Ultra-Large Container Ships (ULCS)

designing to the limit of current and projected terminal infrastructure capabilities

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Abstract

The container shipping market is increasing at about 8% per annum and this is expected to continue for at least the next decade. Studies indicate that ultra-large container ship (ulcs) designs are not only feasible but may be a necessary development if this market expansion is to be accommodated in the most cost effective manner.

Current and anticipated capabilities of container terminals, together with possible improvements in shoreside facilities and ship operational design, are reviewed. Likely developments in this expanding sector of the container shipping market are identified. The study ascertains the optimum capacity of a ulcs, based on infrastructure and market considerations, to be 12,500TEU, a ship of about VLCC size.

Based on the study, possible design configurations and structural arrangements have been examined to establish the design challenges associated with these large vessels.

1. Introduction

Lloyd's Register has, since the introduction of the first ISO standard container in the early 1960s, been involved with the development and the design appraisal of dedicated cellular container ships.

The latest post-panamax ships have a capacity of nearly 8,000TEU.

There have been many studies reported widely in the press examining future prospects for even larger ships. Some of these are considered to be highly speculative, others are designed for specific routes and ports - some have been funded by particular ports.

Lloyd's Register therefore decided to commission an independent investigation into the prospects for ships of this type and size in order to identify potential design challenges, particularly from the Classification aspect. The ULCS study by Lloyd's Register, with Ocean Shipping Consultants (OSC), commenced in the summer of 1999 and the first results were published in March 2000 [1] and July 2000 [2]. The results of our further study were presented at Boxship 2001 in London [5].

The content of this paper is fundamentally in three parts, i.e. evolution of container ships, the design challenges associated with ulcs vessels and the market study.

2. Evolution of Container Ships

In the past 40 years container ships have evolved from small feeders, through panamax to the latest post-panamax ships.

Although Panamax ships still represent the lion's share of the world container ship fleet, the largest post-Panamax ships in service today, with capacities approaching 8,000TEU, now represent some 7.5% of the world fleet of container ships, 22% by total seagoing capacity.

When the current order book is included these figures increase to 8.6% (by number of ships) and 24% (by total seagoing capacity).

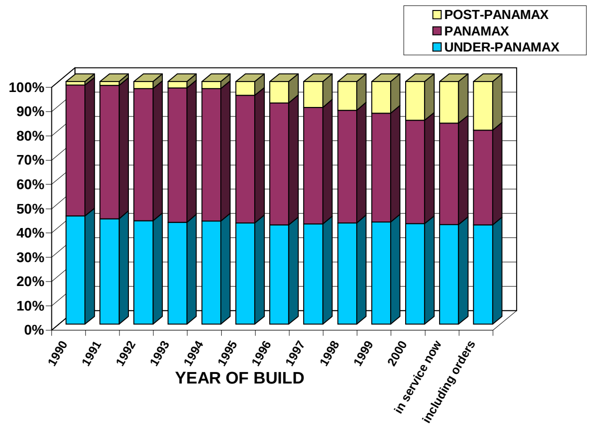

Figure 1 – Evolution of container ship fleet

Figure 1 illustrates the manner in which the container ship fleet has evolved during the past 10 years. It is apparent that the 40% market share held by under-panamax ships has been steady over this period. However, the panamax fleet is declining, in percentage terms, as the post-panamax fleet grows in size.

The future is clearly looking good for post-panamax ships. It was for this reason that it was decided to investigate the future prospects for these largest ships.

3. Design Challenges

The OSC study into the present and projected capabilities of the terminals, which will be detailed later, determined that the maximum principal dimensions of a ULCS will be as follows:

Beam,	B	= 57m (22 boxes abreast on deck)
Length,	Lpp	= 381m
Depth,	D	= 29m
Draught,	T	= 14·5m
Ship Speed	V	= 23-25knots

In order to validate the concept, and to identify the design challenges associated with ships of this type and size, and in particular to identify any structural issues which Lloyd's Register should be considering in anticipation of ULCS design submissions, a number of conceptual designs were developed.

3.1 Ship Structures

- **Conceptual Design 1, Wide Skin Option**

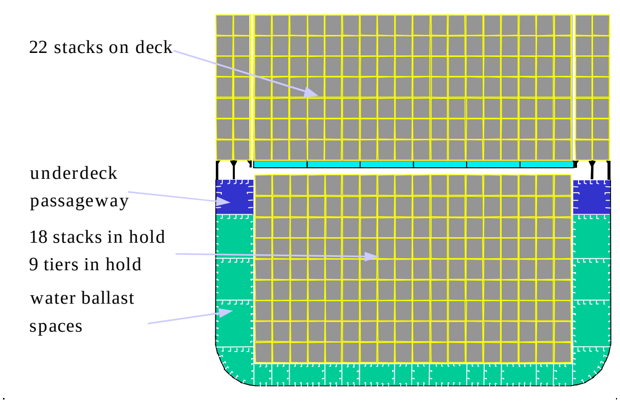

Figure 2 - Conceptual Design 1, Wide Skin Option

Principal parameters:

LxBxD=381x57x29m
7 tiers, 22 stacks on deck
9 tiers, 18 stacks in holds.

For this concept, the side structure has been designed to accommodate two stacks of containers on deck, each side. The double side and double bottoms are for water ballast.

One of the greatest challenges for container ship designers is hull flexibility, particularly from torsion. For this reason, deck containers which straddle two hatch covers are vulnerable to damage, to the lashings and even to the containers themselves, as the hatch covers try to move relative to one another.

A container straddling the side pedestal and the outboard hatch cover is even more vulnerable.

Taking this into consideration, the container stowage arrangements have been determined.

A hull form was developed in order to carry out an accurate container count. It was found that the hull form could accommodate 12,100TEU containers.

- **Conceptual Design 2, Narrow Skin Option**

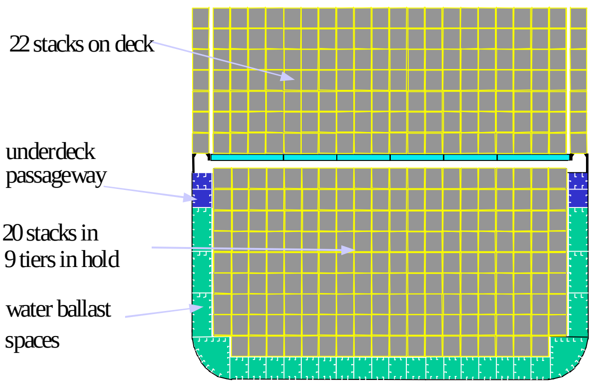

Figure 3 - Conceptual Design 2, Narrow Skin Option

A further design concept was developed with a narrow side structure, wide enough to accommodate just one stack of containers on the deck each side. However, structurally it is more onerous and careful consideration will be required from structural aspects.

This design has a capacity of 12,500TEU. It was further found that this design could have a capacity of 13,000TEU by moving the deckhouse forward.

- **Effect of Re-Locating Superstructure**

When the deckhouse is in the conventional position, above the engine room, the capacity of the wide skin option is about 12,100TEU. Capacity on deck is limited by the IMO visibility criterion which requires that the water surface 500m forward of the bow must be visible from the bridge. There is no requirement for visibility aft.

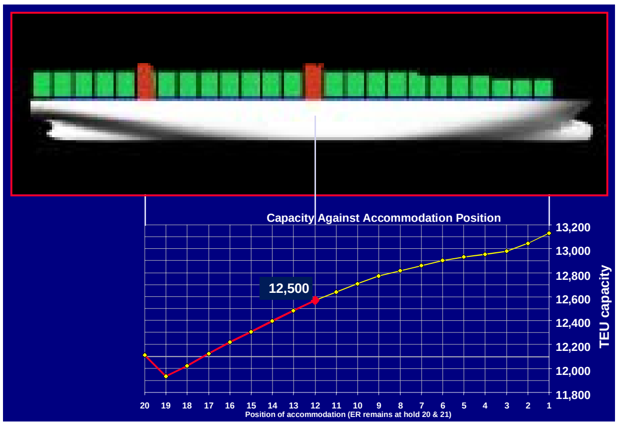

Figure 4 - Effect of Re-locating Superstructure

As the deckhouse moves forward the container capacity increases, as a result of the visibility requirements, Figure 4. By locating the deckhouse at about midships, the required capacity of 12,500TEU can be achieved for the wide skin option. This also provides a number of other benefits such as spare space under accommodation (e.g. for fuel) and improved torsional response.

3.2 Midship Section Scantlings

- **Hull Girder Bending**

The first design challenge is to provide sufficient hull bending strength. Midship section scantlings have been developed, for the wide skin option, Figure 5. HT36 steel has been used throughout, with a frame spacing of about 10 feet. The scantling assessment indicates that the hatch side coaming needs to be about 65mm thick and other topside structure 60mm; the remainder of the structure is "conventional" compared with existing large container ships.

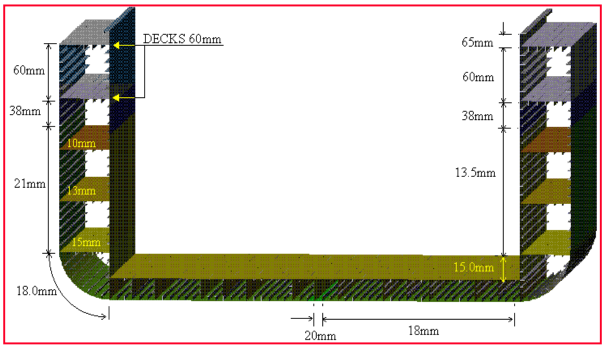

Figure 5 – Midship Scantlings: Wide Skin Option

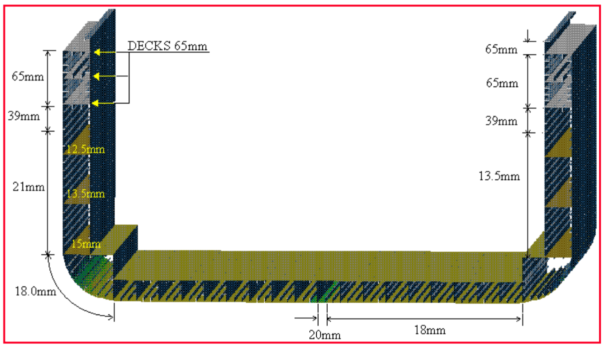

Figure 6 – Midship Scantlings: Narrow Skin Option

Midship section scantlings have also been developed for the narrow skin option, Figure 6.

It has been necessary in this case to introduce an additional deck in order to achieve the required hull girder inertia. The coaming is once more 65mm and the rest of the topside structure is now also 65mm. The remainder of the ship is, again, "conventional".

So, there appear to be no insurmountable difficulties with this design concept.

- **Torsional Strength**

The greatest design issue for container ships having large hatch openings is torsional strength. A detailed torsional analysis has been carried out and the results, Figure 7, indicate that if the deckhouse is located amidships the torsional response is reduced by about 30%, a substantial benefit.

The rate of twist of the wide skinned concept is of the same order as that of existing large container ships, even if the deckhouse is located towards the aft end.

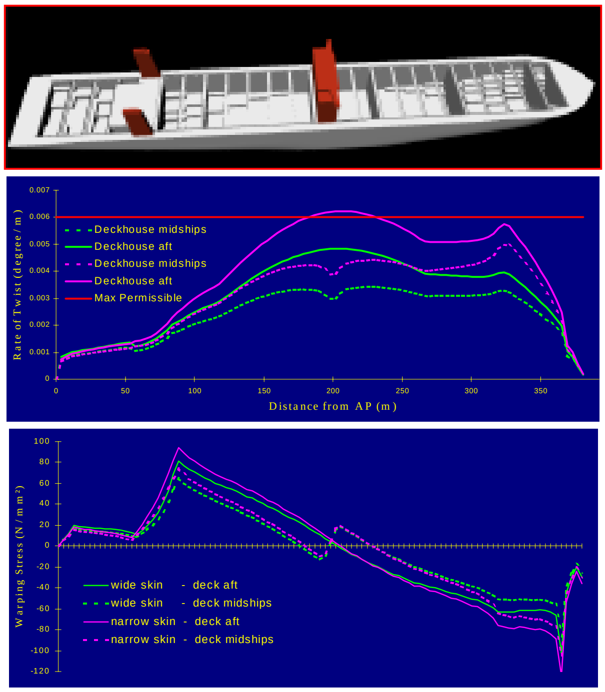

Figure 7 – Torsional Response

It has been found that the addition of the midships deckhouse also has a substantial benefit in reducing the warping stresses.

Peak warping stresses occur at the ends of the hatch opening region and are the most critical at the engine room front, where they are combined with other hull girder load components. If the deckhouse structure is located amidships, the warping stress is reduced by 20% at the engine room front and is of the order of that of existing large container ships.

3.3 Propulsion System

A limited number of propulsion options have been examined for the purposes of this study:

- Single engine, single screw
- Twin engine, twin screw
- Contra-rotating propellers
- Single engine + twin podded units

The aim of this study is to establish the viability of such a ship design and to identify "design challenges", not to produce an optimum design.

The details of our study on propulsion systems are given in reference [4].

- **Powering Requirements**

For this study, we have utilised a 5-hull series ranging between 4,000 and 12,500TEU. The hull form parameters, Figure 8, were carefully selected to confirm that there are no anomalies creeping in.

A series of propulsion calculations has been carried out for each of the ships, at a range of speeds between

21 knots and 26 knots.

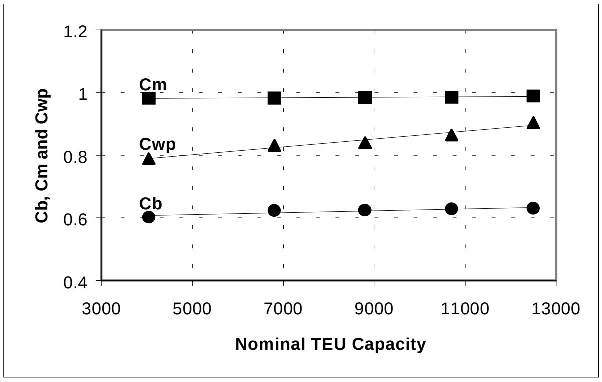

Figure 8 - Hull Form Coefficients

Service speed power requirements were determined at 85% MCR with a 25% sea margin.

In order to develop the largest quasi-propulsive coefficient it is, in general, necessary to use the largest possible propeller diameter. However the resulting radiated hull surface pressures must be controlled so that unacceptable levels of excitation are not transmitted to the hull. This clearly required that a maximum diameter for each of the ships must be determined and for the purposes of this study a value of 70% of the ships' design draughts was assumed. Each of the propellers was designed to have six blades.

The results of the propulsion calculations are summarised in Figure 9.

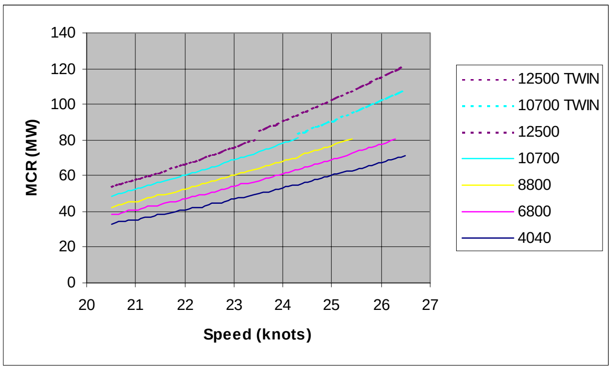

Figure 9 – Propulsion Calculations

Taking an 81MW engine, the maximum within the currently declared slow speed diesel engine programmes, the ship speed achievable is 25·4 knots for 8,800TEU, 24·3 knots for 10,700TEU and 23·5 knots for 12,500TEU.

Thus for ships over 9,000TEU it is necessary to go to twin screw if 25 knots service speed is required. There is, however, a penalty in going to twin screw, i.e. the fuel consumption, daily operating costs and the capital cost increase.

The issue of optimum ship speed and the question of twin vs. single screw has been found to be an important factor in cost estimation.

- **Single Engine, Single Screw**

For a 12,500TEU ULCS, about 98MW is required to achieve a speed of 25 knots using a propeller of 9·8m diameter (70% draught), see Figure 10. A propeller capable of delivering that power into the water would weigh about 130 tonne (nickel-aluminium bronze), the upper limit of today's propeller manufacturing facilities.

However, a problem arises with the blade area ratio BAR. For a propeller of 9·8m diameter, the required BAR is 1·03. With this BAR the propeller will be particularly sensitive to cavitation. Ideally the BAR should be kept below about 1·0. The only practical way to reduce the BAR, and thus to control the susceptibility to cavitation, is to increase the diameter, Figure 11, but this increases the weight of the propeller.

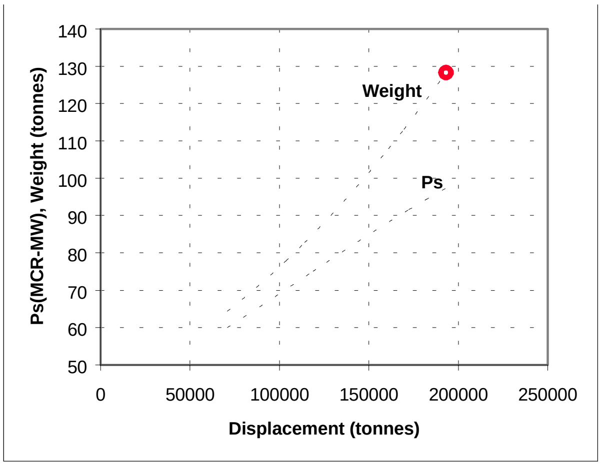

Figure 10 – Propeller Weight

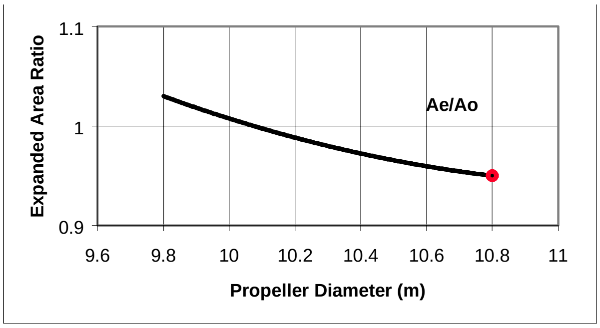

Figure 11 – Effect of Propeller Diameter on Required Blade Area Ratio (12,500TEU design)

So, even if an engine was available which could supply this power, there are practical problems with delivering this power into the water. It is the design of the propeller which limits the ship size and/or speed.

- **Twin Engine, Twin Screw**

The analysis for the twin screw ships was undertaken for the 10,700 and 12,500TEU capacity ships. This was because the machinery analysis showed that, within the currently declared slow speed diesel engine programs, ships up to about 9,000TEU capacity could be propelled using a single screw system at a design service speed of 25 knots. The propeller diameters used were almost the same as those for the single screw study. In this case four-bladed designs were selected due to the easier cavitating environment presented by the twin screw propulsion system.

In twin screw systems, the propellers are lighter and hull surface pressures – a possible source of vibration - can be reduced. Higher ship speeds are possible because of the reduced power requirement from each engine and the reduced loading on each propeller. However, fuel consumption increases slightly, as do the capital and daily operating costs.

From hull strength considerations, care must be taken to consider aft end slamming due to the flat counter stern associated with twin screw arrangements.

- **Contra-Rotating Propellers**

It has been reported that power savings of 12-14% have been proved following installation of contra-rotating propellers (CRP) on a handy-size bulk carrier and a VLCC, with accumulated 20 years service experience. CRPs for larger container ships have now been developed. The power sharing between the two propellers, Figure 12, and the increased efficiency of these units would mitigate the powering limit of the single engine option as identified above and would improve the financial performance of vessels fitted with this propulsion system.

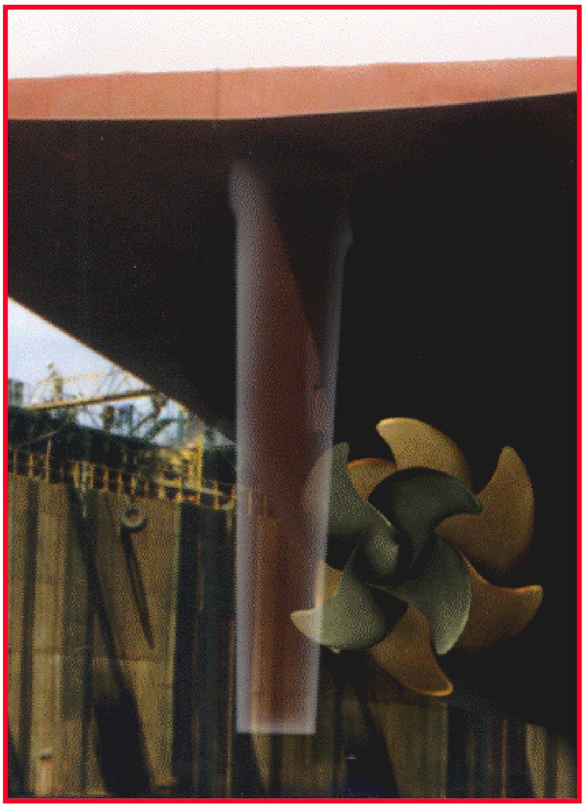

Figure 12 - Contra-Rotating Propellers

An alternative system of contra-rotation has been considered in which a fixed pitch propeller, mounted on a conventional tail shaft, has a podded propeller located astern of it, Figure 13.

Figure 13 - Contra-Rotation using Podded Drive

Currently, podded propellers fitted to cruise ships have achieved powers of the order of 20MW which is significantly below the power ratings considered here for the larger container ships. Nevertheless, the use of powers of this order could be expected to improve the propulsive efficiency of the propeller-pod combination. Model tests have shown that when the two propellers are mounted co-axially a satisfactory blade cavitation performance over both propellers can be achieved. However, if the podded propeller is to be used for steering such a situation may develop unstable cavitation over the podded propeller blades as well as introducing significant bearing fluctuating forces in and from the podded propeller. This aspect is being examined by the designers at this time.

- **Single Engine + Twin Podded Units**

A further option was considered in the early stages of the study, i.e. a conventional single screw arrangement in association with twin podded units.

This option at first sight seems to be attractive. It has the benefit of total redundancy for both propulsion and steering. It also offers the possibility of shutting down the main engine in coastal waters, when a reduced speed is required, which may result in reduced fuel consumption and the possibility of more environmentally friendly operation.

However, these potential benefits must be weighed against the additional complexity and increased capital cost. It is considered that this option is unlikely to be financially viable.

- **Other Propulsion Options**

Other propulsion options include diesel-electric to conventional propellers, gas turbine, multiple podded units and the use of shaft motors/generators.

However, as stated previously, the aim of the current study is to establish the viability of the ulcs ship design concept and to identify "design challenges", not to produce an optimum design. Therefore, having established the issues and limitations with regard to ulcs propulsion, development of a plethora of propulsion options is outwith the scope of the current study.

3.4 Manoeuvrability

Our calculations indicate that, offshore, the ulcs is likely to satisfy all of the IMO manoeuvrability criteria when equipped with a conventional steering system. However, it is in congested waters that manoeuvrability may be more problematic.

The wind loading on the above water profile is likely to be very large.

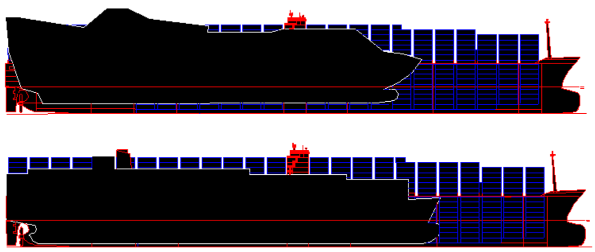

Figure 14 - Windage Area

In Figure 14 the windage area is compared with one of the largest container ships in service and one of the world's largest cruise ships. It is probable that three or four bow thruster units (of about 25 tonne thrust each) will be required if the ship is to be able to manoeuvre itself independently, without the use of tugs.

Aft end control would be adequately provided for by azimuthing podded drive units, if fitted.

4. Market Study

The total capacity of the world container ship fleet is increasing rapidly, in response to the current market growth rate of some 8% per annum. At the same time, the size of container ships continues to increase. Lloyd's Register therefore decided to employ the services of an independent consultant to assess how the market requirements for larger vessels might develop in the next few years. Initial calculations by OSC confirmed the further scope for scale economies in container shipping. The actual maximum vessel size would be determined by the interplay between what could be constructed and driven at the required speed and what could be effectively handled by the container terminals. The study seeks to bring these considerations together and to identify the true economic position on major trades where these vessels could be used. Our perspective is firmly grounded in the entire transport chain. Initially, the focus was on determining what would be the optimum physical configuration of the largest vessel. The technical feasibility of such a vessel was considered by Lloyd's Register with specific reference to the question of powering. In the light of these conclusions a more detailed view of scale economies was developed and these placed into models of major longhaul container trades.

4.1 Physical Design Considerations

The physical configuration of the vessels will be determined by the current *and forecast* development of the container port and terminal industry.

The major determinants will be:

- The length of the vessel - primarily a function of berth availability
- The vessel beam - determined by crane outreach
- Vessel draught - determined by channel and alongside terminal depth
- Trading speed - required to be competitive with current vessels within the limitations of engine power
- Cargo capacity - determined by the maximisation of capacity against physical dimensions
- The capability of major ship repairers to drydock and maintain such vessels.

The most important of these are discussed below.

- **Ship Length**

Maximum vessel length is determined by the capabilities of container berths in the major terminals, and by access considerations.

In the past few years all major container berths have been built to a length of 350m. In most major terminals berths are arranged in a linear manner. This means that theoretically 400m LOA vessels can be berthed - although some crane rail extensions and mooring modifications may be necessary.

Although there are some exceptions, this effectively means that LOA is not restricted by the container terminals themselves. Terminal access is often more problematic. Some terminals - principally those on river locations - will be excluded from these operations. Elsewhere large new coastal terminals are generally accessible from a length perspective. These new vessels will be difficult to manage but, with adequate power and tug assistance, access will be possible for such vessels at the major European, Asian and 'wayport' terminals.

- **Ship Breadth**

The major controlling factor for ULCS beam will be crane outreach. To adequately handle 22 rows of containers, assumed for 12,500TEU ULCS, an outreach of 60m is required. This capacity is technically already available, Figure 15.

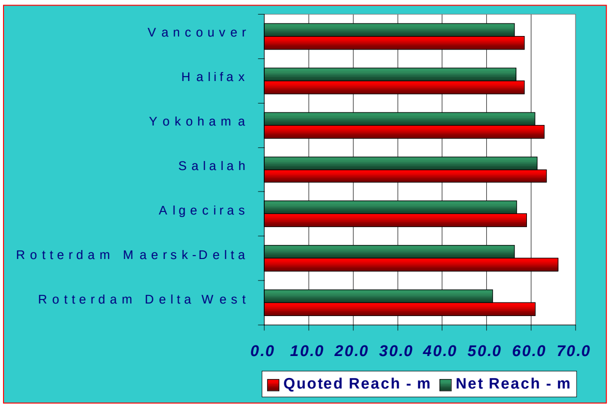

Figure 15 - Effective Crane Outreach at Potential ULCS Terminals

Attention has been recently focused on the inlet berth design that will allow container handling on both vessel sides simultaneously. The accessibility of such berths for ULCS tonnage may be problematic. A review of current conditions indicate that linear berths will be more appropriate.

Gantry crane investment always runs ahead of ship capacity. All new terminals have been investing for super post-Panamax for several years. Given the level of interest in ULCS tonnage, and lack of technical barriers, required crane investment will be forthcoming.

There has been a period of rapid investment in container gantries that are theoretically capable of handling anticipated classes of vessels. By the end of this year there will be around 58 gantries with a rated outreach in excess of 58m, see Figure 16. When we first undertook this analysis in early 2000 the corresponding number was 21. In terms of geographical distribution, these investments are broadly distributed around the major port regions and at wayport transshipment hubs.

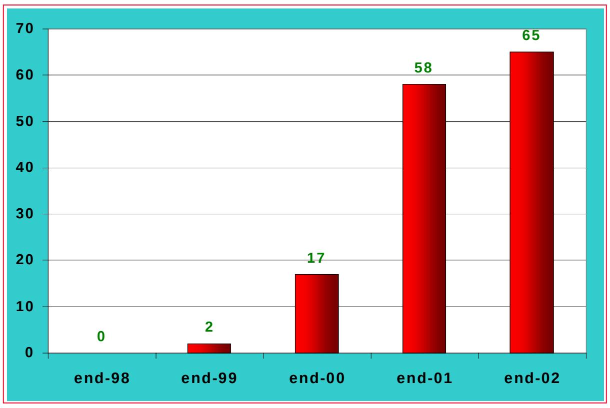

Figure 16 - Number of Container Gantries with Outreach 58m+

From this perspective, the actual ship-shore physical handling of ULCS will be physically possible.

- **Ship Draught**

The physical availability of deepwater container terminals and access channels will be a function of actual depth, operating practices with regard to keel clearance at the berth and in the channel and other factors specific to ULCS trading patterns such as Suez Canal depth. Whilst these are all important factors, the actual draught of a ULCS is seldom likely to be a restricting concern. On the basis of typical container weights and load factors on the major Asia-Europe trades it is unlikely that the vessels will be loaded to maximum draught.

Our analysis indicates that a 12,500TEU vessel will draw a maximum of 14·5m when fully-laden. Water depth is being rapidly improved at most major container terminals where ULCS operations will be targeted. If 15m is taken as a cut-off point for a minimum requirement, then there are currently 17 terminals offering at least this depth, Figure 17. On the basis of committed investments, this will increase to 25 in 2003 and then to 28 in 2008.

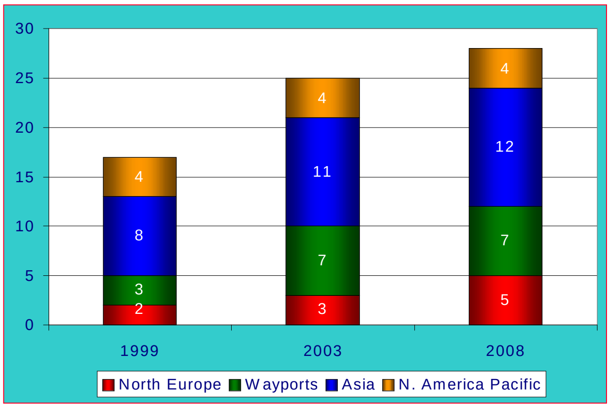

Figure 17 - Number of Ports Offering 15m+ Deep Berths

The required water depth for these vessels is already being provided by major terminal operators and Port Authorities, in the main ports in the major trading regions - together with similar facilities in the developing transshipment ports on trades linking Asia with Europe. It is concluded, therefore, that availability of water depth to berth these vessels will not be a major problem.

- **Ship Speed**

The question of service speed is determined by desired requirements and the actual power available from a single engine.

At present, 25 knots is typically available for large container ships on the arterial trades with the required sea margin. This allows required services to be maintained by a limited fleet and also permits the flexibility to make up lost time and to handle adverse weather conditions.

For example, a twin-hub Europe-Asia service could, in theory at least, maintain a weekly service with five vessels if 25 knots is available. A further vessel would be required if the slower speed was averaged.

As vessel turnaround time in port for such vessels will be somewhat slower - even if fewer ports are serviced - then it will be an important requirement to offer a competitive trading speed. The question of generating and delivering the required power for this is the most important technical factor for these units. We return to this question below.

- **Optimum Physical Configuration**

On the basis of dimensional considerations the optimum ULCS will be configured as follows:

- Overall capacity 12,500TEU.
- Maximum LOA around 380-400m.
- Ship breadth 60m.
- Maximum design draught 14·5m.
- Design speed between 23-25 knots depending upon powering considerations.

The above allows an estimation of scale economies to be developed.

4.2 Scale Economy

The next stage is to build-up cost analyses associated with the use of these vessels. Analysis has been developed of the capital costs associated with such vessels - based upon single and twin engine designs where appropriate - and on the basis of current newbuilding price levels having some direct input from yards. Operating costs will not be markedly different from those incurred by the current largest vessels. These were analysed in terms of manning, insurance, repair & maintenance and other costs.

Fuel consumption is also critical. Powering demand by speed was identified in the foregoing, and the resulting daily consumption levels have been factored into the economic analysis.

- **At-Sea Costs**

Under current bunker prices and newbuilding costs, at-sea costs per slot (TEU) have been estimated for four ship classes between 6,800TEU and 12,500TEU and under different trading speeds between 21 knots and 26 knots, Figure 18. It is these underlying cost levels upon which the entire rationale for the ULCS concept is predicated. The degree to which these advantages at sea can be translated into overall operational savings is fundamental to the analysis.

The cost savings from the shift to 8,800TEU vessels over current maximum capacities is clearly apparent at each trading speed. The position for the ULCS is more complex, with a step change noted at around 23/24 knots. The 12,500TEU ship generates the lowest costs, but the differential between these vessels and the smaller size ranges falls sharply. This is the direct result of the requirement for twin engines and the resulting uprating of capital charges for these vessels trading at 24/25 knots. A significant cost saving remains, but this is much smaller when trading speeds of 25 knots are required for the ULCS.

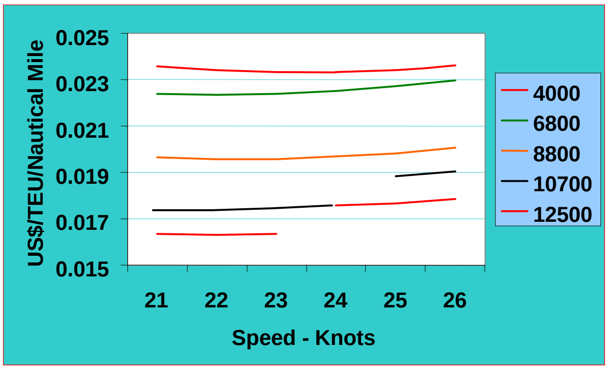

Figure 18 - At-Sea Slot-Mile Costs

In addition, there are cost and operational penalties for these vessels when in port. We have also examined these issues in some detail.

4.3 Container Terminals & ULCS Operations

Scale economies are beneficial when the vessel is at sea; when in port the capital costs continue to mount up. As a result, speed of container handling is of critical importance. Other concerns with regard to stockyard capacity and onward hinterland links represent only a slight modification of the current position. To translate these costs levels into actual trades it is essential to assess the effective possible port turnaround times for such vessels. This requires a review of the terminal sector.

By reviewing crane and terminal productivity and the scope for faster handling, possible ULCS port turnaround times have been identified.

- **Scope for Faster Container Handling**

There is scope to accelerate significantly the rate of container handling:

- Further automation of cranes, improvements in anti-sway and anti-snag systems, integration of the gantry cycle with other automated yard systems.
- Twin-lift spreaders boosting 20’ handling rates.
- Faster hoist speeds and trolleys.
- Multiple trolleys.
- Use of additional cranes.

We have undertaken a major review of crane and yard productivity in the light of planned technical developments and have identified considerable potential for further acceleration in handling rates. Some technical solutions offer the capability to rapidly further develop terminal productivity and - when these are linked to the possibility to apply even more gantry cranes to a vessel with ULCS dimensions - this generates greatly improved scope. It should become possible to offer an hourly rate for container handling with 8,000TEU vessels of some 170 moves per hour in the most efficient terminals.

For the ULCS, rates of up to 280 moves per hour could be achievable under favourable circumstances. However, we have downrated this to a level of 220 moves per hour as the sustainable rates assumed for ULCS operations.

- **Container Yard**

The linkages between the quay and the yard are more problematic but a review suggests that these can also be accelerated. Terminal automation is still in its early stages. Automatic Guided Vehicle (AGV) systems of various configurations are operational and now indicate the scope for considerable cycle acceleration.

In the container yard, improved space utilisation can be achieved by higher stacking of containers, with automation reducing the negative effects of this approach.

The access of containers to/from the terminal can also be improved. For road operations improved gate technologies are accelerating rapidly and increased intermodal investment will see rail and barge systems take a larger market share.

'Dwell Time' - the time a container is in the yard - is a further constraint. The longer the dwell time the fewer containers that can be handled in a period. This is primarily a 'market' factor but there is clear scope - especially in Europe - to significantly reduce this.

- **Consignment Sizes & Turnaround Times**

Consignment size is critical for turnaround time of container ships and depends on how many ports they visit in the trading route. If 10,000 containers are handled for ULCS then a turnaround port time of some 45 hours is generated with a significant improvement in terminal productivity. If 7,000 containers then 32 hours.

4.4 ULCS Trading Route

Having considered the costs and port times associated with introduction of ULCS vessels it is possible to define the annual costs associated with such operations.

Firstly, the question must be 'where will these vessels trade?'. Clearly the options are limited and a review of volumes, growth potential and port capabilities indicates that the Asia-Europe trade will be central. This will either be on a shortened basis linking the ASEAN with North European hubs or extended to east Asia and including transshipment at hub ports in the Indian Ocean and the Mediterranean. Further scope has been identified on the Transpacific trades, although the options here are restricted by the water depth at most US ports. An opportunity has been identified including Los Angeles and Vancouver as ULCS ports.

In addition, these trades can be further linked together by means of 'pendulum' operations, although the degree to which the transatlantic trades could be included remains uncertain.

- **Trading Cost**

A series of voyage and service cost analyses has been developed that identify the vessel costs associated with shipping containers on these trades. Figure 19 illustrates the direct comparative vessel costs involved in shipping a forty foot container between Singapore and Rotterdam, with vessels trading at 25 knots. In order to achieve this service it is necessary to develop capital costs for the larger vessels on the basis of twin engine designs. This data factors-in the fact that larger vessels will offer fewer voyages per annum, given their longer port times. A clear advantage is identified between the 6,800TEU and 8,800TEU shipping systems, with a shift to this size range generating a cost saving of nearly 12 per cent. A further saving of over 9 per cent is generated when a 12,500TEU vessel is utilised - even given the fact that a twin engine design is necessary.

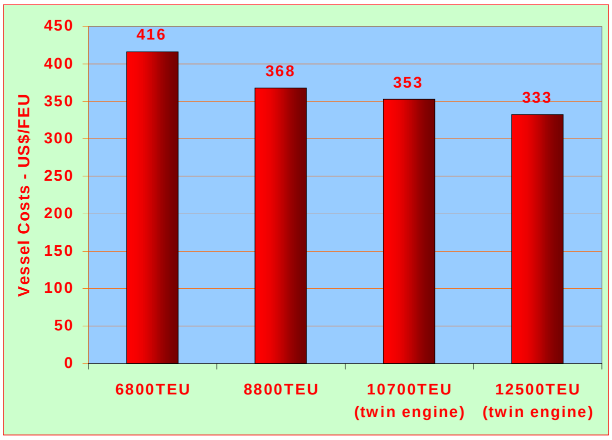

Figure 19 - Comparative Costs: Asia to Europe - direct comparison at 25 knots

A further shipping cost analysis has been made, Figure 20, for 6,800TEU and 8,800TEU vessels at a ship speed of 25 knots and for 10,700TEU ULCS and 12,500TEU ULCS at a ship speed of 24 knots, and 23 knots which can be achieved with single engines. Although annual transport capacity is, of course, reduced, significant

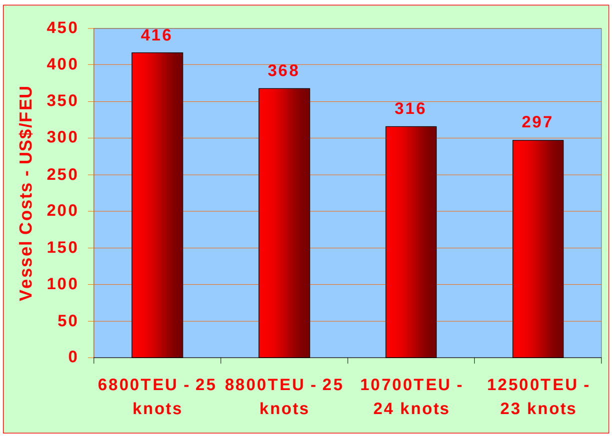

Figure 20 - Comparative Costs: Asia to Europe - cheapest annualised transport costs

additional savings are generated by adopting a single engine. A 12,500TEU vessel at a speed of 23 knots generates a cost saving of more than 19 per cent over a 8,800TEU unit at 25 knots. There will, of course, be some time penalties incurred but - if port calls can be reduced further - then a considerable market opportunity is identified for this option.

In summary, is it clear that 12,500TEU vessels offer marginal savings at 25 knots but very significant potential savings at 23 knots. This represents a valid option for the very highest volume operators.

- **Cost/Benefit Analysis**

In summary, ULCS vessels will have some penalties:

- Slower port turnaround - although these should be minimised.
- Reduced flexibility of employment.
- A much higher capital commitment.

However, analysis of each component indicates that these difficulties do not outweigh the major cost advantages with these vessels. Indeed, a reasonable review of market developments indicates that these units can be physically handled at diverse ports, be turned around in an acceptable period and generate significant cost savings.

4.5 ULCS Fleet Development

Timing the introduction of new generations of vessels is very difficult. However, an attempt has been made for the next few years.

These vessels will only be employed on the Asia-Europe, Transpacific and Pendulum trades. By identifying demand growth, and making an assumption as to the market share of further demand that could be secured by these vessels, a range of possible fleet development can be estimated.

Between 1998/2012 container volumes will increase by around 105 per cent transpacific and by nearly 100 per cent on the Asia-Europe trades.

If 40% of this additional demand is handled by ULCS before 2008 and 60% after this date then a significant fleet is indicated. We estimate that between 20/24 units could be trading over this period.

Given the market factors discussed above, the prognosis for introduction of this new fleet is as follows:

In the short term 9,000TEU vessels will be introduced on the Asia-Europe and Transpacific trades. Competitive pressures will force owners to commit to these investments to maintain competitive position. These vessels will only slightly modify current port rotations, the general pattern remaining at least three port calls in Europe and in Asia. On the transpacific, water depth restrictions on the West Coast may limit deployments. Trading speeds at up to 25 knots will be maintained - unless there is a further increase in bunker prices.

In the longer term - probably in the second half of this decade - the next scale economy step will be taken. Vessels of up to 12,500TEU will be introduced. Two options will be noted:

- Slower units with a single engine calling at fewer ports. For a competitive service to be offered dedicated terminals and controlled feeder systems will be necessary to maintain competitive through-transit times versus faster vessels with multi-port itineraries.
- Twin-engine vessels are another option - there are significant cost savings even with these vessels although the cost advantages are more restricted.

5. Conclusion

The OSC study has concluded that ULCS generates considerable savings and can be economically handled in the terminals and, therefore, that the container shipping industry may well be looking, within the next 5-10 years, for ULCS vessels with a capacity of around 10,700 - 12,500TEU at ship speeds of 23-24 knots, viable with single engines.

Our concept study has not identified any major obstacles to the development of ships of this size, at least from structural and powering aspects.

We therefore conclude that such ships will be built in the near future.

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