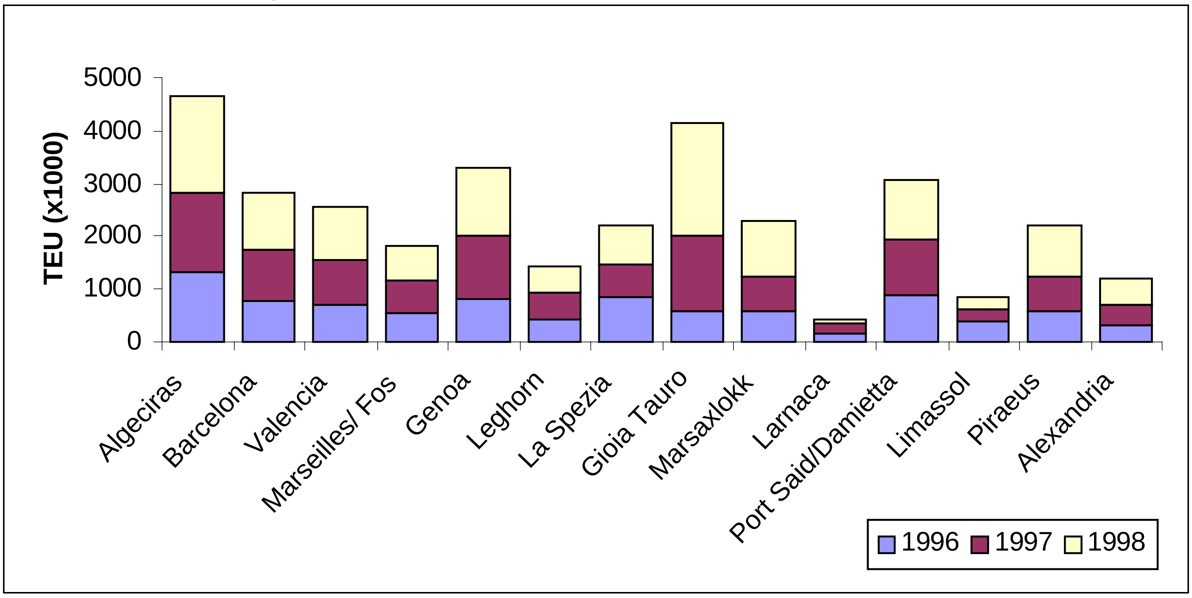
This picture clearly demonstrates that the smaller the diversion distance, the larger the transhipment role of the port. Another geographical factor is that a mainland location has a hinterland, as opposed to an island location. While a major part of the container flows through a transhipment hub moves via feeder vessels, it is also important to offer customers land transport services, such as road and rail. Some of the ports in the Mediterranean offer this option. Finally, the hub should be accessible for Malacca-max vessels with a draught up to 21 metres.

Container throughput

The present container throughput and the growth of the throughput are used as a measure for the potential handling capacity of a port. Figure 5 shows the container throughput of the ports in the Mediterranean for the year 1996, 1997 and 1998. The throughput of some ports decreased during this period, while the throughput of other ports increased. E.g., between 1996 and 1998 the throughput in Algeciras increased with 39%, in Gioia Tauro with 271%, in Marsaxlokk with 77% and in Piraeus with 62%.

On the basis of the diversion distance table and the throughput it is possible to make a first selection of possible hubs in the Mediterranean. The following ports are chosen on the basis of a diversion distance smaller than a hundred miles and a substantial growth rate: Algeciras, Port Said/Damietta, Marsaxlokk, Alexandria and Gioia Tauro.

Figure 5: Container throughput in 1996, 1997 and 1998



Physical constraints

On the basis of physical constraints an extra number of ports are rejected.

The *Port of Damietta* has a restriction in ship's length. The Malacca-max container carrier has a length that exceeds this restriction. Therefore, it is not possible to use this port as a hub for a mega container carrier.

The *Port of Alexandria* has a restriction on the maximum draught, around 12 m. This means that for the Malacca-max carrier it has to be dredged another 10 m. Another disadvantage is that the port is not a real container port and the total berth length is only 720 m.

Port Said has several disadvantages. E.g. the entrance channel is only 11.28 m deep and the berth length is 350 m. The length of the Malacca-max container carrier exceeds this length. However, Port Said is now constructing a new terminal called East Port Said. This terminal is a possible candidate, although the feeder distances to other ports will be substantial due to its eccentric location in the Mediterranean.

The *Port of Algeciras* is a possible candidate. The port handles a large number of containers per annum and the figures show that this is still increasing. Besides, this port has several development plans to increase its container capacity. One disadvantage is that the harbour is not yet deep enough. The deepest quay is now 16 m, but there are plans to increase this to 18 m at the new quay. So the port is in a way already planning to handle mega container carriers. The second disadvantage is that the port is not centrally located in the Mediterranean Sea, which results in larger feeder distances and thus higher feeder costs.

Marsaxlokk is also a possible candidate. It is smaller than Algeciras, but the port has several development plans which reveal serious plans to increase its container business. At the moment the water depth alongside is not yet deep enough. The deepest quay has a draught of 15.5 m, but a new terminal could offer a 21-metre draught alongside. Another advantage is that the port is centrally located in the Mediterranean Sea.

The port of *Gioia Tauro* is a real container port. It handled more containers in 1998 than Algeciras. The port is also centrally located, but there is a deviation of 66 nautical miles from the course from Gibraltar to the Suez Canal. This will cost extra time. Also, the port is not yet capable of handling a mega container carrier, because the draught alongside the quay is maximally 15 m.

The potential candidates for a mega hub container port in the Mediterranean can now be reduced to the following four ports: Algeciras, Marsaxlokk, Gioia Tauro and (East) Port Said. A further selection of these ports is based on more quantitative methods.

Centre of gravity model of the Mediterranean

In order to determine the most centrally located container port among the four potential ports, Algeciras, Gioia Tauro, Marsaxlokk and Port Said, a weighted centre of gravity model of the Mediterranean region has been made. The weight of each of the container ports was determined on the basis of their present share of containers handled. On the basis of this analysis Gioia Tauro is the best location for a mega hub container port in the Mediterranean region, closely followed by Marsaxlokk.

3.2 Far East Hub selection

The optimal hub in the Far East has been examined on the basis of quantitative methods only. The quantitative method used is similar to the one used for the Mediterranean, though there are some significant differences.

In order to make a good estimate of the best location of a hub in the Far East, it is important to know precisely where the trades are going. However, it is impossible to find information on specific port, only on countries. Thus, it will be assumed that the containers will go to only one port in each country.
In some countries only one port plays an important role in international trades, e.g., Manila in the Philippines. Since there is no other important container port, it is assumed that container flows towards the Philippines, pass through Manila. In other cases, the small size of the country makes the choice of a destination of the cargo less important. Thus, assuming that cargo goes to one single port will not lead to large errors.
Problems may arise with China and Japan. Both countries are large (thus distances between national ports are important) and their container imports and exports are huge.

In Japan three container ports play a major role: Yokohama, Tokyo and Kobe. The first two ports account for some 6.5 million TEU of the 12.5 million TEU handled in Japan (*Containerisation International Yearbook*, 1998). Tokyo and Yokohama are located a few miles apart from each other. Kobe, located more in the South, handles some 2.4 million TEU. Hence, as destination for cargo to Japan Yokohama is chosen, Japan’s leading container port.

Hong Kong is obviously the biggest container port in China but there are many other ports handling large numbers of containers. China's main secondary ports are located near Hong Kong, some of them – like the Shenzhen ports of Yantian, Shekou and Chiwan– only within a few miles. The share of Hong Kong and its nearby region in Chinese container traffic is very important.Therefore, it is assumed that all containers loaded onboard the Malacca-max container ships will be imported in China via Hong Kong.

Elementary calculation of a hub location

Analytical methods have been used to determine the optimal location of a hub in the Far East from where the cargo will be distributed within the Far East. The evaluation of the different possibilities was based on the *total transport costs* as the criterion to bring the containers to their final destination. This is a different approach than the one used for the Mediterranean hub selection, since in this situation the costs are a more important item. This is because visiting an extra hub in the Far East means extending the voyage of the main liner.

The total costs made between Singapore and the final destination of the containers can be written as:

$$\text{Total transport costs} = C \bullet D \bullet \sum_i n_i + c \bullet \sum_i n_i \bullet d_i$$

Where:

- C = Cost in US$/TEU/mile for the transport of a container on a deep sea container ship on a relatively short distance
- c = Average cost on a feeder container ship
- D = The distance in nautical miles of the hub from Singapore
- d_i = Distance of a port *i* from the hub
- n_i = Number of containers, measured in TEU, designated for a port

D and d_i are both calculated using Pythagoras' Theorem. Hence, actual sailing routes are not taken into account. Again inaccuracy can be expected from the deformation of the projection of the ports on a plane.

The first term of the equation states the costs between Singapore and the hub whereas the second term states the costs of transporting the containers from the hub to their final destination. This method requires an iterative solution since d_i depends, as D, upon the location of the hub. This is shown in the following equations:

$$D = \sqrt{X^2 + Y^2} \quad \text{and} \quad di = \sqrt{\left(X - x_i\right) + (Y - y_i)}$$

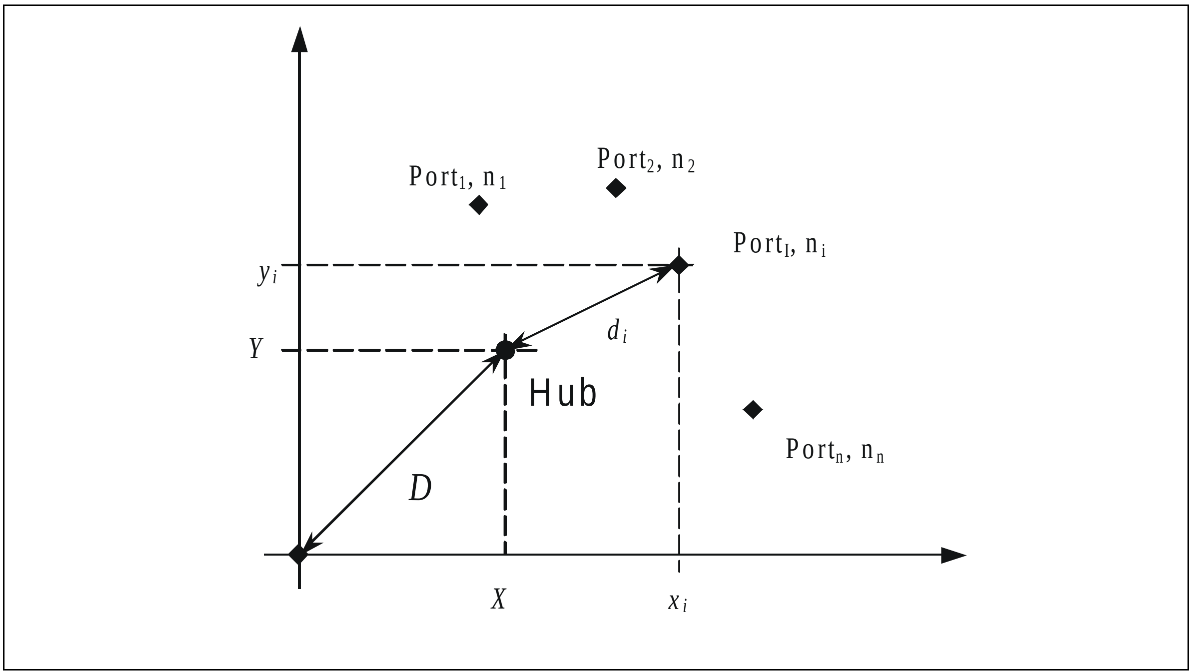
where (XY) are the coordinates of the hub and ($x_i y_i$) the coordinates of port *i*. Table 5 gives an overview of various values of C and c for used for different ship sizes.

Table 5: Estimates of transport costs per slot for various ship sizes

Ship size	C or c [US$/TEU/nm]
Malacca-max	0.0175
6,000 TEU	0.0187
3,000 TEU	0.0205
1,000 TEU	0.03

In the calculation, *C* is taken as 0.0175 US$/TEU/nm as the ships of Malacca-max size are used and 0.0300 US$/TEU/nm for *c*. Figure 7 gives graphically the method used for the iteration.

Figure 7: Calculation method for the iteration



Thus, the problem can be formulated as follows:

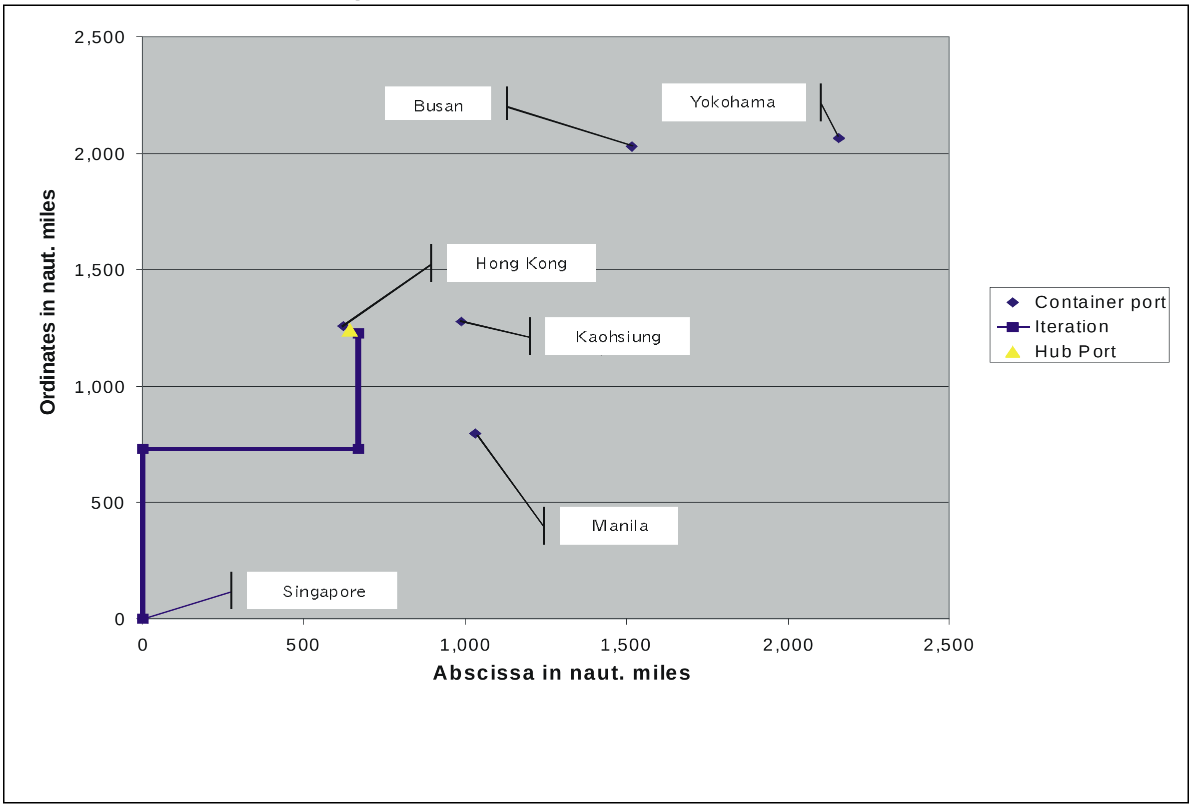
$$\min\left\{C \bullet D \bullet \sum_i n_i + c \bullet \sum_i n_i \bullet d_i\right\}$$

$$\text{s.t.:} \quad D = \sqrt{X^2 + Y^2} \quad \text{and} \quad d_i = \sqrt{(X - x_i)^2 + (Y - y_i)^2}$$

On a practical level, this is done by starting with an arbitrary value for (*X*;*Y*). For example Singapore can be taken as the first hub. Then *X* and *Y* are adjusted in order to minimise the total transport costs. The result of the iteration is clearly shown in Figure 8.

The figure shows that in a case of a single hub in Asia for the deployment of container ships of Malacca-max size, the best choice is Hong Kong. The optimal position of the hub is a few miles off the coast and very close to Hong Kong. Using Hong Kong as a hub may increase the transport costs slightly because of the increased distance from Singapore. However, on the other hand, these costs will be reduced heavily by a substantial reduction in the transhipment costs because of the fact that containers destined to China do not have to be transhipped in Hong Kong. Transport costs are reduced dramatically compared to the initial configuration.

Figure 8: Optimal location of a single hubs



4. TRANSIT TIME

Cost is an important factor for the competitive position of the Malacca-max container carrier. Another important factor is the transit time. A significant transit time increase will not be accepted by shippers. Therefore a detailed analysis has been made of the route and expected transit times have been compared with the transit times of today's carriers.

4.1 Analysis of the route

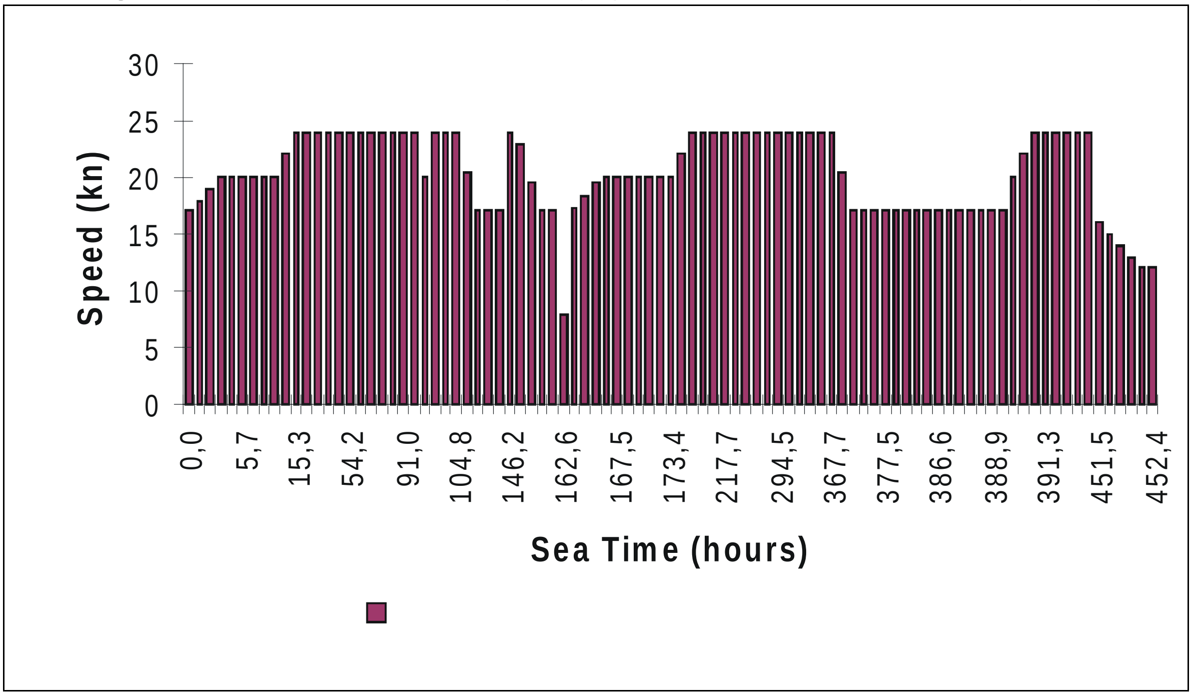
The route between Europe and the Far East is not a straight line. In between there are a number of restrictions the Malacca-max container carrier will encounter on its journey, which will have a negative impact on the speed. The container carrier will not be able to reach its top speed, when the water depth is less than sixty metres.
The ship will reduce speed thirty miles before arriving at the port and at five miles before the port the speed is reduced to manoeuvring speed. This reduced speed is approximately 17 knots. So per mile 1/3 knot in speed is reduced, when the slacking is linear. Some restrictions the ship may encounter are discussed here briefly.

- Until Greenwich buoy the speed is restricted due to shallow water;
- When Gioia Tauro is visited problems are in the Strait of Messina, due to the narrow passage and busy traffic;

- The crossing of the Suez Canal is not yet possible, but it is expected that it will be possible around the year 2010;
- In the Gulf of Suez the speed will have to be reduced due to three shallow banks;
- The Red Sea and the Gulf of Aden pose no problems, except for a shallow bank where the Red Sea enters the gulf of Aden.
- The Strait of Malacca has several shallow grounds, the ship will have to pass the strait at a speed of 17 knots.
- In the Strait of Singapore the ship will have to follow traffic lanes and reduce speed
- The Eastern Bank at the end of Singapore Strait, must be crossed at low speed;
- Until Hong Kong there are no problems;

The journey from Rotterdam to Hong Kong takes approximately 452 hours or 19 days. The restrictions posed by the sea and Suez Canal reduce the theoretical service speed of the vessel as shown in Figure 9

Figure 9: Maximum speed during a voyage between Rotterdam and Hong Kong



4.2 Malacca-max transit time

The transit time is the time it takes to transport the container from the port of origin to the port of destination. It is an important aspect of the service level. The drive for a competitive advantage has stimulated the carriers to invest in very fast container ships with service speeds of 25 knots. Secondly, minor ports are eliminated from the calling pattern in order to reduce port time. Thirdly, quay time is reduced by increasing container handling rates.
Efforts to reduce time are not restricted to terminals. Improvement of hinterland connections, shortsea feeders, inland shipping, rail and road transport, is always very high on the agenda of the operators.

In this section the transit times of today's carriers, are compared to a network in which the Malacca-max container carrier is used. In order to do this a large number of voyages were selected. For each voyage the transit time of the Malacca-max has been calculated. Each transit time has been compared with the present transit times of today's carriers, as can be found in the schedules of the carriers. Two situations have been distinguished:

- The times between mega hubs.
  In this case no transshipment is required and basically the voyages in the present situation of direct services are the same as the ones with the Malacca-max container carrier
- The times between mega hubs and major ports or between two major ports.
  In this case one or more extra transhipments, and thus time, are added compared to the present situation.

Transit times between mega hubs

The transit times between the mega hubs of the Malacca-max container carrier are in line with the transit time ranges of today's carrier schedules, although they are not the fastest transit times. The fastest transit times between these hubs are established by direct service connections of a number of operators. These direct services call only at a small number of ports in two regions, for example Rotterdam and Hong Kong. They do not visit other ports during their voyage.

Also, the total port time of the Malacca-max container carrier is higher than that of today's carriers. The port entry and exit times are for both types of container services the same, but there is a difference in loading and unloading time.

Between mega hubs and major ports or between major ports

99 of the 389 connections investigated have a transit time that is significantly (three days or more) longer than the transit times of today's carriers. Many of these are between ports in adjacent regions, e.g. Northern Europe and Mediterranean; Mediterranean and Arabian Sea/Indian Ocean; Arabian Sea/Indian Ocean and Southeast Asia, and Southeast Asia and North Asia. It seems that the Malacca-max container carrier is less competitive when the service is between adjacent regions. The reason for this is the high port time / sea time ratio.

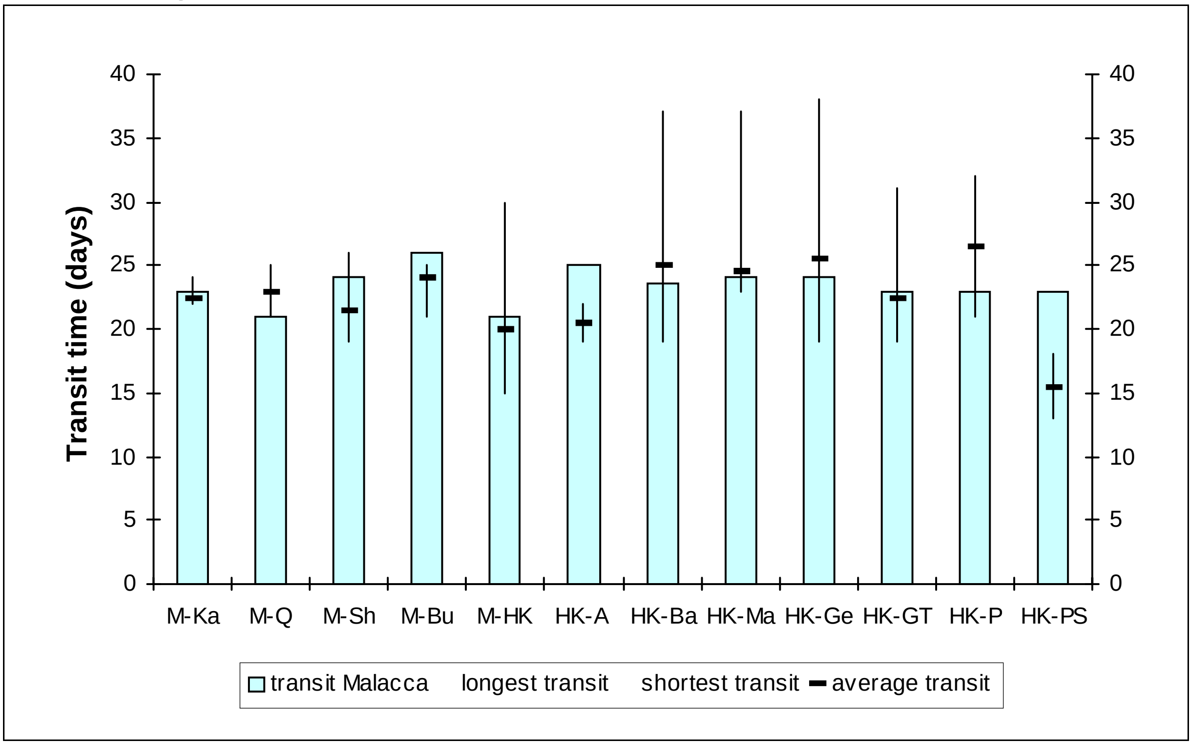
Table 6 gives an overview of transit times between major ports.

Table 6: Transit time comparison

Category	Number	Percentage
Today's carriers	290	74.5%
One/three days longer	57	14.7%
More than three days longer	42	10.8%
Total	**389**	**100%**

Some example are presented in graphical form this is shown in Figure 10. The thin line shows the spread of today's transit times. It should be born in mind that this analysis is a worst case scenario. When the extra day of dwell time of transhipment containers is eliminated, the total number of voyages faster than today's carriers will increase to 57%. The impact of direct feedering instead of loop-feedering would improve the results even more.

Figure 10: Transit times of today's liners compared with Malacca-max



5. CONCLUSIONS

The conclusion of this research is, that it is likely that in the future there will be a market for very large container carriers on the Far East route. This container carrier would sail according to a hub feeder system, and would only visit a small number of ports. These ports would certainly comprise Rotterdam and Singapore and probably Hong Kong. It would probably also visit a port in the Mediterranean.

The costs on port-to-port basis would probably be higher than the present costs, bearing in mind that the number of transhipments increases drastically. With a decrease of the handling rate, this disadvantage would be eliminated. Other research, however, shows that significant savings could be gained by adding feeder ports, which are not visited at the moment. The container would be delivered by sea closer to the customer and the costs of land transport would decrease. The addition would be made possible because the choice of one hub port would make flows to feeder ports thicker and minor flows more significant.

Transit time research shows that the Malacca-max container carrier can establish a transit time that is competitive with the transit times of today's carriers. In a number of cases transit time is significantly slower than now. This mainly concerns connections between adjacent regions.

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