The U.S. Transition to a Motor Carrier Supplied Marine Chassis: Operational Impacts On and Off Terminal

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Abstract

Ocean Carriers serving the United States have traditionally provided chassis to move their containers to and from customers. Because of the high cost of providing chassis and the increasing government concerns over the safety and roadability, ocean carriers have provided notice to their customers that they will no longer provide chassis in the U.S. While change in the short term is difficult, a change in ownership may improve safety, supply chain productivity and equipment utilization among other operating variables. This paper analyzes how intermodal performance, inside and outside the terminal gates, might change as ownership and management of the chassis fleet changes.

Keywords: chassis, chassis supply, intermodal freight, intermodal terminals, intermodal operations, intermodal terminal design, terminal technology, terminal design

1. INTRODUCTION

Intermodal freight transportation relies on a joint production model, and part of that joint production model is the chassis—a necessary “supporting” element for motor carriers to transport the container to and from intermodal terminals and freight customers. In other world markets motor carriers and logistics companies supply chassis. The U.S. is unique in that ocean carriers have owned, supplied, and assumed all the costs of providing the marine chassis as part of their service. After Federal Motor Carrier Safety Administration (FMCSA) roadability regulations were announced in 2005 and implemented in 2009—shifting liability regarding the condition of chassis from motor carriers to intermodal equipment providers (IEP)—ocean carriers, lead by Maersk Lines, in 2009 began announcing plans to discontinue owning and providing chassis in the U.S. The severe recession, which lead to $15-20 billion in ocean carrier losses in 2009, also was a contributing factor as ocean carriers needed to reduce the very high costs associated liability, provisioning, managing and storing chassis to return to profitability.

As an interim step in the evolution toward a motor carrier provided model (owned or leased by motor carrier, cargo owners, or 3PLs), ocean carriers have been increasing their use of neutral, co-op, and terminal-owned pools to reduce their costs, yet still ensure chassis availability. However, the long-term prospects for co-op pools are bleak since pool members would have to invest in new equipment. Figure 1 shows that this has not been happening as over 60% of the fleet is greater than 10 years old, with very minimal new investment in chassis since 2007 (1).

Although there is considerable uncertainty as to the pace of the transition away from the provisioned chassis model, the key performance drivers will be continued improvements in utilization, a reduction in chassis-related operating costs, and improvement in operational efficiency as the provisioned chassis transitions
from a non-transparent absorbed “service” cost to being itemized (either priced at cost or for profit and either on a container move basis or more on a per diem rate). This paper analyzes the operational efficiency improvements attainable based upon greater use of a motor carrier provided model, identifies the market impediments to the transition, and the potential regional impact of trucks—both in terms of miles and number of trips—moving containers between terminals and origin and destination facilities.

2. INTERVIEWS CONDUCTED

We assess the operational drivers of the chassis market change based on 47 interviews conducted with motor carriers, shippers, port terminal operators, Class I Railroads, DOTs and MPOs. Although not statistically significant this sample of users represented all geographic regions, importers and exports and several types of trucking companies providing port services within the context of literature reviewed regarding current and developing intermodal operating models.

3. MOTOR CARRIER OPERATING BENEFITS

The most important benefits of transitioning to a motor carrier model will be improved utilization, lower operating costs/improving operational efficiency, and eliminating the need to store chassis on-terminal. In an intermodal context, we define intermodal operational efficiency as the:

1. Elimination/minimization/reduction of handling and processing containers and chassis
2. Maximization of labor, yard and handling equipment productivity
3. Maximization of land use and productivity

These factors are interrelated in that the operational efficiency of reducing handling and processes of containers and chassis directly results in better equipment utilization, and the reduction of operating costs.

Since the intermodal industry is projected to grow at over a 5% rate through 2025, which would represent more than a doubling in equipment volume in the next 10 to 15 years, improving operational efficiency is critical in that reducing handling and processes of containers and chassis directly results in reduced operating costs. The challenge to improving efficiency and reducing costs is the multiple stakeholders involved in providing intermodal transportation, all trying to self-optimize, and the various ways that costs and pricing are bundled in the supply chain. There is uncertainty as to the feedback effects as well—a change in operation
or policy by one stakeholder intended to achieve a certain goal may lead to unintended responses by other stakeholders. For example, costly gate chassis inspection camera systems, installed for evidence to recover damages from motor carriers that historically has been absorbed by the terminal, resulted in the unintended consequence of carriers finding older inspection photos to prove preexisting damage. Nevertheless, what is certain is that stakeholders will adjust their business models, anticipating, reacting and adapting as ocean carriers exit the chassis business. The Public may also have a reaction to increased gate traffic at specific terminals and to the need for additional chassis parking and storage off terminal.

3.1. Better Chassis Utilization

Better equipment utilization permits smaller and more productive fleets, which can significantly lower both chassis capital and operating costs for the industry. Industry sources estimate the North American fleet peaked at around 820,000 in 2007 (2), which declined to around 722,000 by 2012 (3). Based on an estimate of 38 to 39 million chassis moves per year based on 21 million container transshipments, and between 1.75 and 2 “touches” by truck (effect pick-up, delivery, crosstown, drop lot, empty repositions, etc), the mean chassis utilization was 2.5 revenue loads per chassis per month (4.5 moves per month), which was fewer revenue loads in a month than the typical European and Asian chassis makes in a day (4).

It is worth noting that utilization for marine chassis is significantly lower than domestic chassis. In 2011, 160,000 domestic chassis were used to transport 4.93 million domestic container loads, versus 565,000 marine chassis transporting 7.45 million marine container loads. This, in part, explains why one railroad’s estimated cost of less than $15 per revenue load for their domestic chassis fleet is considerably lower than the $50-70 reported by ocean carriers for their marine chassis fleets (5). Some of this difference can be attributed to the railroad’s lower labor costs, but much of the cost differential is because of much better utilization driven by policies (e.g., shorter free time allowance at the terminal and a chassis per diem).

Although carrier alliance’s practices of pooling their fleets in order to improve chassis utilization and reduce operational problems and delays have effectively improved utilization, one terminal manager pointed out that there are still a high number of chassis stacked and stored at marine terminals. Chassis pools have made a very inefficient system more efficient, but do not address the inherent inefficiencies of storing, managing and maintaining chassis on-dock. Another issue motor carriers note is that any equipment pool is only as good as the last inspection. The issue of shared roadability responsibility has become a significant factor, now that motor carrier safety violations and safety scores are publically posted and impact carrier selection.
The more the chassis is used just for transportation, and not for operations nor storage, the much greater the ability to drive down chassis costs per intermodal revenue move. For example, the replacement cost of the U.S. chassis fleet (565,000 x $10-14K = $5.7-7.9 billion), along with the equipment to rack and stack chassis, it is likely greater than the replacement cost for all U.S. container handling equipment (not including ship-to-shore cranes).

3.2. Reducing Operating Costs

Intermodal terminals consist of three interactive operations: gate, transferring (ramp/berth), and storage. The storage function can be “grounded,” which uses container yards to store containers by stacking them upon one another, or “wheeled” with containers stored on chassis—containers coming off a vessel or train are directly transferred to a chassis, and thus the chassis is required for operations.

Many terminals are neither all wheeled, nor all stacked. A percentage of a grounded terminal’s space is typically reserved for wheeled operation (e.g. high-priority, hazardous, or refrigerated cargo), and wheeled terminals switch to stacked operations when they run out of places to park chassis/containers, or when they run out of chassis, which can result in significant lost productivity as operations shift to grounded.

Wheeled operations usually transfer containers with one lift, but require a significantly larger fleet of chassis, more land to store bare chassis as well as containers awaiting pickup. Many intermodal terminals are landlocked and have limited room for expansion. In Chicago, North America’s largest intermodal freight hub, chassis storage can absorb up to 1/3 of the intermodal terminal footprint. Although chassis costs are greater for wheeled operations, these costs are inherently high whenever chassis are provided on a per container move basis. Absorbed by all shippers, Table 1 identifies the major challenges responsible for the high costs, and Figure 2 shows the multiple processes that must be managed at wheeled terminals. Thus, the adoption of the European model—where chassis are considered part of the truck and generally supplied as a matter of course for transporting containers—has the potential to result in very significant operational efficiencies. Further, the better caretaking of chassis by motor carriers would significantly reduce the cost of chassis damage, maintenance and repair and improve safety.

The motor carrier model, or longer term leasing where the chassis stays with the tractor, will eliminate the time needed for driver and terminal chassis inspections, which will become even more costly because of the more stringent inspection requirements associated with FMCSA 2010. For terminals where chassis are not used for operations (i.e., wheeled), owner-operators, drayage firms, or 3PLs can provide the chassis at a far lower cost, and in time can make marine terminal operations far more operationally efficient. For example, at a rate of $2,000 (September 2008) for service from Asia to the West Coast, the ocean carriers’
chassis provisioning cost ($50-70) from the U.S port to the final destination is 3.5-6% of the rate, yet when rates drop to $1000 (July 2009), the cost rises to 7-12% of the rate. Thus, when chassis are provided by others, the more sustainable lower ocean rates will be, the more consistently ocean carriers can be profitable, and the more competitive U.S. intermodal transportation can become with the rest of the world.

3.3 Chassis Storage and Valuing Terminal Real Estate

Because of capacity constraints, there is continual debate on how best to value land in relation to operations. In a 2007 internal study related to the cost of chassis storage at the Ports of Los Angeles and Long Beach, determined that over 300 acres of usable land was occupied by stored idle chassis (the equivalent of a mega shipping terminal), resulting in an estimated annual storage cost of $50-$60 million. Thus, a greater share of motor carriers providing their own chassis will not only reduce cost, but to also increase throughput: every acre not needed for chassis storage is an additional acre available for container storage and/or faster selection of customer import containers (less stacking needed). Options for expansion are limited. Purchasing adjacent real estate is often not feasible because of lack of availability, community opposition, high cost, and the need for environmental remediation.

Freight in containers generates revenue, not the chassis, which is just a tool necessary for inland haulage. If a container is not being transported, it serves no operational function to be stored on a chassis. Thus, a motor carrier model in which the chassis is used just for transportation, will require far fewer chassis and eliminate concerns about chassis shortages.

Seaport and inland terminals have been increasingly confronting stakeholders with operational considerations to increase throughput to optimize terminal capacity and make the best use of available land (6). However, terminal managers reported that the free time allowance before demurrage charges, usually is a priority secondary only to price for cargo owners negotiating contracts with ocean carriers. A study at the Port of Houston-Bayport found that the average container dwell time for imports was 5.3 days and 6.8 days for exports; further, the day of pickup rankings (greatest number picked up on day 6, followed by day 7, 8, 3, 5, and 4) indicate that the majority of containers are picked up later, rather than sooner (7).

As supply chains became more sophisticated, the nature of temporary container storage at terminals has evolved. Instead of container storage being used solely for the synchronization between transport modes, shippers and logistics service providers started to use terminals for cost-free storage of consignments. Now high dwell times of containers are more likely to be attributed to supply chain strategies rather than port terminal operational challenges. One of the reasons is cash flow. The majority of imported containerized freight is controlled by the receiving
cargo owner, and the terms of payment to vendors in many cases are not cleared until the freight is delivered to the facility. Naturally, receivers want to take delivery of product as close as possible to the date of sale to both improve cash flow and lower inventory carrying costs. Because ports typically give importers five days of free time allowance before demurrage charges, cargo owners benefit with the use of the port container yards as supply chain buffers. It actually can be longer than 5 free days when the demurrage charge clock of a port does not start until all containers are discharged. For instance, the containers unloaded on day one could have a free time allowance of 7 or more days. The international container stored long term at marine terminals worsens chassis and container utilization, with the worst case scenario being the supply chain combination of wheeled port terminals (5 to 8 days) servicing drop/pick cargo receivers (another 10 to 20 days). And depending on the goods being transported/stored in the container, it is worth noting that cargo owners may be willing to pay the demurrage fees if the additional postponement benefits their strategy. Many international cargo receivers have limited container storage space at receiving facilities, and often internal coordination between the transportation department and store fulfillment operations is highly variable.

Reducing average container dwell time not only results in better chassis utilization, but also provides the opportunity to increase capacity. A reduction from seven to four days can increase terminal capacity from 4,500 to 7,900 TEUs per acre (8). More importantly, this reduces the number of rehandling lifts required for stacked terminals, and reduces the size and improves the utilization of the chassis fleet for wheeled terminals. On the downside, reducing free dwell time can put pressure on terminal gates and local access roads since customers have a smaller time window to pick up their cargo. This will become even more apparent as ever larger container vessels start calling in North American ports. Besides ports having to address the greater overall volume from these ships, greater peaks and troughs landside can be expected in the distribution of terminal trips by drayage drivers.

Extended dwell is mainly a marine terminal problem. Rail terminals typically provide 48 hours, yet have reduced their container free time allowance at some higher volume terminals to 24 hours in part to improve container flow. The importance of keeping containers flowing for operational efficiency is often under appreciated. For example, the Maher Terminal at Prince Rupert, which opened in 2007, was originally projected to have a capacity of 500,000 TEUs annually. Because of shorter container dwell times, and the focus on vessel to rail transfers with very little drayage, the estimated capacity has significantly increased above the original projection.

As the percentage of chassis provided by motor carrier’s increases, which in turn requires storage of fewer chassis, terminal operators expect to see an improvement in most performance metrics. Terminal operators also feel the land cost (rent) of domiciling chassis at the terminal eventually will be passed along to the chassis
pools and result in higher per diem lease rates. That is because the current practice of the container yard serving as a supply chain buffer, “free parking” that is commonly considered as part of the service to the terminal’s customers, is effectively giving something away for free that has a significant cost to the provider. There are three parts to this cost: the direct cost in the form of rent, functional costs of constructing, gating, monitoring, lighting and maintaining the storage area, and the opportunity cost of using the land for some other productive use.

4. IMPEDIMENTS IN EVOLVING TO A MOTOR CARRIER OPERATING SCENARIO

Despite all the operational efficiency advantages of the motor carrier model, there are several major market impediments that will forestall a quick transition from the provisioned chassis model.

4.1 Wheeled Terminal Operations

Although most deep water ports are constrained by space and primarily ground containers, the San Pedro ports and most rail terminals are still wheeled operations. In a wheeled operation, the container is lifted off the vessel or train and placed on a chassis; drivers with their own chassis must wait, sometimes over two hours, and pay for a chassis flip (often $75 or more) at wheeled terminals. Chassis flips occur when there is a need to transfer a container from the chassis it is resting upon to another chassis for transportation outside the gate. This practice is a major impediment to the motor carrier model. Nevertheless, all the marine terminal operators interviewed expressed an opinion that all the major terminals eventually will be grounded, especially as the next generation of mega-containerships start calling at U.S. ports and the average number of containers discharged per call dramatically increases. Terminal productivity studies that favored wheeled over grounded marine operations did not include the need for a larger less utilized chassis fleet at wheeled terminals (perhaps because all containers must leave a terminal with a chassis), and the ability to eliminate the costs associated with on-dock chassis storage in their analysis (9,10). They also do not consider the larger chassis fleet as part of capital cost analysis since chassis are not a terminal operator’s capital cost, thereby further skewing productivity comparisons. Another driver toward grounded operations will be chassis storage. Some marine terminal managers believe there is a high probability that centralized off-dock chassis depots will be developed—where motor carriers will have a direct relationship with the pool operators—so that ocean carriers can dissolve on-dock chassis fleets.

Widespread adoption of the more operationally efficient motor carrier model at the ports will take time because of the perceived and real benefits of keeping containers “wheeled” for storage and operational reasons. Even at grounded terminals, cargo owners regularly request “priority wheeled service” for expedited
delivery to drop and pick facilities, driving up operating costs. In the long-term, better information technology will make it possible to derive much higher performance from more automated intermodal equipment to deliver far better value for supply chain customers. But it will require far greater collaboration, and for cargo owners and ocean carriers to understand that wheeled priority service is not necessary for faster turns and better service for import loads. If the terminal knows the trucker is coming via an appointment system, and is alerted when the chassis crosses a proximity zone (alerted by an RFID tag), then the terminal operating system can have the “hot load” staged for immediate selection or positioned for expedited transfer (11), thereby making it possible to eliminate wheeled storage and no longer domicile chassis.

The transition away from wheeled terminals at rail terminals is more uncertain. Some railroads plan to stay with wheeled operations; others interviewed are committed to transitioning. There are several reasons wheeled operations might persist. First, the volume and nature of container flow (the peaks and troughs of chassis demand) differ. Whereas a marine terminal may unload 3000 containers on to chassis from each of the three vessels calling in a week, a railroad may unload 200 or more containers to chassis for each of the 10 inbound trains a day. Secondly, most secondary market rail terminals have to handle trailers along with marine and domestic containers. Wheeled terminals are a historical legacy of handling trailers, which still comprises around 15% of volume, down from over 80% in the early 1980s. And finally, unlike ship-to-shore cranes that can perform over a hundred lifts from one fixed position, grounding containers for rail operations is much more problematic alongside trains 10-12,000 feet in length.

4.2 Beneficial Cargo Owners (BCOs), and Drop and Pick Facilities

BCOs, likely to be the major driver of change, they manage three distinct flows in their supply chains: cash, information and the physical movement of goods. Because supply chains are complicated and knit together various internal functions such as demand planning, sourcing considerations, labor cost, warehouse operations and other functions related to demand management and forecasting, approaches vary. Business sectors, and even companies within business sectors, can be driven by unique and independent management philosophies. Some companies are driven by legal interests and seek to reduce risk, others are marketing based and seek to maximize market share, or are operationally driven and seek to maximize performance often due to the value or volume of goods in the supply chain.

Generally BCOs purchase ocean transportation and select Port-to-Port (or CY) or Port-to-Door terms from ocean carriers. If the BCO purchase terms specify door delivery then the chassis transaction is up to the ocean carrier or the forwarder to source and price. Based upon individually negotiated contracts between the BCO
and the Forwarder or Ocean carriers, charges for chassis may be included in the transaction or separated into a line item on the invoice.

Each BCO approaches transportation purchasing based on the best price and service combination for their specific needs. Some BCOs feel outsourcing transportation purchasing and daily operating decisions allows them to focus on their other core business. Other BCOs with unique needs or specialized facility requirements get directly involved in each transaction due to the overall impact transportation may have on the supply chain. Most BCO’s have a mixture of full container loads directly managed and some split shipments managed by a Freight Forwarder.

Transportation purchasing varies by company size, growth patterns and maturity. Growing BCOs, which are expanding into new markets, may value a turn-key all-in service providers as a good investment to assure compliance. Mature companies, or companies with many competitors, may value a more hands on approach to chassis management and cost reduction.

Contracting for container free time is the highest priority after transportation price. Some ocean tariffs provide 5 to 7 days free time at destination, yet some BCO private contracts include a 14-to 21-day free time allowance. Thus, the major operational consideration is how to best adjust distribution flows based on a new cost center for chassis. This additional supply chain cost will have an impact since the distribution center protocols can be as important to intermodal operational efficiency and drayage productivity which occurs at the terminals.

There are three options for BCOs moving forward: live load/unload, drop and pick, or invest in lift technology. Much like the wheeled versus grounded tradeoffs at the terminal, there are similar tradeoffs. Whereas the operating model for Canada, Europe and Asia is live unload/load—the chassis is essentially part of the truck—U.S. intermodal transportation is a mix of live unload/load and drop/pick. The major advantage of drop/pick is the additional storage, and the ability to flow product in the supply chain based on market demand.

Some Importers utilize transloading operators near the deep water ports to mix product once it arrives in the U.S. This practice takes the contents from an international container and transfers it to a domestic container, usually destined to a regional distribution center. This allows the buyer to buy full container loads and then mix products from many international origins, resulting in full domestic containers to regional points of consumption. In practice this often requires that the chassis/container remain at the warehouse for several days because most product is never actually stored at the cross dock, it is handled only once by the fork truck in the transloading process, with the chassis/container, in essence, serving as a “warehouse on wheels.” As tracking of point of sale data has improved, the nature of transloading has increasingly become more sophisticated and efficient. Although two
53’ domestic containers can carry the contents of three 40’ marine containers to lower the cost of intermodal rail, transloading has been increasing as importers defer issuing purchase orders or consolidating cargo in Asia, and instead wait until arrival in the U.S. to make inventory replenishment decision at the stock-keeping unit (SKU) level. Thus, for the transloaded domestic containers to be optimally loaded for inland destinations, it may require marine containers to remain at the transloading facility for several days. Importers use of transloading, which originated in Southern California, has been a growing trend. As the chassis becomes priced, distribution centers can start to look at their return on investment (ROI) from the use of traditional or emerging container transfer technology as a means of transitioning to the motor carrier model to retain the operational efficiency advantages of the container serving as temporary storage, and at the same time achieving much higher utilization of a much smaller chassis fleet (12). Cargo owners would be evaluating the efficiency gains of an investment in equipment to transfer containers to and from the chassis to support the motor carrier model vs. paying a per diem rate for the dwell of provided chassis at their facility. The ROI will improve significantly if the terminal efficiency gains (no chassis domiciled, less container handling, and greater capacity from shifting some of supply chain buffer) are passed along to the BCO in the form of lower rates. Likewise, lower drayage rates can be negotiated from driver productivity gains by virtually eliminating detention time, which has been estimated to cost motor carriers $3 billion annually (13).

It should be noted that many shippers issue bids for ocean transport and specify the terms and conditions of delivery. Large ocean customers are often able to use their volume purchasing power to demand “merchant haulage” where the ocean carrier purchases a specified number of drayage moves at a substantially reduced rate. This “merchant haulage” allowance will become unbundled as ocean carriers exit the chassis market. Many of the same customers who purchase ocean transportation have their own private trailer fleets for distribution and are keenly aware of trucking costs and efficiencies. Receivers likely will be comparing the chassis usage charge versus their fleet costs in considering whether to invest in their own chassis fleet and/or transfer equipment.

In the short term BCOs, now faced with a new visible cost instead of a bundled ocean rate for international shipments, may choose to take an activity based cost assessment to look at the number of days they use chassis in their drop and pick operation and assess that cost impact on other functions in the supply chain such as ways to reduce facility dwell time and/or optimize appointment setting (once a cost history can be developed). Depending on the inventory carrying cost and the average chassis equipment cost, greater use of supply chain visibility tools (perhaps outsourced to a 3PL with sophisticated tracking technology) will be needed to forecast inbound and outbound container flows to maximize equipment utilization.
4.3 Motor Carrier Impediments and Return on Investment

The ROI for chassis investments will vary enormously because the operating profile of the drayage carrier population varies enormously, from the very small firms using independent operators to the large motor carriers who primarily use employees. A greater share of drayage being handled by large motor carriers is likely because of the increased concerns over driver safety ratings, and the desire to reduce risk of catastrophic accidents and large jury awards.

Aside from the problems associated with servicing wheeled terminals and drop/pick origins and destinations, the following impediments were identified by both large and small motor carriers:

- Availability of capital to invest in a chassis.
- Drayage service may only represent a small portion of the trucker customer base.
- The need for multiple chassis sizes to accommodate customer mix. An explosion in Midwest agriculture exports has increased demand for tri-axle chassis to allow users to fill export boxes to 57,000 lbs.
- It might be more economical to own for baseline demand (e.g., consistently used 5 days a week), and lease on a fee per day basis for their independent operators during peak periods.
- Motor carriers usually compensate independent operators for tractor-empty chassis moves, but not bobtail moves.
- Labors’ current marine terminal inspections requirement of all chassis (out-gate on the West Coast and in-gate on the East Coast), which negates some of the operating efficiency benefits of the motor carrier model.
- It has been cited by some that independent operators and motor carriers may not have storage space or the equipment to stack chassis and maintenance/repair facilities (however 71% of motor carriers interviewed in non-statistical sample did have some storage available). There is an economic disincentive component as well: the land (rent) cost of on-dock chassis pools is a cost that is not yet reflected in the lease rates, and thus absorbed by all intermodal customers.
- Customer behavior, carriers noted that some customers who have been using “free” chassis may refuse to pay for a motor carrier provided chassis.
- The quality of maintenance performed on dock.

All carriers interviewed felt that motor carrier ownership would result in increased productivity (better operating margins), and improved reliability and safety from higher quality and better maintained equipment. In short, better operational control would translate into improved service. The intermodal truckers are paid by the move, any time spent in line for M&R service is not compensated and impacts
driver productivity. If truckers use their own chassis for multiple customers, less time is spent at the dock for chassis pick up, return and gate inspections. A survey of motor carrier’s assessment of impacts a change in ownership will have is tabulated in Table 3.

5. PUBLIC POLICY CONCERNS

Motor carrier chassis ownership will benefit the industry in three major ways:

- Reduce the number of underutilized chassis resulting in more “real estate” for terminal operations and industry growth.
- Increase trucker productivity and increasing his control over equipment quality by reducing time spent in maintenance and repair lines and or breakdowns on the road.
- The chassis, which is essential to the movement of containers, will be visible in the supply chain and information about its use can be properly measured and accounted for, which will allow supply chain users to minimize their costs or pay for the value that the chassis provides.

All of the above will reduce the carbon footprint of intermodal. However, methodologies and tools for robust analysis of emissions per intermodal trip remains in its infancy. Since the focus has been on new and retrofitted replacement technology, models have not yet evolved to capture terminal designs and technology that can reduce the distance and the number of events/movements required for an intermodal transfer (14).

Other public benefits are more uncertain. Table 2 ranks the survey responses of public agency officials asked to estimate the potential planning impact that might result from anticipated changes to the way chassis are supplied and handled. (Some agencies noted that scoring was speculative and a need for more information was necessary to determine actual local impacts.) It is important to note that local agencies had a higher average level of concern about potential chassis issues than State agencies, which is primarily due to the concentrated local impact of these facilities.

In addition to a large reduction in the size of the fleet, the regional impacts of the transition to the motor carrier chassis model will require analysis based on the different pick up and drop off locations, and new traffic patterns (average number of trips per container move affected by the increase/reduction in number of bare chassis, bobtail moves, and empty container repositioning moves). Another major benefit would be the elimination of empty trips back to the terminal that is common with provisioned chassis in an effort to get “off the clock,” especially over holiday or extended weekend periods. Motor carrier ownership also may incent truckers to
support exporters by street turning equipment and reducing empty miles in congested urban environments.

From a planning perspective, respondents felt current planning efforts need to be developed to understand freight flows at port and international intermodal terminals (46% of the public agencies surveyed to not have land use mechanisms in place to address traffic pattern changes or methods to impact traffic), and do not recognize the difference between a truck and a chassis or domestic versus international cargo. There also is a need to develop inventories of available sites that could accommodate off terminal chassis storage.

6. CONCLUSION

The results presented in this paper point to several future research initiatives and highlight the need for more collaboration between industry and public planning agencies. Funding for freight intermodal connectors should be prioritized and the implantation of freight activity fees should be examined in the context of the full freight operation. In particular, modeling is recommended to examine the emissions and energy consumption impacts from the changes in operations at the terminals, and the number and distance of street moves involving bare chassis and bobtail moves from more efficient operations.

The ability of intermodal transportation stakeholders to collaborate in achieving operational efficiency improvements will have a major impact on the future nature of chassis supply. Historically, intermodal efficiency gains have been hampered by stakeholder self-optimization—maximizing revenue and minimizing cost—and not on reducing the overall costs of the supply chain. However, announcements by key industry stakeholders portend a desire for greater collaboration to improve operational efficiency and service. Maersk Line, in the manifesto entitled “The New Normal,” asks for a new collaborative effort with shippers to look at the operational efficiency of the supply chain as a whole, and improve reliability, particularly at the port terminal where two-thirds of all delays occur, either by lack of managerial skills, inefficient port operations, or the lack of integration with the terminal’s customers distribution strategies (15). President and Chief Executive Officer Claude Mongeau desires the Canadian National Railway “to be a true supply chain enabler and bring a new customer-centric focus and commitment to supply-chain innovation so that their customers could better compete in their end markets (16).” These announcements indicate an emerging consensus that to increase intermodal traffic and generate greater revenue, all stakeholders need to take a holistic approach to improve the reliability, speed and operational efficiency of intermodal services. But it is important to note that intermodal equipment, terminal operations, and shippers’ operations vary significantly by region and industry, and change will take time, so chassis pools will serve a useful role during the transition.
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Figure 1. Age of Marine and Domestic Chassis Fleet. (GIER/IANA)

Table 1 Costs Associated with Provisioning Chassis

**Identified Reasons for High Operating Costs Associated With Provisioned Chassis Inspections** (in-gate for East Coast ports and rail, out-gate West Coast Ports, driver inspections)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Description</th>
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<tbody>
<tr>
<td>Quality and consistency of inspections, and difficulty of determining damage vs. defect</td>
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<tr>
<td>Difficulty of assessing tire damage</td>
<td></td>
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<tr>
<td>Legibility of paper inspection, and need to transfer from paper to computer</td>
<td></td>
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<tr>
<td>High capital cost and limitations of automated inspections that would help reduce damage disputes</td>
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<tr>
<td>High labor costs for inspections</td>
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**Damage, Maintenance, Repairs and Liability**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Description</th>
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<tbody>
<tr>
<td>Costs increasing faster than inflation, particularly for tires</td>
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<tr>
<td>Improper repairs and lack of daily supervision and periodic auditing of vendors</td>
<td></td>
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<tr>
<td>Routine maintenance not done (e.g., not keeping tires properly inflated curtails tire life)</td>
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<tr>
<td>High incidence of roadway service needed—80-90% involves tires</td>
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</tr>
<tr>
<td>High cost of damage from parking, racking and stacking</td>
<td></td>
</tr>
<tr>
<td>Equipment theft: replacing OEM parts with substandard equipment, and then selling the OEM parts</td>
<td></td>
</tr>
<tr>
<td>Absorption of damage cost by the wrong party (e.g, terminal operator, not billed to motor carriers)</td>
<td></td>
</tr>
<tr>
<td>Damage disputes, and the high cost of dispute resolution</td>
<td></td>
</tr>
<tr>
<td>Shared chassis asset is less roadworthy than motor carrier owned chassis, increasing liability risk</td>
<td></td>
</tr>
<tr>
<td>High labor costs for maintenance and repair</td>
<td></td>
</tr>
</tbody>
</table>

**Terminal Productivity (Wheeled Operations)**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many chassis processes and steps for a transfer (see Figure 2)</td>
<td></td>
</tr>
<tr>
<td>High incidence of a bad order chassis (motor carriers estimated 25-50% of the time)</td>
<td></td>
</tr>
<tr>
<td>Mis-parked export containers by motor carrier and double handling when owner chassis are missing.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2. Wheeled operations are operationally challenging because terminals must manage five different motor carrier chassis-related arrival scenarios and some combination of seven processes. In comparison, the motor carrier arriving with a chassis at a non-wheeled terminal is the most operationally simple: two arrival scenarios (bare chassis, chassis/container) and two processes (drop off container, pick up container).
Table 2 State DOT and MPO Assessment of Planning Impacts

<table>
<thead>
<tr>
<th>Potential Planning Impact</th>
<th>Level of Concern</th>
<th>MPO/EDC</th>
<th>DOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>More Truck Trips/Container Handled</td>
<td>4.6</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Fewer Containers Due to Increased Costs</td>
<td>4.2</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>Need for Increased Truck Parking/Storage</td>
<td>4.6</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Increased Congestion Around Terminals</td>
<td>4.4</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Need for Increased Truck Route Designations</td>
<td>3.2</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Need for Greater Investment in NHS Connectors</td>
<td>4.2</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Community Aversion to Intermodal Terminals</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Public Health and Safety Issues due to Freight</td>
<td>4.3</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Terminal Relocation Needs Nearby Sites</td>
<td>2.5</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Terminal Relocation Needs Remote Sites</td>
<td>3.2</td>
<td>3.25</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Motor Carrier Assessment of Chassis Changes

<table>
<thead>
<tr>
<th>Motor Carrier Assessment of Chassis Change Impacts</th>
<th>Impact Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result in more cross docking at deep water ports</td>
<td>4.0</td>
</tr>
<tr>
<td>Require more software systems to manage equipment</td>
<td>3.3</td>
</tr>
<tr>
<td>Improve Safety</td>
<td>2.8</td>
</tr>
<tr>
<td>Decrease Land Use Requirements</td>
<td>2.3</td>
</tr>
<tr>
<td>Increase empty miles off terminal</td>
<td>3.8</td>
</tr>
<tr>
<td>Reduce profitability for all parties</td>
<td>3.0</td>
</tr>
<tr>
<td>Reduce Complexity of Intermodal</td>
<td>2.4</td>
</tr>
<tr>
<td>Improve User Experience</td>
<td>2.8</td>
</tr>
<tr>
<td>Reduced Terminal Congestion</td>
<td>3.0</td>
</tr>
<tr>
<td>Improved Asset Utilization</td>
<td>2.8</td>
</tr>
<tr>
<td>Decrease in International Intermodal Locations in U.S.</td>
<td>3.2</td>
</tr>
<tr>
<td>Increased International Business</td>
<td>2.6</td>
</tr>
<tr>
<td>Increased Rail Terminals Costs (due to flips)</td>
<td>4.0</td>
</tr>
<tr>
<td>Improved Driver Productivity</td>
<td>3.7</td>
</tr>
<tr>
<td>More Containers in Secondary Markets due to fees</td>
<td>3.4</td>
</tr>
<tr>
<td>Fewer Containers in Secondary Markets</td>
<td>3.3</td>
</tr>
<tr>
<td>Fewer Markets Served by International Carriers</td>
<td>3.1</td>
</tr>
<tr>
<td>Fewer Intermodal Operators</td>
<td>4.0</td>
</tr>
</tbody>
</table>