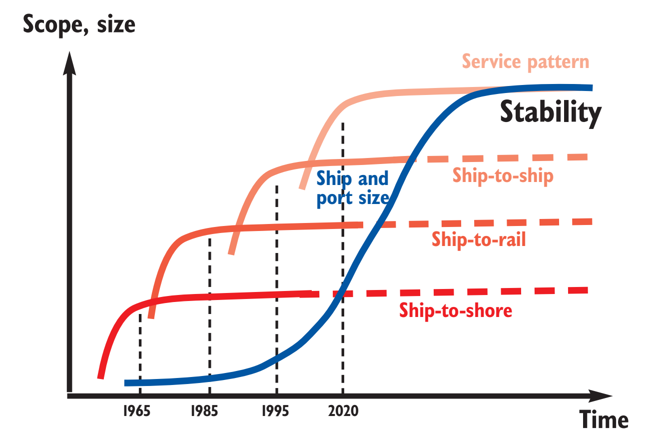
Revolution now!

Following two articles published in *Containerisation International* two years ago*, **Dr Asaf Ashar** addresses two related issues: the need to coordinate the development of ships and ports, and the possible differentiation between two container-shipping systems – a standard (existing) and a specialised system. He also looks at the main features of the specialised system.

The development of the liner shipping system can be characterised as both an evolutionary and revolutionary mixture. As illustrated in Fig 1, the evolution is in the size of the system's main components, ships and ports; the revolution refers to expansion in the system's scope and the related changes in the system's links.

The evolution is depicted by the blue line in the figure; the revolution by the red. The revolution line is composed of several short overriding segments. The first relates to the change in ship-to-shore transfer, introducing containers; the second to the intermodal expansion via landbridges; and the third to the transhipment expansion that created a stratified network of direct and feeder shipping services.

FIG 1: EVOLUTION AND REVOLUTION IN LINER SHIPPING



The evolution has recently reached an advanced stage, whereby the second generation of post-panamax ships, referred hereafter to as Post II, have a capacity of 8,000TEU and are rumored to soon grow to 10,000TEU. Larger ships of up to 18,000TEU are being extensively studied. The author suggests that post-panamax container ships should be classified according to their relationship to Panama Canal locks, discarding the older classification based on TEU capacity and a more recent one that includes superlatives such as 'super post-panamax', 'mega-ships' etc. The most restricting dimension of current locks is their width, equivalent to 13 rows of containers.

Accordingly, Post I would be defined as ships with 14 to 15 rows across, such as APL's 15-wide, 4,340TEU vessels; Post II tonnage would be 16 to 18 containers wide, for example, Maersk Sealand's 17-wide, 8,200TEU ships; and Post III 19 to 22 containers wide. The table shows the typical dimensions of these ships, including the new-panamax (NPX), expected to determine the dimensions of the next generation of containerships, the Post III.

The third revolution, which is still unfolding, completes the expansion of the system's scope; and the fourth is predicted to restructure it. The fourth revolution centres on the emergence of new global service patterns driven by network economies. Network theory suggests that the most efficient east/west service pattern is the equatorial round-the-world (ERTW), following the 'beltway' of the world.

ERTW needs only 6 x 15,000TEU (NPX) ships per string, assuming it only calls at seven pure transhipment ports (PTPs). Since ERTW simultaneously serves all east/west trades, it can employ the largest and most cost-effective ships on the shortest route, and with the highest frequency. The ERTW is expected to bring about a hierarchical 'global grid' of east/west, north/south and regional services, illustrated in Fig 2.

The fourth revolution is expected to be triggered by the expansion of the Panama Canal. The expansion is already under extensive study and, if found viable, a new series of locks and the related NPX ship standard will be in operation in 2010. All east/west trade served by the ERTW is expected to undergo at least two transhipments, with some boxes being transhipped up to four times (regional – north/south – east/west – north/south – regional, as in Fig 2). Transhipment of this magnitude is uneconomical using existing land-based terminals and transfer technologies. Hence, the revolution depends on two equally important factors: expansion of the Panama Canal and a paradigm shift in ship-to-ship transfer technology.

ERTW will not handle all the east/west trade but, perhaps, about half of it. The rest is likely to continue utilising existing service patterns, especially the so-called 'pendulums' which are, in fact, round-the-world services missing one leg. These pendulums, although based on direct calls, will also involve extensive transhipment. Hence, it is quite likely that the transhipment technologies discussed below may also be adopted by non-ERTW transhipment ports.

The fourth revolution is expected to be the final one, as illustrated in Fig 1, at the end of which the system will reach a stage of long-term stability. No further restructuring of service patterns or, perhaps, reversal of the global grid, is expected. This is simply because an ERTW-based shipping system is the most efficient possible, barring radical changes in cargo flows or ship technology. As to the latter, there is a trend toward smaller and faster ships (eg semi-planing, multi-hull), although they are five to 10 times more expensive than ships of conventional design. The faster ships may thus only have a very limited application, mainly for shorter routes and high-value cargoes currently handled by air transport.

While no fifth revolution is expected in the foreseeable future, there is still a question regarding the size of the system's components at the ultimate settling point of the evolution line. The effectiveness of any shipping system is predicated on a coordinated development of its two components: the ship and the port. Ships cannot dictate to ports and ports cannot force ships – neither is a leader nor a follower, both are equal participants in the same shipping system. Desirably (but not necessarily), their coordinated development should settle at the point whereby the system cost, as the combined cost of the ship and port, is at its minimum.

The two components of the shipping system have different cost characteristics. Larger ships have lower costs, while the ports needed to serve these ships have higher costs. Ships' economies dwindle quickly as they grow beyond Post II.

***(see *Containerisation International*, December 1999, 'The fourth revolution' pp57-61, and January 2000, '2020 vision' pp35-39.)**

However, ports' diseconomies accelerate as terminals are enlarged to handle the larger ships. Naturally, at some point, the gains in ships' costs fail to compensate for the additional expenses in ports' costs. Beyond this point, as illustrated in Fig 3, the entire shipping system switches from scale economies to scale diseconomies. The system's cost realities are acknowledged by the ship building industry. For example, Dr Hans Payer, member of the executive board of Germanischer Lloyd, which is the largest classification society for container ships, has said: 'It is doubtful that the economy of scale (in ship size) can be carried on indefinitely.'

No comprehensive research has yet been undertaken to explore the peculiarities of the system cost of container shipping and to determine the optimal size of its components. It appears that the minimum system cost point is reached at ships of 8,000TEU, or at the mid-range of Post II ships, with a fully-loaded draught of about 14.5m, requiring channel depth of about 15.2m (50ft).

There is some evidence that this indeed is the system's optimum. For example, Professor Wijnolst's study of the 18,000TEU Malacamax calculates that on the longest east/west trade between Asia and Europe, increasing ship size by 50%, from 8,000 to 12,000TEU (Suezmax), results in cost savings of US$20/TEU. A similar saving is realised when the size increases an additional 50%, from 12,000TEU to 18,000TEU. The 18,000TEU ship requires a channel depth of 22m (72 ft). The port of New York estimates that increasing its channel depth from the present 13.7m to 15.2m (45ft to 50ft) would cost $1.5 billion.

Using rough extrapolation, the cost to further dredge New York to 22m could reach $7 billion! Assuming the total throughput of New York is doubled from the present 3 million to 6 million TEU/year, and taking 8% per annum for costs of capital recovery and maintenance dredging, the channel cost will average about a $100/TEU ($7 billion x 8% / 6 million TEU). If only half of New York's throughput comes on such large ships, the channel cost of this half will double to $200/TEU, or 10 times the savings in ship cost! New York is not alone in its dredging predicament. Huge dredging costs, far beyond any conceivable savings in ship costs, are also expected in Savannah, Charleston, Antwerp, Hamburg, Bremenhaven, Felixstowe, Shanghai, and many other ports worldwide.

Expansion of the Panama Canal's locks to accommodate Malacamax ships would be even costlier (if possible at all). The above costs did not include the required rehabilitation and expansion of shore-based terminals to handle these ships, along with the expansion of respective road and rail infrastructure. There are also immense environmental impacts and their respective mitigation costs.

SHIPS' CHARACTERISTICS

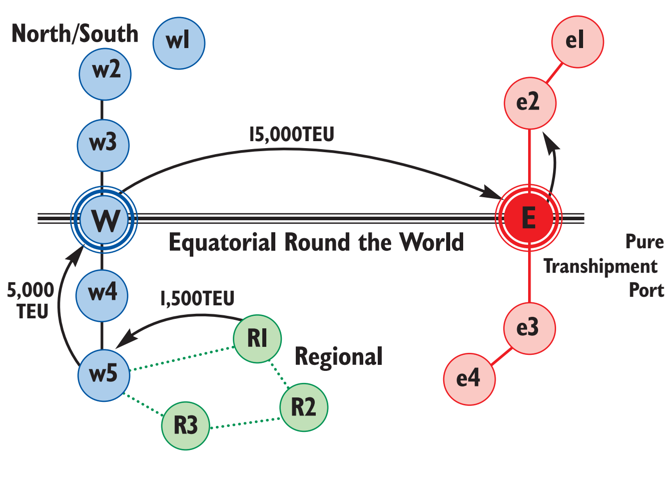
Design	Capacity (TEU)	Length x (m)	Beam x (m)	Draught (m)	Arrangement (rows)
Panamax	4 500	295	32.3	12	8/5/13
Maersk Sealand S-class	7 500	347	42.8	14.5	9/6/17
Samsung	9 200	340	45.6	14.5	10/6/18
Maersk Sealand 'Rumour'	10 500	404	51	14.5	10/6/20
Malacamax	18 000	396	60	21	13/8/23
New-panamax	12-15 000	385	55.2	14.5	9/10 - 6 - 22

Source: Ocean carriers

There is an interesting institutional angle to the problem of ship-port interaction. Port infrastructure is mostly provided by public, tax-supported port authorities and related governmental agencies. Investing public monies in larger port facilities is justified by savings in overall shipping costs that benefit the public at large. There is no point in such investments if the result is a higher system cost. Put differently, public investments in ports and related infrastructures, such as access channels, land reclamation, access road and rail, should be guided solely by the broader public interest and not by that of one party.

The large ships of the future are expected to call mainly at transhipment hubs. Transhipment, or ship-to-ship transfer, is essentially an internal activity of ocean carriers. This is particularly the case when both mothership and feedership belong to the same line. These ports function as private ports and should not be developed by public monies. This new reality has recently been demonstrated in the US with Maersk Sealand electing to develop its Norfolk hub on private land, outside the Virginia Port Authority; and SSA/Americana choosing Texas City, outside the public Port of Houston.

FIG 2: GLOBAL GRID



Containerisation, from its early stage, was involved in unprecedented worldwide coordination and cooperation. The size and weight of boxes were determined by voluntary agreements to allow all ports the use of standard handling equipment. It seems that it is now appropriate for port and maritime authorities, along with respective governmental agencies, to get together and establish a global organisation ('World Maritime Council') that, in turn, agrees on the dimensions of channels, ports and container ships. If, indeed, the system cost reaches its minimum at 8,000TEU, the agreed international standard for access channel should be for a 15.2m (50ft) draught and the respective width and turning angles. A timely agreement could save the costs associated with uncertainty and mistakes, benefiting all participants.

It should be emphasised that coordination on channel dimensions is not intended to limit competition between ports and lines, but to guide it into the range whereby its results are beneficial to the public at large. A revealing comparison is with a public works department that regulates the dimensions of public roads and trucks, while not interfering with the competition among truck operators on these roads.

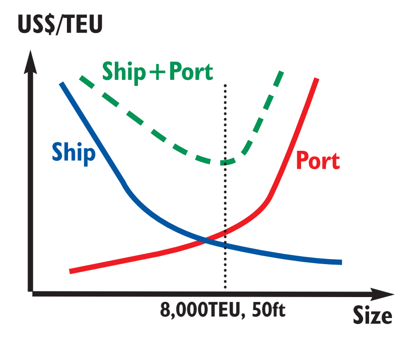
As seen in Fig 3, while system cost increases beyond the 8,000TEU range, ship cost continues to decrease, though at a slower pace. Larger ships have a lower operating cost (mainly due to savings in fuel consumption and labour), construction cost (deeper and wider ships are cheaper to expand as demonstrated by bulkers), propulsion cost (deeper draught allows larger and more efficient propellers), etc. Hence, some ocean carriers may opt to disregard the recommended standards and operate large, 'non-standard' ships.

A possible policy adopted by a World Maritime Council could be to limit non-standard ships to non-standard or specialised ports, to be developed by the carriers at their expense. In line with fourth revolution theory, these ports may be located on the equatorial route and will be dedicated to transhipment and defined as pure transhipment ports. But even if the revolution and the related ERTW fail to materialise, it is logical to assume that the non-standard, large ships will mainly call at transhipment hubs invoking massive ship-to-ship activity.

The result will be the creation of a differentiated shipping system, consisting of a standard system, based on standard ships calling at publicly-supported, shore-based ports; and a specialised system, based on very large ships calling at proprietary, specialised ports geared toward transhipment. The possible characteristics of the non-standard systems are discussed below.

The present layout of the most advanced

FIG 3: SHIPPING SYSTEM COST



shore-based transhipment ports cannot cope with the massive ship-to-ship transfer activity expected in the future for pure transhipment ports. Presently, the box is first moved from mothership to yard, 'buried' there in a nine-high stack served by bridge cranes. Then, 'unburied' and transported by prime-movers to a feedership berthed far from the originating mothership. If all transfers in the future pure transhipment port are between ships, why not avoid the yard and the cumbersome land transport to/from stack? A 'natural' way of moving boxes between ships is by water.

Fig 4 presents a conceptual cross-section of a floating terminal with two-sided handling. To avoid lashing, the pontoons may be equipped with a cellular structure, turning the ship-to-pontoon handling into a fast cell-to-cell transfer. The ship-to-ship transfer process is quite simple: the boxes are first moved from the mothership onto floating pontoons, with each pontoon holding boxes destined to one feedership or even one port. For example, in a Gibraltar pure transhipment port the mothership can discharge the boxes destined to the North Continent feeder onto pontoons classified by port: Antwerp, Rotterdam, Hamburg etc. Other boxes could be discharged to the UK, Baltic, North Africa, western Mediterranean feeders, etc. The pontoons can be moved either to a temporary storage (fleeting) area, or directly to the feederships.

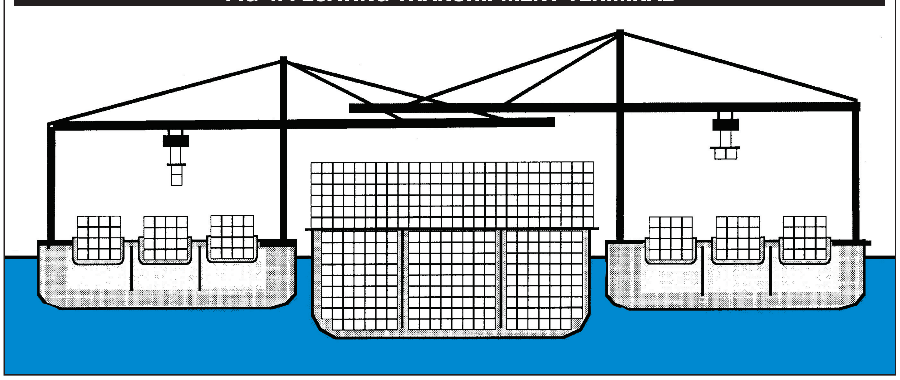
The pontoons of the floating system have a dual role, serving as both transport vehicles and a floating storage yard. They replace the entire system of yard cranes, prime movers, storage stacks, and respective waterfront areas of present shore-based terminals. A preliminary assumption regarding the pontoon dimensions is the use of barges similar to the popular so-called Jumbo barge of the US inland waterway system (195ft x 35ft x 9ft and 1,500dwt), which may hold 128TEU (4 x 4 x 8). They could be designed for quick linkage in a train-like fashion, so that a single tug could tow a train of 4 pontoons with 512TEU, making the ship-to-ship transport quite economical. The 'floating train' could shuttle periodically between mother vessels, feeders and fleeting areas for pick-up and drop-off of pontoons.

Using water for transporting boxes between ships has another advantage. The floating transhipment terminal, unlike present shore-based terminals, is less sensitive to the distance between mother and feeder ships. Hence, mother and feeder terminals can be constructed in different locations and according to different specifications of channel depth, crane dimensions, etc, resulting in significant savings. The mother terminal can be located in natural deepwater bays to reduce dredging costs.

The floating terminal system inverts the notion of a port. Instead of ships coming to port, the port is 'coming to ships.' Another radical change allowed by the pontoon-based ship-to-ship transfer is the handling of multi-box units. A modest beginning could be based on special inter-box connectors to create blocks of 4TEU (see Fig 4). This could dramatically enhance productivity and reduce the number of cranes required to work the ship, although the size of cranes needs to increase. For example, productivity of 400TEU/hour could be achieved by six cranes working at 16 cycles/hour, lifting 4TEU/cycle (6 x 16 x 4).

A bolder option allowed by the floating design is the formation of larger multi-box units similar to the LASH (Lighter Aboard Ship). The ERTW containerships could carry 'packets' of 32TEU (4 x 4 x 2, 350 tons, assuming an average of 10 tons/TEU plus frame) 'framed' together. However, unlike LASH, the proposed ships will not carry barges onboard and will be gearless, since the gantry cranes will be installed at the floating terminals. Assuming an average cycle time of six minutes (10 cycles/hour) and four cranes per ship, the handling productivity could reach 1,280TEU/hour (32 x 4 x 10). Accordingly, a 15,000TEU ship, handling half of its boxes at a pure transhipment port, could be handled within 12 hours.

FIG 4: FLOATING TRANSHIPMENT TERMINAL



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Floating terminals may appear radically different from current land-based terminals. However, there are several notable examples of floating terminals already in operation. The mid-stream transfer of containers in Hong Kong is based on floating derricks mounted on barges with capacities of 60TEU to 100TEU. Typically, four barges are assigned to a mothership (two on each side) with combined productivity of 60 moves/hour. The low productivity can be attributed to the low-tech cranes and the unprotected water. Nevertheless, Hong Kong's midstream barges are currently handling more than 3 million TEU per year.

Large-capacity, general-purpose floating cranes are also available in many ports. Likewise, there are many heavy-lift ships equipped with large cranes. For example, recently a Jumbo 1600 ship was launched, equipped with two cranes, each with a lifting capacity of 800 tons at 28m.

Therefore, the development of the container shipping system has reached the point where size economies are turning into diseconomies. Participants, especially ports and ocean carriers, are aware of this change and are consequently looking for guidance. A voluntary, industry-based council could provide such guidance in the form of an agreed-upon set of dimensional standards for ships and ports.

Lines may disregard these standards and elect to operate non-standard, large ships. In this case, they should also provide their own proprietary terminals to handle these ships. The non-standard ships are likely to only call at transhipment hubs, including the pure transhipments ports of the ERTW which are expected to emerge following the fourth revolution. The present shore-based configuration of container terminals is unsuitable for massive transhipment. It may be replaced by a floating configuration, using pontoons to store and transport boxes, and 300-ton floating cranes for lifting multi-box units.

The result would be a differentiation between two complementary shipping systems. A standard system, based on standard ships and standard shore-based ports geared toward ship-to-shore transfer, and a specialised system, based on larger ships and floating ports geared toward ship-to-ship transfer.