Container terminal planning: improving system productivity to service larger container vessels

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Introduction
The container shipping industry, the backbone of the global economy supply chain, continues to grow, adapt, and change. It responds to an international marketplace that relentlessly exerts influences by demanding better, more efficient, and less expensive services. Those of us providing planning and design services to this industry must understand the direction of these changes and accurately predict the long-range impacts on vessel, berth, and terminal design. In order to succeed at our tasks, we must develop a full understanding of the industry’s goals and needs and then respond effectively.

The shipping industry has been an extremely volatile yet conservative entity, characterised by strong competition, high capital costs, high operating costs, and low profit margins. Labour unions have continued to pressure for the status quo; however, economic necessity is continually driving the industry to explore more efficient work practices. In its attempts to remain economically viable, the industry has moved in several key directions – adopting economies of scale, implementing new technologies, and now integrating automation into terminal operations. Container vessels continue to grow in size as the economies of scale are explored and pushed to the limits of current hull and engine design technology. The impacts of larger vessel size on terminal design will become even more severe as vessels continue to increase in size and capacity.

Terminal planners and designers have faced the challenge of larger vessel deployments by providing facilities with higher velocity handling equipment and complex stowage schemes. Increased storage demand has caused terminals to grow in size and density. Increased terminal size has produced longer in-terminal travel distances. Increased density has resulted in larger container stacks with both an increase in the number of re-handled containers and traffic aisle congestion. The theoretical increase in quay productivity from the higher velocity equipment has been offset by increases in the inefficiency of backland operations.

As in most container terminal operations, the efficiency of the backland operations acts as the throttle that controls the velocity of the entire system.

Comparing ongoing to previous operations at upgraded container terminals has validated this point. ‘Net’ quay crane lift counts experience only marginal productivity increases. Quay cranes with a theoretical sustained productivity level in the forty lifts per hour range, with few exceptions, are found to operate in the low to mid thirties at best. The upgraded operations do process more container volumes; however, the resulting individual crane productivities demonstrate only marginal increases. Greater throughput is achieved by adding more quay cranes, more land, more backland equipment and yard cranes. Rarely is the true productivity of the container handling system itself greatly altered.

New approaches and technologies
The implementation of new approaches and technologies offers a potential solution that is starting to be developed. Technological advancement has been slow to materialise in many sectors of the industry. This has primarily been due to resistance from labour to change and/or reluctance of terminal operators to commit capital funds without a guaranteed return on investment. As new technologies have become proven in the marketplace, this reluctance has started to dissipate. One is starting to see more usage of video camera monitoring systems, optical character recognition (OCR), automatic equipment identification (AEI), differential global positioning systems (DGPS), and now automated container handling operations.

Technology in the form of more sophisticated terminal operating systems (TOS) is starting to have major impacts on the operations of modern terminals. This is demonstrated in such diverse areas as inventory control, equipment maintenance scheduling, vessel planning and yard planning, and automated terminal operations. Gate appointment and transaction data can now be integrated to facilitate the pre-planning of terminal service fleet assignments. Equipment resource assignments can be modified in ‘real time’ to meet the ever-changing needs of the operations and result in more efficient use of those resources.

Container handling equipment automation can also be used to eliminate some of the problems conventional terminals...
experience in addressing peaks in activity. No longer does terminal management have to anticipate and book extra labour in advance to handle what might be an hour or so of peak gate or shipside activity. Automated container handling equipment operations need not be limited to defined working labour shifts. Accordingly, container shuffling, based on the next day’s planned activities, can occur automatically throughout the night, placing containers for the next day’s deliveries to the forefront. The results are better service to the customer and more cost efficient terminal operations.

**Ship-in-a-Slip concept**

One innovative approach to improve large vessel turnaround time has been employed at the Ceres Paragon Terminal in Amsterdam. The solution here is the ‘Ship-in–a-Slip’ concept where as many as nine quay cranes can service a vessel from two sides (Figure 3). The Ceres system productivity is designed to be greater than 350 ship lifts/hour. In this example, the main increase in performance is achieved by servicing the vessel from two sides; hence, doubling the service area for the vessel. The use of straddle carriers further enhances the Ceres operations by ‘uncoupling’ the hand-offs between quay cranes and container transport vehicles. Because both the quay cranes and straddle carriers can independently place and receive containers from the grounded buffer area below the cranes, each type of machine is able to function at peak efficiency.

**Tandem-lift concept**

Another innovation to increase productivity is the use of tandem-lift spreaders (Figure 4). These spreaders are capable of simultaneously lifting two 40-foot containers or four 20-foot containers. Mechanical linkages between the two spreaders are used to adjust to different container heights and to adjust side-to-side clearances of two containers quayside while landing them onto adjacent yard chassis.
Planning approach
As terminal planners, we continue to develop the background knowledge, processes, and tools to properly analyse and plan maritime facilities that meet the needs of the market place. The processes and tools, particularly simulation modeling programmes, have been developed to focus on the specific operating centres within a maritime facility – quay operations, storage yard operations, and gate operations. The use of simulation modeling tools in the planning process enables the planner to analyse terminal operations with a much higher degree of complexity than was previously possible. By using these tools, we are able to focus on areas where our clients can achieve the greatest return on their investment. Resource loadings and cost comparisons can be modeled to measure the economic benefits of one scheme against another. Figure 5 shows an example of a terminal layout within the simulation programme used for the Ceres Terminal simulation modeling analyses.

Figure 6 is an example of one type of statistical output that can be derived from the modeling effort. Various dock crane productivities are depicted here based on variations in the quantities of handling and transport equipment.

Conclusion
The acceptance of new approaches and new technologies is helping the industry to develop higher-velocity, higher-productivity container terminals. As an example, the Ceres Terminal in Amsterdam is now in operation and the planned productivity of the ship-in-a-slip concept can now be substantiated by actual operations. The implementation of automated operations at terminals in Europe and in Australia is serving as an example for the rest of the world. The benefits of these new approaches and technologies can now be validated by real world experience, giving more credibility to the preceding simulation modeling efforts. We, as maritime facility planners using these tools, look forward to continue to facilitate the evolution of modern maritime facilities to meet the needs of the industry.

Robert Johansen currently manages JWD’s planning group and is a Senior Project Manager, focusing on the master planning, conceptual design, and detailed design of maritime and intermodal facilities. He has over 40 years of diversified experience in planning, design, project management, and construction management. He started in the maritime industry designing container cranes at PACECO, has worked in the area of project controls for Bechtel Corp. and SOHIO Construction; and was principal in his own Consulting Business servicing the maritime and mining industries. Prior to joining JWD, he was Manager of Facilities Engineering for American President Lines, where he served as project manager for the planning, design, and construction of APL’s Global Gateway Intermodal Container Terminal at the Port of Los Angeles.

Bob holds a Bachelors degree in Architecture from the University of California, Berkeley, and is a registered civil engineer in both California and Texas. Bob is a member of American Society of Civil Engineers (ASCE), and a past member of the Project Management Institute (PMI), American Society of Professional Engineers (ASPE), and American Association of Cost Engineers (AACE).