DESIGNING INTERMODAL TERMINALS FOR EFFICIENCY

Ronald N. Zimmer
Sverdrup Civil, Inc.

ABSTRACT

The introduction of the double-stack container train in the mid-1980s brought railroads back to the waterfront at a level of activity that had not been observed before. Since that time, the term "intermodal" has become synonymous with the ubiquitous "box." Much effort has gone into speeding the movement of these containers from point A to point B, whether by water, rail, highway, or air.

Seaport, airports, and railroads have worked to make the interface among transportation modes an integral part of the shipping system. For some, the search was for the ideal terminal that could be built on any piece of land and that would solve all modal interface problems. Sadly no such treasure was found. Instead we find that the ideal terminal is not a certain physical configuration of pavement and tracks, but an organization of services integrated with a physical plant that meets the business needs of a specific marketplace. These physical plants may take many forms, which are influenced by the characteristics of the landscape, their proximity to the marine terminal or major industrial complex, their location relative to the mainline railroads, and their distance from the country's highway network.

This paper looks at the early development of the modern intermodal terminal and the improvements made during the periods of rapid growth. It will evaluate some facilities that work well and some that do not and explore the reasons why. The paper addresses current developments in equipment and labor use, reviews marine intermodal terminals, and inland terminals, looks at the requirements of both good rubber-tired and steel-wheeled access to the terminal, and sets forth some guidelines for future intermodal terminal development, including the development of an inland seaport.

INTRODUCTION

Intermodal transportation has been a part of the transportation scene since people first sought to trade the fruits of their labors for goods produced by others. People began using intermodal transportation early in history, when they initially carried their goods while walking and then transferred them to a beast of burden or to a raft or other vessel, and water transport was added to the equation.

Some authorities on the evolution of the rail intermodal movement in the United States frequently point to the circus trains as an example of its origins. Others point to the carriage of stage coaches on railcars. The terminology of early rail intermodal comes from these origins. "Piggyback" means to carry one mode's (road) vehicle on the vehicle of a second mode (rail). The loading method "circus ramp" reflects the process used by circuses to loading wagons on a string of railcars from one end and rolling the wagons from one car to another until they reached their final position.

Piggyback, also called trailer-on-flat-car (TOFC), expanded in the 1950s and 1960s as businesses located further from locations served by rail and as improved roads made it easier to get to a central rail terminal. The idea of eliminating the rehandling of goods between tracks and boxcars also was very attractive. Railroads favored this approach because it enabled them to use their labor more effectively. Efficiency in the operation of an early piggyback terminal was measured by the ability to get all loads for the day secured on the railcars in time for the "local" or switch crew to pick them up. Unloading was accomplished as soon as possible, and customers were called as soon as their trailer had been unloaded. Terminals were simple and widely scattered across the rail system. Physical needs were minimal: any length of track would do. After that, some old railroad ties were needed to contain the dirt required to build a ramp and a piece of an old flatcar was needed to make the transition from the ramp to the piggyback cars. A leveled and surfaced area to park trailers made the terminal complete. The volume of trailers at any one terminal was generally low. In fact, many terminals could be operated by only two people.

By the late 1960s containers had become a part of the piggyback equation; however, they were usually carried on their chassis because few mechanized ramps were in operation. In some corridors the volume of containers between two ramps was high enough that lifting equipment was installed to permit containers to be moved without their chassis. Container-on-flat-car (COFC) service was born.

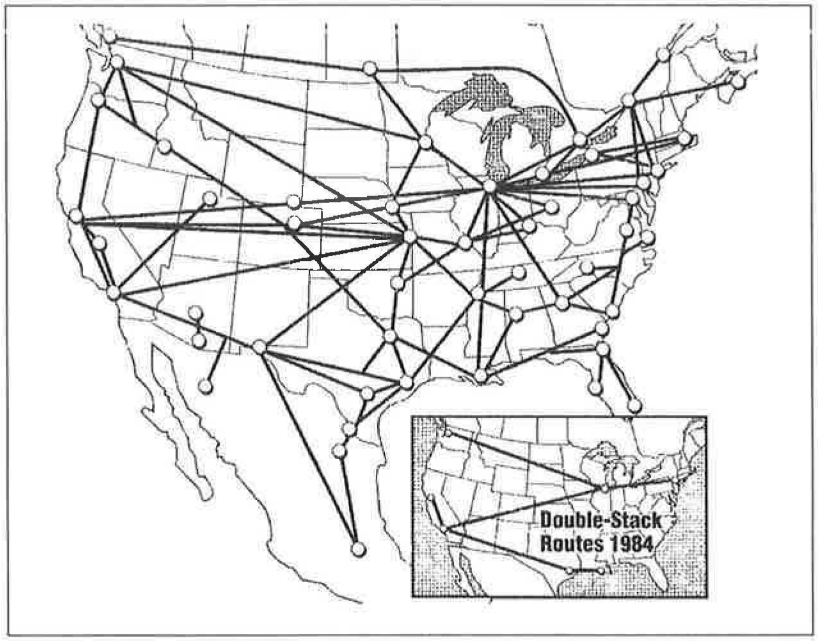

FIGURE 1 Double-stack routes, 1993.

As container movement in the Los Angeles-to-Houston corridor grew, interest was generated for a railcar that would permit more containers to be carried on a train whose length was controlled by the length of sidings along single-track mainlines. The first double-stack container car was built by American Car Foundry for service on the Southern Pacific carrying SeaLand containers. As piggyback (intermodal) business increased, more terminals became mechanized to allow strings of railcars to be loaded or unloaded at several points at the same time. This mechanization also permitted railcars to be loaded in random order rather than having to wait until all loads were in the terminal before loading. Mechanization increased both the productivity and efficiency of a given terminal.

By the early 1980s the rail intermodal network was being used extensively for the movement of international containers. Most containers still moved mounted on their chassis but the rail terminals were experiencing greater day activity associated with the weekly arrival of container ships plying particular trade routes. These cargo surges led to even more mechanization of the railroad's intermodal terminals.

In 1984 a significant milestone was reached. American President Lines introduced the stack train. APL combined the practice of stacking two containers on each platform of an articulated railcar with the operating plan of a contract unit coal train at points where the railroad only provides point-to-point haulage. The result was a transportation system that requires tight control and efficient unit handling to produce a smooth and efficient flow of goods. Success of this concept is demonstrated in Figure 1, which indicates double-stack routes for 1993.

INTERMODAL TERMINALS

Even though there are many important elements in the intermodal transportation chain, the intermodal terminal holds a pivotal position. Terminals that serve the international market at seaport locations face unique challenges. Because of the growth in intermodal transportation, ever-increasing demands are placed on these facilities. These demands are most intense at terminals that serve the international market at seaports. A single vessel can carry more than 1,000 containers that must be moved by rail. Because the costs associated with transporting goods can be tremendous, all parties have an interest in moving cargo as quickly and efficiently as possible. Much of this paper will focus on terminals that serve this international market, in which issues of efficiency are most critical.

The intermodal terminal must receive cargo from the carrier, identify the cargo's intended routing, plan the cargo's loading pattern on the railcars, plan the configuration of cars in a train, inspect railcars for suitability for the intended service, perform minor railcar

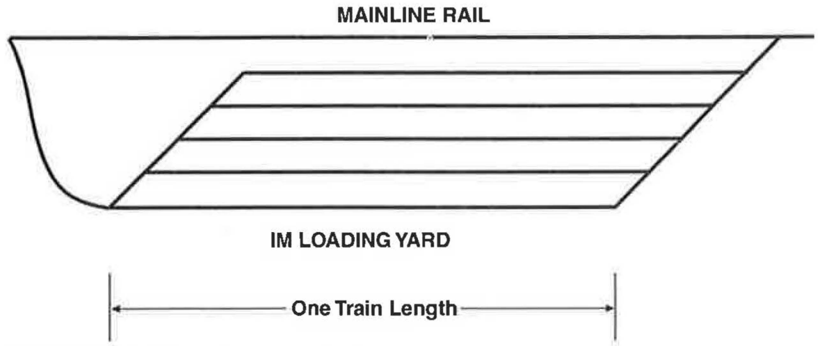

FIGURE 2 The ideal terminal.

repairs, load or unload the railcars, and prepare loaded railcars for departure. The past 10 years have observed major advances in the efficiency of these operations, and improvements continue to be made today.

Electronic transfer of data on cargo moving toward the intermodal terminal before its arrival permits the operator to plan the position of each load on the trains. Such data transfer facilitates the most favorable positioning of railcars ahead of time. Further advancements in this area should permit the positioning of loads on the train "on the fly" as they arrive at the terminal. Position selection will be determined by the loads that already have been positioned and those still expected. This procedure will minimize the "open holes" on the train yet ensure that platforms are overloaded and that the loads are distributed appropriately throughout the train.

The process of transferring loads from the marine terminal to the ramp area has been improved greatly by the cooperation and planning of all those involved in the transfer. By moving loads to the rail terminal in a planned manner, containers can be placed next to the railcar on which they are to be loaded or even brought in for a live lift. This process reduces costs by minimizing both double handling and the space required for unit parking.

Lift Equipment and Operations

Lift equipment and its use are major factors in the performance of an intermodal terminal. The two most common types of lift equipment are the top-pick and the rubber-tired-gantry (RTG). The straddle-carrier is showing high-levels of performance at the Port of Tacoma; however, its best performance is achieved when the entire terminal's container-handling system is based on this type of machine. A proposal for the development of the Norfolk, Virginia, North Terminal has been based on straddle-carrier use throughout the terminal. The new kid on the block for intermodal terminals is the reach-stacker, which combines the mobility of the top-pick with the ability to reach a load on a second track.

Top-pick equipment requires a major operating aisle, serves only one track, and must be used in a live-lift operation for double-stack rail equipment. Although some consider the live-lift requirement to be a limitation, most operators find that this requirement, along with the maneuverability of the machine, is beneficial, particularly when there is room nearby to pool the loads in a parking area before loading.

The RTG adds the operating flexibility of permitting loads to be staged along the track before the railcars are in position. Once the loads are staged, the RTG can simply start at one end of a string of cars and load each car in succession. The loss in efficiency comes with the next step. Once the containers are placed on the railcars, the hostlers must return to remove the empty chassis before the cycle can be started again. In a recent study that we conducted for an import support terminal, a top-pick system completed the work assignment in approximately 10 percent less time than RTG after the start of vessel discharge. The load plan involved 2,500 containers for 12 rail destinations: all containers were to be discharged in a random array and intermixed with nonrail loads.

Many operators have placed as many as four railroad tracks under the span of an RTG. Even though this site layout appears to save space within the terminal, it increases the total time required to load all four tracks. Because the RTG can lift only one container at a time, it actually prevents railcars on the other three tracks from being loaded at the same time. As a result, this plan can increase physical congestion in the operating area fourfold. As the cargo volume increases, this particular terminal configuration becomes less and less efficient.

The straddle-carrier, on the other hand can perform well, particularly when the entire operation is designed around its use. This, however, is generally not the case. As a lift-and-carry machine, the straddle-carrier takes loads directly to the railcars and loads them or it directs the load to temporary rest until the appropriate railcar is ready. The straddle-carrier also can load any platform on a string of railcars as long as the bottom position is loaded first. Thus the straddle-carrier combines the random operation of prestage with the productiveness of live lift and does so using the smallest amount of real estate per track of any of the lift systems.

The reach-stacker very new to the rail intermodal terminal. Its ability to serve two tracks from the same operating position saves real estate but, as is the case with the four-track RTG, only one track can be loaded at each position at any one time, and loads on the near track can obstruct the movement of the machine boom when it attempts to load the second track. These machines also apply a front axle load that is 20 to 25 percent higher than the equivalent top-pick when the boom is fully extended at maximum load. Most terminal pavements and utility protection systems are not designed for loads of this magnitude.

Intermodal Terminal Rail Design

Rail service to and within terminals remains one area in which good planning and design can make a major impact on overall efficiency. Many facility designs seem to be limited to preparing a sufficient length of track to position the desired number of railcars and then connecting the tracks to an entry-area rail line. These layouts are frequently difficult for the line haul or switching railroad to serve. The primary issues that must be dealt with when designing the rail-service aspects of a intermodal terminal are train arrival, internal switching, railcar servicing and repair, load blocking, predeparture inspections, and train departure.

For railroads, the ideal intermodal terminal would consist of a series of tracks running parallel to the mainline tracks. Each track in the terminal would be long enough to hold one complete train (Fig. 2). Additional track length would be provided so that the train could be broken into several segments to accommodate cross truck and equipment traffic. The arriving train would simply be switched from the mainline track onto one of the terminal tracks. Once the train pulls fully into the assigned track and is separated at the designated crossing points, the locomotives would be removed from the head of the train and sent to the railroad's assigned holding area for servicing. The track spacing of this ideal yard would be determined by the choice of loading equipment and the location of container and chassis parking, if it is provided.

Because today's intermodal trains are rapidly reaching 2750 m (9,000 ft) in length, such an ideal terminal would be difficult to construct in almost any urban area or large port area. The tracks in question need not be straight or even level, but with curve limitations of 12 degrees it is impossible to locate such a terminal close to a marine facility.

Because the ideal terminal is not viable, more thought must be given to each rail movement that will occur in and near the terminal throughout the process of train arrival, internal switching, and train departure. Failure to facilitate the convenient execution of any one of these steps will seriously reduce the terminal's efficiency in processing loads.

Frequently the reality of train arrival is clouded by visions of a set of powerful locomotives pulling a long train of loaded double-stack cars into a new intermodal terminal. Before being trapped by this vision, we must make sure that it can really happen. During planning for the south intermodal yard at the Port of Tacoma, we quickly realized that this scene would rarely occur. The combination of trackage rights and primary direction of operation made it obvious that special effort and extra work would be required for either the Burlington Northern or the Union Pacific to pull their trains directly into the terminal or to pull directly out (Fig. 3). The most likely entry by a road crew would be backing into the terminal. Departures most likely would be from nearby railroad yards, where the departing trains would be assembled by local switch crews.

This recognition relieved the terminal design of certain constraining factors. For example, it became evident that the north end of the loading yard track work need not be joined together to facilitate the escape of locomotives pulling cars onto these tracks. It was much more likely that all cars would be pushed into the loading tracks and then pulled out from the south end of the yard.

Train Arrival

Train arrival can be the most difficult issue to deal with when designing an efficient intermodal terminal. The two elements that influence the design are the length of the train and the fact that motive power is applied to a train or string of railcars from one end only. When the terminal's receiving tracks at a terminal are shorter than the length of the train, railcars must be placed on more than one track. Efficiently placing railcars on multiple tracks requires the cars furthest from the locomotives to be placed first. This efficiency is based on maintaining air pressure in the train's brake line. Separating cars at the end of the train only requires that the train be stopped and the air-line valve, at the point of separation, to be closed before the cars are uncoupled and the train is allowed to proceed. To place railcars from the head end of a train onto separate tracks requires that the full train first be stopped outside the terminal area, where the cars behind those to be positioned are uncoupled and the forward portion of the train is pulled onto the terminal track. Once the cars have been positioned on the terminal tracks, the locomotives are uncoupled. The locomotives must then be moved back to the cars left outside the terminal and recoupled. Once recoupled, the air line is reconnected and the air valves are reopened. The air in the brake lines of these cars must be brought to operating pressure before operations can continue.

One way to ensure that arriving trains can be "put away" in an efficient manner is to provide a sufficient length of track beyond the limits of the terminal. For example, if the terminal's loading tracks are one-fourth the length of a full train, a tail track opposite the rail entry end of the terminal should be capable of holding three-fourths of the train plus the engines. With this track configuration, the rear section of the train can be positioned first by having the train pull through the appropriate track and onto the tail track until the rear section of the train is in proper position. After uncoupling the train's rear section, the remainder of the train is pulled forward until it has cleared the switch to the track on which the last section of the train is to be placed. The direction of the train is then reversed, and the train is pushed onto the track for placement of the next section. This process is repeated until the entire train is put away. The tail track need not be totally independent. It may be a portion of the mainline or serve some other purpose when it is not being used for train arrivals. The essential requirement is that the tail track be long enough to hold the maximum-length train, less the portion that can be positioned on the first terminal track.

Switching

In the ideal world, all railcars placed in an intermodal terminal would have the characteristics appropriate for the loads planned for their specific position in the outbound train. Railcars usually are not delivered in this ideal manner or they may arrive carrying inbound loads for discharge and must be repositioned before they can be reloaded. Whatever the reason, there will be occasions when the set of railcars at a terminal must be switched.

At railroad terminals, this task is accomplished by local switching crews. At larger terminals, one or two switching crews may be assigned solely to serve the needs of the terminal. At independently owned and operated terminals, such as those at or in marine facilities, access to switching services may not be as convenient. In these cases, the terminal operator may want to consider acquiring its own switching locomotive or other equipment with which to move railcars.

When terminal operators move railcars, they must deal with the question of track authority and their rights, or lack thereof, to operate on trackage located outside the terminal. The usable length of any tail track should be equal to the capacity of the tracks being serviced plus the length of the car-moving equipment being used. The tail track used for train arrival may or may not be appropriate for this switching activity, based on operating jurisdictions.

Railcar Servicing

Before any railcar can be operated in regular train service, it must be inspected for compliance with certain railroad and Federal Railroad Administration regulations. Any elements not in compliance with these regulations must be repaired before the car can be moved beyond the repair facility. Items that may require repair include brake shoes, air-line hoses, operating elements of the air-brake system, and wheels. Items known as dangling appliances may require cutting, welding, or bending back into position. Most of these repairs can be made quickly when the railcar is positioned on the terminal's loading tracks. If repairs are to be made in the loading area, good access for the equipment used to service the railcar should be provided. For example, in areas where multiple tracks are close together, the spacing of alternate pairs of tracks should be increased to 25 ft for service-vehicle access. At large terminals it may be desirable to provide separate repair tracks for the servicing of cars requiring significant service time.

Load Blocking

The earliest of the modern double-stack intermodal trains generally ran between two terminal points. These points usually were one of the West Coast ports and either New York City or Chicago. In this point-to-point operation, little attention was paid to the order of cars in a particular train. After all, they were all going to the same place. Today the service destinations have expanded greatly. A given train may now carry blocks of cars for multiple destinations such as Houston, New Orleans, and Atlanta or Dallas, Memphis and Cincinnati. The loading area and all elements of the track at the terminal, therefore, should be organized for maximum flexibility in the loading and handling of blocks of cars bound for different destinations.

One method of accommodating this requirement is to combine more moderate-length loading tracks with a large support yard. The greater number of tracks permits loads headed for different destinations to be handled at different rates on different tracks. As the railcars on each of the tracks are completely loaded, they can be switched to the support area, and another set of railcars can be positioned for continued loading. Once all blocks are loaded, they can be strung together in the appropriate order for the departing train.

Inspections

Shortly before a train departs, its cars must be inspected and proper operation of the air brakes must be certified. Because this is a relatively time-consuming process and because the presence of an assembled train in a terminal can be disruptive, steps must be taken to minimize this disruption. Because the inspection of the air-brake systems on individual cars may be executed before the train is assembled, many terminal operators choose to complete this service before the railroad's locomotives arrive at the terminal.

To perform these tests, compressed air must be provided at various locations throughout the terminal. The connection points must be located so that they can be coupled with the ends of railcars near the head of the proposed train. The air-brake test must be performed by qualified personnel, and the results must be certified in writing and given to the train crew when they arrive. Once the test has been performed, air pressure must be maintained on the car's air system until it is connected to the engine's air-supply line.

Train Departure

The requirements for train departure are somewhat simpler than those for train arrival. If the tail track used for train arrival is under complete control of the terminal operator, the operator may choose to assemble the train fully before the road engines arrive. If the train is fully assembled, the road crew needs only to place the end of train into position, link the train's end with the head of the train, test the brake system for continuity throughout the length of the train, receive track authorization for departure, and leave. In the best situation, the train will depart within 30 minutes of the crew's arrival at the terminal.

When it is not possible to assemble the entire train before the road crew arrives, the departure process takes somewhat longer. In most cases the direct outbound departure of the train is possible. To achieve this departure the road locomotives are first coupled into the head block of cars for the proposed train. These cars are pulled from their tracks and the entire block is connected to the cars of the second block of the train. The process is continued until the entire train is assembled. At this point, the head of the train is well down the mainline, more than a mile away from the terminal. Any remaining tests are then performed before the train's departure. After the train's crew has walked back to the head of the train, the train may depart.

Efficiency

In each of the areas mentioned previously, efficiency is measured on the basis of impact on the overall loading-unloading process. Any action that disrupts or delays the lift process has a negative impact on the efficiency of the terminal. If the terminal's throughput is small compared with its static capacity, the effects of the delay may be small, but as the volumes of cargo handled increase, these interferences can combine to make the overall performance unsatisfactory. An intermodal terminal, particularly one serving in a marine terminal environment, must be capable of extremely intense activity for concentrated periods. Other intermodal facilities may be able to work at rates that more closely approximate a steady-state, average condition.

Case Studies

Following are the ways in which the aforementioned design issues were addressed at two terminals currently being designated.

Terminal 1

Terminal 1 is an on-dock intermodal railyard that will be contained within the marine container yard at a

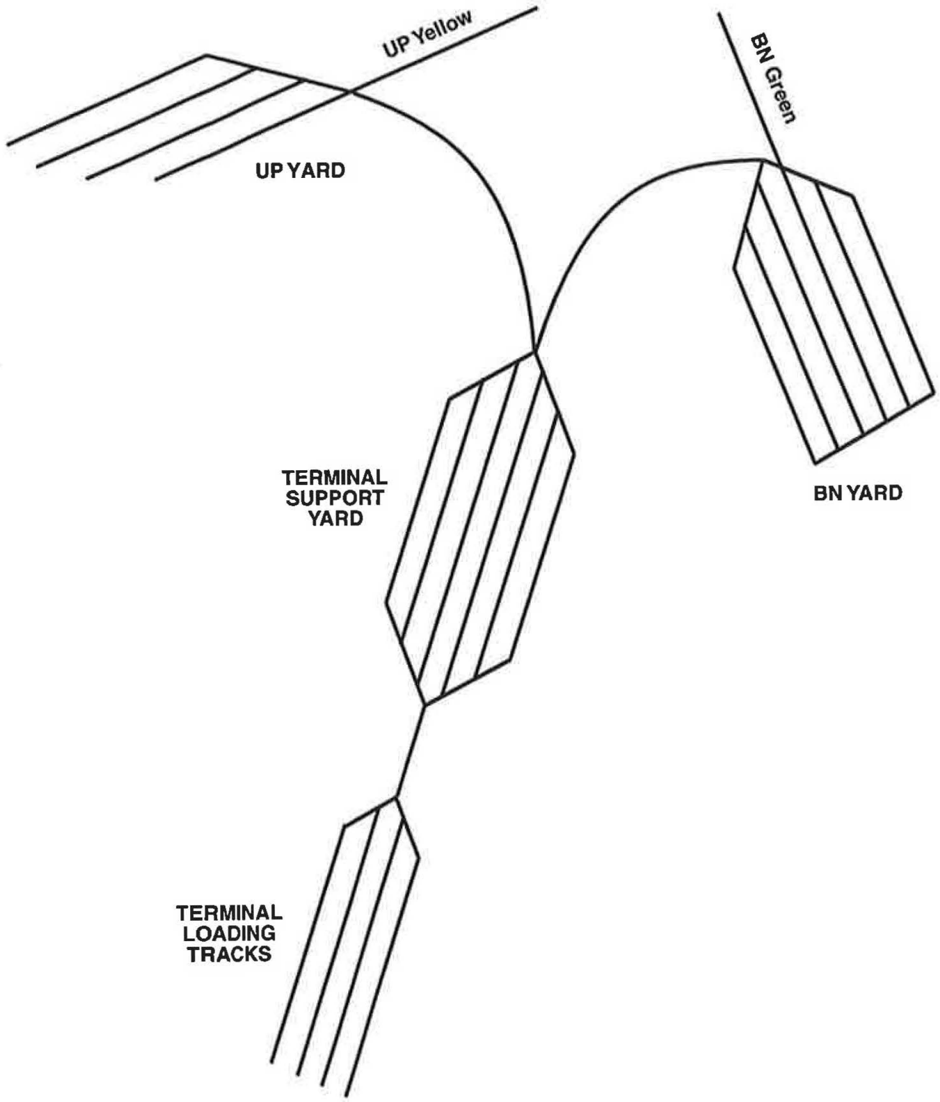

FIGURE 3 SIM Tacoma.

West Coast port. The capacity of the terminal is defined as one unit train, 28 double-stack railcars with a combined length of 305 ft.

Because the anticipated cargo will contain a high volume of 20-ft containers going to selected destinations, the terminal operator expects to do a lot of preloading switching to put the right cars in the right position. A higher number of wheel set replacements are anticipated during the winter; therefore, the operator wants two or three car positions on each repair track. In addition, the existing "heavy-lift" track along the wharf must remain in service, added trackage is needed under the hook of the dockside cranes, and encroachment on the container yard must be minimized. Railcar maintenance and predeparture air-brake testing will be performed in the terminal. The port requires that mainline track use be minimized, particularly for terminal switching, and that maximum flexibility be provided for rail traffic elements in the immediate area. Based on preliminary geometric layouts, the terminal operator selected a reach-stacker as the lift machine for this terminal.

The track plan that evolved benefited greatly from the elongated hexagonal shape of the marine terminal property. The port's double-track mainline passes along the eastern edge of the site. All arrivals and departures will be from and to the north because there is only one marine terminal past this point. The plan places two pairs of loading tracks along the southern and south-western limits of the property (Fig. 4). The paired tracks will be separated by a 21.5-m (70-ft) wide working

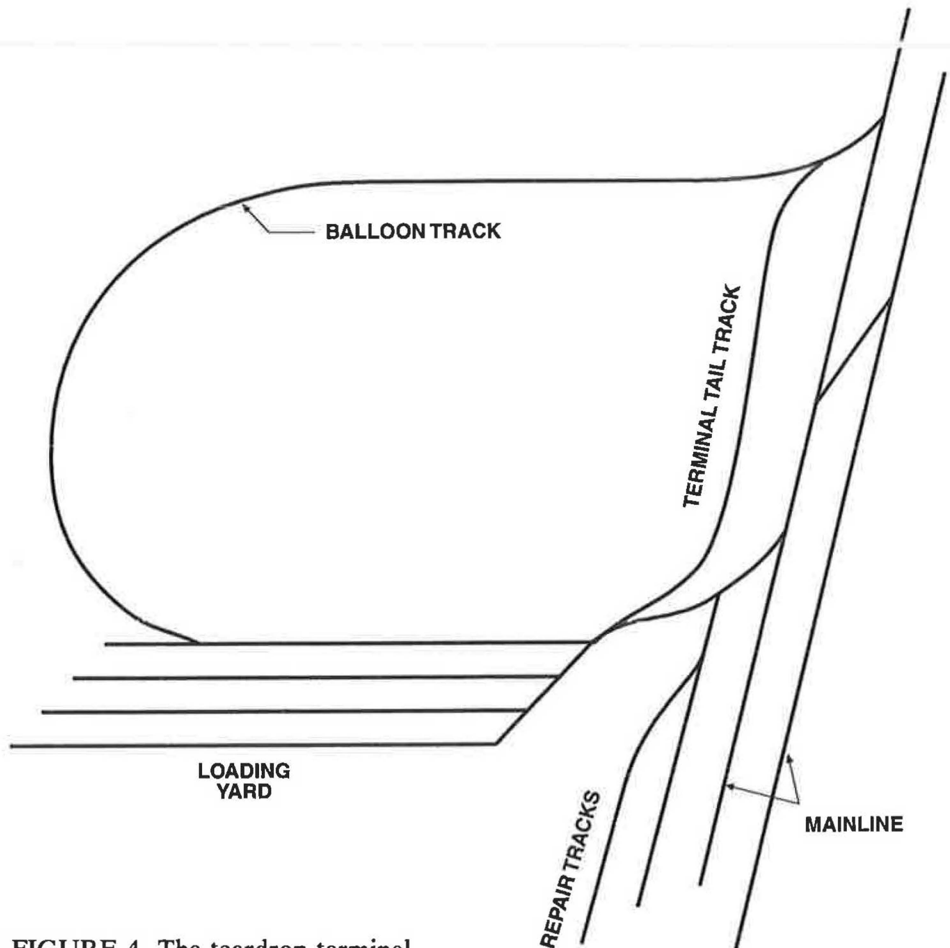

FIGURE 4 The teardrop terminal.

aisle for lift equipment. Two connections will be made to the mainline, and an internal connector track will run parallel to the mainline. This connector track will be within container terminal property, between the two mainline connection points. The second track under the dockside crane, the "backreach track," will not terminate but will curve around the west end of the site until it intersects the northernmost loading track. This track configuration will accommodate several train arrival and departure plans and keep all in-terminal switching on terminal tracks.

Although the loading-track requirements were defined on the basis of a single train, actual operations will vary widely. Arrivals may range from a fully loaded train of 28 cars to short cuts of empties. Departures may range from one or more blocks of loaded cars, each with a different destination, that will be integrated with a regularly scheduled intermodal train in another part of the city, to a fully loaded 28-car contract unit train for one inland destination. The terminal plan must be flexible enough to accommodate this spectrum of operating possibilities.

The operation of the terminal is based on the assumption that a train arriving when there is no vessel at the dock will enter the terminal through the north entrance, then travel along the backreach track, around the west end of the terminal, into the north loading track, and head toward the south entrance. The length of the arriving train will influence the arrival options available. If the arriving train has fewer than 21 double-stack cars, the train will be able to continue along the interior connector track and return to the mainline where it entered the terminal. Trains between 21 cars in length and the design criteria of 28 cars in length will have to exit the terminal and return to the mainline through the south entrance. If train length exceeds 2750 m (9,000 ft), the train will have to use the crossover between the north and south entrances to avoid running into its own rear. The train will continue to pull through the terminal until the last car fully enters

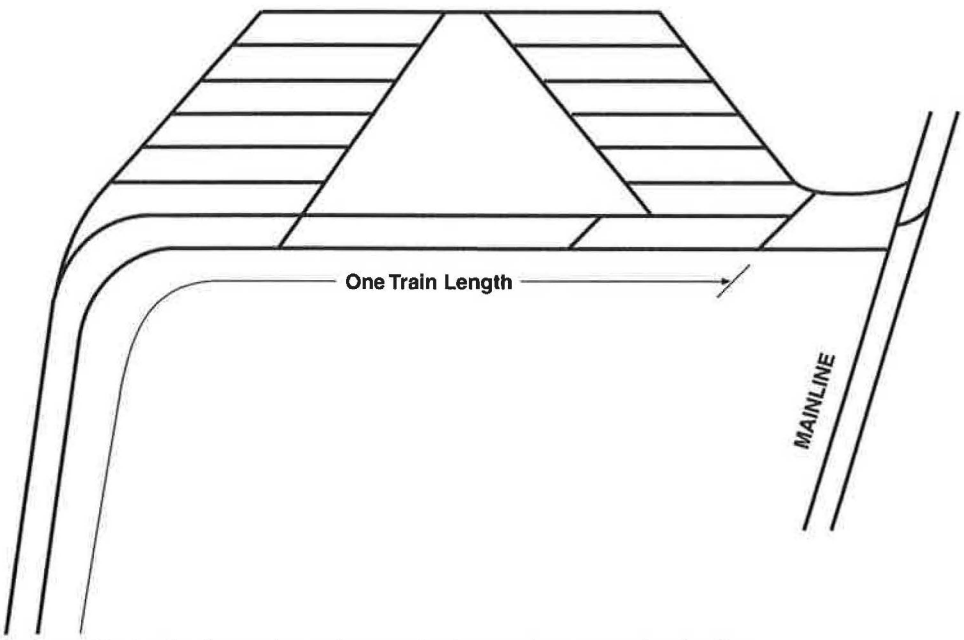

FIGURE 5 The latest bow tie terminal container transfer facility.

the north loading track. The train will then stop and be pushed back until the last car is at the end of the north loading track. The desired number of cars will be left in place on the north loading track, and the train will pull ahead slightly until the "new" rear of the train clears the entrance to the next loading track. The direction of the train again will be reversed, and the appropriate number of cars left will be on the second track. This process will be repeated until all railcars are positioned.

If dockside activity precludes a train's moving along the backreach track, the train will be stopped on the mainline, north of the terminal. The locomotive will be removed from the head of the train to be repositioned at the end of the train using the second main. At this point, everything will be in position so that all cars can be pushed onto their respective loading tracks using either the north or south entrances. These are the two basic arrival techniques. There are numerous variations on each basic plan that may be used for general or specific circumstances.

Departure will bey straightforward. The railroad engines will be coupled with the cars that represent the head of the departing train. This string of cars will be pulled forward and then doubled by connecting to into the cars representing the next segment. The process will be repeated until the full train is assembled, and a train brake is set. A release test then will be made and the train will be allowed to depart.

The terminal operator will perform internal railcar switching by using car-moving equipment and the interior connector track. The operator will connect the cars to be switched and pull them back along the interior connector track until the needed car can be pushed to another track. The remaining railcars then can be returned to their original tracks. By using the interior connector track, the operator will have ample track length to conduct all internal switching that may be necessary, without interrupting mainline traffic going to other terminals.

Terminal 2

Terminal 2 is a "near dock." It is an independently operated intermodal terminal serving four nearby marine container terminals at a West Coast port. Steamship lines calling at these container terminals currently make extensive use of scheduled intermodal train services provided by three of the western railroads at the railroads' own intermodal terminals as well as some contract unit train services dedicated solely to a contracting steamship line.

The terminal's performance criteria were developed as part of the planning process. The primary focus was to provide a very high and sustainable container lift rate. Operations and services at the proposed terminal had to be at least as versatile as those available at the railroads' facilities. Users of railroad facilities that have the largest volume of traffic provided information about their anticipated rail volumes, based on current rail service patterns and destination blocks. The flow of cargo to the intermodal terminal was based on two vessels with the maximum amount of intermodal cargo arriving in port on the same day, to account for cargo growth to the year 2020.

Other terminal layout requirements include: the need to accommodate the arrival of maximum-length trains that would not have to stop or switch while on the mainline access tracks; hard limitations on the site perimeter imposed by the needs of adjacent projects; and alternate track layout solutions for the west end of the terminal to meet a future container terminal expansion plan and associated street relocation plan.

The terminal plan has six project elements (Fig. 5): the loading track area, storage/holding track area, arrival/departure tracks, railcar maintenance tracks, engine layover tracks, and the bypass track.

The loading tracks will function in concert with the storage/holding tracks to provide a smooth flow of lift activity. The tracks in the loading and storage/holding areas accommodate seven double-stack cars, 93 m (305 ft) in length. With this track-length compatibility, cars will be moved from track in one area to a track in another area, without clearance concerns. Arriving cars initially will be placed in the storage/holding yard by the line-haul railroad, then moved to the loading area by the terminal operator for loading or unloading. Unneeded cars and loaded cars will be moved back to the storage/holding area; loaded cars also will be moved onto the departure tracks.

As their name implies, the arrival/departure tracks will serve a dual purpose. Arriving trains will enter the terminal at the east end pass through an assigned storage yard track, and move out onto the arrival departure tracks. This will prevent disruption of work in the loading area. The last cars of the arriving train will be left on the first storage track, and the remainder of the train will be put away by repeated push-pull movements, onto other assigned storage tracks. Line-haul railroads will pull outbound cuts of cars directly from any storage/holding track, or the terminal operator will assemble longer strings of cars, up to 28, on any departure track for subsequent departure.

The railcar maintenance tracks will accommodate cars that require more extensive work than can be executed conveniently in the loading yard. General maintenance such as brake-shoe replacement, hose replacement, minor cutting and welding, and brake mechanism adjustment will be performed on unloaded cars in the loading yard area whenever possible. The maintenance area, two yards, and the arrival/departure tracks will be equipped with compressed-air distribution piping and convenient connection points to permit inspection, testing, and certification of air brakes at any point in the terminal.

Engine layover tracks will be located outside the terminal area and will serve any terminal. The layover tracks will reduce congestion on the mainline approach to the port complex and its many rail facilities. The engines of arriving trains will be placed on the layover tracks, and the crew will be transported back to their duty points by taxi or van. Wide aisles and spill protection will make it possible to fuel and service engines while they are on the layover tracks. When a railroad has a departure, the new crew will be transported to the engines, start the engines, and move the engines the short distance to the terminal. Keeping the engines in the area will reduce many of the light engine trips on the mainline and thus significantly improve the efficiency of the complex.

The bypass track will be critical to the maintenance of rail-service for several existing rail service users in the area. It will connect to the backside of the other two major rail facilities currently being developed, providing an emergency escape route for rail equipment in case the facility's primary entry is temporarily obstructed. This connection will maximize the flexibility of the entire rail complex.

FUTURE GROWTH

There is little doubt that intermodal traffic will continue to grow, placing increasing demands on terminal facilities for the efficient handling of cargo. There are several areas in which efficiencies in cargo handling can and will be achieved.

One of the primary areas will be in the use of advance information. As space is booked for a particular train, most data necessary to assign the particular load to a position on the train also becomes available. With the availability of aggregate data for a given train, a rational load plan can be developed by computer on the fly. As each load arrives at the terminal, the computer assigns a prestage location based on the most convenient position that maintains proper load blocking and balance and also provides maximum use of rolling stock.

The other key area for maintaining intermodal rail terminal efficiency is in the supporting facilities. The complete process of train arrival and departure must be considered to prevent interferences with internal vehicle circulation or critical rail switching. Where internal switching is an integral part of terminal operations, it should not interfere with vehicle circulation in the loading area. For terminals that do not have internal rail support yards, adequate support yards must be available from the line-haul railroad at a convenient distance and must be readily accessible for the transfer of railcars between the support yard and the intermodal terminal.

Rail traffic is growing, and terminal facilities must be in a position to respond to this growth with ever-increasing efficiency.