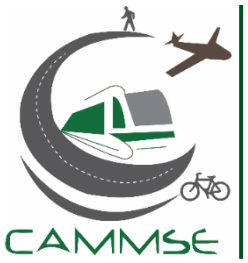

Center for Advanced Multimodal Mobility Solutions and Education

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INNOVATIVE COUNTERMEASURES FOR REDUCING THE TRUCK WAITING TIME AT MARINE TERMINALS

Final Report

by

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DISCLAIMER

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EXECUTIVE SUMMARY

International trade and volume of freight have been increasing since the past few decades, especially at US marine terminals. Forecasts suggest that this growth will increase dramatically by 2020. Most of the goods arriving at and departing from marine terminals are carried by trucks, and this results in congestion inside the ports and at the gates of the marine terminals. Marine terminal congestion is an important issue that has economic implications for stakeholders of the supply chain community.

The objective of this report is to identify the cost-effective countermeasures that can be used to reduce waiting times for trucks at marine terminals. This research focuses on operational level countermeasures some of which are Gate Appointment System, Extended Gate Hour Operation etc. At first, previous studies related to some of the countermeasures that have already been applied to reduce truck congestion have been reviewed and synthesized in this report. After that, surveys were conducted among the officials at the drayage companies and truck drivers. Based on the results of the analysis of the surveys, feasible and cost-effective countermeasures/strategies for reducing truck congestion at marine terminals were recommended.

Chapter 1. Introduction

1.1 Problem Statement

Trade internationally has immensely increased in the last twenty years especially between Asian and US Marine Terminals (MTs) and thus freight volumes have also increased. Recent forecasts of container shipping volumes suggest an attractive growth rate to take place in the next five years. Bureau of Transportation Statistics (BTS) suggests water-borne goods shipments account for almost about 28% of all US international merchandise trade in terms of value (Bureau of Transportation Statistics 2006). The increasing number of containers causes higher demands on the container terminals, logistics, and management and on technical equipment. That is why Marine Terminals (MTs) need to increase the handling capacity as well as productivity. Marine Terminals are places where most of the world's goods are transferred. Most of these goods are carried to the terminals by trucks. According to the Bureau of Transportation Statistics, 60% of the domestic freight by weight and nearly 70% by value are carried by trucks (Bureau of Transportation Statistics 2006). This increase of trade has impacted the roadway transportation systems of metropolitan areas, especially around the major generators that are ports, airports, rail yards, and industrial areas causing congestion, delays, air and noise pollution. Recently, truck waiting time has continued to increase owing to the use of larger vessels, which has increased congestion at terminals. The increased container volumes required to be handled by MTs in optimum time highlight the need for the development of innovative countermeasures at a strategic, tactical and operational level. The following Figure 1 shows global container trade between years 1985-2012.

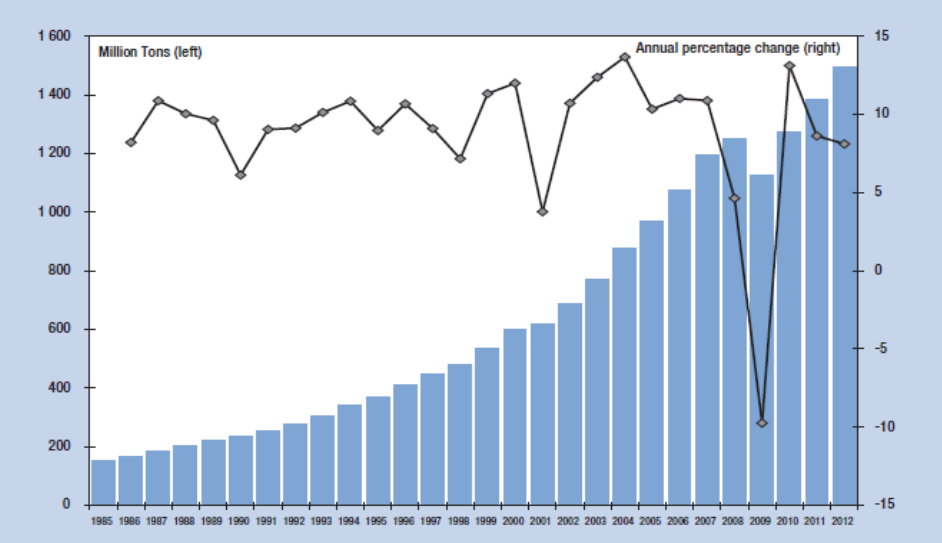


Figure 1. 1: Annualized Purchase Cost, O&M Cost, and Total (EAC) Costs
(*Source: UNCTAD based on Clarkson Research Services' Shipping Review & Outlook, Spring 2012*)

1.2 Research Goal and Objectives

The goal of this study is to conduct an in-depth investigation of innovative countermeasures for reducing truck waiting times at marine terminals and to recommend the most feasible cost-effective countermeasures to improve marine terminal operations. In general, countermeasures for mitigating truck congestion at marine terminals can broadly be categorized into three categories. The first type of countermeasure is at strategic level. For instance, expanding the capacity of the terminal can be considered as a strategic level countermeasure. The second type of countermeasure is at operational level. For instance, gate appointment system and extended gate hour operation are some of the popular operational level countermeasures. The third type of countermeasure is technologies based, that use different types of automation technologies to smooth the operation of marine terminals. For instance, automatic gate system has been increasingly used in US marine terminals. Since marine terminals are usually located in or near major cities, where right of way is limited and very expensive, implementing operational strategies to reduce the effect of the terminals' truck related traffic on the surrounding roadway network and the terminal operations is generally more feasible than physical capacity expansions (Barber et al. 2001, Mongeluzzo et al. 2005). Thus, this study focuses on the operational level and technology-based countermeasures. To investigate the effectiveness and limitations of these countermeasures, a thorough literature review was conducted conducted at first, followed by a survey to the truck drivers.

1.3 Report Overview

The remainder of this report is organized as follows: Chapter 2 provides background information regarding marine terminal structure and operation. Chapter 3 introduces countermeasures to reduce truck congestion at marine terminals. Chapter 4 summarizes previous studies that have been conducted before to mitigate truck congestion at marine terminals. Chapter 5 summarizes the results of a survey conducted on trucking companies and truck drivers operating within greater Houston and finally, Chapter 6 concludes this report with a summary and a discussion of the directions for future research.

Chapter 2. Marine Terminal Operation

2.1 Introduction

Before introducing the different countermeasures to mitigate marine terminal congestion, it is important to have an understanding of the marine terminal operation. Chapter 2 will give a brief description of the marine terminal functions, various elements, and the basic structure and activities of a typical marine container terminal.

2.2 Terminal Functions

A Marine Terminal has four basic functions: 1) receiving, 2) storing, 3) staging, and 4) loading. These four functions are performed for all containers, whether they are imports, exports, or transshipments. Transshipments are containers that are discharged from a vessel, stored temporarily in an intermediate terminal, and stowed onto another vessel prior to reaching their ultimate destinations. The receiving function involves providing entry for import containers or export containers, recording their arrivals, and capturing relevant information about the containers. The storing function involves placing the container on the terminal at a certain location where it can be retrieved when needed. The staging function involves getting a container prepared to leave the terminal. An export container may be staged at the time of initial storage, or at a later time. Lastly, the loading function involves placing the correct container on the ship, truck, or train.

There are other activities that take place at a terminal in addition to the mentioned four functions. An activity that is always performed is the surveying of containers and chassis. Such activity entails inspecting for things like damages on containers, the operability of chassis, and whether or not the proper container and/or chassis is being taken in or out. Inspections by U.S. Customs and United States Department of Agriculture (USDA) are often performed, though not for every container. There is also the activity of packing and unpacking containers at the terminal's warehouse. This is performed whenever containerized cargo has "less than container load" in size. These small shipments must first be consolidated into a single container.

2.3 Marine Terminal Elements

The most important elements of a typical marine terminal are containers, wharf cranes, and yard cranes. A brief description of these elements is provided as follows.

2.3.1 Containers

Containers are large and standardized boxes used to transport goods from one destination to another. They are designed to facilitate the movement of goods because they can be readily handled by terminal equipment and transportation system. Their dimensions are standardized by the International Standards Organization (ISO) and most containers are 20 or 40 feet. Figure 2.1 shows pictures of a 40-foot container on the left and a 20-foot container on the right. The term TEU (twenty-foot equivalent unit) is used to refer to one container with a length of twenty feet. Thus, a 40-foot container is two TEUs.

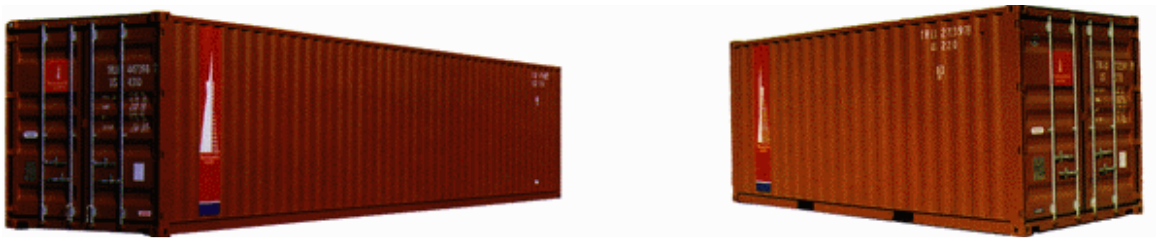


Figure 2. 1: 40-foot and 20-foot containers (Source: Huynh et al. 2005)

2.3.2 Wharf Cranes

Every terminal has one or more wharf cranes (Figure 2.2). A wharf crane is a type of large dockside gantry crane found at container terminals for loading and unloading intermodal containers from container ships. They are positioned on the shore and can slide back and forth along a track as it works a vessel. They can lift anywhere from 40 to 100 tons and load or discharge between 25 to 50 containers per hour. These wharf cranes can process two containers at once and could reach across 22 rows of containers on board a ship; that is, they have an outreach of 60 meters or more.

Figure 2. 2: Wharf Crane (Source: Google Image)

2.3.3 Yard Trucks/Vessel Trucks

Yard Trucks/vessel trucks are to take import containers from wharf cranes at the dock and transport those containers to the stack area for yard cranes to store. Unlike regular trucks that can travel on the road, yard trucks can only operate within the terminal.

2.3.4 Yard Cranes

Yard cranes (Figure 2.3) are the container handling equipment for loading containers onto or unloading containers from trucks in container yards in marine terminals. The yard cranes can also move the container in and out of a truck's chassis.

Figure 2. 3: Yard Crane. (Source: Google Image)

2.4 Marine Terminal Structure & Activities

Basically, MTs can be divided into five areas, namely the berth, quay, transport, storage yard, and gate (Carlo et al. 2013). These five areas comprise three different zones. Berth and the quay are called the "Seaside", the storage yard is called "Yard Side" while the gate is called the "Landside". Each side has some operations which usually interact with others. In addition to that, MTs can also be viewed as three different sectors. The gate area is called the gate sector, the storage yard area is called the yard sector and the berth and quay area together is called the quay sector. In summary, a typical diagram of all the sectors of an MT is shown in Figure 2.4. The basic operation flow of a Marine Terminal is also shown in Figure 2.5.

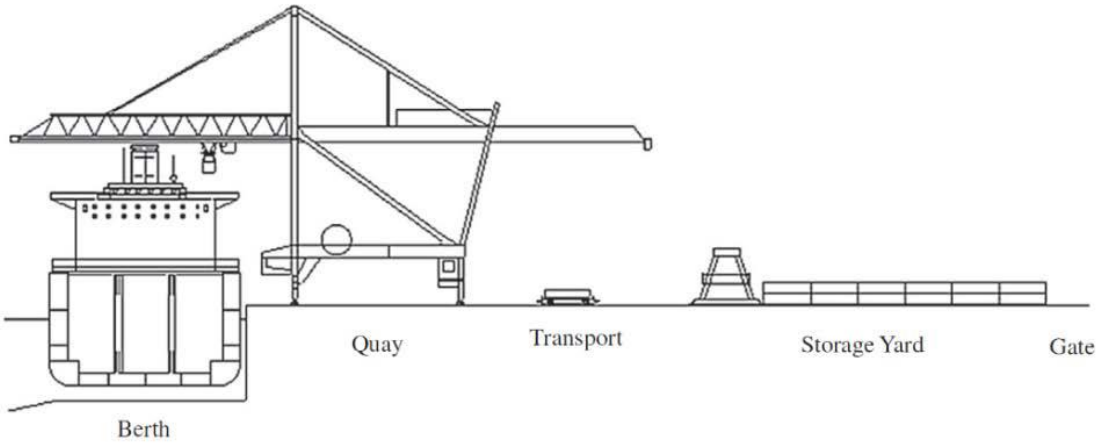


Figure 2. 4: Different Sectors of Marine Terminal (Source: Azab et al. 2016)

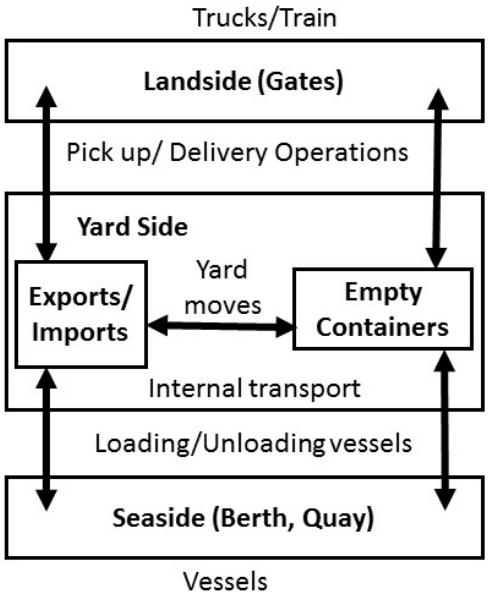


Figure 2. 5: Operations of a Marine Terminal (Source: Azab et al. 2016)

A brief description of different sectors/zones of a Marine Terminal is provided in the following section.

2.4.1 Gate Sector/Terminal Gate

The Gate Sector (Figure 2.6) is the entrance point for the container trucks and represents the first contact point between truck drivers and terminal authorities.

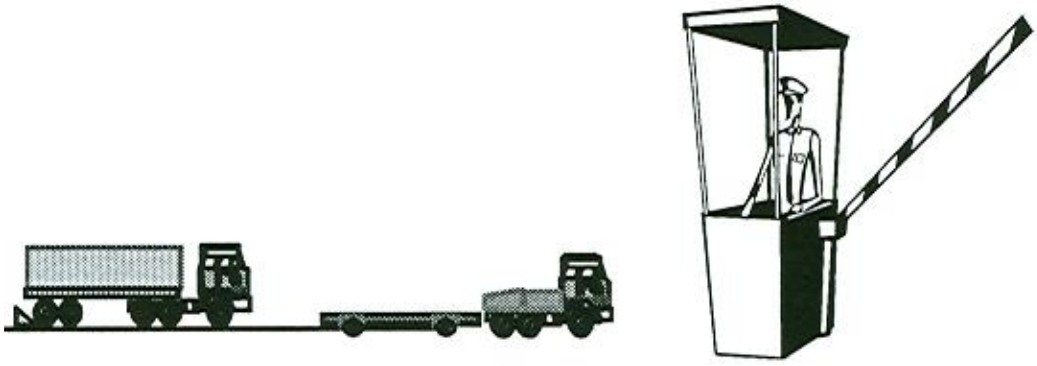


Figure 2. 6: Typical Gate Sector (Source: Levelton Consultants Ltd. Et al. 2006)

Operations included in this sector are container availability and storage location, trucker appointments, equipment identification and security. Example of typical gate sector is shown in Figure 2.7.

Figure 2. 7: Example of a Gate Sector (Source: Levelton Consultants Ltd. Et al. 2006)

2.4.2 Yard Sector

The Yard Sector (Figure 2.8) includes all ground or rail activities, which take place inside Example of a Gate Sector the terminal as well as security. The yard sector includes the interfaces between the Gate and the Quay at which ships are berthed.

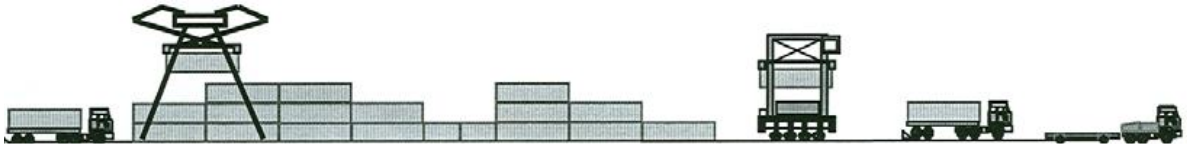


Figure 2. 8: Typical Yard Sector (Source: Levelton Consultants Ltd. Et al. 2006)

These activities include the loading and unloading of containers on terminal trucks, trains and stacking containers in the yard. Most terminals employ a mixture of storage organization. The main different types of storage organizations are chassis storage, stack-with-yard crane storage, and stack-with-straddle carrier storage. In chassis storage, the container is stored with the chassis in the yard as a married unit. Yard crane storage involves moving a container in and out of the stack by a yard crane. Lastly, a container can be stacked using a straddle carrier (Figure 2.9). Chassis storage requires the most land but makes it fast for trucks to drop off and pick up containers. Straddle carriers tend to be more flexible and mobile than yard cranes but require more land (Maria et al. 2014). A straddle carrier can stack at most 1 container wide and 2 containers high whereas a yard crane can stack up to 7 containers wide and 5 containers high. Typically, it takes longer for a truck to pick up a container at a terminal if the container is stacked because it takes time for the yard crane or straddles carrier to dig out the container.

Other activities include container tracking, dispatching, and inventory.

Figure 2. 9: Straddle Carrier (Source: Google Image)

2.4.3 Quay Sector

The Quay Sector (Figure 2.10) represents the marine entrance and exit point of the Marine Terminal. Its activity addresses all operations of loading and unloading containers on or off the vessel as well as container identification.

Figure 2. 10: Typical Quay Sector (Source: Level on Consultants Ltd. Et al. 2006)

2.4.4 Processes at a Container Terminal

The association between terminal functions and terminal equipment/organization can be understood by examining the flow of containers. When a ship arrives at the terminal, import containers are unloaded. This is done by wharf cranes, which remove the containers from the ship's hold or deck and place it onto yard trucks (a.k.a. vessel trucks). After receiving the container, the yard truck moves to the stack. The yard cranes then take the container off the yard trucks and store it in the stack. After a certain period, the containers are retrieved from the stack by the yard cranes and placed onto road trucks or trains for delivery to the recipient. The process is reversed for an export container. Note that, terminal managers may assign a set of yard cranes to serve yard trucks (vessel operations) and another set to serve road trucks (road

operations). There are instances when a yard crane may serve both yard trucks and road trucks. A diagram showing the processes at a marine container terminal is shown in Figure 2.11.

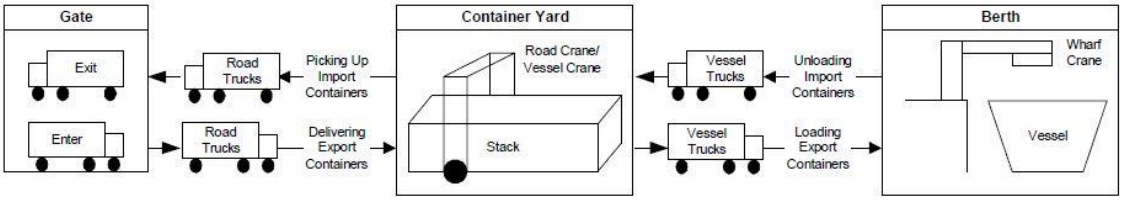


Figure 2. 11: Processes at a Marine Container Terminal (Source: Huynh et al. 2005)

Chapter 3. Countermeasures for Reducing Truck Waiting Time

To improve overall terminal yard side-to-landside operations and reduce congestion at terminal gates, different countermeasures have been proposed and implemented over the last few years. These countermeasures can be broadly categorized into three types: 1) planning/strategic level (e.g. capacity expansion), 2) tactical/operational level (e.g. extended gate hours, gate appointment systems) and 3) technology-based (e.g. automatic gate systems, virtual container yard). As we mentioned before, this study focusses on the second and third types of countermeasures. Follow is the introduction of these two types of countermeasures.

3.1 Tactical/Operational Level Countermeasures

Two of the most popular operational countermeasures are 1) gate appointment system and 2) extended gate hours.

3.1.1 Gate Appointment System

Gate appointment is a truck reservation system that provides a certain number (limited by the capacity of the terminal) of reserved transactions during a specified time slot (usually one hour). Appointments are made by the use of the Internet or by phone. Modern distribution centers that are fully automated have appointment systems for trucks in use for pick-up and drop-off cargo. An appointment system requires the dedication of shippers, drayage operators, and terminal operators, in order to be effective (Bureau of Transportation Statistics 2006). Gate appointment systems can be very effective in controlling the random arrival of trucks, modifying the peak hours of demand, minimizing congestion of idling trucks, and improving the utilization of the terminals' capacity (both at the delivery area and the storage yard). In order for a gate appointment to be successful, further strategies should be in place for processing the trucks arriving before or after their appointment time. Methods of processing arriving trucks with appointments differ from terminal to terminal. One way of processing trucks is to have dedicated lanes for trucks with appointments. Faster processing of trucks with appointments is assured if the conditions inside the terminal are well organized. Besides separate lanes, another method of processing trucks without appointments is to gather them all in a marshalling yard and service them according to a pre-determined pattern. This way all trucks with an appointment have priority (Theofanis et al. 2008). When there are no dedicated lanes for trucks with an appointment, the same queue can be used for all trucks, and trucks with appointments can be pulled out of line if the wait time exceeds a limit for trucks with appointments. Overall, according to literature, following two strategies for processing the trucks with or without appointments are recommended:

- Having dedicated lanes for trucks with appointments.
- Gather all trucks in marshalling yard and service according to a pre-determined pattern.

However, the following issues have been identified regarding gate appointment system:

- Availability to match Border and Customs operation (BCO) priorities, vessel cut-offs, free time, etc.
- Inability to make enough advance appointments

- Harder to plan dual transactions
- Same-day appointments extremely difficult
- Cancellation and reset rules vary
- Lack of visibility for available appointments
- Empty return and chassis complications

To fully take advantage of an appointment system, terminal operations must also be organized, so that when a truck makes an appointment, containers are ready for pick up. To facilitate this objective, containers can be reshuffled the day before, or when time is available, based on the appointment schedule so there are no delays at the slot interchange area of the terminal (i.e. area for pick-up and delivery of the containers by trucks).

Moreover, according to literature, several other strategies can be applied along with the gate appointment system in order for the gate appointment system to be more successful. These strategies are:

- Appointments can be made during the day, not just 24 hours ahead of time,
- Allow for reservation by phone,
- Re-assign reserved time that has been canceled,
- Decline or discourage double/triple appointments for the same container,
- Fines for missed appointments,
- Handle cancellations of appointments by phone, and
- Operate based on container appointment (not truck appointment).

3.1.2 Extended Gate Hours

In addition to a gate appointment system, the strategy of extending the hours of operations of the gates is another way to manage the demand patterns of truck arrivals and avoid high concentration during peak hour periods. Both strategies can exist in isolation or can be implemented together and complement each other. One of the major problems at marine container terminals is that the terminal gates, where trucks enter and exit the terminal to deliver or pick-up a container, are only open during certain hours on weekdays; due in part to union agreements, although operations within the terminal carry on 24/7. Consequently, trucks are forced to pick-up and deliver containers during specific hours of the day, resulting in high demand over certain periods. This phenomenon has led to inefficient gate operations that can spill traffic over to the surrounding roadway network causing serious safety and congestion problems.

By extending gate hours, the demand for processing containers are spread out throughout the evening, night, and even on weekends. This reduces the likelihood of congestion occurring during peak hours. There are three main issues that affect the successful implementation of this strategy: 1) providing incentives to drayage operators that will encourage them to utilize the extended hours of gate operations, 2) adjustment of hours and pay of workers at the terminal (Giuliano and O'Brien 2007), and 3) the ability of delivery locations to accommodate the truckers that pick-up containers during the extended hours of gate operations. Peak hour surcharges are an option to encourage traffic in off-peak hours. The

improved truck turn times within the terminal and increased credibility of the terminal operator in keeping the promised truck turn times could also facilitate the successful implementation of this strategy.

Several strategies can be implemented to make extended gate hour system work more efficiently. These strategies are:

- Use extended gate hour on weekends,
- Use extended gate hour with the gate appointment system,
- Provide incentives to drayage operators,
- Regular hour surcharge to encourage truck arrivals in extended hours.

3.1.3 Other Operational Countermeasures

Apart from the gate appointment system and extended gate hour, there are other operational countermeasures. The following are a brief description of these countermeasures.

- Pre-staging containers for bulk delivery: for trucks that are needed to carry more than one container from the terminal, containers are prepared and stacked together before the truck arrives at the port so less time is required for the truck to get the containers.
- Pre-entering truck and cargo information before arriving at the port: truckers can provide information to the terminal operators regarding the details of the container before arriving in the terminal. In that way, less time is required for the terminal operators to prepare the designated container for the truck.
- Using cellphone lots: the trucks are shifted away from the gates and drivers are notified by a smartphone application
- Using off-dock storage yard: containers are shifted to another place outside the main terminal container yard area to reduce congestion of trucks inside the terminals. Sometimes, empty containers are returned to the off-dock storage yard.
- Connect truckers and cargo owners by third parties: it is known as triangulation of trucker calls where containers from major customers are moved to an off-dock storage area where truckers quickly peel off those containers destined for distribution centers inland.
- Promoting two-way loaded movement: encouraging the truckers to come to the terminal for both import and export activity at the same time. In that way, trucks come to the port carrying an empty container, delivers it to the yard area and receives an import container in that same visit to the terminal. Which eliminates the need for the trucks to come to the terminal only for dropping off empty containers.

3.2 Technology-Based Countermeasures

Another approach is to improve operational efficiencies with the implementation of advanced technologies and information systems. In this part, state-of-art technologies used to reduce truck congestion in marine terminal will be introduced.

3.2.1 Automation Technologies

Automation technologies including tagging, tracking, and information management systems can be used to expand the capacity of marine terminals. These technologies are:

3.2.1.1 Optical Character Recognition (OCR)

Optical Character Recognition (OCR) is an automated identification and data collection technology, which provides an efficient, hands-free means of asset identification, tracking, and control (Figure 3.1). It is one of the lowest cost ways with the growth of the demand for automated container handling processes. In the port, OCR used to identify trucks automatically upon entry into the port so that it reduces truck waiting time significantly. It can be classified in the following operations:

Gate operations: OCR is first associated with a container, then processed through the gate area. Additionally, the movement of containers and trucks will be identified and tracked through terminal gates. Automatic Gate Systems (AGS) is a specific system that uses OCR to read the number on the container, search the billing file to see whose cargo it is, and determine where it needs to go. Drivers can be identified with fingerprints, increasing security and accountability. Workers, therefore, will not need to be on the ground checking in drivers.

Yard operations: Containers and trucks identified by OCR uniquely when waiting for service at the container handling equipment. The truck precise location will be identified and reported automatically to the terminal operating system. The process without human intervention which will minimize labor friction and optimize driver productivity.

Quay operations: Containers and operators are automatically identified and matched under the quay crane. It improves worker safety by removing staff from under the cranes and also enables subsequent transitions will also then be automated.

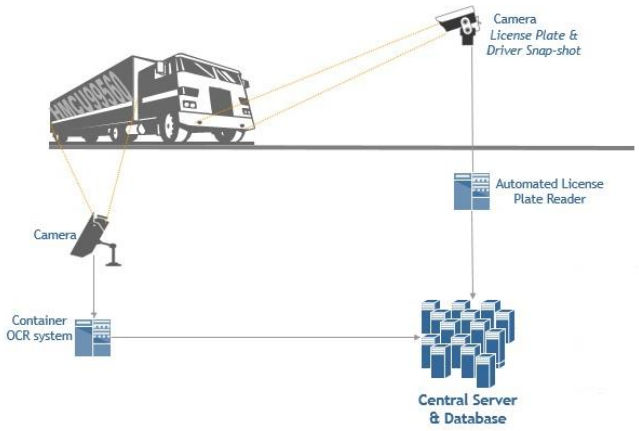


Figure 3. 1: OCR Technology (*Source: kritikalsolutions website*)

3.2.1.2 Radio Frequency Identification Device (RFID)

Radio Frequency Identification Device (RFID) technology (Figure 3.2) is another way to collect data automatically in marine terminal. Generally, there are five components: active or passive tag (transponder), antenna, transceiver, reader, and information system. Tags are programmed with data that identifies the container to which the tag is attached. Other information within the tag may be where the container originated, destination,

goods within the container, and owner of the goods. Truck and driver information collected through the RFID tag on the truck's front window, then will be recorded through an image recognition system.

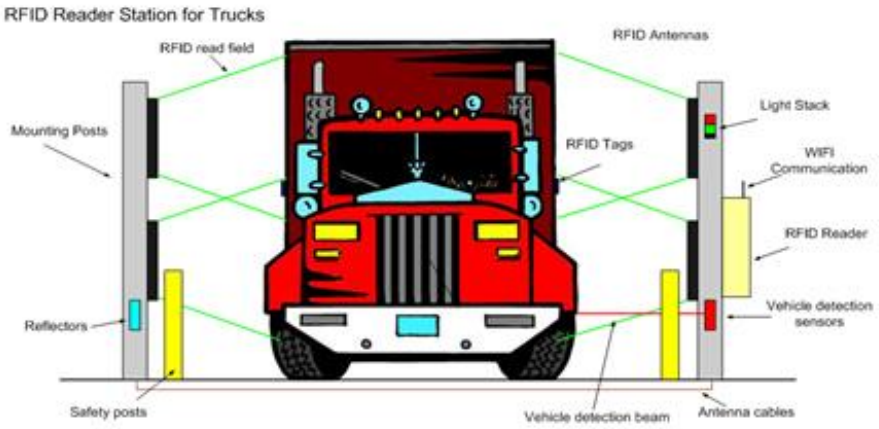


Figure 3. 2: RFID Technology (Source: Peacocks website)

3.2.1.3 Global Positioning System (GPS)

Global Positioning System (GPS) (Figure 3.3) is a constellation of navigation satellites called Navigation Satellite Timing and Ranging (NAVSTAR), maintained by the U.S. Department of Defense. In the port, GPS technology mainly used to identify container position in marine terminal. It also used to constantly track trucks' position, communicate between drivers and headquarters fast, archiving electronic of increase speed of the transport process, transparency, timeliness, and accuracy of information.

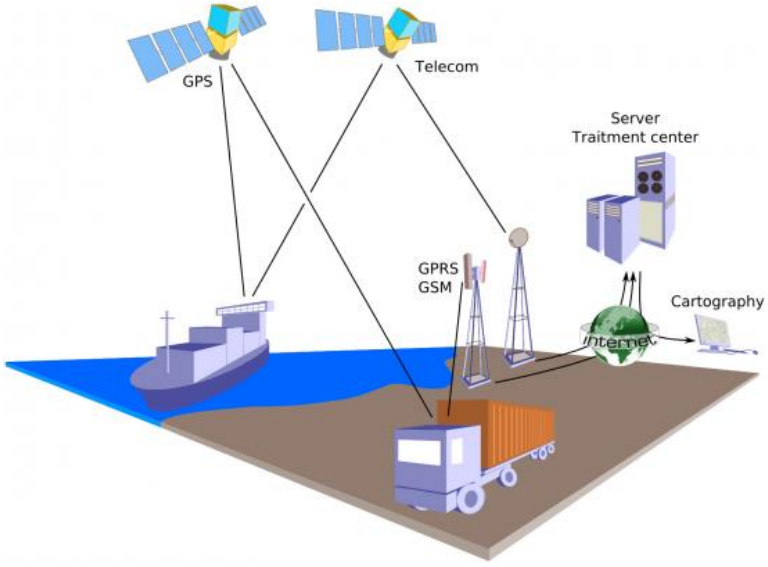


Figure 3. 3: GPS Technology (Source: navipedia website)

3.2.1.4 Barcode Reader

Barcode reader is a wireless scanning technology that communicates with the host computer (Figure3.4). Barcode is ideal, especially for shipping manifests and outer packing cases or other exposed surfaces. Reader is easy to use where the ambient light environment in the container terminal is high. Barcode reader is capable of providing prompt information required by customs when vessels at berth. It operates most effectively in a controlled environment particularly when relatively small amounts of data need to be captured. In the rough environment of a port terminal where the visibility of the straddle carrier operator is minimal, this wireless system provides effective services to most terminal operators and operational systems.

Figure 3. 4: Barcode Reader (Source: Colourbox website)

3.2.1.5 Voice Recognition

Voice recognition technology provides communications between the crane operator and the ground personnel. This technology can be used either as a standalone or integrated with other technologies during the loading and unloading of a vessel. Voice recognition uses pattern recognition similar to that in barcode systems. Instead of an image, the computer recognizes words in a preprogrammed vocabulary. When it is activated, crane operators speak into a microphone; the machine recognizes words or phrases and then converts them into electronic impulses for the micro- or host computer. The high-performance units operate at an accuracy rate of 99.5%. One of the advantages of the system is message recording. This would assist the terminal operator in providing the final report on the position of containers loaded on to the ship. When properly integrated, the system can assist in the automatic capture and processing of marine terminal data.

3.2.1.6 Automated Guided Vehicle (AGV)

Automated Guided Vehicle (AGV) driven by an automatic control system that serves as the driver. It is considered to be the most flexible type of material handling system, suited to be deployed for terminal operations very well because of the repetitive nature of movements within the terminals. Sensors on the road or infrastructure and onboard the vehicle provide measurements about the location and speed of the vehicle. It can achieve the following benefits: high container throughput, controllability and reliability; automated and consistent container handling operation and continuous operation (24 hours a day, 365 days a year); reduced operational costs, especially labor costs.

To summarize, Table 3.1 listed the automation technologies mentioned above.

Table 3. 1: Automation Technologies Summary

Technology	Main Application
Optical Character Recognition	Automatically identify containers, truck plate and chassis information at entry and exit gates, yard and quay operations
Global Positioning System	Identify container position in terminal
Radio Frequency Identification Device	Track trucks, containers and cargo in terminal
Barcode Readers	Identify containers position in terminal
Voice Recognition	Assist in capturing and processing data, provide communications between the crane operator and ground personnel
Automated Guided Vehicle (AGV)	AGVs are used to move containers in some maritime container terminal. The main benefits are reduced labor costs and a more reliable (less variable) performance.

3.2.2 Terminal Operating Systems (TOS)

The main purpose of Terminal Operating Systems (TOS) is to provide a set of computerized procedures to manage cargo, machines and people efficiently and effectively. The systems can get up to the minute information which allows for more timely and cost-effective decision making. TOS utilizes technologies such as the internet, electronic data interchange processing, laptops, wireless local area networks and RFID to monitor the flow of products in, out and around the terminal efficiently. Data is either a batch synchronization with, or a real-time wireless transmission to a central database. The database can then provide useful reports about the status of goods, locations and machines in the terminal. Terminal operating systems can be standalone systems managed as a service or utilize cloud technologies. The following paragraphs summarize the existing TOS as well as provide a reference and a brief description of each.

3.2.2.1 Freight Information Real-Time System for Transport (FIRST)

FIRST is an Internet-based, real-time network that integrates many resources into a single, easy-to-use web site on cargo and port information. The FIRST Web site (www.firstnynj.com) provides real-time information on cargo status to ocean carriers,

exporters, importers, foreign freight forwarders, customs brokers, terminal operators, and rail and trucking services. Truck companies can use the system to find out the status of a cargo container waiting to be picked up at the port. By verifying that the container is at the terminal and has been released for pickup, the trucker can avoid multiple telephone calls to the terminal and prevent unnecessary trips to the port.

3.2.2.2 Pacific Gateway Portal (PGP)

PGP is a web-based port community information system that serves stakeholders and customers in the Vancouver area. It provides for information on containers status, vessel activity, and real-time video images from port landside infrastructure as well as driver validation. The web portal also features a dangerous goods application and a truck appointment system available to registered users for a fee. Benefits of the system to truckers are scheduled and seamless processing with minimum delays.

3.2.2.3 SynchroMet

SynchroMet™ On-Line, the virtual container yard service provider for the Port of Oakland. The Port Authority and SynchroNet Marine Inc have partnered to implement a congestion management tool to alleviate public road and port congestion at local marine terminals. Empty container can be released through SynchroMet and matched in real-time with off-dock equipment needs to cover export bookings, which can reduce empty truck miles and waiting time at local marine terminals. SynchroMet also provides trucks with the ability to access empty equipment direct from local ramps and outside the terminal and automate the confirmation process via electronic data interchange

3.2.2.4 SEA LINK®

SEA LINK® provides for the thousands of trucking companies serving the Port of New York and New Jersey a central database of registered trucking companies and their truck drivers doing business. It helps speed these trucks through their marine terminal gates, allowing their terminals to move thousands of containers each day to and from markets. With a single identification card for calls at any of the Port of NY and NJ's Marine Terminals, drivers save time, clearing gates quickly for dropping off and picking up cargo.

3.2.2.5 eModal

eModal is designed to improve efficiency and decrease congestion at container terminals. It provides a single point of contact for multiple container terminals and delivers valuable tools to the entire intermodal community. eModal gives one easy-to-use Web site for all container information needs, which offers detailed container status, vessel schedules, terminal locations, truck driver lists and more container, vessel and terminal information. These tools improve service to all parties in the transportation community. eModal also provides extra benefits for trucking companies and terminal operators through a gate appointment system. Trucking companies use eModal to pre-approve their drivers for container pick up and drop off. eModal automatically sends this preapproval information to the terminals. Terminals also rest assured knowing they are delivering containers to the

trucking company's designated drivers. eModal's trucker status features also reduce trucker turn times and improve security at the terminal.

3.2.2.6 NAVIS (Yard Management)

NAVIS is a system that automates and integrates data input functions, allowing terminal operators to see what is happening in real-time, including container movements from the gate to vessels or rail, in their container terminal. NAVIS SPARCS, used by more than 175 terminals in 44 countries around the world, enables the operator to fully automate and optimize vessel and rail planning, yard allocation, and equipment dispatch, with minimal human interaction, which means faster, more efficient loading and discharge. Additionally, SPARCS terminal operating system keeps pace with advances in equipment technology (OCR, RFID), allowing the terminal operators to maximize their investment in the latest equipment, such as twin lift straddle carriers. By helping optimize equipment, land and container moves, vessels spend less time at the quay, enabling a terminal to accept more requests from shippers and increase throughput. Many terminals implement simple systems for servicing quay cranes resulting in the underutilization of container handling equipment, leading to longer travel distances, un-laden travels and delays. Because SPARCS terminal operating system operates in real-time, operators can track current container handling equipment and productivity which means truck drivers won't have to wait for work instructions, assuring that drivers are making strategic moves, saving them time and allowing them to concentrate on driving, and not on the context of the move.

3.2.2.7 COSMOS (Yard Management, Gate Control and Container Tracking)

COSMOS System is a fully integrated yard control, terminal/vessel planning system supported in real-time by radio frequency, using handheld and vehicle miles traveled in all terminal operations. SPACE is COSMOS' yard planning software. Based on user-defined parameters, it automatically determines the optimal position for containers that enter the terminal until they are loaded on the right vessel, barge, truck or train. A location in the terminal will be automatically assigned to every container entering the terminal. The characteristics of the container, such as the type of container, its destination, the date of departure, weight, etc., determine the selected area. Within the assigned area, containers will be stacked according to user-defined algorithms. The planner defines planning rules; based on these rules, the system then determines the optimal position for each container. The planner just handles the exceptions and fine-tunes his planning rules. SPACE can operate in any terminal environment, wheeled or grounded, and container handling equipment employed. An important module of SPACE is TRAFIC. This module automatically generates and transmits instructions to terminal equipment drivers. As soon as these drivers have confirmed the execution of the move, SPACE is updated in real-time, guaranteeing the accuracy of the system.

COSMOS also provides Gate Control and Container Tracking functionalities. Every container entering the terminal is checked administratively and physically, after which the order is confirmed. Checkers use hand-held terminals linked to COSMOS to update the database in real-time. After the container is checked, all other software programs

linked to the central database are able to use the available container information. COSMOS also monitors all operations. Whenever the information concerning a container is changed, e.g. a container is moved or a vessel arrives, COSMOS is automatically informed and the database is kept up-to-date at all times.

3.2.2.8 Embarcadero (ESC) (Yard Management, Gate Control and Appointment System)

ESC's Web-based visibility tools (VoyagerTrack and webTAMS), employ Differential Global Positioning Systems and wireless local area networks to report on the exact position of equipment and provide real-time communication for the terminal community complement terminal operating system software. Outside the terminal, ESC also provides cargo visibility at any event using real-time Web access tools. With automated intermodal solutions from ESC, terminals improve yield management by increasing terminal and yard efficiency, reducing operational costs, improving throughput, and elevating levels customer service.

ESC's Premier Appointment System is a real-time appointment module for motor a carrier that extends the functionality of VoyagerTrack®. The PAS module comes standard with VoyagerTrack. This capability in VoyagerTrack allows truck drivers to schedule arrival appointments at the gate resulting in reduced wait time for motor carriers.

ESC smartGATE™, providing centralized, remote processing of gate transactions for intermodal facilities. SmartGATE includes hardware (OCR, RFID, GPS, and Smart Camera Technologies) and software. A key module of smartGATE is Intelligent Camera, a Closed-Circuit Television that provides accurate and real-time images of the terminal. VoyagerTrack and webTAMS-allow intermodal customers, motor carriers and other transportation community stakeholders' access to secure real-time critical information and notifications. With VoyagerTrack and webTAMS, container transportation communities have the ability to check container availability, schedule appointments for pickup and delivery, and make on-line demurrage payments.

3.2.2.9 Maher Terminal Logistics Systems Gate and Yard Automated System

Massport launched a web-based Gate and Yard Automated System at Conley Terminal. The system uses an internet browser-style interface to provide the intuitive tools to enter bookings and manifests, as well as locate important information concerning bookings, containers, manifests, and trucker contracts. This system is designed for use by carriers, truck drivers, brokers, and forwarders. This software also gives Massport an automated approach to yard management, providing the most efficient and productive use of terminal staff and yard storage space. Companies moving cargo through Conley Terminal have been assigned passwords with varying degrees of access to the system. Each company's access is determined by the level of control they have in the transportation of cargo through Conley Terminal, and is limited to their cargo and equipment.

The following Table 3.2 summarizes port information system.

Table 3. 2: Summary of Port Information System

System	Description	Used in Port Authorities
FIRST	Web-based real-time network integrates many resources into a single show on cargo and port information	New York and New Jersey
PGP	Web-based system provides containers status, vessel activity, and real-time video images from port landside infrastructure and driver validation	Vancouver
SynchroMet	Virtual container yard to alleviate public road and port congestion at local marine terminals	Oakland
SEA LINK	Truck driver identification system to speed trucks through marine terminal gates	New York and New Jersey
eModal	Web-based system provides all container information needs: container status, vessel schedules, terminal locations, truck driver lists	Los Angeles, Long Beach, New York and New Jersey, Oakland, Tacoma, Vancouver, Seattle, Miami, Jacksonville
NAVIS	Automate and integrate data input, real-time monitoring at the terminal	Houston, Montreal
COSMOS	Integrated yard control and terminal/vessel planning system in real-time by radio frequency	Halifax
ESC Embarcadero	Web-based visibility tools use DGPS and WLANS to report the position of equipment and provide real-time communication	Long Beach, Oakland, Seattle
GYAS	Web-based gate and yard automated system	Boston

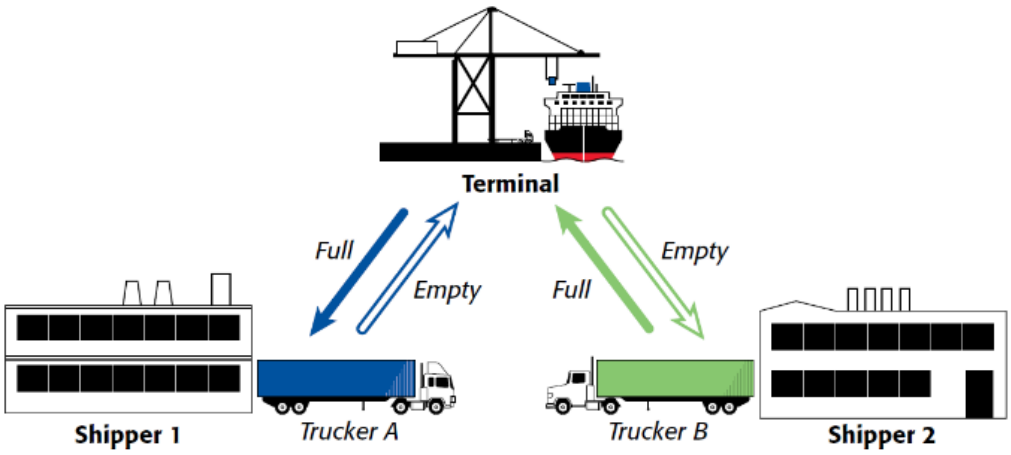
3.2.3 Others

3.2.3.1 Virtual Container Yard (VCY)

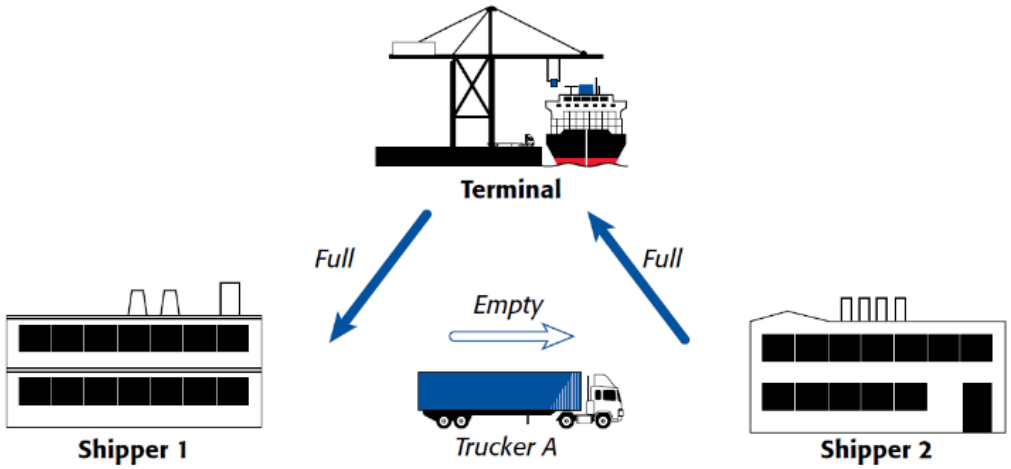
For truck congestion because of empty container issues, the virtual container yard is essential. A web-based information system with inventory of empty containers allows suppliers and shippers to access containers at convenient storage locations outside the terminal. This avoids unnecessary trips to the terminal and results in savings to both terminals and truckers. The scheme essential reduces the number of truck trips and increases drayage productivity. In addition, having dedicated truck access roads when traveling between terminals can reduce traffic congestion on roadways.

After import containers are unloaded, they are most often moved empty from customers' premises straight back to terminals, rail ramps and container yards. That represents a lose-lose-lose: (1) carriers pay unnecessary gate charges and storage fees, and experience wear and tear on equipment; (2) truck drivers waste hours waiting in line at ports, rail ramps, and container yards to return empty equipment; (3) container-facility operators lose operating efficiency because of congestion, and face pressure from local communities and regulatory bodies to reduce truck traffic and pollution from engines idling at their gates. The inefficiency stems from simultaneously having two empty containers on the road when one would suffice. As Figure 18(a) illustrates, Trucker A carries a full load from the terminal or ramp to Shipper 1, and then hauls back an empty. At the same time, Trucker B carries an empty to Shipper 2, and then brings back a load into the terminal or rail ramp. It is estimated that between 30% and 40% of all containers on the road at any given time are empty. Rather than have both truckers move empty

containers back and forth, it is much more efficient for one of two things to happen. First, as shown in Figure 18(b), Trucker A could take the empty box from Shipper 1 and deliver it to Shipper 2, and then carry Shipper 2's load to the terminal. As an alternative, Trucker A could interchange Shipper 1's empty container with Trucker B out on the street. In either case, a trip segment would be eliminated. Although street turns are a highly efficient means of utilizing container assets, they may happen as little as 2% of the time, mainly because of the difficulty of knowing when containers are available.



(a). Lose-Lose-Lose (Source: IAS web)



(b). Win-Win-Win (Source: IAS web)

Figure 3. 5 Virtual Container Yard

The summary of automation countermeasures and planning level countermeasures that can be used at marine container terminals to reduce congestion is presented in the following Table 3.3.

Table 3. 3: Summary of Planning Level and Automation Technologies based Countermeasures

	Name	Description
Planning/Strategic level countermeasures	Adding Yard Cranes	Improve the level of service for managing the trucks, reduce the truck turnaround time
	Gate Expansion	Physically install more gates to serve the trucks at terminal gate
	Increasing Land Area	Adding more land area to the existing area of the Terminal
Automation Technologies	OCR	Automatically identify containers, truck plate and chassis information at entry and exit gates, yard and quay operations
	GPS	Identify container position in terminal
	RFID	Track trucks, containers and cargo in terminal
	Barcode Readers	Identify containers position in terminal
	Voice Recognition	Assist in capturing and processing data, provide communications between the crane operator and ground personnel
Terminal Operating Systems	FIRST	Web based real-time network integrates many resources into a single show on cargo and port information
	PGP	Web based system provide containers status, vessel activity, and real time video images from port landside infrastructure and driver validation
	SynchroMet	Virtual container yard to alleviate public road and port congestion at local marine terminals
	SEA LINK	Truck driver identification system to speed trucks through marine terminal gates
	eModal	Web based system provide all container information needs: container status, vessel schedules, terminal locations, truck driver lists
	NAVIS	Automate and integrate data input, real-time monitoring at terminal
	COSMOS	Integrated yard control and terminal/vessel planning system in real time by radio frequency
	ESC Embarcadero	Web-based visibility tools use DGPS and WLANS to report position of equipment and provide real-time communication
	GYAS	Web-based gate and yard automated system
Others	Virtual Container Yard (VCY)	Virtual container yards are Web-based platforms where users can match empty containers to container needs at the dock rather than returning them to the terminal.

Chapter 4. Existing Studies

The existing studies have used analytical, simulation and survey-based approaches to investigate the marine terminal gate congestion problem and its impacts. In this chapter, some representative studies of different approaches are introduced as follows

4.1 Analytical Based Studies

4.1.1 Guan et al. (2009), "Analysis of Marine Container Terminal Gate Congestion, Truck Waiting Cost, and System Optimization"

In his dissertation, Guan (2009) applied a multi-server queuing model to analyze marine terminal gate congestion and quantify truck waiting cost. Based on the data collected during field observations, online camera observation and terminal day-to-day operation records, some relationships between the number of vessels, cargo volumes, gate transactions, and truck volumes were developed by using statistical charts and descriptive statistics. It was found that the ratio of every import/export container to truck trips is 1:2, to gate transactions is 1:1.4. The statistical analysis showed that these ratios are very consistent.

The major contribution of this study is the development of a model for analyzing the marine terminal gate congestion and quantifying congestion costs. Based on the developed cost estimation method, the optimum numbers of booths at the terminal gate can be derived for different truck arrival rates as shown in Table 4.1 below.

Table 4. 1: Estimated optimum numbers of booths at terminal gate for different truck arrival rates

Fixed Indices		Calculated and Observed Performance Indices							Optimized Performance Indices						
Hour	Truck arrival rate	Number of gate booths working	Average number of truck waiting	Average waiting time per truck (min)	Gate operating cost per hour	Truck waiting cost per hour	Total gate cost per hour	Total hourly cost/Hourly truck waiting cost	Number of gate booths working	Average number of truck waiting	Average waiting time per truck (min)	Gate operating cost per hour	Truck waiting cost per hour	Total gate cost per hour	Total hourly cost/Hourly truck waiting cost
6am-7am	90	4	6.0	4.0	503	194	697	21.7	5	1.1	0.7	628	35	663	20.6
7am-8am	95	4	15.9	4.0	503	512	1,014	31.5	5	1.6	1.0	628	53	681	21.2
8am-9am	138	6	9.3	10.0	754	300	1,053	32.8	7	1.3	1.1	879	82	961	29.9
9am-10am	94	6	0.6	4.1	754	18	772	24.0	5	1.6	1.0	628	53	681	21.2
10am-11am	105	6	1.0	0.4	754	33	787	24.5	5	3.2	1.8	628	102	730	22.7
11am-12pm	95	6	0.5	0.3	754	17	771	24.0	5	1.6	1.0	628	53	681	21.2
12pm-1pm	145	6	39.2	16.2	754	1,259	2,013	62.6	7	3.7	1.5	879	118	997	31.0
1pm-2pm	146	6	52.0	21.4	754	1,672	2,426	75.5	7	3.7	1.5	879	120	999	31.1
2pm-3pm	81	5	0.6	0.4	628	19	647	20.1	4	2.2	1.6	503	71	574	17.8
3pm-4pm	79	4	1.7	1.3	503	54	557	17.3	4	1.7	1.3	503	54	557	17.3
4pm-4:30pm	25	4	0.2	0.2	251	5	256	15.8	3	0.7	0.9	188	24	212	12.5
Total	1,093				6,909	4,083	10,992					6,972	764	7,736	

Source: Guan, 2009

Note: Hourly truck waiting cost = $32.15 per truck (Texas Transportation Institute, 2003)

Furthermore, in this study, by applying the developed cost estimation model, the effectiveness of some gate congestion mitigation countermeasures was also investigated. These countermeasures are: 1) gate capacity expansion: add more gate lanes and service booths, 2) productivity improvement: improve service rate/reduce service rate at each booth, and 3) gate approximant system: control the truck arrival rates. For different countermeasures, the average waiting time and the overall gate congestion cost were estimated based on a model developed by this study. Following are the major findings for each countermeasure:

- Gate capacity expansion: two additional gate booths can reduce 27% of the overall system costs and 71% of the direct truck waiting cost.
- Productivity improvement: the annual truck waiting time can be reduced by 62% based on 10% service improvement and 81% based on 50% service improvement, respectively.
- Gate Appointment system: the gate operating cost can be reduced by 7% and truck waiting cost can be reduced by 70% respectively.

In addition, the author also provided the following comments regarding the implementations of these three countermeasures:

- Gate capacity expansion requires flexibility in-gate lanes opening and closing as well as the use of gate clerks. This might be difficult to obtain due to labor contract requirements. Large scale physical expansion may not feasible due to the limitation of waterfront land.
- Productivity improvement also requires flexibility in gate manpower and the number of gate booths. This can be improved by the technologies used for the terminal operation system.
- The gate appointment system seems to be the most effective way to reduce gate congestion and improve system efficiency. It allows the marine terminal to match supply and demand for gate processing capacity, and control the congestion level at the marine terminal gate.

4.2 Simulation-Based Studies

4.2.1 Chen and Yang (2014), "Methods for Estimating Vehicle Queues at a Marine Terminal: A Computational Comparison"

Chen and Yang (2014) used a micro traffic simulation tool, PARAMIC, to simulate a container terminal gate system and observe the formation process of a truck queue. Based on the results of simulation, a simulation-based regression model was developed for estimating the truck queues at a container terminal gate.

The major idea is that, since a queue cannot reach its steady state instantaneously, it separates queue length estimation into two stages: I) queue formation stage and II) steady state stage which can be seen in Figure 4.1 below. For stage II "steady state", stationary queueing model is used for estimating the steady queue length according to the arrival rate. For stage I, a model for estimating the queue length during the queue formation process was developed

based on the simulation results. The key issue in this method is to find the critical point that separates the two stages.

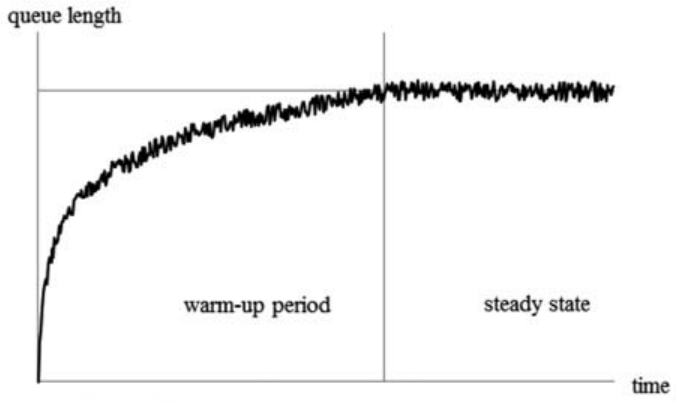


Figure 4. 1: Queue formation process (Source: Chen, 2014)

This study also compared the queue estimation results from different methods with the simulation results as shown in Figure 4.2. It was found that the stationary queuing models obviously overestimate a queue length, and cannot handle the situation when the demand is greater than the capacity. In addition, the fluid flow model underestimates the queue length because of neglecting the stochastic queuing phenomenon.

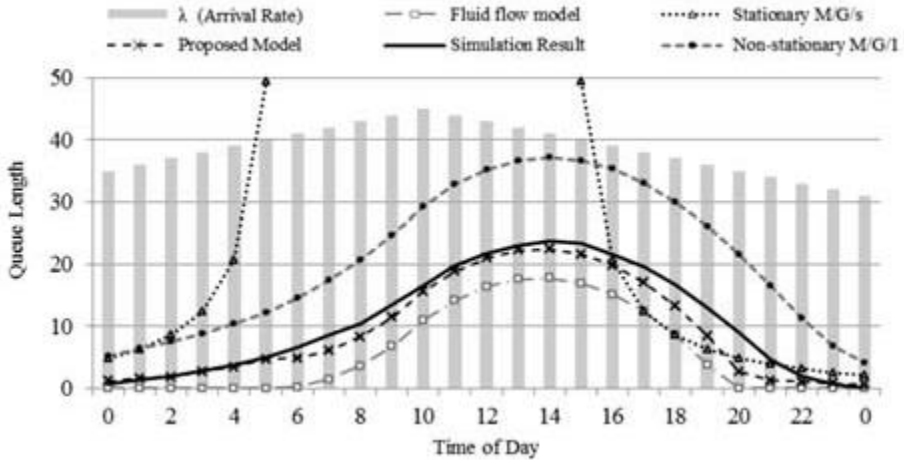


Figure 4. 2: Estimation result of each model in the numerical experiment (Source: Chen, 2014)

4.2.2 Boile et al. (2014), "Evaluating Strategies to Improve Access to Marine Container Terminals and Streamline Gate Operations"

In this research, a simulation-based study was conducted to model the inbound and outbound trucks at marine terminals and the surrounding road networks. The purpose of the study was to evaluate the effect of three different countermeasures: a) Gate Appointments System, b) Extended Gate Hours and c) Roadway Expansion on reducing truck travel times and emissions generated from the trucks.

Traffic simulation software PARAMICS was used to simulate the prototype marine terminal considered in this study. Congestion and emission were calculated for the prototype marine terminals. Three different scenarios were designed and simulated: 1) AS represented the Gate

Appointment System strategy, 2) EG represented Extended Gate Hours strategy and 3) RE represented Roadway Expansion strategy. In addition, a base scenario representing the Current Operation (CO) was also developed.

Figure 4.3 illustrates the layout of the road network and the marine terminals used in the study. The port network consisted of three main access roads. Vehicles enter the port area from the south (R1), northeast (R2) or northwest (R3). The figure also shows three container terminals (I, II, III) within the port study area.

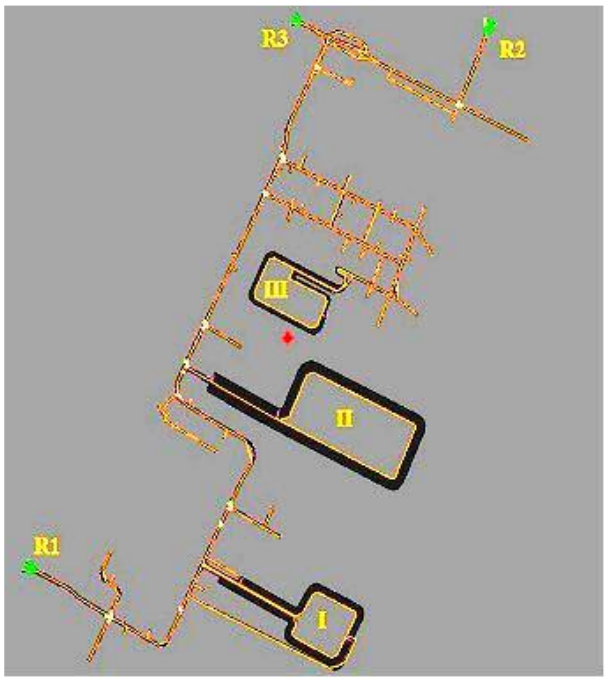


Figure 4. 3: Representation of the prototype port (Source: Boile et al. 2014)

The model simulations use 24-hour periods to model the prototype port activity. The hourly distribution of the different types of vehicles using the terminal network is shown in Figure 4.4. Figure 4.5 shows the total delays per hour and Figure 4.6 shows total travel times per hour. These results indicate that the Gate Appointment System strategy can reduce up to 62% for delays and about 34% for the travel times.

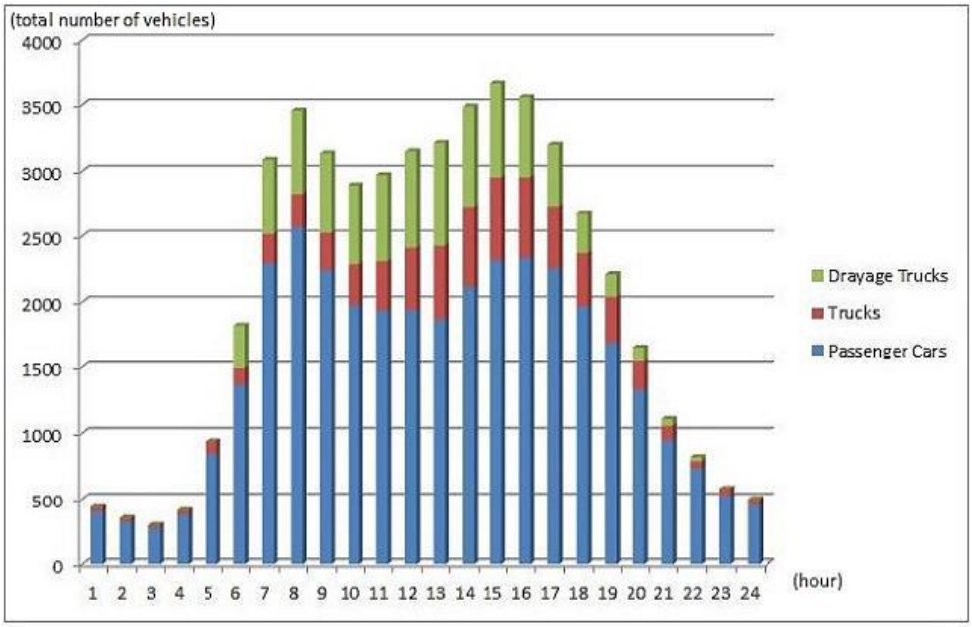


Figure 4. 4: Hourly distribution of the different types of vehicles in the port access network (Source: Boile et al. 2014)

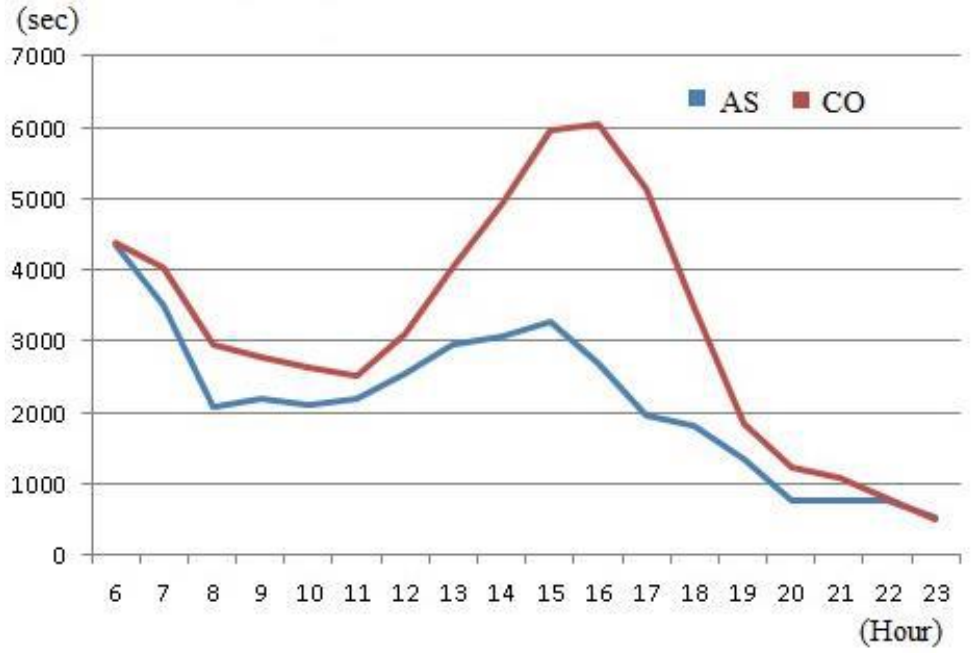


Figure 4. 5: Total delays per hour (sec) (Source: Boile et al. 2014)

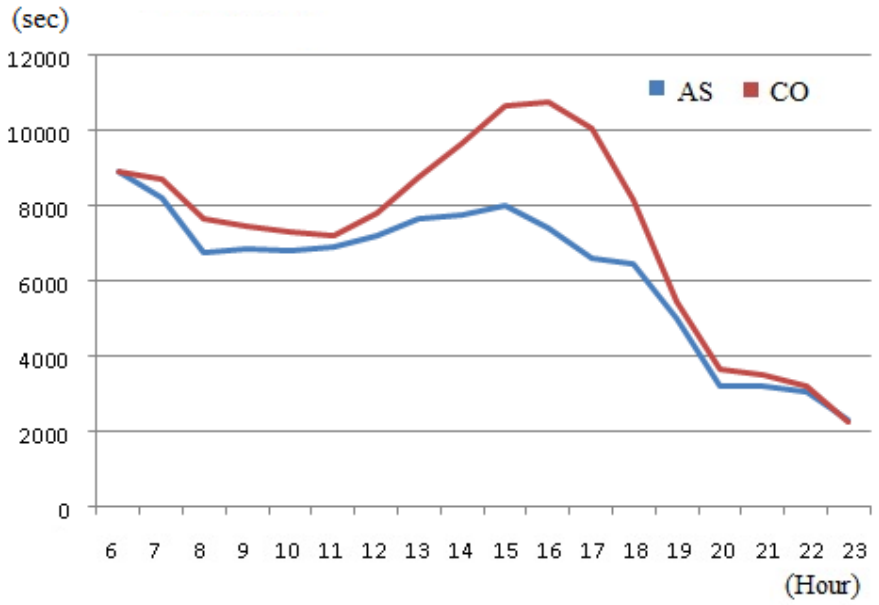


Figure 4. 6: Total travel times per hour (sec) (Source: Boile et al. 2014)

Figure 4.7 represents the travel times for the three scenarios (CO, EG and RE). The results indicate that Gate Appointment System and Extended Gate Hours can provide better results in reducing truck congestion compared with Roadway Expansion.

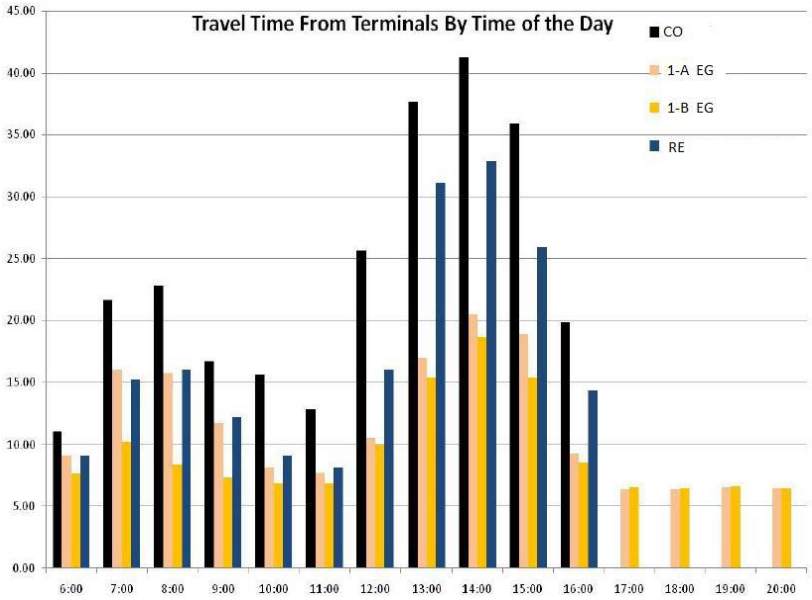


Figure 4. 7: Travel times (in min) for CO, EG and RE (Source: Boile et al. 2014)

To summarize, the purpose of this research was to perform simulation of prototype marine terminals to study the effect of Gate Appointment System, Extended Gate Hours and Roadway Expansion on reducing travel times of trucks as well as reducing emissions generated from the trucks. Based on the results of this study, Extended Gate Hours is more effective compared with Roadway Expansion. Note that, these results were derived based on

the assumption of the demand patterns from one existing terminal. Therefore, the results may be case-specific and may be different if a different port/terminal is analyzed.

4.2.3 Azab et al. (2016), "A Simulation-Based Study of the Effect of Truck Arrival Patterns On Truck Turn Time in Container Terminals"

Azab & Eltawil (2016) conducted a study to identify the problem of long Truck Turn Time (TTT) for external trucks in marine container terminals. The objective was to identify the effect of arrival patterns of trucks on truck turn time and gate congestion. The results can be used for improving the Gate Appointment System.

The authors used a simulation model to study the effect of various truck arrival patterns on the TTT in container terminals. The following equation describes the TTT:

$$TTT = Twg + Tsg + Twy + Tsy + Txg$$

Where :

Twg: waiting time at the gate.
Tsg: service time at the gate.
Twy: waiting time at the yard.
Tsy: service time at the yard.
Txg: time spent at gate exit.

Figure 4.8 shows the 3D model for the main areas of the container terminal: quayside, yard area, and gate side. This simple model considers one gate, one-yard block, one-yard crane, one quay crane, and one vessel. FlexSim CT software*, special simulation software for container terminal operations, is used for estimating the TTTs for different arrival patterns. Both export and import container arrivals are simulated. Various truck arrival patterns are tested for investigating the truck turn time changes with various patterns. The main target of this study is to illustrate how to keep the TTT at the minimum and maintain the gate throughput as high as possible. For simplify purpose, one vessel is assumed to reach the terminal during the analysis time period and the vessel is assumed to deliver 200 import containers and to be charged with 200 export containers which come via the gate by the external trucks. Similarly, the imports will be picked up during the analysis time period by the external trucks. The model parameters are shown in Table 4.2. These parameters are the default parameters in FlexSim CT with little modification.

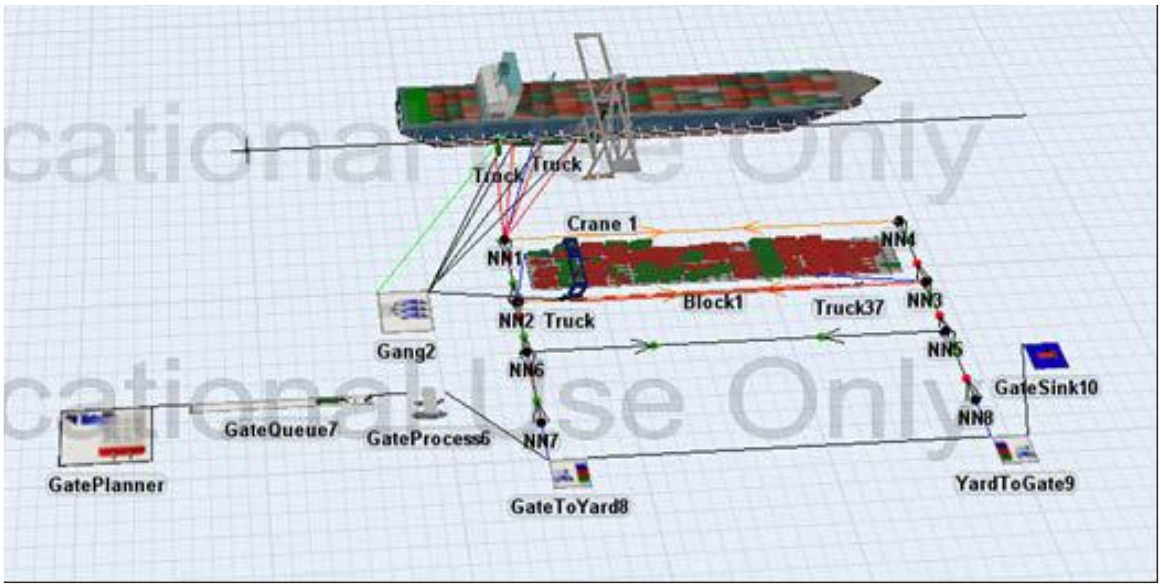


Figure 4. 8: Discrete Event Simulation Model (Source: Azab et al. 2016)

Table 4. 2: Model Parameters

Gate parameters	
Working hours/day	6:00 am – 8:00 pm
Trucking speed (max)	300 m/min
Process time	Triangular (5, 15, 10)
Pick up travel time	triangular(2,5,3)
Drop off travel time	triangular(2,5,3)
Dwell time variability	12 hrs.
Yard parameters	
Container dwell time	3 Days
Pick up time	triangular(0.2,2.0,0.5)
Drop off time	triangular(0.2,2.0,0.5)
Yard crane speed (max)	180 m/min
Quayside parameters	
Quay care speed (max)	120 m/min

In Figure 4.9 the process flow is described.

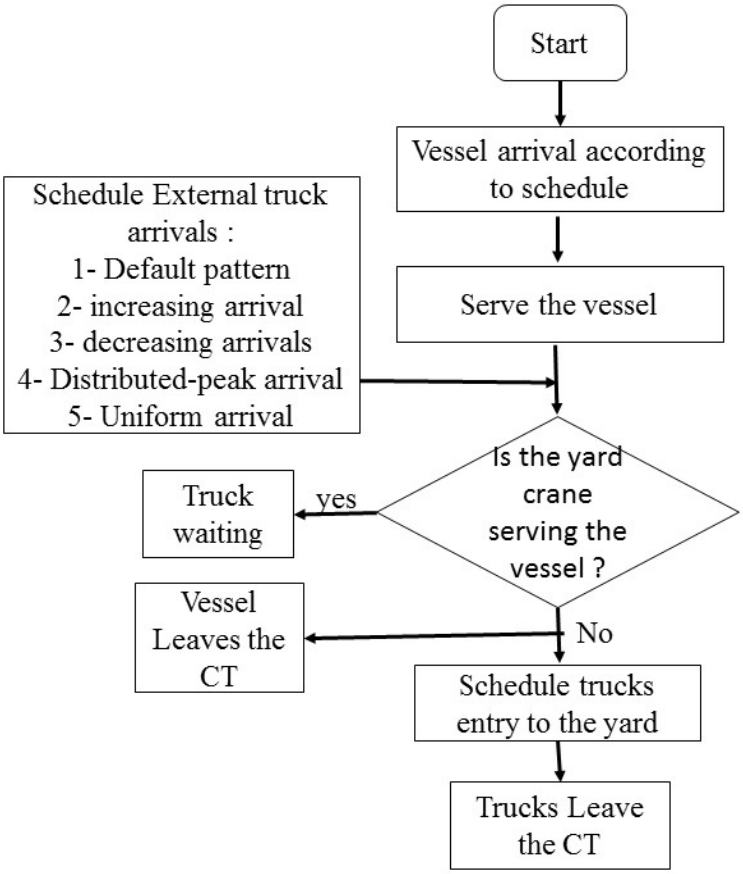


Figure 4. 9: Process Flow (Source: Azab et al. 2016)

Five arrival patterns were tested; the default arrival pattern (Def.), increasing arrival pattern (Inc.), decreasing arrival pattern (Dec.), uniform arrival pattern (Uni.), and distributed-peak arrival pattern (Dist.) (Figure 28). The vertical axis represents the number of external trucks and the horizontal axis represents the day's working hours. These five patterns are developed using the "Gate Planner", which is a part of the FlexSim CT software for planning the gate appointments.

The default pattern shows that arrivals reach a peak in the middle of the day. This situation is simulated using increasing and decreasing patterns. The uniform arrival pattern proposes a stable level of arrival over the day. For the distributed-peak arrival pattern, the arrival peaks are distributed to the beginning and the end of the working day. Figure 4.10 shows the arrival patterns and the actual arrivals on a specific day after running the simulation model. The gray bars represent the actual arrival pattern that is needed to be matched by the gate planner.

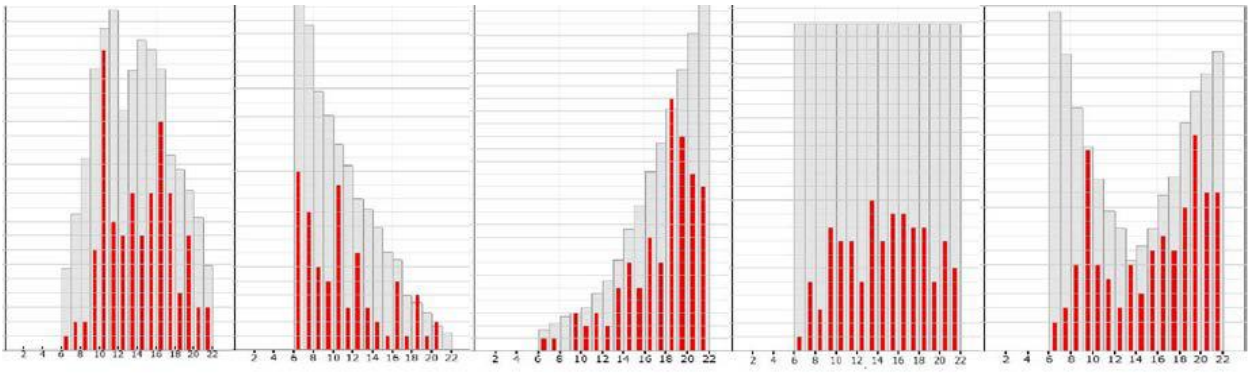


Figure 4. 10: Arrival Patterns: (a) Default Arrival, (b) Decreasing Arrival, (c) Increasing Arrival, (d) Uniform Arrival, and (e) Distributed-Peak Arrival (Source: Azab et al. 2016)

The model is run for 50 replications with a one-week length for each replication. The measures of effectiveness (MOE) studied are the average TTT, minimum and maximum TTT, and maximum queue length at the gate. From this result, it can be seen that the uniform arrivals exhibited the minimum value of TTT among all patterns. The decreasing arrival pattern had a maximum TTT of about 6 hrs. As noticed from the results, the average gate throughput is kept at the same level. This means that the arrival pattern can be used to reduce the TTT without limiting truck arrivals or reducing terminal productivity. The results of the simulation are shown in Table 4.3.

Table 4. 3: Simulation Results

Performance metrics	Def.	Inc.	Dec.	Uni.	Dist.
Average TTT (min)	29.3	48.8	55.1	**20.5**	25.1
Min TTT (min)	11.4	11.4	11.3	11.4	11.3
Max TTT (min)	266.5	417.2	361.6	198.9	200.4
Max Queue length (trucks)	26	41	35	19	19
Average Gate throughput/week	398	398	398	398	398
Variance of gate throughput/week	80.4	71.3	69.2	71.6	67.7

From the results, the uniform arrival pattern exhibited the lowest average of TTT. The simulation work is extended to obtain the best arrival schedule per each hour. 10 replications for the uniform arrivals are performed and the scheduled arrivals for each hour of the working day are recorded. Figure 4.11 shows the average numbers of trucks which are expected to achieve the minimum truck turn time and max gate throughput. Using truck schedules, the terminal operators can design Gate Appointment System which avoids the congestions and long queues at the gates.

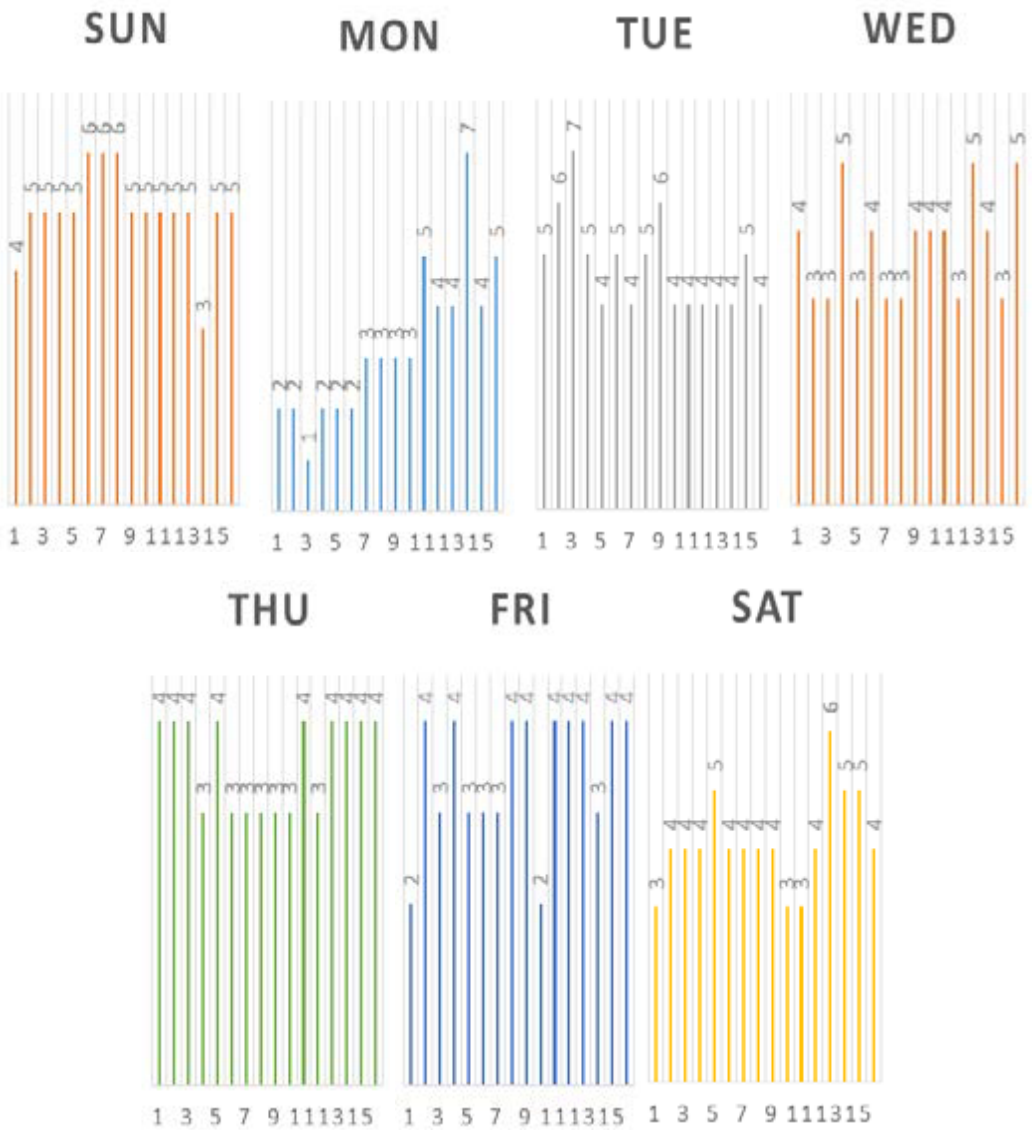


Figure 4. 11: Scheduled arrival during the week according to a uniform arrival pattern for 16 working hours/day (Source: Azab et al. 2016)

4.2.4 Huynh et al. (2005), "Methodologies for Reducing Truck Turn Time at Marine Container Terminals"

The authors of this study investigated the effects of two possible countermeasures to reduce truck turn time at Marine Terminals based on the data collected from Port of Houston Barbours Cut Marine Terminal. The first countermeasure was to see the effect of adding more yard cranes to facilitate the handling of containers more efficiently to reduce truck waiting time. The study tried to find the answer whether it would be beneficial in investing more yard cranes in the terminal. The second countermeasure was to implement a Gate Appointment system. This study analyzed whether the Gate Appointment system can help in reducing the truck turn time. For the Gate Appointment system countermeasure, two issues were investigated: 1) the effect of limiting truck arrivals on crane utilization, and 2) the effect of limiting truck arrivals on the truck turn time.

To investigate the effects of adding more yard cranes on truck turn time, the authors developed two methodologies. The first method was to use statistical models. In this method, field data, including road moves (amount of time a road crane needs to move container from yard storage to trucks), vessel moves (amount of time a yard crane needs to move container from vessels to yard storage), other yard moves (amount of time a road crane needs to perform other movements for transferring containers), re-handles (amount of time a road crane needs to put container on top of another container) and observed Truck Turn Time were collected. Then, three different regression models, including multiple regression models, polynomial regression models and non-linear in parameter regression models, were developed. Table 4.4 shows the list of dependent and explanatory variables for the study.

Table 4. 4: List of Variables for the Multiple-Regression study

Independent Variable	Dependent Variable
Truck Turn Time (TTT)	Vessel moves
	Road moves
	Other yard moves
	Re-handles

The results from the Multiple Regression analysis were shown in Table 4.5.

Table 4. 5: Truck Turn Time Multiple Regression Model

	Model 1		Model 2		Model 3		Model 4	
Variable	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Intercept	50.618	4.14	53.044	5.58	52.559	7.83	35.874	17.35
Cranes	-1.656	-4.44	-1.84	-9.54	-1.842	-9.77		
Vessel Moves	0.002	0.61						
Road Moves	0.018	1.58	0.20	1.92				
Other-yard Moves	0.007	0.56						
Rehandles	0.02	1.95	0.021	2.09				
Total Road Moves					0.021	4.45		
Total Road Moves/Crane							0.185	10.85
Adjusted R^2	0.6728		0.6839		0.6917		0.7254	

Source: Huynh et al. 2005

The second method was to use simulation modeling to model the precise movements of trucks and yard cranes. Then, based on the simulation results, the relationship between the number of cranes and the Truck Turn Time can be obtained.

Figure 4.12 shows the results of the simulation model. Results suggested that overall more crane will result less TTT, which is consistent with the regression results. However, adding additional yard cranes does not necessarily lower truck turn time when number of cranes reaches to certain level. It was due to the randomness in various processes. Another reason was because of the placement of the yard crane in the yard where it might not have the opportunity to perform more moves because work in closer to other cranes.

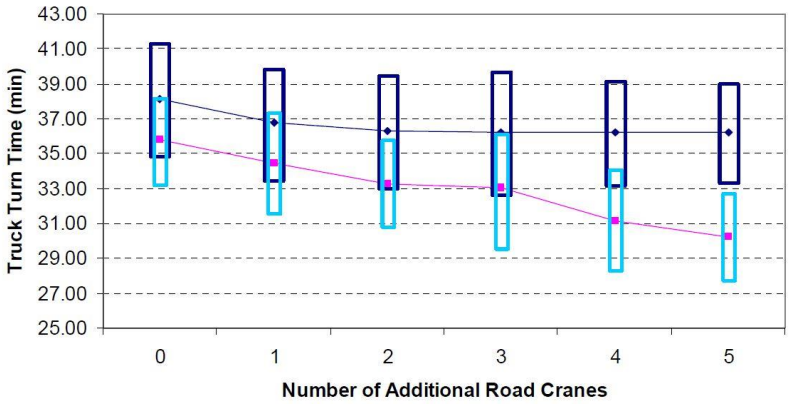


Figure 4. 12: Truck Turn Time vs. Additional Number of Road Cranes. (Source: Huynh et al. 2005)

The simulation method was also used for studying the effect of Gate Appointment System on Truck Turn Time. In this study, a simulation model was developed to find out the optimum number of trucks to be allowed at a given time at the terminal gates.

Figure 4.13 and Figure 4.14 show the results obtained from the simulation. Results indicates that capping which is limiting the arrival rate of trucks can be beneficial in reducing truck turn time. But beyond a certain level, setting the caps too low will result in an increase in truck turn time. Crane utilization is unaffected as long as the cap value is above a certain level. Setting the cap value too low will lead to an inefficient use of resources.

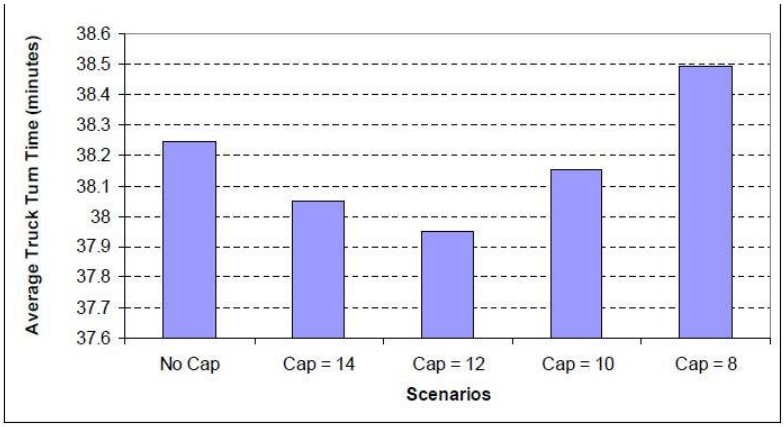


Figure 4. 13: Effect of Capping Truck Entry on Truck Turn Time (Source: Huynh et al. 2005)

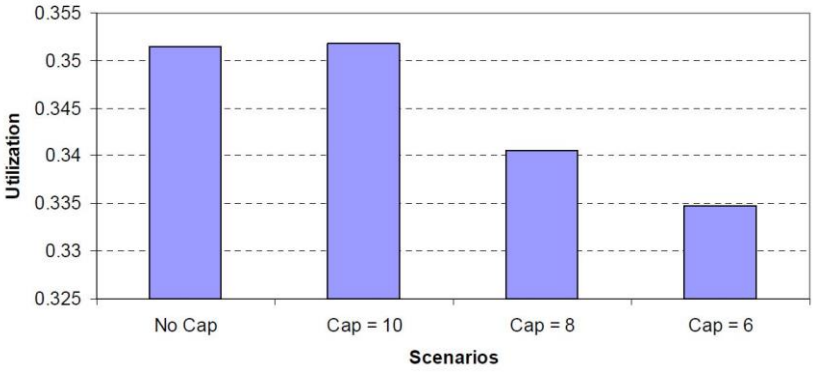


Figure 4. 14: Effect of Capping Truck Entry on Crane Utilization (Source: Huynh et al. 2005)

The study developed several methodologies to address truck turn time. These methods included statistical models and simulation models. This study found that adopting Gate Appointment System can provide better results in terms of reducing truck turnaround time compared with adding extra yard cranes. However, the study was based on the data and layout design of a particular port, i.e. Port of Houston and the results may vary for different ports. Therefore, the results from this study, such as setting a cap of 12 trucks per hour can minimize the TTT, cannot be readily applied to other ports with different resources, capacities, demands, and layouts.

4.3 Survey Based Studies

4.3.1 Philippe Morais et al. (2006), "Terminal Appointment System Study"

The Transportation Development Center of Canada conducted a study that reviewed present strategies and practices used at North American Ports for reducing the truck congestion at Marine Container Terminals.

The study was performed by conducting extensive literature reviews, survey of ports followed by on-site visits and interviews. Twelve largest North American ports by highest annual transiting container volumes (TEUs per year) were selected for the study. Table 4.4 shows the information about the ports selected for this study.

Table 4. 6: List of Ports for the study (Source: 4.3.1 Philippe Morais et al. 2006),

Port Authorities	Containerised Cargo Terminal	Volume (TEUs) in 2003	Existing Terminal Operations Systems(TOS)	Description
Port of Los Angeles	Y	7 178 940	Y	GT Nexus, eModal, shipment link
Port of Long Beach	Y	4 658 124	Y	eModal, Automated Manifest System (AMS), ESC Embarcadero
The Port Authority of New York and New Jersey	Y	2 382 639	Y	eModal, SEALINK, FIRST
Port of Oakland	Y	1 923 104	Y	eModal, ESC Embacadero
Port of Tacoma	Y	1 738 068	Y	eModal, shipment link
Vancouver Port Authority	Y	1 539 058	Y	EModal, Pacific Gateway Portal, Container Terminal Scheduling System
Port of Seattle	Y	1 486 465	Y	EModal, ESC Embacadero
Port of Houston Authority	Y	1 437 585	Y	NAVIS
Montreal Port Authority	Y	1 108 837	Y	NAVIS
Port of Miami	Y	1 041 483	Y	eModal
Jacksonville Port Authority	Y	692 422	Y	eModal
Halifax Port Authority	Y	541 651	Y	COSMOS

In this research, it was found that the use of the appointment system at the observed ports was quite successful in reducing the truck turn time at Marine Container Terminals. However, the findings of the study also stated that the appointment system must be flexible in order to be successful. The study reports that the appointment system should be able to do the following things:

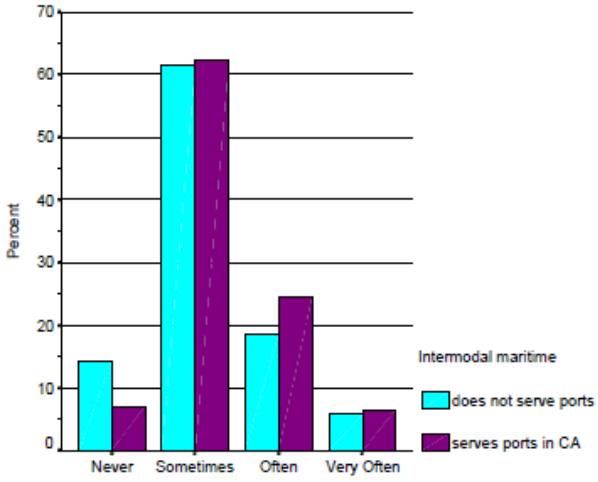
- Handle cancellations.
- Re-assign reserved time which has been canceled.
- Able to make the appointment during the day, not just 24 hours earlier.
- Discourage double/triple assignments for the same container.
- Assign fine for missed reservations.
- Allow one-hour window for the truck to show up.
- Allow reservation by phone.

4.3.2 Golab & Regan (1999), "Trucking Industry Perceptions of Congestion Problems and Potential Solutions in Maritime Intermodal Operations in California"

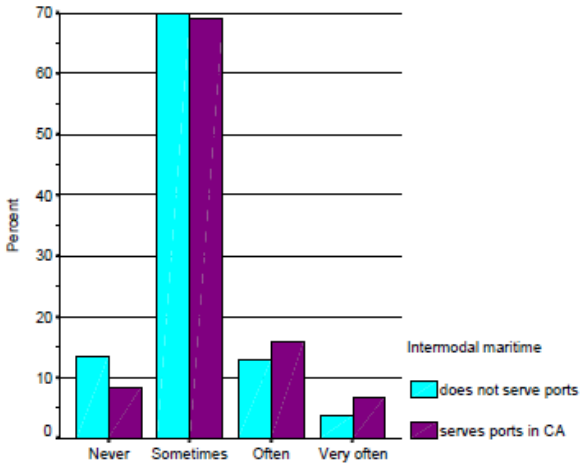
A survey-based study was conducted on about 1200 private for-hire drayage trucking companies operating in California to find out congestion-related problems and solutions faced in marine container terminals. Among these 1200 companies, more than 450 companies had operations involving marine container terminals in California. The purpose of this study was to provide significant insights into the current state of the industry.

The survey was conducted as a computer-aided telephone interview (CATI) in the spring of 1998. Questions were posed to the logistics or operations manager in charge of operations in California. The sample was drawn randomly from a set of 5258 freight operators, broken down into: (1) 804 California-based for-hire trucking companies, with annual revenues of over $1 million, (2) 2129 California-based private fleets of at least 10 vehicles (power units) and (3) 2325 for-hire large national carriers not based in California with annual revenues of over $6 million. The list of companies and individual contact information was drawn from a database of over 21,000 for-hire carriers and 25,000 private fleets maintained by Transportation Technical Services Inc. An overall response rate of 22.4% was obtained, with many of the national carriers excluded on the basis of insufficient operations in the state of California. Eliminating the contacts with no operations in California and invalid telephone numbers, the effective response rate was approximately 35% (1177 participants).

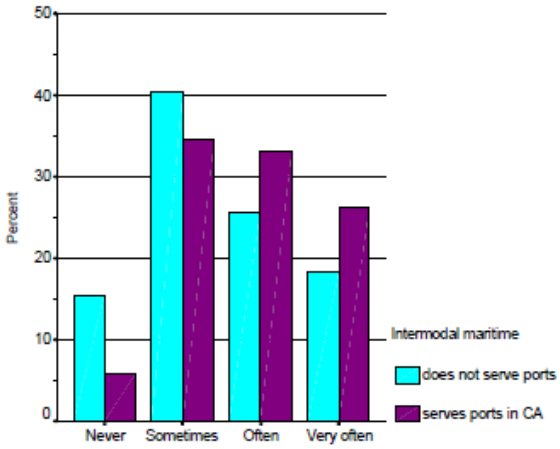
Based on the results of the survey, lots of different factors were analyzed. These factors can be divided into 3 main categories that are: 1) The overall congestion problem, 2) Congestion Problems at Ports In General and 3) Congestion Problems at Specific Ports. For the overall congestion problem, the different factors that were analyzed are: a) frequency with which schedules are missed because of congestion, b) frequency with which drivers are re-routed because of congestion, c) Frequency with which customer time-windows for pickup and delivery force operator to work in congested conditions when the operator would otherwise wait for less congested times and d) Perceived seriousness of the congestion problem. The results of these factors are shown in the following Figure 4.15.



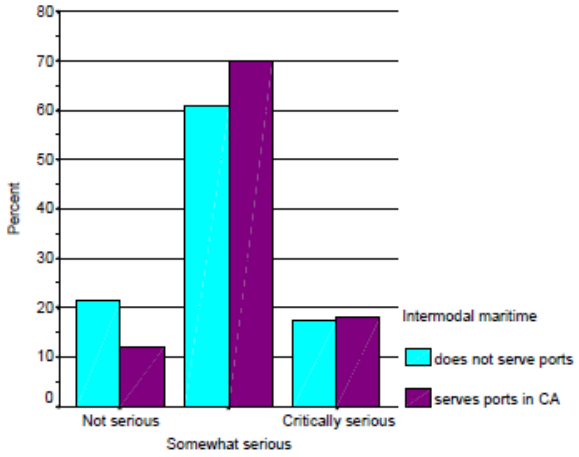
a) Schedules are missed because of congestion



b) Drivers are re-routed because of congestion



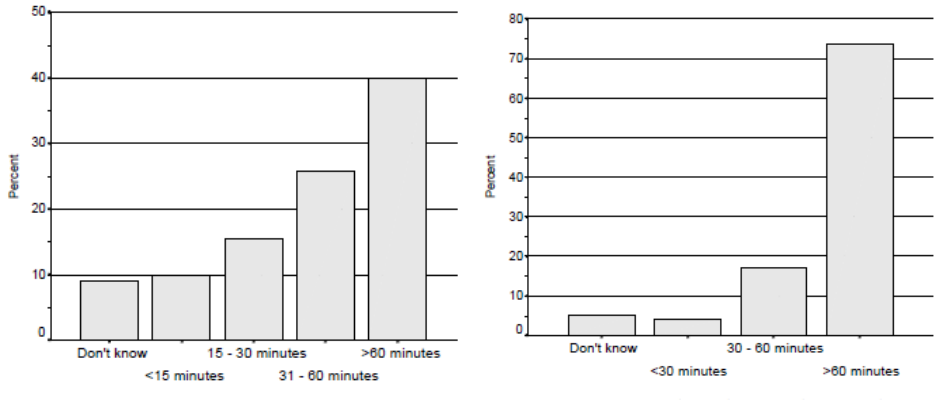
c) Force operator to work in congested conditions



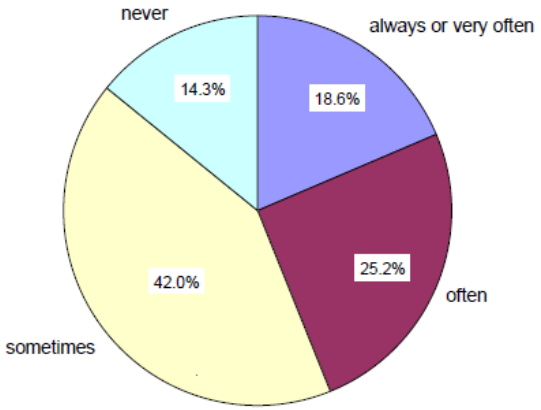
d) Perceived seriousness of the congestion problem

Figure 4. 15: The Overall Congestion Problem (Source: Golab & Regan, 1999)

For the congestion problems at ports in general, the different factors analyzed were a) typical time spent waiting outside a port to get in, b) typical time spent inside a port and c) frequency with which congestion or other problems at maritime port facilities impacts operations. These results are shown in the following Figure 4.16.



a) Typical time spent inside a port **b) Typical time spent outside a port**



c) Frequency with which congestion or other problems at maritime port facilities impacts operations

Figure 4. 16: Congestion Problems at Ports in General (Source: Golab & Regan, 1999)

Some of the questions from the survey were focused on the use of technologies, such as container-status inquiry systems that allow carriers to call ahead for information on the readiness of their loads. However, port operators report that motor carriers use these systems much less than that was expected and drayage trucking companies report that the systems are not as reliable as they would like.

The authors conclude that congestion experienced by truck drivers at California ports is considerable. The continued growth of traffic through her busiest ports, Los Angeles, Long Beach, and Oakland is threatened by the current situation. Whether additional congestion mitigation measures will be needed in that region is unclear at this time. The authors also suggest that Information technologies hold particular promise for reducing delays inside and outside ports. Increased use and reliability of container status inquiry systems which supply carriers with information about what has been unloaded and where on the port property containers are stored could go a long way in preventing the problem of drivers arriving at the port before their loads are ready to be moved. Additionally, information about when carriers

have scheduled their pickups at the port could help port operators make more appropriate decisions about short, medium and long-term staging areas for unloaded containers.

The survey provides valuable insights about the port operators and the trucking companies' perception of truck congestion problems faced at terminals. It can be concluded that congestion problems need to be addressed for better operation within the terminal and efficient drayage operation as well. However, the survey only focused on the problems of terminals and no effective countermeasures were proposed that can help reduce the truck congestion problems, especially at terminal gates. Moreover, the effectiveness of different countermeasures also needs to be evaluated.

4.3.3 Giuliano et al. (2006), "The Terminal Gate Appointment System at the Ports of Los Angeles and Long Beach: An Assessment"

The purpose of this study was to present an evaluation of the terminal gate appointment system at the ports of Los Angeles and Long Beach. The appointment system was implemented in 2002 in response to California Assembly Bill (AB) 2650, which seeks to limit highway congestion by reducing truck queuing at marine terminal gates and distributing truck traffic over a greater period of time throughout the day. The legislation mandates terminals to adopt either gate appointments or off-peak operating hours as a means of avoiding fines for truck queues. This research focuses on an overall assessment of AB 2650 and its impact on the terminals.

The study was conducted by monitoring the gate appointment system over a 16-month period from January 2004, six months after its operational implementation, through June 2005. The data was collected from a number of sources: 1) extended interviews with managers at both ports (Los Angeles & Long Beach), 8 terminal operators, trucking industry representatives, longshore labor, public agency representatives and elected officials; 2) field observations at two terminals; 3) a trucking company survey, 4) SCAQMD compliance reports; 5) publicly available data on port operations; 6) newspapers and newsletters, and 7) data provided by selected terminals.

The intent of AB 2650 was to force some changes in port operation to reduce truck congestion by mandating the terminals to use either gate appointment system or extended gate hour operation. The appointment system was implemented differently across terminals. Some terminals chose to use extended gate hour operation. The most popular web-based information system used to make appointments was e-Modal which existed prior to AB 2650 which provided information on container availability.

Terminal Operator Responses

When the terminal operators were asked about the assessment of the appointment system, they had differing responses. Those who did not see appointments as a useful strategy made the following observations: First, terminals must be flexible and organize their operations based on the nature of their business. Second, the web-based container information systems were already providing data on container availability; hence it was unclear what additional benefit appointments would add. Third, the most promising option for improving productivity is technology, such as efficient use of OCRs (Optical Character Recognition),

using GPS (Global Positioning System) to track container movers, and streamlined cargo tracking. Fourth, an appointment system adds to the data burden of terminal operators. Finally, there is a discouragement for the use of appointments because it was found that, the greater the proportion of appointments, the more likely there will be a long queue, and hence the greater risk of being fined.

The three terminals that had already developed an appointment system see it as an essential means for managing dock operations. They said that appointment slots can be determined for each yard area so that traffic on the docks is smoothed across the day, and so that high demand areas can be rationed.

Trucking Company Responses

A survey of drayage trucking companies was conducted to elicit information on their responses to the appointment system. Results were obtained from 27 companies. All but three firms reported that they use the appointment system, but the extent to which it is used varies greatly, which is consistent with the reports from terminal operators. The average percentage of appointments kept is 63, with a range of 6 to 100percent. Since there is no penalty for missing or canceling appointments, the incentive is to keep appointments only when convenient to do so. The most common reason given for missing an appointment is the delays at the marine terminal. There is an overall perception that the appointment system has not improved conditions for truckers. The majority stated that it did not improve their ability to meet customer demands, or in reducing turn times. No firm gave an unequivocally positive response.

Survey participants were also asked to rate the effectiveness of the appointment system at each terminal in reducing turn times because the intent of AB 2650 was to reduce queuing at the terminal gates, which should, in turn, lead to shorter turn times. Results show that it was also possible that the appointment system would simply shift the queue to inside the terminal if the rate of processing transactions did not change. Written comments, as well as the open-ended discussion conducted with survey participants after completion of the survey, provide some explanations for their negative assessment. First, there was an expectation on the part of truckers that appointments would reduce transaction time by assuring that containers and/or chassis were ready and available for pick-up. However, this was not the case; practices “inside the gate” did not change as a result of the appointment system. Survey participants commented that those with appointments still must wait in line for container moves, may find that the container is not available, or that a chassis is not in working order. Second, some survey participants noted that the real constraints are limited gate hours and limited dock labor. If container volumes are increasing and the container processing rate remains constant, transaction time will increase, with or without appointments. Third, several survey participants noted the difficulty of using several different appointment systems, rather than having one system for all terminals and all appointments. Finally, survey participants cited the difficulties of making and keeping sequential appointments, because any delay with an earlier transaction cascades to all other later transactions.

The survey also included an open-ended question regarding the advantages of using the appointment system. Of the 16 survey participants who answered, 7 said there were no

advantages. Others stated that the appointment system could work better if containers and equipment were ready, on-dock transaction times were reduced, or those with appointments did not have to wait in line at the terminal gates or on the dock.

A number of conclusions can be drawn based on this study. First, the use of the appointment system varies greatly and depends upon operating policies of individual terminals. Second, perceptions of the appointment system's effectiveness differ across user groups. Third, there is no evidence that the appointment system has affected queuing at marine terminal gates and fourth, while a majority of the terminals that did not offer extended gate hours implemented an appointment system in response to the legislation, most did so in order to avoid paying the high labor costs associated with extending operations to off-peak hours. Following is an explanation for the finding concluded from this study:

- The regulation was imposed from the outside, not as an industry response to a perceived problem.
- There were other operational changes already underway that had a more dramatic impact on the ability of terminals to operate more efficiently.
- The costs and risks of not complying were low compared to the alternative of extended gate hours.

However, this study was conducted on the ports of Los Angeles and Long Beach. Further studies should also be conducted across different ports of U.S.A to measure the effectiveness of the countermeasures proposed in this study.

Chapter 5. Survey for Assessing the Effectiveness of Countermeasures

To assess the effectiveness of various countermeasures to reduce truck waiting time at Marine Terminals, a survey was conducted within the greater Houston area. The survey was conducted on various trucking companies and truck drivers. A questionnaire survey was prepared and distributed through mails and emails. Moreover, various truck stops were visited within greater Houston and truck drivers were approached and asked to participate in the survey. The following sections will provide more details regarding this survey-based study. The survey instrument is presented in the Appendix section.

5.1 Methodology

In order to assess the effectiveness and feasibility of the existing countermeasures, a survey was conducted to the officials from drayage companies and truck drivers. The purpose of this survey was to find out the perception of truck drivers and officials of drayage companies about the truck congestion problem at ports and solicit their feedback on the existing countermeasures for reducing truck congestion. A questionnaire survey was prepared which consisted of 22 questions. The survey was conducted on a total of 130 people. The questions were divided into 3 parts.

1) Part 1: general questions regarding marine terminals and operations of drayage companies.

2) Part 2: questions related to truck congestion and other problems faced by truck drivers at marine terminals.

3) Part 3: questions about countermeasures for mitigating truck congestion at marine terminals.

The detailed survey instrument is provided in the appendix. The participants of the survey comprised of truck drivers and officials of different drayage companies in the greater Houston area. All these surveyed drayage companies and truck drivers had regular business with ports and need to go to marine terminals for picking or delivering goods on a regular base.

The survey was conducted by three different approaches. First, the survey was sent through e-mail to different truck drivers and officials of drayage companies. Second, the survey forms were mailed to drayage companies situated in the greater Houston area. Third, a field survey was conducted on 6 truck stops within the greater Houston area where truck drivers were approached directly and asked to participate in the survey. Besides, an interview with the gate manager of Barbour's Cut Container Terminal was conducted to gather opinions from the port authority. After the survey was completed, the responses were recorded and analyzed. From the survey responses, problems at the marine terminals were identified and the effective countermeasures for mitigating truck congestions at marine terminals and the strategies for improving their effectiveness were also identified.

5.2 Data Collection

Data were collected through conducting a survey through mails and emails to various trucking companies operating within greater Houston. Besides, an interview with the gate manager of Barbour's Cut Container Terminal was also conducted to gather opinions from the port authority. Moreover, a number of truck stops were visited and truck drivers were approached and requested to participate in the survey and their responses were collected. All the data collected were analyzed in statistical software SPSS and Microsoft Excel. After analyzing the responses, conclusions were drawn and presented in this report.

5.3 Results & Discussion

5.3.1 General questions regarding marine terminals and operations of drayage companies

Types of Services Provided by Drayage Companies

Survey participants were asked the types of services they provided (Pickup, Delivery or both). 45 out of 130 responders said that they provided both pickup and delivery services which constitute about 35% of all the participants. 47 people answered only delivery, and 27 people answered only pickup.

Average Length of Movement by Trucks

Responders were asked the average length they have to travel from/to the marine terminal. The options were less than 50 miles, 50-99 miles, 100-249 miles, 250-499 miles, and 500+ miles. 34 out of 130 people responded they traveled less than 50 miles whereas only 8 people responded 500+ miles.

5.3.2 Questions related to truck congestion and other problems faced by truck drivers at marine terminals

Perceived Seriousness of Congestion Problem at Terminals

Survey responders were asked about the seriousness of truck congestion at marine terminals. Only 28 people out of 130 responded that the congestion problem is not serious at marine terminals. The rest of the responses ranged from somewhat serious to very serious apart from the 11 missing responses. Figure 5.1 presents the survey results regarding the perceived seriousness of congestion problem at terminals.

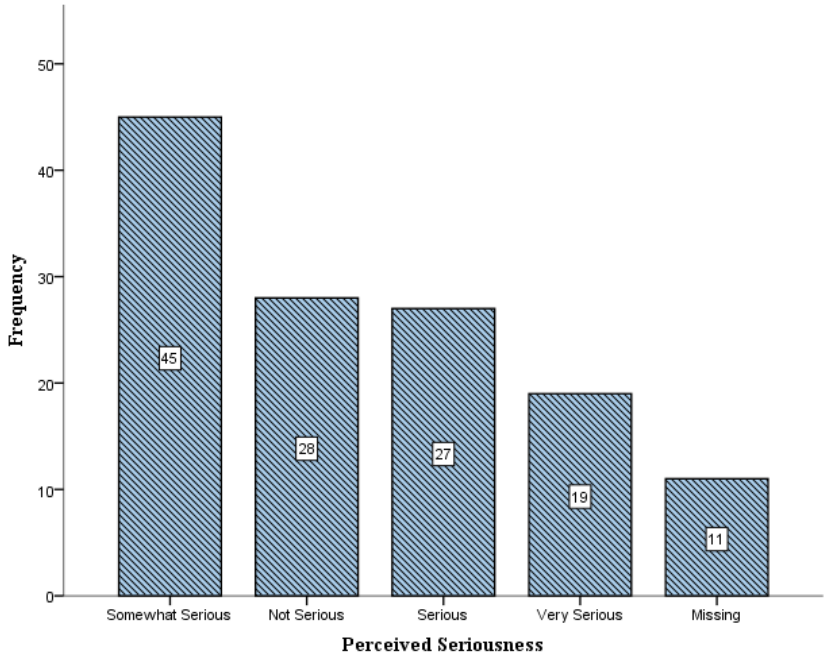


Figure 5. 1: Perceived Seriousness of Congestion Problem

Problems Faced at Marine Terminals

Several problems that are faced by truckers at marine terminals have been identified by the literature and the survey participants were asked to rate the problems according to their severity. The mean scores of each of the problems were calculated on a scale of 4. Figure 5.2 presents the survey results regarding the problems faced at terminals. Based on the responses, "Congestion/Waiting/Delays" is identified as the most severe problem faced by truckers which received a mean score of 2.82 and followed by "Slow Operation" which received a mean score of 2.62.

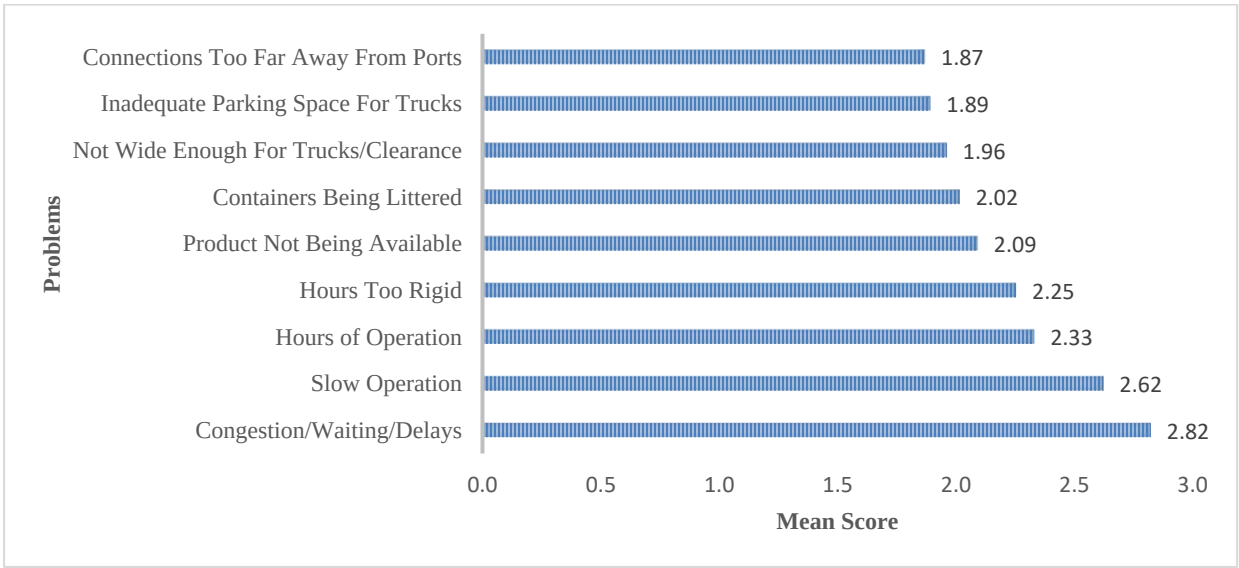


Figure 5. 2: Mean Values of Problems Faced at Terminals (On a scale of 4).

5.3.3 Questions about countermeasures for mitigating truck congestion at marine terminals

Effectiveness of Gate Appointment System

Survey participants were asked about the effectiveness of the gate appointment system. The options ranged from not effective to very effective. Figure 5.3 presents the survey results regarding the effectiveness of gate appointment system. Only 30 people felt it was not effective and the rest of the responders felt gate appointment system was at least somewhat effective in reducing truck congestion at marine terminals.

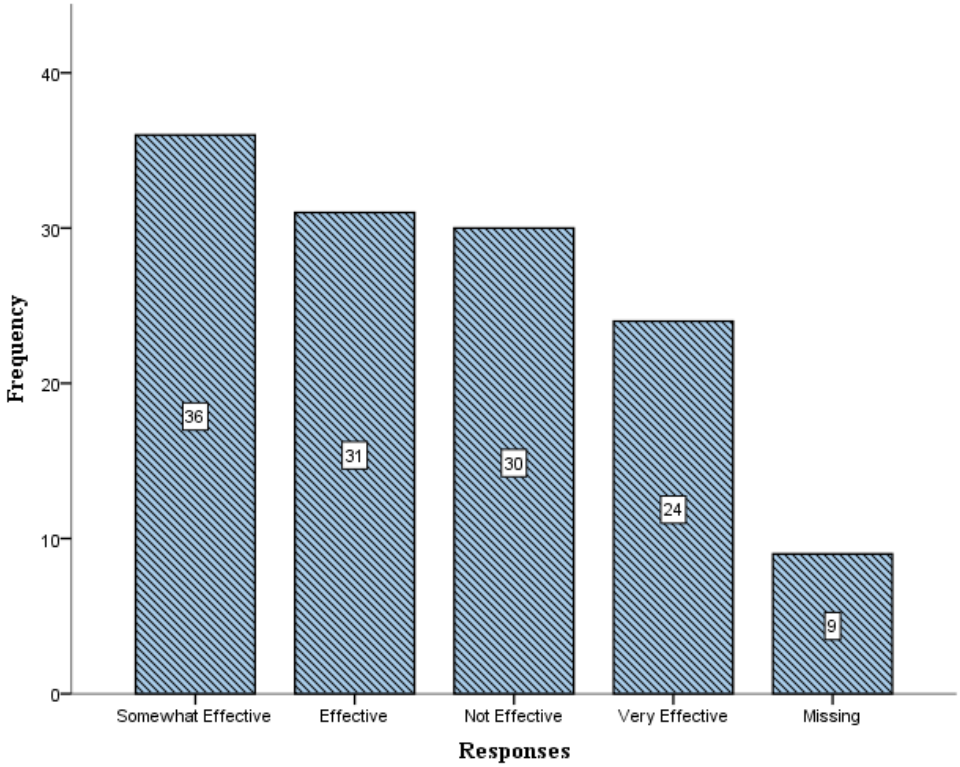


Figure 5. 3: Effectiveness of Gate Appointment System.

Strategies for Improving the Effectiveness of Gate Appointment System

As discussed in the "Countermeasures" section, the gate appointment system can be more effective by applying several strategies. The survey participants were asked to vote for the strategies that can improve the effectiveness of gate appointment system. The participants were provided with the option to select more than one strategy. Table 5.1 presents the survey results regarding these strategies.

Table 5. 1: Strategies for Improving the Effectiveness of Gate Appointment System

Strategies	Number of Votes	Percentage
Having Dedicated Lanes for Trucks with Appointments	80	61.50%
Agree to Appointments Made During That Day	70	53.80%
Handle Cancellations of Appointments by Phone	69	53.10%

Allow for Reservation by Phone	64	49.20%
Re-assign Reserved Time That Has Been Cancelled	64	49.20%
Better Organization of Terminal Operations	64	49.20%
Gathering All Trucks in Marshalling Yard	54	41.50%
Decline Double/Triple Appointments for The Same Container	53	40.80%
Fines for Missed Reservations	54	41.50%
Operation Based on Container Appointment	50	38.50%

It's clear from the above table that "Having Dedicated Lanes for Trucks with Appointments", "Agree to Appointments Made During That Day" and "Handle Cancellations of Appointments by Phone" were the most popular choices among the participants as 61.50%, 53.80% and 53.10% people selected those strategies over other strategies respectively.

Effectiveness of Extended Gate Hour

Participants were asked about the effectiveness of extended gate hour in mitigating truck congestion at marine terminals. 26 people responded it was very effective and 30 people responded it was not effective. Figure 5.4 presents the survey results regarding the effectiveness of extended gate hours.

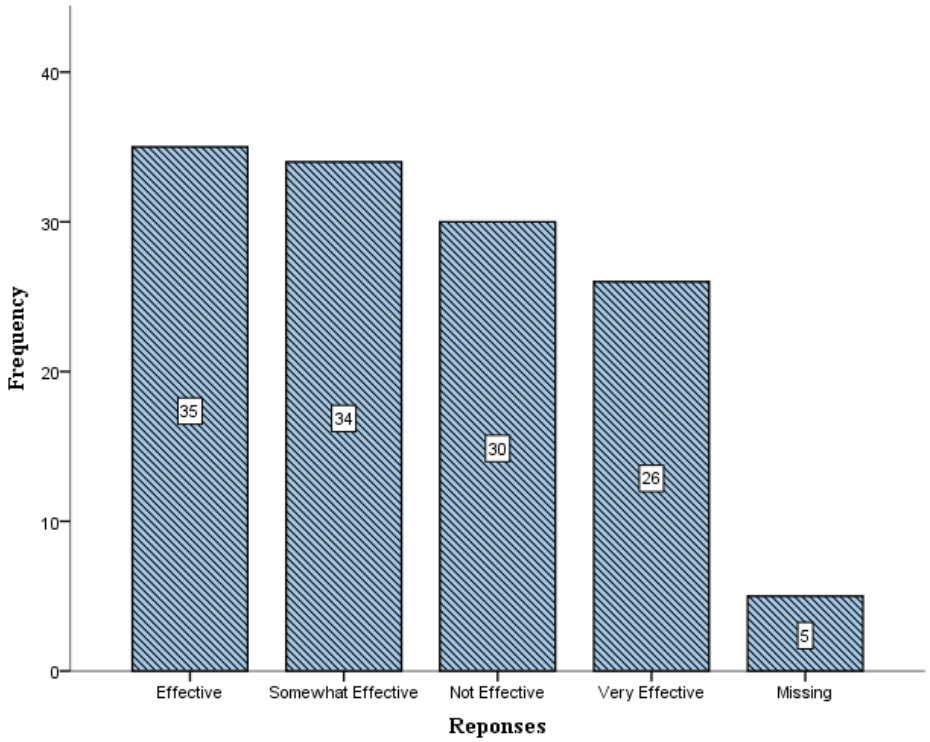


Figure 5. 4: Effectiveness of Extended Gate Hour

Strategies for Improving the Effectiveness of Extended Gate Hour

Similar to the question about strategies for gate appointment system, survey participants were also asked to vote for the strategies that can improve the effectiveness of extended gate hour. Likewise, the participants were provided with the option to select more than one strategy. Almost 61% people preferred the strategy "Use Extended Gate Hour with Gate Appointment System" over other options. "Provide Incentives to Drayage Operators" were preferred by almost 53% of participants. The following Table 5.2 shows the strategies for extended gate hour.

Table 5. 2: Strategies for Extended Gate Hour.

Strategies	Number of Votes	Percentage
Use Extended Gate Hour with Gate Appointment System	79	60.80%
Provide Incentives to Drayage Operators	68	52.30%
Regular Hour Surcharge	57	43.80%
Use Extended Gate Hour in Weekends	79	60.80%

Other Operational Countermeasures for Reducing Truck Congestion at Terminals

Several other operational countermeasures were identified from the literature review. Survey participants were asked to rate the countermeasures based on their effectiveness. The mean score of each of the countermeasures was calculated on a scale of 4. Figure 5.5 presents the survey results regarding other operational countermeasures. "Connect Truckers and Cargo Owners by Third Parties" received the highest mean score of 2.75 among all the other countermeasures which was followed by "Promote Two-way Loaded Movement" (a mean score of 2.54) and "Pre-staging Containers for Bulk delivery" (a mean score of 2.39). All the other countermeasures received scores below 2.

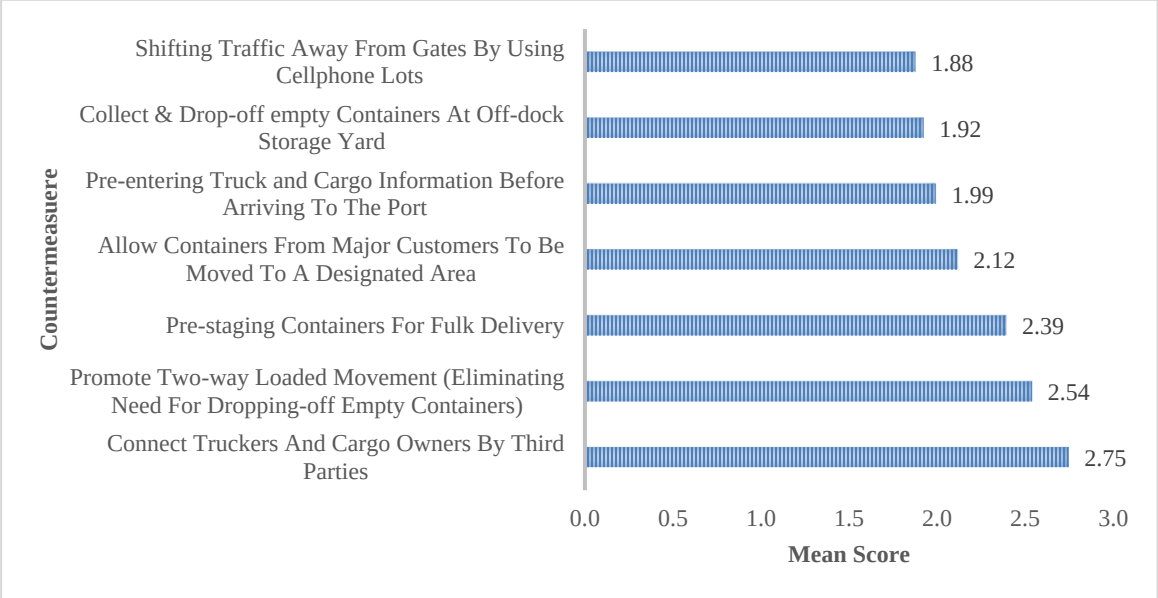


Figure 5. 5: Mean Values of Countermeasures to Reduce Truck Congestion at Terminals (On a scale of 4).

Effectiveness of Technology-Based Countermeasures

Participants were asked about the effectiveness of different technologies used in marine terminals for improving operation and reducing truck congestion. Only 22 out of 130 people felt technologies were not effective. 9 responses were missing. Figure 5.6 presents the survey result regarding the effectiveness of technology-based countermeasures.

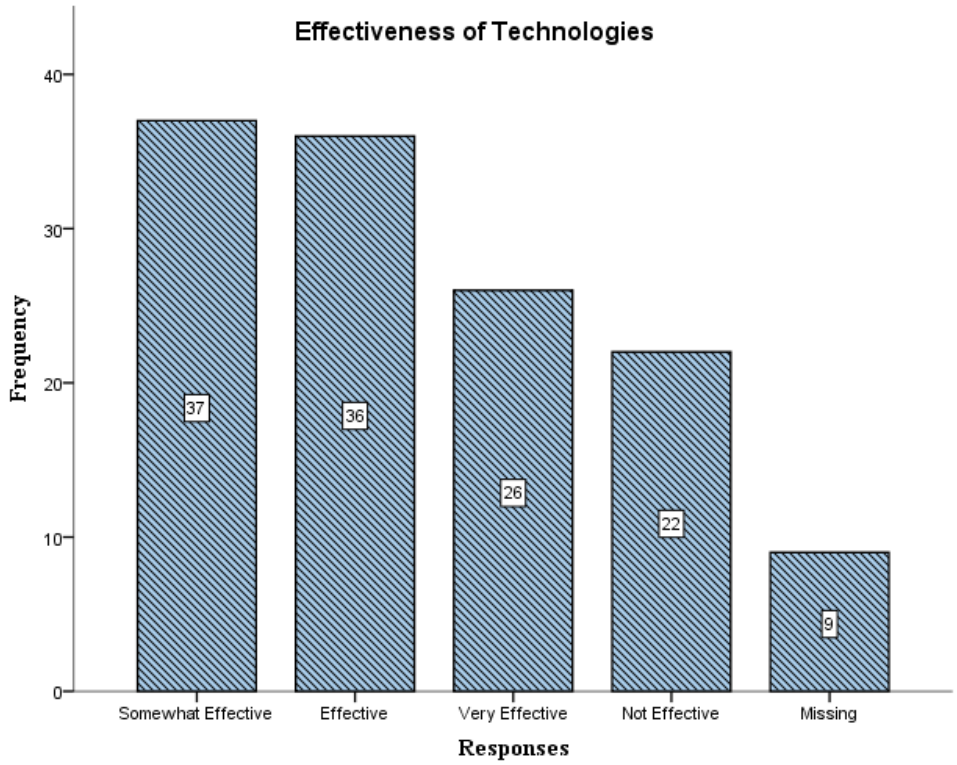


Figure 5. 6: Effectiveness of Technology-Based Countermeasures.

5.3.4 Summary of the Open-ended Questions

In the survey questionnaire, the participants were also asked some open-ended questions to provide their suggestions/comments regarding problems faced at terminals and countermeasures. Some of the participants provided their opinions regarding these issues. The main findings from these responses are summarized below:

- Off-dock storage yards are effective in mitigating truck congestion when the number of trucks doesn't exceed a certain limit. This number depends on the configuration and capacity of the terminal.
- Technologies can be used to improve the communication between drivers and terminal operators so that the drivers don't arrive at the terminal before the availability of the container.
- The procedure to resolve issues regarding trouble tickets could be improved by using innovative technologies to reduce truck waiting time inside the terminal.

- The gate appointment system will not work for the trucks that need to visit the terminal more than once in a day. It is because that the truck turnaround time in the marina terminal is very difficult to predict. If the trucks miss one appointment, all the rest of the appointments needs to be rescheduled. Therefore, the gate appointment system is more feasible for the trucks that only need to visit the terminal once a day.

Chapter 6. Conclusions and Recommendations

In this study, a thorough literature review on countermeasures/strategies for reducing truck congestion at marine terminals was conducted. In addition, a survey was conducted to the officials and truck drivers from drayage companies who perform regular operations at marine terminals.

Key findings revealed by the literature review include:

Gate Appointment System

- In order for a gate appointment to be successful, further strategies should be in place for processing the trucks arriving before or after their appointment time. Two strategies for processing the trucks with or without appointments are recommended: 1) having dedicated lanes for trucks with appointments; 2) gather all trucks in marshaling yard and service according to a pre-determined pattern.
- To fully take advantage of an appointment system, terminal operations must also be organized, so that when a truck makes an appointment, containers are ready for pick up.
- Several other strategies can be applied along with the gate appointment system in order for the gate appointment system to be more successful. These strategies are:

    1) Appointments can be made during the day, not just 24 hours ahead of time,
    2) Allow for reservation by phone,
    3) Re-assign reserved time that has been canceled,
    4) Decline or discourage double/triple appointments for the same container,
    5) Fines for missed appointments,
    6) Handle cancellations of appointments by phone, and
    7) Operate based on container appointment (not truck appointment).

Extended Gate Hours

- Extended Gate Hours can exist in isolation or can be implemented together with Gate Appointment System.
- Several strategies can be implemented to make extended gate hour system work more efficiently. These strategies are:

    1) Use extended gate hour on weekends,
    2) Use extended gate hour with the gate appointment system,
    3) Provide incentives to drayage operators,
    4) Regular hour surcharge to encourage truck arrivals in extended hours.

Other Operational Countermeasures

- Apart from gate appointment system and extended gate hour, there are other operational countermeasures, such as pre-staging containers for bulk delivery, pre-entering truck and cargo information before arriving at the port, using cellphone lots, using off-dock storage yard, connect truckers and cargo owners by third parties, and promoting two-way loaded movement.

Technology-Based Countermeasures

The implementation of advanced technologies and information systems could also improve the operational efficiencies of marine terminals. In this report, state-of-art technologies used to reduce truck congestion in the marine terminal were introduced, which include:

1) Automation Technologies, such as Optical Character Recognition, Global Positioning System, Radio Frequency Identification Device, Barcode Readers, Voice Recognition, Automated Guided Vehicle (AGV)
2) Terminal Operating Systems, such as Freight Information Real-Time System for Transport (FIRST), Pacific Gateway Portal (PGP), SynchroMet, SEA LINK®, eModal, NAVIS, COSMOS, Embarcadero (ESC), Maher Terminal Logistics Systems Gate and Yard Automated System
3) Other Technology-Based Countermeasures such as Virtual Container Yard (VCY)

The description for each countermeasure was summarized into several tables.

The results of the survey conducted in this study lead to the following key findings:

- "Congestion/Waiting/Delays" and "Slow Operation" are the two most concerning problems faced by the US marine terminals.
- Gate appointment system and extended gate hour operation are two effective and most popular countermeasures that have the potentiality to mitigate truck congestion and there are some strategies could be used with these countermeasures to improve their effectiveness. Specifically,
    - "Having Dedicated Lanes for Trucks with Appointments", "Agree to Appointments Made During That Day" and "Handle Cancellations of Appointments by Phone" are the preferred strategies for using a gate appointment system, and
    - "Use Extended Gate Hour with Gate Appointment System" and "Provide Incentives to Drayage Operators" are the preferred strategies for using extended gate hour operation.
- There are other operational countermeasures that can mitigate truck congestion at marine terminals. Among them, "Promote Two-way Loaded Movement", "Connect Truckers and Cargo Owners by Third Parties" and "Pre-staging

Containers for Bulk Delivery" are preferred by the truck drivers and drayage companies.

In addition, more useful information about the effectiveness and limitations of some countermeasures are obtained from answers to the open-ended questions. The findings of this study will help port managers to select the most feasible and cost-effective countermeasures for reducing truck congestion at marine terminals in the future. In this study, the survey responses are received from 130 participants in the greater Houston area. The results of this research could be improved by conducting a survey on more truck drivers and drayage companions in different areas in the future.

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Appendix: Survey Instrument

Survey Consent Form

The transportation researchers at Texas Southern University is conducting a research project titled "innovative countermeasures for reducing the truck waiting time at marine terminals" for the Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE). For this study, we are conducting a survey on different marine terminals and trucking companies in Texas. The purpose of this survey is to assess the effectiveness of different innovative countermeasures for reducing truck waiting times at marine terminals. Your responses to this survey will provide important information for formulating solutions in reducing terminal congestion in the future.

PARTICIPATION

Your participation in this survey is voluntary. You may refuse to take part in the research or exit the survey at any time without penalty. You are free to decline to answer any particular question you do not wish to answer for any reason.

BENEFITS

You will receive no direct benefits from participating in this research study. However, your responses will help us to determine best possible countermeasures to mitigate truck turnaround time at Marine Terminals especially at terminal gates.

RISKS

There are no foreseeable risks involved in participating in this study

CONFIDENTIALITY

Your survey answers will remain anonymous. No one will be able to identify you or your answers, and no one will know whether or not you participated in the study. However, you will be asked to provide your name, contact information and email address but it's completely up to you whether you want to provide this information or not.

CONTACT

If you have questions at any time about the study or the procedures, you may contact me (Hasin Fahad Jinna) via phone at 713-345-0627 or via email at h.jinna7327@student.tsu.edu.

CONSENT

"This study has been explained to me. I volunteer to take part in this research. I have had an opportunity to ask questions. If I have questions later about the research, I can ask one of the researcher(s) listed above. If I have questions about my rights as a research participant, I can call the Texas Southern University Office of Research at 713-313-4301, or go to visit the Office of Research on the Texas Southern University website (http://www.tsu.edu)."

Please select your choice below. You may print a copy of this consent form for your records. Clicking on the "Agree" button indicates that

- You have read the above information
- You voluntarily agree to participate
- You are 18 years of age or older

Agree ☐
Disagree ☐

Enclosed you will find a self-addressed, stamped envelope to use when returning the survey. Please feel free to include any additional comments you deem necessary or relevant to this project. Your response and time is greatly appreciated. Thank you!

Name of Port/Terminal: _____ E-mail: _____

Contact No: _____ Years in Practice: _____

Part 1. General questions

1. What are the operating hours in the terminal when trucks can enter/exit the terminal precinct?

_____

2. Does the terminal operate during the weekends? A) Yes ☐ B) No ☐

Part 2. Congestion related questions at Marine Terminals

3. How serious the truck congestion problem is especially at ports? A) Not serious ☐
B) Somewhat serious ☐ C) Serious ☐ D) Very serious ☐ E) Extremely serious ☐

4. What is the typical time that import/export trucks have to wait at the gate of container terminals to get in?

A) < 15 minutes ☐ B) 15-30 minutes ☐ C) 30-45 minutes ☐ D) 45-60 minutes ☐

E) >60 minutes ☐

5. What is the typical time that import/export trucks have to wait inside terminals?
A) < 15 minutes ☐ B) 15-30 minutes ☐ C) 30-45 minutes ☐ D) 45-60 minutes ☐
E) >60 minutes ☐

6. How frequently, there is congestion of import/export truck activity during the peak hours?
A) Never ☐ B) Sometimes ☐ C) Often ☐ D) Very often ☐ E) Always ☐

7. How frequently, people serving the trucks in the landside area are shifted to the quayside area to serve the vessels? A) Never ☐ B) Sometimes ☐ C) Often ☐ D) Very often ☐
E) Always ☐

8. How often the terminal is over saturated by the number of trucks? A) Never ☐ B) Sometimes ☐ C) Often ☐ D) Very often ☐ E) Always ☐

9. How often the number of trucks to be served at the gates is greater than the service rate (The time allotted for each truck to be served)? A) Never ☐ B) Sometimes ☐ C) Often ☐ D) Very often ☐ E) Always ☐

10. Typically during which period of the day, the number of trucks to be served is the highest and greater than the service rate? A) Early morning ☐ B) Morning ☐ C) Noon ☐ D) Afternoon ☐ E) Evening ☐ F) Night ☐

11. Please provide your comments/suggestions/concerns about truck congestion in ports/terminals.

Part 3. Countermeasures to mitigate Truck Waiting time at Marine Terminals

12. Please rate the following countermeasures according to the measure of effectiveness in reducing truck turn time at Marine Terminals (1= not effective to 5 = very effective).

Countermeasure	Not effective				Very effective
	1	2	3	4	5
Pre-staging containers for bulk delivery					
Pre-entering truck and cargo information before arriving to the port					
Shifting traffic away from gates by using cellphone lots and paging drivers using a smartphone application					
Collect & drop-off empty containers at off-dock storage yard					
Allow containers from major customers to be moved to a designated area (off-dock storage yard) where truckers could quickly peel off those containers destined for distribution centers inland.					

Connect truckers and cargo owners by third parties (triangulation of trucker calls) in a region so that a container that is unloaded at a distribution warehouse is matched with an exporter that needs the empty container.so that trucker delivers the empty container to the exporter rather than bringing it back to the marine terminal					
Promoting two-way loaded movement (eliminating the need for dropping off empty containers)					
Assigning specific yard cranes to serve import/export trucks only					

13. Please provide your comments/suggestions/concerns about reducing truck turn time at Marine Terminals.

Gate Appointment System

14. Does your port/terminal use the Gate Appointment System? A) Yes ☐ B) No ☐ (If yes, then answer the following set of questions, otherwise skip this section)

15. Do you think Gate Appointment System is effective in mitigating truck waiting time at terminal gates? A) Not effective ☐ B) Little effective ☐ C) Somewhat effective ☐ D) Effective ☐ E) Very effective ☐

16. Please select the following strategies in order for a Gate Appointment System to be successful (Check all that apply).

A) Having dedicated lanes for trucks with appointments ☐ B) Gather all trucks in marshalling yard and service them according to a pre-determined pattern ☐ C) Better organization of Terminal Operations ☐ D) Handle cancellations of appointments by phone ☐ E) Re-assign reserved time that has been cancelled ☐ F) Agree to appointments there are made during the day, not just 24 hours ahead of time ☐ G) Decline or discourage double/triple appointments for the same container ☐ H) Fines for missed reservations ☐ I) Operate based on container appointment (not truck appointment) ☐ J) Allow for reservation by phone ☐

17. Please provide your comments/suggestions/concerns about the Gate Appointment System.

Extended Gate Hour

18. Does your port/terminal use the Extended Gate Hour Operation (Off-Peak Program? A) Yes ☐ B) No ☐ (if yes, then answer the following set of questions, otherwise skip this section)

19. Do you think Extended Gate Hour Operation is effective in mitigating truck waiting time at

terminal gates? A) Not effective ☐ B) Little effective ☐ C) Somewhat effective ☐ D) Effective ☐ E) Very effective ☐

20. Please select the following strategies in order for Extended Gate Hour Operation to be successful at mitigating truck waiting time at marine terminals (Check all that apply).

A) Use Extended Gate Hour in weekends ☐ B) Use Extended Gate Hour with Gate Appointment System ☐ C) Provide incentives to drayage operators ☐ D) Peak hour surcharge ☐

21. Please provide your comments/suggestions/concerns about Extended Gate Hour Operation in reducing truck turn time at terminals.

Technologies

Following is a table of summary of technologies that are currently being used in ports/terminals.

A) Optical Character Recognition: Automatically identify containers, truck plate and chassis information at entry and exit gates, yard and quay operations.

B) Global Positioning System: Identify container position in terminal.

C) Radio Frequency Identification Device: Track trucks, containers and cargo in terminal.

D) Barcode Readers: Identify containers position in terminal.

E) Voice Recognition: Assist in capturing and processing data, provide communications between the crane operator and ground personnel.

F) Automatic Gate Systems: Use camera portals and optical recognition to read the number on the container, search the billing file to see whose cargo it is, and determine where it needs to go. Drivers can be identified with fingerprints, increasing security and accountability.

G) Automated Guided Vehicle: Driven by an automatic control system which serves as the driver. It is considered to be the most flexible type of material handling system.

H) Virtual Container Yard: A web-based information system with inventory of empty containers allowing suppliers and shippers to access containers at convenient storage locations outside the terminal.

I) FIRST: Web based real-time network integrates many resources into a single show on cargo and port information.

J) PGP: Web based system provides containers status, vessel activity, and real-time video images from port landside infrastructure and driver validation.

K) SynchroMet: Virtual container yard to alleviate public road and port congestion at local marine terminals.

L) SEA LINK: Truck driver identification system to speed trucks through marine terminal gates.
M) eModal: Web based system provide all container information needs: container status, vessel schedules, terminal locations, truck driver lists.
N) NAVIS: Automate and integrate data input, real-time monitoring at terminal.
O) COSMOS: Integrated yard control and terminal/vessel planning system in real time by radio frequency.
P) ESC Embarcadero: Web-based visibility tools use DGPS and WLANS to report position of equipment and provide real-time communication.

22. What are the technologies that are used in the terminal where you work? (please provide names)

23. Do you think Automation Technologies are effective in mitigating truck waiting time at terminal gates? A) Not effective ☐ B) Little effective ☐ C) Somewhat effective ☐ D) Effective ☐ E) Very effective ☐

24. Please provide your comments/suggestions/concerns about using Technologies in reducing truck turn time at terminals.