National Cooperative Freight Research Program

Project 14 – Truck Drayage Practices

Task 3 - Literature Review

Standalone Deliverable Prepared for Panel Review

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<u>Prepared by</u>
The Tioga Group
University of Texas Center for Transportation Research
University of South Carolina

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1. INTRODUCTION

The project team undertook a comprehensive review of the available literature on truck drayage practices. ***The focus of this review is specifically on seaport drayage***. The review is intended to be a standalone document, and hence it includes some background information on seaport container terminal operations. Following a brief introduction to drayage operations and characteristics, the review documents how terminal operations affect truck drayage. It also identifies performance metrics and best practices currently in effect or under consideration to improve drayage efficiency. The review below includes up-to-date studies found using transportation and engineering databases such as TRIS, Compendex, Scopus, and Web of Science. Other sources include Google Scholar, Journal of Commerce, and other web-based sources. In all, over 100 relevant sources were reviewed and summarized. The review is grouped into distinct sections as follows.

- Drayage operations and characteristics
- Factors affecting drayage operations
- Consequences of inefficient drayage operations
- Current and potential initiatives to improve drayage operations
- Performance metrics

Definition Of Drayage

The term drayage was first used to describe the overland transport of cargo to or from barges or rail yards. In a broader sense drayage includes regional movements of loaded and empty equipment (trailers and containers) by tractors between rail yards, shippers, consignees, and equipment yards (Morlok and Spasovic 1994). The Port of Oakland[1] classifies moves up to 250 miles as drayage, which include (1) shuttle haul or land bridge between a rail yard and a marine terminal, (2) short haul dray serving a marine terminal at less than 100 miles, and (3) regional haul drays which is in range of 100 – 249 miles.

The definition of drayage used by Harrison et al. (2008) is more in line with the focus of the NCFRP 14 project: ***truck container pickup from or delivery to a seaport terminal with both the trip origin and destination in the same urban area*** **(although this study covers linger trips as well)**. Subsequent discussions of drayage refer to a delivery/pickup of a container to/from a seaport container terminal. For this reason there is a stronger focus in the literature review on studies directly or indirectly related to seaports as opposed to the abundant drayage work related to rail intermodal facilities or the system of cross border trucking that exists along the US-Mexico border. For completeness and to show breadth and depth of the literature in the area of general drayage, an annotated bibliography of these sources is provided in the Appendix.

[1] www.portofoakland.com/pdf/ctmp_carrierSurvey.pdf.

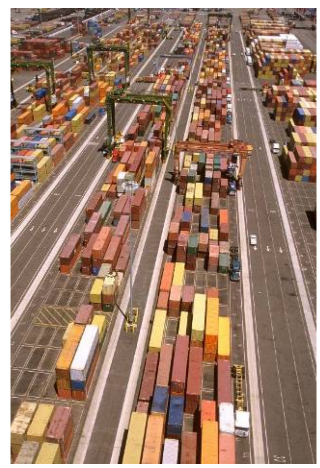
2. DRAYAGE OPERATIONS AND CHARACTERISTICS

2.1 Overview of Port Drayage Operations

Port drayage provides the critical link between marine container terminals and customers, railroads, and other facilities. A typical drayage move involves either a delivery of an export container to the seaport terminal or pickup of an import container. A drayage driver arriving to pick up a loaded import container may encounter one of three basic systems.

- ***At wheeled terminals*** the driver will simply locate and retrieve the container on its chassis in the parking area. Wheeled terminals store containers on street-legal chassis in large parking areas. The yard tractors position the street chassis to receive the container from the vessel, and the container remains on the chassis for storage and subsequent delivery. This process typically entails minimal interaction with terminal staff once the truck has cleared the gates.

- ***At stacked terminals***, the driver will usually first retrieve a street-legal chassis from a chassis lot, then position the chassis in the container storage stacks to receive the container from a lift machine. Stacked terminals store containers in stacks or rows off the chassis (right). These terminals typically use in-terminal chassis (known as "bomb carts") between the vessel and the storage areas. At the storage areas, a variety of mechanical lift types transfer the container. Some terminals that use stacking may also reserve a percentage of the terminal space for wheeled operations; this is typically done to facilitate the drayage operations of high-priority cargo or out of necessity because of the cargo type; hazardous, oversized, and refrigerated cargo are usually stored on chassis.

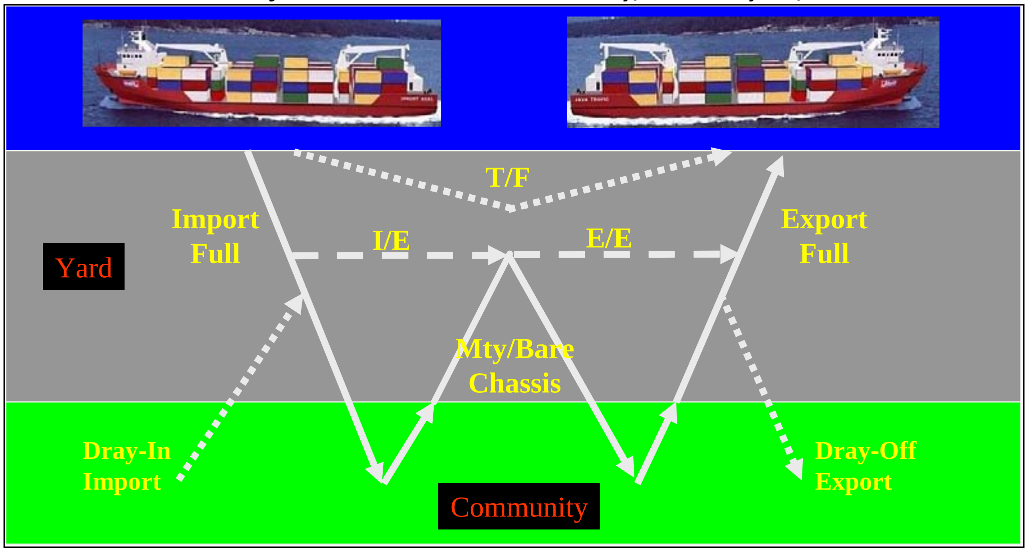


- At some stacked and straddle carrier terminals, the drayage driver will retrieve a street-legal chassis then proceed to a designated transfer zone. A lift machine then brings the container to the waiting driver. At a few terminals, "straddle carriers" (right) move the containers within the terminal.

These operations and procedures are generally reversed for export containers or empty containers being returned to the terminal.

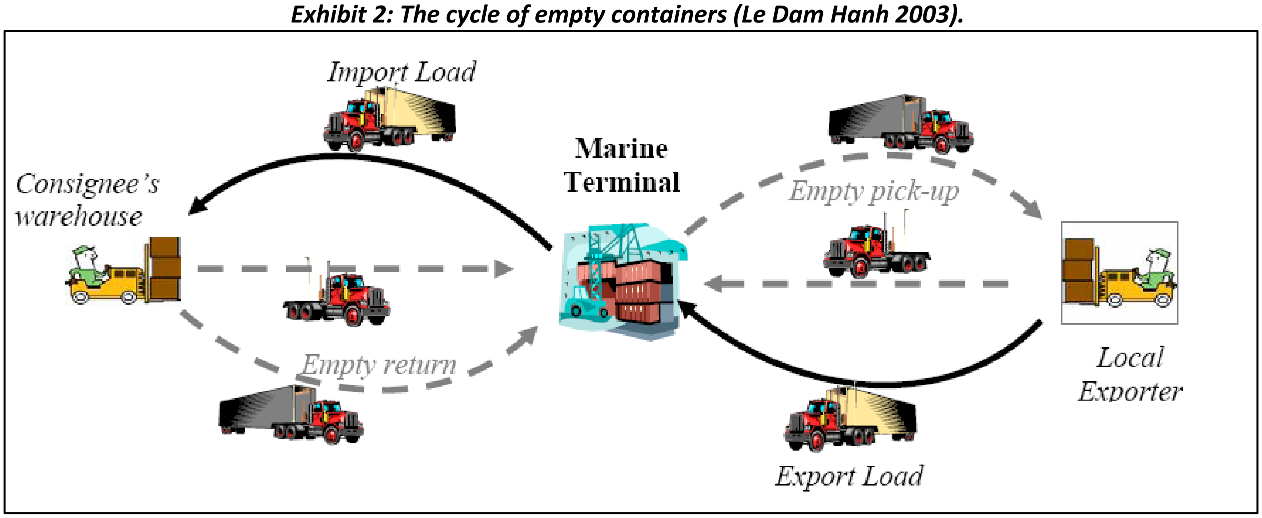
At most terminals, a portion of the trucks performs *both* the delivery of an export container and a pickup of an import container on the same trip; this is termed a "double move" in the industry. Exhibit 1 shows other types of gate transactions a drayage truck can perform at a seaport terminal: 1) dray-in import[2], 2) empty or bare chassis drop off, 3) empty or bare chassis pickup, and 4) dray off export[3].

Exhibit 1: Flow of containers between community, terminal yard, and vessels.



The delivery and pickup of empty containers and chassis are part of the inventory cycle. Exhibit 2 illustrates the role of empty container in logistics.

Exhibit 2: The cycle of empty containers (Le Dam Hanh 2003).



The process to pick up an import container involves the following general steps for a truck serving a marine terminal with stacked containers. (Giuliano, D. Sloane et al. 2006).

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[2] A dray-in import is an import container that is discharged from one terminal and is brought to another terminal for storage and subsequently picked up by a road truck.

[3] A dray-off export is an export container previously brought to the terminal for storage and slated for a vessel that is brought back out of the terminal.

1. Order to pick up import container
2. Go to terminal; wait in line
3. Order verification; enter terminal
4. Pick up chassis
5. Go to container location
6. Wait in line
7. Receive container
8. Exit terminal
9. Deliver container

A more detailed description of the drayage process for import and export moves is given below for a truck serving Barbours Cut Terminal (BCT) at the Port of Houston. Note that BCT is a stacked terminal that uses Rubber Tired Gantry (RTG) cranes (right) to load and unload containers from a truck to a yard stack and vice-versa.

Import Moves

When a truck arrives at the terminal for an import load, the driver is presented with a gate pass from a security guard. The truck then proceeds to the lane. The driver submits the transaction request which he filled out ahead of time to a logistic associate for processing. The logistic associate verifies that the container has been released by the steamship line and that no other holds exist on the container (e.g. USDA inspection, Customs exam). If there is a problem with the paperwork (e.g. wrong container number), the truck is sent to customer service. If everything is valid, an interchange is printed and the truck is cleared to proceed into the terminal. The interchange document includes the location where the import container resides in the yard. The truck can then proceed to the transfer location. Directions to the transfer location are provided, if needed. Upon arriving at the specified transfer location, the truck waits for RTG cranes for service (i.e. have the requested container put on the truck). After the container is placed onto the truck, the truck proceeds to the outbound lane. Before exit, the container and chassis are checked. If everything is valid, the driver is given a copy of the interchange document and the truck may exit (Huynh and Hutson 2008).

Export Moves

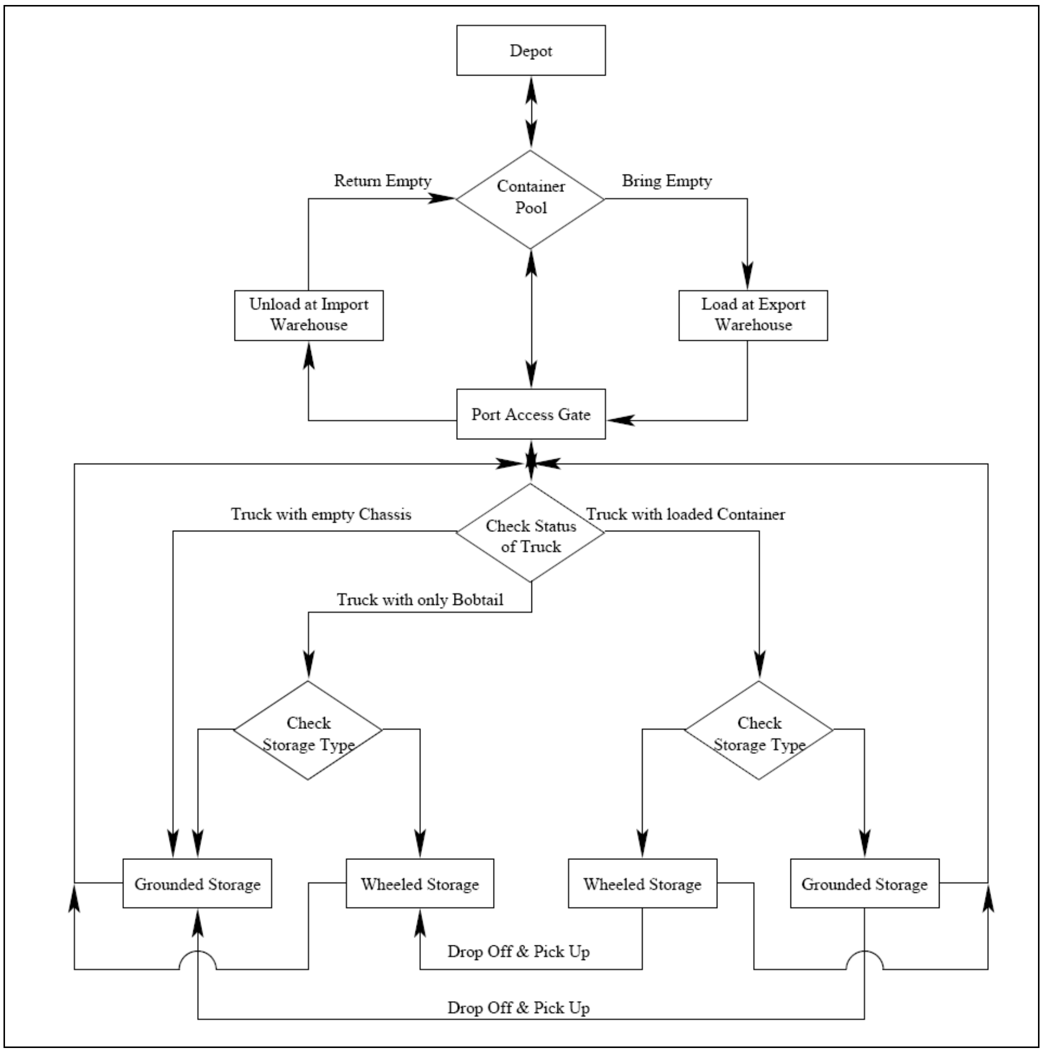
When a truck arrives at the terminal with an export load, the driver is presented with a gate pass from a security guard. The truck then proceeds to the inbound lane and onto the scale. The truck is then checked by a clerk; the clerk checks to make sure the container is not over the weight limit, that the seal on the container is intact, the container is not damaged, the chassis is functional, etc. After the clerk finishes checking the truck and chassis, the inspection form and the transaction request which the driver filled out ahead of time are submitted to a logistic associate for processing. If there is a problem with the paperwork (e.g. booking number not on file), the truck is sent to customer service to get the problem resolved. If the paperwork is valid, then an interchange document is printed and the truck is clear to proceed into the terminal.

The interchange document includes the location where the export container is to be placed. Directions to the transfer location are provided, if needed.

Upon arriving at the specified transfer location, the truck waits for RTG cranes for service (i.e. taking the container off the truck). After the container is taken off, the truck exits through a lane designed for quick exit, since no checking of the container is necessary. The check out process involves a clerk checking the interchange document to ensure that the proper move has been made. If everything is valid, the truck may exit.

Exhibit 3 provides an overview of the drayage activities from an off-terminal storage depot to a seaport terminal and vice-versa.

Exhibit 3: Activities performed by drayage vehicles serving a port (Namboothiri 2006).



Each type of gate transaction at the seaport terminal described above (e.g. export delivery, import pickup) requires processing time, and potentially some waiting time when the port is congested due to the lack of resources such as gate capacity. During peak hours of the day and/or during peak times of the year, the delay due to congestion can be quite significant (Namboothiri 2006).

2.2 Drayage Characteristics

The following discusses results obtained from studies done by (Harrison et al. 2007; Harrison et al. 2008) at the Port of Houston's Barbour Cut Container Terminal on driver demographics, working conditions, truck characteristics, and route characteristics. These results are compared against results obtained studies in the Los Angeles area and New York-New Jersey (conducted by Bensman and Bromberg, 2009).

Driver Demographics

In a survey of 103 Houston area port drivers, it was found that most drivers were between 35 and 44 years old. The age profile of the drivers is consistent with the results found at the Ports of LA/LB and NY-NJ. Monaco and Grobar (2005) found that the mean age of drayage drivers operating at the Ports of LA/LB was 40.4 with 10% of drivers 30 or younger and another 10% 52 or older. Bensman and Bromberg (2009) found that most drivers at the ports of Newark, Elizabeth, and Bayonne are men, with the modal age being 35-44 and consists of mostly Latino immigrants (67%). With regard to educational attainment, the Port of Houston survey found that a relatively small percentage (16%) of drivers did not have high school equivalency, while one third (34%) reported having some college training. This is again consistent with Monaco and Grobar’s findings at the Ports of LA/LB, where 17.4% of respondents did not have a high school degree and a combined 29% had either a vocational or technical degree, associates, or some college. Drayage drivers at the Port of Houston have worked in the trucking industry for an average of 12 years. ***On the whole, drivers tend to be highly experienced, with the majority of drivers having more than six years of experience in the trucking industry (80%).***

Working Conditions

Working conditions can affect the well being not only of drivers but of all who come into contact with drayage trucks. Drayage is often a more physically demanding industry than is long-haul trucking since the drivers must frequently exit their vehicles and may assist in the process of loading and securing cargo as well as inspecting chassis and other equipment. The combination of high physical activity with the demographic profile of drayage drivers – mostly middle aged men – make excessive physical exertion particularly concerning. ***The Port of Houston survey found that, on average, drivers work 10-hour days and 50- to 55-hour weeks.***

Only a third (33%) of the drivers interviewed had health insurance. In the NY-NJ study by, it was reported that 73.5% of independent contractors and half the employee drivers do have health insurance. The majority of Houston drivers (76%) owned their own truck. In NY-NJ, more than half the independent contractors over 35 have finished paying off their leases; less than half the drivers below the age of 35 have done so. Although the drivers are technically independent owner-operators, they typically subcontract their services to a drayage firm rather than attempting to do business alone. The majority of the Houston drivers (90%) reported that they worked with a trucking firm.

Truck Characteristics

In the United States, there is generally no physical distinction between trucks used for drayage and trucks used for other longer haul purposes. Due to the fact most drayage drivers buy used vehicles, the vehicles they purchase are often more tailored for over the highway hauls rather than intracity deliveries. For example, officials at the port of Los Angeles and Long Beach have also reported the prevalence of sleeper cabins amongst the drayage fleet[4].

The trucks in the Houston sample were relatively old, but not as old on average as the reported LA/LB fleet. ***The average truck as reported in 2006 was nine years old with 637,000 miles***. In comparison, a 2004 analysis by Starcrest Consulting Group (2006) found that ***the average truck serving the Ports of Los Angeles and Long Beach was 12.9 years old***[5]. ***In the case of NY-NJ, the average age of a truck was 11 years old.*** Respondents who were identified as primarily intracity drivers reported that they drove their truck on average 61,000 miles last year. The total sample average was 123,000 miles per year but this figure also includes drivers who were primarily long haul truckers. The median of 60,000 miles per year matched the estimates provided separately by Houston dray industry managers.

<u>Trip Characteristics</u>

According to the Houston port drivers, the median dray distance, defined as one haul from either a pickup point to the port or from the port to a delivery point, was 60 miles. If the subset of drivers who reported an average dray distance of 100 miles or less are analyzed separately, ***the average dray haul was 48 miles*** and the ***average number of trips to the port per day was 3.2***. The drivers indicated they would likely use toll facilities more frequently if congestion became more burdensome. ***In NY-NJ, a typical drayage trip is 75 miles or less one way, and drivers usually make 2-3 trips per day.***

<u>Wages</u>

Bensman and Bromberg (2009) reported in their study that independent contractors at the ports of Newark, Elizabeth, and Bayonne net $28,000 per year, without health insurance or pension benefits, whereas employee drivers earn about $35,000. Some employee drivers receive health benefits but few receive pension contributions. In hourly terms, the independent contractors earn a bit less than $10 per hour and employee drivers earn about $12 per hour. The DrayFLEET model developed by Tioga (2008) used an estimated cost of $12 per hour for drayage labor in developing cases studies for the ports of LA/LB, Virginia, Houston, and NY-NJ.

<u>Service Area</u>

A substantially higher percentage of the cargo processed at the Port of New York is consumed locally when compared with other major US container ports. Based on studies performed by Tioga, the estimated distribution is as follows.

- 15% of the cargo is handled by rail, most using on-dock rail facilities and the rest using nearby rail intermodal terminals.

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[4] http://www.polb.com/civica/filebank/blobdload.asp?BlobID=2967.

[5] "2007 Goods Movement Air Emissions Inventory", Starcrest Consulting, http://www.portofhouston.com/publicrelations/environment.html.

- 60% of the cargo moves to the four surrounding New Jersey counties; much of this is transloaded for delivery in New York and other northeastern cities.
- 4% moves to locations within 260 miles to nearby destinations in NY, CT, PA, MA, and RI.
- 15% moves to U.S. locations beyond 260 miles such as Pittsburgh, Cleveland, and Buffalo.
- 3% moves to Canadian locations such as Montreal and Toronto.

The large share of local consumption means that the landside access modal share associated with motor carriers is unusually large.

The Norfolk marine terminals in Virginia serve a substantial market beyond the immediate urban area. The population of the Norfolk metropolitan area is approximately 1.6 million, but the port also provides primary marine facility access for the Commonwealth of Virginia's 7.6 million people as well as for much of Eastern North Carolina and Maryland. The port also records significant truck volume moving to Western North Carolina, Tennessee and Kentucky. Norfolk port drayage operations are therefore characterized by a greater frequency of medium range (100-250 mile) movements than a more compact hinterland such as urban New York/New Jersey.

At the Port of Long Beach and Los Angeles, drayage trips radiate well beyond the relatively compact and well-defined port areas. With few exceptions, each port drayage trip originates or terminates at a marine container terminal or nearby container depot. A very large fraction of these trips use Interstate 710 (I-710) and account for the largest and most visible segment of trucking activity on this highly congested route. As documented in the Tioga DrayFLEET Report (2008), there are four major clusters of regional distributions centers as potential destinations for drayage trips in LA/LB:

- An area within 10-15 miles north of the ports.
- A second area running along Interstate 5 southeast of downtown Los Angeles, typically around 20 miles from the Ports.
- A third are in a crescent along State Route 60, typically about 25 miles from the Ports.
- A very large fourth area centered around Mira Loma in the Inland Empire, roughly 60 miles from the ports.

3. FACTORS AFFECTING DRAYAGE OPERATION

3.1 Terminal-Related Factors

Drayage delays documented in the literature stem from a number of sources. The very first potential source of delay while performing a delivery or pickup of a container is ***in-gate***

queuing. The time spent in an inbound gate queue is the product of the time required for the gate transaction and the number of trucks queued at each gate.

At terminals where containers are stacked, trucks can incur excessive ***delays while waiting for service from a container handling equipment*** such as an RTG or top loader. The delay is a function of the equipment available and the equipment deployment strategy. Most terminals do not employ the first-in first-out strategy. Typically, trucks that are closest to the equipment get service first.

At terminals where containers are left on chassis, there is a potential delay if the container and/or ***chassis are not in the correct location***. If the container is on the wrong chassis or if the driver brought his own chassis, a "flip" is required (i.e. transfer of container on existing chassis to another chassis). The swinging or flipping operation can take 40 minutes or more to perform depending on the availability of equipment.

A commonly used strategy by terminal operators to increase throughput is increasing storage density. For imports, the storage density (yard storage productivity) can be increased by stacking containers higher and/or stacking recently unloaded imports on top of those that are already in the yard. However, ***higher stacks, especially mixed ones, require additional rehandling*** (shuffling) of containers in retrieving the target container. The higher the number of rehandling moves associated with an import delivery to a road truck, the lower the rehandling productivity. (Huynh 2008).

Another commonly used strategy by terminal operators to increase throughput is reducing the container dwell time defined as the number of days a container remains in the terminal. This is accomplished by reducing container free time and increasing demurrage fees. Free time is the period during which a container can reside in the container yard without being assessed a demurrage fee. ***Reducing free time and/or increasing demurrage fees may have a negative impact on drayage because it reduces the time window truckers have to pick up the import container***. As a result, a truck may be dispatched to pick up the import before a workable return load can be scheduled. Since July 1, 2005, the Port of Long Beach has reduced its free time for import containers from five days to four and free time for export containers from seven days to six. Other ports such as New York-New Jersey, Vancouver, Washington, Los Angeles, and Houston have also reduced their free times in an effort to boost throughput.[6]

Historically, export containers were dropped off at terminals well in advance of the current vessel, as far as four or five ships out. To free up space in their yards, many terminals have reduced this time window (termed export first receipt window). For example, in 2005, Barbours Cut Terminal (BCT) began to turn away export containers that are dropped off seven days ahead of their vessel's expected arrival date (The Port of Houston Authority Tariff No. 14). BCT notifies truckers daily via the Port of Houston's website regarding which vessel it is receiving cargo for and which it is not. As in the case with free time, ***the introduction of export first receipt window reduces the flexibility of dray providers***. The lists of vessels with

[6] The Week. Journal of Commerce, June 27, 2005, pp. 10.

guaranteed receival dates was created in response to truckers complaining about making a plan to drop off the container only to find out the next day the vessel's arrival has been pushed back. (Huynh 2006).

Import containers going out of the terminal typically require inspections. Depending on the outbound lanes available and the time it takes to inspect a container, ***trucks could also incur delay at the out-gate***. Data from BCT showed that in 2005 the inspection process of import containers generally took about 6 minutes to complete.

Other terminal-related delays include the following.

- ***Trouble transactions*** – occasions when drivers leave the normal terminal queue to deal with documentation problems (e.g. improper equipment type on booking), equipment faults (e.g. overweight container), or other problems (e.g. no documentation for hazardous cargo).
- ***Chassis flips*** – situations where a container has been mounted on the wrong chassis (due to error or expediency) and must be transferred while the driver waits.
- ***Equipment issues*** – instances of defective containers or chassis that raise roadability, safety, or liability issues and may entail waits for repairs or resolution.
- ***Chassis search*** – situations where drivers spend an inordinate amount of time searching for a suitable chassis. The search could be exacerbated if the shipping line of his import load is not a chassis pool member and/or vessel operations are taking up most of the chassis.

3.2 Extraneous Factors

Road and traffic conditions are among the extraneous factors that affect drayage operations. In the studies conducted by Regan and Golob (2000) and Golob and Regan (2000), a survey was performed of 1200 private and for-hire carriers operating in California to examine the efficiency of maritime intermodal transfer facilities in California, from the point of view of the trucking companies that use these facilities. Their study reported that about 19% said that traffic congestion or other problems at the ports impacted their operations always or very often, and an additional 25% said that congestion at the ports often impacted their operations. Their survey also asked respondents to react to twelve hypothetical congestion-relief policies. It is reported that responses of operators serving ports were more positive than operators not serving ports in four policies: completing installation of electronic clearance stations, having longer hours at ports and distribution centers, having truck-only streets for access to ports, rail, terminals, and airports, and installing electronic clearance stations at international border crossings.

In a follow-up study, Golob and Regan (2001) discussed the impact of highway congestion on freight operations. In particular, they sought to determine how five aspects of traffic congestion differ across sectors of the trucking industry. The five aspects are (1) slow average speed, (2) unreliable travel times, (3) increased driver frustration and morale, (4) higher fuel and maintenance costs, and (5) higher costs of accidents and insurance. Using a structural equations model, the authors uncovered a number of interesting relationships. Of noteworthy is that ***unreliable travel times is viewed as most problematic***, followed by driver frustration and morale and slow average speed.

Although stakeholders have taken steps to enhance freight mobility, including port drayage, ***public planners*** in areas with nationally significant freight flows, especially those with nearby ports, ***face challenges when attempting to advance freight improvements***. These challenges include competition for public funds from non-freight projects, gaining community support in the planning process, lack of coordination among various government entities and private sector stakeholders, and limited or restricted availability of public funds for freight transportation (GAO report 2008).

The successful implementation of programs to improve drayage activity is ultimately dependent on receiving willing participation from drivers. The most informative and complete analyses of drayage have included the sociological element of the drayage sector as well as the engineering challenges. The early survey work funded by METRANS (Monaco and Grobar 2005; Monaco 2008) was a prime example of how the recognition of drayage drivers' situation can aid in determining which solutions are most likely to be effective. The basic survey methodology of drayage drivers established by Monaco and Grobar has since been repeated in other studies, such as the GCCOG Survey of Dray Drivers Serving the San Pedro Bay Ports (CGR Management Consultants 2007). ***The working conditions of drayage drivers in terms of hours, compensation and benefits are important factors to consider along with other factors such as the desire expressed by many drayage drivers to stay in or near their home city***. Another cultural factor that has sometimes been overlooked in the proposed reforms of the drayage sector is the preference expressed by some drivers for the autonomy associated with being an owner-operator, even in cases when this decision entails less certainty of income. This factor also comes into play in literature sources that discuss new security requirements that drivers will need to adhere to in the future. The sources on drivers issues describe how drivers are responding to the rapid series of changes that is now occurring to their industry – an industry that had, until recently, been free of revolutionary change or significant outside attention for decades.

NYNJ was one of the first ports to implement a uniform truck driver identification card, called SEALINK. The uniform ID was one of the building blocks that is used to simplify business processes at marine gates and reduce the time taken to process trucks. However, the Department of Homeland Security has mandated the Transportation Workers Identification Credential (TWIC) for all personnel requiring access to secure or restricted areas of U.S. Coast Guard regulated facilities, including the marine terminals in the Port of New York and New Jersey. To continue the use of SEALINK, the Port and its terminals will require drivers to link their new TWICs to their existing SEALINK IDs.

At the Port of Charleston, the TWIC has come into effect and currently being used and enforced. The deadline for Houston transportation workers to enroll in TWIC is approaching and many drivers have already pre-enrolled. According to the press release from the US Coast Guard's website[7], April 14, 2009 is the TWIC compliance date for owners and operators of facilities located within the U.S. Coast Guard Captain of the Port Zone of Los Angeles-Long Beach, California.

Lastly, ***government policies can have a significant role in improving or deterring progress in port drayage***. One such policy was the deregulation of the U.S. trucking industry in 1980 by the Federal ICC Termination Act of 1980. This particular policy made possible the current environment where drayage moves are conducted by small companies that assign most of their shipping orders to independent contractors who are paid by the load instead of large trucking firms. Another effect of the Termination Act of 1980 is the elimination of the unionized Teamsters who did port trucking under collective bargaining agreements (Bensman and Bromberg, 2009).

TRB Special Report 236 (Schneider 1992) provided an excellent summary of the effects of regulatory reform on technological innovation in marine container shipping. In this special report, the committee recommended changes to remove impediments to efficiency and innovation as well as recommendations on opportunities for improvements. The applicable recommendations include (1) better staffing of US Customs Service and communication with port officials to improve the process of clearing imported cargo, (2) all of the modes involved in marine container transfers should be represented in planning the logistics and no particular mode should be unfairly burdened, and (3) a database that includes accurate and current information about containers be made available to both public and private users to improve the marine industry's efficiency. Unfortunately, progress in these areas has not been significant to yield the positive effects on the industry, in particular drayage, as originally intended. In all fairness to the industry, no one could have predicted the events of September 11 which has led to a significant increase in security at ports (e.g. radiation portal monitors, transportation worker identification card).

4. CONSEQUENCES OF INEFFICIENT DRAYAGE OPERATIONS

Improving the environment has often been the central goal of initiatives to evaluate or moderate dray activity. There is no question that drayage activity can have a significant impact on urban air quality. ***On a ton-mile basis, drayage is certainly among the most polluting components of the intermodal freight supply chain*** (Center for Ports and Waterways 2007). Dray drivers traditionally preferred trucks with simple mechanical diesel engines that required low initial capital investment and were easy to maintain for hundreds of thousands of miles after they had been retired from long haul service (Jeff Ang-Olson 2008). California Air Resources Board plans in the mid-1990s for a self-funded scrappage program were abandoned in part because the ARB did not assign sufficient value to older trucks[8]. Yet, with certain pollution controls standardized in US diesel engines now for almost a decade, many of these vehicles are exiting the market. As a result the gap in environmental performance separating

[7] https://www.piersystem.com/go/doc/834/233490/

[8] "Program Analysis Incentives To Replace Pre-1987 Heavy-Duty Vehicle": Appendix A http://www.arb.ca.gov/msprog/moyer/Historic/appendixa.pdf

dray trucks from other pre-2007 long haul trucks may be shrinking. The compiled literature sources include several examples of specific environmental initiatives that have been attempted at different ports to speed turnover of the fleet to boost overall environmental performance.

Much of what is currently known about dray patterns of activity has been learned in the context of improving dray environmental performance. As an example, the Gateway Cities Council of Governments Initiative to modernize trucks in port service started as a rather modest scrappage program to eliminate the worst polluting vehicles in the San Pedro bay region (Leonard and Couch 2007). The concept of dray vehicle replacement then expanded to become a key component of the Clean Trucks Program in the San Pedro Bay Ports Clean Air Action Plan. Finally, the effort to keep track of the dray vehicles that have taken part in Gateway Cities provided GPS data on dray truck movements that would not otherwise have been generated and can be used for purposes beyond emissions reductions[9]. Other examples of wide-scale operational data having been generated from environmental incentives include the Goods Movement Emissions Inventories that were performed at Los Angeles and recently in Houston provided estimates of total emissions, but in the process also provided significant information on the description of the fleet and principal origins and destinations of dray trucks that will be useful for general planning purposes (Starcrest Consulting Group 2009). The sources cited below illustrate the many ways in which environmental issues have become intertwined with the study of drayage. As long as dray trucks continue to operate primarily in urban settings, this connection will continue. The sources cited below provide an overview of environmental initiatives connected to drayage, with special attention to the initiatives

5. CURRENT AND POTENTIAL INITIATIVES TO IMPROVE DRAYAGE OPERATIONS

Faced with the need to handle ever-increasing demand, port authorities and terminal operators have taken initiatives to increase their terminals' capacity and reduce truck turn time. It is noted that many U.S. terminals cannot easily add additional berths and container terminals because there is little room for expansion. Building “greenfield” terminals is becoming more challenging with rising construction cost, growing environmental permitting issues, and the need to address environmental justice issues. For these reasons, terminal operators first look for ways to boost throughput and productivity. Studies that document current and potential strategies aimed to improve port drayage are summarized below. International drayage strategies are also provided (in a separate section).

5.1 Extended Gate Hours

An early report in the Metrans efforts (Mallon and Magaddino 2001) applied economic break-even analysis to extended gate hours. The authors suggested introduction of a “community based appointment and scheduling system to coordinate truck dispatch with gate transactions.” The authors define “throughput velocity” as the number of twenty-foot equivalent units (TEU) per acre per month multiplied by the average dwell time. This definition has the curious effect

[9] Ibid

of yielding higher “velocities” for containers with longer dwell times (i.e. that sit still longer). The study makes the common assertion that extended gate hours are only feasible with a commitment to extended shipping and receiving hours by regional customers. This assertion may be unnecessarily limiting. In Southern California, at least, there are major concentrations of distribution centers 60-90 minutes away. Normal shipping hours of 8:00 am to 5:00 pm for these more distant customers would generate numerous truck trips during extended gate hours. To reach an import customer 90 minutes way at 8:00 am, a drayman would have to be in line at the marine terminal by 6:00 am to leave with a container by 6:30 am. If a shipper 90 minutes from the port releases an export container at 5:00 pm, the drayman will not reach the marine terminal until 6:30 pm and will probably not be done until 7:00 pm at the earliest. Extended gate hours are thus necessary for regional customers to use their full 8:00–5:00 shipping day. The report also contains potentially useful data on the manning costs of marine terminal gates. Since these data likely reflect year 2000 labor costs, however, they would probably need to be updated.

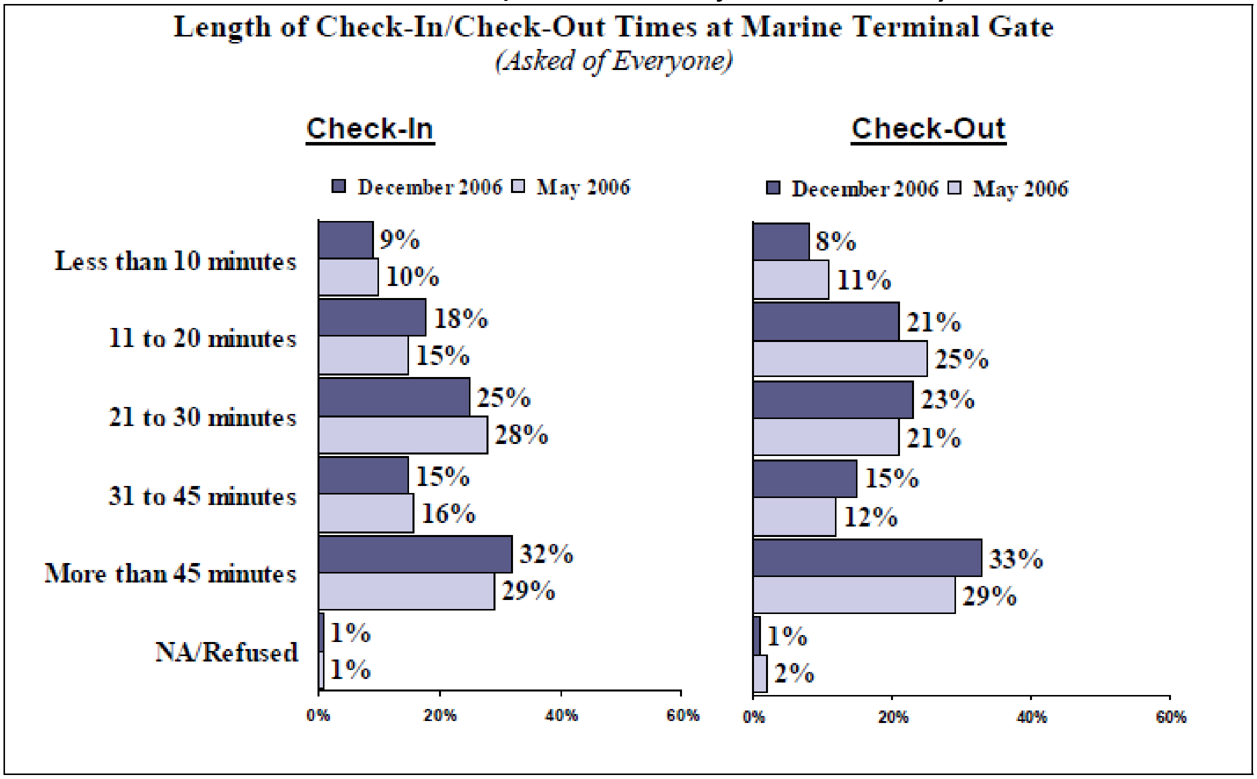
The Southern California PierPASS system of extended gate hours and its OffPeak truck traffic diversion initiative is well documented and has been the subject of company-sponsored drayage industry surveys (Fairbank and Maislin 2006). The PierPASS OffPeak program imposes a fee of $50 per TEU ($50 for a 20-ft. container, $100 for a 40-ft. container) for gate arrivals during “peak” daytime hours and waives the fee in off-peak hours. About 40% to 45% of the eligible loaded drayage trips at the Ports of Los Angeles and Long Beach have shifted to off-peak hours. In the first year of operation since July 2005, about 2.5 million truck trips were diverted to off-peak hours. Annual diversions for 2006 were expected to be 2.8 to 3.0 million trips.

Drayage driver surveys taken on behalf of the PierPASS program, most recently in late 2006, reveal mixed acceptance of PierPASS and the OffPeak incentive system. Of those drivers familiar with OffPeak in December 2006, 61% had an overall positive opinion and 29% had a negative opinion (10% were neutral). The survey found that 67% of the drivers experienced reduced traffic congestion and that 45% were able to complete more trips per shift. Half of those familiar with OffPeak reported less congestion on the I-110 and I-710 freeways serving the ports. Two surveys were combined to produce the check-in/check-out time charts in Exhibit 4.

Although not showing dramatic changes, these survey data may be valuable in assessing the separate and combined impacts of the multiple terminal management initiatives being pursued in Southern California.

At NYNJ, Maher Terminal extended gate hours to 6 am – 10 pm without penalty charges and had been almost as successful as PierPASS at increasing gate capacity by spreading the demand for gate services over a longer period of time. The extended gate hours have since been curtailed as a cost-cutting measure by the new terminal owners.

Exhibit 4: Check-in/Check-out Results from PierPass Survey



5.2 Appointment Systems

The Transportation Development Centre of Transport Canada commissioned a very extensive study of truck appointment systems and other efforts to reduce greenhouse gas emissions from container trucks at North American ports (Morais and Lord 2006). The authors conducted a literature review, a largely unsuccessful telephone and fax survey, and in-depth interviews with a few major Canadian and U.S. ports. The study focused on appointment systems, finding that the implementation, usage, and benefits of such systems varied widely.

- Early Southern California appointment systems implemented due to the Lowenthal Bill[10] (as opposed to those that were subsequently incorporated into eModal and VoyagerTrack) were under-used and delivered few benefits. Information systems such as eModal are heavily used, and the PierPASS program has successfully shifted truck trips to off-peak hours.

- The STS terminal in Oakland has a comparatively more successful appointment system[11].

- The Vancouver terminal appointment systems (unnamed) have achieved progress despite implementation problems.

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[10] California Assembly Bill 2650. Complete text at http://www.leginfo.ca.gov/pub/01-02/bill/asm/ab_2601-2650/ab_2650_bill_20020930_chaptered.pdf .

[11] The STS terminal uses VoyagerTrack.

Reading between the lines in this study, it could be concluded that appointment systems with commitment from terminal operators tend to succeed (Oakland, Vancouver), while appointment systems reluctantly implemented due to outside pressure (Southern California) tend to fail. The report stops short of providing detailed information on the appointment systems that did or did not succeed. It does, however, offer extensive information on the use of gate and information technologies (optical character recognition, closed-circuit television, etc.) terminal operating systems (NAVIS, COSMOS) and yard equipment control technology (GPS, RFID), to reduce the time spent by trucks in gate queues and container yard operations. Significantly, the report concludes in passing that truck <u>idling</u> time is the critical factor because truck <u>travel</u> time is a function of terminal size and design rather than of terminal management. Finally, this report includes a valuable discussion of truck idling emissions factors and modeling approaches.

A 2006 Metrans study (Giuliano, Hayden et al. 2006) concurred in the generally negative assessment of the initial appointment systems at the Southern California ports. Those systems were implemented in 2002 in grudging response to the Lowenthal Bill, which allowed terminals to either implement an appointment system or extend gate hours to avoid paying heavy fines for gate queues. The Metrans report found that the early appointment systems had little impact on gate queues. Use of the systems varied widely as a function of terminal operating practices. The variability of appointment system use across terminals is a key finding of the Metrans report. Of the 14 container terminals at LA and Long Beach, 10 offered appointment systems and 4 did not. Three different appointment systems were offered, and system implementation varied even between terminals on the same system. These systems were eventually phased out and replaced by VoyagerTrack and eModal, described below.

Another in the series of papers on modeling terminal transactions examined the use of “time windows” (appointments) in a theoretical framework (Ioannou, Chassiakos, A. et al. 2006). The approach assumed that container terminals run optimization algorithms to general “wide” time windows for container pickup, and that trucking companies would then run their own algorithms to narrow the time windows. The paper also assumes that the customer (i.e. the import distribution center) does not assign delivery windows, although in practice most do use delivery appointments. This paper also describes “Terminal Simulation” software developed by the authors. Further investigation would be required to determine the potential utility of this simulation software in analyzing alternative terminal management strategies.

Still another in the series of modeling papers by Ioannou, et al (2002) addressed the limitations of standard algorithms (the “Multi-Traveling Salesman Problem with Time Windows,” or M–TSPTW) by developing two alternative methods. The first is a hybrid dynamic programming/genetic algorithm method. The second is a heuristic insertion method. The later method was preferred for the dynamic environment of port drayage and offers potential efficiencies in calculations.

Huynh (2008) studied how the various scheduling rules affect resource utilization and truck turn time in grounded operations at a container terminal. The author noted that such understanding could influence terminal operators and appointment service providers to make changes to the current scheduling practice. The study developed a framework for the evaluation of (1) the performance of various simple appointment-scheduling rules under a variety of operating scenarios, and (2) the major factors affecting the performance of scheduling rules. It considered two types of appointment scheduling strategies, adopted from the healthcare sector: (1) individual appointment systems (IAS), and (2) block appointment systems (BAS). To determine the effectiveness of the scheduling strategy, the study relied on a simulation model of a container terminal. The developed simulation model was constructed using Flexsim CT, the first commercially available "off-the-shelf" simulation tool for container terminals. Experimental results showed that there is a clear benefit for a terminal without an appointment system to employ the IAS. Such scheduling system will keep the yard cranes highly utilized while improving the internal yard turn time by about 44%.

In another study related to port appointment system, (Namboothiri and Erera 2008) examined the management of a fleet of trucks providing container pickup and delivery service (drayage) to a port with an appointment-based access control system. The authors developed a drayage operations planning approach based on an integer programming heuristic that explicitly modeled a port access control system. The objective of the integer program was to minimize the transportation cost to operate the truck fleet. Their study concluded that terminal operators need to carefully consider the productivity impacts to drayage firms when designing a port access system. The following lists the key findings from their analysis.

- It is critical that terminal operators provide drayage firms with enough access capacity. Results show that vehicle productivity can be increased by 10–24% when total access capacity is increased by 30%.
- Drayage firms must make good port appointment selections in order to maintain high levels of customer service; differences between the best and worst selections for a capacity distribution resulted in decreases in number of customers served by up to 4% for a fixed level of total access capacity.
- The duration of the appointment windows also may affect the ability of drayage firms to provide high levels of customer service. Test results indicate that up to 4% additional total capacity may be needed to maintain the same level of customer service if the slot duration is reduced by half.

5.3 Virtual Container Yards

A 2002 study by the Tioga Group (The Tioga Group 2002) on behalf of Southern California planning agencies and ports encompassed several aspects of the potential for reuse of empty import containers or rationalization of their movement. The Tioga study distinguished two types of potential rationalization:

- ***"street turns"*** – reuse of an empty import container for an export load without an intervening empty move to the marine terminal.
- ***"depot direct off-hires"*** – moving an empty leasing company container directly to an off-dock depot without first taking it to the marine terminal.

Identifying the "depot direct" rationalization opportunity significantly increased the potential reduction in VMT in the Tioga study.

The Tioga study described the internet-based information systems operating in 2002: eModal, VoyagerTrack, InterBox, and SynchroNet. None of these systems functioned as a Virtual Container Yard, although all included features that could contribute to a VCY solution. Analysis in this study included a listing of VCY information requirements (Exhibit 5).

The Tioga study noted that the key purposes of a VCY are to:

- post needed information about containers (status, location, etc.)
- facilitate communication between parties (motor carriers, ocean carriers, leasing companies, chassis pool operators);
- permit equipment interchange and other processes to take place without moving the container to the harbor; and
- assist the parties to make optimal decisions regarding container logistics (return, reuse, interchange, etc.) rationalize moves, and plan ahead.

Exhibit 5: VCY Information Requirements.

Info Source	*Container Info*	*Chassis Info*
Ocean Carrier	**Box Serial No.**	**Chassis Serial No.**
	Box Type & Specs	**Chassis Type**
	Reuse Limits	**Reuse Limits**
	Return Location	**Return Location**
	Free Time/Per Diem	**Free Time/Per Diem**
Trucker	**Location**	**Location**
	Time/Date Available	**Time/Date Available**

The Tioga study made the critical observation that a VCY would not be a dispatching system, since trucking firms would retain their own dispatching functions. Instead, the VCY would provide truck dispatchers with usable information and a means to make better dispatching decisions. Finally, the Tioga study provides extensive coverage of the institutional factors that impinge on the potential of virtual container yards and related systems, notable among these institutional factors are:

- ocean carrier free time and per diem provisions;
- inspections, and liability for damage on interchanged containers;
- ocean carrier incentives for empty return versus export loading; and

- the legal framework of the Uniform Intermodal Interchange Agreement (UIIA) that governs most container and chassis interchanges.

A subsequent study of Southern California empty container logistics (Le Dam Hanh 2003) may have been somewhat hampered by unfamiliarity with some aspects of the container shipping business (e.g. an assertion that, "for the most part, containers are still owned by carriers," when in fact about half are leased) and by a tendency to dismiss institutional problems such as damage liability on the basis of a successful but anecdotal example. The report may also have confused the function of a VCY in posting the availability of empty containers (posted by truckers) with sharing information on the availability of export loads (which is strictly proprietary). The study touches briefly on the potential role of chassis pools but devotes more attention to collapsible containers, an oft-proposed but never implemented concept.

Ioannou et al. (2006) focused on the empty container interchange problem, in this case through a simulation of substituting one type of container with another type. The simulation includes substitution between containers owned by different ocean carriers (steamship lines). This is not a form of substitution in current practice, but it would increase the potential for reuse.

Most recently, Janakiraman et al. (2007) developed a stochastic, simulation-based model of VMT changes resulting from implementation of a VCY at the Port of NY/NJ. The authors ran multiple simulations covering a range of container volumes and interchange nodes, and three different VCY collaboration scenarios.

- No collaboration between ocean carriers.
- Collaboration between ocean carriers on container sharing within groups.
- Universal collaboration.

With the largest volumes, the most modes, and full collaboration, the authors estimated total VMT reductions of nearly 20%. In common with other modeling efforts, this paper and the model it presents rely on assumptions.

- Truckers are not exclusive to one or a group of ocean carriers. This is generally the case in practice and should not affect the validity of the outcomes.
- All containers are owned by the ocean carriers. Ocean carriers, in fact, own about half the containers. They do, however, control leased containers for extended periods, so this assumption may not cause problems.
- Import and export sites have the same geographic distribution from the port. This assumption would rarely be borne out in practice, and may prove to be a limiting factor on the success of VCYs.
- The ratio of import to export sites is 0.42[12].

[12] Since this implies a strong surplus of export sites, the paper may have misstated this ratio.

The paper did not examine the sensitivity of the model results to variations. This model is apparently focused on the role of a VCY in container sharing between ocean carriers, and uses the foreign destination of the export movement as a significant dependent variable. This is a different objective than reducing empty inland movements or reducing VMT, and is the objectives of other systems (Synchronet, IAS) rather than VCYs. The street turns facilitated by VCYs would include:

- reuse of a given container for another customer of the same ocean carrier and trucker, and
- reuse of a given container by a different trucker to serve another customer of the same ocean carrier.

The paper showed the frequency of interchange rising from zero in the non-VCY base case to 15.4% in the full collaboration case with 100 nodes and 15,000 containers. The basis for this percentage of interchanges is, however, unclear from the paper.

Interbox and eModal together are in the process of developing an operating VCY in Southern California, and eModal is developing a system for NYNJ. Recent contacts with stakeholders indicate that the systems are not yet fully functional and not yet delivering anticipated benefits.

5.4 Information Systems

Each terminal has an information system that maintains container status and availability information. Accurate information permits motor carrier dispatchers to plan work efficiently and to avoid "dry runs" – moves made with the goal of picking up a container that is not available for some unforeseen reason. The information system and associated operating discipline has had the further benefit of reducing visits truckers make to the "trouble window" for exceptional or difficult movements. Terminal operating systems used by terminals include Navis, Cosmos, and Tideworks; there are some terminals that use their in-house software (e.g. the Port of Charleston).

There is extensive documentation of the major on-line port container information and appointment systems, eModal[13] and VoyagerTrack[14]. Both systems were developed in Southern California. Both have since been implemented in other West Coast ports and eModal has also been implemented on the East Coast. Both systems offer drayage firms the ability to check the status of containers on-line and to make appointments. eModal (U.S. EPA SmartWay Program 2006) has added more features, such as electronic settlement of fees, electronic delivery orders (eDO), and an identification and registry system for drayage drivers (Truckercheck). The documentation for these systems, however, is primarily informational rather than analytic. Performance metrics for the VoyagerTrack system were incorporated in DrayFLEET model features.

[13] http://www.emodal.com.

[14] http://www.voyagertrack.com/File/en/VTHome.html.

The Georgia Port Authority's WebAccess[15] is an interface for entering and accessing real-time container information and reports, using information managed by Navis' SPARCS and EXPRESS integrated terminal software. WebAccess connects to SPARCS, Navis' graphical planning and control system for yard, vessel, or equipment planning; and EXPRESS, Navis' comprehensive information system that manages and maintains all terminal business transactions in an Oracle database. Web Access, in combination with extended gates hours and other port and terminal initiatives, reportedly reduced average truck turn times at Savannah from 75 minutes in 2000 to 42 minutes in 2004 (U.S. EPA SmartWay Program 2006).

The Freight Information Real-Time Support for Transport (FIRST) was designed by the Port Authority of New York and New Jersey (PANYNJ) FIRST (2003) was intended to combine information from ocean carriers, marine terminals, railroads, and drayage companies for access through a common web portal (not unlike eModal or comparable systems at other ports). FIRST was expected to help rationalize truck trips, reduce VMT, ease congestion, and improve terminal efficiency. A 2002 review of freight transportation technologies by the New York Metropolitan Transportation Council mentions FIRST, which was then just starting out (New York Metropolitan Transportation Council 2002).

The FIRST website was launched in late 2001. The FIRST website (http://www.firstnynj.com/) is active but provides no background information on the system. Customer acceptance was lackluster. By March of 2003, only 1% of the known port motor carriers were registered with FIRST.

- Drayage firms found the information available via FIRST to be limited, and not always accurate or timely.
- Ocean carriers saw no benefits from FIRST, and some stopped providing data.
- Terminal operators and ocean carriers began providing their own websites, supplanting FIRST.

The evaluation team found that FIRST was underused due to both internal and external factors and that the expected benefits did not materialize. The ongoing value of this evaluation is in its analysis of reasons for success and failure, its comparisons with other systems, and its efforts to model FIRST's potential benefits. The evaluation team compared FIRST with the Pacific Gateway Portal (at the Port of Vancouver) and eModal (originally at Los Angeles and Long Beach). The key distinctions included:

- careful upfront planning by a comprehensive stakeholder group
- incorporation of a functional appointment system
- features that deliver concrete benefits to users.

[15] *Navis Launches WebAccess for Real-Time Container Information Exchange and Reporting Via the Internet*, Press release, January 22., 2002, and WebAccess website at http://webaccess.gaports.com/express/about.jsp.

The simulation model yielded estimates of significant emission benefits, but under the assumption that all trucks had appointments.

5.5 Chassis Pools

In a co-op neutral chassis pool each steamship line participant contributes their chassis to the pool and then is able to use any chassis in the pool as needed to meet ordinary and extraordinary demands. Maher was one of the early innovators in the establishment of a co-op neutral chassis pool in 1995. Among the benefits commonly cited is a 25% reduction in the on-terminal chassis fleet despite a growing cargo volume. The workings of the chassis pool are described in various presentations and press releases.

The Ocean Carrier Equipment Management Association (OCEMA) has been developing neutral chassis pools at rail intermodal terminals. Union Pacific and CSXI have done likewise. Here too, the publicly available information is descriptive and promotional.

Virginia International Terminals at Hampton Roads established a port-wide chassis pool. All ocean carriers that use its terminals at Norfolk, Portsmouth and Newport News, joined the Hampton Roads chassis pool. The pool, HRCP II, manages all chassis stored at the port's public terminals. It was created in October of 2004 as the successor to HRCP I, a smaller voluntary pool. The pool now manages 15,700 chassis contributed by the pool's 25 member carriers. It was reported to have reduced the required chassis inventory by 23% (very similar to the Maher results) and increased asset utilization by 27%[16]. The system received the 2006 IANA Intermodal Achievement Award (Leach 2005).

5.6 Multi-Strategy

Fischer et al. (2006) summarized the potential contribution of several truck trip reduction strategies to the goal of reducing VMT at the Ports of Long Beach and Los Angeles. The analysis used the Quick Trip truck trip generation model developed as part of the Port's travel demand model. The trip reduction strategies assessed included:

- a Virtual Container Yard (VCY);
- extended marine terminal gate hours (including the PierPASS program);
- expanded on-dock rail transfer;
- rail shuttle trains; and
- expanded near-dock rail.

The VCY analysis used the results of the Tioga Study (2002), which postulated 5% and 10% container reuse percentages with a VCY compared to 2% without. (The Fischer Study did not include an independent reassessment of the VCY potential.) The Quick Trip analysis yielded an

[16] Virginia Port Authority News Release, November 21, 2006.

estimated 2005 VMT reduction of 0.7% for 5% reuse and 1.8% for 10% reuse. The authors noted that additional cross-town trips required to interchange the containers would offset the reduction in trips to and from the Port. Emissions reductions were proportional to the VMT reductions.

Extended gate hours were found to have no VMT reductions, as expected, since the point of extended gate hours was to reduce congestion in peak periods rather than to reduce trips. The authors note, correctly, that reducing congestion and the time trucks spend idling or creeping in traffic would reduce emissions, but that reduction is not captured in the Quick Trip model.

A 2005 study of multiple innovative transportation strategies by the LBJ School of Public Affairs (2005) discussed the initiatives being pursued by Maher Terminals at the Port of New York/New Jersey, including:

- automated gate systems
- extended hours
- chassis pooling
- on-dock rail

The report is largely descriptive, as the initiatives discussed had only a short track record to date. As of the study date, Maher expected to raise the share of on-dock rail from 11% to 25%; expand the share of containers handled in extended gate hours above 10%; and increase overall terminal throughput capacity.

The modeling efforts tend to be theoretical rather than pragmatic in orientation. A manageable modeling approach commonly requires a series of simplifying assumptions to cope with complex realities. Some of these efforts may suffer from lack of familiarity with industry practices. The major value in these studies is the accumulated knowledge on various modeling approaches and methodologies.

A Canadian Federal-Provincial Task Force completed a study of container movements at British Columbia Ports in October 2005. The study covered best practices at North American ports, including extended gate hours, information systems, virtual container yards, and appointment systems (Canadian Ministry of Transport and et al 2005). The task force findings included the following.

- The implementation of extended gate hours at container terminals has emerged as the single most effective method for reducing delays accessing the terminals." The system at the Port of Montreal and PierPASS were cited as best practices.
- Common user information systems can speed processing of gate and terminal transactions by integrating necessary information for all participants." The Port of Montreal and eModal were cited as examples.

- From our research, it appears that few terminals in North America currently rely on a reservation [appointment] system as a key element in optimizing their efficiency." The Evergreen terminal in Los Angeles (which uses VoyagerTrack) was cited as an example of a successful system.

5.7 Automated Gates

The NYNJ marine terminals have been continuously improving gate technology. In particular, Maher was a leader in the implementation of Optical Character Recognition (OCR) technology at marine terminal gates. Similarly, Trans Pacific Container Service Corp. was leading the way in incorporating technology into its terminal. TraPac was the first terminal in the Los Angeles port complex to automate its gates, container yard, and vessel operations. Its gates are equipped with optical character readers and cameras. Its container-yard equipment is equipped with a global positioning satellite system and radio-frequency identification tags, and its container cranes are equipped with OCRs (Mongelluzo 2005). Together, the system automatically updates container inventories and sequence equipment movements. A gate transaction immediately sends the move information to the operator of a transtainer or RTG. When the trucker arrived in the yard to pick up the import container, the operator is fully aware of what container he needs to load. In the event that the operator needs to reshuffle containers, their new positions are updated in the system automatically.

TraPac improved its productivity through the use of technology. In 2002 it was moving 7,000 containers a week through its 175-acre terminal. In 2005, the volume was 12,000 containers a week, using the same acreage. Its 2005 density was 7,500 TEUs per acre. TraPac averaged 100 to 120 container movements per piece of container-handling equipment during an eight-hour shift in 2005. Truckers got in and out within an hour – about 30 minutes to drop off an export container and 30 minutes to pick up an import container (Mongelluzo 2005).

5.8 Gate And Yard Congestion

In a study by (Shui F. Lam, Jeho Park, and Cheryl Pruitt 2007), the researchers sought to track truck traffic at a specific terminal in the Los Angeles/Long Beach Twin Ports in an attempt to acquire statistics on truck arrivals, as well as truck waiting and flows at this terminal. Such reliable and accurate data would make building usable analytical and/or simulation models of a port's operation feasible. The team employed digital cameras to capture trucks at various critical points which include the arrival at the initial waiting line, the entry gate, the bobtail entry, the pedestal, and the exit gate. Based on the observations obtained from the equivalence of one full-day of day-time monitoring of truck movements through the selected terminal, the researchers produced the following data that will be useful in analytical and simulation studies:

1. "A detailed distribution of truck wait times (also known as the queue time, from arrival to admittance with ticket issued), along with the mean, standard deviation and other useful statistics."

2. “A detailed distribution of truck flow times (also known as transaction time, from ticket issued at the pedestal stations to the exit gate), along with the mean, standard deviation, and other useful statistics.”

3. “A detailed distribution of truck turn times (from arrival to the exit gate), along with the mean, standard deviation, and other useful statistics.”

4. “An understanding of the arrival to the main entry gate as well as the bobtail gate.”

5. “An understanding of the initial queue lengths outside of the entry gates prior to the opening of the terminal in the morning.”

In the study by Huynh and Hutson (2008), the researchers developed a methodology for examining the sources of delay for drayage trucks at container terminals in order to isolate the causes of abnormally high truck turn time. The work was motivated by the need of port authorities and terminal operators to develop specialized solutions to reduce turn time based on the terminal-specific causes. While many ports have taken steps to improve the general level of service for trucks, such as establishing chassis pools and extending gate hours, fewer have performed the transaction-level analysis required to determine why a certain subset of operations are significantly higher than the average, thereby hindering the overall level of service. The objective of the study was to isolate which steps in the truck transaction process are problematic so that terminals can select and deploy a range of technological or organizational countermeasures to address the problem. The study analyzed truck activity at the Port of Houston. The results, obtained from the decision tree technique, indicated that import transactions that required chassis tend to have high truck turn time because truckers need to find a matching chassis. While the finding is intuitive, the work demonstrated how decision trees can be used by port authorities and terminal operators to gain insight to their operations without the need to perform exhaustive data analysis.

Guan and Liu (2008) addressed the gate capacity issue in their work. Harbor truckers are paid by trip, not by the hours they drive. Therefore, waiting time at the terminal gate is detrimental to their economic well-being, especially in today’s high fuel cost environment. Gate congestion also causes environmental pollution. The authors employed a multi-server queuing model to analyze marine terminal gate congestion, and they developed an optimization model to minimize gate system cost. In applying the developed models to one particular case study, the authors found that a significant reduction in truck waiting time can be achieved using their optimization model and that the queuing model indicates a high degree of sensitivity when the system utilization rate is high. It should be noted that the decision variable in the developed optimization model is number of gate lanes, which is a costly option to pursue for terminal operators. The authors concluded that a truck appointment system appears to be the most viable alternative to reduce gate congestion and increase system efficiency.

5.9 Other Terminal-Related Initiatives

Staggered lunch breaks, two-stage gates, container pre-advice, gate webcams, and on-dock rail terminals have all been used by terminals to reduce the number of trucks in each queue. No published work that quantified the exact benefits of these strategies was found in the literature. It is generally known in the industry from work of consultants such as Moffat and Nichol that two-stage gates have been shown to reduce the gate transaction time to a third or less. For example, in an internal report prepared for the Port of Houston Authority by Moffatt and Nichol, it was estimated that the new two-stage gate would reduce the average in-gate processing time from 22 minutes to six.

5.10 International Initiatives On Drayage

There is limited research on port drayage outside the US. The few studies found were conducted in Canada and Europe. These studies examined port drayage for the same reasons they are being addressed in the US: labor issues, environmental concerns, and freight mobility.

In the summer of 2005, container truckers shut most road transport to the Vancouver Port Authority and the Fraser River Port Authority (Port Metro Vancouver, the largest and busiest port of Canada) to demand higher pay. Subsequently, the federal Minister of Transport, in collaboration with others established a Task Force to "examine the functions and structure of the transportation and industrial relationships issues related to the movement of containers into and out of ports in the Lower Mainland of British Columbia (BC) with a view to recommend a long-term strategy to facilitate industry relations, prevent the disruption of the movement of containers and maintain the efficiency and effectiveness of the national transportation system" (Canadian Ministry of Transport and et al 2005). The Task Force recommended eleven initiatives to improve the port logistical chain. It noted that the federal and provincial governments, the Port Authorities, and private sector companies should share the costs of implementing the suggested initiatives.

As documented previously in the Appointment System section of this literature review, in 2006, Transport Canada R&D[17] commissioned a study to review programs and strategies currently applied at North American ports to accelerate cargo handling at ports and terminals aimed at reducing congestion, gate idling time, and greenhouse gas emissions (Morais and Lord 2006). The study also investigated the merits of a gate reservation/appointment system. The general conclusions are that (1) terminal appointment systems and extended gate hours are essential for balancing capacity at terminals, and (2) a substantial reduction in greenhouse gas (GHG) emissions can be achieved through the implementation of gate reservation systems and advanced gate technologies because these system significantly reduce idling time.

In a recent study by Konings (2008), the author developed a theoretical framework for identifying solutions to improve the service and cost performance of drayage in Europe. The analysis examined trip characteristics of drayage operations and their cost structure. The author concluded that that the "contribution of drayage to the competitiveness of intermodal transport is not only determined by the performance of drayage operations, but is also strongly affected by characteristics of the terminal service area in terms of number and size of customers and the distribution pattern of the customers." The author further suggested that

[17] http://www.tc.gc.ca

land use policies could be used to create the conditions necessary to the improve the intermodal freight transport.

5.11 Government and Port Initiatives

Funded in part by an Environmental Protection Agency (EPA) grant received by the South Carolina State Ports Authority (SCSPA), truck owners that serve the Port of Charleston may apply for a rebate to help cover part of the cost for technologies such as auxiliary power units, or smaller generators that reduce truck idling[18]. According *to* John F. Hassell III, interim president & CEO of the South Carolina State Ports Authority, "Through this collaborative grant program, it's much more affordable and accessible for truckers to upgrade their equipment. These technologies not only improve fuel use and cut costs of running the trucks, but they also reduce air emissions, providing a broader environmental benefit to the entire community."

6. PERFORMANCE METRICS

The literature review identified the following metrics that were used in the referenced studies to assess drayage productivity.

- ***Truck turn time.*** This is a key metric used by both truckers and terminal operators. It is the duration it takes a drayage truck to complete a transaction such as picking up an import container or dropping off an export container. It often does not include the in-gate queuing time.

- ***Rehandles per import pickup.*** Ideally, the metric would have a value of zero. However, in reality, import containers are not stacked in a manner aimed to minimize rehandles as done with export containers.

- ***Daily trips made to and from the terminals.*** The literature indicates that the value for this metric ranges from 2 to 3.5. Since drayage drivers are paid by the load, this metric is important to drayage drivers. The more efficient drayage operations become, the higher this metric will be.

- ***Free flow time.*** This metric indicates the time it takes to perform an operation unimpeded, and hence it can serve as a useful benchmark.

- ***Delay time.*** This metric would represent the queuing time a drayage driver experiences at each process.

- ***Daily and annual drayage truck VMT.*** This metric is useful for measuring changes to management practices, terminal operations, and cargo volume.

- ***Annual tons of pollutants (HC, CO, NOX, PM10, PM2.5, CO2).*** This metric is useful for gauging the effectiveness of environmental initiatives aimed at reducing drayage-related emissions.

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[18] http://www.scspa.com/spa/news_statistics/news/pressroom/pressroom.asp?PressRelease=229.

With the exception of free flow time, it can be said that measures or initiatives that could reduce the quantity of any of the aforementioned metrics is positive for drayage operations.

7. SUMMARY

It is evident from this literature review that there exists an emerging body of knowledge on port drayage, most of which has been performed within the last five years. The combination of modeling and empirical studies have substantially contributed to researchers' and practitioners' understanding of the issues and potential techniques for addressing them. Much of the modeling literature represents new applications of modeling techniques that were originally developed to describe other activities that share key characteristics with drayage such as parcel delivery or demand responsive transit. General mathematical problems that have been applied to drayage include the shortest path, travelling salesman and Multi-Resource Routing Problem. Because mathematical approaches such as these rely on approximations of real life conditions, and have often not been validated with comprehensive data and/or implemented in a real world environment, they are principally of use in allowing planners to properly conceptualize the problem and guiding researchers in gathering empirical data. Models can also be used to update or calibrate findings from previous studies in which comprehensive information was collected or to test the current reality against putative future conditions. The empirical studies conducted by Lam et al. (2007) and Guiliano et al. (2006) provides useful information and the data collection techniques they employed may benefit the project team in this particular project.

This review has identified a number of improvements that have been recommended or are in some stage of implementation and are intended increase throughput, reduce air pollution, improve freight mobility, and increase truck driver productivity at marine container terminals around the country. These goals sometimes concur and at other times conflict with each other. The challenge will be in creating the conditions under which stakeholders can make the necessary modifications in practices and/or investments without losing competitiveness. As noted by Tioga in the DrayFLEET report (2008), most marine terminal operating practices are aimed at minimizing terminal operating cost, maximizing throughput, and turning vessels on schedule. Initiatives such as neutral chassis pools, multi-stage gates, container pre-advice, and gate webcams are primarily aimed to assist terminal operators; however, they can also benefit drayage operations. Initiatives that solely benefit drayage operations at the expense of terminal cost or efficiency are unlikely to be implemented or sustained. For example, while theoretical and empirical studies have shown that container appointment systems to be an effective means to lower truck turn time, very few terminals have embraced this concept absent pressure from the public sector. Also, as noted by Tioga, port authorities and terminal operators rarely see the problems encountered by dray providers because port drayage operations, like trucking in general, is highly adaptive. Over time, drayage firms and drivers develop coping mechanisms to accommodate or mitigate local bottlenecks or other operational problems. These ad hoc strategies for ameliorating problems, however, may not be as efficient as a centralized strategy for anticipating and pre-empting operational problems.

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