

Shared Intermodal Terminals and the Potential for Improving the Efficiency of Rail-Rail Interchange

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Abstract:

While largely due to conditions outside their control, the configuration and setting of current intermodal rail terminals contribute to congestion and increased freight handling volumes that have resulted in additional transportation costs for shippers and carriers. Although a substantial body of research has focused on improving the efficiency of port operations and multi-modal freight shipments (particularly ship/rail, and ship/truck operations), transmodal shipments (flows within the components of a single mode) have received far less attention. Because of the rapidly growing volume of freight entering North American ports bound for the Midwest, particularly Chicago, improving rail/rail interchange is becoming increasingly critical to overall system efficiency. With average rail/rail transmodal interchanges between Chicago's terminals exceeding 24 hours, these interchanges represent an increasing fraction of overall preventable delays that is a major concern for freight forwarders. This paper identifies the main inefficiencies of current intermodal rail interchange operations (such as fragmented terminals, unnecessary intercity truck trips, shipment inefficiency, and congestion). It also investigates the concept and potential of shared intermodal facility solutions (multiple railroads concentrate transmodal interchange at one facility), and analyzes governmental and market impediments to the development of shared intermodal facilities. Shared intermodal facilities will bring enormous quantifiable financial, time and energy benefits to shippers and carriers. However, before such facilities can be developed, there is a critical need to gather performance metrics on rail line volume entering the region, the percentage of that volume that is transmodal traffic, and the speed and cost of current interchange. The potential to reduce energy consumption and terminal heavy-duty truck emissions are also explored. Published performance metrics and estimates from field practitioners are used in this preliminary analysis of potential benefits, laying the groundwork for future simulation modeling efforts designed to better quantify these benefits.

Keywords: Freight Transportation, Intermodal, Intermodal Transfer Facilities, Transmodal, Rail, Containerization, Shared Intermodal Terminals, ThruPort.

Introduction

Most rail yards were built in the 19th Century, a boom time for the railroads. Usually sited on undeveloped land at the edge of urban areas, rail yards were eventually engulfed by urban development. Before the internal combustion engine, industrial development logically clustered around these yards. However, as the trucking industry matured and highway infrastructure was expanded and improved, greatly aided by the federally funded construction of the interstate highway system, many businesses no longer found it necessary to locate adjacent to rail yards. Even though rail transportation is generally more fuel-efficient than other modes, supply chains quickly responded to the availability of the ubiquitous highway infrastructure connecting a significantly larger number of potential origins and destinations and took advantage of the door-to-door speed and flexibility of trucking.

Railroad visionaries—without federal subsidies enjoyed by the ports, airports, and highways—still saw an opportunity to advance intermodal operations because of the flexibility of trucking and the labor and energy efficiency of rail. But first, the issue of modal interchange had to be addressed. Early intermodal rail yard operations were almost exclusively piggybacking. It typically took 2 to 4 hours and considerable labor for “circus” loading and unloading of trains (rolling wagons on and off trains), which proved costly, inefficient and time consuming. The revolution in rail intermodal began when Mi-Jack introduced a reliable rubber tire mobile gantry crane in 1963. Loading and unloading trailers and containers dropped to one-to two-minute cycle times. Moreover, the gantry crane eliminating wrong way car switching, bridge plates, and raising and lowering stanchions, dramatically lowered operating costs. According to intermodal historian David DeBoer (DeBoer, 1992), the gantry crane allowed the industry to grow efficiently, paving the way for the tremendous growth that followed.

Because of the poor financial health of the railroad industry brought on by a lack of federal investment and intense competition by the trucking industry, little capital was available to venture into building completely new intermodal terminals. Hence, intermodal freight handling technology evolved within existing rail yards. This approach, although not ideal, generally proved to be adequate until the early 1980s when, after several decades of relatively flat freight volumes, the United States economy expanded significantly and international trade volumes began to grow rapidly. This growth severely strained the rail transport system and exposed significant weaknesses in existing rail terminals. A major wave of public/private investment in intermodal terminals went into several major ports (such as the Port of Oakland Joint Intermodal Terminal and Alameda Corridor) that experienced a substantial growth in container traffic. The productivity and efficiency of port terminals thus improved, but most inland freight flows continued to rely on trucking for inter-line transfers. As long as energy costs remained relatively low, and congestion manageable, the trucking industry simply coped with the growing inland containerized freight flows.

Recently, the convergence of increased urban congestion, higher energy costs, and higher long distance shipping volumes has challenged this approach. For example, ACT research (2006) reports that truckload carrier operating costs rose 14.5 percent between 2004 and 2005. More tellingly, expenses as a percentage of revenue went from 12.6 to 15.4 percent. In addition, many

ports have started to improve their ship-to-rail capacity, spurring additional demands and higher requirement in the timing of inland containerized shipping.

Improving transmodal¹ rail interchange is part of the solution to the capacity and congestion problems faced by the trucking industry (Rodrigue, 2006). Privately owned inland rail freight terminals are just now beginning to benefit from public/private partnerships (Columbus Terminal for the Heartland Corridor) long enjoyed by American ports and airports. Therefore, as more public/private partnership are proposed for intermodal rail, advanced terminals designed to be shared by multiple railroads—as a way to concentrate rail transmodal activity—should be considered along with a national plan for an integrated network of new terminals.

Constraints to the Development of Advanced Terminals

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 to capture a significant fraction of international freight, yet only a small fraction of the domestic market. Federal investment at ports has helped relieve congestion caused by the surge of imports. However, there has been no commensurate investment in inland intermodal terminals. 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 economically. According to Martland (2004), 54% of intermodal unit volume in 2003 was composed of international containers, up from 51% in 2000. Truck tonnage, on the other hand, is 95% domestic. Poor local and system-wide transmodal rail interchange is likely to be a major factor in its small share of the domestic freight market.

While free market solutions to this problem would be preferable, there are a number of market imperfections that impact the practicality of purely private solutions. A public and private consensus and partnership will likely be required to meet the goal of developing an efficient intermodal terminal system that best serves both metropolitan regions as well as the nation as a whole. At the micro level, there are enormous efficiencies that can be gained. At the macro level, there is a need for a nationwide plan to oversee the construction of an integrated national system of efficient shared intermodal facilities tailored to the needs of each particular region.

Real Estate

As intermodal traffic began to grow in the 1960s, retrofitting conventional rail yards for intermodal operations proved problematic. Because of the more “squared” proportions of conventional rail yards, with multiple rail spurs to permit the assembly of railroad cars to form train blocks, the transformation was less than ideal. Intermodal operations are best served by larger, more rectangular real estate tracts with longer rail spurs, because these optimally involve operations on fully formed train assemblages. Intermodal train service also differed from earlier practice by serving a much more limited number of cities, with some terminals dedicated to a single destination. The results of this retrofitting were thus dependent on the historical development of individual cities and their rail infrastructure. Some rail yards had adequate real estate available to adapt to intermodal operations whereas, due to specific local conditions, others did not. Further, the construction of highway bridges over intercity rail yards, local

¹ Transmodal refers to transfers within the same transportation mode.

zoning restrictions and/or the high property values of adjacent real estate often made further land acquisition impractical. Collectively, these factors often severely limited design and expansion options and, in many cases, forced the development of new yards at substantial distances from city centers where adequate land could be obtained.

Fragmentation

From a national perspective, the current inland rail intermodal terminals encounter market, supply chain, and ownership fragmentation impediments:

- **Market Fragmentation.** This is primarily a global production and national retail-oriented distribution problem where only a few gateways must service excessively diverse distribution networks. Shipments are decomposed at 3 to 4 major gateways (ports) on each coast, with much of the volume reaching Chicago (intermodal rail central) for distribution. The “dry port” of Chicago, which in 2004 handled more volume than all but 3 ports in the world (Hong Kong, Singapore, and Shanghai), consists of 6 Class I Railroads operating 18 intermodal rail terminals
- **Supply Chain Fragmentation.** In a just-in-time world, closer time integration between the manufacturer's suppliers of raw materials and component parts is imperative. The ability to operate at lower inventory levels more than compensates for the higher cost of guaranteed motor freight service; moreover, faster freight service means faster payment. Rail corridors linked to intermodal terminals with accelerated transmodal interchange are necessary to make rail more reliable to appeal to supply chain managers.
- **Ownership Fragmentation.** Consolidation allowed Class I Railroads to gather market share, lower costs, achieve revenue growth, and greater economies of scale. Nevertheless, each rail carrier still operates their own terminals, and services the customers along its rail networks. To improve rails comparative advantages in labor and energy, joint ventures or shared terminals are the next needed step to help intermodal rail better achieve terminal networks comparable to those of major truck line carriers and air freight companies. However, joint ventures or shared terminals will be viewed problematically because the costs and benefits may be more difficult to estimate and equitably divide.

Performance Metrics

In two recent comprehensive reports, *Freight-Rail Bottom Line Report (AASHTO, 2003)* and the *Rail Freight Solutions to Roadway Congestion* (Martland, 2004), acknowledged that rail provided one of the best solutions to the problem of truck-freight congestion. However, neither study directly addressed transmodal rail interchange in terms of volume, speed, nor reliability.

Rawlings (2006a) reports in *Intermodal Volumes III* that Chicago intermodal volumes reached 13.98 million TEUs in 2004, up from 12.4 million TEUs in 2003. While Rawlings (2006b) estimated that the transmodal rail interchange is not greater than 30 percent of this total, other freight management professionals have provided estimates as high as 50 percent (see Table 1). One of the reasons for the wide discrepancy in estimates is the difficulty of accounting for the volume from independent brokers. Aside from intermodal sales generated by direct railroad sales to the truck carrier industry, independent brokers (third parties) generate the majority of rail intermodal sales. Since each sales entity understandably does not share their daily interchange volumes, it is extremely difficult to estimate overall interchange volume. When an independent

broker's container leaves a terminal, the railroad has no idea if it is destined for its final destination or headed to another railroad. Accurate transmodal rail interchange volume metrics for Chicago, as well as other major cities, are critically needed for assessing the overall efficiency of the freight transportation system.

A major reason for this neglect of inland rail transmodal interchange is that most research has focused on terminals from an operational perspective. The focus is usually on volume and not terminal efficiency. In *Intermodal Volumes III*, Rawlings reports Chicago freight volume growth, and the railroad terminals that opened and closed to expand capacity, yet this study provides no performance metrics as to how these changes have impacted delay and service times. The development of modern logistics has however changed this requirement, the issue of time has often become as relevant as the volume.

Freight stakeholder need to know, for both long-and short-term planning, the efficiency of interchange. In particular, the mean and standard deviation for interchange times as well as the likelihood of delay greater than a specified threshold. Although a significant fraction of interchange in Chicago is "steel wheeled" (run through and not lifted), and it is a strategic intention of many railroads to increase this volume, the majority of interchange is still "rubber tired" (lifted and trucked across town) to another railroad's terminal.

Interchange speed is critical. Although interchange estimates run from 30 to 50 percent, the most important fact, regardless of the actual percentage, is that the share would be considerably greater if throughput was improved. Intermodal rail service from the West Coast to Chicago is as fast, or faster, than motor carrier service. However, when transmodal interchange between railroads consumes 48 hours before completion of the final leg of the trip further east rail-to-truck interchange in Chicago becomes the preferred choice. If transmodal rail interchange took only a few hours rather than a few days, then the percentage of interchange would be much higher. Reducing the time for transmodal interchange will require the use of new enabling infrastructure, as marginal improvements to the exiting infrastructure will be insufficient.

The standard deviation for interchange and probability for critical delay, both measures of reliability, is currently far larger than what could be achieved with advanced terminals. Reliability is critical because of scheduling. One of the great labor and energy efficiency advantages of rail is that you can move 200 containers at a time in one train. Yet the requirement of assembling trains can also be an impediment. From a logistics perspective, the larger and more fragmented the freight, the longer and more challenging the task of quickly assembling trains. Further, a delay in interchange or an employee error, which can occur during the multiple stages of transmodal interchange at standard terminals, will result in missed connections for outbound corridors. This, in turn, will entail additional delay waiting for the next available train.

The lack of funding to assist the railroads in accommodating companies with their shipping strategies can have dire consequences. United Parcel Service (UPS), which claims to be the largest user of rails in the U.S. and is a pioneer in the intermodal industry, has been forced to shift away from rail intermodal an onto highways because of guaranteed package delivery times (Eskew, 2006). UPS and LTL shippers have extensive terminal networks, and run full-load line haul on regular routes between their terminals. In an ideal world, the full-load line haul routes

all should be going by intermodal rail instead of by double trailers. For example, a UPS full-load line haul double trailer might leave Minneapolis, drop one trailer in Chicago, and pick up another on its way to Detroit. Both legs could be handled by the intermodal system if transmodal rail was efficient in Chicago. However, interchange times of 24 to 48 hours is not acceptable in a world of guaranteed delivery times. In general, intermodal rail speed matches or exceeds the service of truckload carriers from the West Coast ports to Chicago, but once containers with destination elsewhere arrive in Chicago, slow rail transfer, which drives up total transit time through the supply chain, forces most of the market to the highways in reaching the final destination.

There is also a need for performance metrics for truck traffic into and out of intermodal terminals during both peak and off-peak periods. Besides the drain on truck driver productivity from delays at the terminals, rail terminals also have some of the highest concentrations of nitrogen oxide and fine particulate matter emissions in the transportation sector. Improving performance in and out of the terminal not only will reduce in-terminal truck idling from trucks picking up and dropping off containers/trailers, but also will increase the capacity of the terminal.

Because of a lack of published data for actual intermodal terminal performance, Table 1 provides a consolidated estimate from several intermodal rail professionals and consultants for current operations of the Chicago terminals. Equally important for designing shared intermodal facilities, and not addressed in Table I, is the need for rail corridor volumes for all the railroads using the terminal. With the Panama Canal operating beyond design capacity, the increasing level of globalization of trade also calls for an attempt to quantify the landbridge traffic crossing the continental United States.

Table 1. Estimates of Intermodal Interchange Performance for Chicago

Percentage of Traffic that is Interchange	Rubber Tire Interchange	Steel Wheel Interchange	Interchange Time increase from 2000 to 2006	Ave. Time In-Terminal for Trucks (Peak)	Ave. Time In-Terminal for Trucks (Off-Peak)
30-50	24 hours +	30-70 hours	20% +	45-60 minutes	45 minutes

Types of Terminals and Performance

Well functioning rail networks benefit the economy by providing cost and energy efficient mobility for freight. Yet rail freight, with its fixed infrastructure network of 100,000-miles of track, is inherently less flexible than trucks and takes much longer to adapt to a changing environment, especially in an era of minimal federal funding. There is currently a need for a new generation of highly automated shared terminals aimed at dramatically reducing the need for in-terminal equipment and the number of required container lifts for transfers in order to significantly lower transfer costs, and improve throughput times while minimizing overall real estate needs, pollutant emissions and energy consumption.

Conventional Terminals

Conventional terminals include retrofitted from rail yards dating back to the 19th century. These terminals built long ago usually have poor truck access due to the ad-hoc evolution of the local

transportation system, and require a 13-step process for transmodal interchange. Figure 1 illustrates the conventional terminal process.

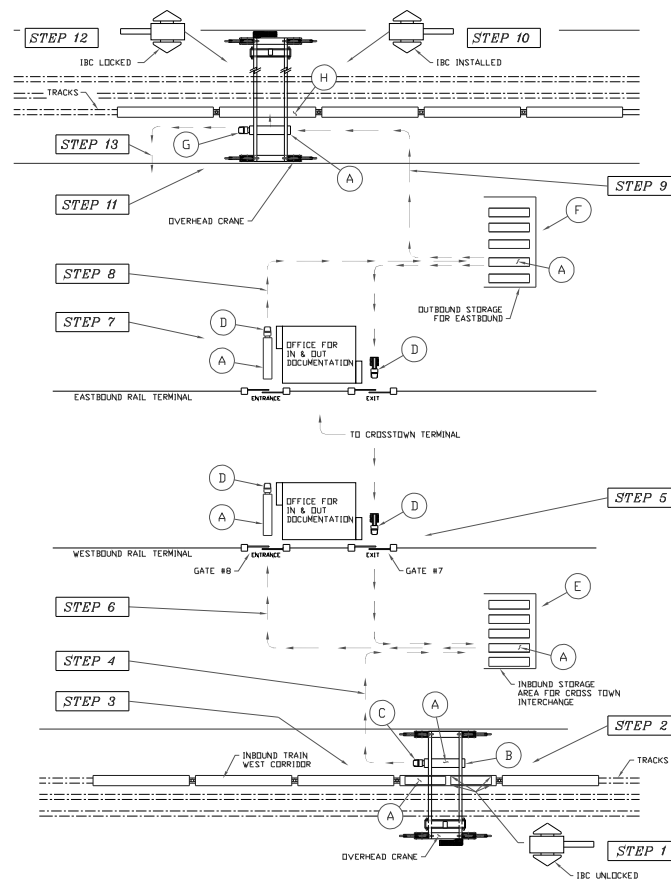


Figure 1. Illustration of a Conventional Terminal Process

1. IBC (inner-box connector) is unlocked for top container unloading from double stack car.
2. Empty container chassis brought trackside next to double stack car of Westbound (inbound) operator.
3. Crane unloads top container and loads on chassis.
4. Yard tractor hooks up to chassis/container and delivers it to the outbound storage yard.
5. Cross-town driver checks in at the entrance gate of Westbound operator, and is given the location of chassis/container that he is to pick up.
6. Cross-town driver picks up the chassis/container and checks out at the exit gate of Westbound operator.
7. Cross-town driver presents papers at the entrance gate of Eastbound (outbound) operator, and is given instructions where to drop off the chassis/container at the storage area.
8. Chassis/container left in the storage area, and driver leaves exit gate of Eastbound operator empty if dead-end run.
9. Yard tractor picks up container/chassis at the storage area and delivers it trackside, next to double stack car for Eastbound departure.
10. IBC inserted in open position to make ready for the second container to be loaded on top of the double stack's bottom container.
11. Crane unloads container from the chassis to double stack car.
12. All IBC connectors are locked for departure.
13. Chassis removed from trackside and stored in an empty chassis area.

Two-For-One Terminals

The last major advance in terminal design was the Santa Fe Railroad’s Willow Springs Terminal, which began operating in 1995. From an operational perspective, the Willow Springs terminal proved to be 50% more efficient than any other terminal in the country because of a “two-for-one” track layout design. First proposed 1970s, the two-for-one concept is a single-track design where trailers are unloaded to one side and reload from the opposite side, thereby reducing the number of steps required for transfer (see Figure 2). This design doubled capacity for the service vehicles, increased the availability of parking, and reduced the need for hostlers because local drayage could pickup and deliver directly to trackside. This had the effect of, greatly reducing the terminal’s need for storage of trailers. Aside from significantly lower operating costs, the “two-for-one” design also generated far higher throughput per acre, and helped reduce Chicago-area truck traffic because of good highway access.



Figure 2. Illustration of the Two-for-One Terminal Process

Outbound

1. Trailer is unloaded from the train and temporarily left on trackside.
2. City driver checks in at the inbound entrance gate with proper identification for the pick up.
3. Driver goes to pickup trailer at trackside.
4. Driver checks out at the outbound exit gate.

Inbound

5. City Driver arrives at entrance gate of terminal.
6. Driver delivers trailer to trackside.
7. Crane loads trailer from trackside to flatcar.
8. Driver checks out at exit gate.

The efficiency of Willow Springs prompted United Parcel Service, Schneider, JB Hunt and other major trucking firms to redirect traffic to this facility. Designed to handle 350,000 lifts/trailers annually, this unanticipated added demand has resulted in volume increasing to 769,939 lifts/trailers by 2005.

The Rail ThruPort

Featuring several massive gantry cranes, the ThruPort, first finalized proposal was presented in 1992 at the IANA Expo, is the first proposed high-volume intermodal terminal designed specifically to meet the needs of both the railroads and truck carriers (see Figure 3). At its most efficient operation, the ThruPort involves one step, where each lift is a transfer. Even when containers must be shuffled between trains and line storage, significantly fewer cargo movements are required. ThruPort operations will essentially eliminate the operation of yard tractors, hostler, and chassis, as well as the cross-town delivery of containers to other freight terminals. Aside from the increase in efficiency, there is far less a chance for damage from the numerous operations a container undergoes. Operating much like an “airport” for freight, the ThruPort is conceived to be a neutral facility where freight is consolidated in a confined area (gated community) for redistribution without ever leaving the terminal. As described by Rodrigue (2006), the ThruPort will dramatically improve throughput times for the enormous number of transmodal interchanges currently occurring system wide, and has the potential to decrease dramatically the volume of domestic freight currently using long- -haul motor carrier service.

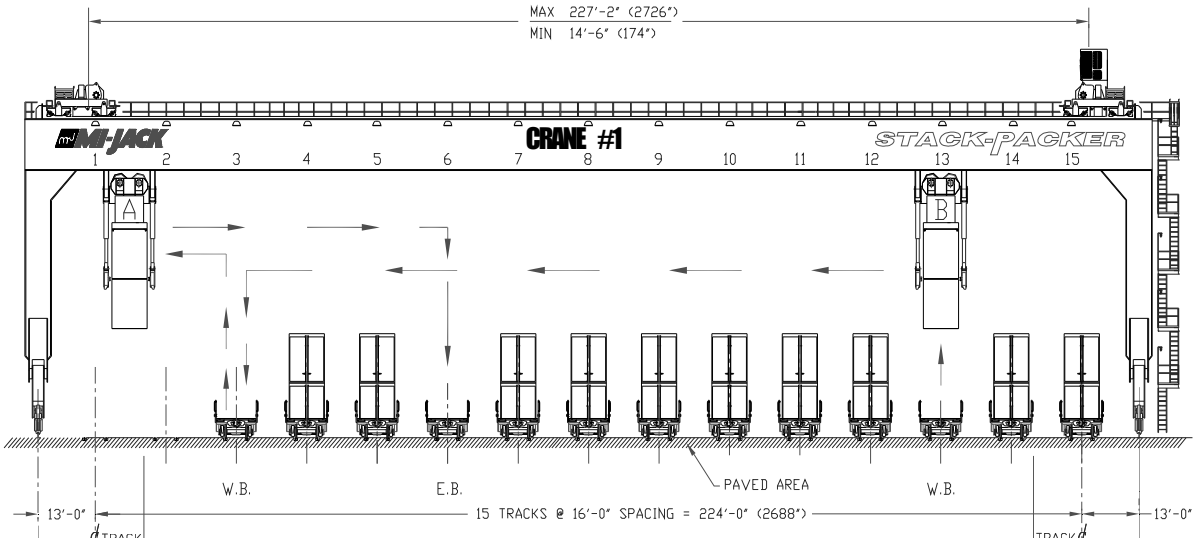


Figure 3: The Rail ThruPort

For a conventional terminal, to interchange 1 container requires 13 sequence steps to move from corridor 1 to corridor 2. Comparatively, the proposed ThruPort sequence requires 97% less movement. For example:

1. To interchange 4 containers (2 - 40 foot or larger containers per grapppler) via locked IBC's requires only 2 sequence steps.
2. To interchange 6 containers (1 - 40 foot or larger container on top sill and 2 - 20 foot containers on bottom sill per grapppler) also only requires 2 sequence steps.
3. Stack Packer grapppler is designed to take advantage of the loading characteristics of both IBC and container; there is no need to lock and unlock IBC connectors.

The “airport” model has many parallels to the ThruPort. Each successive generation of airport, or major expansions and renovation, has made operations more efficient. This includes increasing the number of take-offs and landings, reducing congestion for departure and arrival road traffic, improving ticketing and check-in, expediting baggage handling, and speeding rent-a-car pick-up and drop-of. Much like new or expanded airports, it is imperative that freight

transportation capacity also increases to match demand. ThruPorts, particularly in the Chicago area, will give the domestic freight transportation system the ability to efficiently cope with additional capacity demands, and at the same time address environmental challenges.

The Hybrid Rail ThruPort

A Hybrid ThruPort would function as a combined 2-for-1 and ThruPort Terminal. Depending on land availability, both facilities can operate adjacent to each other under the same cranes (see Figure 4). A large hybrid terminal would feature 15 tracks with 16-foot paved track centers and trackside parking. The wide track centers provide Grunt² machine operations for IBC and in-service car inspection. The 16-foot track centers also provides working space to operate a rail wheel change-out device on bad order cars by removing the double-stack cars adjacent to the required track of the cars that need to be repaired.

Depending on operations, any of the paved 15 track corridors of double-stack cars can be removed resulting in a 22-foot wide roadway, or serve as a trackside storage area. By removing every other lane of double stack cars, a portion of the operation converts into a “two-for-one” track layout. In effect, the ThruPort Transfer Facility can be converted into a 2-for-1 operation; conversely, a 2-for-1 Terminal can be converted into a ThruPort.

A hybrid ThruPort facility is desirable. The major benefits of having an Intermodal Terminal in conjunction with the ThruPort Facility is while all transcontinental interchanges can be handled by the ThruPort, the Hybrid aspect allows access to multiple Class I Railroads for outbound traffic. This concept can most easily be realized in the Chicago area due to its high freight volumes and multiple Class I railroads operating in this market. In the Chicago area, a hybrid terminal will give shippers far more outbound departure options and direct routes (no rail interchange interruptions) than any other terminal in the nation. Outbound containers can be loaded directly to corridor assigned trains; consequently, eliminating handling at other local terminals, reducing congestion and lower costs of operation. For motor carriers, manufacturers, and major distribution centers located at the Hybrid ThruPort, the efficiencies will be substantial. For all railroad customers not located at the Hybrid ThruPort, this will be an additional drop-off option, alleviating congestion at other terminals. System-wide cost reductions should result from decreased handling of freight in the Chicago area.

The Hybrid ThruPort will give more “flexibility” to compensate for unforeseen circumstances such as, late inbound arrivals, late outbound departures, derailments, peak volumes of freight, and unanticipated container-to-trailer ratios (likely to vary from 50/50 to 60/40.) It also would free up space at current landlocked intermodal terminals, permitting the railroads to expand their operations to generate additional revenue at their other terminals.

Hybrid Rail ThruPorts can be part of a cohesive transportation system strategy that better enhances the comparative advantages of all of the transportation modes. Although ThruPort terminals shared by multiple railroads are optimal in many regions, other regions may warrant

² A Grunt is a mobile unit used to transport personnel accessing to remove or install IBCs at a safe height and to check in the event an IBC is left unlocked.

different strategies. For example, a single railroad may wish to operate a ThruPort outside of urban areas to service its own multiple corridors.

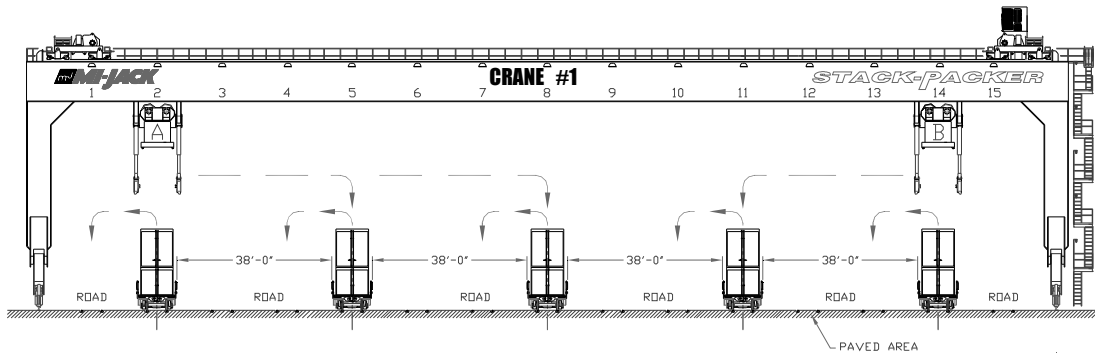


Figure 4. Hybrid Rail ThruPorts Perform both ThruPort and Two-for-One Functions

Table 2 summarizes similarities and differences between the four terminal types.

Table 2. Terminal Designs and Operations

	Conventional Terminal	Two-for-One Terminal	Rail ThruPort	Hybrid Rail ThruPort
Interchange Steps	13-step	7-step	1 step	1 step ThruPort/4-step 2 for 1
Real Estate Needs	Major	Major	Minimal	Minimal
Potential Locations	Abundant	Abundant	Limited; need access for multiple railroads	Limited; need access for multiple railroads
Container Storage	Necessary	Necessary	Not Necessary	Not Necessary
Chassis Storage	Necessary	Necessary	Not Necessary	Not Necessary
Drayage	Yes	Yes	No	No
Drayage Dead-Ends	Yes	Yes	No	No
Drayage Bobtails	Yes	Yes	No	No
Truck Traffic	Inbound and Outbound	Inbound and Outbound	None	Inbound and Outbound
Trailers-to-Tractor Ratio Intermodal	6:1	6:1	3:1	3:1

In *Rail Solutions to Congestion*, Martland (2004) makes several recommendations for intermodal terminals:

- Improve locations
- Minimize local truck miles by providing dispersed terminal facilities
- Serve new industrial areas by locating facilities on the perimeter of a metropolitan area
- Develop facilities with better highway access
- Expand capacity to handle growth
- Achieve economies of scale in terminal operations by consolidating terminal operations

A Hybrid ThruPort would address all the rail terminal solutions proposed. Moreover, in the case of ThruPorts, the total is greater than the sum of its parts: by expanding the distribution potential of each railroad—better access to the freight markets of other railroads—they also will be enhancing service for current customers by permitting better rail access to regions outside that railroad’s network for long-haul routes requiring transmodal interchange.

Because of faster and more reliable transmodal rail interchange, ThruPorts can help rail intermodal viably compete with truck line carriers along most long-haul intercity corridors. The ThruPort will help other rail corridors achieve economies of scale similar to what occurred in the West Coast to Chicago corridor as explained by Martlan (2004). For a long time, the West Coast to Chicago trade corridor was a lucrative long-haul truck market, but with the advent of double-stacked intermodal trains, the number of loads for motor carriers began to drop. Essentially, the railroads took just enough business to severely hurt profitability. Motor carriers were forced to either drop west coast service because it was becoming unprofitable, or developed plans for multi-modal cooperation with the railroads. Long haul trucks remained essential for time-sensitive and temperature-sensitive products like produce, but the economies of scale reached in container volume warranted additional rail investment, further improving the comparative advantage of rail for the transportation of all other products.

Potential Energy and Emissions Benefits of ThruPorts

Perhaps equally important to the reduction in exchange times is the potential impact of a ThruPort through reductions in energy consumption and air pollution both directly through reductions in truck VMT and associated emissions, but also indirectly by reductions in congestion through removal of these trucks from already overtaxed highway infrastructure.

Because fuels are combusted to release energy and perform work, the fuel consumption of any particular technology generally depends upon the time and load under which the vehicle is operated. By convention, this is normally divided into idling time and operational loads.

During idling, when the vehicle is not moving, all energy generated by the prime mover through consumption of fuel dissipates through internal friction and accessory loads. Fuel consumption and emissions from idling are normally assumed to be dependent primarily on idling time, with relatively minor impacts due to environmental factors.

Operational loads include the additional loads associated with vehicle movement, including overcoming frictional forces, aerodynamic resistance, and grade loads. To first order, these later

loads can be modeled as proportional to the external work performed by the vehicle (i.e. brake-horsepower hours or kW hours) and fuel consumption and the emissions of load dependant pollutants (e.g. nitrogen oxides) are assumed to be linearly dependent on the total work performed. Emissions of other pollutants typically have some non-linear response to the way the vehicle is operated (e.g. stop and go driving versus a steady cruise) but still depend principally on total work performed.

For efficient vehicles operating with relatively dense cargos over relatively constant terrain, the total work performed can be adequately modeled on an average basis as being proportional to the weight and distance moved by the cargo (i.e. ton-miles). Differences between modes in terms of their fuel consumption per ton-mile are primarily due to frictional and aerodynamic losses and thus the ratio between modes remains relatively stable. Rail has remained three to five times more fuel efficient on a ton-mile basis than trucking, even though both modes have undergone significant improvements in absolute fuel economy over the last two decades.

ThruPorts provide substantial direct fuel savings (and associated emissions reductions for nitrogen oxides and particulate matter) due to displacement of fuel consumption associated with yard tractors, hostlers and a reduced number of lifts associated with the transfer in addition to the fuel consumption associated with the truck transfer itself. Using typical values for the transfer of a single FEU in the Chicago area (i.e. a 25 mile transfer distance; average truck fuel economy of 6.5 miles/gallon; an average of 30 minutes of truck idle at each end of the transfer; a reduction in average lifts from 4 to 1, and elimination of yard tractor and hostler operations averaging 2.8 transfers/hr), the ThruPort is estimated to result in an average direct energy savings of 11.3 gallons of diesel fuel (or its equivalent) per transmodal container transfer and an average of 4.3 gallons per container for containers of local origin or destination. Assuming a 30% transmodal transfer rate and 20% of containers having a local origin or destination, this would result in a fuel saving of approximately 20.7 million gallons of diesel fuel on an annual basis. Associated emissions reductions would amount to approximately 1500 tonnes of nitrogen oxides and 21 tonnes of fine particulate matter. Both these fuel consumption and air pollution emissions reductions have substantial societal values beyond their direct financial impact. Additional estimates of indirect effects associated with reduced terminal-to-terminal freight movements by heavy-duty truck and potential reductions associated with reduced congestion are discussed below.

Reduced Highway Freight Movements

As discussed earlier, ThruPorts provide a significant benefit to Interstates, highways, and major arterials by eliminating the need to transport containers between Class 1 rail yards. The elimination of truck activity in the Chicago area associated with moving containers/trailers between primary rail yards would provide significant emission reduction and fuel consumption benefits. According to the initial screening analyses for Chicago, a ThruPort would eliminate more than 4000 cross-town truck movements (typically 25 miles/haul). This should constitute a direct NOx emissions reduction of 0.5 to 1.5 tons/day, depending upon the composition of the truck fleet and the conditions under which the vehicles currently operate. The direct onroad reduction benefits can be readily estimated using standard emission modeling tools, once the detailed activity is quantified and vehicle fleet composition is determined.

A significant (yet-to-be-quantified) benefit also accrues from reducing traffic congestion on the freeways and arterials serving these freight terminals. The presence of heavy-duty trucks in the fleet during congested periods contributes to traffic congestion. Heavy-duty vehicles are equivalent to multiple light-duty vehicles in consuming available system capacity. Under highly constrained flow conditions, when transportation demand exceeds capacity, emissions from the fleet can increase. In addition, trucks can affect onroad vehicle speed and acceleration profiles (Grant, 1998), potentially increasing emissions from other vehicles in the fleet by inducing weaving and passing maneuvers. The congestion reduction benefits (especially the time-savings associated with reduced congestion) cannot be quantified using standard travel demand models. Assessing the congestion reduction impacts from removal of significant numbers of heavy-duty vehicles from onroad operations on the specific yard-to-yard transportation corridors requires the implementation of traffic simulation models. By developing corridor-level simulation models for Chicago similar to the large-scale simulation model developed for Atlanta (Lee, et al., 2005), and applying new modal emissions modeling tools, the indirect energy and emissions impacts from congestion reduction can be assessed.

Conclusions

After World War II, the railroads two sources of income were threatened when the federal government proceeded to subsidize the development of airports for the passenger airlines, and the building of highways for truck freight. In combination, this seriously compromised the profitability and even the viability of railroads. Ironically, public investment in rail terminals is now the best solution to the freight capacity problem. The development of strategically located ThruPorts—along with high speed rail corridors, additional main lines, strategic overhead grade crossings, remote switching from the cab, and radar in all locomotives to prevent rear end collisions—now presents a unique opportunity to develop an extremely efficient intermodal freight system with substantial energy, environmental and competitive advantages that will benefit all modes of transportation.

The ThruPort concept offers significant advantages in terms of operational and logistical efficiency for inland intermodal transfers in terms of decreased per transfer and delay times and improved transport reliability. As the ThruPort dramatically reduces transfer times (from 24+ per transfer hours to 45-60 seconds per individual transfer and under one hour for complete train assemblages), which in turn results in dramatic improvements in total transit time through the supply chain. At least 10 to 20 percent of the annual 300 million long distance tractor trailer originations (>300 miles, *The Road Ahead*, 2006) could shift to the rails, with time-and temperature-sensitive shippers being the biggest benefactors. More importantly, ThruPorts will help get American goods to international markets faster and more efficiently, improving the competitiveness of US manufacturers.

The ThruPort concept also offers significant advantages in terms of direct fuel consumption, providing a significant energy cost savings to industry, and therefore consumers, and helping to reduce dependence on foreign oil. In addition, the concept has desirable ancillary impacts on both total emissions and potential “hot spotting” of emissions associated with terminal facilities.

The concept has the further advantage of potentially reducing congestion and improving safety due to displacement of large numbers of truck trips concentrated in urban areas.

The ancillary benefits provide ample justification for public involvement in the process of developing and operating these facilities. Much like a toll road, a shared intermodal terminal can be designed to pay for itself from the income generated from each lift. The current cost for each interchange ranges from \$125 to \$150 (drayage costs, which depends upon the distance traveled between each railroad terminal, and two lifts: off and on). Assuming a conservative estimate of only 30 percent interchange for the 12 million shipments for rail intermodal entering Chicago, and a ThruPort Interchange cost of \$95 per lift (lower transfer costs passed on to shippers), the ThruPort terminal would generate \$342 million annually in revenue. Obviously, if rail intermodal traffic growth continues to rapidly increase, or the percentage of interchange proves to be significantly higher than 30 percent, annual revenue projections would be much higher. However, before substantial public investments can take place, there is a strong need for improved information on current conditions and studies to analyze these data to quantify the benefits to be expected to a much greater extent than can be performed using existing databases.

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