such facilities, and the limited viable available alternatives.

Further, they must be prepared to justify such zoning through any available appeal processes, such as mobilizing, when necessary, business, industry, and civic leaders in order that the community as a whole may be made aware of the need for intermodal facilities. Emphasis should focus on reduced overall transport costs, energy conservation, reduced congestion, increased employment, and, most important, a more efficient and less publicly intrusive transport network.

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Rail and Water Terminal Interface

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A discussion of how the growth of bridge traffic and today's competitive industrial environment have forced changes in marine intermodal terminal design trends is presented. The objective of the changes is to improve productivity of both the terminal operation and the transportation system in which the terminal participates. Specific examples and case studies of productivity improvements in terminals and in transferring containers to and from the marine terminal and the railroad are presented.

The marine terminal is an increasingly important partner in a more complex, competitive, and integrated world transportation network. Competition among terminals for local traffic has spurred design changes to improve productivity and lower the costs of container moves. Also significant are design changes in response to the requirements for terminals to interact more efficiently with railroads; therefore, the overall productivity of intermodal transportation networks is raised. This requirement results from the growth of bridging, which is a relatively new segment of the transportation industry. Bridging involves the use of both rail and ship for transporting containers moving under a combined bill of lading.

There are different types of bridges. A land bridge involves moving containers from port to port by rail. For example, a shipment from Japan to France would be off-loaded at a U.S. West Coast port, shipped by train to the East Coast, and then loaded onto a vessel to complete the journey to Europe across the Atlantic Ocean. Also, combined bills of lading are used increasingly to ship containers from a port by rail to inland destinations--a microbridge. A minibridge is for when a container is unloaded at one port, shipped by rail over a high-volume route to another port, and then shipped from this second port by rail (or truck) to its final destination.

Since 1972, bridging has been one of the fastest-growing segments of the transportation industry. It was made possible by the maturing of the marine container freight transportation system that began about the same time. Figure 1 shows that the level of U.S. import minibridge traffic has grown from approximately 0.7 million long tons per year in 1976 to 1.1 million long tons per year in 1981. (Note: Traffic data in this paper are based on import minibridge movements because of data availability. Although indicative of trends, actual growth rates of total bridge traffic may vary.) This growth rate of approximately 10 percent/year is substantially higher than the annual growth rates of 5 percent or less for all waterborne and rail traffic during the same period.

The growth in bridge traffic is due to the relative economic advantage of using railroads to transport containers from the first landfall port to inland points rather than using all water routes. This is true even when the hinterland destination is another port on the other side of the North American continent. Bridging results in shorter overall distances and transit times and allows shippers to take advantage of generally lower rail transportation rates. It also increases the number of round-trip voyages that a container vessel can make.

Capturing an increasing share of bridge traffic offers an important growth opportunity for the water carrier, port, and railroad networks, which offer the lowest-cost bridging chain. The chain that flows from Europe through Gulf Coast ports to California has diverted traffic from East Coast ports and has increased the Gulf's share of California-bound shipments from Europe from 35 to 80 percent since 1976 (see Figure 2).

Another example of a successful bridging chain is that of the Ports of Los Angeles and Long Beach. As shown in Figure 3, these two ports have increased their share of minibridge imports from the Far East from 55 percent in 1976 to 65 percent in 1981.

Container terminals are working to improve the productivity of their operations and to integrate those terminals that operate more efficiently with those of their transportation partners in order to capture a greater share of bridge traffic and improve their overall efficiency in these times of intense competition. Such improvements in container terminal operations aid both bridging and local container movements.

Although there are many opportunities to enhance overall efficiency, two of the most significant means of reducing terminal costs of moving containers are in the transfer of containers to rail sidings (rail interface) and the discharge and loading of vessels (water interface).

RAIL TERMINAL INTERACTION

In most ports, containers for bridge movements are transferred from the marine terminal to an inland terminal because, traditionally, rail terminals have not been located at sites adjacent to ports. For import containers, this requires discharging the containers from a ship and storing them on a chassis for a brief period of time. They are then moved (drayed) on chassis to the railroad siding and stored or loaded on a flatcar. Because of short storage time and rapid transfer rates, storing the container on a chassis in the marine yard is preferable to stacking. However, the process does require up to two sets of container moves, which cost approximately $30 each, and incurs a drayage cost of $100-$150/move. There are also other costs involved, e.g., the use of a chassis for transferring the container and rapid high-volume block container movements.

In these competitive times, it is no longer feasible to have a water carrier pay up to $200/container to link up to the railroad. This is especially true because the rail segment of the trip might cost only $900 (West Coast to Chicago) or $1200 (West Coast to East Coast). An entire move-

Figure 1. Import minibridge movements in the United States.

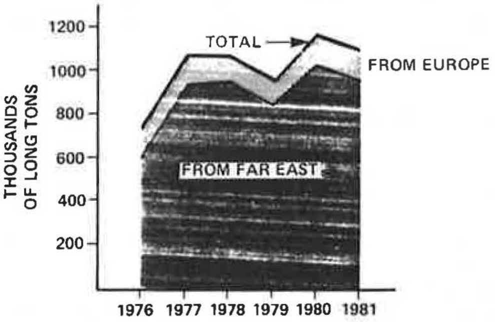


Figure 2. Minibridge movements from Europe to the West Coast.

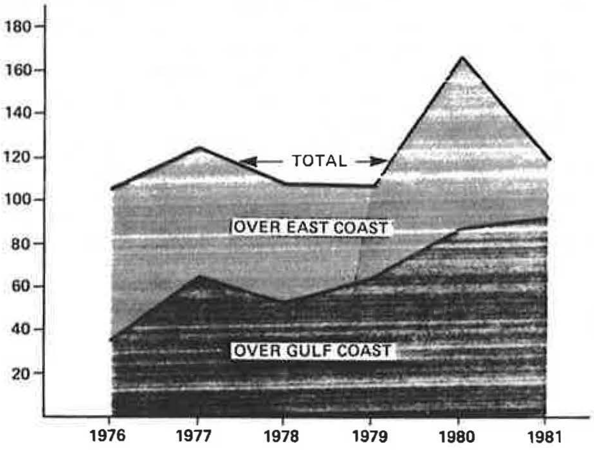
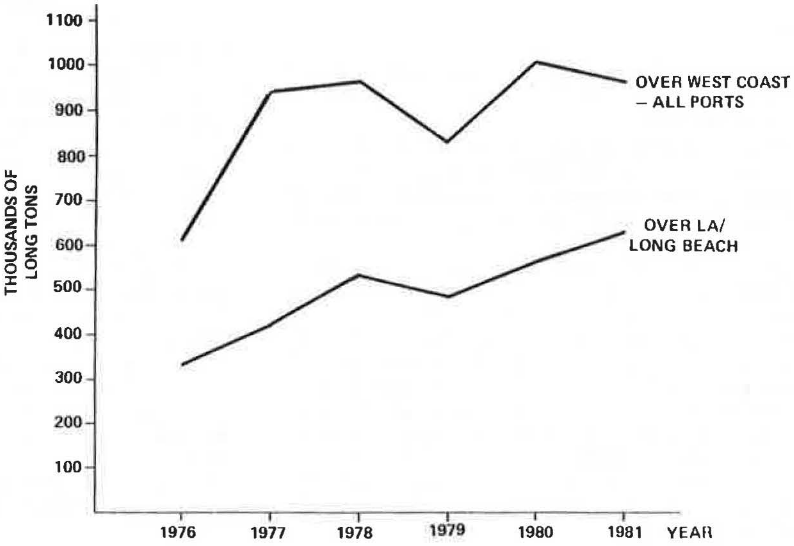


Figure 3. Far East import minibridge movements.



ment from the Far East might bring in only $2,000-$2,500 in revenue--and revenue levels are softening.

The long-term trend in high-volume bridging applications will be for the rail loading to occur at the marine terminal. Direct transfer of containers from the vessel to railcars is also possible. In high-volume applications, the terminal interacts directly with the railroad and not with an intermediary that adds cost, but no value, to the system. This integrated approach, however, is probably not feasible in low-volume bridging applications because of complexities in operating trains for a relatively small number of container moves and the cost of extending rail spurs to the port. To date, however, this integration concept is not widely accepted by the U.S. railroad industry.

Although no organization (as of yet) has made a commitment to completely integrate rail and marine terminal operations because of constraining technological and institutional factors, some companies are trying to integrate rail and water operations by reducing the distance between the respective terminals. These include the Ports of Los Angeles and Long Beach, New York City, and Sea Land.

Ports of Los Angeles and Long Beach

The Los Angeles and Long Beach port complex is serviced by three railroads: Southern Pacific; Atchinson, Topeka, and Santa Fe; and Union Pacific. These railroads have rail transfer facilities, located between 22 and 28 miles from the port complex, that serve both marine containers and domestic piggyback trailers. During periods of low traffic density, one-way road time between the ports and the rail yards averages about 90 min. During periods of peak traffic, the transfer takes much longer.

To reduce the cost of transporting bridge containers through the Ports of Los Angeles and Long Beach, the respective port authorities have agreed to jointly construct a new railroad yard for the railroads at a site approximately 2.5 miles from each port complex. This was determined to be more feasible than constructing two smaller rail yards at each port. The proposed facility is expected to be developed in four phases. At its projected completion in the year 2000, it will cost approximately $130 million. The facility is expected to increase the amount of bridge traffic carried through Los Angeles and Long Beach by reducing the cost to ship via these ports. So far, however, only Southern Pacific has expressed its willingness to use the new integrated facility.

New York City

New York City has captured only a small share of the container traffic that enters and leaves the Port of New York. This is partly because the city does not have as good a rail connection as do the facilities on the New Jersey side at Port Newark/Elizabeth. Only 2 percent of the waterborne container cargo is transferred to rail in New York City compared with 15 percent in Port Newark/Elizabeth. The city is attempting to improve railroad service to its ports by revitalizing its railroad car float industry. Reconstruction of a rail yard in Owls Head is under way to support railroad-based industries in Brooklyn. In another effort, the city is attempting to bring waterborne traffic back to the facilities located in New York City by developing a modern terminal in south Brooklyn. It has identified a rail link as an important ingredient to a successful terminal in south Brooklyn and is emphasizing the availability of the nearby Owls Head terminal in its planning efforts.

Sea Land at Tacoma

Sea Land Service recently announced its intention to relocate its port facility from the Port of Seattle to the Port of Tacoma. When the move occurs, the Port of Tacoma will increase its ranking from the fiftieth largest to the eighth largest container port in the country. There are many reasons for the move, one of them being the availability of a rail siding at the new terminal. Sea Land currently drays its containers in the Port of Seattle to and from its marine terminal--a distance of 30 miles. The company feels strongly enough about the importance of railroad access that it will not only bear the costs of moving to a new facility, but it will also incur additional ocean costs as its vessels will have to travel an additional half-day to reach the new terminal.

DISCHARGING AND LOADING VESSELS

An increase in crane productivity is currently one of the greatest leverage points in raising overall marine intermodal terminal productivity for vessel operators. Improved crane productivity reduces the port time of vessels calling at the terminal, and it lowers vessel costs by allowing operators to make more voyages per year. In addition, increased crane productivity allows the high overhead cost of cranes and berths to be spread over more container moves, thereby reducing costs.

Increasing the productivity at the berth aids in increasing overall transportation system efficiency and therefore promotes an increase in bridge traffic to those systems that pass through the terminal. In addition, increased productivity provides the unloading capacity needed to handle large blocks of container movements expeditiously.

The key to improving vessel discharge and loading is not increasing the speed of the crane motions or developing a new series of crane motions, but rather it is eliminating the constraints to higher production rates that are inherent in today's stevedoring operations. Meaningful results are being achieved by

1. Reducing the number of unproductive moves,
2. Reducing crane waiting time,
3. Decreasing crane cycle times,
4. Automating crane functions, and
5. Installing diagnostic computer systems.

Unproductive crane moves occur when containers are relocated within the vessel during port operations. Some unproductive (or redundant) moves are unavoidable; e.g., when containers are loaded with refrigerated or hazardous commodities, they must be placed above deck before reaching their destination. Some redundant moves can be eliminated by using computer-aided stowage techniques. These techniques expedite stevedoring planning by developing stowage plans that optimize vessel trimming (to reduce vessel operating costs) and by satisfying other loading criteria (e.g., port destination sequencing and hazardous commodity stowage).

Even the most productive terminal operation has idle cranes when there are containers to move. This can often account for as much as 15 percent of the working time of the cranes and results when the coupling of the stevedoring tractors, the crane, and the ship is out of synchronization. To prevent yard operations from slowing down crane operations, crane buffers are being employed, notably in the Matson system and by ECT in Rotterdam. The buffer device (Figure 4) provides a place for depositing off-loaded containers and supplying containers to be onloaded.

Figure 4. Schematic diagram of crane buffer.

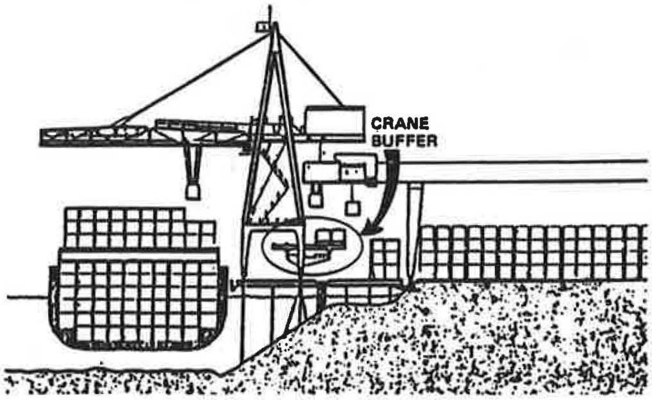
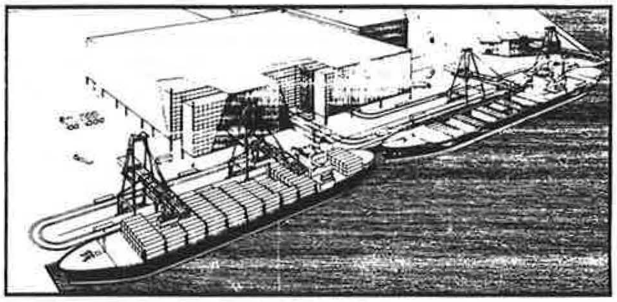


Figure 5. Possible future intermodal terminal.



Productivity is also improved by reducing the time used to locate spreader bars over containers and containers over chassis in order to decrease crane cycle times. "Dancing" motions can take 10 sec or more in a single crane cycle of 90-175 sec and are caused by the pendulum effect of the dangling spreader bar. Landside container guides and antisway cables reduce these unproductive hunting motions.

Container guides have been pioneered by ECT in Rotterdam and consist of movable guides at the roadway level underneath the crane. These guides eliminate the dancing by providing lateral support at the lower end of the pendulum. Another approach (available through Paceco, Kocks, and others as an option on their cranes) is employing antisway systems that reduce pendulum swings underneath the crane both on the landside segment of the cycle and on the shipside segment.

Semiautomatic crane functions also improve the discharge and loading of vessels by making production uniform. In a system developed for the Port of Los Angeles, the crane operator programs a microprocessor by going through one cycle of crane motions manually. The hoisting, lowering, and trolley travel of subsequent cycles are then directed by the computer for the remainder of the lifts at the hatch being worked.

In another approach, the Port of Seattle has provided computer diagnostic capabilities on its cranes. The computer monitors critical parameters such as temperature, current draws, and voltage drops to identify components that might fail. This warning system allows the component to be replaced before a breakdown during operation occurs, thus improving productivity by reducing equipment unavailability during critical periods.

These and other approaches that enhance crane production result in cranes achieving a production level of 40 moves/hr or greater.

LONG-TERM VIEW

Over the next 15 to 20 years, terminal systems will evolve in response to industry demands for increased terminal productivity and more effective integration with street and rail vehicles. The terminal systems of the future (such as the Paceco Speed-tainer system shown in Figure 5) will depart radically from those we see today. Technology will be used to the fullest extent possible as a vehicle for generating a large number of these changes. The terminal of the future will be more complex and more capital intensive, but it will also achieve higher levels of production and lower throughput costs.

In many respects, the modern container terminal may evolve in the same way as the modern bulk terminal of today--a sophisticated, high-volume, low-throughput-cost marine process plant that is fully integrated with its supporting railroad system.

Furthermore, the superior economies (but high required throughput levels) of these next-generation systems will combine with the possible emergence of 2,000 forty-foot equivalent unit (FEU) class vessels and a more rational regulatory environment to create a network of high throughput ports. Because the total volume of U.S. import and export traffic over the next decade probably will not grow substantially, the emergence of these ports will have to develop from a centralizing process. The innovative 6 to 12 ports that have access to the required rail networks and make the investment in technology will emerge as the future container load centers of the United States.

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