Background Paper for TOC Conference Hong Kong 20-22 February 2001

Next Generation Berth and Yard Layout

by Gordon Rankine – *director Beckett Rankine Partnership, London*

Container Terminals Today

The movement of containers around the world has increased steadily since their introduction in 1960/1970s. After an uncertain start, terminals have gone through a steady evolutionary process to keep pace with demands from the major shipping lines who are their main customers.

The present position is that terminals are operating effectively with efficient arrangements for handling containers from the ship at the berth through the container yard and to the road and rail links connecting to their hinterland. The technology is tried and tested, equipment has been designed for economy and then mass-produced – it all works well and is now a low-risk technology.

To date, terminals have always managed to keep just ahead of the shippers' requirements by introducing more berths and bigger cranes at the appropriate time. However with containerisation now increasing penetration into the biggest markets, and in particular China's 20/30 % annual growth and approaching WTO agreement, a significant increase in world wide container trade can be expected.

We continue to see terminals around the world competing with one another for the large shipping lines to call. Even now it is a very competitive business with shippers looking for best ports of call for their service. Even the largest and most efficient ports are not immune from this transient position, for example Singapore has recently suffered from a large move of cargo to a nearby competing port.

It is only natural therefore that many ports are looking to move forward development plans for new sites just to demonstrate to their customers that they will have competitive facilities available for the foreseeable future.

Another factor to consider is that the evolutionary container terminal development process is approaching maturity of the present concepts:

- While it is technically feasibility to fabricate even larger quayside gantry cranes the efficiency of operating on a cantilever of over 60 metres is questionable, with crane cycle times showing little change over the years (see Figure 1).

- Container yard storage with a density greater than the present maximum of 1 over 5 and in rows 7 wide would result in an excessive number of unnecessary box moves.

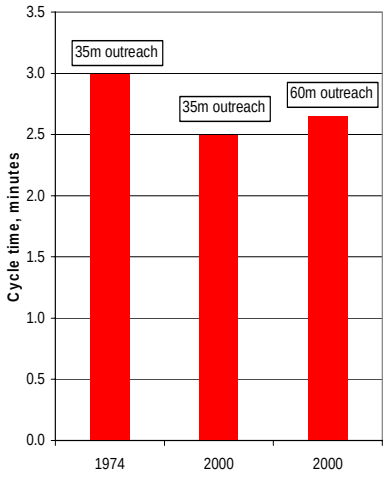

Figure 1. Ship-to-shore Container Crane Cycle Times

Yes, we can keep squeezing to improve throughput but without the introduction of new concepts it is most likely that the ship terminals will become the pinch point in the system – holding back greater efficiencies that can be introduced to the supply chain for containers for the benefit of world trade.

The World Market

The worldwide trade of goods by container is expanding quickly. A global 8% growth in 1998 was followed by an 11% growth in 1999 (Reference 1). This is substantially driven by the dynamics of the largest markets for example China. Many predictions have been made for future trends in container trade; developments in the global marketplace indicate a likelihood that the present rate of growth is largely sustainable with about two-thirds of growth in the near future focussed on markets in Western Europe, South East Asia and the Far East.

It is reasonable to assume that the container volumes will double at some stage in the next few years. This will occur within ten years with average growth continuing at a slightly lower level of 7%.

This points towards doubling of the number of ship slots and doubling the quantum of port infrastructure in this timeframe in order to maintain the present status quo of utilisation to capacity. Clearly the distribution will be uneven around the world with a doubling of capacity needed even more quickly in China and less quickly in the US and other places where the facilities are already more developed.

Shipping Lines

There has been much discussion on how shipping lines will address the projected increase in demand for container movements. The resulting decisions will be enormously relevant to planning for the development of the next generation of container terminals. Many consider that there will be a focussed development of a relatively small number of very large ports at strategic locations around the globe, serviced through a fleet of very large ships together with an increase in the proportion of transhipment cargo. While expansion of this hub and spoke system can reasonably be expected we should not forget that there will also be a substantial increase in direct calls that will cater for long distance, inter-continental trade without the need for transhipment.

Inevitably the shipping companies will have to continue their heavy investment in new tonnage to keep pace. While it is possible that they will build more vessels of the same size as at present it is more likely that they will develop larger vessels in the quest to improve levels of service and to increase profitability (see Figure 2). There are two important points to consider from the port development viewpoint:

- Pressure from the market place will demand that these larger vessels will have to deliver containers more quickly and for less cost than at present.

- When shipping companies introduce larger vessels this is likely to occur in significant steps i.e. from 6,000TEU to 9,000TEU, because it would not be economical to go through the development process for a new ship only for a small increase in capacity.

The advances in ship technology are therefore also relevant to the planning of future container terminals. The technology exists for significantly larger ships to be introduced on the main trade routes. When the issues relating to engine selection have been resolved, larger vessels with a capacity of say 12,500TEU are likely to enter service. Still larger vessels with a capacity of 18,000 TEU are even being spoken of. It is quite feasible that the introduction of bigger vessels could lead

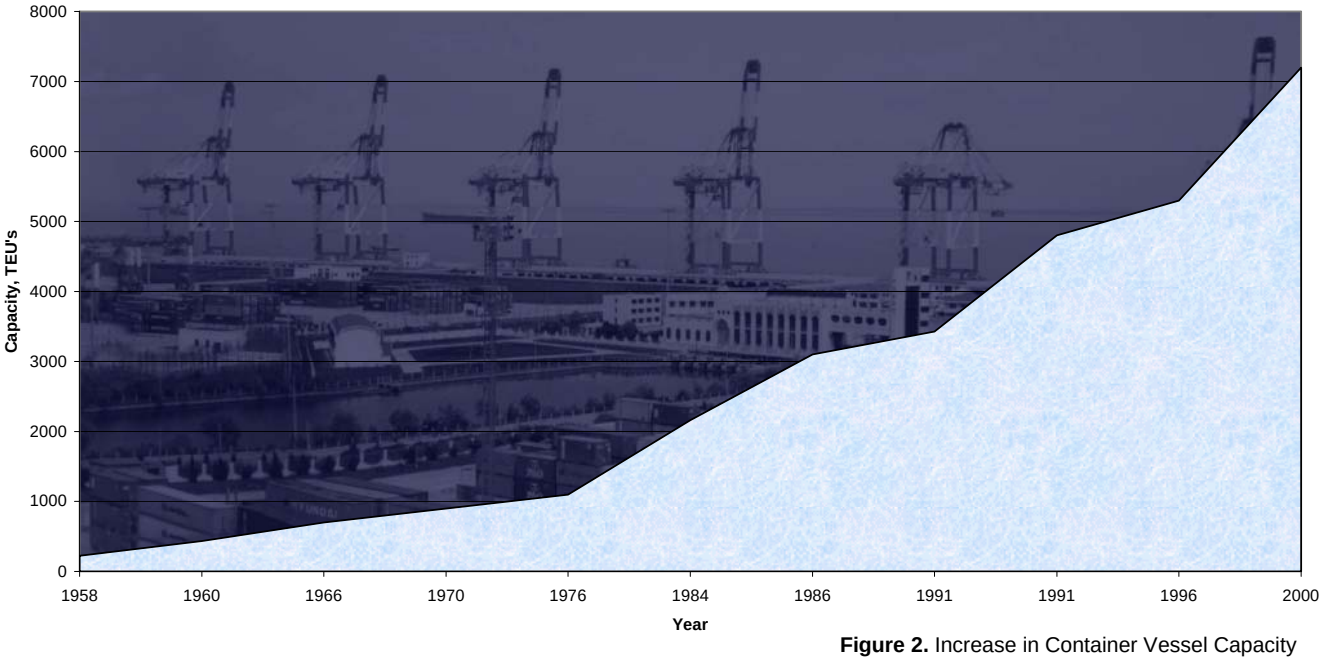

Figure 2. Increase in Container Vessel Capacity

to faster delivery and lower cost journeys. However, for this to work it will be necessary for the ports of call to be fully capable of handling these vessels quicker and for a lower unit cost than at present.

Simple economics of the cost to the consumer will ultimately dictate, but the detail of how this will happen is not yet clear. However, what is clear is that if the new larger vessels plying the routes between terminals in the hub network do not perform both in terms of time and cost then the consumers will turn to the vessels on the direct call routes, probably using present day vessel sizes. Here the importance of time should not be underestimated – examination of the container movements in Southern China through the Hong Kong and Shenzhen area shows a surprising willingness for consumers to pay a premium for a better (i.e. quicker) service for export to the world markets.

This sets up a challenge for the entire industry. With ports being the largest single cost item for liner operators it is critical that the huge investments needed to satisfy demand are introduced in the most efficient way. This will require full co-operation between various parts of the industry.

Next Generation Terminals

Terminal operators now face a twofold challenge, that is:

- How to provide facilities to accommodate an increased throughput of containers of the order of a doubling in capacity over ten years;
- How to handle the larger volumes of container transfer from each of the prospective larger vessels and yet to turn the ship around at least as quickly as at present and for a lower unit cost.

These are quite separate issues and will be dealt with differently at individual ports. The volume increase issue will face most terminals around the world to a greater or lesser extent. However the vessel size issue will be a greater focus for those ports brave enough to set themselves up as the hub ports of the future.

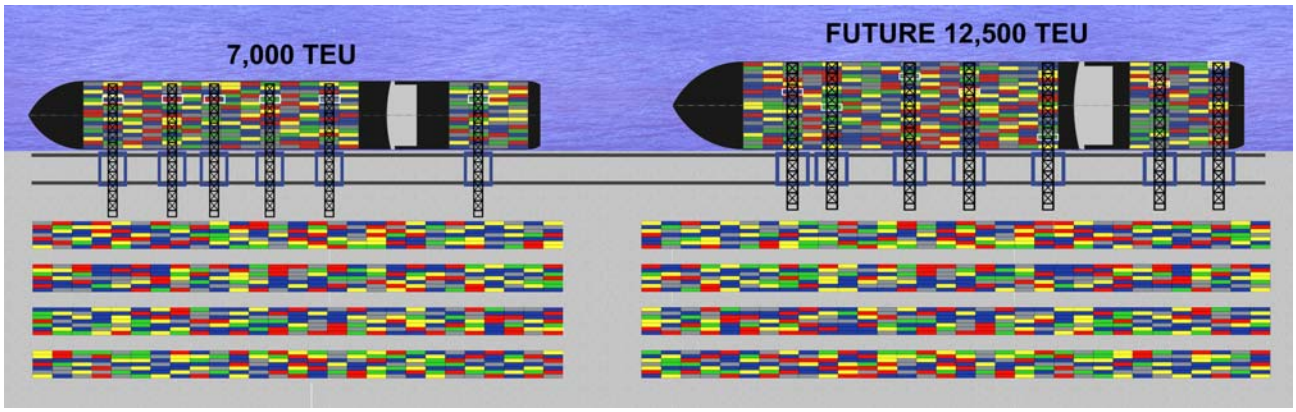

Figure 3. A Conventional Container Terminal

At some port locations it will be possible to introduce the new facilities at their present site by converting or extending berths. However for many it will be necessary to develop new sites. Each case is different but in general terms the advantages of sticking with existing port sites are that existing infrastructure can be used with marginal improvements such as deepening channels as necessary. For example:

- Continuing use of deep water for shipping together with established approach channels;
- Breakwaters and other high cost infrastructure are already in place for protection of berths from adverse weather conditions;
- Road/rail links are well established;
- Re-development of existing port sites is environmentally more acceptable.

Unfortunately some ports are already hemmed in and will simply not have enough land for yard development or even space for new berths. In those cases large terminals will have to be constructed at new port sites. However every effort should be made to encourage the redevelopment of existing port sites because, in overall terms, this should be more economical and more attractive in terms of the environment. In some countries there is increasing governmental pressure for the redevelopment of brown field sites.

The "Conventional" Approach

If we consider that the concept of doubling the worldwide container traffic is to be successfully accomplished using the conventional port handling systems that are currently in widespread usage, it soon becomes apparent that the total available number of berths will have to be increased dramatically. On the assumption that evolution of the present techniques will develop further through a combination of improvements to cranes yard stacking and operational efficiencies, this could give an improvement of say 10% in throughput achievable at each berth. Further berths will have to be constructed to provide to accommodate the additional new demand. This will equate to about 40% of the major berths that are currently in use.

Continued utilisation of the favoured straight-line berth layout would call for a considerable demand for new land and there are few ports that would be able to identify adequate land from their own site. Refurbishment of old breakbulk quays may be an option, although this is difficult in many cases because of the deeper water and greater yard space that is needed.

A conventional layout is shown in Figure 3.

The requirements for overall throughput do not take account of the additional need for hub ports to provide facilities for larger ships as discussed above. Specifically there will be the desire to

transfer all of the cargo between these vessels and the shore at least as quickly as at present even if, as seems likely, ships are introduced on the main trade routes that are significantly larger than at present.

The number of containers that have to be transferred to and from an individual ship at any particular hub port will obviously be greater for the larger ship, possibly more than by the direct ratio of ship sizes because of the increase in transhipment caused by the improved service. For example with the introduction of a 9,000TEU vessel the jump would be about 25% from today's largest vessels. A productivity improvement of at least 25% will therefore be needed in order just to keep pace with present day turnaround times for the ship. This will be difficult to achieve using conventional berth and yard layout.

Let us consider the arrangement of these new bigger vessels – will they be longer, wider or deeper? Probably all three is the answer. What does this mean for the conventional port?

If the new vessels are longer then an existing straight-line quay will accommodate fewer vessels simultaneously. These berths will therefore have to be lengthened and additional cranes procured to increase the capacity.

If the new vessels are wider it will be necessary to introduce new cranes with greater outreach – this has been done before and no doubt it can be done again. However there are a few points worth noting:

- These cranes will have a greater outreach and therefore the trolley will have to travel a greater distance in order to handle the outermost boxes;
- Loads on the seaside bogeys increase considerably with greater outreach – this may result in a requirement to strengthen the quay.

These factors contribute to making the handling process more time consuming and more costly. So it will be necessary for improved technology to be introduced simply to maintain the status quo.

If the vessel is deeper the handling operations would not be significantly affected, assuming that there is enough water depth for the vessel to be berthed alongside.

Access to the berths from the sea is also an issue but not discussed here because this is likely to be achievable at most major ports and is not dependent on the type of berthing layout that is to be adopted. This will come into the discussion at ports where the layout is such that new berths cannot be accommodated at the present location and that new berths have to be developed at a new site.

Turning to the container storage yard, it will clearly be necessary to provide a sufficient amount of compatible storage that can be accessed quickly enough to at least match the ship handling. For many terminals this will require additional yard area or higher stacking arrangements. The required amount of land may not be readily available close to the berth. Schemes are already being promoted for direct transfer to containers trains at the berth – simply to clear the congestion in this area.

The "Next Generation" Approach

In order to truly move forward to a next generation for the berth and yard layout two key issues have to be addressed, these are:

- How to turnaround the larger next generation of container ship at least as quickly as at present and with lower unit cost than present operations.
- How to make more efficient use of increasingly scarce land areas available for port use.

As far as speeding up the ship turnaround is concerned the most significant factor is the number of cranes that can work on the ship simultaneously and effectively. Time taken for each cycle is also relevant but has a lesser effect while multiple lifting arrangements are also beneficial.

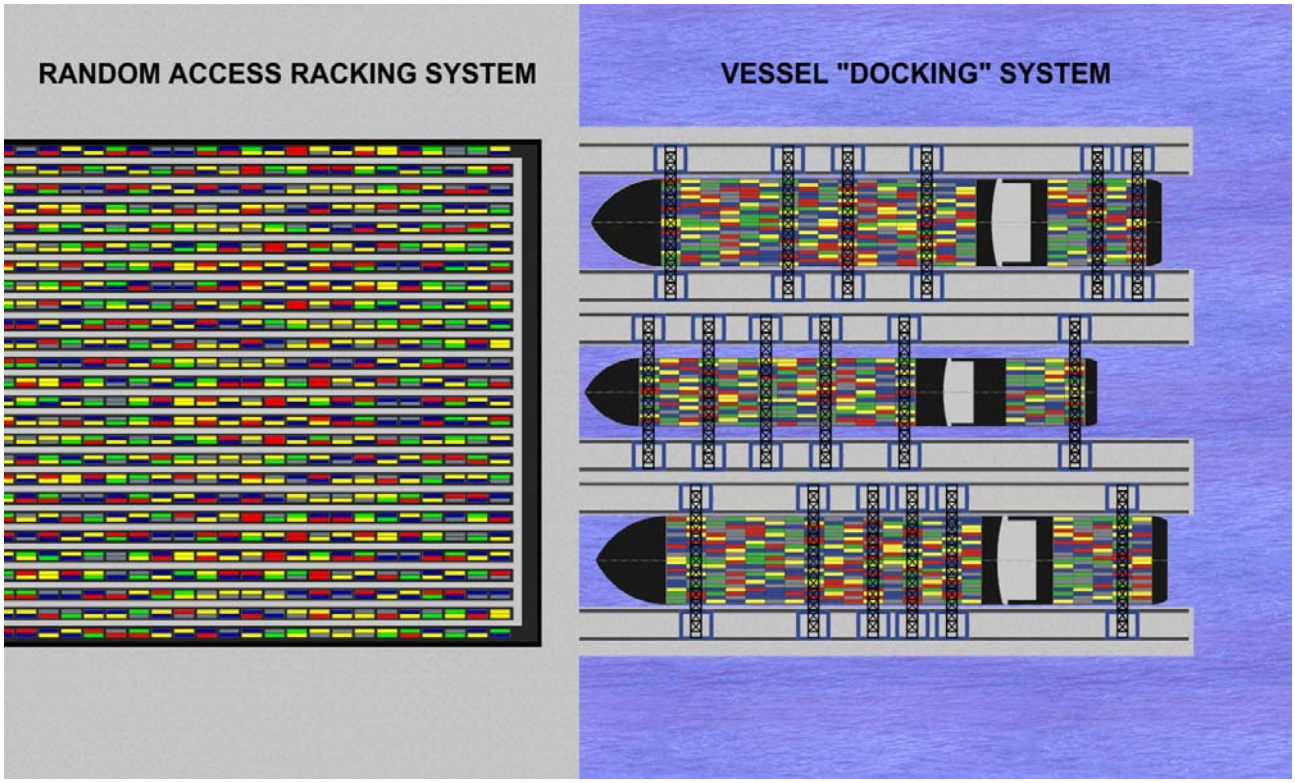

Figure 4. The "Docking" Container Terminal

Increasing the efficiency of land utilisation inevitably means stacking containers higher in an arrangement that is close and readily accessible to the ship berths and to the outgoing road and rail connections. In stacking to higher levels it is essential that any particular container can be accessed at least as easily as at present – preferably more easily.

The **Container Vessel "Docking"** concept coupled with the **Random Access Racking System (RARK)** meets this challenge. Both ideas have been presented to previous TOC events have generated considerable informed discussion. They are considered to be workable.

By adopting both of these forward thinking concepts in parallel it will be possible to deliver a real benefit to the worldwide container transport industry.

Berths

The container vessel "docking" system has been explained previously (References 3 & 4). The objective of this concept is to berth container vessels in such a way that makes it possible to transfer containers at least as quickly for larger vessels as for smaller vessels. Realistically, this can only be achieved by working both sides of the vessel simultaneously.

A typical layout of a docking berth is shown in Figure 4.

The key benefits of adopting this system are:

- Increase in the number of hooks over the vessel;
- Shorter over-ship trolley movements;
- Lower crane costs;
- Compact footprint – easier and more suitable for redevelopment of old port sites;
- Concentrated flow of containers – making it compatible and more suitable for linking with automated yard systems – in particular RARK.

The "docking" concept can be achieved using conventional equipment with relatively modest ship to shore gantry cranes on both sides of the vessel. The Ceres Terminal in Amsterdam will shortly be operating on this basis and we will all be interested to see how it performs.

Maximum benefits will be gained both in terms of speed and cost by handling the ship through overhead portal gantry cranes.

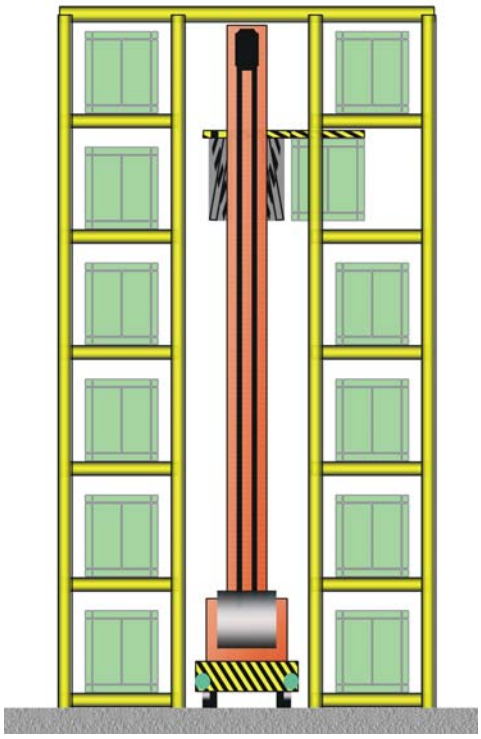

Figure 5. Cross Section Inside the Random Access Racking System

Yard

RARK, or the container terminal warehouse, has been explained previously (Reference 2). Containers are transferred between the berth and the terminal end of the rack by AGV (or conventional yard trailers) with automatic stacking and unstacking within the system. Loading in and out to road and rail is at the other end.

A typical cross section of RARK is shown in Figure 5.

The key benefits of this system are:

- More efficient use of land – typically using only 40% of conventional terminal storage area.
- Immediate access to all stored containers.
- Fully automated process.
- Lower overall cost than conventional terminal storage taking capital expenditure and operating costs into account.

RARK has been developed from tried and tested technology that is now in regular use in the warehouse industry. Transposing these systems to container storage is a relatively small progression of this technology and this will make a significant improvement to efficiency.

The system will be located close to the berths and is ideally suited for use in conjunction with the vessel "docking" layout so that transit distances between ship and storage can be minimised.

The Way Forward

There is now an opportunity for a big step forward in the container transport industry and grasping this opportunity will need close co-operation between the shipping lines and container terminals. The potential rewards are significantly high for both sectors of the industry.

This opportunity will be lost unless the next generation of berth and yard layout is adopted because the alternative of enlarging the conventional terminal layout will not generate the level of improvement needed for the effective introduction of significantly larger vessels.

References

1. Cargo Systems – Top 100 Container Ports July 2000.
2. The Container Terminal Warehouse – Christopher Blackstone - TOC 98.
3. Innovative Terminal Design – Developing “Docking” Systems – Gordon Rankine - TOC 99 Genoa.
4. Developing a Container Vessel “Docking” System – Gordon Rankine – Singapore Maritime and Port Journal 2000.