Relieving Congestion at Intermodal Marine Container Terminals: Review of Tactical/Operational Strategies

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ABSTRACT

Until 2009, intermodal marine container terminals had experienced constant growth in container volumes since widespread containerized trade began. Even with the downturn in freight volumes due to recent economic conditions, forecasts are that freight volumes will rebound and will increase dramatically by 2020, resulting in substantial increases in congestion. The port industry is under pressure to develop strategies and capacity to accommodate these increasing freight volumes. Efficient gate operations are crucial to intermodal freight terminals since their impact is not isolated to the efficiency of the operations within the terminal but also extends to the road traffic on nearby freeways and access ramps. Inefficient gate operations can spill over to the surrounding roadway network causing serious safety and congestion problems, and degrading the reliability and performance of carriers, shippers, and terminal operators. Since intermodal freight terminals tend to be 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 to the surrounding roadway network becomes more important and more viable than physical capacity expansions. There is an ongoing discussion concerning the implementation of different gate operation strategies that may relieve these effects. Among the gate operation strategies being considered to relieve the impacts of congestion and delay are gate appointment systems, extended hours of operations for terminal gates, and advanced technologies for gates and terminals. The purpose of this paper is to critically review the published literature on the different gate strategies. This paper also presents existing attempts at reducing truck queues at terminal gates and improving terminal operations and traffic conditions in the vicinity of the terminals and the technologies available that support the implementation of this type of strategies.

INTRODUCTION

International trade has greatly increased in the last twenty years in particular between Asian and US intermodal marine container terminals (IMCTs), and especially for movements involving intermodal containers. According to the Bureau of Transportation Statistics (BTS), water-borne goods shipments account for about 28% of all US international merchandise trade in terms of value (Bureau of Transportation Statistics 2006). IMCTs are places where most of the world's goods are transferred. They represent major nodes of transportation networks, where freight commodities leave and arrive via truck, train and/or vessels. Demand for all modes of transportation carrying freight has increased over the last 25 years, especially for trucks that today carry approximately 60% of the domestic freight by weight and nearly 70% by value (Bureau of Transportation Statistics 2006). Projections indicate that by 2020, 80% of domestic freight by weight will be moved by trucks (Bureau of Transportation Statistics 2006). According to Madsen H-O (2009), VP Business Development for the APM Terminals, "Current World Bank analysis calls for a decline in world trade volume of -2.1% for this year, before rebounding to a projected 6% growth in 2010. Even allowing for the current downturn in global trade, and the first potential decline in container traffic ever in the more than three decades since the inception of wide-scale containerization, current projections call for world-wide container volumes to double by the year 2020." This increase of trade has impacted the roadway transportation systems of metropolitan areas, especially around the major generators (ports, airports, rail yards, and industrial areas) causing congestion, delays, and air and noise pollution (Bureau of Transportation Statistics 2006).

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. The problem of congestion also extends to the yard of the terminals where coupled with capacity issues, it can degrade the reliability and performance of carriers, shippers, and terminal operators. In addition to the deterioration of the performance of terminal and drayage operations, the environmental effects from idling trucks has also been starting to emerge as a serious problem as truck emissions have been linked to health conditions including asthma, cancer and heart disease (Solomon and Bailey 2004). Since intermodal freight terminals tend to be 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 becomes more important and more viable than physical capacity expansions.

There is an ongoing discussion concerning the implementation of different operational strategies that may relieve these effects, while ensuring better handling and storage operational conditions inside container terminals. These strategies include, among others, gate appointment systems, gate extended hours of operation, truck buffer areas etc. The purpose of this paper is to review current literature regarding gate appointment systems and extended gate hours. In addition to reducing waiting times at terminal gates and improving the overall terminal operations (i.e. truck interchange and storage yard operations), these strategies may also be able to reduce congestion in nearby communities. This paper explores the problem of the anticipated increased intermodal traffic at ports, legislation that has spurred the need for efficiency and congestion reduction, existing attempts at reducing truck queues at terminal gates, technologies available for truck appointment systems, and the long-term viability of these strategies. In addition, the resulting impact on other transportation stakeholders and application to other modes is briefly discussed.

The following section describes the two most common operational strategies, gate strategies and extended gate hours, applied to marine container terminals to deal with truck traffic congestion in the vicinity of and within the terminal. The third section provides a description of the automation technologies currently available that foster the implementation of operational strategies as tools for

relieving congestion. The fourth section provides a detailed description of studies presented to date and the last section discusses the long-term.

OPERATIONAL STRATEGIES AT MARINE CONTAINER TERMINALS TO RELIEVE TRUCK TRAFFIC CONGESTION

Marine container terminals are open systems of material flow with two external interfaces: the quayside where containers arrive/leave via vessel and the landside where containers arrive/leave the terminal via trucks or trains. Within the terminal we can distinguish three areas: the berth area where vessels are berthed for service, the storage yard area where containers are stored waiting to be exported or imported, and the terminal gate that connects the container terminal to the hinterland. Accordingly operations in a container terminal can be broken down to three categories: seaside operations, landside operations, and yard operations, all of which interact with each other. Seaside operations consist of the vessels' berthing operations at the quay, and the loading and unloading of containers onto the vessel. The seaside operations interact with the yard operations via the internal transport equipment used to transport containers from/to the vessel and to/from the storage yard. The yard operations manage the containers during the transfer between the landside and the seaside. It includes operations such as the internal transport of the containers from/to the vessel and from/to the trucks/rail, and the storage operations in the storage yard. The landside operations deal with activities of receiving and delivering inbound and outbound containers to and from the storage yard. While each system can be viewed as an independent entity, and its' operations are usually studied as such, interactions between the systems are unavoidable and play a crucial role in the efficient management and operation of a container terminal. A schematic description of a container terminal operations and interactions between the different systems is portrayed in figure 1.

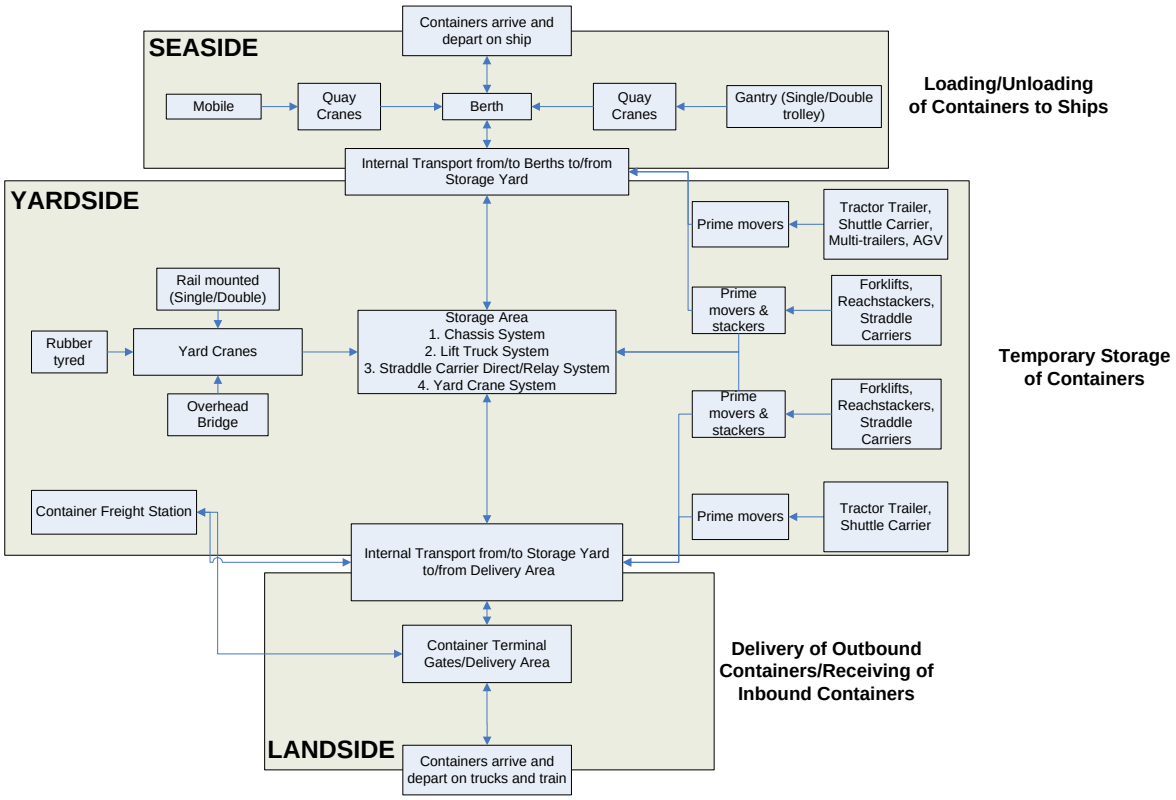

FIGURE 1 Schematic representation of container terminal activities and operations.

To improve overall terminal yard side-to-landside operations, reduce congestion at terminal gates and its resulting economic, operational and environmental implications different solutions have been proposed and implemented over the last few years. These can be distinguished into two planning/control levels: a) the strategic level (e.g. capacity expansion), and b) the tactical/operational level (e.g. extending gate hours, appointment systems etc). The latter strategy, which is the focus of this paper, is implemented with the objective of reducing congestion at peak hour periods by evening out and controlling the demand at the gate side of the terminal while at the same time minimizing the stochasticity in the planning of the yard side operations (i.e. time and sequence of pick-up or delivery of containers arriving or leaving the terminal by truck). In addition, overall roadway congestion could be lessened by some of the strategies, due to a trickle-down effect (Cambridge Systematics, Inc. 2009). In order for these strategies to be implemented and effective, further encouragement and support needs to be provided to the terminal operators through the development of policies, laws, and enforcement strategies. Examples of such policies are the California Assembly Bill AB 2650 and the Off-Peak Program created by PierPass (Cambridge Systematics, Inc. 2009). As demand increases and operation efficiency decreases at the landside of marine container terminals and the surrounding roadway network, it is expected that more states will follow this paradigm.

Gate Appointment Strategies

Gate appointment is a truck reservation system that provides a certain number (limited by 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 of cargo. An appointment system requires 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 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, as shown by the current literature (Lord and Morais 2006). 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. 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).

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. The latter strategy allows the demand for processing containers to be 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 the this strategy: a) providing incentives to drayage operators that will encourage them to utilize the extended hours of gate operations, b) adjustment of hours and pay of workers at the terminal (Giuliano and O'Brien 2007), and c) 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.

AUTOMATION TECHNOLOGIES

Growth of freight and containerized traffic around the world has influenced industries to use new and advanced automation technologies for management and operating technologies and systems at intermodal terminals. Use of these systems increases gate productivity and overall truck turn time through the terminal. Automated identification and container tracking is also very important for security issues. New technologies use Terminal Operation Systems (TOS), which manage every component of the terminals' operations. Many companies offer TOS services, but most of them use specific functions of terminal operations. Every individual terminal is different and each must decide which technologies to implement within their TOS to maximize operational efficiency and security.

Technologies used at the terminal gates are:

- *Optical Character recognition (OCR)* used to automatically identify containers, chassis information and truck plates at entry and exit gates, with the use of cameras and scanners (Ioannou 2008).
- *Global Positioning System (GPS)* used to identify container position anywhere within a terminal
- *Radio Frequency Identification Device (RFID)* wirelessly transmits object location by radio waves. This system is used to track trucks, containers and cargo at terminals. It can also pass information at marine terminals from one piece of equipment to another (Ioannou 2008).
- *Closed-Circuit Television Camera* used to monitor traffic and terminal activities and gates.
- *Bar Code Readers and Mounted Data Collection Computer* used to identify containers at gates and anywhere else at terminals.
- *Real-Time Location Systems (RTLS)* used to track and identify location of trucks and containers in real time using simple, inexpensive tags attached to containers and devices that receive wireless signals from these tags. They are used to improve terminal gate congestion and help terminal operators manage movements more efficiently. RTLS can also combine information on queues and traffic delays with terminals and delivery scheduling (Ioannou 2008).

The following section describes components of TOSs available for use in the market that can help improve the terminals' gate operations.

Automatic Gate Systems

Automatic Gate Systems (AGSs) help establish a connection at gate terminals between trucks and terminal operators. Truck handling at the terminal gates is controlled by the Gate Operating System (GOS). In order to process the collected data, communication needs to be established between the customer's advanced Gate Operating System and the terminals application or usually Terminal Operating System (TOS) (COSMOS 2008). AGSs 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 of the first two fingers on the left hand, increasing security and accountability. Workers, therefore, will not need to be on the ground checking in drivers.

Pacific Gateway Portal

Pacific Gateway Portal (PGP) is a port user information system in a web-based form, operated by the Port of Vancouver. The information available on PGP includes container status, vessel activity, and real time video images from both the port terminal side and also truck and driver identification. This system also has an option of an appointment system for trucks and dangerous goods applications. A truck appointment system is in use at all three terminals within the Port of Vancouver, and is very successful. In order to make appointments truck companies use the terminal's web page. Appointments are matched with transactions determined by the terminal on the basis of capacities of terminal. Dedicated lanes are in

use for trucks with an appointment (Pacific Gateway Portal 2008). An approved Truck Licensing System (TLS) License is required by any party wishing to access Port of Vancouver's property for the purposes of draying marine containers to or from any of the terminals under the jurisdiction of Port Metro Vancouver. Trucks without a TLS license are not allowed to access Port Metro Vancouver property (Pacific Gateway Portal 2008). Truckers also have to be in line at the gate entrance at least 15 minutes before expiration of their reservation time. If trucks arrive late they are required to go to the line for trucks with no reservation, or they will need new reservation. There is no fee to use the reservation system, but there is a fee to use the web portal.

SynchroMet

SynchroMet is a virtual container yard service provider used at the Port of Oakland, as an on-line service. It integrates ocean carriers with motor carriers through a virtual container yard (VCY) to perform mutually beneficial congestion management, to reduce costs and to ease port and public road congestion. The SynchroMet service, accessed through the Internet at www.synchromet.com, is where inbound containers can be posted as empty street-turn opportunities and matched in real time with off-dock equipment needs to cover export bookings (SynchroMet 2009). SynchroMet reduces empty truck miles and waiting time at local marine terminals, which has a positive impact on the local environment.

SeaLink

SeaLink provides trucking companies serving the port of New York and New Jersey access to the regions highway system, helping them move cargo to their final destinations. SeaLink is a uniform truck driver identification system, which helps trucks move more efficiently through terminal gates. It uses ACES (Automated Cargo Expediting System) to send out information from truck drivers to terminal operators, which ensures more efficient flow of containers through the prot (The Port Authority of NY &NJ 2009).

eModal System

The eModal system applications focus on truck and marine terminal gate interfaces. It is designed to improve efficiency and deal with the congestion at container terminals, so that it can reduce truck queuing and idling (eModal 2009). eModal uses a common portal of container and export booking status information (US Environmental Protection Agency). eModal has information on detailed container status, vessel schedules, terminal locations, truck driver lists and other important terminal information. Trucking companies and terminal operators can also use eModal for a gate appointment system. Trucking companies use it to pre-approve their drivers for container pick up and drop off. When drivers are pre-approved eModal sends this information to terminals, which helps reduce the time drivers spend at gates. With the possibility to integrate all the processes online, eModal helps to speed up transactions at terminals. The only problem is that there needs to be greater usage of the system by trucking companies in order to fully realize the system benefits.

Edge Manager Auto Gate

Edge Manger Auto Gate is developed by NAVIS, a part of Zebra Enterprise solutions and it is one of the leading solutions for automated gate systems. Gate transactions are monitored with the use of different technologies like RFID, OCR, GPS positioning, reefer monitoring, e-seals and mobile computers (Zebra Enterprise Solutions, 2009). Truck drivers use a self service pedestal to check-in. Terminal inspectors use a mobile graphical interface for checking the cargo that comes to the terminal. Edge Manager Auto gate can be used with Navis Yard mangement or other Terminal Operating Systems, which provides easier and more integrated overall terminal operations.

NAVIS

NAVIS is an automated system that allows terminal operators to see what is happening in real time from terminal gate to rail or vessel, at their terminals yard. Paper based systems and bar code based systems at yards are not able to provide real time and up-to-date automated information. NAVIS yard management

software includes capabilities for dock and yard management, gate scheduling and automation, security, container tracking and visibility of property (NAVIS 2009). With the use of NAVIS customers are served better, operating cost of the terminal is lowered and capacity is increased.

COSMOS System

COSMOS System is a fully automated and integrated yard control and planning system for terminals and it includes a lot of different software that can be customized for different yards or terminals. It can help optimize and automate operations like yard and vessel planning, equipment control and tracking, gate administration, invoicing and management reporting. COSMOS uses already available components of an individual terminal to build the best possible terminal (COSMOS 2008). COSMOS also provides gate control and container tracking capabilities. Software programs are linked so that a when container is checked at a gate, all the container information is used to plan activities inside of the yard. Every time the container is moved, the COSMOS system software is updated (Lord and Morais 2006).

Embarcadero System

Embarcadero (ESC) System is a full service provider to marine, rail and intermodal terminal operators, and it offers technology software and integration services. ESC automates intermodal operations, providing integration of cargo handling and visibility inside and outside the terminal. Web based tools used by ESC are VoyagerTrack and webTAMS and they use Differential Global Positioning System (DPGS), and wireless local area networks (WLANS) to pinpoint the exact equipment position and provide real-time communication for the terminal operating software. ESC uses Premier Appointment System (PAS) that includes VoyagerTrack, and this allows truck companies to schedule arrival appointments at the gate. The other solution from ESC is smartGATE, which is an automated terminal access solution, and it provides centralized gate transactions. SmartGATE uses Optical Character Reader (OCR), RFID, and GPS and technologies. A unique feature to SmartGATE is Intelligent Camera, a CCTV (Closed Circuit Television) that improves the accuracy of OCR, giving terminal operators better real time images. With the use of this system productivity of the gate terminal is improved, and the yard security and safety is greatly enhanced (Lord and Morais 2006).

CATOS System

CATOS system is a fully integrated TOS which is used in 72 container terminals worldwide (Total Soft Bank 2009). Most of the terminals that use CATOS are in Asia (Thailand, Taiwan, Malaysia and Vietnam) and they have been using it for more than 10 years. CATOS has the capability to use one database server for different terminals. CATOS system is integrated with different parts of the terminal system which provides better system optimization. CATOS system is interfaced with Gate Automation System, Gate Weighing Scale, Crane Automation and Monitoring System and RFID System.

Jade Master Terminal (JMT) System

Jade Master Terminal TOS is used in container terminals, rail company operations, bulk and general cargo operations, log marshalling and vessel scheduling. It has been used in New Zealand for past 15 years, in more than 15 terminals (Jade Logistics 2009). US and Austarlia have started to use Jade TOS recently. Jade TOS operates best in small or mid-sized terminlas. Jade is installed on every terminlas computer like any other program, and it makes technology for terminals systems. Jade can offer intergration for any part of terminla system from gate to vessel scheduling. New techologies like OCR, RFID, GPS can be used with Jade TOS, and this techologies can be added if terminal wants to use them.

CASE STUDIES AND RELATED LITERATURE

The impact of tactical/operational level gate strategies on drayage operation efficiency is not very well understood, and is an area where researchers and practitioners are becoming increasingly involved. This section provides a detailed description of the studies that have been published to date.

One of the first studies to appear on modeling the truck arrivals at a marine container terminal was by Sgouridis and Angelides (2002) who performed simulation modeling of all the major processes and handling of containers arriving at port, in order to improve operational efficiency of the second largest container terminal yard in Greece. This paper focused on the service of the arriving trucks at the terminal. A discrete event simulation model for the inbound arriving containers and their processes was developed based on the existing conditions at the port. The potential terminal improvements were also considered in the model. The objective was to minimize the truck turnaround time (TTT) and to better utilize available handling equipment. Benefits of computer management system for yard operations were also analyzed. The findings from the modeling were that the arrival of trucks should be organized and evened out throughout the day in order for the TTT to be minimized. The TTT was reduced by 15% with trucks arriving evenly during the day. The use of computer management system was implemented in simulation, and the truck import area was improved with the use of two instead of one import pads for trucks waiting to be serviced. The organization proved to be very effective with 40% improvement, and 24% improvement of TTT with heavier truck traffic.

Delay of trucks waiting at queues at port terminals is caused by different factors, some of which are large truck arriving volumes, short operation hours of ports and slow gate processes (Juang and Liu 2003). Juang and Liu applied a queuing model to study delay factors at the A.P. Moller, Port Elizabeth Terminal (APM). The purpose of the model was to analyze the need for state legislation in extending gate hours. Parameters used in the model included average arriving volume of trucks and service time at the gate. Numerous interviews and observations and terminal functions were used to come up with these parameters. Trucks are arriving on random bases at terminal gates, and this is represented with Poisson's distribution. The model results showed that when the port terminal has a low ratio of containers arriving over service time then there are no queues. Operations at port terminal could then be organized with less gates opened and full utilization of terminal equipment. Results from the model also indicated that service time is a very sensitive parameter and any changes to service time can cause huge delays (Juang and Liu 2003).

Research published in 2008 used a multi-server queing model to analyze marine terminal gate congestion and overall cost of trucks waiting at the gate, due to lost time (Guan and Liu 2008, 4). The authors chose one of the marine container terminals in the Port of New York/New Jersey as a test case. An optimization model was developed to minimize overall gate system cost. Minimizing cost at a gate is good both for trucking companies, since their wait will be reduced and gate operators, since they can have a minimum number of gates open while providing good service to all trucks. The goal of the study was to have both satisfied by minimizing overall gate system cost. Capacity of a gate system is determined by the number of gate lanes, by hours of operation, and the productivity that gates operate under. The Multi-Server queing model developed is based on gate capacity, and it utilizes information regarding physical layout and and characteristics of terminal and its operations. The model also depends on truck arrival rate which is dynamic. The model is validated using field observed data and statistical testing. For truck arrivals, two peak periods in a day were analyzed, one in the morning and one in the early afternoon. The goal was to more evenly distribute truck arrivals throughout the day. In order for a system to be optimized, there are two things that can be done: one is to increase number of gate booths, and the other is to control truck arrival rates, which can be done with truck appointment systems. The authors find the appointment system approach more feasable since it doesn't require greater expenditure of manpower and land expansion. But in order for an appointemnt sytem to work there has to be coordination between shipping lines, terminal operators, shippers and trucking companies. All major stakeholders must be involved in developing operating procedures and must realize benefits in order for a succesful appointment system to be implemented.

A study from the Logistics Institute of Georgia looked at planning of drayage operations given a port access system. Planning is based on an "integer programming heuristic that explicitly models a port access control system" (Namboothiri and Erera 2008, 185). The model is based on minimal transportation cost to determine drayage company operations of pickup and delivery. Drayage firm operations are restricted by the system that a port is using. The schedule for a driver of a drayage company is determined

on the basis of appointments made to pick up certain numbers of containers during the day, and best routes for a drayage company based on appointments during the day. The research shows that optimization of drayage operations is complicated by adding port access systems. Access capacity provided by port terminals is important, since vehicle productivity can be increased by 10 to 24% when access capacity is increased by 30% (Namboothiri and Erera 2008). Drayage firms need to schedule an appointment by the demands of customers, and also to improve customer satisfaction. The length of the appointment window is also important for drayage firms, and test results from the study indicate that reducing appointment windows by half can have significant impact on drayage firm functioning by reducing their ability to maintain expected levels of customer service.

In September 2002, California Assembly Bill AB 2650 was passed and became active in 2003. It presented regulations that required marine port terminals to either: a) begin using appointment systems for trucks, b), extend the hours of operations for the pick-ups and deliveries by trucks, or c) find another way to reduce truck queues at the terminal gates (Giuliano and O'Brien 2007). This was the first bill in any US state aimed at port terminals, to lower congestion and air pollution. It included fines on marine terminal operators who allow heavy-duty trucks to idle for more than 30 minutes while waiting to enter the terminal.

The use of a gate appointment system at the port of Los Angeles and Long Beach was studied in California after the enactment of AB 2650. The appointment system was monitored over a 16-month period from January 2004 through June 2005 (Giuliano and O'Brien 2007). Prior to this, no data was available on terminal gate queues. During the study period trucking companies only made appointments 5-30% of the time, many appointments that were made were not met by the truckers, terminals were not always ready for the trucks with appointments and didn't have special arrangements for trucks inside the terminal, so many trucks waited as long inside the gate as they had waited outside the gate before the appointment system.

One possible problem that has been noted with the existing programs at the ports of Long Beach and Los Angeles is that there is very limited ability by the state to monitor operations inside the terminal and to enforce the current laws. AB 2650 mandated that terminal operators reduce congestion and therefore emissions, which allowed them to put their own system into service. Fees collected could be used to offset the additional cost of the system being used. In some instances, trucks were moved inside the gate just before the time limit on waiting outside, and then trucks remained in lengthy queues inside the terminal, out of sight of government monitors. In other instances, the added cost of labor for additional operations was viewed as a higher burden than just paying the fines incurred by not complying. Some of these fines could eventually just be passed on to truckers in various fines and fees. The system in Long Beach and Los Angeles has the potential to work really well if implemented whole-heartedly by all stakeholders. If reductions do not occur when the system is left to the terminal operators, additional oversight and enforcement may be needed. Funds collected from fines could be used for other congestion and air quality projects.

In February 2004, Assembly Bill (AB) 2041 was introduced in California requiring extended gate hours (Solomon and Bailey 2004). The OffPeak program was created to provide an incentive for cargo owners to move cargo at night and on weekends, in order to reduce truck traffic and pollution during peak daytime traffic hours and to alleviate port congestion, at the ports of Los Angeles (LA) and Long Beach (LB). In July of 2005, the program was implemented and through legislative influence (AB 2041), required the Ports of LA and LB to charge for goods moved at peak hours from 8:00 a.m. to 5:00 p.m. All cargo owners of loaded containers entering and leaving the ports during the day shifts were charged a Traffic Mitigation Fee (TMF). A recent study by Cambridge Systematics (Cambridge Systematics, Inc. 2009) evaluated the OffPeak Program in order to analyze the effectiveness of the program in reducing congestion, and the possible factors that can lead to better results if implemented at other ports. Truck traffic analysis at different periods of day was performed and results showed that the program managed to increase the number of trucks at off peak hours, and relieve pressure at gates during peak hours. Truck traffic congestion within the terminal was also reduced throughout the day. One of the major problems reported in that study was the increased demand during the last hour that the port gates operated (between

5:00 and 6:00 p.m.). Higher numbers of trucks at gates was also reported at ports during the 6:00 p.m. and 10:00 p.m. time period, which resulted in gate capacity problems. Analysis of truck traffic on the nearby freeway I-710 indicated that there was no major change in truck traffic volumes from daytime peak to nighttime traffic. Therefore the OffPeak Program did not have major impacts on reducing congestion on roadways. The recommendation was that the congestion problems could be solved with the use of the OffPeak Program in combination with different strategies, like pricing strategies and appointment systems, and that this combined approach should be used if a similar program is implemented at other ports.

The Transportation Development Center of Canada published a study in 2006 (Lord and Morais 2006) that reviewed current practices and strategies used at North American ports, to speed up handling of cargo, in order to reduce congestion and idling of trucks at the gate (Lord and Morais 2006). Information for the project was assembled in a literature review and survey of ports, followed by on-site visits and interviews. The report concentrated on the twelve largest North American ports by highest annual transiting container volumes (TEUs per year), and by availabilty of automated technologies.

The use of appointment systems at observed ports was mainly successful, and dependent on factors producing congestion. The major problem at the ports with no mandatory appointment system is that the truck drivers largely ignored it. The main reason given for not using appointment systems was difficulty for truck drivers to set up an appointment 24 hours in advance, mainly because of the other transactions scheduled that day. There is also the unknown of road congestion on a given day, and number of trips planned for one day. Although an appointment was made, some drivers also failed to keep appointment times. The findings of the report indicate that appointment systems must be flexible to be successful. This means that it must (Lord and Morais 2006): “

- Handle cancellations,
- Re-assign reserved time that has been canceled
- Agree to appointments there are made during the day, not just 24 hours ahead of time
- Decline or discourage double/triple appointments for the same container
- Fines for missed reservations
- Allow one hour window for trucks to show up
- Operate based on container appointment (not truck appointment)
- Allow for reservation by phone” (Lord and Morais 2006).

The researchers found one of the best ways to improve efficiency is by the use of gate appointment systems and documented components to establish a good system in Canada. They found that in order for improvements to take place at Canadian ports there has to be a detailed strategy in place, which includes policies and regulations, air quality mitigation programs, infrastructure improvements, and new port information systems and technologies (Lord and Morais 2006). Close coordination of all stakeholders is necessary for the succesful operations.

Freight Information Real-Time System for Transport (FIRST) is supported by the Federal Highway Administration’s Office of Freight Management and Operations, the Congestion Mitigation and Air Quality Improvement Program, and the I-95 Coalition. It began in 2001 to provide real time information to the port of NY/NJ freight community members (Srour et al. 2003). FIRST uses Intelligent Transportation Systems (ITS) technology to manage intermodal freight systems. It is an internet-based, real-time network that incorporates different sources of freight information into a web portal that is accessed by port users to obtain port and cargo information. It was designed by the private sector of the intermodal freight industry and public sector partners. The web site used for the FIRST system provides real-time information on cargo status to all involved customers and terminal operators. Trucking companies can find out the status of containers online and plan each trip to the port so unnecessary trips are not made. A simulation model using accepted transportation queuing theory concepts was developed to study benefits of the appointment system. Queuing activity at terminals was observed with or without the appointment system in use at various levels of acceptance (0-100%). Data used was from field observation of queuing activity over a five-day period in June of 2002. The results were that when appointment systems were used at 100%, the total time vehicles spent in terminal was reduced by 48%,

compared to 0% use of the appointment systems. The success of the appointment system depended on the level of compliance, since with the low acceptance queuing increased at gate terminals. According to the FIRST evaluation report (Srour et al. 2003), this system did not make a significant impact since it was not used as desired.

Huynh (2005) observed operations at the port of Houston (Babours Cut Terminal) with the purpose of reducing truck turn time. Two alternatives that can have an effect on truck turn time reduction are adding more yard cranes and utilization of truck appointment systems. This dissertation (Huynh 2005) looked at the effect of both alternatives, through a simulation model done with simulation package Arena, and also with a regression model for adding more cranes to the yard terminal. Findings were that if more road cranes are used to handle trucks in and out of the terminal, truck turn time would decrease. Huynh also looked at the implementation of truck appointment systems, and he proposed a methodology for determining the number of trucks terminals should allow, especially the trucks allowed in a specific area of yard per time window (referred to as cap) (Huynh 2005). Capping was important in order for an appointment system to be effective so that yard cranes can serve the trucks entering a yard with the appointment system schedule in the shortest time. The issue of no-show and delay is also a part of the model. The model was developed with the maximum number of trucks a terminal can handle with the specified resources. The results of the model showed that truck appointment system was beneficial in reducing truck turn time. On the other hand if the cap was set too low for a certain time frame, it had a reverse effect on both the crane operation and truck turn time.

Hong Kong International Terminals (HIT) is one of the world's busiest ports. It operates with very limited space, with no possibilities for expansion to meet the growing demand. In 2003 Hong Kong operators handled 20 million twenty-foot equivalents (TEUs), making Hong Kong the busiest port in the world (Murty et al. 2005). With the increase in exports from this region, Hong Kong terminal had to optimize their operations. In 1995 one of the researchers, Professor Katta G. Murty and several IEEM faculty members, began working on a decision support system for HIT. One of the critical decision problems at the port is allocation of appointment times to external trucks to minimize their turnaround time, to smooth out truck arrivals, and to reduce the number of trucks in yard during busiest times. HIT started using an appointment system in 1997. Trucks coming to the terminal to pick up had to make an appointment, while the trucks bringing export containers did not have to make an appointment. The reason for this is that most trucks that bring export containers arrive from mainland China and they have to wait at the border crossing. In every 30-minute time slot, each block at the terminal has a certain number of appointments available. The number of appointments at each block or quota is determined using a simulation model. Several estimates were required for the simulation. The number of external trucks that do not show up for an appointment is estimated from past data. The time it takes a yard crane to serve a truck is also estimated. The target is to limit the number of trucks waiting for service to six or fewer. Since there are not a lot of slots available, the earlier the trucker makes an appointment the more slots it will be able to choose from. If a truck tries to enter with no appointment, it is rerouted to a booking center to make an appointment, unless it is an external truck with export container that also has to pick up a container.

The Port of New Orleans uses the appointment system, which is made mandatory, to improve the terminal operations and the use of the system. The appointments are made online with the use of Gate Entry Management (GEM) system. The operation of the web system is organized with the use of digital cameras, optical character readers, transponders and AM radio broadcasting within the gate system (EPA Smartway Transportation Partnership 2009). This system allows trucks companies to make appointments within available time period, and it also allows Terminal Operators to organize terminal operations in the order of arriving trucks. Truck drivers have a 30-minute window within their scheduled appointment (Port of New Orleans 2009). The amount of time a truck spends at the gate is also reduced, because all the paperwork is eliminated with the use of web application. Terminal operators also have more time to eliminate possible errors. The use of the appointment system was very beneficial for Port of New Orleans, since truck idling at the gate was reduced, terminal operations and throughput were improved, and truck companies and terminal operators are cooperating better with fewer delays.

The Georgia Port Authority including Port of Savannah also implements a web-based system for containers entering and leaving the port. The system is a real-time online system and it provides 24-hour access to customers to update data on container shipments. Since its implementation, the system has been very beneficial to The Georgia Port Authority, because it has managed to lower truck queues and waiting times at gates and overall truck processing time at terminals by 30% (EPA SmartwayTransportation Partnership 2009).

LONG-TERM VIABILITY AND LESSONS LEARNED

Coordination between trucking companies and port intermodal terminals is essential for efficient terminal operations. Gates that are clogged can worsen terminal capacity and this creates not only an operational but also an environmental problem. For a tactical/operational level gate strategy system to be effective, a large percentage of trucks will have to use it, and there has to be some priority or benefit for trucks with appointments. Incentives are necessary to get trucking companies to buy into appointment systems and actually make appointments (and keep them). Incentives may also be needed for the terminals to use the systems effectively. Gate appointments are a more favored alternative than extended gate hours, since the cost is lower.

Gate appointment systems have the potential to dramatically improve operations inside the terminal as well as at the gate, and as a secondary result, reduce congestion on the roadway system, and therefore reduce harmful emissions in the neighboring communities. Of course, as freight shipping increases, there will be a point that limits the amount of trucks and containers that can physically be processed within the constraints of terminal boundaries, but there is certainly room for improvement now, before reaching that point. For extended gate hours, additional workers are required at off-peak times, but this is a viable option to increase throughput at terminals. It will require that additional workers be added, hours and pay contracts be adjusted and associated businesses buy-in, but there is potential for greater amounts of container movement without the need to expand terminals.

Increased efficiency at intermodal port terminals due to any or all of the strategies discussed in this paper can affect the overall transportation community and all other types of intermodal transportation by allowing more containers to be shipped, and moved more quickly away from the ports, onto the other forms of transportation, and to their final destinations. Appointment systems and extended hours, as well as the managing technologies can be used by other modes experiencing congestion and air quality concerns to increase efficiency, thereby lowering congestion and emissions. The key to developing effective gate appointment systems is to ensure participation from all key stakeholders.

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