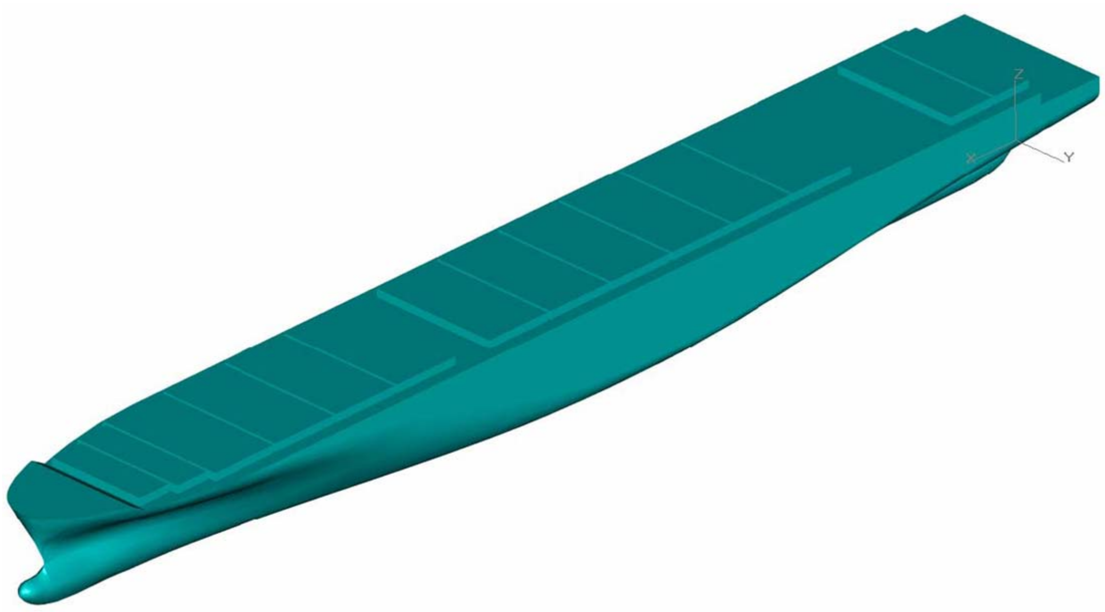
NATIONAL TECHNOLOGY UNIVERSITY OF ATHENS

DEPARTMENT OF NAVAL ARCHITECTS AND SHIPPING ENGINEERING

DIPLOMA THESIS

ECONOMIC FEASIBILITY STUDY OF ULMCS



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February 2007

I would like to dedicate this thesis to the loving memory of my father.

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What is the Vision?

The European Maritime VISIONS Network is a pre- competitive network initiative of the European shipbuilding industry, together with the European maritime universities and leading research institutes. It implements an annual creative process for the definition and validation of visionary concept ideas for vessels and floating structures. Answering to professional market and society scenarios for the next 5-15 years, VISIONS is a "Think Tank" for product ideas with medium to long term commercialization perspective.

From the market study described on the next pages we notice that there is an increasing trend for construction of even larger ships. This fact was the beginning for the first loop of preliminary design of a ship with capacity 17.500 TEU. This concept design was our project for the Vision contest. Our team qualified at the finally round and took the 4th place among 30 participations. Another criterion is the physical constraints of the terminals and the canals. This is why the ship size had to fit some specific dimensions. Consequently the main particulars had to be approximately of a Loa about 415-420 meters, a Beam about 55 meters and a draft less than 15,5 meters so that the approach to the terminals could be possible. Under consideration of the above facts and some empiric elements we conclude to the following final main particulars.

L_{OA}: 416,6 m	**Deadweight:** 156.844 tons	**Container total:** 17500
L_{BP}: 400 m	**Light Ship:** 55.650 tons	**Rows on deck:** 22
Width: 55 m	**Engine power:** 114.400 kW	**Rows in hold:** 20
Depth: 32,4 m	**Engine type:** MAN B&W 10K 98MC-C	**Layers on deck:** 7
Draught: 15,25 m	**Speed:** 25 knots	**Layers in hold:** 12

Due to the fact that an Ultra Large Mega-Containership (ULMCS) has never been designed before, it was impossible to estimate its main particulars based on similar vessels. For that reason, the aforementioned estimation had to be made on the one hand by empirical features of already existent smaller containerships and on the other by both the TEU capacity and the strength of the ship. Consequently, the first question that demanded an imminent answer was what the particular dimensions of such an ultra large vessel ought to be, so that it would be able to transfer 17.000 – 18.000 TEU. However, the answer of the previous question generated a completely new query: Would a ship of the prior dimensions satisfy the strength regulations posed by the Classification Societies?

If we take for granted that the answer of the first question provides sufficient answers for the second question as well, it is now apparent that we can proceed to the initial design of ULMCS.

The initial design was conducted via "TRIBON M2 Initial Design (Lines, Surface/Compartment, Calc)".

The ship was designed with a comparatively low Block Coefficient (C_b = 0.63), so that its hull would hydrodynamically assist in the ship's propulsion. Moreover, the Engine Room (E.R.) extends in a 40 meters length, its starting point being 50 meters ahead of the After Peak (A.P.). The position of the E.R. was hard to be defined, since it should be situated neither too fore nor too astern. The former location would demand excessively long axes, whereas the latter would cause a space confinement for the two main engines to fit, owing to the lines narrowing. As far as the compartmentation is concerned, the ship was divided in 15 cargo holds plus the E.R.. Most of them extend in a 25 meters length apart from the smaller ones which extend in a 12,5 meters length. The smaller holds are located sternwards to the collision bulkhead, below the accommodation decks and next to steering gear room. [16]

Why study a Mega Containership?

With internationalization and globalization shipping has obtained a central role in world trade. More than 90 % of the world transport volume is being transported by ship. Ships are basically compatible with the environment and have benefits from economies of scale. Fuel-consumption per ton and mile is about one fifth for a ship as compared to a truck, or about one twentieth of that of airfreight. A major problem for governments is the traffic on land which becomes more and more crowded while oceans offer a better solution for transporting. Container transport has obtained such a central role in world trade that the significant growth continues even through economic crises, as we have seen with the Asian crisis towards the end of the nineties. The container volume has had such a pronounced growth during the past twenty years that on most major routes we have experienced a doubling of volume in less than ten years.

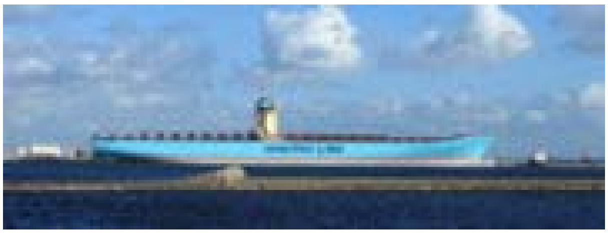
Transports with Containerships constitute high-level transports as they offer:

- Efficient and cost-effective delivery of goods
- Tight time schedule deliveries
- Largely independent from weather and sea states on route
- The cargo is well protected in containers
- Containerships are generally well maintained and have a good safety record

Economy of scale has driven the development of container shipping right from its beginning. The trend towards larger ships has accelerated in recent years and can be observed with the increasing size of long haul ships as well as feeder vessels. Container ships have been developed close to the limits of the technically possible right from their beginning in the 1960ies.
Container ships have ballooned in size to accommodate rapid growth in global trade. The amount of cargo carried in containers has grown by about 9.5 percent every year since the early 1990s, and it’s expected to maintain that pace well into the next decade. With the bigger vessels, ship owners are also able to lower the cost of moving each container by spreading expenses – such as for the crew and fuel – over more boxes.

After we finished are work with the design of ULMCS the biggest container carrier was delivered. Emma Maersk is a container ship owned by the A.P. Moller-Maersk Group and is the largest container ship ever built, and the largest ship currently in use. (The largest ship ever built was the supertanker Knock Nevis). Officially, Emma Maersk is able to carry around 11,000 TEU, however many analysts believe this figure to be much greater, possibly approaching 15,000 TEU.

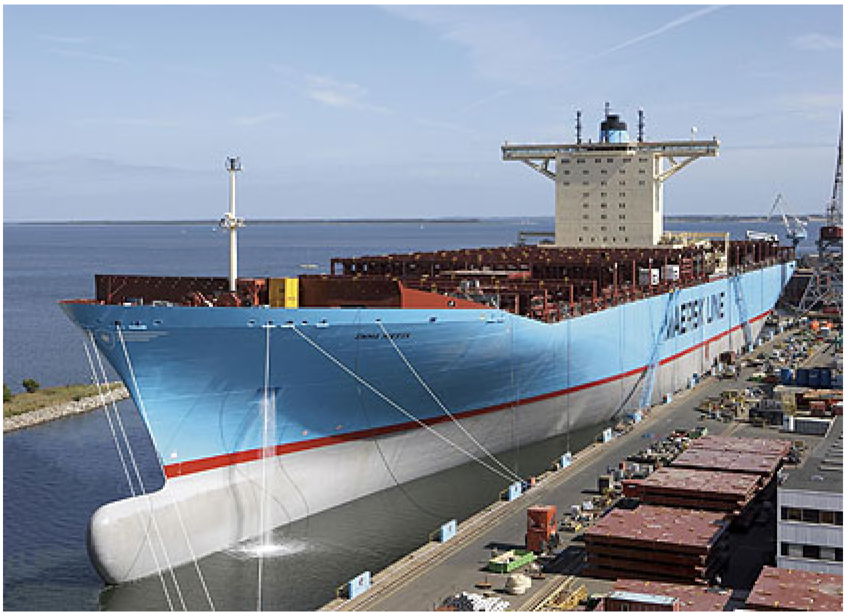
The ship was built at Danish Yard and delivered at summer of 2006 with estimated cost around $145 million.



The main particulars are as follows: Length o.a 397 m, Beam 56 m, Depth 30 m, Service speed: 27 knots.

The propulsion machinery is a 14-cylinder Wartsila diesel engine developing 110,000 BHP or 80,000 kW at 102 RPM. Five diesel generators with a combined power of 20,700 kW and one combined gas/steam turbine generator of 8,500 kW driven by the main engine exhaust are installed. The bunker fuel tanks are placed away from the outer part of the hull.

M/S Emma Maersk can carry 1,000 forty foot reefer containers and can therefore be operated by a crew of 13 persons only. Accommodation is arranged for 30 persons.



The Emma Maersk will be at service between Asia and Europe, with a round trip of 63 days, calling on ports in China, Japan, England, Sweden and the Netherlands, among other countries.

No ships larger than the Emma Maersk are expected for some time, say industry watchers. One reason is that shipyards are already clogged with work and likely won't be accepting new orders until 2009. The vessels ordered can carry between 9,000 and 10,000 20-foot containers.
For instance, Zim Integrated Shipping Services Ltd., an Israeli line, announced in June that it has ordered four ships capable of moving 10,000 20-foot containers.

Maersk Line will build 10 identical sister ships to the Emma Maersk at its own shipyard in Denmark. The next ship should arrive at the end of September with another vessel being delivered every four months until the order is complete.
Such jumbo haulers are initially destined for the Asia-to-Europe trade lane because that's the longest shipping route, making it the most logical place to try to lessen operating costs. After that, they could be used in routes from Asia to the West Coast, the location of the two biggest U.S. ports.
Bringing these container ships to the East Coast is problematic because they can't fit through the Panama Canal, necessitating a longer journey through Egypt's Suez Canal, even if the Panama Canal's planned expansion is completed as scheduled in 2014. Also, many East Coast ports don't have shipping channels deep enough to handle such ships. Ref. [26, 28]

		TEU's	Dimensions
1st Generation 1960 – 1970 	Converted Cargo vessel Converted Tanker	500 – 1000	L = 135 – 200 m T < 9 m
2nd Generation (1970 -1980) 	Cellular Containership	1.000 – 2.500	L= 215 m T = 10 m
3rd Generation (1980 – 1988) 	Panamax	3.000 – 4.000	L = 250 – 290 m T = 11 - 12 m
4th Generation (1998 -2000) 	Post Panamax	4.000 – 5.000	L = 275 - 305 m T = 11 – 13 m
5th Generation (2000 - ?) 	Sub post Panamax	5.000 – 10.000	L = 335 m T = 13- 14 m
6th Generation 	Suezmax	10.000 - 15.000	L = 400 m T = 17 m

Containership Fleet

Containerships after the sixties when the shown up (1.000 TEUs), followed a rapid and unabated development until now (9.200 TEUs today, and 13.000 TEUs in the near future), displacing the general cargo carriers

Their success depends on the primary idea of quick and safe transport of every unitized cargo (especially high value) inside containers, which introduced primarily with success in terrestrial transports of US in 50ies, and nowadays applies in every kind of transportation. This allows the 'door to door' services quickly and cheap. The increase of the ship size keeps up with the demand of capacity, and is relative to the living standards and especially of the major countries. By now containerships with capacity between 15.000 and 18.000 TEUs are visionary ideas, the technological challenges are in further research and solutions are prospective.

The capacity of the global fleet has increased by an average of 11% per annum over the last 10 years. There has been no comparable development with any other ship type in the history of shipping. Some of the growth is at the expense of the traditional general cargo ship. This ship type is being replaced today by multi-purpose vessels or by pure containerships. The containership has become the dry cargo carrier of the future.

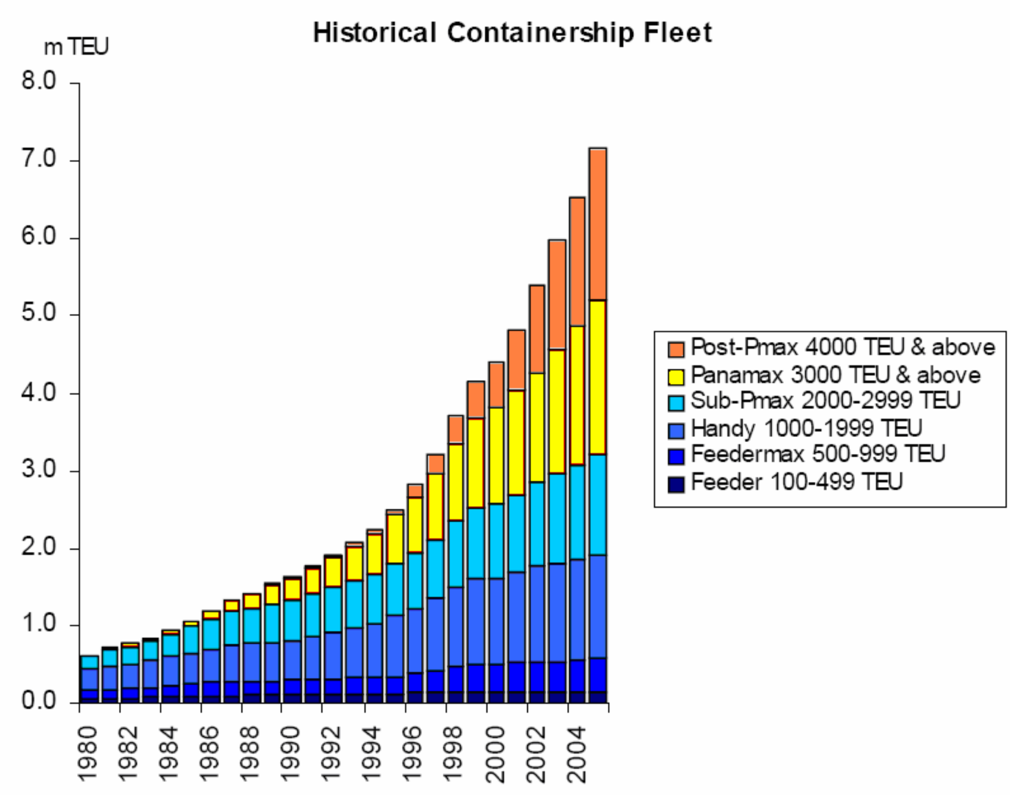


Fig. 1

Until the mid-1990s, size was limited by the dimensional constraints of the Panama Canal (principally, 32,2 m beam).

Later with intermodal transport increase Post-Panamax vessel shown up. The last decade the capacity of Post-Panamax fleet (above 4000 TEUs) increases rapidly whereas the feeder ships capacity stays almost unchangeable (Fig. 1).

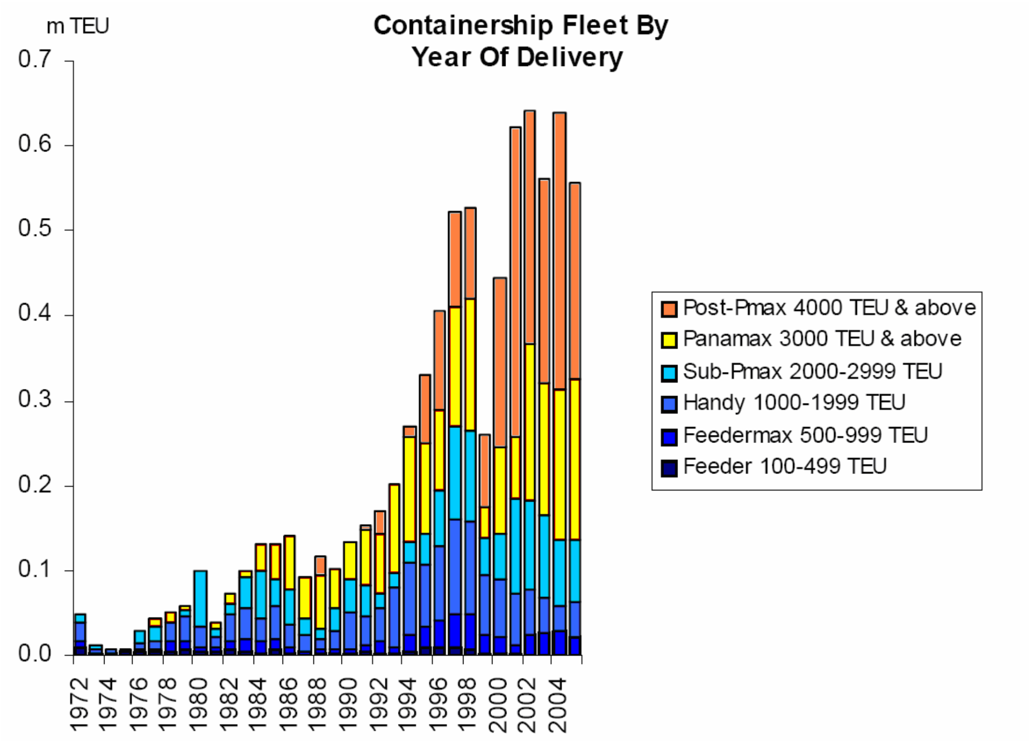


Fig. 2

Because we face a big demand and the Containerships are more expensive than other types of ships, the newbuildings have a huge growth the last 3 years. Generally we can say that newbuildings consider large ships, since more than 70% of newbuildings from 2005 until today are Panamax and Post-Panamax. As a result the fleet is relatively young with an average age overall of 11.3 years. [19]

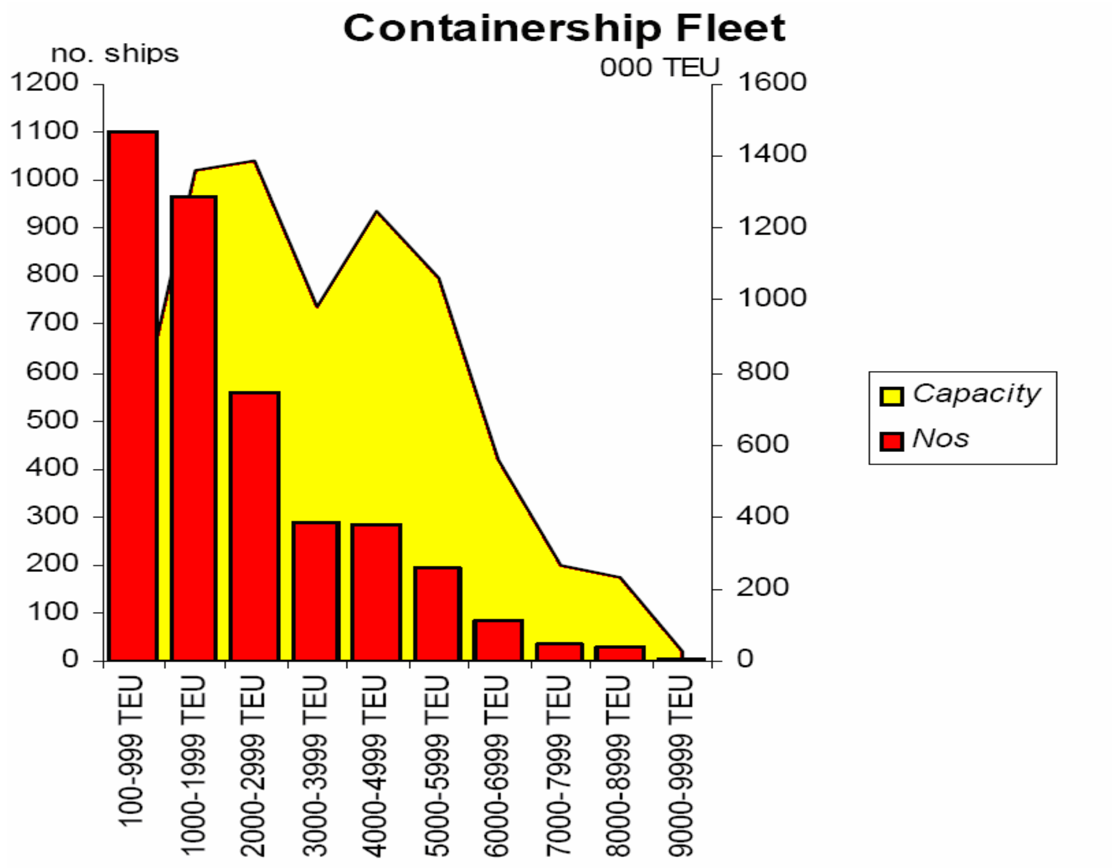


Fig. 3

Although everyone pays attention in the construction of large vessels, the feeder fleet stays almost unchangeable. This depends on the conviction of the market that we lead to radical revision of the container transport network. So we move on from direct calls to intermodal transports, with hubs development. Feeders will have an important role under these new circumstances.

Today's condition of containership fleet in shown in fig. 3. It's obvious that the majority of containerships are still at the smaller end of the fleet, a large amount of the capacity is in the larger size sectors.

It's a fact that ship owners where alarmed in 2006 because there is a never shown before tonnage waiting to be delivered by the shipyards. The container ship orders with delivery in 2007-08 will increase the total capacity of the fleet over 2.500.000 TEUs. But the analysts believe in the growing markets of China and India for the absorption of the tonnage. [19]

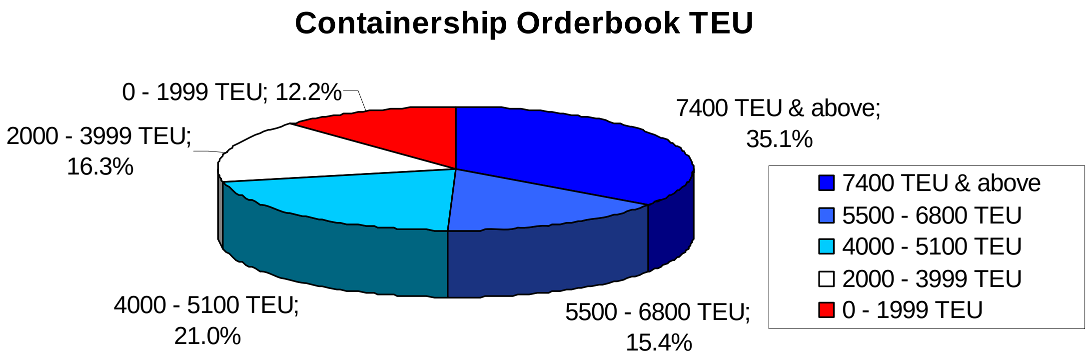


Fig .4

The fleet will be around 1.3 mTEU in 2006 with 50% of the order book to be over 5500 TEUs. In 2005, according to Clarksons lists, the fleet capacity delivered was 959.000 TEUs, following 828.000 TEUs in 2004 which was the highest ever since. Never before the container ships operators call to absorb such a huge amount of capacity. Although according to BRS-Alphaliner, the consequences cannot be estimated because only the 80% of total capacity has been assigned to the operators.

The world's larger shipyard, Hyundai Heavy Industries, has a total of 21 Mega Containerships of over 10.000 TEU on its order book. Including a contract that sing in September of 2006 with the French operator, CMA-CGM for eight 11.400 TEU containerships, worth 1.2 billion $. Ref [21]

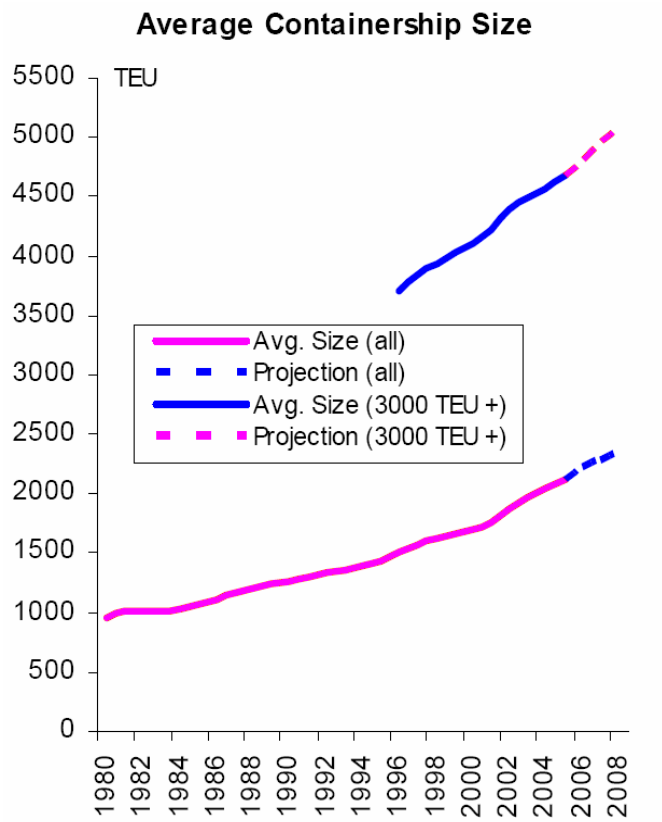


Fig. 5

Average size of containerships still rising. This is even more marked in the 'Deep Sea' 3000+ TEU sector (Fig. 5).

GPD & Trade Growth

Due to the slowdown in the world economy growth from 1994 to 2000 there was a decrease in worldwide market growth rate. This decrease wasn't so hard in containership market. But the comeback to healthy growth rates for the major trade partners of the world cause rapid increase on the growth of container transport. Besides as we notice in Fig. 6, there is higher rate of increase in the world trade market and in container trade that in the GDP.

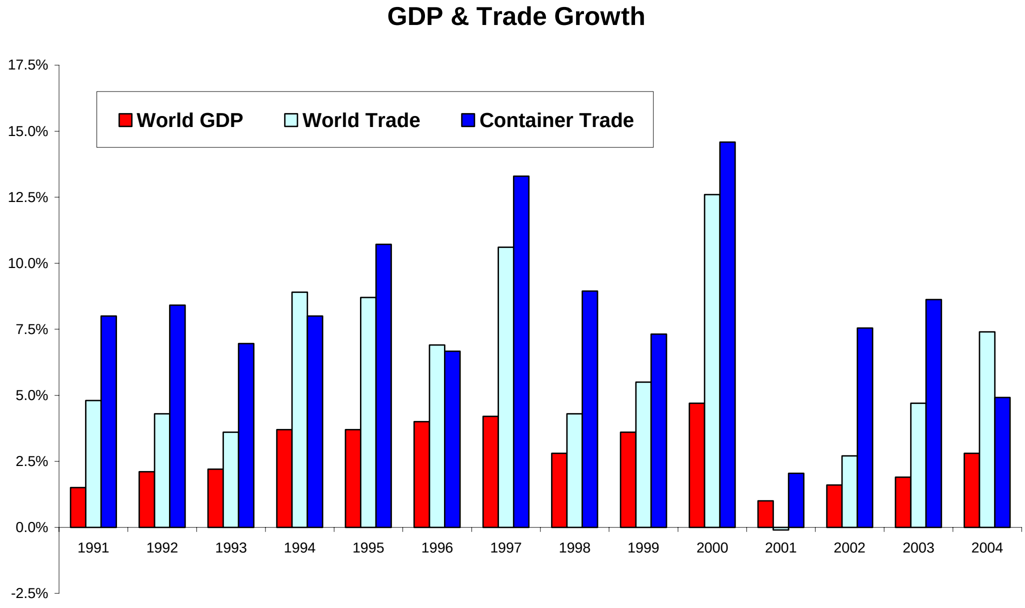


Fig. 6

Manufacturers scan the world for cheaper manufacturing, assembly locations and new markets. By opening up maritime highways to new areas of opportunity, the container industry stimulated a "virtuous cycle" of expansion for global business and created new cargoes for itself. This has been particularly noticeable in the relocation and outsourcing of manufacturing to China, and the growing importance of new regional and intra-regional sources of demand. [19]

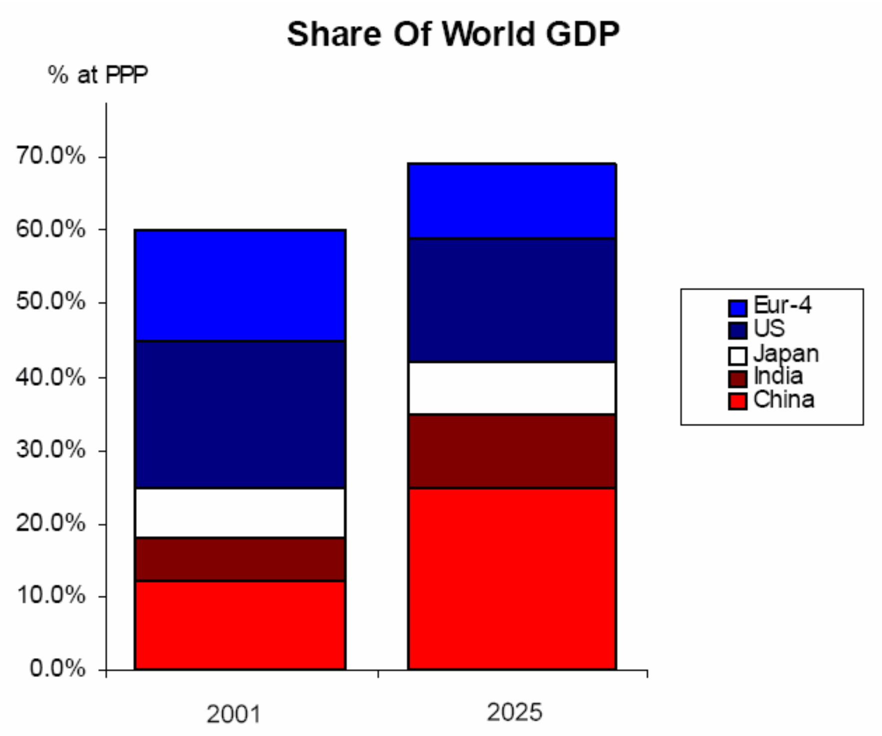


Fig. 7

If mainland Chinese growth follows development pattern of Japan or South Korea then relatively rapid economic growth period (on average) should remain in the medium to long-term. Due to the fact that workers move from rural occupations into industry china will have for many years cheap labour.

Ship Size Development

Ships generally like any other mean of transportation are easily affected by economy of scale, in other words this means that doubling of capacity doesn't lead in doubling of new building price and even less in doubling of operating cost (especially fuel cost and crew expenses).

The limits on ship size have more to do with the ports and with constraints of their infrastructure rather than with the ships themselves. Larger container ships might face numerous and infrastacture problems, requirements for hub capacity and feeding costs.

The growth of size of container ships is affected by the following basic factors:

- ***Transportation volume demand***

If there is demand in the market which is stretched in periods of economic growth, more ships are required or bigger ones, or both. In the long term average demand growth levels of around historical per annum average (or more) will require larger and larger additions of capacity each year. If this increased demand is noticed in major trade flows then Mega Container Ships could be the most efficient way of dealing with trade expansion.

- ***Short – Term and Long – Term Trends***

2005 saw a further 959.000 TEU of containership capacity contacted, following 959.000 TEU in 2004 and with order book stretching further ahead the capacity is expected to increase for 2.500.000 TEU. Despite the difficulties from 1994 to 2000 in the world economy, predictions are generally positive for the future. There are strong indications that world trade – if somewhat slower than in the recent past - will continue to grow. Every percentage point growth of world sea trade calls on the average for about 7 additional dead-weight tons of the world merchant fleet.

- ***Economies of scale***

The new building price ($/TEU) reduces while the capacity increases. In the same way the operating costs are reduced

($/TEU). From this is obvious that the transportation cost is less. However, although possibly declining at larger sizes, economies of scale can be shown to exist in the 10.000 TEU & above containership range. Mega Containerships which control large transportation volumes and pursue large scale operation will no doubt try to derive some benefit from economies of scale.

- *Strategic factors*

Whilst delivery of order container ships can be used for direct service the major carriers are also continuing to develop hub port capacity to allow access to benefit of big ship scale economies. Mega containerships deployed to carry key trade flows between strategically located hubs, could deliver the rewards of this investment. Consolidation amongst carriers makes strategy paramount. Access to key strategic hubs, and large scale capacity to take advantage of them, and with them lower unit costs, could be the key.

- *Sufficiency of know-how and technology*

It ensures the possibility of designing, manufacture and operation of Mega Containerships

Limitations to the development of Mega Containerships today come from the following aspects:

- *Technological & Economical limits*

Inhibitory factor in the rapid development of the containerships is the required infrastructure (berth length, draft limit, automated terminals), not to all but in the large hubs, something that need high investments, although the decrease of the total transport cost is not ensured. This means that this problem is economical and not technical at all. However the uncertainty in depreciation of the investments, and the estimation of the affection in freight rates act inhibitory in the increase of ship size.

- *Regulations of Safety*

The regulations of safety, that are renewed to strictest after big accidents, slow down the increase of sizes of containerships, and at periods they lead also in the absolute reduction of bigger sizes.

- *Management*

Preferable to operate homogenously sized ship strings.

- *Panama Canal*

An expansion of Panama Canal is under consideration. This 8 years project will double the capacity and allow to 12.000 TEU's ships (L = 366 m , B = 49 m , T = 15 m , DWT = 170.000 tons) to pass. This change in dimensions likely to set the limit to ship size for a while.

The impact of Mega Containerships on Shipping market and Ports

Effect on Shipping

Containerships as Link in the Container Transport System

The containership, transcontinental carrier as well as feeder vessel, is only a link in the overall container transportation system. Contrary to most other ship types, the container transportation concept have included both land and sea transport aspects from the beginning. The basic idea by Malcolm McLean from SeaLand in the '50, of loading the cargo-container from trucks directly onto the ship without touching the contents, reflects this concern. It is therefore not surprising that the partners involved with the transport of containers have worked more or less together during the development of the container transportation system and network. As container transportation matures and ships become even larger the transportation system becomes more complex and the co-operation of partners and the alignment of logistics becomes more and more important.

De Monie proposed a scenario in which 15,000 TEU or larger ships are deployed on the main East-West routes. North-South linkages are maintained with feeder ships of anywhere from 250 to 6,000 TEU. This calls for special port facilities. The role of 15,000 TEU ships will be very different to that of the present large containerships. They will exclusively be used for maintaining the East-West/West-East long haul maritime segment, all containers carried will therefore have to be transhipped.

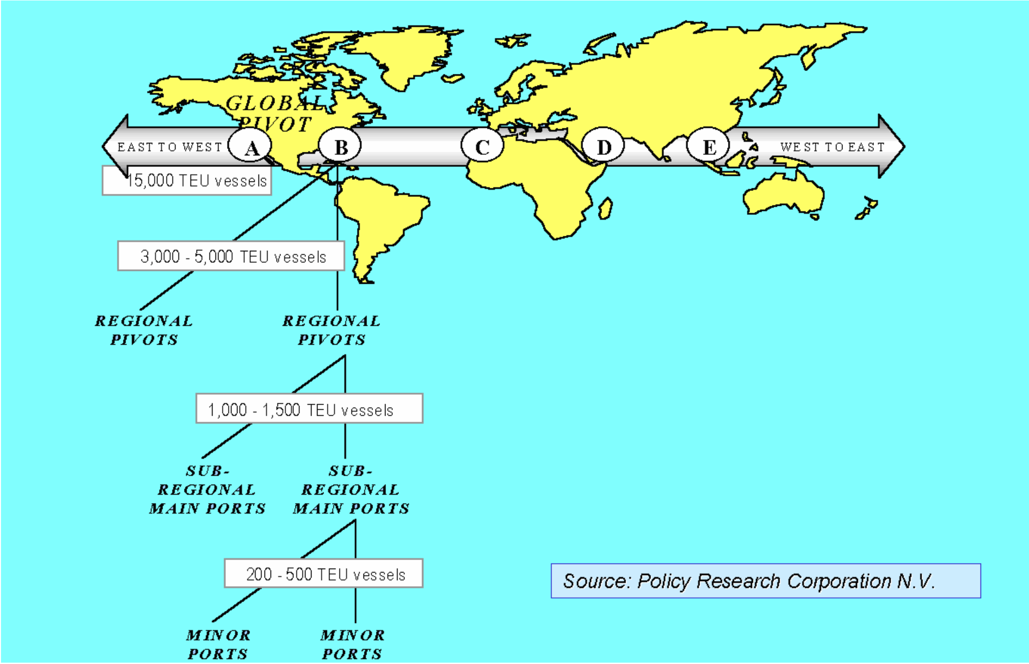


Fig. 8

With an expected length overall of 400m, a breadth of 69m and a draft of more than 14m, few ports would be able to accommodate these vessels at their present facilities. Moreover the selected ports have to be located on the main East-West trajectory, on a site that is sufficiently central to serve a large sub-region and allows feeding costs to be minimized.

The most likely locations for the four "mega hubs" *(A hub port is a container port that provides terminal and marine services to handle and facilitate the transfer or transhipment of containers between feeder and mother vessels in the shortest possible time.)* in the world are Southeast Asia, the Western exit of the Mediterranean, the Caribbean and the West Coast of Central America. Such "mega hub" facilities could well be 'off shore', as they will exclusively cater for transhipment. A tentative layout of an off-shore "mega hub" offers two berths for 15,000 TEU ships and six berths for large feeders and up to eighteen berths for large and small feeders.

Containerization of Cargo

The major portion of semi-products and finished goods today is shipped in containers, which are carried on most major routes by container ships. Predictions are that by the year 2010 the container traffic in European ports will be twice that of the year 2000. This growth will probably be even faster for some regions, where local awakening of the economies will stimulate accelerating trade.

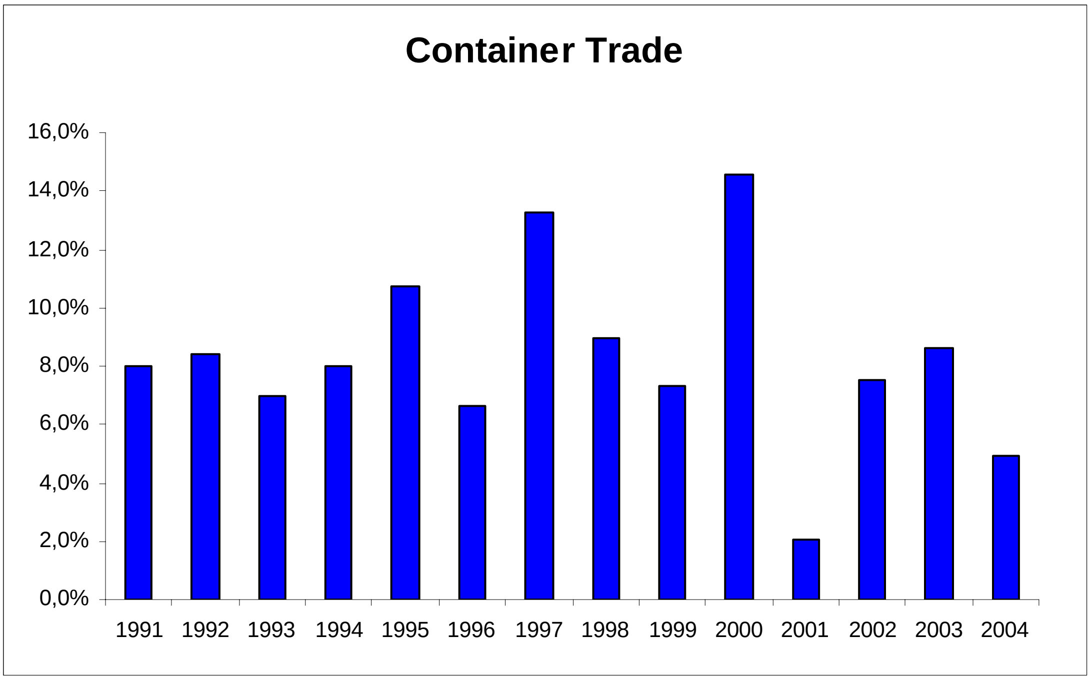


Fig. 9

The positive predictions for the transcontinental trade and transport are also not significantly revised today. Global container activity, in terms of TEU lifts, expanded by an average of 10% per annum in the period 1994-2004.

Also here the container volume is expected to double within the next ten years. Asia, spearheaded by China, has led the growth in global container exports. Today containers reach the most remote corners of the world. [19]

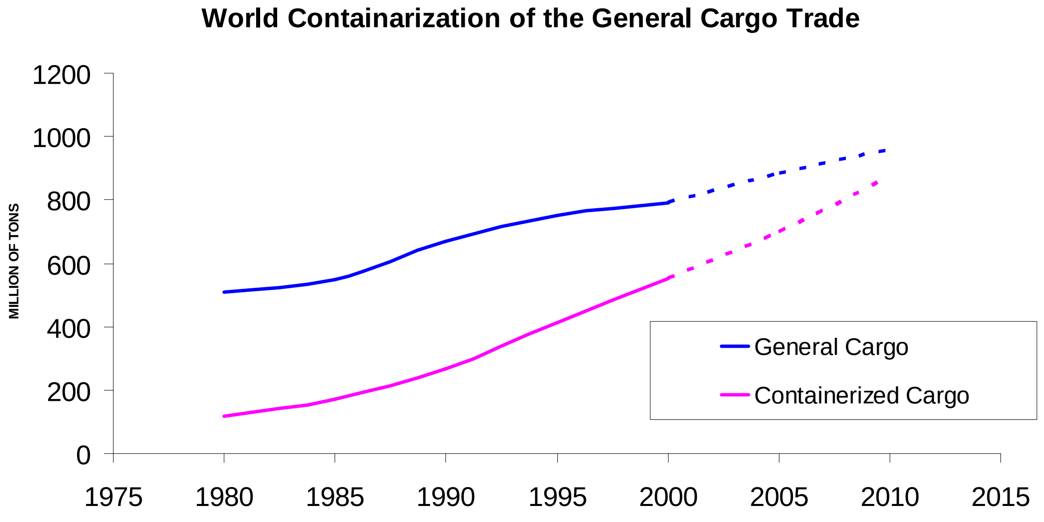


Fig. 10

Experience shows that - contrary for instance to the bulker trade - with falling transport rates more cargo will turn up in container shipping. Thus also the shipping crisis of 1998/99, when container rates on most routes dropped to less than 50% of what they were only two years earlier, but still had the beneficial effect of drawing more cargoes and new kinds of cargo to be shipped in containers.

The developments of container ships are continuing, whether we have a crisis in shipping or not. And these developments will be assisted by the relevant technical know-how and extensive feed-back from ship operations, particularly collected by Classification Societies.

Container transportation - efficient, secure, clean and economical - is so convincing that almost any cargo will stay with the container concept, once shippers have seen the benefits and become used to them. This, together with the growth of world trade, growth in share of global trade of containerized goods and relocation and outsourcing of manufacturing to China has been the basis for a continuous growth of container shipping, with the annual growth rates over 10%.

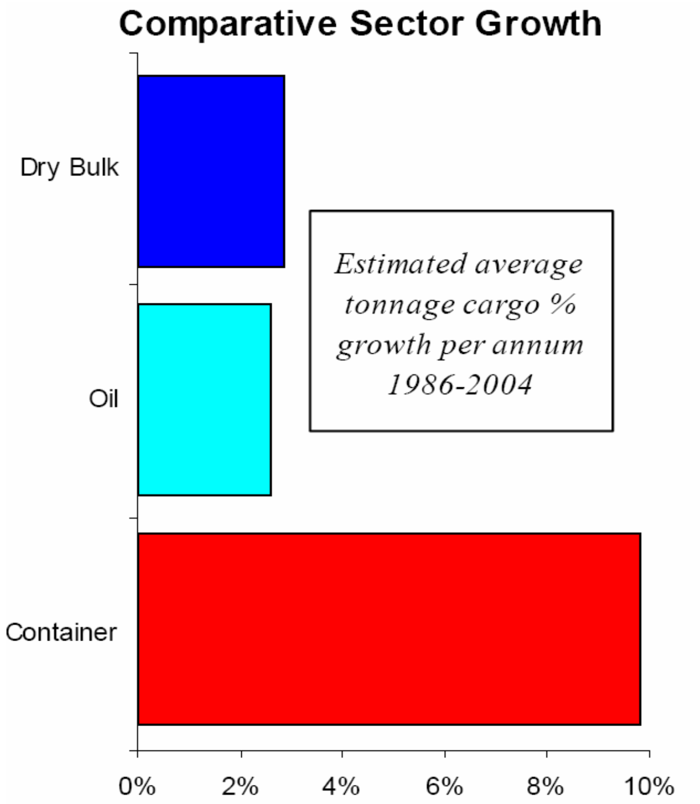


Fig. 11

Average per annum growth in cargo levels in the last decade and half has stood at over three times higher in the container market than in the oil (2,1%) and dry bulk sectors (2,5%).

Asia, spearheaded by China, has led the growth in global container exports.

Estimated Chinese box exports expanded by 3 times compared to the global average between 1999 and 2004. Mainland China in 2004 was responsible for over 70% of the Asian export growth on the Far East-Europe trade, and for growth equivalent to almost all of total Asia-US volume growth on the eastbound Transpacific route. [19]

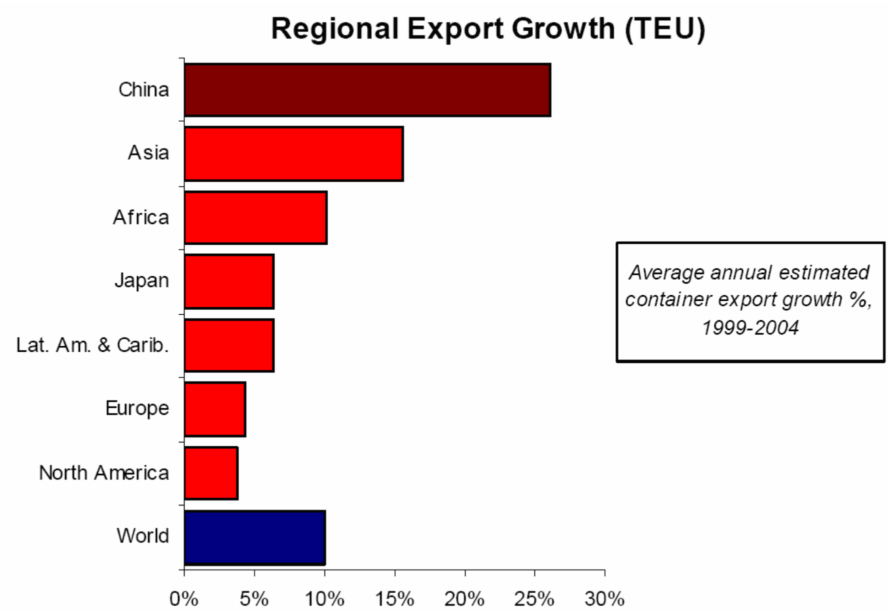


Fig. 12

Impact on ship size & owners investments

With the imitation of Mega Containerships the ship-owners will come forward with investments in order to keep a competitive fleet. Recently, 6.000TEU+ vessels are replacing 4.500TEU vessels in the Asia-Europe and trans-Pacific trades. Assuming a company that offers a fixed day weekly services from Asia to Europe, a fleet should composed of 5 ships and 32 days of one round voyage period. So If existing 4,500 TEU vessels are operated and owned by the company, the ship price is 68,4 million dollars for each vessel, which is total 342 million dollars for the total fleet. If 4,500TEU vessels are replaced by 6,500TEU vessels, the ship price becomes 96,8 million dollars for each vessel, which is total 484 million dollars[1]. Accordingly, approximately 140 million dollars of additional investment is required. In order to maintain competitive in one route, at least three to four routes must be operated. Therefore,

[1] The prices refer to September of 2006 according to Clarkson Database while the distance between Asia – Europe is 8288 sm and speed of 25 kn.

excluding additional costs such as branch management costs and terminal investment, additional costs for the ship-owners in ship investment costs becomes approximately from 200 to 550 million US dollars by increasing the size of the vessel from 4,500TEU to 6,500TEU.

If ships of 4,500TEU are replaced by 10,000 or 12,000TEU or larger ships, the ship-owners investment amount increases even more. Therefore, if the ship-owners desire to invest the same amount of money despite the larger sizes of the vessels, 5 vessels of 6,500TEU must be reduced to 3 vessels of 12,000TEU. Ref [10]

Calling ports reduction

The number of calling ports is determined by the length of the trade route and the number of vessels in a fleet. The insertion of Mega Containerships as we saw above means a ship price increase, wherefore the shipping companies strives to reduce the number of vessels in a fleet if possible but also to keep the same frequency of services. For example in case of trans-Pacific trade, it provided 42 days round voyage period weekly service with six vessels when 2.500TEU vessels are operating. However, as it increased the size of the vessels to 4.000~5.000TEU, it changed to 35 day period with five vessels. Moreover, in case of Asia-Europe trade, one fleet was organized by nine vessels with 63 day round voyage period. However, it changed recently to 56day period service with eight vessels.

When a vessel is reduced from a fleet, the need to shorten voyage days arises. In order to accomplish this, about 2~3 terminals in the calling ports on the service must be removed.

Strategic alliances

The severe freight competition between shipping lines began by the US Shipping Act of 1984, and another Revised Shipping Act of 1998. Revised Shipping Act of 1998 deregulated the market than the previous Shipping Act of 1984 and transformed the industry into free competition market allowing further freight competition. Nowadays as it seems in the next table the 20 biggest liner companies operate 2.050 ships which is the 27% of global fleet with capacity of 5.807.188 TEU which represents the 63% of the capacity of global fleet. From the above facts it is obvious that this companies prefer to operate large ships, and this trend is expected to become even more intense the following years because the bigger the capacity of the ship the less the costs per unit.

With the insertion of Mega Containerships, the ship costs began extremely higher. Thus, there is a need to distribute these risks in investment. Shipping lines formed strategic alliances to become a large scale groups aiming to have economy of scope and distributing investment risks. Therefore, international shipping liners were reorganized into several strategic alliances such as Maersk - Sealand merger, Grand alliance including NYK, and OOCL, New World alliance including Hyundai merchant and APL, United alliance with Hanjin Shipping, and CKY Group. The mega-strategic alliance will strengthen their market dominance such as the number of vessel operating and the market share of ocean transportation. That is, as the strategic alliance groups become larger and fewer in number, it will establish itself as oligopoly in the market. Therefore, stronger market presence of large scale strategic groups could change the calling ports in the main trunk lines and transform them into hub and feeder.

The 20 Biggest Liner Companies

Company	Rank	Total Fleet		Order Book	
		TEU	Ships	TEU	Ships
World Fleet		9.210.724	7.554	4.256.114	1.118
Maersk Sealand	1	857.960	309	431.266	77
Mediterranean Shipping Co SA	2	667.691	254	338.473	45
P&O Nedlloyd Container Line Ltd	3	428.495	147	224.284	38
CMA CGM SA	4	357.164	126	241.134	44
Evergreen Marine Corp (Taiwan) Ltd	5	338.305	120	53.698	9
APL Ltd	6	310.326	100	51.252	9
Cosco Container Lines Ltd	7	296.976	119	191.840	25
Hanjin Shipping Co Ltd	8	273.722	69	89.275	13
China Shipping Container Lines Co Ltd	9	265.271	101	250.904	43
NYK Line	10	246.032	77	106.600	16
Orient Overseas Container Line Ltd	11	235.661	69	106.380	18
Mitsui OSK Lines Ltd	12	214.569	69	125.491	20
Kawasaki Kisen Kaisha Ltd	13	209.032	71	72.642	12
Hapag-Lloyd Container Linie GmbH	14	207.990	55	77.300	9
CP Ships	15	192.354	81	39.877	10
Yang Ming Marine Transport Corp	16	180.313	64	118.430	28
Zim Integrated Shipping Services Ltd	17	161.330	58	17.000	4
Hyundai Merchant Marine Co Ltd	18	142.257	37	125.200	20
Hamburg Sudamerikanische Dampfschifffahrts-Gesellschaft KG	19	116.932	58	64.166	19
Pacific International Lines Pte Ltd	20	104.808	66	62.558	20

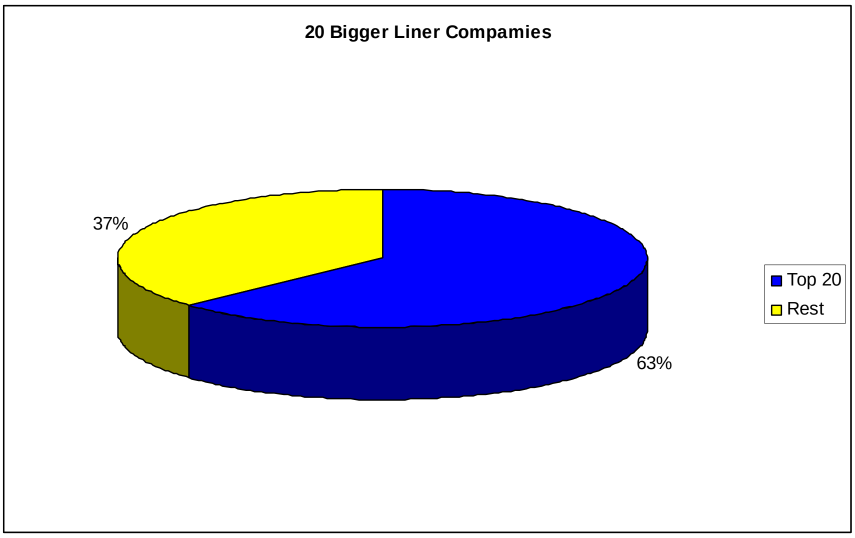


Fig. 13

Effect on Ports

Hub and feeder port

With the insertion of Mega Containerships 15.000~18.000TEU it is predicted that there will be changes in shipping transport structure to minimize the number of vessels in one fleet, and largely reduce the number of calling ports since their port laytime is over twice the existing 5,000~6,000TEU for handling large quantity of shipment.
According to the review of future changes in shipping transport, there is a common prediction that there would be a large reduction in the number of calling ports that cause a hub & spoke transport system.
Several scholars proposed a revised transport network and location of the future Major Hubs.
Dr. Hans Payer of Germany presented an idea of shipping trade that will be completed in 4 mega-hub ports around the world in case of operating 15.000TEU container vessels. Moreover, this mega-hub

ports were presented as off-shore floating ports for transhipment. Dr. De Monie presented a shipping transport structure where 15,000TEU very large container ships will service between the East and West trade, and rather small size vessels(250~ 6,000TEU) will transport transhipment(T/S) cargoes for North and South service at each port of call.

Dr. Ashar from National Port Waterway Research Center in USA proposed Equatorial Round the World Service with the assumption of extending Panama canal. Here, the calling port has the pure transhipment port function and has the structure to achieve north/south connection transport using feeder vessels.

Increase of port investments

Introducing Mega Containerships, we now have greater needs related to performance and capacity. Due to the vessel size increase, it is necessary to have deeper channels. However, the post-Panamax vessels have tended to be designed in such a way that most of the increased capacity is provided by increasing the beam rather than the length or draft of the vessels: the first post-Panamax vessels were actually shorter than the first Panamax vessels, and required less draft.

The emphasis of greater breadth has, however, had important implications for terminal investment. Ports and terminals that want to be called by the Mega Containerships needed post-panamax cranes which are more expensive because are taller and have bigger outreach. As a result, we have an increase in the size of container terminals as the demand for land backing has risen in line with increases in vessel size.

Larger vessels also bring with them a need for better handling performance and container management in order to ensure that the time spent in port does not become excessive. This need is met in part by investment in increasingly sophisticated information technology system.

The bigger cargo quantities that Mega Containerships discharge with fast rate, increase stress on the land transport interface, and generate a need for faster and more efficient intermodal connections.

Port management reform

The competition among ports to retain large alliances began intensified. Selected as a calling port by these strategic alliance groups means large profit for the port. However, it would be a great loss for the ports or terminals that lost these alliances
according to the group's calling port change. This pressure has as result that ports reconsider their administrative model.

A new management model come up for both developing and developed countries which is shown by the decentralization of the port and the fact that ports became more commercial.

Since centralized bureaucracy has been proved unsuccessful to meet the new challenger, what it must be done is to task the decision making to local level. Few national ports authorities have survived, and those that have survived operate within a much narrower remit.

I order the more decentralization model to succeed, more sober monitoring is required with clearer standards. Usually, these are modelled closely on the commercial disciplines faced by private sector firms, and include requirements to achieve a certain rate of return on capital invested.

Private firms policy indicate that more competitive prices needed but using regulated prices results to decrease of reserve funds and make future investments to depend on loan or equity by government or private equity investors. Ref [14]

Global Terminal Operators

Historically, providing port services has tended to be a domestic industry, dominated by firms that are nationals of the country in which the port is located but the expanded range of opportunities for private investment in the port sector has given rise to a new species, the international port entrepreneur.

This has changed radically, with the emergence of a number of major global players, the biggest four are shown on the next table

Global Big Four Terminal Operators

Operator	Throughput2000	share	Throughput2010	share
HutchisonPorts	25,3 m TEU	11,3%	71,6 m TEU	16,5%
PSA Singapore	19,7 m TEU	8,8%	36,8 m TEU	8,5%
MaerskPorts	13,3 m TEU	5,9%	47,9 m TEU	11,0%
P&O Ports	8,3 m TEU	3,7%	29,9 m TEU	6,9%
Top 4	66,6 m TEU	29,7%	186,2 m TEU	42,9%
Rest	156,4 m TEU	70,3%	248,8 m TEU	57,1%
World total	225 m TEU	100,0%	435 m TEU	100,0%

As well as the port specialist, some major shipping lines also control international terminal networks. Some, like Maersk, are clearly focused primarily on controlling stevedoring for their own vessels.

Others, have developed facilities that are clearly intended to serve a range of shipping lines, including both allies and competitors. Terminal of Gioia Tauro is a prime example of this type of development.

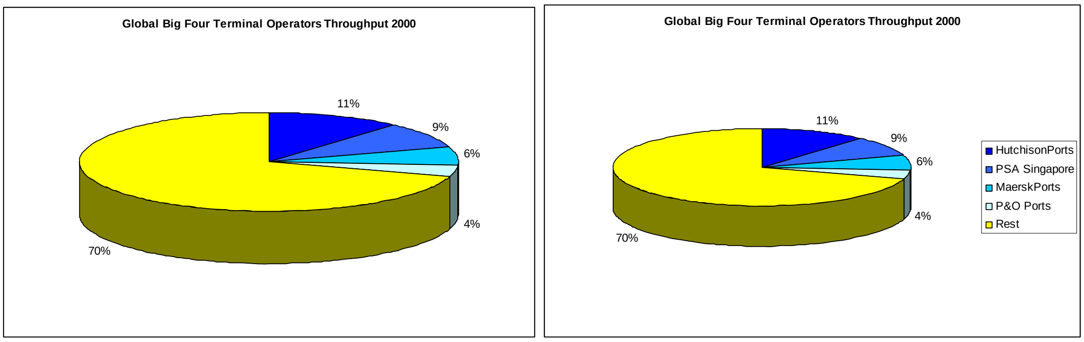


Fig. 14

These investments made by bigger liner companies are done to negotiate from a powerful position with major ports. The most dramatic recent example of course is Maersk's Lines to transfer its business from Singapore to new Tanjung Pelepas port in Malaysia. This decision of a single shipping line is expected to cost Singapore approximately 15 per cent of its total business.

As we see many liners companies already have and plan to get privet ports and look for terminal activities and direct control over landside operators.

Shipping lines can make profit also from terminal operation and this makes them even more competitive. As we see at figure 15. Ref. [14]

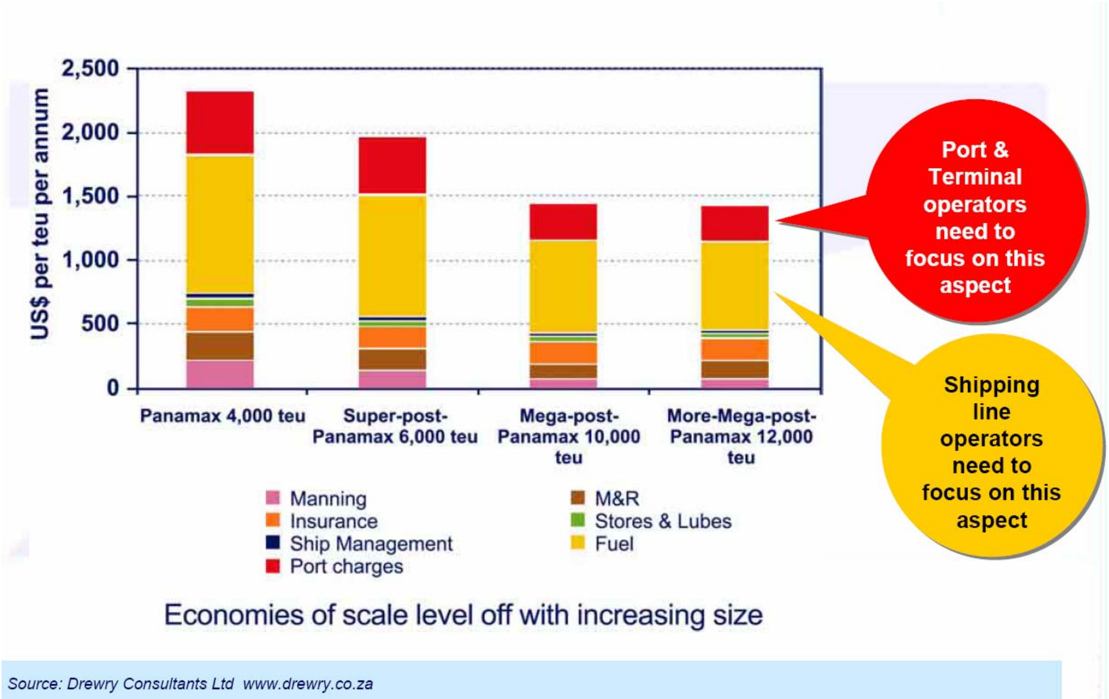


Fig. 15

High technology port handling and operation system

Overseas advanced hub ports are continually implementing development and investment in various fields such as new port design, existing port's reengineering, and new handling system. Among these, the first priority in research and development is the development of new concept port handling system in preparations for the future.

New concept port handling system can be examined in two categories. Container cranes can be either renovated or developed as new concept that are different from existing methods in order to facilitate improved productivity in berth. In addition, advanced integrated handling system have to be developed also to improve productivity in transport between quay and yard, and in yard work for backing up high quay productivity. The most probable proposal with current technology is automated container terminal. It is an unmanned handling system with high technology controlled by intelligent operation system. This system is in operation in ECT of Netherlands and CTA of Germany and is under construction at Gwangyang port in Korea. Besides handling system, since existing berth structure cannot meet the required productivity by the very large container ships, new concept of terminal such as indented berth terminal, speed port, and floating terminal developments are underway.

Port as a Logistic Platform

A hub port where very large container ships would call must not only be a simple hub-port, but also become a logistic platform. Therefore, a port must be developed into a concept that forms a part of the logistic chain in a company. In order to respond to the needs of strategic alliances after the appearance of very large container ships, ports must adopt a strategy to create a more competitive supply chain than other ports

A key element in determining the competitiveness of the supply chain is the process integration of critical asset. This indicates that ports must function as a logistic platform with horizontal and vertical process integration with inland container depots, rail operation, trucking, feeder system, forwarding, warehousing, and value added

activities. The competitive source for ports has been determined mainly by the vessel wait time, cargo handling productivity, and transhipment service for the vessels until now. However, in the future, the port competitiveness will depend on the integrated and efficient transport network for rail transport, feeder transport, and inland transport by truck, and the vertical and horizontal cooperation providing value added service to the port users.

Review of existing and future Port facilities

Worldwide container trade is growing at a very high rate. It is anticipated that the growth in containerized trade will continue as more and more cargo is transferred from break-bulk to containers. By 2010, it is expected that 90 percent of all liner freight will be shipped in containers. Every major port is expected to double and possibly triple its cargo by 2020. That's why port authorities are under an enormous pressure to find and deploy effective container handling systems in order to increase the throughput of the current container terminals.

High-density, automated container terminals are potential candidates for improving the performance of container terminals and meeting the challenges of the future in marine transportation. Recent advances in electronics, sensors, information technologies and automation make the development of fully automated terminals technically feasible. Europe and other countries are ahead of the U.S. in using automation to improve their terminal operations. The Port of Rotterdam is operating a fully automated terminal using Automated Guided Vehicles (AGVs) and automated yard cranes to handle containers, whereas the Port of Singapore, Thamesport of England, and the Port of Hamburg are experimenting with similar ideas. Sea-Land at the Port of Hong Kong implemented a grid rail system referred to as the GRAIL, a high density manually operated terminal. It is envisioned that competition in the global market will begin to put pressure on all sides involved to cooperate in order to improve productivity and reduce cost through the use of advanced technologies and automation.

Current channel/berth draught

The insertion of bigger ships places additional burdens on ports to increase the depth of water in entrance channels and alongside berths far above what is currently offered. This implies that much greater investment is necessary in port infrastructure. Channel width must also be increased to take account of the wider ship beam, plus turning circles have to be enlarged to take account of greater vessel length. Modifications necessary on the shoreside include bigger cranes with longer outreach, lift height, and loading capacity. Current ‘super’ post-Panamax cranes can weigh over 1,300 tones with greater wheel loads necessitating far stronger quay structures.

There is a major problem concerning the draft of the terminals:

- Major ports are repeatedly finding themselves being criticised for draught limitations
- Terminals are required to provide even more post-Panamax container gantry cranes per vessel (four or more), in order to turn them around as rapidly as vessels half their size and
- Container yards need to be capable of accepting volumes of containers twice as large as before but in the same period of time

Most major container ports in the world offer a minimum water depth of 15.0m or above alongside the berth. However, this does not alter the fact that there is still a potential tidal delay facing the largest container vessels entering or leaving most of these ports when fully laden. As ships get even bigger this delay will worsen, with knock-on effects to other ports in the multiport schedule, adding to carrier costs, or it will trigger further major and expensive dredging programs at each port (as announced at Shanghai, for example, and anticipated at Los Angeles, New York and Bussan).

Major terminals and maximum berth depth			
Port	**Draft**	**Draft Plan**	**TEU Throughput**
Hong Kong - Hong Kong	15,5		21.932.000
Singapore - Singapore	15,3		21.300.000
Shanghai - China	12,5	15,5	14.500.000
Rotterdam - Netherlands	16,6		7.000.000
Hamburg - Germany	16,7		4.689.000
Piraeus - Greece	16	-	1.542.000
Barcelona - Spain	16	-	1.400.000
Long Beach - United States	16,8	Deeper	5.400.000
Los Angeles - United States	14,3	16,15	7.300.000
New York & New Jersey - United States	14	15,2	4.480.000

Dredging in some ports involves capital expenditure running to several hundred million dollars. The current four-year program of investment in channel deepening and infrastructure projects planned at US ports amounts to a total of 7 billion $. Mega ships are more easily handled at specially built offshore transhipment terminals than depth-constrained and congested cityports. New offshore mega-hubs being built in a number of locations around the world have the natural benefit of deep water and therefore avoid high capital and maintenance dredging expense. Furthermore, as almost all containers are transhipped at such facilities, the port itself neither contributes to, nor suffers from, landside bottlenecks.

Although many physically constrained cityports continue to seek to provide mega ship scale facilities, the cost of doing so is increasingly likely to fall on port users (i.e. the carriers). As competition increases between ports, it is clear that subsidies given for dredging are not consistent with a fair competition policy, or in ensuring that new investments are demand driven. Ref. [12]

Offshore Terminals

Over recent years a number of offshore container transhipment terminals have been developed in answer to the many physical and environmental constraints associated with ongoing expansion within constrained traditional port locations. The next table lists some seventeen of these new ports.

The main advantages of offshore hubs include:

- Typically a natural water depth of at least 15.5m or so with minimal dredging expense
- Quick and easy access from the open sea compared to many inland river and city-ports
- Preference for island or remote peninsula locations and feedering, thereby avoiding land transport through congested and densely populated urban areas
- Plentiful and relatively inexpensive land for future expansion
- Competitive labour rates and working practices compared to traditional ports
- Majority of cargo consists of transshipment, limiting need for investment in land transport infrastructure
- Terminals often owned/part-owned by carriers who are able to quickly transfer large volumes of containers to the new hub.

- Allows ever increasing demand (for freight transport) to be distributed across more ports in any given region. It also permits growth to be managed more efficiently and effectively
- Reduced pressure on existing constrained land areas at mature traditional mainports;

Major offshore transhipment hub terminals and maximum berth depth		
Port	**Max berth depth (m)**	**Remarks**
Algeciras - Spain	16.0	Maersk-Sealand terminal
Malta Freeport	15.5	
Salalah - Oman	16.0	Maersk-Sealand equity share
Sines - Portugal	17.0	PSA terminal
Taranto - Italy	16.0	Evergreen terminal
Port Said - Egypt	16.0	ECT/Maersk-Sealand
Aden	16.0	PSA terminal
Freeport - Bahamas	16.0	Hutchison Ports
Sepetiba - Brasil	18.5	German operator
Colombo	16.0	P&O Ports
Tanjung Pelepas – Malaysia	16.0	Maersk-Sealand equity share
Kabil - Batam Island	17.0	Still at planning stage

Review of major ports investment programs

In major ports around the world there are big investment projects in progress. To the port of Shanghai after six years of feasibility studies, the islands of Xiao Yangshan and Da Yangshan in the

Hangzhou Bay, 27.5 kilometres from Shanghai's southern coast, was chosen as the site of the deepwater port of Shanghai. The project enjoys a strong backing by the central government of the People's Republic of China.

The island of Xiao Yangshan

The average water depth in the area of the islands is over 15 meters. And the first phase of the Yangshan Deepwater Port construction started in the middle of 2002. It will be completed by the and of 2006. A land area of 1.53 square kilometres, equipped with a storage yard of 720,000 square meters and 15 container cranes will be built in the first phase. This phase will also see the first five container berths from Xiao Yangshan Islands to Huogaitang with a 1600-meter quay waterfront. The designed water depth of the channels will be about 15.5 meters, capable of accommodating the fifth and sixth generation of container ships. Each berth was designed to handle 440,000 TEU per year. The total annual handling capacity will therefore reach 2.2 million TEU, which should meet the fast growing demand of Shanghai Port in the mid-term future.

According to the master plan, the whole project will be completed by 2020. At that time, the manmade area will increase to 18 square kilometres and the deepwater coastal line will reach 22 kilometres. More than 50 container berths, capable of handling the fifth and the sixth generation of container ships (5,000-6,000 TEU) will be built.

The annual handling capacity of the deepwater port will increase to around 25 million TEU, making it one of the bigger and busier container terminal in the world.

The budget for the first phase was approved to be 1,73 billion $, but no final budgetary target has been announced for the whole project. In June 2002, the Shanghai Tongsheng Investment (Group) Co Ltd. was offered 907 million $ in loans for the first-phase construction by a consortium of five domestic banks. A larger consortium made up of those five banks and five other financial institutions also signed a deal in June 2002, providing a 2.06 billion $ credit line for the port construction up to the year 2020.
Also a long bridge, standing in the northern part of Hangzhou Bay and linking the deepwater port with the mainland, was named "Donghai Bridge". The bridge construction has already begun with the underwater foundations and should be finished by the end of 2006, during the first phase of the portproject.

The Donghai bridge

In US a four-year program of investment in channel deepening and infrastructure planned at US ports amounts to a total of 7 billion $.

The Los Angeles port

Especially in Los Angeles the US government has prompted a collaborative effort of the Port of Los Angeles and the U.S. Army Corps of Engineers to implement the Channel Deepening Project. With this project, the Port will deepen its federal channels by 2,4 m to accommodate the industry's shift to larger container vessels. In addition to greater navigability, deepening the Main Channel from 13,7 to 16,1 m improves safety and shipping efficiencies and provides beneficial use of dredged material to create new land for future terminal development. Dredging for the project began early 2003 with end of construction scheduled for 2006. Apart from dredging improvements there are also improvements to infrastructure and superstructure

At Yang Ming Container Terminal proposed three-phase program to upgrade a container terminal with 10 Km of new wharves to accommodate deep draft vessels and 12 container cranes. Additional work includes redevelopment of 28 acres of backland, terminal buildings and rail improvements.

At TraPac Terminal proposed project to redevelop approximately 0,45 Km^2 and develop and additional 0,22 Km^2 of terminal land. Improvements include construction of 800 m of new wharf, five new cranes, 30 m gauge crane rail, new buildings and entry gates and new on-dock rail facility.

In Europe for port of Rotterdam the Dutch government announce that will fund the massive land reclamation project called Maasvlakte 2. The project in the North Sea is estimated at about 2,57 billion $ and will enlarge the port area by 20%. It is reported that the Dutch government is willing to fund he 726 million $ needed for the reclamation in exchange for a one-third share in the port, with the city holding on to the other two-thirds.

The Rotterdam port

At the busiest terminal, meanwhile, the rapidly growing trade from Asia has led to an 270 million $ investment in terminal expansion. Between 2004 and the end of 2006 the number of quay cranes will be increased from 22 to 36, enabling capacity to expand from 2,2 to 4 million moves. Also new equipment include 45 more automated stacking cranes and some 80 extra automated guided vehicles. The

ECT Delta Terminal took delivery of 9 new Automated Guided Vehicles (AGV) since end-February, with another 26 due to arrive in December. The vehicles complement the recent installation of three new quay cranes on the south side of the Delta Terminal to transport containers to the stack.

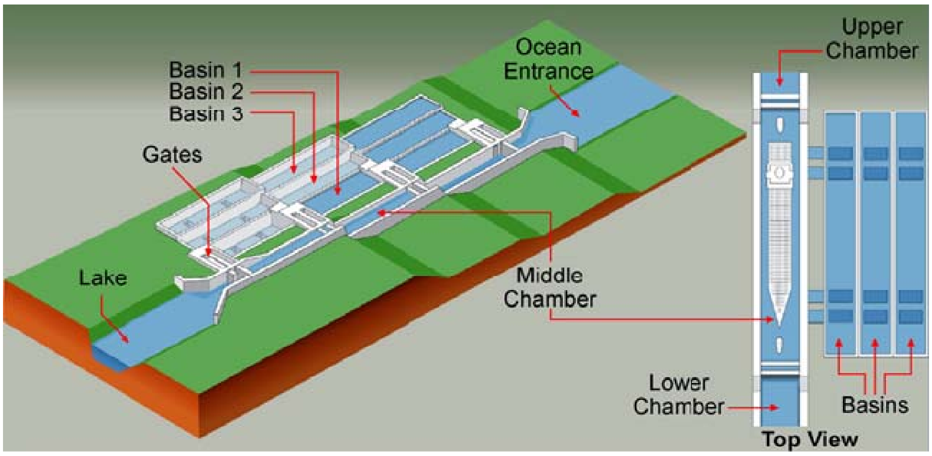
The Port of Hamburg has more than 320 berths and 41 km of quay walls for ocean-going ships, around 200 partly computer-controlled container bridges and cranes as well as grab-cargo cranes and siphons for all types of liquid commodities. Some 100 km from the open sea, the port on the river Elbe is accessible to large vessels up to 8,500 TEU. Some 320 million $ has been earmarked for the dredging of the river to start in 2007.
According to analysts, the handling volume in the port of Hamburg will double by 2015 to an overall handling volume of around 222 million tones. Accordingly, in the same period, container handling figures will increase from 7mn TEU today to 18mn TEU in 2015.

The Hamburg port

In 2005, the Special Port Investment Program (SIP) by the government secured the implementation of some of the measures in the Port Development Plan. Up to 2009, the government will invest an additional 262,4 million $ in the development of the port infrastructure. With the 484 million $ already allocated from previous budgets and medium-term financial planning, a total of 746 million $ will be invested in the port between 2005 and 2009.

Panama Canal expansion

The expansion will be the largest project at the Canal since its original construction. A Panama Canal expansion will double capacity and allow more traffic. The project will create a new lane of traffic along the Canal through the construction of a new set of locks. The Canal's entrances at the Atlantic and Pacific channels will be widened and deepened, as well as the navigational channel at Gatun Lake. One lock complex will be located on the Pacific side to the southwest of the existing Miraflores Locks. The other complex will be located to the east of the existing Gatun Locks.

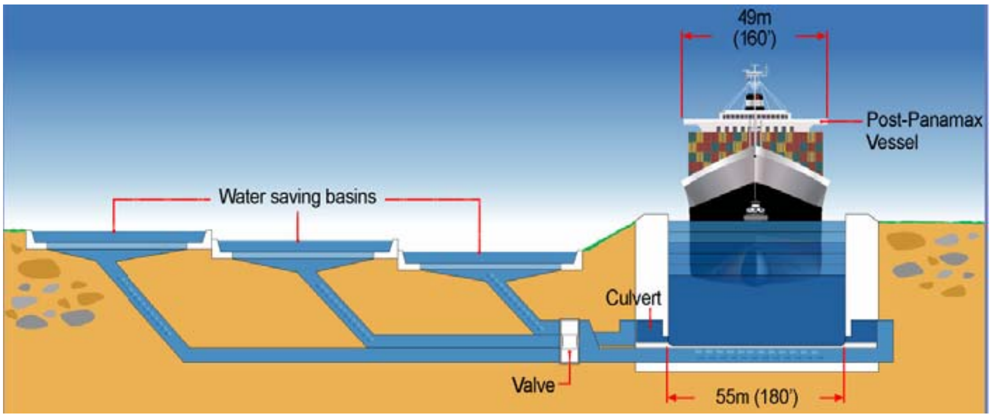


Conceptual Isometric View of the New Locks Complex

Construction for the project is slated to conclude by 2014. All creative means will be employed by the Panama Canal Authority (ACP) to stretch capacity until the construction is done (the Canal's capacity is currently at 93 percent). The Panama Canal Authority has determined that expansion will not interrupt current operations. During the construction process, no current lanes will be closed, and since all construction sites are outside of existing channels and operating areas, the Panama Canal Authority is confident that there will be no delays of transits.

Current Lock Dimensions	Future Lock Dimensions
4.000 TEU's	12.000 TEU's
L = 294,13 m	L = 366 m
B = 32,31 m	B = 49 m
T = 12,04 m	T = 15 m

The expansion program is in response to the booming demand anticipated for the next 20 years. It is anticipated that expansion will double Canal capacity to more than 600 million Panama Canal tons. Shipping industry analyses conducted by the Panama Canal Authority and top industry experts indicate that it would be beneficial to both the Canal and its users to expand the Canal due to the demand that will be served by allowing the transit of more tonnage. The project is estimated to cost $5.25 billion and will be paid entirely by users of the Canal through a graduated system of tolls.



Cross Section of the New Locks Complex

The Panama Canal's Authority Board of Directors has now presented its recommendation to expand the Canal to the President and the Cabinet Council of Panama. If approved by the Cabinet Council, the matter is referred to the National Assembly for approval. The National Assembly will then create a law mandating a referendum, in which the people of Panama will vote on expansion. Ref. [25]

Container transhipment hub requirements

Approximately one quarter of all containerized cargo in ports relates to transhipment, and the general trend is towards a greater proportion of transhipped containers. Reflecting the pressure for more container transhipment, there are at least 16 new container transhipment hub terminals either recently completed or currently under construction.

Fig. 16

Aside from natural deep water, and adequate shelter for vessels, the key requirement of any transhipment hub is its strategic position. A hub has to be in a geographically suitable location, preferably resulting in reduced steaming time for carriers. The key attributes of container hub terminals include

- Being centrally located to main shipping routes and feeder ports (both in time and distance). Feeder shipping, transport distance is critical for the increase in costs per container unit because of small amount of shipment.
- Being accessible to larger ships — that is, having sufficient water depth and harbour space.
- Offering appropriate infrastructure and superstructure, including good intermodal linkages and appropriate container lift equipment.
- Having a reputation for continued high productivity (in terms of the number of container moves per hour).
- Having competitive rates and tariffs.
- It must provide excellent service guaranteeing safety, on-time service, and accuracy. To do that a hub port facilitates adequate port facility, equipment, and stevedoring system.
- Any costs involved in transhipment must be minimized. In case of hub port calling rather direct calling, there is a possibility that most of transhipment cost will be paid by the shipping lines

In addition, shipping lines try to achieve other demands on major container terminals, such as

- Ensuring that guaranteed berth windows are available.

- Providing spare capacity (equipment and labour) to meet peak demands (such as the seasonal variation in traffic from China and Asia to meet the Christmas season).
- Providing good security.
- Offering competitive prices.

The site itself must be sufficiently central to serve a large sub-region, and allow feeding costs to be minimized. Additional attributes attractive to users include 24 hours service, advanced information technology (IT) capabilities, a broad range of support activities, and overall service customized to fully comply with customer requirements.

In addition, there must be significant cost savings for lines in their choice of a nominated hub. As offshore locations are also much cheaper to develop and to maintain than existing ports, lower running costs further benefit global carriers.

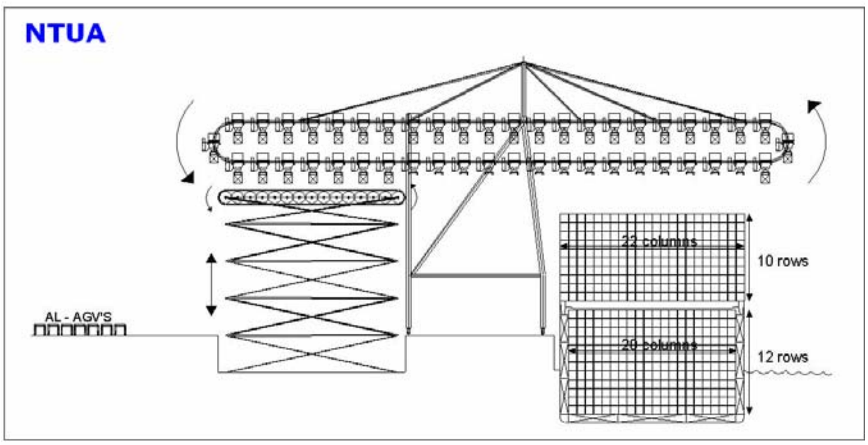
Container terminal productivity

Most ports average a discharge rate of approximately 23 moves. Carriers are always looking for productivity improvements to provide faster port turnaround. The need for improving the level of productivity becomes more intensive due to the arrival of Mega Containerships.

An obvious way to increase productivity is to deploy more cranes per ship. However, at present there is a limit of 6 quay cranes per ship, and in some ports even less than this.

The Ceres 9-crane paragon terminal

It is worthy to mention that in Hong Kong, which has today the larger productivity (40mph with 6 quay cranes), will be needed 58 hours to unload 14.000 TEU and to Ceres new 9-crane paragon terminal in Amsterdam with productivity of 35 mph will be needed 44 hours.



Crane proposed by N.T.U.A. team

With the idea developed for Vision competition with 5 cranes we can have performance of 16 “classic” cranes and unloading of the ship (movement of 14.000 TEU) in 18 hours. This solution will give a mega ship productivity level between 750 and 780 container moves per hour. A super post-Panamax container crane with 57 meters outreach cost about 6 millions $ and has productivity of 25-30 gross moves per hour.

Now there are various potential solutions to this problem, and practical examples have been considered in the study.

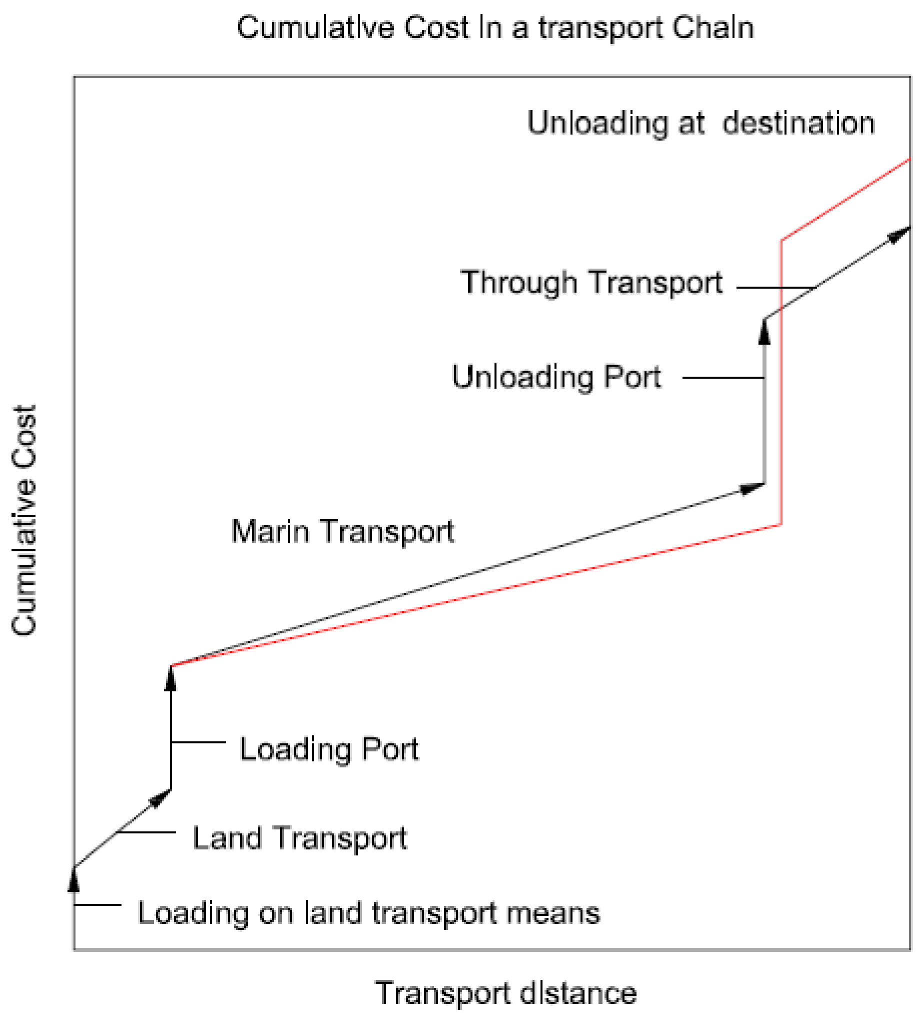


Fig. 17

However, with the increasing size of container ships, it is anticipated that, in the near future, hub terminals will have to achieve higher productivity levels, including

- Container-stacking densities of 2000–4000 TEU per 10.000m^2
- 24 hours dwell time.
- 30-minute truck turnaround times.
- On-dock rail service.

The Impact of Port Productivity of Unit Cost

A recent study of economies of scale in large containerships gives an indication of the unit cost benefits that can be obtained by use of increasingly larger containerships — and the benefits that can be achieved by increased cargo handling productivity that reduces port time. The study prepared by K. Cullinane and M. Khanna and published in the Journal of Transport Economics and Policy models the impact of using containerships with nominal capacity to 8000 TEU, assuming current cargo handling rates and rates that would be 100 percent higher.

Declining Unit Cost With Larger Ships

To the right is a chart taken from the study that shows the relationship between voyage cost per TEU, ship capacity and route distance on three major linehaul routes. Unit cost declines at a decreasing rate as ship capacity increases. In deriving these unit costs, the authors assume that port time for various size ships reflects current cargo handling productivity, which in turn is a function of the number of cranes assigned to a ship and the handling rate per crane. Based on a questionnaire by the authors, current practice is to typically employ one to two cranes on ships under 1000 TEU capacity, three to four cranes on ships 3000 to 4000 TEU capacity and five cranes on ships of 6000 TEU capacity. Crane productivity under current practices is assumed to average about 22 moves per hour. On this basis, five cranes working a 6000 TEU containership can load and discharge 2000 20 ft. boxes and 2000 40 ft. boxes at a rate of 110 moves per hour, and the ship can be fully discharged and loaded in 72 hours.

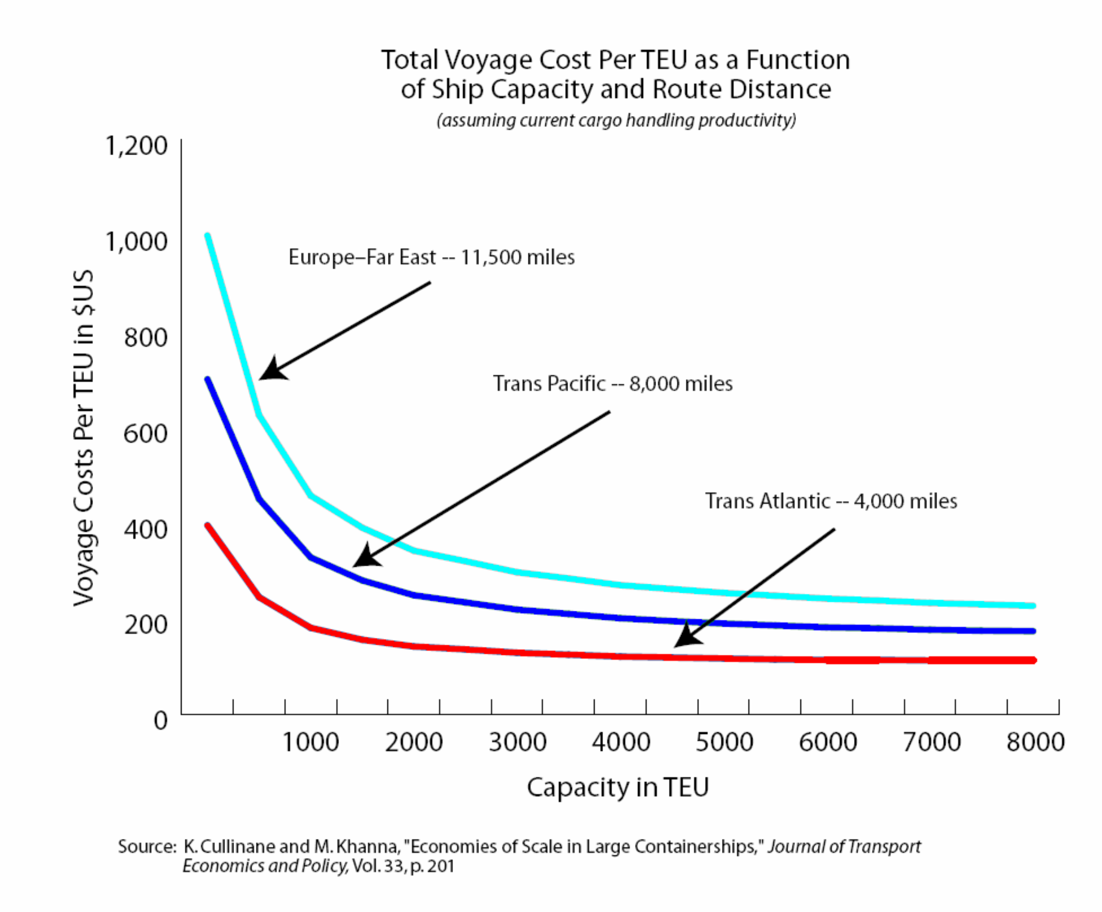
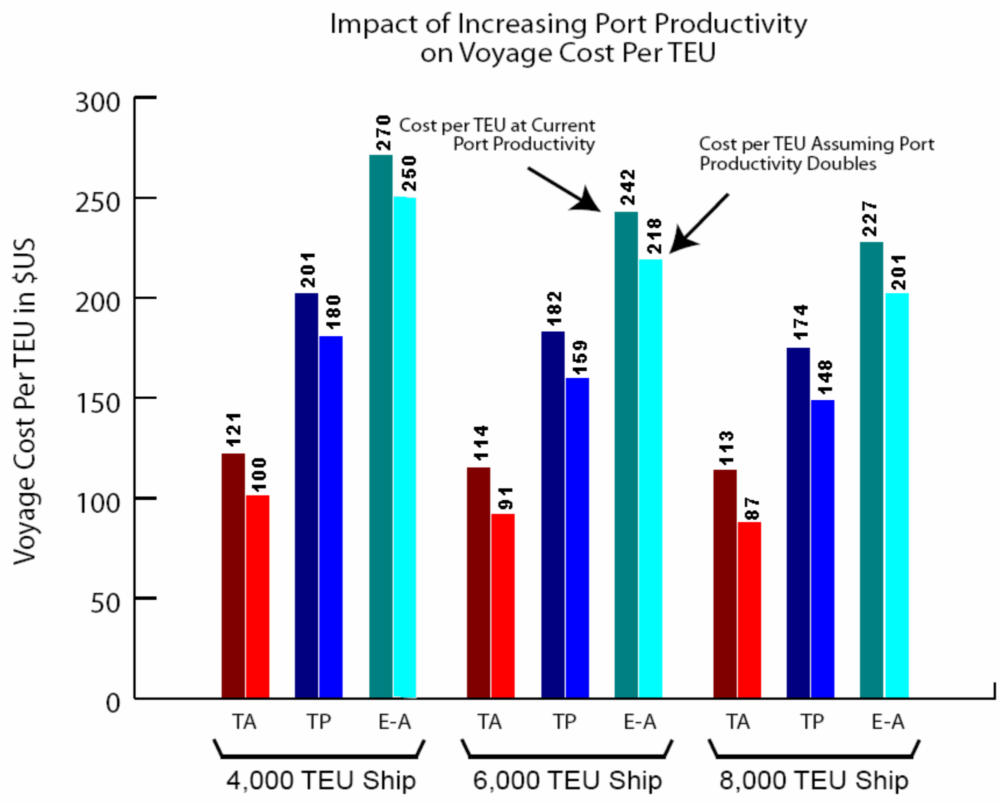


Fig. 18

Increasing Port Productivity

The authors then examine the sensitivity of reducing port time through increased cargo handling rates. They show that a cargo handling rate double that of the current rate will significantly reduce the unit cost, as the ship will be able to carry more containers in a given time period. For example, doubling the cargo handling rate will reduce the unit cost of a 6000 TEU ship from $114 to $91 per TEU on a trans-Atlantic voyage. The unit cost of a similar ship on a trans-Pacific voyage would drop from $182 to $159 per TEU and on a Europe-Far East voyage from $242 to $218.



Source: K. Cullinane and M. Khanna, "Economies of Scale in Large Containerships," *Journal of Transport Economics and Policy*, Vol. 33, p. 202

Fig. 19

Economic Feasibility Study of ULCS & Mega Hub

Serving tomorrow's Mega Containerships

Investments required from the ports so as to be able to serve Mega Containerships concern three points:

- Investments required so as the terminal to handle the increase demand.
- Required deepening of channels and breadths.
- Required increase of the productivity of the ports.

From the three above points the first is connected mainly with the profound increase of the handling of containers as a result will happen either going in the market of Mega Containerships or not.

The deepening of the ports is not made only having as a criterion the efficiency of the investment but Governments handle the cost of deepening, so as to keep the traditional ports, which are in the cities, their lead role and not to create social and political problems.

To estimate the cost that ports will have to cope with in order to face the increased demand and insertion of Mega Containerships we used the study, by Steering Group, which occurred for the creation of a modern terminal in the port of Scapa Flow of Scotland. Ref [12]

Terminal facilities and cost

TEU Per Annum	1.120.560	2.241.120	3.921.680
Cranes	8	16	28
Straddles	24	48	84
Quay length	850 m	1.701 m	2.976 m
Terminal area	297.649m^2	595.298 m^2	1.041.696 m^2
Cost infrastructure	$ 130,7 m	$ 261,5 m	$ 457,6 m
Cost superstructure	$ 65,4 m	$ 130,7 m	$ 228,8 m
Total Cost	$ 196,1 m	$ 392,2 m	$ 686,4 m

The above cost is separated as 2/3 to infrastructure and 1/3 for superstructure.

The terminal which has productivity of 320 mph needs investments of about 88 million $ in order to achieve productivity of 750 mph, which is required to have efficient unloading of a ship with capacity of 17.000 TEU. The above refers to a terminal which handles 1.120.560 TEU per year. We weigh up the investments required so the port is able to handle Mega Containerships and also the increase on demand.

Terminal facilities and cost

TEU Per Annum	1.120.560	2.241.120	3.921.680
Cranes	19	38	66
Straddles	56	113	197
Quay length	850 m	1.701 m	2.976 m
Terminal area	297.649m^2	595.298 m^2	1.041.696 m^2
Cost infrastructure	$ 130,7 m	$ 261,5 m	$ 457,6 m
Cost superstructure	$ 153,2 m	$ 306,4 m	$ 536,3 m
Total Cost	$ 283,94 m	$ 567,87 m	$ 993,85 m

TEU Per Annum	1.120.560	2.241.120	3.921.680
Extra investment	$ 87.836.458	$175.672.916	$ 307.450.000
Extra cost by TEU Per Annum	$ 78,39	$ 78,39	$ 78,40

Economic Feasibility Study of ULCS

To valuate how profitable is buying and operating a Mega Containership we need to estimate the following:

- *Fixed Annual Operating Cost(s)*

Concerning the Crew Costs, Lubes & Stores, Insurance, Maintenance & Repair and the Administration costs. The total annual operating cost estimated 4.475.800 $/year with an annual increase rate of 3%.

- *Building Cost*

Building cost is broken into labor and materials cost for each of hull steel, outfit, hull engineering and propulsion machinery, miscellaneous costs, accommodation costs, overhead costs, yard's profit and owner's expenses. The new building price estimated around $ 163.500.000. [2]

- *Timecharter Rates*

The freight rate estimated from Clarckson's database for 6-12 months Timechartering and is 23.026.000 $/year granting that the market will stay at today's level.

- *Demolition Price*

The demolition price estimated from Clarckso's database and is $ 16.150.000. This price has parametric relation with lightship.

Moreover we need to make some assumptions about the flag registry etc. That's how we estimated the NPV and the Payback Period (PBP) of the investment and ULCS's Break Even.

1. The ship price is $ 163.500.000 with 70% loan for 12 years at 5% interest.
2. Equal repayments of loan over 12 years.
3. Year -2 is contract signing, end year 0 delivery.
4. Building installments: 15% down, 15% after one year and 70% with delivery
5. Owner pays his 30% first and remaining 70% advanced to pay instalments.
6. The ship operating with a 20 years timecharter.
7. Dry Dock Survey will be at the fifth year with $ 600.000 cost, tenth year with $ 800.000 cost and on fifteenth year with $ 1.000.000 cost.

[2] Special Thanks to :
K. Dermatis, Intermodal Shipbrokers
A. Gavrilidis, Ancora Investment Trust
T. Baltratzis, Technomar Shipping LTD
G. Doulgarakis, Gains INC

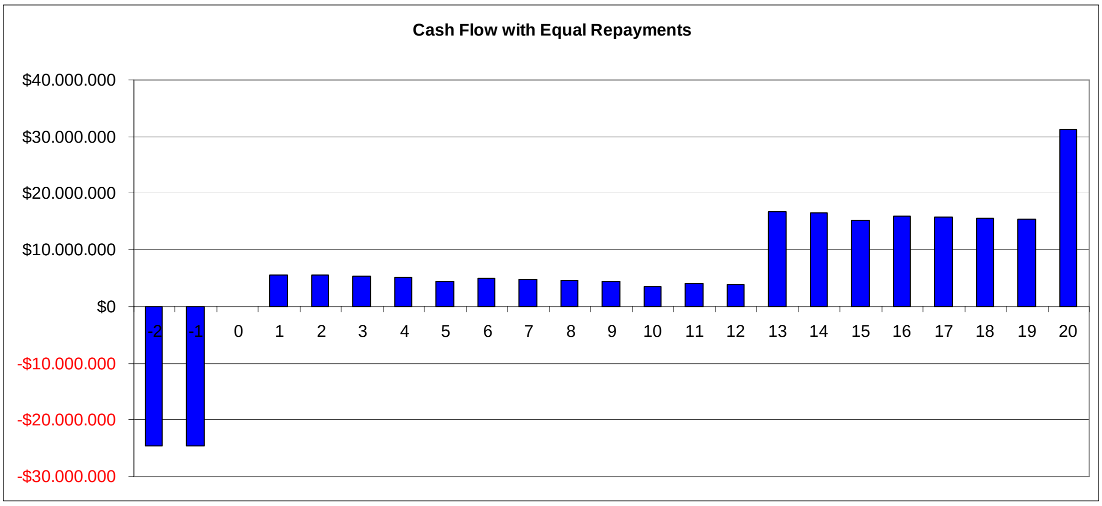


Fig. 20

Finally we found out that the NPV of the investment is $ 67.314.851 and the Pay Back Period is 10 years. The Break Even of the ship is 16.896.890 $/year, 26% under present freight rate.
With balloon payment the NPV is $ 61.670.343.

Supposing a trip between some major terminals, this can be a route via from Hong-Kong to Singapore then to Piraeus, then Rotterdam, then Los Angeles and finally Hong-Kong again. The total distance is 29804 sm.

	Panamax	PostPanamax	Sub PostPanamax	ULMCS
	4000 TEU	**4800 TEU**	**6000 TEU**	**17000 TEU**
Building cost (BC)	$ 63.773.580	$ 73.101.150	$ 84.517.175	$ 163.522.324
Recovery factor (CR)	0,067	0,067	0,067	0,067
Annual building cost (ABC)	$ 4.286.586	$ 4.913.546	$ 5.680.882	$ 10.991.269
Annual operating cost (AOC)	$ 2.850.666	$ 2.916.655	$ 3.741.530	$ 4.475.845
Time in ports	60	60	80	90
Service Speed (Vs)	23	24	25	25
Distance of round trips (D)	24024	29804	29804	29804
Number of round trips per year (NT)	8	7	7	7
TEU Capacity (Wc)	4000	4800	6000	17000
BHP in Kw	33264	43800	54750	105000
Fuel Cost per year (FC)	$ 15.151.637	$ 20.124.499	$ 24.712.687	$ 47.024.551
Required freight rate (RFR)	0,0297	0,0294	0,0281	0,0183

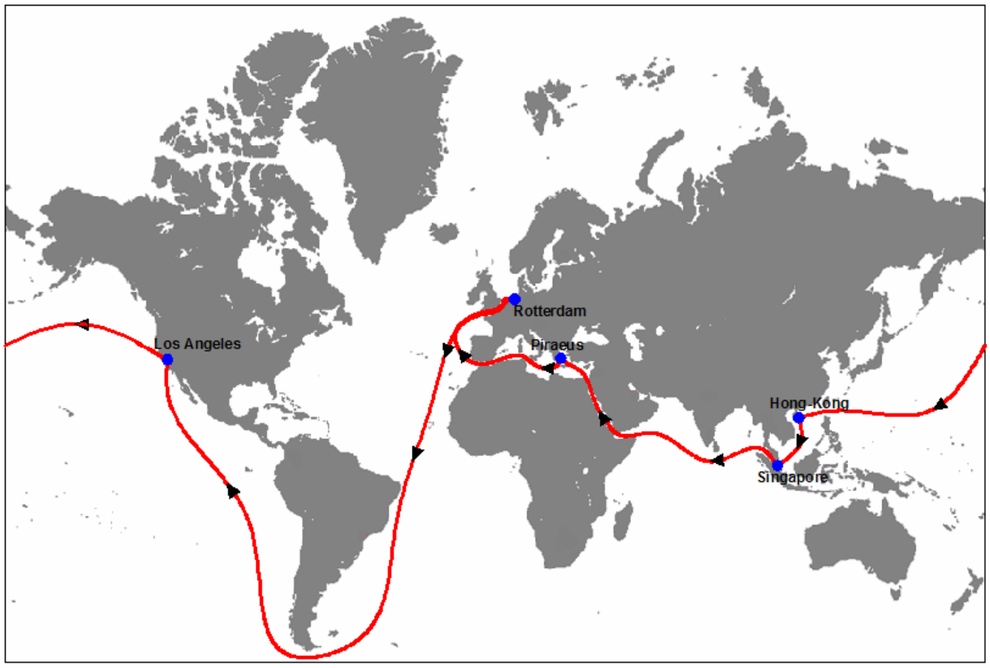


Fig. 21

The required freights rates for 4000, 4800, 6000, and 17000 TEUs containerships is then expressed as the total average annual cost per TEU of cargo carried per mile. $RFR = \frac{ABC + AOC + FC}{NT \times W_C \times D}$

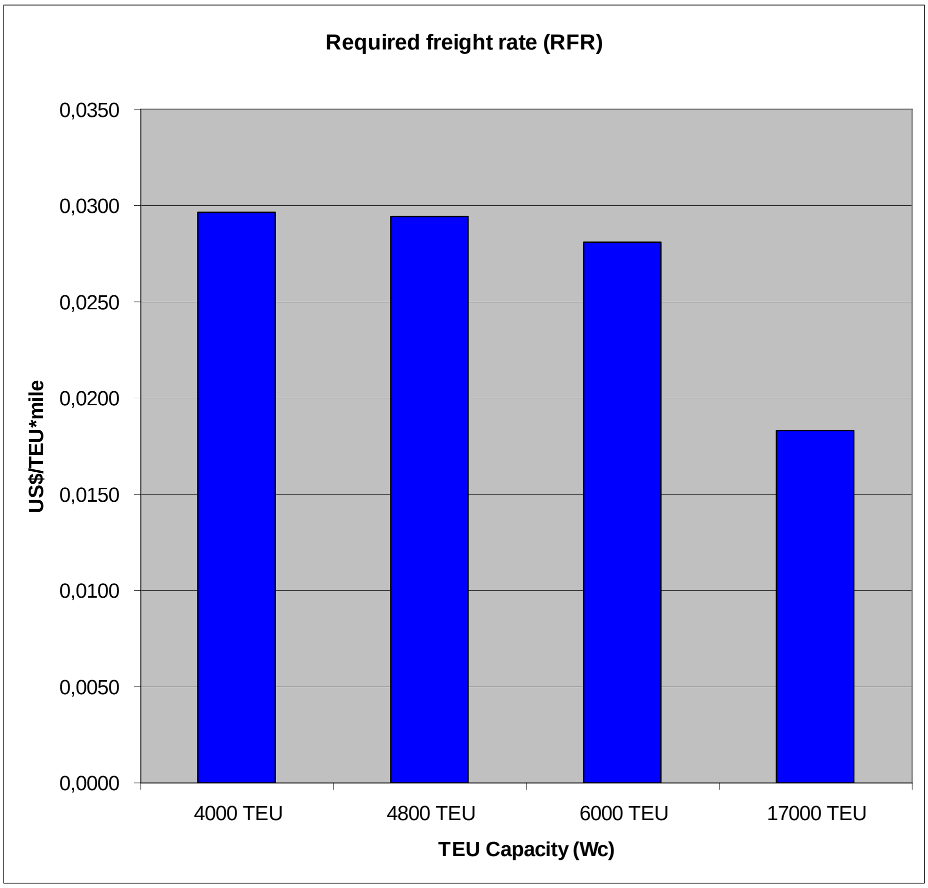


Fig. 32

We also calculated the transportation cost of a TEU from Rotterdam to Singapore and we compare the cost with smaller ships.

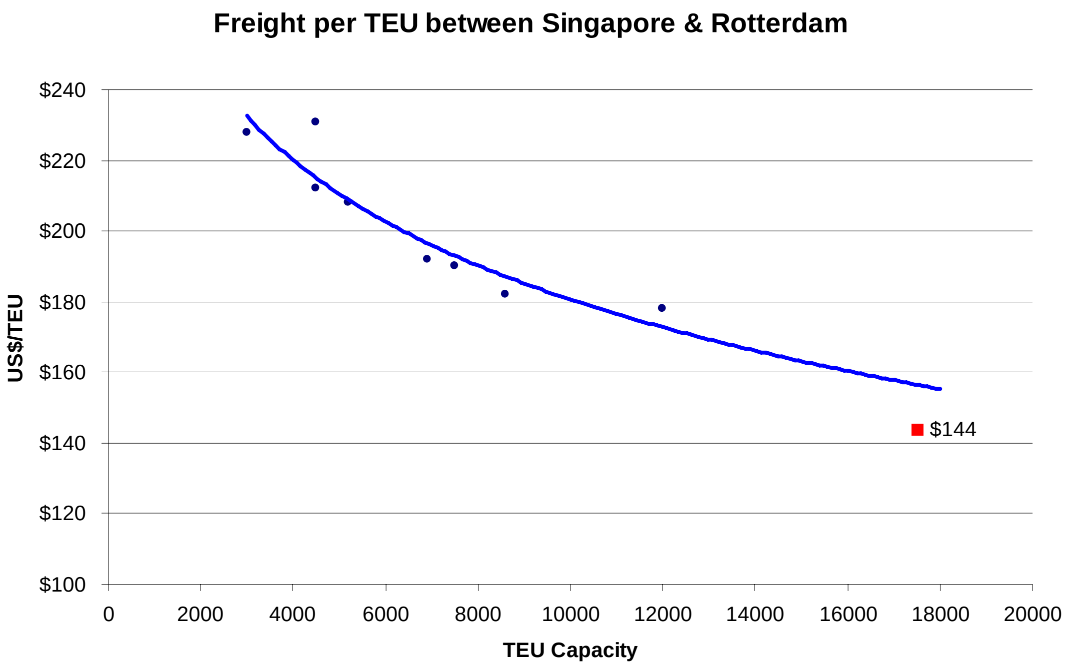


Fig. 22

Conclusions

The containership market is an increasingly important and attractive transport market segment, which may be expected to become of even greater importance in the future. The future will bring larger containerships thanks to the benefits offered by their economies of scale. This project is about making "ocean giants" reality capable of transporting huge relatively amounts of containers in a short period of time. For the time issue an innovative unloading crane is presented by N.T.U.A. team for Vision contest.

N.T.U.A. team managed in a few words to achieve:

- A container ship design capable of carrying 17500 TEU.
- Structural arrangement having the strength required and according to classification societies.
- Propulsion to ensure a 25 knots service speed and good maneuverability.
- Innovative concept to unload in 18 hours such a great amount of container.
- Economic feasibility studies in order to built and operate this "giant".
- Relatively reduced freight rate between major trade routes.

In the market study we see:

- Containership market increase continuously
- Globalization and improvement of quality of living (increase of GPD) lead to better ways of transportation which provided by containerships.

In the feasibility study of Mega hubs we see:

- The major ports try to keep their position in the continuously competitive market investing huge amounts for the development of their substructure.
- Due to the rapid increase of the handling containers, great attention is paid to the increase of port productivity, so as terminals to be able to serve Mega Containerships. We estimated the investment required for the overdoubling of the productivity and we found out that will increase the transportation cost by TEU at about 75$/TEU.
- Almost all major ports have in their Master Plan as target to serve Mega Containerships with a time horizon 5-10 years.

In the feasibility study of Mega Container we see:

- We estimated the building cost and the operating expenses that such a ship will have and found out that it is an advantageous investment.
- All indications drive us to the conclusion that we will go to a revised transport network from direct calls to hub and spoke system with feeders and mother vessels. To the revised transport network earnings cash in on from the economies of scale offered from Mega Containerships.

Taking into account future port infrastructure development plus market trends we are very close to characterize this ship design as the carrier of the future.

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APPENDIX

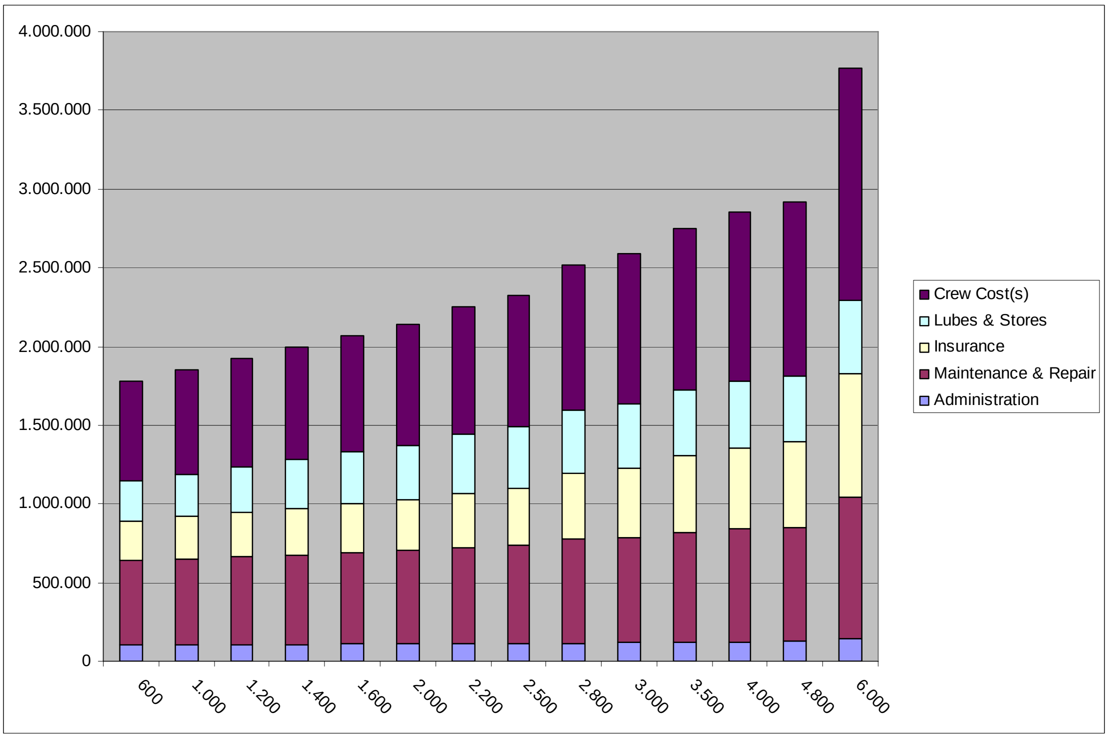
Fixed Annual Operating Cost

Estimated Container ship Cost (US$ Price Levels)

Twenty-Foot Equivalent Units (TEUs)	**600**	**1.000**	**1.200**	**1.400**	**1.600**	**2.000**	**2.200**
Deadweight Tonnage (DWT; metric tonnes)	**9.000**	**14.000**	**17.000**	**20.000**	**23.000**	**28.000**	**31.000**
Fixed Annual Operating Cost(s)							
Crew Cost(s)	631.745	658.859	685.972	713.086	740.199	767.313	807.983
Lubes & Stores	251.566	270.393	289.220	308.047	326.873	345.700	373.941
Maintenance & Repair	532.123	544.439	556.756	569.073	581.390	593.706	612.182
Insurance	254.363	268.449	282.534	296.619	310.704	324.790	345.917
Administration	106.081	106.654	107.227	107.801	108.374	108.948	109.808
Total Fixed Annual Operating Cost(s)	**1.775.878**	**1.848.794**	**1.921.709**	**1.994.626**	**2.067.540**	**2.140.457**	**2.249.831**

Estimated Container ship Cost (US$ Price Levels)

Twenty-Foot Equivalent Units (TEUs)	**2.500**	**2.800**	**3.000**	**3.500**	**4.000**	**4.800**	**6.000**	**LASH**
Deadweight Tonnage (DWT; metric tonnes)	**35.000**	**39.000**	**42.000**	**49.000**	**55.000**	**66.000**	**82.000**	**40.000**
Fixed Annual Operating Cost(s)								
Crew Cost(s)	835.096	924.157	953.884	1.028.061	1.072.591	1.102.278	1.473.363	821.540
Lubes & Stores	392.767	403.033	406.455	415.009	420.142	423.564	466.337	383.354
Maintenance & Repair	624.498	658.634	670.013	698.459	715.527	726.905	896.138	618.340
Insurance	360.003	419.386	439.181	488.667	518.358	538.153	785.584	352.960
Administration	110.381	115.506	117.214	121.485	124.047	125.756	147.109	110.094
Total Fixed Annual Operating Cost(s)	**2.322.745**	**2.520.716**	**2.586.747**	**2.751.681**	**2.850.665**	**2.916.656**	**3.768.531**	**2.286.288**


4.000.000
3.500.000
3.000.000
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2.000.000
1.500.000
1.000.000
500.000
0
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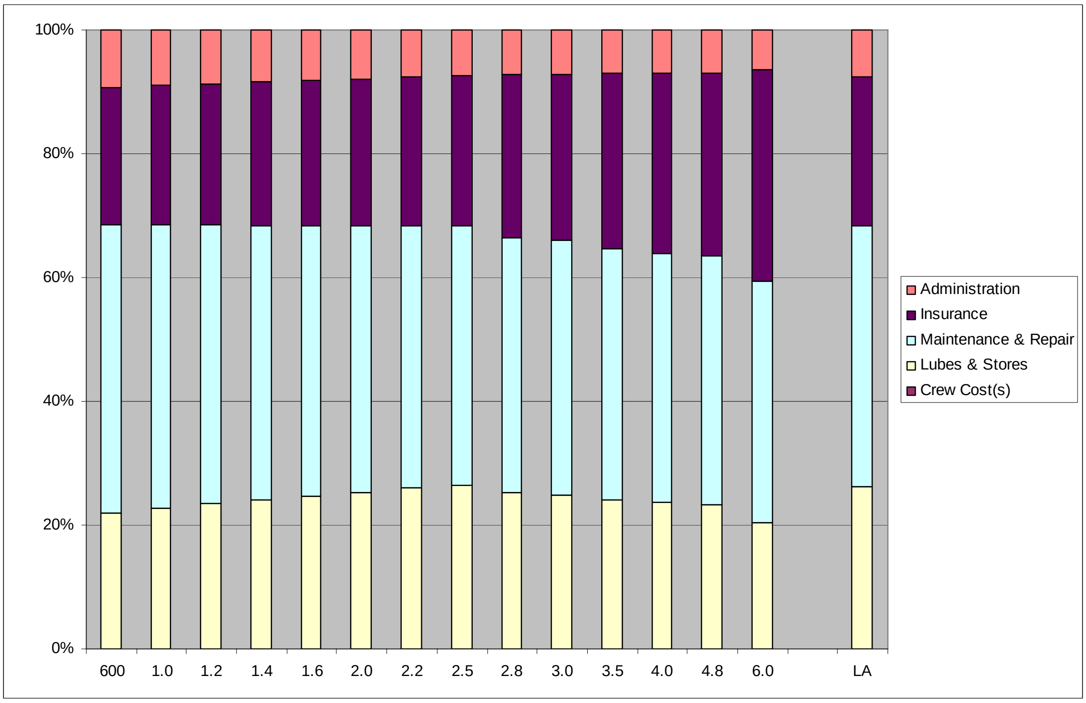
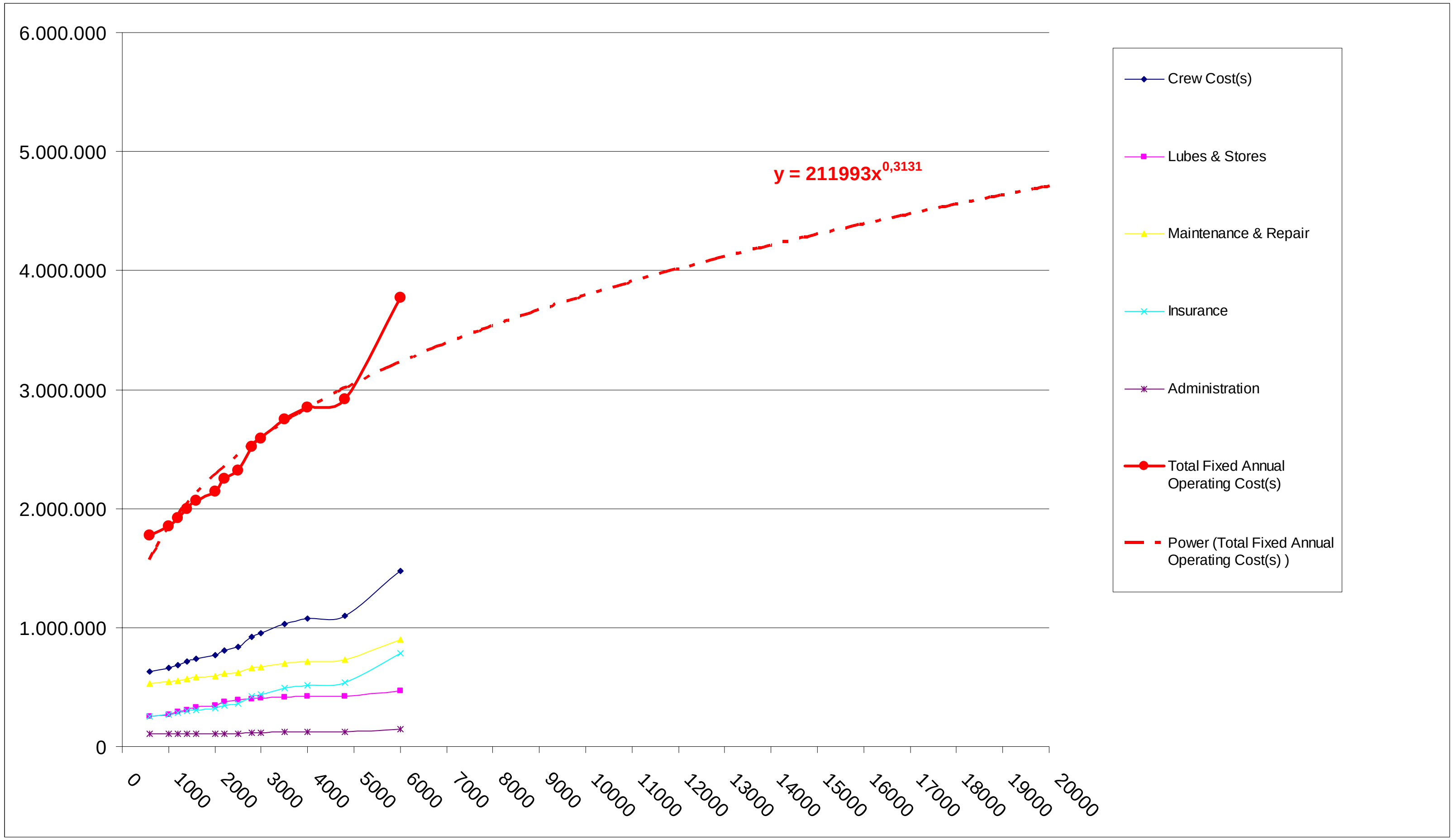
1.000
1.200
1.400
1.600
2.000
2.200
2.500
2.800
3.000
3.500
4.000
4.800
6.000
Crew Cost(s)
Lubes & Stores
Insurance
Maintenance & Repair
Administration


100%
80%
60%
40%
20%
0%
600
1.0
1.2
1.4
1.6
2.0
2.2
2.5
2.8
3.0
3.5
4.0
4.8
6.0
LA
Administration
Insurance
Maintenance & Repair
Lubes & Stores
Crew Cost(s)


6.000.000
5.000.000
4.000.000
3.000.000
2.000.000
1.000.000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
y = 211993x0,3131
Crew Cost(s)
Lubes & Stores
Maintenance & Repair
Insurance
Administration
Total Fixed Annual Operating Cost(s)
Power (Total Fixed Annual Operating Cost(s))

Newbuilding Prices		
	2005-05	2006-03
2.6/2.9K TEU Containership Newbuilding Prices	$ 54.000.000	$ 49.000.000
3.4/3.6K TEU Panamax Containership Newbuilding Prices	$ 63.000.000	$ 54.000.000
4600/4800 TEU Containership Newbuilding Prices	$ 82.000.000	$ 68.000.000
6200/6500 TEU Containership Newbuilding Prices	$ 105.000.000	$ 94.000.000
Containership Average Newbuilding Prices	26.939,46 $/TEU	23.837,96 $/TEU
17500 TEU	**$ 163.522.324**	
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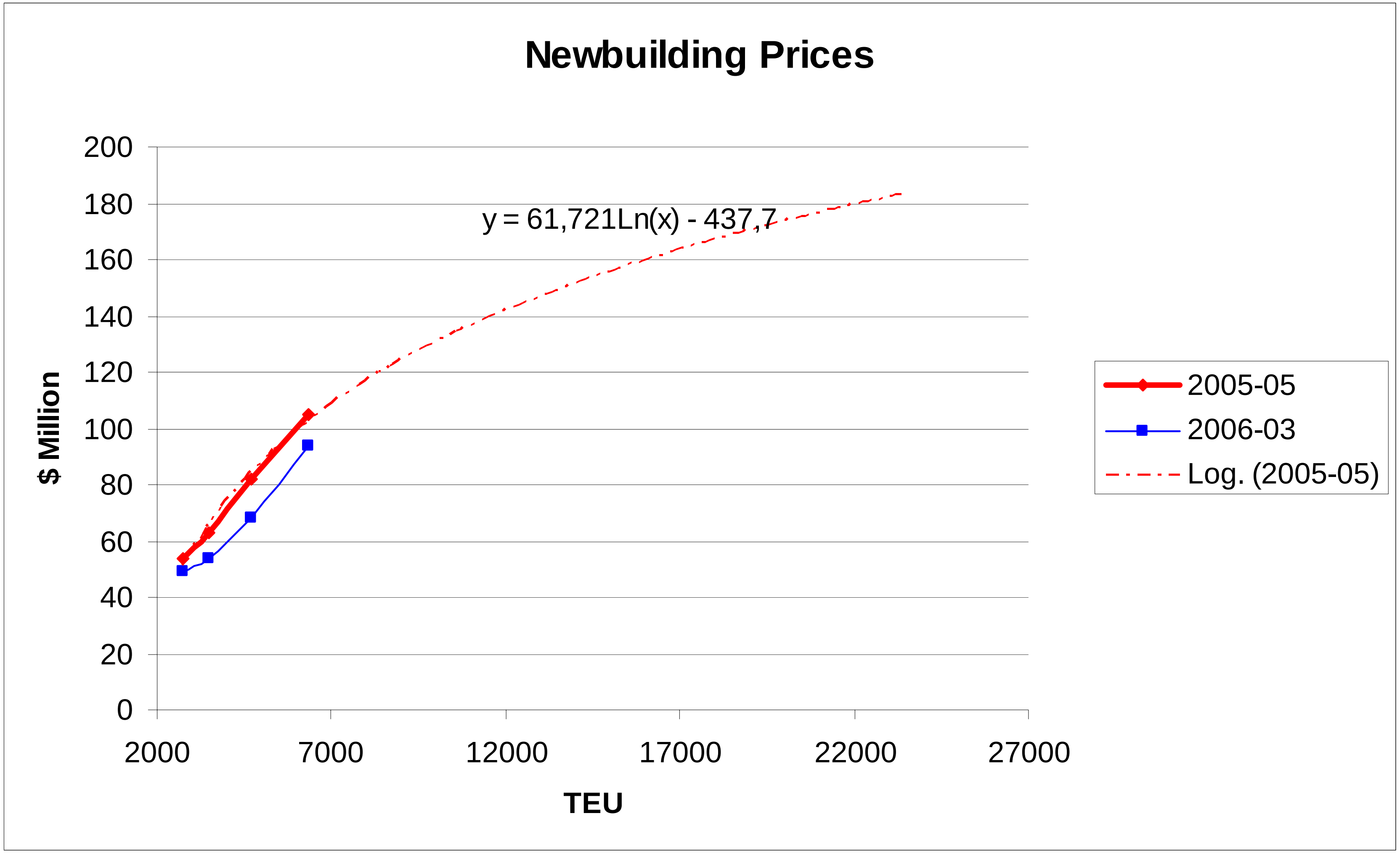

Newbuilding Prices
y = 61,721Ln(x) - 437,7
$ Million
200
180
160
140
120
100
80
60
40
20
0
2000
7000
12000
17000
22000
27000
TEU
2005-05
2006-03
Log. (2005-05)

Timecharter Rates				
	2750 TEU	**3500 TEU**	**4400 TEU**	**17500 TEU**
2004	33850 $/Day	35.621 $/Day	43.375 $/Day	
2005	34813 $/Day	38.427 $/Day	43.000 $/Day	
2006	22500 $/Day	27.500 $/Day	33.250 $/Day	63.084 $/Day
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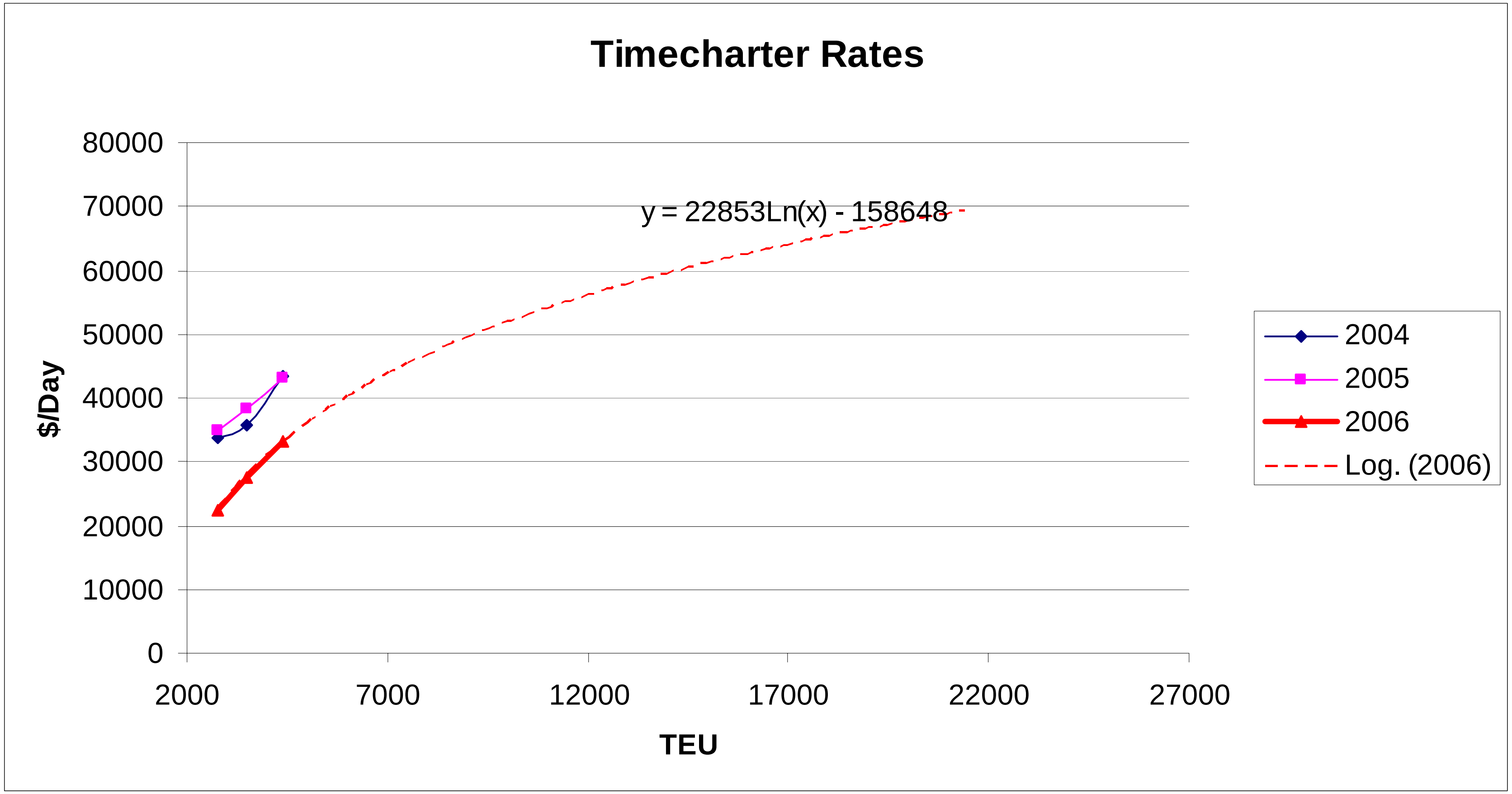
Timecharter Rates
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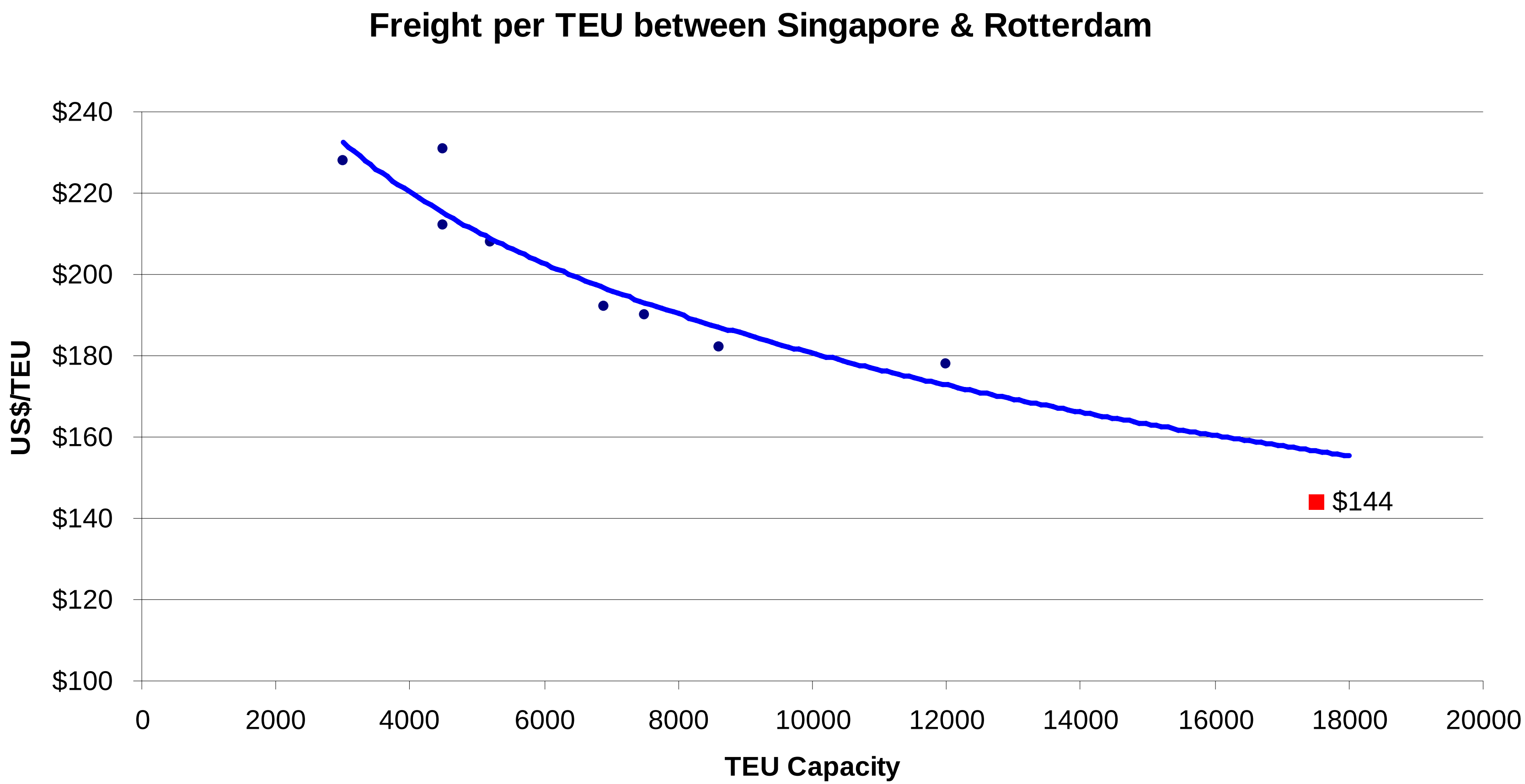
70000
60000
50000
40000
30000
20000
10000
0
$/Day
2000
7000
12000
17000
22000
27000
TEU
2004
2005
2006
Log. (2006)

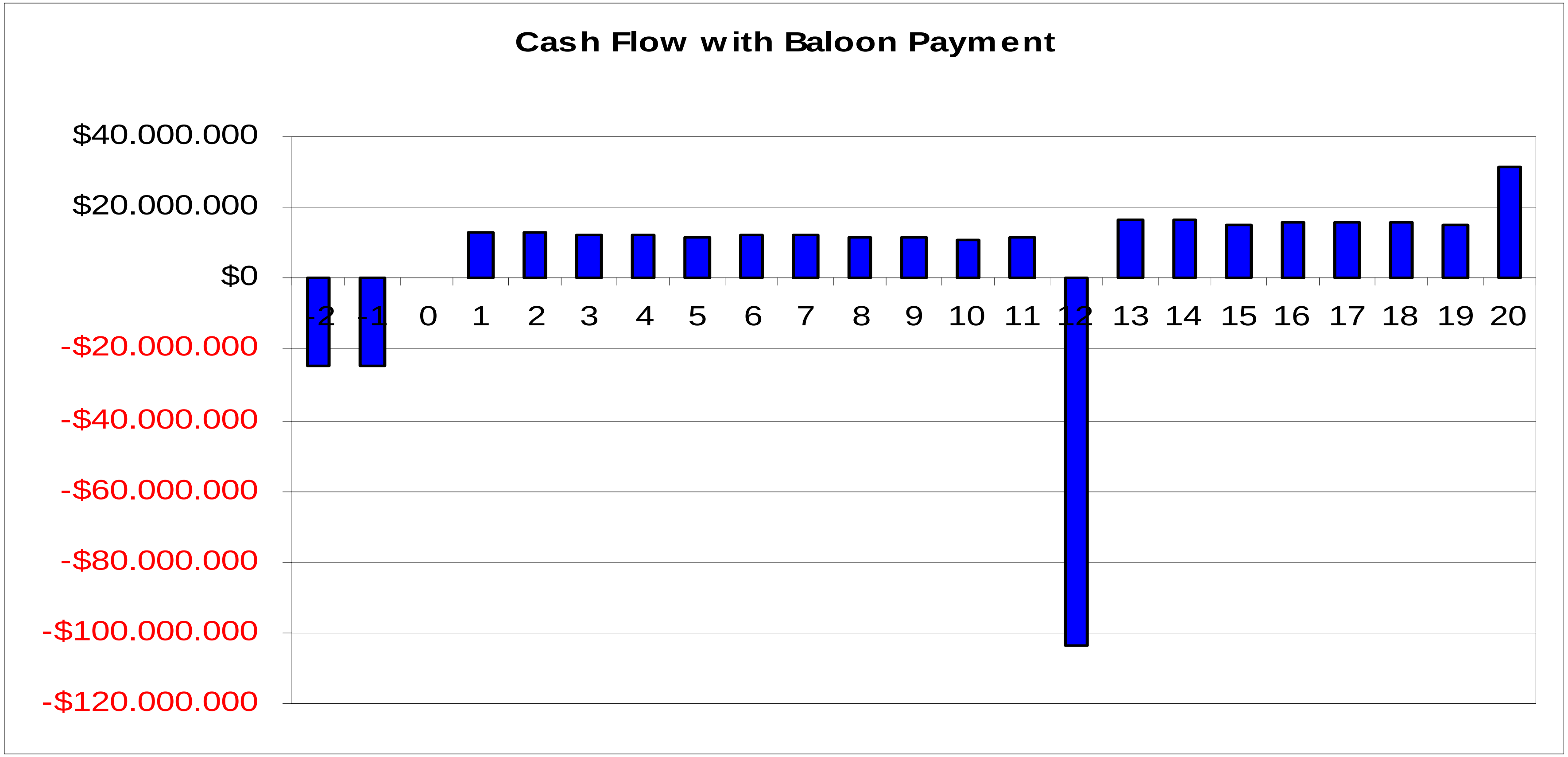
Freight per TEU between Singapore & Rotterdam

Distance between Rotterdam and Singapore		8288	sm			
Vs		25	kn			
At Sea		331,52	h			
At Sea		13	days	and	20	h
Voyage per year		28,07692308				
Engine type		10K98MC				
Power		114400	Kw			
Specific Fuel Oil Consumption (SFOC)		171	gr/Kwh			
Total Fuel Oil		6485	tons			
HFO price		318	$/ton			
Fuel Oil Cost per voyage	**$**	**2.062.334**				
	$	118	$/TEU			
Fixed Annual Operating Cost	$	4.475.800	$/year			
Operating Cost per voyage	**$**	**159.412**				
Building Cost	$	163.500.000				
Annual Building Cost	$	8.175.000				
Building Cost per voyage	**$**	**291.164**				
Total Cost per voyage	$	2.512.910				
Freight per TEU between Singapore $ Rotterdam	$	144				


Freight per TEU between Singapore & Rotterdam
$240
$220
$200
$180
$160
$140
$120
$100
US$/TEU
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
TEU Capacity
$144

Data					
Data	Ship price		$	163.500.000	
	Demolition price		$	16.150.000	
	Fixed annual operating cost		$	4.475.800	
	annual increase rate	3%			
	Timecharter rates		$	23.026.000	per year
	Investment duration	20	years		
Loan contract	Type		balloon		
	Loan	70%	$	114.450.000	
	Owner's	30%	$	49.050.000	
	rate	5%	$	5.722.500	
	duration	12	years		
Building instalments	down	15%	$	24.525.000	
	after 1 year	15%	$	24.525.000	
	with delivery	70%	$	114.450.000	
	Owner pays first				

Cash Flow with Baloon Payment													
Year	**Building Instalments**	**Owner**	**Loan**	**Loan Repayments**	**Loan Outstanding**	**Loan Interest**	**Operating Cost**	**Dry Dock Cost**	**Total Operating Cost**	**Outcome**	**Timecharter Income**	**Income**	**Cash Flow**
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]=sum[4]**	**[7]=[rate]*[6]**	**[8]**	**[9]**	**[10]=[8]+[9]**	**[11]=[2]+[5]+[10]**	**[12]**	**[13]=[4]-[11]**	**[14]=[13]-[11]**
-2	$24.525.000	$24.525.000	$0		$0				$0	$24.525.000	$0	$0	-$24.525.000
-1	$24.525.000	$24.525.000	$0		$0	$0			$0	$24.525.000	$0	$0	-$24.525.000
Delivery	$114.450.000	$0	$114.450.000		$114.450.000	$0			$0	$114.450.000	$0	$114.450.000	$0
1			$0	$5.722.500	$114.450.000	$5.722.500	$4.475.800		$4.475.800	$10.198.300	$23.026.000	$23.026.000	$12.827.700
2			$0	$5.722.500	$114.450.000	$5.722.500	$4.610.074		$4.610.074	$10.332.574	$23.026.000	$23.026.000	$12.693.426
3			$0	$5.722.500	$114.450.000	$5.722.500	$4.748.376		$4.748.376	$10.470.876	$23.026.000	$23.026.000	$12.555.124
4			$0	$5.722.500	$114.450.000	$5.722.500	$4.890.828		$4.890.828	$10.613.328	$23.026.000	$23.026.000	$12.412.672
5			$0	$5.722.500	$114.450.000	$5.722.500	$5.037.552	$600.000	$5.637.552	$11.360.052	$23.026.000	$23.026.000	$11.665.948
6			$0	$5.722.500	$114.450.000	$5.722.500	$5.188.679		$5.188.679	$10.911.179	$23.026.000	$23.026.000	$12.114.821
7			$0	$5.722.500	$114.450.000	$5.722.500	$5.344.339		$5.344.339	$11.066.839	$23.026.000	$23.026.000	$11.959.161
8			$0	$5.722.500	$114.450.000	$5.722.500	$5.504.669		$5.504.669	$11.227.169	$23.026.000	$23.026.000	$11.798.831
9			$0	$5.722.500	$114.450.000	$5.722.500	$5.669.810		$5.669.810	$11.392.310	$23.026.000	$23.026.000	$11.633.690
10			$0	$5.722.500	$114.450.000	$5.722.500	$5.839.904	$800.000	$6.639.904	$12.362.404	$23.026.000	$23.026.000	$10.663.596
11			$0	$5.722.500	$114.450.000	$5.722.500	$6.015.101		$6.015.101	$11.737.601	$23.026.000	$23.026.000	$11.288.399
12			$0	$120.172.500	$114.450.000	$5.722.500	$6.195.554		$6.195.554	$126.368.054	$23.026.000	$23.026.000	-$103.342.054
13							$6.381.421		$6.381.421	$6.381.421	$23.026.000	$23.026.000	$16.644.579
14							$6.572.863		$6.572.863	$6.572.863	$23.026.000	$23.026.000	$16.453.137
15							$6.770.049	$1.000.000	$7.770.049	$7.770.049	$23.026.000	$23.026.000	$15.255.951
16							$6.973.151		$6.973.151	$6.973.151	$23.026.000	$23.026.000	$16.052.849
17							$7.182.345		$7.182.345	$7.182.345	$23.026.000	$23.026.000	$15.843.655
18							$7.397.815		$7.397.815	$7.397.815	$23.026.000	$23.026.000	$15.628.185
19							$7.619.750		$7.619.750	$7.619.750	$23.026.000	$23.026.000	$15.406.250
20							$7.848.342		$7.848.342	$7.848.342	$39.176.000	$39.176.000	$31.327.658
Total	**$163.500.000**	**$49.050.000**	**$114.450.000**	**$183.120.000**		**$68.670.000**	**$120.266.422**	**$2.400.000**	**$122.666.422**	**$469.286.422**	**$476.670.000**	**$591.120.000**	**$121.833.578**

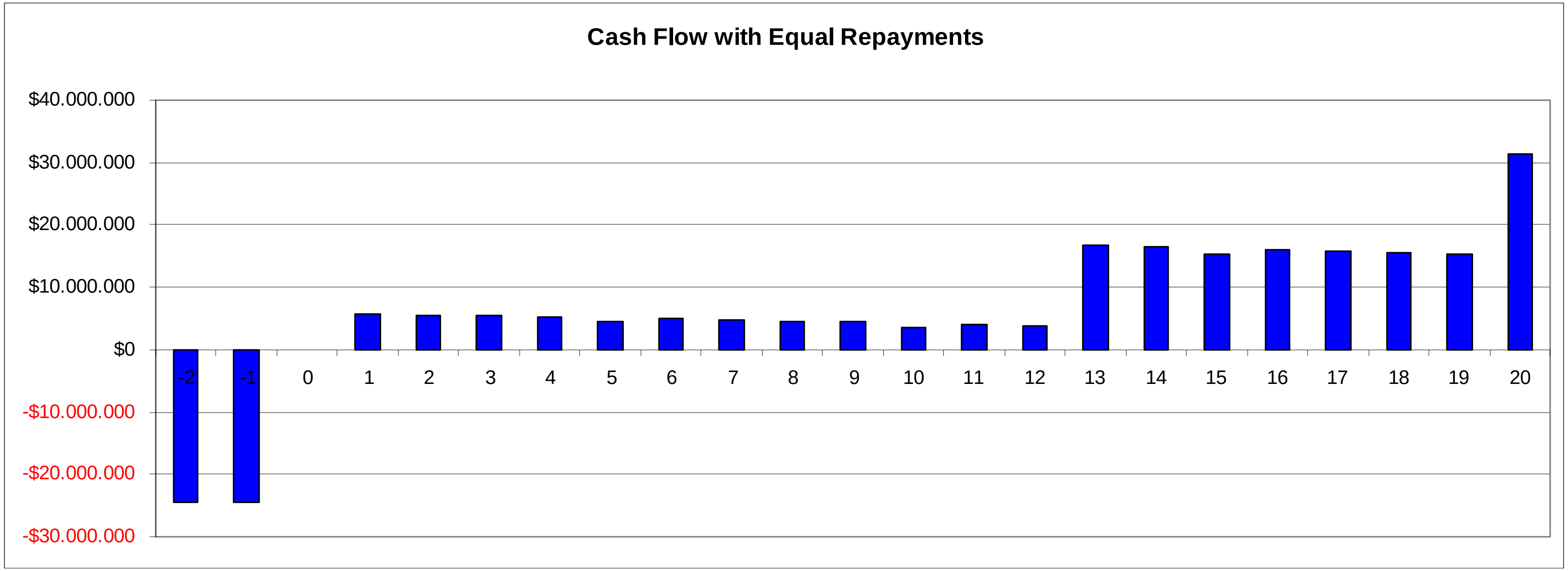


NPV	$ 61.670.343,79	3,5%
IRR	14%	

Data				
Data	Ship price		$ 163.500.000	
	Demolition price		$ 16.150.000	
	Fixed annual operating cost		$ 4.475.800	
	annual increase rate	3%		
	Timecharter rates		$ 23.026.000	per year
	Investment duration	20	years	
Loan contract	Type		Equal Repayments	
	Loan	70%	$ 114.450.000	
	Owner's	30%	$ 49.050.000	
	rate	5%	$ 5.722.500	
	duration	12	years	
Building instalments	down	15%	$ 24.525.000	
	after 1 year	15%	$ 24.525.000	
	with delivery	70%	$ 114.450.000	
	Owner pays first			

Cash Flow with Equal Repayments

Year	Building Instalments	Owner	Loan	Loan Repayments	Loan Outstanding	Loan Interest	Operating Cost	Dry Dock Cost	Total Operating Cost	Outcome	Timecharter Income	Income	Cash Flow
[1]	[2]	[3]	[4]	[5]	[6]=sum[4]-[5]	[7]=[rate]*[6]	[8]	[9]	[10]=[8]+[9]	[11]=[2]+[5]+[7]+[10]	[12]	[13]=[4]-[11]	[14]=[13]-[11]
-2	$24.525.000	$24.525.000	$0		$0				$0	$24.525.000	$0	$0	-$24.525.000
-1	$24.525.000	$24.525.000	$0		$0				$0	$24.525.000	$0	$0	-$24.525.000
Delivery	$114.450.000	$0	$114.450.000		$114.450.000				$0	$114.450.000	$0	$114.450.000	$0
1			$0	$12.912.868	$107.259.632	$5.722.500	$4.475.800		$4.475.800	$17.388.668	$23.026.000	$23.026.000	$5.637.332
2			$0	$12.912.868	$99.709.745	$5.362.982	$4.610.074		$4.610.074	$17.522.942	$23.026.000	$23.026.000	$5.503.058
3			$0	$12.912.868	$91.782.364	$4.985.487	$4.748.376		$4.748.376	$17.661.244	$23.026.000	$23.026.000	$5.364.756
4			$0	$12.912.868	$83.458.614	$4.589.118	$4.890.828		$4.890.828	$17.803.696	$23.026.000	$23.026.000	$5.222.304
5			$0	$12.912.868	$74.718.677	$4.172.931	$5.037.552	$600.000	$5.637.552	$18.550.421	$23.026.000	$23.026.000	$4.475.579
6			$0	$12.912.868	$65.541.743	$3.735.934	$5.188.679		$5.188.679	$18.101.547	$23.026.000	$23.026.000	$4.924.453
7			$0	$12.912.868	$55.905.962	$3.277.087	$5.344.339		$5.344.339	$18.257.207	$23.026.000	$23.026.000	$4.768.793
8			$0	$12.912.868	$45.788.391	$2.795.298	$5.504.669		$5.504.669	$18.417.538	$23.026.000	$23.026.000	$4.608.462
9			$0	$12.912.868	$35.164.943	$2.289.420	$5.669.810		$5.669.810	$18.582.678	$23.026.000	$23.026.000	$4.443.322
10			$0	$12.912.868	$24.010.322	$1.758.247	$5.839.904	$800.000	$6.639.904	$19.552.772	$23.026.000	$23.026.000	$3.473.228
11			$0	$12.912.868	$12.297.970	$1.200.516	$6.015.101		$6.015.101	$18.927.969	$23.026.000	$23.026.000	$4.098.031
12			$0	$12.912.868	-$0	$614.898	$6.195.554		$6.195.554	$19.108.422	$23.026.000	$23.026.000	$3.917.578
13							$6.381.421		$6.381.421	$6.381.421	$23.026.000	$23.026.000	$16.644.579
14							$6.572.863		$6.572.863	$6.572.863	$23.026.000	$23.026.000	$16.453.137
15							$6.770.049	$1.000.000	$7.770.049	$7.770.049	$23.026.000	$23.026.000	$15.255.951
16							$6.973.151		$6.973.151	$6.973.151	$23.026.000	$23.026.000	$16.052.849
17							$7.182.345		$7.182.345	$7.182.345	$23.026.000	$23.026.000	$15.843.655
18							$7.397.815		$7.397.815	$7.397.815	$23.026.000	$23.026.000	$15.628.185
19							$7.619.750		$7.619.750	$7.619.750	$23.026.000	$23.026.000	$15.406.250
20							$7.848.342		$7.848.342	$7.848.342	$39.176.000	$39.176.000	$31.327.658
Total	**$163.500.000**	**$49.050.000**	**$114.450.000**	**$154.954.418**		**$40.504.418**	**$120.266.422**	**$2.400.000**	**$122.666.422**	**$441.120.840**	**$476.670.000**	**$591.120.000**	**$149.999.160**



NPV	$ 67.314.851,69	3,5%
IRR	11%	