Automated Transfer Management Systems and the Intermodal Performance of North American Freight Distribution

by John Zumerchik, Jean-Paul Rodrigue, and Jack Lanigan, Sr.

For capacity, energy and environmental reasons, intermodal transportation is widely regarded as the preferable option for inland freight distribution. But because of the relatively high embedded costs, intermodal rail is currently only an attractive option for containerized goods carried over long distances. Transfers that in theory should entail only a few operations at a terminal in reality require multiple operations. This paper argues that by incorporating new terminal designs and an automated transfer management system (ATMS) at terminals and distribution centers, the resulting efficiency advances and productivity gains could significantly improve the economics for both long and short haul intermodal movements, including port shuttle trains. This system not only could significantly lower fixed costs and make intermodal more price competitive, but improve time and reliability to make intermodal more service competitive as well.

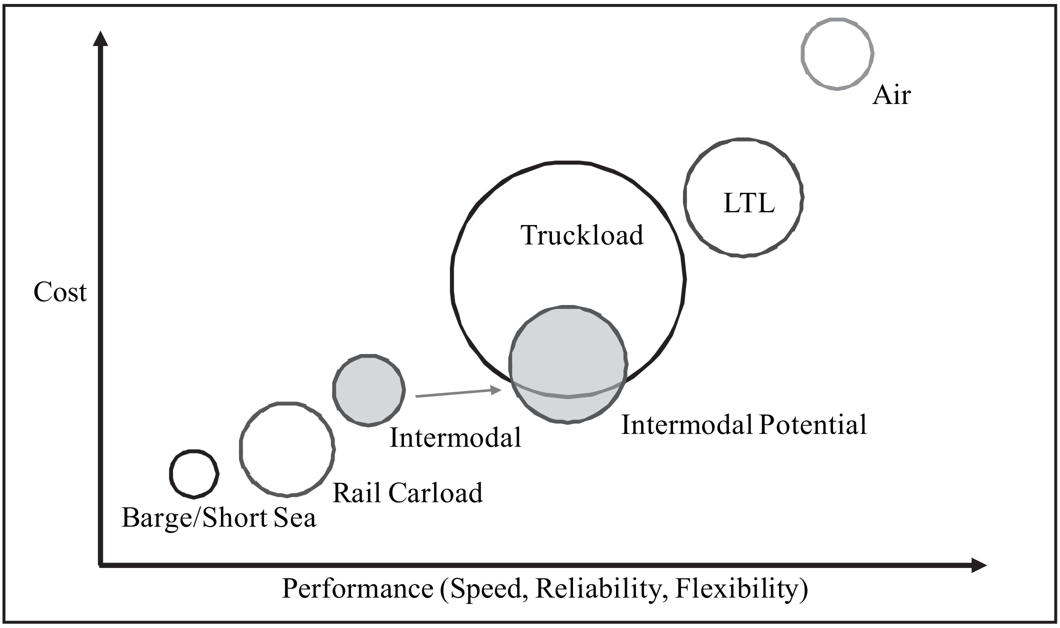
CHALLENGES TO THE NORTH AMERICAN INTERMODAL RAIL SYSTEM

The ownership structure of rail transport systems in North America involves substantial maintenance costs paid by private operators. The surge in traffic up to 2008, particularly imports, has resulted in congestion in various segments of the North American transportation system. While importers have benefited, North American manufacturers are impacted by greater rail and roadway congestion, which has made it more expensive to service domestic markets and to reach export markets. Constraints on growth in the trucking industry, including a shortage of drivers, highway congestion, high insurance rates and increasing fuel and labor costs, have helped intermodal rail operations capture a significant fraction of international freight, yet only a small fraction of the domestic market. Although the domestic long distance market is enormous and growing, the costs associated with intermodal transfers, both for containers and trailers on flat cars, are a major factor accounting for the small share of the domestic freight market for intermodal rail.

One of the great labor and energy efficiency advantages of rail is that about 200 containers can be moved at a time in one unit train. Yet the requirement of assembling long intermodal trains presents an impediment to reliability that is not applicable to goods movement by truck. From a logistics perspective, the larger and more fragmented the freight, the more challenging the task of quickly assembling trains. Further, a transfer delay, which can occur during the multiple operations of the truck-rail transfer at conventional intermodal terminals, will result in missed connections and delays for the outbound corridors. While intermodal rail services have grown, attracting additional traffic will require improving connectivity between the modes to significantly improve supply chain performance and thereby reduce the volume of truckload freight creating highway congestion.

Intermodal rail has significantly contributed to improvements in freight distribution, and the potential remains to maintain similar cost structure to rail carload service while providing the service level of truckload freight (See Figure 1). By reducing the number of times a container is handled, the number of operations involved in the transfer, the distance (in the terminal) over which a container is handled, and the labor, equipment and time needed for a transfer, efficiency and productivity improvements (better asset utilization) can be achieved. Equally important would be improving vessel and train turn times (from inbound arrival to outbound departure), and reducing drayage costs by shortening the wait time for drivers delivering and picking up containers from

Figure 1: Cost / Performance Relationships for Inland Freight Transportation Modes



shippers and consignees, particularly at port terminals, as well as an elimination of deadhead, empty loads and empty trips.

In view of growing international intermodal traffic, many investments have been made in expanding port capacity in North America (e.g. Savannah, Hampton Roads), spurring additional demands and higher requirement in the timing of inland containerized shipping (Rodrigue and Hesse 2007). This has placed pressures on investment needs in inland intermodal transportation. Without improvements in the intermodal network to increase capacity and improve speed, reliability and the costs associated with intermodal and transmodal transfers (rail to rail), goods movement will remain dominantly serviced by trucking over increasingly congested highways. For instance, a number of East Coast distribution centers have been relocating further inland in Pennsylvania and Upstate New York to minimize roadway congestion disruption, and to avoid transmodal interchange between Western and Eastern railroads; many shipments are trucked from Chicago instead of being railed.

Even after more than two decades of intermodal developments, there is a glaring need for closer integration between maritime and inland rail transportation. It is argued that the setting of a universal, highly automated transfer management system (ATMS), which provides immediate selection for crane operators and truck drivers, presents an opportunity for North America to develop a more efficient intermodal freight system with significant energy, environmental and competitive advantages. This paper will explore the expected economic and operational characteristics of such a system.

INTERMODAL TRANSFER ECONOMICS

Over the last 20 years, the components of many supply chains have been outsourced, particularly to Asia. The trade-off in taking advantage of lower labor costs internationally has been increasingly more distant and complex logistics. This has been made possible by the containerization of supply chains, with the container becoming a transport, storage and management unit (Notteboom and Rodrigue 2009). The current context underlines that supply chains are attempting to switch to the more energy efficient modes of rail and barge service (still very marginal) for inland freight distribution of containers whenever practical. The “weakest” link in the inland system remains the intermodal and transmodal (ship-barge, rail-rail) connections, which undermines intermodal with reliability, flexibility and time disadvantages vis-à-vis truck transportation.

Although the velocity of each mode has remained stable for decades, there is still great potential to improve intermodal and transmodal transfers so that each mode is used in its most cost- and time-effective way. When a segment of the container transport chain becomes unreliable, the whole chain is adversely affected. Intermodal rail delays during transfer, which the trucking industry does not have to contend with, include missed connections between railroads, delays in unloading a train, an inability to get the desired unit on the first train out and locating mis-parked containers at the terminal. Supply chains react to these delays by building an extra day into most intermodal delivery schedules.

Congestion, rising energy prices and government pressure to curtail emissions have been driving supply chains to adjust their just-in-time practices. This probably will be reflected in more consolidation (less frequent and larger shipments), and a reliance on better planning (reliability becomes more of a priority than speed) to take advantage of barge and rail transportation. However, for this strategy to be effective, it will require some fundamental changes in the industry to expand capacity for these ever more complex and distant supply chains, as well as to make service attractive for shorter haul domestic shipments.

Intermodal was designed to capture the best of each mode – combining the economies of shipping vessels and rail line haul (with its much lower average cost per mile) with the flexibility of trucking for local drayage. Railroads comparative advantage rests with line haul efficiency. Moving freight by double-stacked rail cars is three to five times more energy efficient than by truck (Bryan et al. 2007). Despite double-stack service providing line haul cost savings of 30-40% per container vis-à-vis single container loading (Spychalski 2009), often the intermodal line haul cost savings prove smaller than the added time and costs associated with terminal operations and drayage.

Drayage is required to get containers to and from the terminal, entailing the all-important first and last mile of an intermodal trip. To move a container over-the-road, a chassis (the frame supported on springs and attached to the double axles) must be provided at both ends of the transportation chain—at the shipper's facility and at the consignee's facility. To pick up a load, a tractor, with chassis and container, are dispatched to a shipper's location, and the driver can either "stay with" the equipment while the container is being loaded, or "drop, leave, return and pick" (the tractor leaves the chassis and container with the shipper for loading at another time). Once the container is loaded, a tractor would be dispatched to pick up the container for loading on an outbound train. The same two options exist for the destination drayage consignee.

Because it can take up to an hour to fully load a palletized container, the "stay with" option entails a significant loss of driver productivity associated with waiting while the shipper is loading or while the consignee is unloading. The time penalty can be significantly greater—from two to 12 hours—when the product is "floor loaded" (common for international shipments) to take full advantage of the available container volume (Maltz 2007). Unless the product is palletized and ready to be loaded immediately, the "drop, leave, return and pick" option is usually favored, because the costs associated with leave and return empty trips is less than the driver's idle time. To make drayage more attractive to independent operators, the goal is to minimize the wait time for the driver at the terminal and distribution center to bring the cost-per-mile of drayage service closer to that of short haul trucking operations.

Distance from the terminal to the distribution center is another major variable. A basic characteristic of intermodal economics is the closer the terminals are to where freight originates and terminates, the more efficient intermodal is, because rail line haul constitutes a greater percentage of the trip. Further, the greater the drayage distance, the greater the inefficiency costs that need to be absorbed (empty trips), which also creates congestion costs for everyone using the transportation system. However, automated real-time communication technology and better collaboration between railroads, shippers, truck line carriers and consignees can be effective in reducing these non-revenue generating trips.

Total transfer intermodal costs are equally affected by the distance of drayage, equipment utilization (truck/chassis) in both directions, and the time required of drivers to pick up and drop off containers at the terminal and the distribution center. Except for the largest of customers, most notably UPS and the U.S. Postal Service, intermodal drayage service increasingly has been provided by independent truckers, with independent third-party agents selling the service. Intermodal rail terminals must transport and stack containers at remote sites, because these third-party agents do not pick up containers sequentially as they are unloaded. Containers are picked up, usually before incurring a demurrage charge, at the convenience of the customer, who often uses the ports and rail terminals as supply chain buffers (Rodrigue and Notteboom 2009). The free time allowance varies by terminal, generally three or more days at the ports and 24 to 48 hours at high volume rail terminals. Although quick pick ups are the general rule for trade between major electronic manufacturers and U.S. retailers, small Asian manufacturers of low-value goods have little leverage to demand quick pick up (and more importantly, payment) from large U.S. retailers who use the terminals as supply chain buffers (Maltz 2007).

Truck loads do not need terminals, so delays in handling—whether at the terminal or distribution center—are disadvantages for intermodal to overcome. These costs are fixed—that is, they do not vary at all with the length of the intermodal haul. Fixed transfer costs include transaction, providing the terminal facility, remote container and chassis storage (including the additional lifts required for stacked storage), cranes for loading and unloading containers, securing and releasing interbox connectors, drayage at both ends, gate costs and chassis-related operations. In particular, trying to achieve the free flow of equipment among railroad and highway operations (chassis fleets), which is critical for efficiency, is extremely problematic in practice.

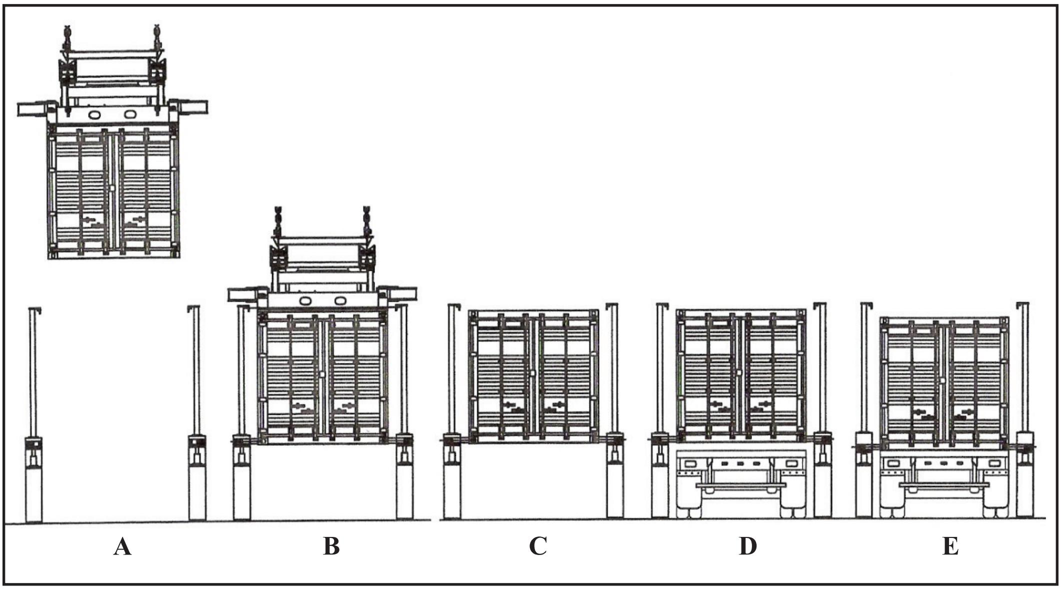
The breakeven point can be determined by comparing rail line haul costs plus transfer costs to the truck line haul cost-per-mile for the same trip. There is no definitive breakeven distance. It is highly situational, with many cases where truck provides some long distance service and where intermodal provides some regional service. In particular, when there are high volumes of freight moving in well-defined corridors, intermodal can be competitive for relatively short distances (Bryan et al. 2007). This is especially true when drayage is minimal, such as when distribution centers are located adjacent to intermodal terminals (co-location).

AUTOMATED TRANSFER MANAGEMENT SYSTEMS

The major challenge facing intermodal is to better synchronize the multiple modes to work together efficiently and seamlessly, since each has different operational and technical characteristics. A potential element needed to streamline the processes is the integration of automated transfer management systems (ATMS). An ATMS is, in essence, an active parking stall, a mini-crane, that can elevate, lower, store and position the container for the truck carrier or crane to lift (Figure 2). Designed to position and transfer a container between or among modes, ATMS applications include:

1. Trackside at rail terminals
2. Vessel loading / unloading
3. Chassis flips
4. Port stack container yards
5. Chassis storage
6. Loading bays at distribution centers

Figure 2: (A) Crane Unloading Container from a Railcar; (B) Loading Container on to an ATMS; (C) Awaiting Truck Pickup; (D) Truck Chassis Backs into ATMS; (E) ATMS Lowers Container on to Truck Chassis



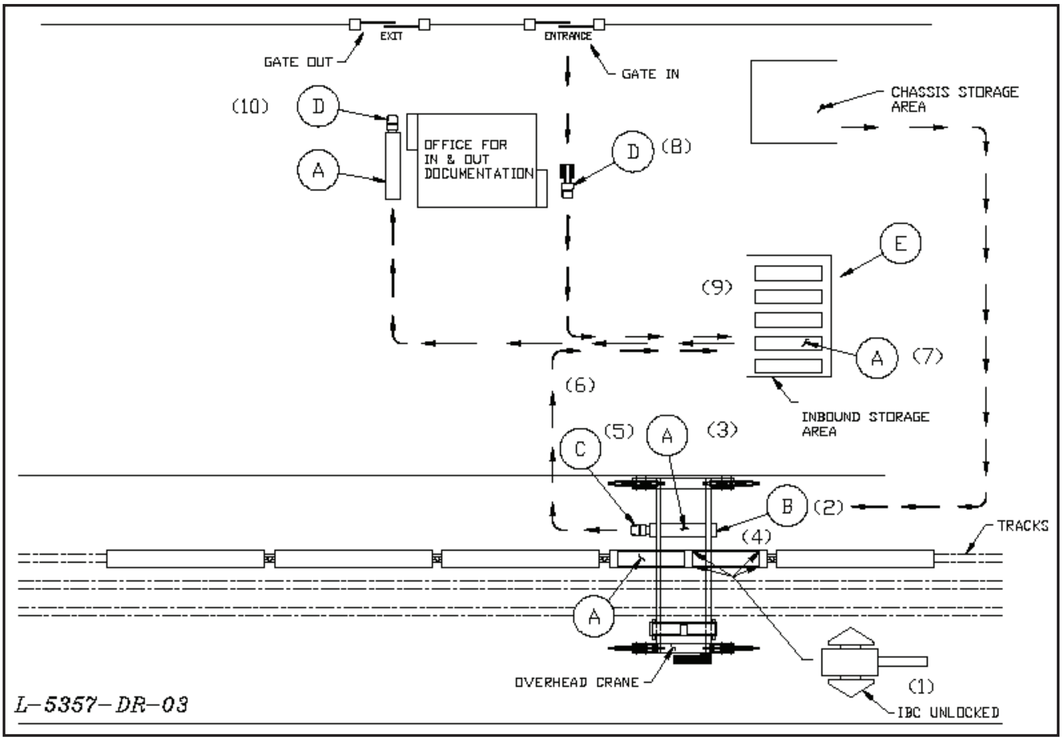
Trackside at Rail Terminals

At the terminals, there are three main logistic processes that interact with each other: (1) loading and unloading containers from trains and ships (intermodalism); (2) storing containers (warehousing); and (3) receiving and delivering containers (throughput). Currently, intermodal terminal operations are equipment- and labor-intensive. The costs of providing the terminal facility includes the gate system and gate personnel, hostler (yard truck) and hostler drivers, employees who check for mis-parked containers, and security personnel. For the trackside loading/unloading of containers, this includes gantry cranes and operators and personnel to secure and release the interbox connectors for double stack railcars. For chassis storage and the remote container storage yard, a storage yard supervisor and two or more cranes and crane operators are required. Conventional terminals operations are usually a combination of wheeled or stacked. In a wheeled operation, containers are offloaded from a train and a yard tractor parks the container at a remote storage yard for the drayage truck pick up. Usually once the terminal runs out of parking spots or available chassis the containers are stacked.

High volume and long dwell time requires inbound containers to be shuttled to a remote storage yard to await pickup, and containers have to be shuttled from a remote storage area to the ramp operation for loading onto a double-stacked car for outbound service. Trackside storage and large overhead cranes are not currently used at conventional terminals, despite its many advantages (e.g. reduced number of lifts and shuttling of containers from remote storage), because of congestion concerns—trucks waiting in line for the overhead crane to load or unload containers to or from the trackside storage area to the truck line carrier's chassis.

Rail-truck intermodal transfers using remote storage typically involve 10 labor- and equipment-intensive operations (Figure 3), and require approximately twice as many for transmodal interchanges (from one railroad's terminal to another) (Lanigan et al. 2007). The ATMS operation will reduce the number of operations from 10 to five, requiring only one lift but no hostlers, hostler drivers, remote storage and remote storage labor. Containers always sitting atop an exact position ATMS also will make it easier to automate and expedite two of the five remaining steps: entrance and exit gate operations. Consequently, the ability of the ATMS to reduce the number of operations, and the equipment and labor to perform the operations, will significantly lower the terminal-related transfer costs.

Figure 3: The 10 Operations of an Intermodal Transfer at a Rail Terminal



Inbound Container Operations:
1. Inter Box Connector (IBC) unlocked.
2. Chassis removed from storage area and brought trackside.
3. Top container unloaded to chassis from railcar.
4. Take out IBCs and put in pocket of railcar.
5. Hostler hooks up the chassis.
6. Hostler brings container to the remote storage area.
7. Container unloaded at storage area, or leaves chassis/container.
8. Drayage driver checks in at the entrance gate and given location of container to be picked up.
9. Crane loads container on chassis (need “dig” lifts if not atop a stack) or driver connects chassis.
10. Drayage driver checks out at the exit gate.

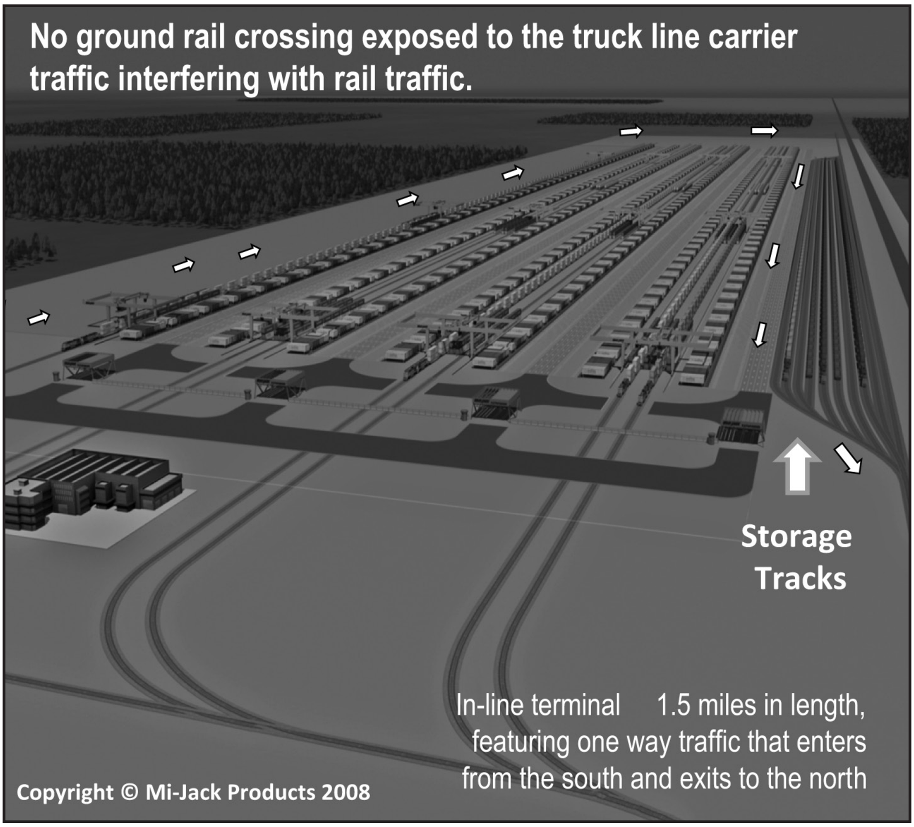
(after IBCs removed, steps 2, 3, 5-10 repeated for bottom cell of double stack car.)

The great advantage of wheeled vis-à-vis stacking terminals is fewer "rehandles" or lifts: always one per transfer. Nevertheless, wheeled operations have several major shortcomings. Foremost is acquiring an ample chassis fleet (about three available per container), maximizing chassis utilization and providing for their storage, stacking, tracking and maintenance. Second, wheeled operations require a large fleet of yard hostlers to shuttle chassis, with and without containers, to and from the remote storage area. Third, labor productivity and air quality suffers from the considerable amount of time drayage and hostler drivers spend connecting and disconnecting the chassis. Fourth, the operation of the cranes and yard hostlers must be synchronized, which is made more difficult by late arriving trains. And lastly, high container volumes require significant real estate, especially the greater the free container dwell time allowance (before incurring demurrage charge) at the terminal. Therefore, the objectives of an inline ATMS terminal are to reduce or eliminate:

- the number of times a container is handled.
- the number of operations involved in interchange.
- the distance over which a container is handled within a terminal.
- the labor, equipment and time needed for an interchange.
- the in-terminal time of trucks delivering and picking up containers.
- the handling of chassis and the use of hostlers to bring containers trackside or to storage areas.

By automating and streamlining the loading and unloading, minimizing the storage function, expediting the receiving and delivering of containers to and from truck line carriers, dictating all roadway traffic moves in one direction for safety and efficiency and expanding capacity (at a lower cost) for any given acreage, an inline ATMS terminal can achieve substantial cost and time benefits. (Figure 4)

Figure 4: Inline ATMS Terminal with Four Ramps



No ground rail crossing exposed to the truck line carrier traffic interfering with rail traffic.

In-line terminal 1.5 miles in length, featuring one way traffic that enters from the south and exits to the north

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Terminal Performance. For any given terminal volume estimate, the number of cranes and ATMS bays will vary depending upon daily number of train arrivals/departures, how tight the schedule for arrivals/departures are and the expected spike in traffic for peak seasons.

The greatest performance gain with an inline ATMS terminal will be derived from permitting drayage drivers and crane operators to load and unload containers immediately and unassisted. In other words, the crane operator never has to wait for chassis/containers to be brought trackside, and the drivers never have to wait for the crane operators. For example, there is never a need to wait on the 10 terminal cranes at a 600,000 annual lift terminal to load or unload a container. If there are 2000 ATMS bays, this means that there are 2000 bays available for immediate selection for container pick up or drop. The result is much faster cycle times for the crane (and faster train turn times), and a reduction in the time spent in terminal by drayage drivers picking up and dropping off containers.

Optimization for One Mode No Longer Has to Come at the Expense of Another Mode. For instance, container stack operations are currently optimized for the crane, with drayage trucks servicing order determined by quickest accessibility, not by order of arrival. Because drayage drivers would be entering and leaving the terminal with the same chassis, ATMS also will significantly lower terminal costs associated with chassis purchase, maintenance, storage and phantom damage claims. Gate communication can be improved as well, because the ATMS instructs the gate as to what inbound container it is sitting atop ready for truck pickup, along with what ATMS are available for the loading of an outbound container from the truck line carrier. The ATMS system also instructs the crane operator when a trackside outbound container, atop an ATMS, is ready for loading on an outbound train. Containers entering the terminal are, in essence, “automatically” blocked when the truck line carrier delivers the container to the appropriate ATMS. Aside from the gate personnel, the ATMS can communicate with the truck line carriers, ship lines, railroads, shippers and the consignee (and thus be a component of their inventory management system). At any given time, the ATMS can inform all these players of a container’s position. The ATMS-equipped terminal, providing common data interchange among all partners in the intermodal chain, will lower transfer costs by eliminating poor communications between shipping companies, brokers, draymen, warehouses and importers that exacerbate the planning and execution difficulties for the supply chain.

By improving the terminal turn times for trains, an inline ATMS terminal will make it possible to transition from the “sprint and wait” reality. If terminal turn time was reduced from, say, 13 to five hours, an 80 hour line haul plus terminal turn time would be reduced to 72 hours. Over the course of a month, the increase in car miles per day could result in 10 trains per month instead of nine, or 12 more trips annually. Train turn time savings currently come in small increments, or are too inconsistent, to depend on in developing accelerated schedules, but when the terminal turn time is reduced in a reliable and predictable manner, the reduction can be captured and result in accelerated schedules.

Crane Double Cycling (Overlapping). The inline ATMS ramp operation design can boost crane performance by double cycling—containers are loaded and unloaded in the same cycle, converting empty crane moves into productive moves. A cycle is a complete round trip of the crane. Implementing double cycling at the ports have the potential to reduce the number of single cycles by over 20%, improving vessel, crane and berth productivity (Goodchild and Daganzo 2007). Double cycling currently is not a widespread practice because of the perception that it complicates land operations. Because containers are only two-high in a double stack train compared to eight-high above deck and eight-below deck on a vessel, double cycling for rail will be easier to achieve. The crane sequence will be to unload an inbound container to an ATMS, and then load an outbound container from the adjacent ATMS to the train. New outer box connector technology will be required; currently all double stack top containers are unloaded first. Outer box connectors used with double cycling operations also will significantly reduce the crane’s gantry travel and ground personnel requirements.

To turn a 100-wellcar double stack train, single cycling requires 200 lifts / 200 empty moves to unload followed by 200 lifts / 200 empty moves to load: 400 lifts / 400 empty moves in total. The sequence would be to single cycle unload the top and bottom container of the first well car, and thereafter double cycle the rest of the way down the ramp: 400 lifts / two empty moves. By nearly eliminating empty moves, the cranes will be much more productive and trains can be turned (inbound to outbound) much more quickly or with fewer cranes. And the greater the span of the cranes working the ramp (distance from loading track to truck lane/ATMS), the greater the crane productivity gain. For example, reflecting the greater trolleying and lifting distances, crane operators usually achieve around 25 single cycles an hour (up to 40) at the ports (URS 2009) and 40 single cycles an hour (up to 60) at the rail terminals.

Improved Outbound Blocking Sequence. When a driver delivers a container to a conventional intermodal terminal for interchange (outbound move), the gate attendant directs the driver to an outbound block number storage area to park the container/chassis. Because of rushed schedules, unfamiliarity with the yard and heavy congestion, drivers often just drop the load at any parking area so that they can leave the terminal quickly, or quickly pick up an inbound container for local delivery.

After the inbound train arrives, containers are unloaded on to a chassis and then moved to a remote inbound parking area for pickup, the unloaded inbound train becomes an outbound train, and the hostler tractors start bringing the outbound containers—parked in the destination-specific outbound storage area—trackside for loading on to the outbound train. There is usually an equivalency between the number of outbound parking areas and number of destinations. Because each outbound parking storage area is a block, each block is loaded on separate cars, and each block goes to different destinations. Failure to reposition containers in a timely manner leads to delays and even a temporary “loss” of the container. ATMS eliminate the risk of mis-parked containers; a driver can deliver a container to the wrong parking lot, but not the wrong ATMS. The driver must bring the container to the right ATMS bay, because his pass key will only operate that ATMS. There are several possible pass key systems, including programmable cards, pass codes or RFID. This could eliminate the need for the labor required to find misplaced containers, and the improved reliability that comes from not mis-parking containers will lead to another significant reduction in transfer costs.

To further expedite service and limit congestion, usually the outbound and inbound assignments will be adjacent ATMS bays. After the driver bringing in an outbound container is verified at the terminal gate, he is given a key pass for the outbound designated ATMS, and at the same time also given a key pass for an inbound container resting on another ATMS awaiting pickup.

The railroad, or the terminal operator, will negotiate with various truck line carriers guaranteeing an immediate pickup of an inbound load for delivery after the drop off of a container for outbound shipments. Reducing the time for the pick up and drop off and guaranteed inbound and outbound loads will result in significantly more loads per day and attract more drivers to the ATMS terminal, since they can tally more revenue generating trips per day. Transfer costs also would be reduced by information systems that automatically generate a railroad to shipper invoice once the container is picked up from the ATMS bay, and a program can be designed for the shipper to the consignee as well. In all, a good terminal operator can capitalize on his experience to optimize terminal performance by optimizing the use of ATMS stations.

Elimination of Remote Storage. The benefit of switching to a trackside storage system is the elimination of intra-terminal movements and lifts, a reduction in time and distance that a container is moved in completing an intermodal transfer. Presently, trackside storage is an anomaly, requiring a large overhead crane with a width to straddle seven to 10 tracks.

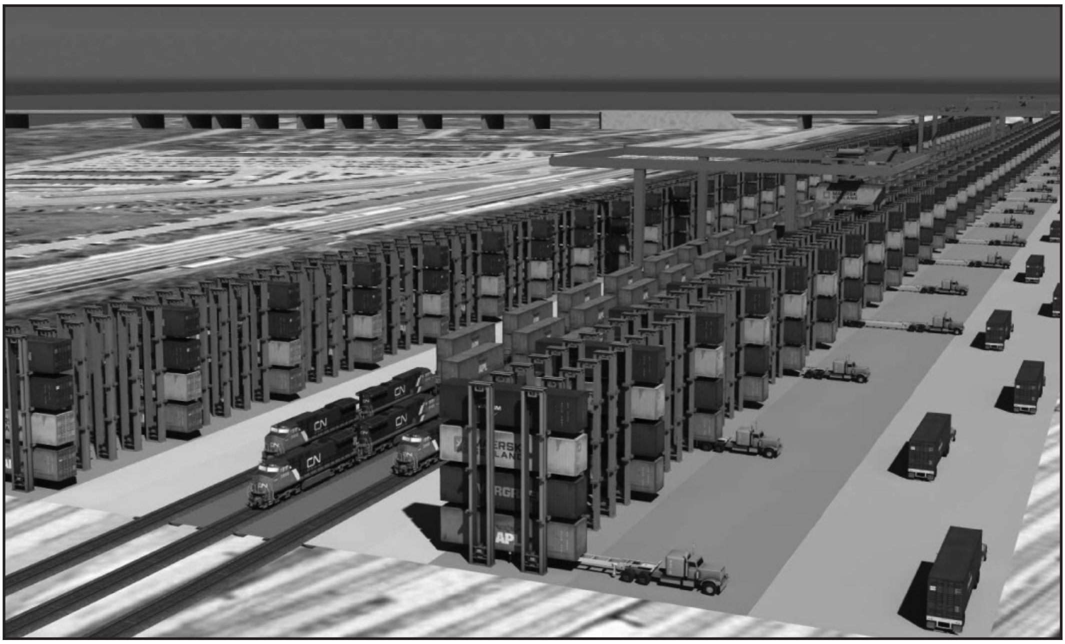
An ATMS terminal can make trackside storage operational, retaining the advantages (intermodal proximity) while eliminating the disadvantages (capacity and congestion). Once an empty ATMS becomes available, stacked inbound containers under the crane will be loaded on to the ATMS for pickup by drivers. The crane operator will not be waiting for a chassis to be brought trackside. There are no tight requirements for coordination, or sequential steps, for either the crane operator or the driver. The only requirement is a flexible time buffer for a container to be brought to and removed from an ATMS. This includes a container arriving too early or too late to be placed on its assigned unit train or a container that failed to be picked up trackside by its consignee.

The greatest transfer cost savings for a terminal without remote storage is the elimination of hostler operations (carrying containers by truck within the terminal), since the truck line carrier goes directly trackside when picking up and dropping off a container. Because ATMS will be significantly reducing terminal congestion and the problems associated with assembling trains, the focus of providing direct as possible long distance single-train service can be reexamined. An ATMS transmodal terminal would achieve the fluidity necessary to make the development of hub-and-spoke container networks much more attractive. And an efficient hub-and-spoke network, similar to air freight, seamlessly serving both the domestic and international market has the potential to greatly improve the economic viability of intermodal rail along many more corridors (longer trains with higher frequency). With sufficient density, many more corridors can attain equivalency with the high-capacity, high-frequency corridor from Los Angeles to Chicago, where rail matches over-the-road truck service. Furthermore, the ongoing shift from domestic trailer to container improves the prospects for intermodal compatibility so that domestic intermodal freight can more easily take advantage of railway economies of density—the greater the density along a corridor, the easier and more profitable it is to provide more frequent service. Many corridors still need to grow the volume to support double stack service in the transition from trailer service. The BNSF Railway—the largest intermodal rail carrier in the world—has gone from a traffic mix of 62% containers/38% trailers in 1998 to 92% containers/8% trailers by 2008 as intermodal volume grew by 48% (Kelly 2008). The additional weight of the container/chassis unit versus the trailer unit should not slow the containerization trend, because freight usually “cubes out” before it “weights out.” Inline ATMS terminals will eliminate the necessity of chassis fleets—the key piece of equipment for wheeled terminals—for ship lines and railroads. Currently, the capital and operating cost of the chassis fleet is a major cost for terminal operators, and the ship lines and railroads have taken many different approaches to the chassis supply problem.

Vertical Storage and Delivery Options. For high volume terminals, or terminals where multiple ramps are not an option, a vertical stacking ATMS system would be the most appropriate (Figure 5). After the inbound train arrives at the terminal, four inbound containers are unloaded into a high-rise, four-cell ATMS. Inbound containers are loaded on to the truck line carrier’s chassis one by one from the bottom cell; outbound containers are loaded on to the train one by one from the top cell. The four-high design is appropriate for terminals where two trains have the same scheduled arrival time, and a truck line carrier services blocks of containers (several containers bound to the same customer or location). After downloading the bottom container on to the chassis and pulling away from the ATMS bay, the third container from the top is automatically lowered, immediately available for the ship line’s next truck to pickup. The second, and then top container, are similarly lowered once the container below is picked up by the ship line’s carrier. For the loading of a railcar or a ship from the ATMS, the process reverses: truck carriers unload to the bottom cell and the crane loads the outbound train from the top cell. After the crane lifts the top container, the ATMS automatically lifts the container from below, which immediately becomes available for selection by the crane.

In an era of strong local opposition to new developments, high-riser four-cell ATMS systems, which increase active parking stalls by four times compared to the conventional system for inbound or outbound traffic, would give terminal designers the flexibility needed to modernize older terminal locations to handle greater traffic volumes where real estate constraints and community opposition are major deterrents.

Figure 5: A Ramp With Vertical ATMS Stations



Vessel Loading/Unloading

At the port, the four-cell-high ATMS shipside could achieve faster dock crane loading and unloading, because containers can be transferred to and from the ATMS stations at ship deck level. Further, there would be immediate selection for the crane operator and the hostler drivers; the operations of both would no longer have to be synchronized. This will make it much easier to double cycle containers below and above deck (ports currently using double cycling only do so with below deck containers, but it can be done with above deck containers as well). ATMS also can achieve faster ship-to-rail transfer than conventional on-dock rail operations because the system eliminates the need for additional lifts (e.g., due to on dock drop and stacking), extra in-terminal drayage and temporary storage. Constrained by land availability, currently it is extremely difficult for on-dock operations to achieve loading and unloading processes where ship stowage matches rail stowage, which is why many North American ports are switching to near-dock rail operations to handle greater surges of containers from larger vessels (Ashar and Swigart 2007). The ATMS buffer function would make it possible to better match ship stowage to rail stowage, bringing fluidity and operational flexibility for ship-to-rail transfers.

In an ATMS intermodal world, containers off loaded from ships or trains are never dropped, respectively, on dock or trackside. All containers are in position for immediate selection, either for self-service loading by the trucker, or for crane loading on to a ship, barge or train. Containers are still "stored," but unlike a traditional terminal, the ATMS simultaneously stores and positions containers for loading or unloading.

Chassis Flips

A chassis flip is when a truck needs to remove a container from the chassis to put it on another chassis. For wheeled operation terminals, this occurs when a driver arrives with his own chassis or after the driver discovers a problem with a chassis the container sits atop. A substantial amount of time can be spent changing a chassis, with waiting times of two hours not being uncommon

(Harrison et al. 2009). With an ATMS at the storage yard, the truck driver can execute the chassis flip without assistance, which will be an enormous time saver for the driver and result in significant equipment and labor savings for the terminal operator (crane and crane operator). Because terminal costs for chassis flips are substantial and ATMS stations can be incrementally introduced to assure a high rate of return, this is likely to be the first widespread ATMS adoption.

Truck turn time also could be increased by allowing drivers, who want to retain their chassis, to have the option of making ATMS appointments at wheeled operation terminals; a hostler driver can upload the appointment container onto an ATMS so that the container will be ready for a quick pickup when the drayage driver arrives.

Port Stack Container Yards

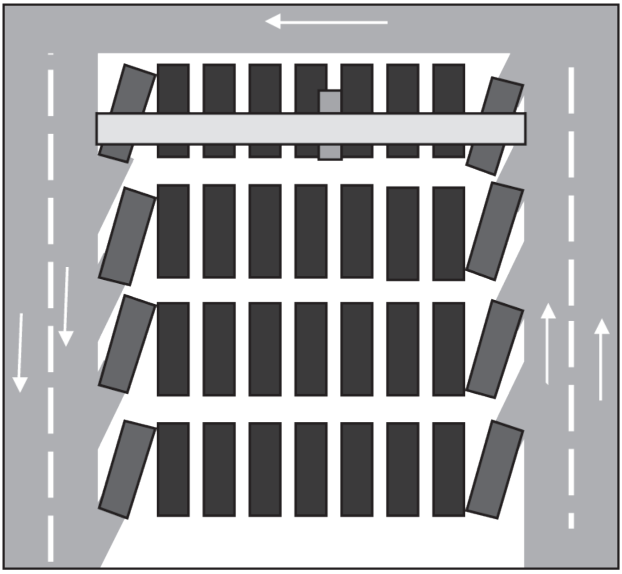
Because port container yard operations seek to maximize yard crane productivity, trucks often spend long periods waiting for a crane to load a container to their chassis during peak periods. Appointment systems have the potential to improve truck turn time (see Huynh 2009 for details regarding individual appointment systems); however, they have not been widely adopted by terminal operators because appointment systems require additional IT and staff resources.

In Figure 6, the ATMS bays are angled to the stacks and serviced by a widespan gantry crane. Hostler drivers, using inline one-way roadways, bring containers from the vessel and upload them to the ATMS, and then the containers are either placed in the stacks by the crane or left in the ATMS for immediate pickup (e.g., time- or temperature-sensitive loads). Another option could be fewer ATMS bays, but two-high—the lower cell would be for near term individual appointments, while the upper cell allows the crane operator the flexibility to load for a later appointment.

The great advantage of adding ATMS stations to the operation is that it allows trucks and stack cranes to operate independently and lowers truck turn time by offering immediate selection. After experiencing the ATMS immediate selection advantage, few trucks are likely to arrive at the terminal without an appointment, and thereby eliminating “waiting truck” terminal congestion and diesel emissions problems.

Improving the performance of the container storage yard is critical for marine terminals transitioning from wheeled to stack operations. The current ratio of three to four stacking cranes per ship-to-shore could be reduced, because the ATMS will allow crane operations to plan and work ahead of appointments. The use of ATMS also will dramatically reduce truck idling in the terminal by eliminating chassis flips, as well as the 15 minutes of engine idling common for wheeled operations while trucks connect the chassis, lighting and air brakes (Michaels 2007).

Figure 6: An ATMS Port Container Stack Operation



Chassis Storage

In real estate constrained marine and rail terminals, chassis storage entails a fork truck stacking chassis against one another at around a 75-degree angle, with the nose toward the sky. An ATMS chassis storage system would eliminate stacking, instead providing up to 10 bays high of storage, not only eliminating the need for fork trucks to stack and unstuck chassis, but eliminating the potential for chassis damage in the stacking and unstacking process. ATMS storage also would address the chassis tracking and phantom damage problem—the key pass that would allow trucks self-service in chassis pickup and dropoff would be maintaining a record of usage of each chassis. Another advantage for marine terminal operators would be to assign specific ATMS bays to specific ship lines to mitigate traffic congestion when multiple ships are being simultaneously unloaded.

Distribution Centers

The objective of installing ATMS at distribution centers and terminals is to address the "stay with" and "drop, leave, return and pick" operating models that negatively impact drayage productivity. The drayage driver servicing ATMS distribution centers will have an advantage over his counterparts because of more efficient pick up and deliveries—drop off of one container, followed by a pickup of another container from ATMSs (less than five minutes), is faster than the truck line carrier can disconnect one chassis/container (or trailer) and then connect another chassis/container (20 to 30 minutes). Theoretically, each truck will be able to retain the same chassis for the lifetime of the truck, and thereby mitigating the terminal problem of space-using chassis storage.

There also will be significant air quality benefits from a reduction in truck idling and roadway congestion. If federal, state or local governments mandate off-hour (6 PM to 6 AM) deliveries, business will be able to accept deliveries to ATMS-equipped facilities 24/7 without having to add labor. Further, when the business opens in the morning, early hour labor will be more productive, since shipments will be awaiting unloading.

For the railroad customer, products will be shipped expeditiously once the inbound train is unloaded into the ATMS. With the high-riser design, as opposed to the single container design, this will be achievable for extremely high-capacity distribution centers as well. ATMS at the distribution centers provide a container management system that, in essence, can vastly increase warehousing space. By giving managers the ability to stack containers vertically at the loading dock, as well as move containers in and out of the loading dock, the de facto supply chain container buffer that is currently at the port or inland terminal, or being stored remotely for the warehouse at a truck line carrier facility, can be instead at the warehouse. This brings fluidity to goods movement. While container storage would be mostly vertically stacked by the ATMS for a real estate constrained distribution center, single cell ATMS stations could be used for distribution centers with plenty of chassis/container parking.

Currently, generous free time allowances at the terminals have turned the ports and inland terminals into "extended" warehouses, acting as supply chain buffers (Rodrigue and Notteboom 2009). The terminals are presented with the problem of storing containers awaiting pickup, which usually means stacking three to five in height at high-capacity terminals. Warehouse-directed container pick up delays drive up the transfer cost of intermodal because of the need to transport the container from trackside to remote storage, the lifts needed to stack for storage and unstack for pickup, as well as the costs related to the resulting congestion. An equally detrimental aspect of extended storage is the impact of delayed billing on suppliers' cash flow. The ATMS system, which will allow distribution centers to store containers at the facility, could shift the supply chain's warehouse buffer from the terminal to the distribution center. Once a drayage driver uploads a container from their chassis to the distribution center ATMS, the warehouse manager can either unload the container immediately, store it by raising (high rise ATMS) or download it on to a chassis for unloading later. By retaining a small fleet of "yard" chassis at the distribution centers, containers can be downloaded on to these chassis, parked in the yard and only brought to the loading dock when it is convenient to off load.

Stacked storage of containers to minimize lifts is a major logistical challenge at the terminals. Demurrage charges are actually calculated from the day the entire ship is unloaded. An 8,000 TEU vessel might take five days to unload, so in effect if the free dwell time is five days, the actual free dwell time could be 10 days for the first unloaded containers. Immediate pickup ranging to 10 days significantly increases the cost of providing storage. Thus, once distribution centers have the ability to warehouse containers at their facilities, it eliminates the need for the additional lifts associated with remote storage at the terminal or some other storage facility. The result would be an uninterrupted flow of containers to the consignee. This would also improve security and reduce vulnerability to theft. Container fluidity moving through the ports and inland terminals would also reduce insurance rates, further reducing intermodal costs.

TERMINAL SITE SELECTION

By having the ATMS system shift the warehousing function from the port/rail terminal to distribution centers, common real estate constraints facing terminal facilities are mitigated. Intermodal rail terminals ideally require large tracts of land in proximity to city centers, good access to rail corridors, as well as highway connectors. These stringent site requirements apply much less to distribution centers, since they are mostly influenced by highway accessibility.

The goal of new intermodal terminals should be to maximize equipment and labor productivity in achieving the highest throughput possible per unit of surface. This also expands the pool of potential sites, which is important since location has a major impact on air quality, energy consumption and congestion. Potential sites in metropolitan areas involve constraints (large tracts of property, unavailability of land and expensive land) and the environmental concerns of surrounding communities. Further, conventional terminals usually cannot be easily retrofitted into modern terminals. While conventional rail freight terminals have more “squared” proportions with multiple spurs to permit the assembly of railcars to form train blocks, a modern intermodal rail terminal ideally needs more real estate (rectangular) and longer rail spurs to serve a much more limited number of cities.

Compounding the retrofit problem in many cases has been the construction of highways over rail yards that negatively impact redesign and expansion options. Thus, inline ATMS terminals makes retrofitted terminals a viable option by confining all activity under large gantry cranes, automating intermodal transfers and reducing or eliminating the need for the storage of containers and chassis. In most cases, this option appears preferable to distant sites that drive up the cost of drayage service. Yet, the logistics sector that intermodal rail is servicing has also relocated to suburban areas, with new intermodal terminal developments (e.g. Rickenbacker, Richards Gabaur) tending to have a systematic co-location strategy, where freight distribution activities are set in conjunction within a planned logistics park.

Planning and Funding

Tax incentives and public/private investment will be well warranted for optimally located inline ATMS terminals, because they provide significant social benefits, such as reduced energy consumption, harmful emissions and highway congestion and require considerably less real estate than conventional terminals. Other public benefits, such as improvements in business output, employment and tax revenue from improved accessibility to markets, would justify even greater public investment.

Capital costs of an ATMS equipped terminal will vary because optimization requirements will vary, dependent not only on the volume of traffic, but also throughput factors such as the number and schedule of inbound/outbound trains, the mix of inbound/outbound containers, the number and peak of one-way truck trips, terminal access (highway connectors) and property dimensions. Although the capital costs are greater than a conventional terminal, terminals are like commercial buildings; the most important cost is operating costs. Return on capital is not only recovered through lower operating costs, but capital costs can be depreciated for tax purposes, while operating costs cannot.

Inline ATMS ramps, which achieve much lower operating costs due to the reduction in the number of chassis, hostlers, manpower and operating cranes, are for mega terminals forecasting volumes greater than 600,000 annual lifts. Wherever conventional mega terminals have reached capacity at their current locations, retrofitted ATMS terminals should be more attractive than the construction of new conventional terminals in a suburban setting. And unlike conventional terminals or real estate constrained high stack terminals, the marginal cost of each additional equipment, labor and energy input will not increase as volumes increase. That is because the ATMS interface between the modes ensures the same minimal amount of handling occurs regardless of the traffic volume. Further, the scalability of inline ATMS terminals (convertible to a two-, three-, or four-high) ensures the terminal can adapt as volumes increase.

A network of well-located ATMS equipped terminals supports a paradigm enabling intermodal to fulfill the potential of containerization. Automating the process to achieve fluidity would not only improve the speed and reliability of transfers, but create multiplying effects in regard to efficiencies and productivity advances beyond the terminal and throughout the intermodal network and supply chains. More importantly, it would make short distance port rail shuttle services more viable. Currently, rail shuttle services from port terminals are being considered in regions where highway capacity is restricted, and there is an opportunity to move high volumes of traffic along well-defined rail corridors. The rail shuttle train distance for most of the proposed rail shuttles—port to inland terminal—ranges from a very short haul of less than 50 miles to over 250 miles.

Where rail capacity exists, a public/private partnership investment in a rail shuttle linked to ATMS terminals would be far more attractive than the alternative of adding freeway lanes because of the very high cost per lane mile for urban highway construction. And where rail capacity does not exist, adding another track usually costs far less per mile because of the 100-foot rights-of-way railroads already retain. However, the intermodal economics of port shuttle trains currently are still not very attractive because of the high embedded intermodal transfer costs entailed with conventional terminals. Alternatives, such as adding truck only toll lanes to freeways in response to projected truck traffic growth, are instead being favored (Meyers and Saber 2006).

For marine and rail terminals, the multiple sorting and storing "rehandling" operations taking place does not work well with the optimal goods movement strategy of keeping all containers flowing until reaching the final destination. Fluidity and transfer efficiency are vital for the more sustainable rail port shuttle solution to be viable. Fluidity should trump speed. Since the distance is too short to gain meaningful time, eliminating or reducing transfer operations to achieve fluidity should be a much higher priority than speed along the rail corridor. Currently, transfer costs are difficult to reduce because of the number of times the container needs to be handled and stored (ship-to-hostler, hostler-to-storage, storage-to-hostler, hostler-to-rail, rail-to-storage, storage-to-truck, and truck-to-distribution center). To make the port shuttle train economically viable without subsidies, participating ATMS equipped ports, terminals and distribution centers need to eliminate many of the transfer costs experienced with current heavy engineering and manual container handling practices.

There are over one million container drayage trips taking place annually to distribution centers in Southern California's San Bernadino area, and a similar number of empty containers being drayed back to the port after being unloaded. Currently, the San Pedro ports five-day free dwell time allowance permits customers to use the valuable real estate at the port as a supply chain buffer. Shifting the storage option to the prospective inland terminal for container shuttle train service would require absorbing the transfer costs involved in six or seven transfers. It also reduces the number of potential sites, because an intermodal terminal that provides storage requires much more real estate. Without an ability to store containers at their distribution center, supply chain managers probably would not be receptive to embracing the shuttle train concept if it meant forfeiting the ability to use the free time allowance at the port or inland port terminal.

Container depots also can be located at sites nearby the inland port and distribution cluster to serve the important function of being an inland depot for exporters needing empty containers (as opposed to having to get empty containers sent inland from the ports). This would significantly lower the costs of container repositioning and, more importantly, help get North American goods to international markets faster and more efficiently, thus improving the competitiveness of North American manufacturers.

CONCLUSION

In a world where supply chains are getting integrated, the time component in supply chain management is imperative. The ability to operate at lower inventory levels tends to compensate for the higher cost of guaranteed truck freight service. Moreover, faster freight service means faster turnover, payment and return on investment. ATMS equipped ports, rail corridors linked to ATMS equipped intermodal terminals, and ATMS distribution centers are strategies worth considering to significantly reduce costs, while simultaneously improving the reliability of intermodal goods movements.

To stay competitive in the global market, lower energy costs and reduce highway congestion, it is imperative for the North American economy to reduce intermodal transfer costs. Terminals and distribution centers with ATMS could offer significant advantages in terms of operational and logistical efficiency for inland intermodal transfers by decreasing transfer costs and delays and improving transport reliability.

A network of terminals with ATMS connections between modes, excellent highway connectors and common data interchange will give North America an enormous global competitive advantage in moving freight efficiently and with minimum externalities. Yet faced with how to best allocate limited capital and capacity, the economic reality for Class I Railroads is to weigh investments in intermodal terminal technology against investments in infrastructure that benefits all the freight categories. The wide adaptation of the ATMS technology at a number of gateways, inland terminals and distribution centers along strategic rail corridors would go a long way in supporting returns on investments for Class I Railroads, which would generate additional investments in new ATMS terminals to further improve the efficiency of inland freight distribution. Public funding for the highway connectors and tax incentives for the terminal's roadways—especially justifiable for shared terminals supporting transmodal interchange—would significantly reduce railroad capital costs, which, in turn, would further leverage railroad capital costs to accelerate ATMS adoption.

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***John Zumerchik**, Director of Planning, Mi-Jack Products Inc. After a career in the publishing industry as an editor for McGraw-Hill and the American Institute of Physics, and then working independently as an author/editor on several award winning titles, Mr. Zumerchik joined Mi-Jack in 2004 to assist in developing innovative intermodal transportation solutions. Among his award winning publications is the three-volume Macmillan Encyclopedia of Energy (2001), an American Library Association Outstanding Reference Source for 2001, Library Journal Best Reference for 2001, and Reference and User Services Association's Outstanding Reference Sources for 2002.*

***Jean-Paul Rodrigue**, associate professor, Dept. of Global Studies and Geography, Hofstra University. His research interests primarily cover issues related to freight transportation, logistics and globalization, particularly as they relate to the economies of North America and Pacific Asia. Recent work is focusing on the integration of maritime and inland freight distribution systems through the setting of gateways and corridors and how containerization impacted freight distribution. Rodrigue developed a large transport web site (The Geography of Transport Systems) that has received global adoption.*

***Jack Lanigan, Sr.**, Chairman of the Board, Mi-Jack Products Inc. Since founding Mi-Jack in 1954, Lanigan has been credited with collaborating with the railroads on many important intermodal innovations. Lanigan introduced the first Drott reliable overhead rubber tire gantry crane in 1963 for TOFC (trucks on flat cars), now called intermodal. Working with the Santa Fe in the mid-1960s, Lanigan helped convince the shipping industry to standardize container lengths and corner castings so that the railroads (Santa Fe, Union Pacific and the Southern Pacific) could accommodate all the ship lines' containers, which made the landbridge feasible. In 1967, Mi-Jack delivered the first crane with the twist lock top pick for the new standardized container, but because Matsen, APL and Sealand all had different corner castings and container sizes, Lanigan developed a corner side latch as a temporary top pick for the nonstandard containers during the transition. In the late 1970s, he Lanigan worked with the Southern Pacific Railroad and APL on the top spreader that would accommodate the high side wall double stack car, and at the same time encouraged the development of the low side wall so that any type of side loader or overhead crane could load or unload double stack cars. Aside from equipment innovation, Mr. Lanigan is credited with developing the two-for-one terminal design (now the standard), and establishing one of the largest rail and port terminal operations in the nation, culminating in the 1997 Mi-Jack/Kansas City Railway Company joint venture to rebuild and operate the Panama Canal Railway to significantly reduce the volume of trucks transporting containers across the Isthmus highway. Lanigan was awarded the Intermodal Association of North America's Silver King Award (1989) and Intermodal Achievement Award (1992 on behalf of Mi-Jack) in acknowledgement of his contributions.*