

Domestic Containerization: Overview of Terminal Design and Operating Issues

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Containerization of U.S. domestic intermodal shipments is receiving new interest as a result of lower line-haul costs that can be achieved with double-stack rail cars in large-volume trains. One of the key challenges in pursuing domestic containerization is the ability of the current system of trailer-based intermodal terminals to adapt to container-based systems. This paper provides an overview of terminal design and operating issues that trailer-on-flatcar (TOFC) terminal managers and designers will face with a transition to domestic containerization. The issues covered include management and control of chassis, terminal mechanization requirements, alternative highway and rail transfer methods, labor requirements, and requirements for container and chassis staging and parking. In each of these areas, terminal managers and designers will face a variety of trade-offs in selecting operating techniques to maximize the utilization of labor, equipment, and fixed facilities. For the most part, domestic containerization will not require radical redesign of major TOFC terminals or heavy investment. It will, however, result in increased terminal operating costs and a significant challenge for terminal managers to effectively coordinate and control the increased complexity of equipment.

Domestic containerization is defined as domestic U.S. freight traffic that moves in container-on-flatcar (COFC) intermodal service. Domestic COFC service is distinct from conventional domestic piggyback service--trailer-on-flatcar (TOFC)--where the highway wheels ride on the rail car, either attached to a trailer or attached to a chassis on which a container is mounted.

Many industry participants believe that domestic containerization can provide significant long-term benefits compared with trailer-based systems because of line-haul cost savings that result from lower tare weight and economies of scale possible with large trains. The current interest in domestic containerization has been sparked by the rapid growth of high-volume, double-stack COFC trains carrying from 150 to 280 40-ft equivalent container units (FEU) per train. Studies have shown that these trains have line-haul costs that are approximately 40 percent lower than conventional TOFC and door-to-door costs that are 20 to 25 percent lower in long-haul corridors.

Although the prime purpose of these trains has been to handle international traffic, the trains are having a significant impact on domestic intermodal traffic as well. Lacking sufficient export traffic to balance the heavier volume of imports, ocean carriers are aggressively seeking domestic freight to fill out westbound trains. In addition, many of the trains have been priced on a round-trip "take-or-pay" basis, giving steamship companies an even greater incentive to fill the trains on the return movement.

Between early 1984 and early 1986, more than 30 new double-stack train sets were placed in operation or planned for operation (Figure 1). Some industry participants speculated that the swift growth of double-stack trains signaled the beginning of a transition to domestic containerization, implying that significant portions of the current trailer-based system could be converted to domestic COFC.

Despite this new level of interest, many observers are concerned about how a shift to domestic containerization will affect terminal design and operations, primarily because of the complexities added with the introduction of chassis to the terminal environment.

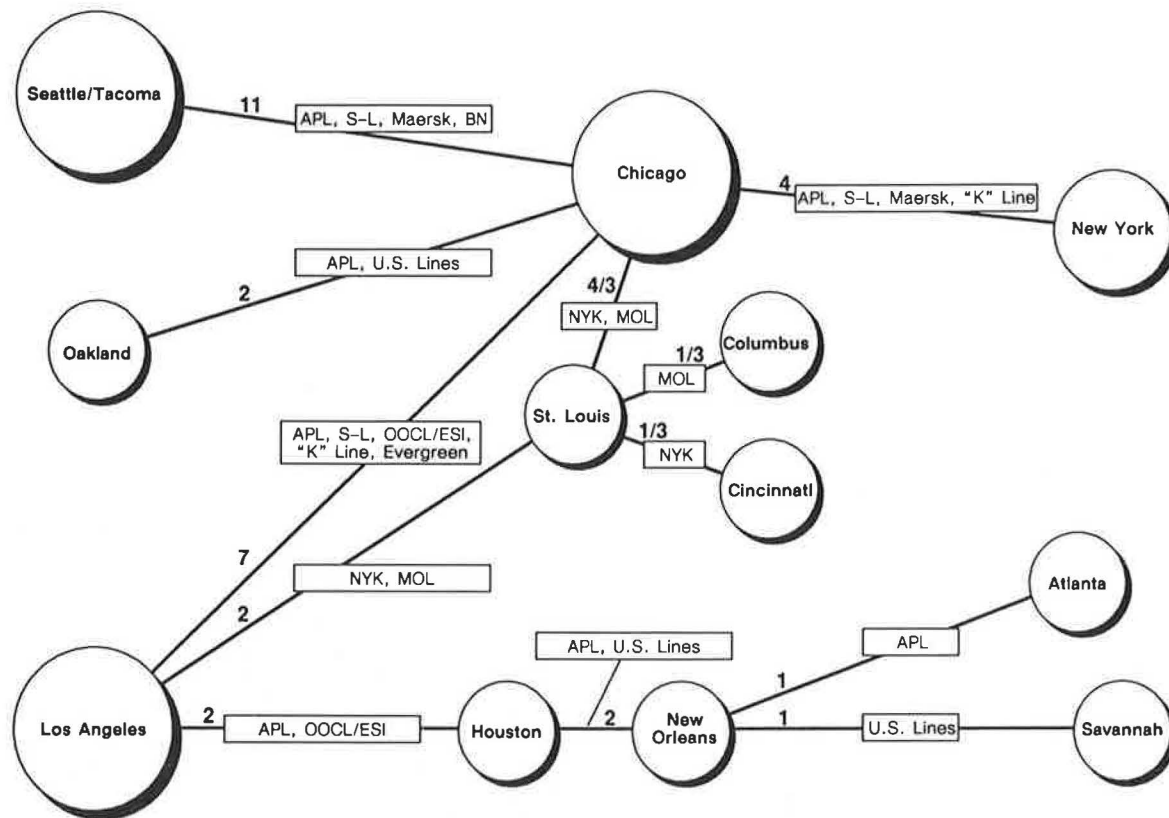
IMPACT ON TERMINAL ACTIVITIES

The activities of domestic intermodal terminal operations may be categorized in six basic functions: equipment management, transfer operations, staging and parking for trailers and containers and chassis, train spotting and switching, gate operations (including clerical), and drayage. COFC terminal operations differ significantly from conventional TOFC operations in only the first three of these primary areas, listed in priority order of impact in the following table:

<u>Primary Terminal Activity</u>	<u>Impact of Domestic Container Operations</u>
Equipment management	Significant
Transfer operations	Significant
Staging and parking	Significant
Train spotting and switching	Minor
Gate operations (including clerical)	Insignificant
Drayage	Insignificant

* Equipment management involves the general coordination of cars, trailers, containers, and chassis. Domestic containerization increases the complexity of this function because of the separability of the containers and chassis, which requires greater coordination and control.

* Transfer operations involve the transfer of containers or trailers between rail cars, chassis, and the ground. COFC transfers are different from those required for TOFC because (a) mechanical lift



Note: Train sizes range from 150 to 280 units (FEU).

FIGURE 1 Double-stack unit trains announced as of February 1986 (weekly departures and carriers).

equipment is required; (b) the introduction of the chassis adds greater complexity to the management of equipment, which requires more coordination among terminal activities; (c) lift cycle times and hostler cycle times are generally longer; and (d) additional labor is required.

- Staging and parking areas are located adjacent to the transfer operation or at remote locations to hold containers or trailers awaiting pickup by highway drivers or hostler pickup for train loading. These functions are also significantly affected by domestic containerization because COFC operations require additional staging and parking areas for bare chassis and, in some cases, for grounded containers.

The other three primary terminal activities will not change significantly with domestic containerization:

- Train spotting and switching involve the placement and shifting of rail cars at the intermodal terminal. Because double-stack cars are nearly half the length of conventional cars (on a per unit basis), switching time can be reduced. However, the trend to unit trains or large block trains moving between major hubs, and placement or pulling of trains by road crews, has diminished the importance of switching. For this reason, domestic containerization will probably have only a minor impact on switching activity, but that impact will generally be positive.

- Gate operations, controlling entry and exit of trailers or containers-on-chassis entering or leaving the intermodal terminal, are not significantly affected by use of containers instead of trailers.

- Drayage, the trucking of containers-on-chassis or trailers between the intermodal terminal and the

customer, is not affected by domestic containerization. When a container has been mounted on a chassis, it can be handled almost exactly like a trailer.

Focusing on the terminal functions most affected by a changeover from TOFC to domestic COFC, there are several key issues related to each activity:

1. Equipment management
 - Chassis fleet sizing
 - Chassis control
2. Transfer operations
 - Terminal mechanization
 - Alternative transfer methods
 - Labor requirements
3. Staging and parking
 - Location of chassis storage
 - Land area required for chassis storage

Each of these issues is discussed hereafter to give terminal designers and managers a general awareness of the various operational alternatives and trade-offs involved with domestic containerization. In general, no attempt has been made to quantify the net impact of the various alternatives because, in most cases, meaningful quantification must be developed by managers on a site-specific or system-specific basis.

EQUIPMENT MANAGEMENT

Chassis Fleet Sizing

Perhaps the greatest unknown with regard to COFC terminal functions is the size of the chassis fleet required to adequately serve an individual terminal,

as well as a total system. Many intermodal participants have expressed concern that, under domestic containerization, chassis supply will be inadequate (creating shortages and delays in train loading and unloading), inefficient (resulting in a larger number of chassis than containers in the system and possibly excessive terminal parking requirements), or both.

This concern is valid because chassis coverage ratios (the total number of chassis in a system divided by the total number of containers) must be fairly low to result in investment savings in comparison with a trailer system. For example, assume approximate costs of \$14,300 for a 48-ft trailer, \$8,000 for a 48-ft container, and \$7,500 for a 48-ft chassis. A chassis coverage ratio of 100 percent (one chassis for every container) implies that the investment required for chassis and containers is 8 percent greater than for trailers. To produce significant investment savings, say 10 percent, in a container and chassis system versus trailers, the chassis coverage ratio must be 65 percent or less, or roughly less than two chassis for every three containers.

Much of the concern about fleet sizing is based on the experiences of earlier domestic containerization programs (Table 1), particularly those of the New York Central (1956-1970) and the Southern Railway (1961-1973). The Canadian Pacific's experience

(chassis coverage ratio of from 40 to 50 percent). Most traffic was Plan II or Plan V² and the NYC's trucking subsidiary, NYC Transport, performed much of the drayage. (Plan II involves door-to-door service and rates provided by a railroad in a railroad trailer. Plan V involves door-to-door service and rates provided under a joint railroad and motor carrier tariff). The amount of repositioning of empty chassis from surplus to deficit terminals was relatively minor and pretty much limited to movements from St. Louis to Chicago.

It was not until a second system of interline TOFC was introduced that chassis utilization deteriorated. In 1964-1965, NYC decided that, because of the lack of strong interest on the part of connecting railroads in following NYC's domestic container approach, it was necessary to use trailers in TOFC service to expand its intermodal business into interline markets. The existence of a second system created a problem because of the customer discipline required to load domestic containers with local NYC freight and trailers with interline freight. Invariably, some customers loaded the domestic containers to interline destinations, thereby tying up chassis for much longer periods of time. In time, chassis coverage deteriorated to a highly inefficient ratio of six chassis for every five containers (120 percent). Some believe that this problem could have been controlled with price penalties for loading containers off-line; however, the motivation to establish such incentives was constrained by competitive considerations (e.g., do not burden shippers with the inconvenience of matching trailers and containers with specific loads or they may shift their traffic to other carriers).

TABLE 1 Chassis Management Experience

Company	Experience
New York Central (1956-1970)	Chassis coverage ratio was adequate (50-60%) in early years when system was limited to local traffic only Chassis coverage deteriorated to approximately 120% when the system became mixed with interline TOFC
Southern Railway (1961-1973)	Could not expand beyond local short-haul markets Chassis shortages tied up cars in yards 60-70% coverage (chassis/box); but this was never sufficient
Canadian Pacific (1978-present)	Plan II operation enhances control Long-haul markets maximize chassis savings (2,000+ mi) 60% coverage (chassis/box) "Live" loading minimizes chassis fleet requirements Chassis average 4-5 days "on the street"
Ocean Carriers	Many prefer TOFC container operations to COFC Two extra drays required for "C" operation versus "T" operation (to and from chassis yards that are typically not within the rail terminals) Managed by third parties in Canada and Europe Uniformly negative about management by railroads of damage liability concerns Generally open to neutral pool concept but remain skeptical about implementation details, especially cost/day and potential damage expense

Source: Temple, Barker & Sloane (TBS), Inc., Interviews.

(1978-present), however, provides insight into several factors that can make chassis management efficient and effective.

New York Central Experience

Interestingly, the New York Central (NYC) experience indicates that chassis management was fairly efficient in the first stage of its Flexi-Van program of domestic containers, which handled local traffic only (1956 to 1964-1965). Approximately 2.5 to 3.0 chassis (bogies) were required for every six containers

Southern Railway Experience

In addition to the dual system problem, Southern's domestic containerization program had the problem of low chassis efficiency in short-haul markets. Short-haul markets (which characterize many of Southern's local markets) generally imply only a day or so savings in chassis time compared with long-haul corridors where COFC line-haul time can be 3 to 6 days, thereby reducing the potential savings in the number of chassis versus the number of boxes. Even this small savings could be easily lost if chassis spent considerable idle (bare) time in terminals before and after unloading. Southern's chassis coverage ratio was around 60 to 70 percent, but this was never sufficient--at times, several hundred cars were waiting to be unloaded for lack of chassis, sometimes for as long as 10 days. Like the NYC, Southern was unsuccessful in getting its connections to embrace COFC and found chassis "escaping" the system because they were loaded as TOFC to interline destinations.

Canadian Pacific Experience

In contrast, the experience of Canadian Pacific (CP) has been much more positive, and for reasons that are consistent with the problems experienced on New York Central and Southern. CP's domestic intermodal business is very much a closed system, with local, noninterline traffic predominating and with the railroad controlling the full door-to-door service under Plan II. In addition, the average length of haul is more than 2,000 mi with a few short-haul markets, which increases the potential for savings in the number of chassis versus the number of containers. As a result, the CP's chassis coverage ratio has been fairly stable at about 60 percent.

Chassis Control

The control of chassis is also an issue. In each of the railroad domestic container systems described earlier, the railroads owned and managed their own chassis, which were supplemented to a limited extent by chassis owned by other parties, such as motor carriers. With international COFC traffic, most of the ocean carriers supply and manage their own chassis, resulting in chassis owned by numerous entities entering and leaving each railroad intermodal terminal. This situation creates a considerable management challenge for railroad terminal operators, particularly in matching the right chassis to the right container at the right car at the right time.

To limit this matching problem, two railroads have established what are known as "neutral chassis pools." The pools are composed of a chassis fleet owned by a third party that substitutes for the multiple ownerships. By substituting a "generic" chassis for one of specific ownership, the railroad increases its flexibility by being able to use a pool chassis in combination with any container. The total system can benefit as well, because the inefficiencies of multiple inventories, multiple storage yards, extra drayage, and multiple chassis management systems are reduced or eliminated.

The two railroads that have started chassis pools (both located in Chicago) have slightly different programs (Table 2). One railroad's pool is the required supply source of chassis for all steamship lines using the railroad's double-stack train. The

TABLE 2 Comparison of Neutral Chassis Pool Initiatives in Chicago

	Railroad	
	Burlington Northern	Conrail
Application	Mandatory	Optional
Billing	By neutral pool operator	By neutral pool operator
Pricing structure	No charge until chassis leaves terminal Daily rate increases over time	No charge until chassis leaves terminal First 6 days at fixed rate/day Subsequent days at higher rate/day
Grounding	None	None; if ocean carrier does not supply chassis, container will be placed on a neutral chassis
Chassis not returned to terminal	Drop-off charge if returned to other locations	Drop-off charge if returned to other locations
Location of chassis inventory	On-terminal	Off-terminal
Chassis assignment	Dedicated to terminal	Operator's free-running pool
Damage liability	No nuisance charges for maintenance	Ocean carrier liable for all maintenance and repairs

Source: TBS interviews with Burlington Northern, Conrail, and ocean carriers.

pool is located within the terminal, adjacent to the lift operation, and addresses ocean carriers' damage liability concerns by waiving nuisance damage charges. The other railroad's pool is provided as an optional source of supply to the steamship lines and is located off-site.

It is interesting to note that the two systems have a number of similarities. Both pools involve wheeled operations in which containers are transferred directly between rail cars and chassis with no ground storage involved. Both pools also have pricing structures that provide users with strong

incentives to minimize the time spent outside the terminal and encourage captivity at Chicago. The ocean carrier users are billed by the third-party pool operator in both cases, rather than directly by the railroad.

Many intermodal participants believe that the neutral pool concept could be expanded to encompass several or all railroad terminals within a metropolitan area, theoretically improving flexibility and efficiency even further. However, it may be difficult to establish universal pools in each metropolitan area given the historical resistance of railroads to coordinating their intermodal operations, particularly if head-to-head competition is involved. Without such pools, however, domestic container terminals will become extremely difficult to manage, resulting in suboptimal transfer operations and complex equipment management problems.

TRANSFER OPERATIONS

Terminal Mechanization

Major TOFC terminals typically load and unload trailers with mechanical lift equipment, either side-lift "piggybackers" or overhead cranes. Lift equipment, however, is not a requirement. Indeed, the majority of U.S. intermodal terminals still load and unload trailers using the drive-on method, known as "circus loading," where trailers are driven up an end ramp and across several flatcars into position. Although these terminals are generally small or medium-sized terminals that do not handle a majority of traffic (probably less than 20 percent), they do provide an intermodal "presence" in many communities and reduce the need for costly drayage to larger, more distant hubs. Their future under domestic containerization is unclear.

With domestic containerization, lift equipment is essential. By definition, a COFC container cannot be driven on and off rail cars because the chassis and wheels have been separated from the container. Therefore, containers must be mechanically lifted on and off the rail cars.

The number of TOFC/COFC terminals has been reduced by 69 percent since 1978, from nearly 1,176 in 1978 to 361 in early 1986 (Table 3), primarily because of railroad mergers and a growing emphasis on concentrating volume at "hub centers." Of the existing terminals, however, only 175 (48 percent) are mechanized.

If the industry moves to domestic containerization, the consolidation trend will probably accelerate, particularly because double-stack train economics are most attractive with large-scale operations that can consolidate volumes into trains of 200 or more units. Even with a network of "super hubs," however, there will probably still be a need for mechanization of existing circus ramps. Assuming long-term consolidation to 250 to 300 terminals, 75 to 125 terminals would have to be mechanized. Assuming each terminal has 30 to 40 car spots, and mechanization costs of \$100,000 per car spot (based on

TABLE 3 Trend in TOFC/COFC Terminal Consolidation and Mechanization, 1978-1986

	1978 (1,2)		Change
	1978	1986 ^a	1978-1986 (%)
Total U.S. TOFC/COFC terminals	1,176	361	69
Mechanized terminals	131	175	34
Percentage of total	11	48	336

^aInformation as of Jan. 1, 1986, supplied by Trailer Train.

discussions with several railroads), the industry would have to invest \$225 million to \$500 million to fully accommodate domestic containerization in the terminal network. This investment can probably proceed at a reasonable pace because the transition to domestic containers will be likely to occur first in large-volume corridors between major hubs.

Alternative Transfer Methods

There are three basic methods of terminal transfer for COFC, each of which has different trade-offs among lift productivity, chassis productivity, and hostler productivity (Table 4).

These three methods assume handling techniques based on traditional TOFC lift equipment--side-loading piggypackers and gantry cranes. It is not anticipated that other techniques--such as straddle carriers and wide-span single-beam bridge cranes--will have wide application to domestic terminals, particularly in the short term.

The greatest level of chassis productivity can be achieved with ground stacking of containers, allowing lift and chassis operations to be virtually independent of one another. Chassis need not be prestaged when a train is unloaded, and, similarly, containers returned to the terminal can be separated from their chassis, allowing the chassis to be mated with another load or empty. As a result, chassis can spend a minimum amount of time in the terminal. The major disadvantage of ground stacking, however, is the need for two lifts for each container (car to ground, ground to chassis, or the reverse), which seriously dilutes the productivity of lift equipment and crews. Hostling is also less productive because hostlers may be required to wait by the grounded containers as the packer or crane makes its rounds. In minor variations on this approach, grounding could be limited to empties or to loads that will not be picked up until the next day or later.

The most common method, "live loading," requires the greatest coordination among the three elements of a COFC lift operation (lift equipment, container, and chassis). This method is preferable when using side-lift equipment, which is unable to lift a container off a rail car if a chassis is positioned parallel and next to the car. With this method, a side-lift machine lifts the container off the car, pulls back from the track, and then places the container on a chassis that has been driven immediately in front of the machine. The hostler then pulls the mounted container away from the track area, allowing the side-lifter to unload another container from the train. Because lift operators must wait for chassis drivers, and vice versa, poor lift utilization can result from a lack of coordination. One solution is to add a "buffer" hostler who works closely with the lift crew, clearing the track area to a nearby stag-

ing point, where other hostlers pick up for a second hostling move to a parking space.

A method that may result in the poorest chassis and hostler utilization but the best lift utilization involves prepositioning of chassis at trackside before train arrival or departure. Although this method allows the lift operator to proceed independently from the hostling activity, chassis must sit idle for long periods as they wait to be loaded or unloaded. A crane, rather than a piggypacker, is required to reach over the chassis to the car. Hostler utilization is poor because two separate moves are required--one to position the chassis and a second to remove the load, or the reverse. In addition, chassis spotting at trackside must be carefully matched to specific containers in the expected train consist or to light load-heavy load matching requirements dictated by double-stack payload weight restrictions.

Most railroads appear to favor wheeled transfer operations rather than methods that ground the containers because the service requirements of domestic traffic make extended ground stacking undesirable. The choice of the live-loading method versus the prepositioning method will be determined largely by an individual railroad's type of lift equipment, labor costs, capability to prestage containers and chassis on the basis of available train consist information, and the extent of equipment pooling versus individual ownership. Railroads may also need to consider train-to-train transfers, particularly if double-stack clearance limits require transfer from double-stack to single-stack trains for movement beyond major double-stack hubs.

Labor Requirements

A TOFC transfer crew is typically composed of a crane or piggypacker operator, a groundperson who assists the operator, and a hostler who moves trailers between the lift operation and central or remote parking. In general, the TOFC hostler can complete a cycle between trackside and parking lot in about the same amount of time that the operator and groundperson take to load or unload. With a COFC transfer operation, additional labor is required, primarily for hostling and in some cases for an additional groundperson.

First, hostling cycles are longer because each cycle has three or four legs rather than two legs so that, in general, a hostler cannot work at the same rate as the lift crew. A TOFC hostler simply cycles back and forth between trackside and parking (two legs), whereas a COFC hostler must follow a triangular route to and from chassis parking, trackside, and mounted container parking (three legs) or must make two separate moves if the prepositioning method

TABLE 4 Basic Options for COFC Transfer Operations

	Ground Stacking	"Live" Loading of Chassis with Driver	Chassis Prepositioned at Trackside
Lift utilization	Best at trackside but worst overall because two lifts required for each car-to-chassis transfer	Requires close coordination with hostler; best method for piggy-packer	Best overall but requires a crane
Chassis utilization	Best--chassis can be virtually independent of lift operations	Can be best if closely coordinated with lift operations	Worst overall because chassis sit idle at trackside; careful planning required if using multiple ownerships
Hostler utilization	Can suffer if hostlers must wait at container stacks for lift equipment	Can be best if closely coordinated with lift operations	Worst overall because two separate trips are required

Source: TBS analysis.

is used (four legs). As a result, more hostling time is required to perform the same amount of work.

Second, one type of double-stack car, known as the interbox connector (IBC) type, may require an additional groundperson. The IBC type of double-stack car has a locking device (an interbox connector) at each corner casting to secure the top container to the bottom container. Securing the IBC is a two-stage process. To load, the bottom container is placed in the well of the car and a groundperson must climb onto the car to lock an IBC at each corner. Then, the second container is placed on top of the bottom container and the groundperson climbs onto the car again to lock the IBC to the top container. This procedure may be reduced with the development of semiautomatic or automatic IBCs; however, some additional labor may always be necessary. This additional cost associated with an IBC car must be weighed against potential line-haul savings resulting from a lower tare weight compared with a bulkhead-type double-stack car.

STAGING AND PARKING

Location of Chassis Storage

An issue related to staging and parking is whether the inventory of bare chassis should be located within the terminal or off-site.

Off-site storage is probably a reasonable approach if a terminal has congestion problems or if additional land is only available at a premium. An advantage of off-site storage is that it may allow for a more organized flow of terminal activity because chassis storage is physically segregated from the lift operation and parking areas for mounted containers. For example, American President Lines (APL) loads and unloads double-stack cars by shuttling its chassis through Conrail's New Jersey terminal from an off-site location, keeping the terminal fluid. However, the basic disadvantage of off-site storage is the requirement for additional drayage (two to four extra drays for each movement) and the extra expense associated with this activity. Ocean carriers, who all maintain off-site chassis storage locations away from the rail terminals, have noted that this extra drayage expense is a major reason why certain intermodal routes (particularly the relatively short-haul North Atlantic trade) are dominated by wheeled containers (TOFC) rather than COFC.

As a long-term strategy, maintaining an on-site inventory would appear to be more favorable, particularly if chassis pools reduce the number of separate ownerships that must be managed. With on-site storage, drayage expense is minimized and access

to specific chassis is improved. Although land constraints may be a problem, these can be dealt with through high-utilization storage techniques such as horizontal stacking and vertical stack racks, discussed later. Long-term land constraints can be reduced if double-stack becomes the norm, freeing terminal areas now required for transfer operations related to longer conventional trains.

Land Area Required for Chassis Storage

When the location of the chassis inventory has been determined, the issue of how much land area is required for storage still remains. Table 5 gives three basic storage alternatives that have widely different land area requirements: horizontal ground storage, horizontal stacking, and vertical stacking.

Horizontal ground storage is simply the parking of chassis in the same fashion in which trailers or mounted containers are parked. Although this method involves the simplest operation, the land requirements are substantial: more than 3 acres are needed to store 200 chassis. With chassis spread out over a large area at ground level, it is often difficult to locate specific pieces of equipment, and search time is increased because of longer travel distances compared with methods that make more intensive use of land.

An alternative is to stack the chassis on top of each other, generally two or three high. This method reduces the required land area for 200 chassis to about an acre but requires a forklift operator to maintain the stacking arrangement.

Vertical stacking involves the use of racks to store chassis in an upright position. Vertical stack rack systems can reduce the required land area to one-tenth of that required for regular storage, or about one-third of an acre for 200 chassis. These racks also make it easier to identify chassis types and lengths. Despite the requirement for a forklift (or "flipper") operator, the system can reduce hostling requirements because of more efficient movement in and out of the chassis inventory. A stack rack system has been installed at Southern's Atlanta terminal for handling of APL double-stack traffic.

Obviously, the choice of storage alternatives can vary from railroad to railroad and from terminal to terminal and requires a careful analysis of trade-offs among land costs, equipment costs, and the impact on hostling cycles.

SUMMARY

Domestic containerization will have a significant impact on terminal operating costs and will increase

TABLE 5 Chassis Handling and Storage Options Within the Terminal

	Horizontal, Ground Level	Horizontal Stacking	Vertical Rack
Basic method	Herringbone pattern parking, random access	3-high horizontal stacking; side-pick or endpick	Modified forklift places and removes chassis to/from a vertical storage rack
Labor required	Driver access	Forklift operator	Forklift (flipper) operator
Land area required per 40-ft chassis	677 ft ²	209-287 ft ²	74 ft ²
Land area required for 200 40-ft chassis	3.1 acres	0.8-1.0 acre	0.3 acre
Capital expense	None	Forklift	Forklift and racking system
Impact on lift operations	Can result in extra hostler requirements due to longer travel time	Can result in delays in moving stacked chassis to access desired unit	Ease of access can reduce hostler requirements
Identification/location	Relatively difficult to identify/locate specific chassis	Relatively difficult to identify/locate specific chassis	Relatively easy identification of lengths and specific units

Source: TBS interviews and S.S. Corbett (3).

the challenge for terminal managers to coordinate and control equipment. In general, however, it appears that domestic containerization will require neither a radical redesign of existing TOFC terminals nor heavy investment.

Terminal operating costs will increase because transfer cycle times will be longer and extra hostlers will be required to make the longer trips between chassis parking, trackside, and container-on-chassis parking. An extra groundperson will also be required if IBC double-stack cars are used. Terminal operating costs will also be adversely affected if terminal management cannot consistently coordinate equipment resources to maximize the utilization of labor and equipment. In general, however, these higher costs in the terminal are not enough to offset significant line-haul cost savings of COFC, particularly for long-haul, high-volume movements.

Terminal managers will be faced with a variety of trade-offs in selecting the best transfer method, making the best use of labor, and coordinating activities to accommodate the complexities introduced by chassis. The management challenge is particularly critical in coordinating cars, containers, and chassis for the transfer operation and in maintaining chassis inventory at levels that will result in equipment savings as well as fluid operations. The management challenge will be made even more difficult if chassis pooling arrangements are not established within individual terminals and among terminals in metropolitan areas.

In terms of terminal design and investment, many terminals that are already mechanized will require only minor modifications and investment to handle domestic containerization. Incremental parking areas for bare chassis will probably be required, but land

requirements can be offset by the various stacking systems available or by transfer areas freed as a result of shorter trains. Obviously, development of super hubs through further consolidations will require substantial investment, but this trend is largely independent of domestic containerization, which will only serve to accelerate the process. Perhaps the largest incremental investment will be to mechanize circus ramps that survive the consolidation process. The pace of this investment, however, should be reasonable given a logical evolution of domestic containerization from high-volume corridors between major mechanized hubs to lower volume corridors served by smaller terminals.

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