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Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data

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16. Abstract

The introduction of mega-ships (i.e. post-Panamax vessels) presented an opportunity for ports to be even more competitive and cost-effective. For example, the construction and investment commitment of over $ 3.45 billion between 2013 and 2018 into Port Newark/Elizabeth are being made with a goal of maintaining and improving navigation transportation infrastructure and developing new terminal capacity. In late 2013, The Port Authority of New York-New Jersey (PONYNJ) established a task force to identify challenges to port efficiency and service reliability, and recommend potential solutions. For this reason it is necessary to understand and quantify the effect of the increasing introduction of the mega-ships and related changes in port operations on highway system. Better understanding of these effects will help planners identify the solutions and evaluate their effectiveness in preventing serious disruptions. The developed simulation model is used to analyze "what-if" scenarios that depict the change in truck demand on terminal gate operation. Three developed scenario illustrated the impact of change in truck demand on Port access roadway network. The analysis compared the truck queues and delays at the gate as results of change in truck demand. Two policies, commonly used to control the truck arrival patterns at the gate, the extended gate hours and the gate appointment system, were examined to address the gate operation. Their impact on truck delays and queues at the gate is observed and noted. In addition, analysis investigates the critical truck demand that will cause a queue spillover on a surrounding highway network. The sensitivity analysis identified network deficiencies and truck demand at which queue will reach highway access point.

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DESCRIPTION OF THE PROBLEM

Ports have tremendous impact on the regional and national economy of a country depending on the cargo going through the ports. In 2011 it was measured that U.S. container ports handled a total of 110 million metric tons of containerized cargo, 17 percent more than previous year. It is roughly estimated that 1 container in every 11 that is engaged in global trade has origin or destination in United States[1]. Nine of top 10 U.S. ports recorded an increase in throughput of containerized cargo. In addition, anticipated completion of Panama Canal expansion project in 2014 is expected to alter the logistics chains for vessels arriving to U.S. It is projected that the container traffic growth at East and Gulf coast ports will likely outpace container traffic at West coast ports after the Panama Canal expansion project is completed.

The introduction of mega-ships (i.e. post-Panamax vessels) presented an opportunity for ports to be even more competitive and cost-effective. For example, the construction and investment commitment of over $3.45 billion between 2013 and 2018 into Port Newark/Elizabeth[2] are being made with a goal of maintaining and improving navigation transportation infrastructure and developing new terminal capacity. These investments are expected to produce over 4,800 direct jobs annually and over $5.6 billion in business income. Capital investments in roadway and bridge (i.e. Bayonne bridge) improvements was estimated to be over $1.5 billion. Terminal operators are investing over $680 million in berths, buildings and equipment while the investment into the rail infrastructure and equipment are close to $300 million. These investments with additional investment for Goethals bridge replacement are all geared towards accommodating arrival of mega-ships after the Panama Canal expansions has been completed.

As the ports around the country are preparing for arrival of mega-ships, the important question is what will be the impact of mega-ships on land transportation system. Currently, an estimated 73.7% of the total value, 70.0% of the weight and 38.1% of the overall ton-miles is being hauled by trucking industry. But the road condition, congestion and accident are limiting factors on the trucking industry capacity. In 2010, 40% of congestion is attributed to insufficient roadway capacity, 25% to accidents and 15% due to weather. In late 2013, The Port Authority of New York-New Jersey (PONYNJ)[3] established a task force to identify challenges to port efficiency and service reliability, and recommend potential solutions. The task force produced recommendations that were divided into three tiers prioritizing recommendations based on their impact on operation of PONYNJ. Tier one projects are large scale management and infrastructure projects that have significant impact on operation followed by Tier 2 projects that deal with enhancing the efficiency and effectiveness of daily operations. Tier 3 projects are designed to contribute incrementally in improving ports operation.

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[1] Hoovestal, L."Globalization Contained: The Economic and Strategic Consequences of the Container", 2013
[2] A. Strauss-Wieder, Inc. "The Economic Impact of the New York-New Jersey Port Industry",2012
[3] The PONYNJ Port Performance Task Force "A Collaborative Effort for a Collective Change", 2014

For this reason it is necessary to understand and quantify the effect of the mega-ships and related changes in truck traffic on a highway system. Better understanding of these effects will help planners identify the solutions and evaluate their effectiveness in preventing serious disruptions in a regional transportation system.

APPROACH and CHALLANGES

The objective of the proposed study is to develop a simulation model that will be capable of ascertaining the impact of the marine terminal operations on a highway system that provides access to the port. The model will be specifically focusing on the underlying relationship between the changes in the truck volume caused by introduction of large on surrounding roadway network. A set of variables are defined describing the terminal gate operation, such as truck arrival distribution and gate processing times.

Several papers explore the impact of Gate management strategies on terminal performance. In this study two gate strategies were analyzed as well. But what this study intent was to develop "what-if" scenarios involving different combinations and iterations of the growth in freight demand, that will allow users to investigate the impact of the increasing truck traffic on highway assess ramp The analysis attempts to identify volume that will eventually cause a truck queue spillover on highway access point.

There are many challenges in realizing the above vision for this research. One of the key technical challenges is realistic representation of the processes within the study area. The complexity of the system and obsolete travel pattern data and information resulted in reducing the complexity of the model. Also the unavailability of the INRIX travel time data for the study area limited the number of study area visits for the research team to collect travel time data, queue data within the study area.

LITERATURE REVIEW

A literature review is performed to identify suitable port performance variables and operation characteristics and to understand the use of simulation models to analyze interactions between the marine ports and surface transportation systems. The literature is classified into three groups: studies that focus on port operations, the ones that consider ports as a part of intermodal transportation and the studies generate policies that have been proposed or implemented domestically and internationally in order to address the efficiency of port operations with respect to the adjacent surface transportation systems.

Puglisi (2008) integrates a port operation model developed in ARENA simulation software for the Port of Savannah and a microscopic traffic simulation model VISSIM that is used to simulate the roadway network surrounding the port. This paper evaluates the increase of container traffic at Port of Savannah and address major concerns regarding the roadway network surrounding the port and the overall operations of the port. The model allows the user to measure the total time that containers spent at each location and travel times and intersection queue lengths on the local roadway network. The delay experienced by individual entities can be measured as well. Later, Wall (2012) presented a research that improves and expands the model developed by Puglisi (2008) with a goal to develop a fully federated, large-scale platform for modeling both roadway transportation and port operations systems. The goal is to analyze the impacts of rising truck volume generated by the port on surrounding roadway network. The interaction among the VISSIM and Arena models is established by developing a database that collects data from one model and then disseminates to the other model. The performance measures analyzed are the facility queue lengths; roadway travel times truck utilization and location, and facility processing rates.

Prassana and Bakshi developed an integrated traffic modeling and simulation framework based on TerSim and VISSIM that to investigate the impact of various technologies and control strategies on freight transportation systems. Framework was also used to conduct simulations to evaluate generic traffic control algorithms. The control logic implemented in Matlab and VISSIM integrates ramp metering and speed limits with an objective to relieve congestion, suppress shock waves and improve safety on a freeway stretch. Rizoli et al. developed an operations research simulation model to evaluate the impact of new operations policies, not only to validate the policies, but also as a tool to convince the decision-makers of the potential advantages in adopting the proposed enhancements in the management. The simulation model replicates the terminal activities such as rucks arriving at terminal gate; ships arriving at terminal pier; trains arriving at terminal to investigate management policies that could improve the terminal performance and allocate fewer resources. AnyLogic Simulation tool was used to evaluate the rail infrastructure required to support demand requirements. The model also determined the location where the facility should be located. Osman et al, developed Arena-based simulation model for evaluating the performance of a container terminal. The model analyzed an average productivity, average resource utilization and average waiting time (e.g. of quay cranes waiting for a carrier) to identify potential bottlenecks in the operational areas (quay cranes, storage yard, or transportation) in container terminals. Abadi et al. presented three models to analyze the effect of inspection of trucks on performance and cost to the terminal. The microscopic urban traffic simulation model simulates the flow of traffic on the road network adjacent to the twin ports. The macroscopic terminal simulation model simulates the flows of containers in each terminal. The cost model takes inputs from the terminal model to generate the cost of moving containers through the terminal. The interaction between the macro and micro simulation is also investigated by Dougherty (2010) to mimic the operations of the incoming and outgoing drayage trucks at a port. It uses the model to implement and evaluate the effect of different gate strategies on the drayage operations and the reduction of roadway congestion produced by the drayage trucks. The Port Newark/Elizabeth Marine Terminals is selected to be the study area in evaluating the roadside impacts of gate appointments and extended gate hour's strategies. Later, Tsitsamis and Vlachos (2010) developed a simulation-based methodology for evaluating tactical decisions for truck operation planning demonstrated for the Container Terminal of the Port of Thessaloniki, Greece by analyzing historical data of the port for the period 2006-07. The gate and the yard operation are simulated with straddle carriers servicing the yard and transporting containers between the yard and trucks. The study evaluates the emission due to truck queues. The emission mitigation strategies such as implementing additional equipment or appointment system are investigated. Similarly, Moini (2010) presents a study on intermodal freight transportation that establishes a relation between truck gate activities and wharf operations at a marine container terminal using analytical and simulation approaches. The analytical approach of this dissertation is designed to depict the value of information collected by terminal operators on a daily basis and the simulation model in ARENA identifies the tasks and functions into six modules of terminal operations: truck arrivals, entrance gate (pre-gates and main gates), interchange area, yard, apron, and departure gates. The analytical phase defines attributes affecting the relationship and developed models to draw the connection. The simulation phase examines this interrelationship in a virtual environment. Karafa (2012) developed a dynamic traffic simulation model that measure congestion and emissions levels at intermodal container terminals before and after a gate strategy implementation by using Paramics micro simulation software. Rizzoli et al. (2002) develops a simulation tool for combined rail/road transport in intermodal terminals. The terminal is modeled as a set of platforms, which are served by a number of gantry cranes and front lifters. The model provides a platform where the user can define the structure of the terminal and the train and truck arrivals to assess the performance of the terminal equipment, the ITU residence time, and the terminal throughput. Klodzinski and Al-Deek, (2004) developed an innovative methodology for analyzing freight movement on local road networks by merging previously developed truck trip generation models using artificial neural networks (ANNs) and a microscopic network simulation model. Analyzes a seaport considered a special generator of heavy truck traffic and an adjacent road network that includes identified intermodal routes that connect to a seaport. This methodology was successfully tested with two network microscopic simulation models. The methodology is tested at Port of Tampa and Port Canaveral.

Cortes et al. (2007) focused on the simulation of the freight transport process through the estuary and its arrival to the port dependencies including the load/unload processes by the logistics' operators at the Seville Inland Port. Assessment on performance of the port facility is carried out on the docking times and traffic analysis. The analysis concludes that the port facilities are able to cope with the current incoming logistic flows, except for temporary difficulties in the container traffic. Another example of a model that investigate the impact of various technologies and concepts on the terminal capacity and cost as well as on the traffic network outside the terminals in an integrated manner was developed by Ioannou et al. (2007). The model consists of three modules: TermSim, TrafficSim and TermCost. Measures of container terminal performance analyzed include gate throughput, truck turnaround time, ship turnaround time, labor productivity, crane productivity, and utilization of berths, cargo handling equipment and yard vehicles, labor, gates, and storage yard.

METHODOLOGY

In this study, microscopic traffic simulation software Vissim is selected as a tool to assess the impact of increased truck demand, as a result of Post Panamax vessel arrival on surrounding highway network. Vissim is one of the microsimulation tools available for simulating multi-modal traffic flows, including cars, goods vehicles, buses, heavy rail, trams, LRT, motorcycles, bicycles and pedestrians (PTV America, 2010). The Vissim has an ability to simulate 24-hour operation and record delay, speed, density, and travel time by vehicle type which is crucial in this study.

STUDY AREA MODEL

Description of the Study Area

The selected study area roadway network facilitates truck traffic to three marine terminals (the APM and Maher marine terminals and port Newark container terminal) part of the Port Newark. An aerial view of the study area with terminal locations is shown in Figure 1.

Figure 1. Port Newark Marine Terminals within the Study Area

The study area is bordered by I-95 on the west and I-78 to the north. Truck traffic from the south predominantly is entering from the Interstate I-95 using North Avenue as an access road to terminals and chassis depots. From the north vehicles are either utilizing Port Street (from interstates I-95 and I-78) or Doremus Avenue.

This study focused on developing a simulation model that will analyze the operation of a single marine terminal. It was chosen to use develop a simulation based on a Maher terminal gate configuration. The model development in Vissim started with establishing an accurate representation of the physical attributes of the roadway network facilitating Maher terminal. The implementation of map features in Vissim based Microsoft BING Aerials enables accurate roadway network development. Figure 2 show the developed study area network in Vissim including BING map overlaying the Port Newark.

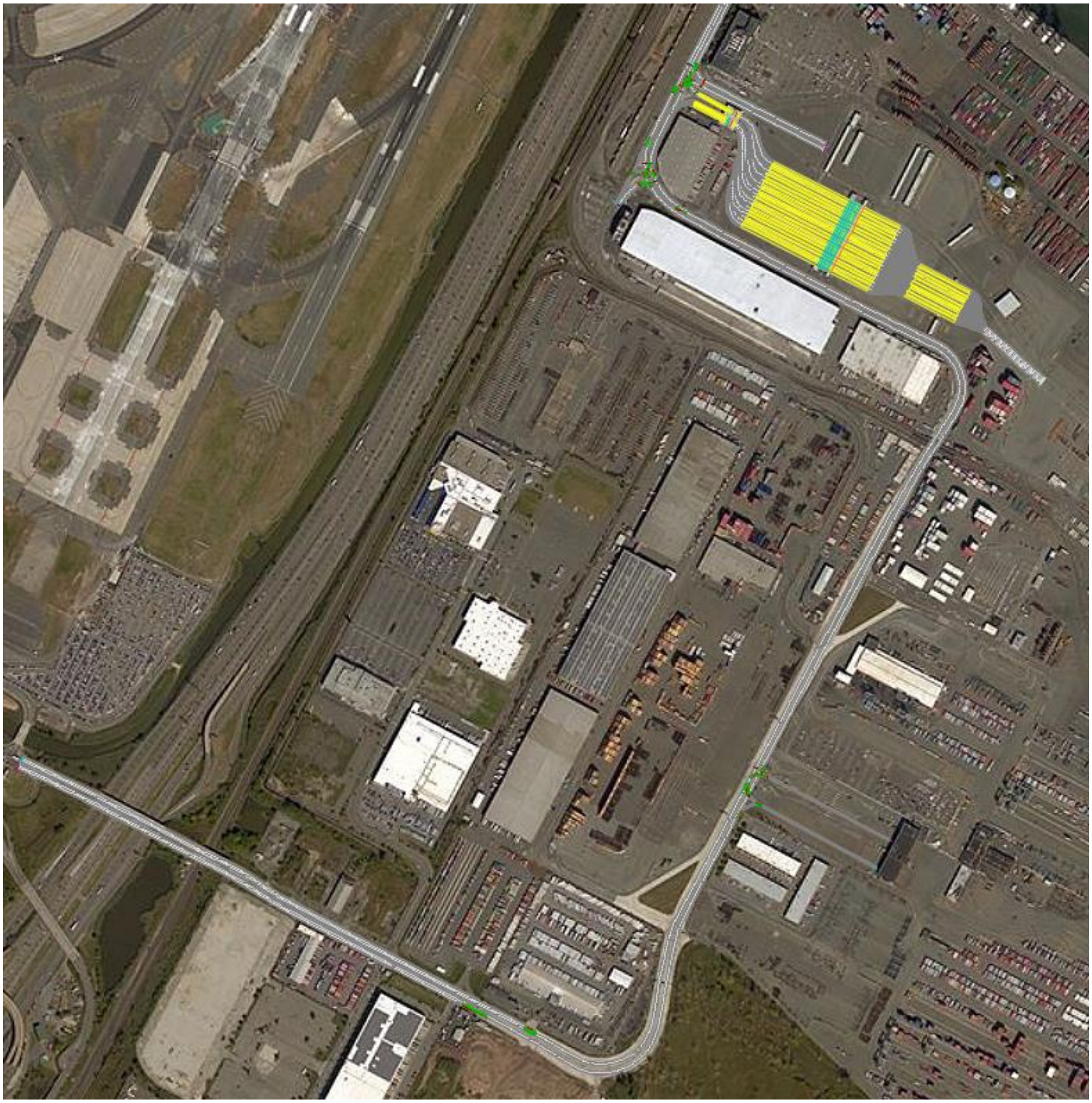

Figure 2. Study Area in Vissim

Available Data

Accurate data allows the researchers to better understand the traffic condition such as travel time, delays and queues that vehicle experience in the vicinity of the terminal. The Port Authority of New York and New Jersey (PANYNJ) Comprehensive Traffic Study conducted in 2006 provides detailed turn traffic counts at each intersection within the study area for peak periods (7:00-8:00AM, 12:00-1:00PM, and 3:00-4:00PM). The New Jersey Department of Transportation (NJDOT) daily hourly traffic counts collected within the study area provide additional source of information. The traffic counts were collected in different years (2010, 2011, 2012, and 2013) on different locations. The locations where traffic counts are available are shown in Figure 3.

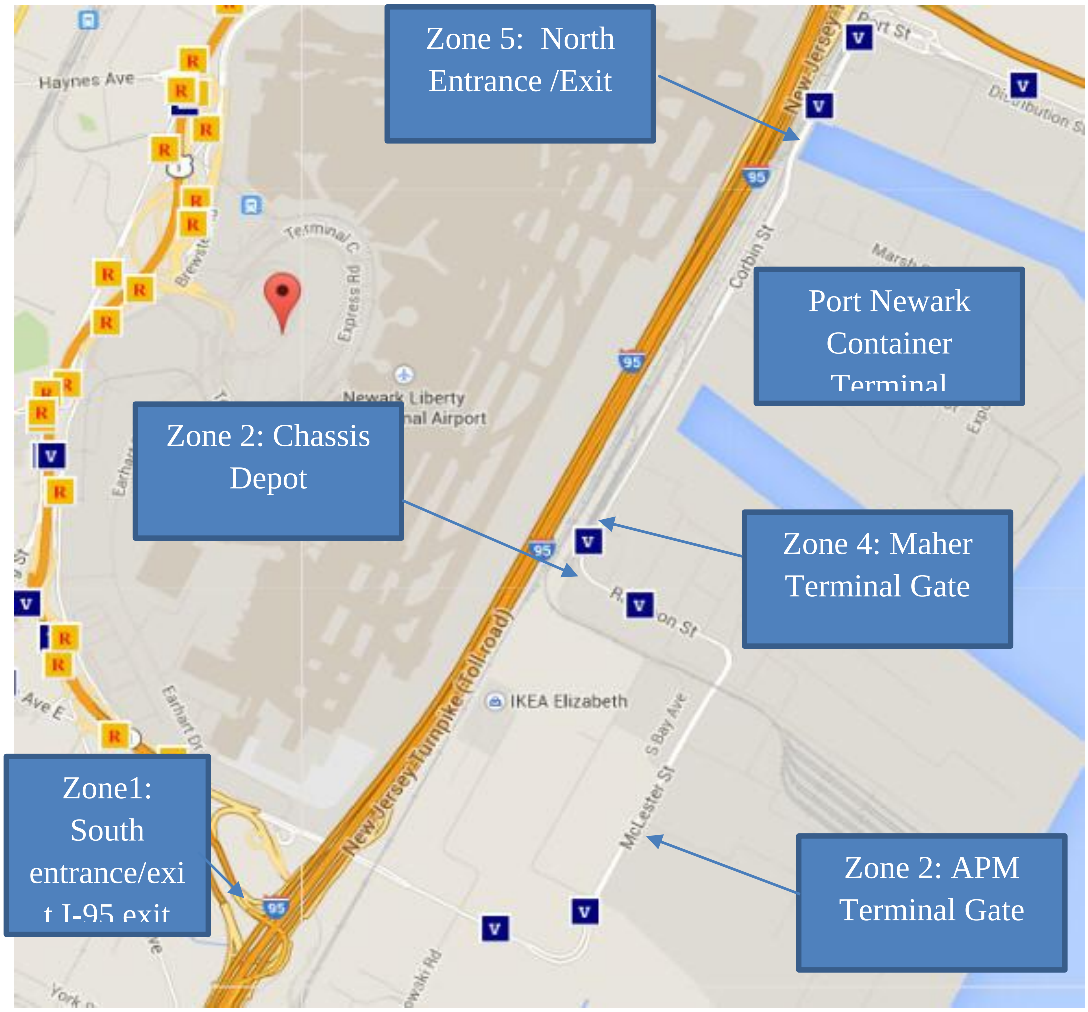

Figure 3. New Jersey DOT Traffic Count Location in the Study Area

The studies by Karafa and Dougherty presented the trip distribution, trip allocation to each terminal and traffic patterns that occur between terminals and chassis depot within the Port Newark area. The traffic pattern knowledge in conjunction with recent traffic counts is used to develop the demand by vehicle type (cars and trucks) and total demand for the simulation model. The vehicle demand by time of day is shown in Figure 4. It can be observed that the car volume peaks during the morning peak period while the truck volume increases during the day peaking during the midday hours.

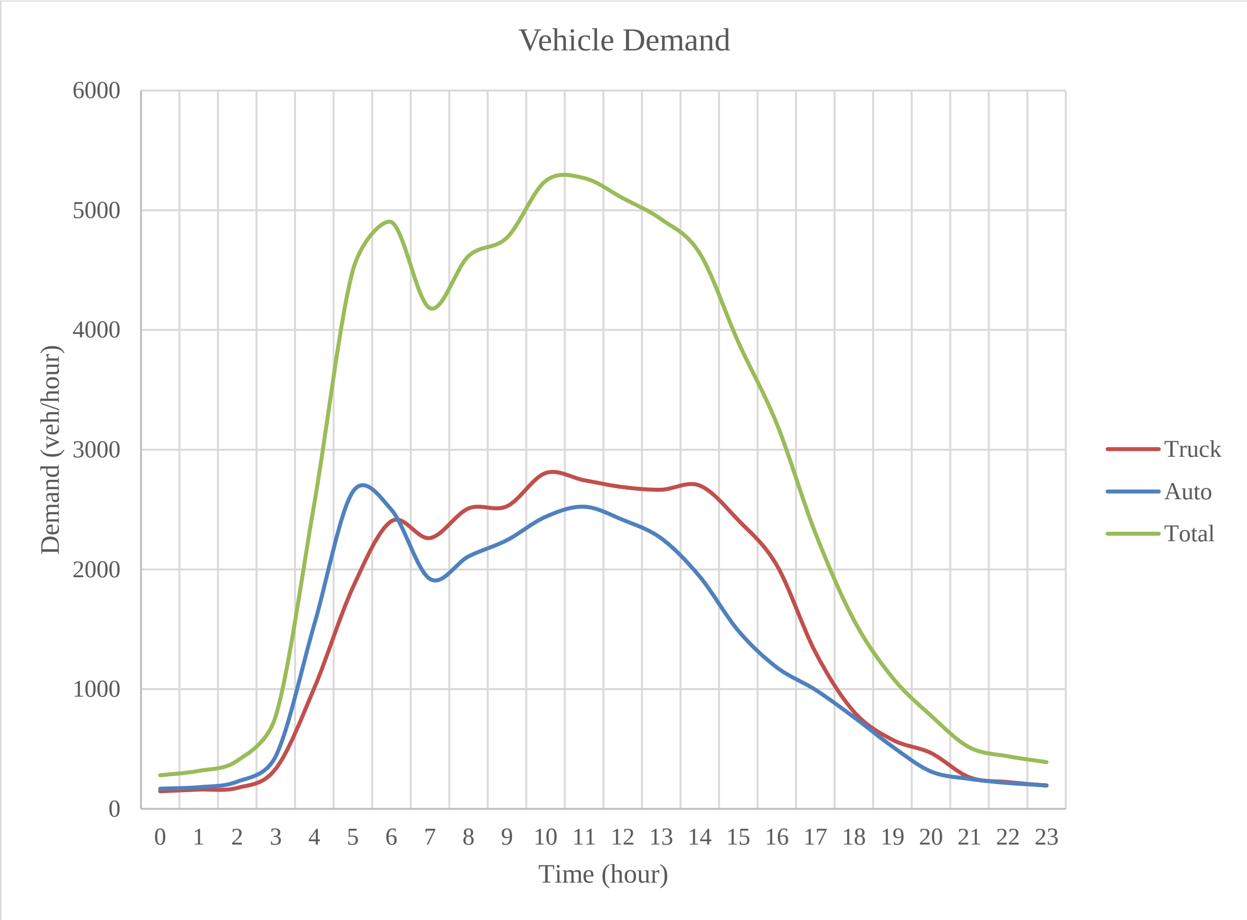

Figure 4. Vehicle Demand in the Study Area

These studies summarize and present the percentages of truck and auto demand that reflects traffic patterns within the Port Newark area. Table 1 show the trip distribution between major highways and terminals.

Table 1. Trip Distribution within the Study Area

Origin/Destination	**South (I-95 and North Ave)**	**North (Port St and Doremus Ave)**
APM Terminal	90%	10%
Maher Terminal	20%	80%
PNCT	5%	95%
Other	50%	50%

NJDOT's hourly counts supplemented with PANYNJ turn counts are used to develop hourly production and attraction of vehicles for 5 zones in study area for a single day (Figure 3).

The study area visits help research team observe the traffic conditions, vehicle behavior, queue formation and record signal timing information. The research team adjusted production and attraction from zones to match turn counts and to prevent doubling of the demand for terminals due to counts which included both trucks arriving at and departing from terminals. The traffic counts and site visits also helped to determine the travel patterns of thru traffic (having origin at one end at destination at other end of the study area). The study area visits were also used to collect travel time information from the study area entry points to the intersections and terminal gates. This knowledge was used to further calibrate the network. The vehicle parameters in VISSIM associated with vehicle look ahead distance was adjusted to enable thru vehicles sooner to select left lanes and avoid being held in queue in lanes that are channeling traffic into the terminal gates.

Gate Configuration and Operation

Figure 5 shows the entrance gate area modeled in Vissim. The approach to the entrance gate area consist of 5 lanes wide roadway section. The section containing the terminal entrance gates and queuing area is 20 lanes wide. The exit gates are also 20 lanes wide. The gate operation was modeled as a 2-tier configuration. Based on the literature review, gate delays were implemented in Vissim that represent the in-gate truck processing time.

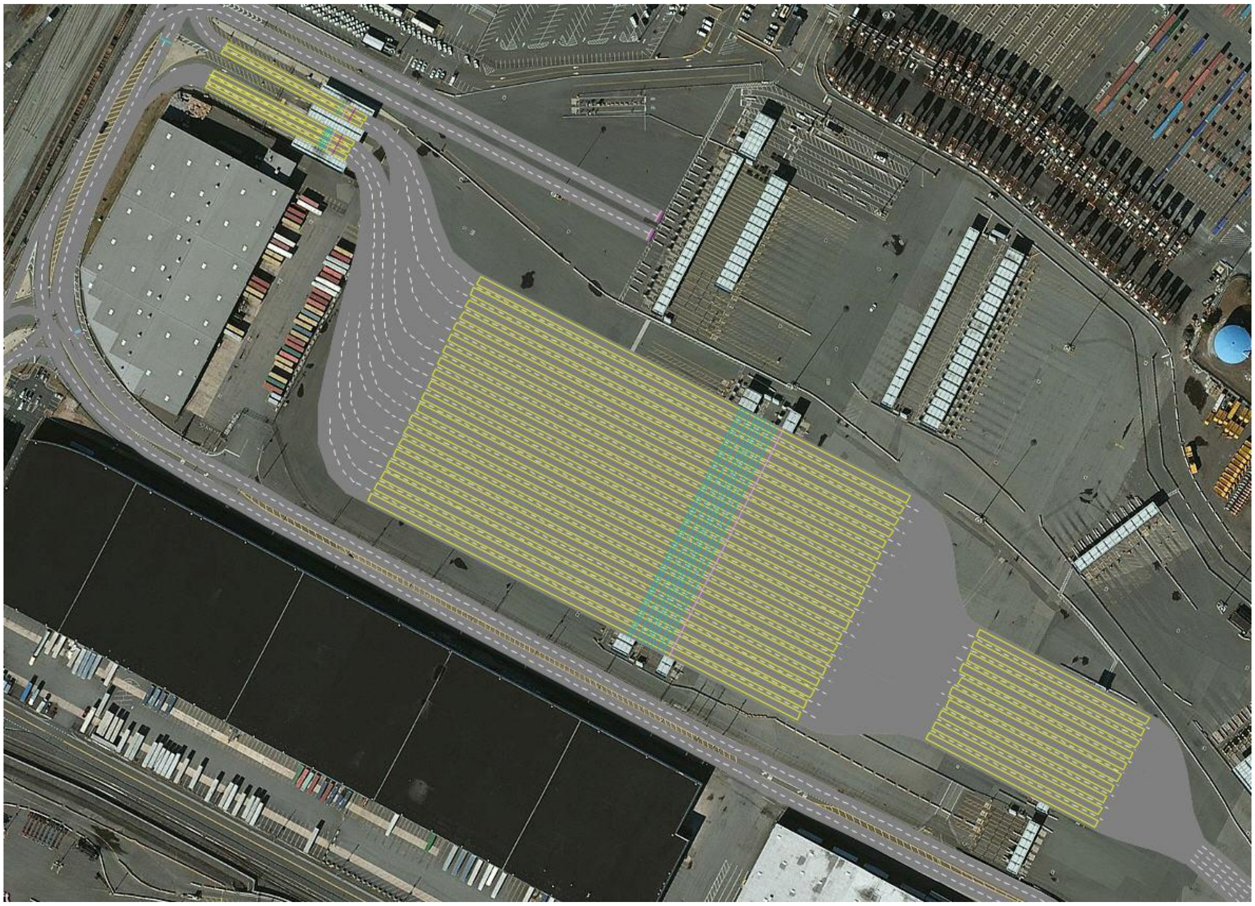

Figure 5. Entrance Gate Model in Vissim

Modeling Delays at the Gate

The entrance gate queues at a marine container terminals have long been identified as primary cause for bottlenecks and delays that occur at the marine terminals. The double moves within the terminal that consist of bringing in a fully loaded container and returning an empty container and vice versa on the same trip contribute to longer truck turnaround times as well. The chassis demand and location of the chassis depot is recently a focal point of efforts to improve the operation in Port of Newark. The literature review states that irregularities in tickets add an average of about an hour to turnaround times. The terminal operators implemented programs such as extended hours, appointment system and off-peak programs to try to alleviate the congestion during the peak hours. Appointment strategies goal is to allow shippers to make efficient dispatching plans consequently reducing truck queue times. In southern California the PierPass system has been offered to shippers encouraging the movement of containers in off-peak hours. These strategies were modeled and analyzed by many researchers in analyzing marine terminal operation deficiencies and improving gate productivity.

Thus it is important to efficiently estimate and simulate traffic conditions in the vicinity of the terminal gate entrance and at the gate. Usually, there are no adequate data available on truck queuing at the entrance gates since terminal operators do not capture queue times. Practically all the data available in the literature are from driver surveys[4].

Marine container terminal gate throughput capacity is a function of the number of gates available, the hours they are open, and the rate at which they process truck identification and documentation. Terminal entrance gates have two standard configurations; one-stage and two-stage. At one-stage entrance gates, all processing transactions are handled at one gate by an employee in a booth. For two-stage entrance gate configurations, truck driver usually completes a portion of paperwork transactions electronically before arriving at a manned entrance gate to complete the entrance process. The process typically includes verifying driver identity, in case the driver is picking up the container operator is determining availability of the specified container, delivering instructions to drayage operators for container pick-up and dispatching yard equipment. If the driver is dropping off a container, container related paperwork and possible container inspection has to be conducted before the truck is assigned and dispatched to a specific slot. At exit gates, in-gate delays typically consist of verifying that the correct container has been picked up.

To efficiently simulate processes within the terminal gate system in Vissim, a speed reduction section was implemented to replicate trucks slowing down while approaching gates. At each gate, a Vissim built-in feature stops, holds and releases vehicles at a specific point to simulate gate transactions. The operations was implemented by applying predefined distribution based on which trucks will be stopped, seized and released. This feature was used to simulate in-gate processing time of each truck at each stage within the gate. The literature review suggest that the mean delay for an entrance gate at each stage can be represented by a normal distribution with a mean of 1 and 4 minutes respectively at each stage.

The pattern of arrivals over the week depends on vessel schedules and customer choices. When vessels are arriving, a surge of import containers from the vessel into the terminal is expected. Import cargo carriers typically want their containers quickly, so there is a swell of drayage activity as well. Exports containers have a tendency to arrive at the terminal during the week prior to vessel arrival. The literature review suggests that a weekly cyclical truck arrival pattern is repeated in the aggregate over a monthly period when all types of transactions are taken into combined consideration. In this model the gate is designed to process trucks from 6:00 A.M. to 9:00 P.M. Monday through Friday. Out of 20 lanes, 6 lanes are dedicated for chassis/bobtail operation while remaining 14 lanes service container trucks. The trucks in Vissim are modeled as two vehicle types to represent the container trucks and chassis. The container truck represent 75% of total demand while 25% are chassis trucks. The ability of Vissim to assign demand to specific lane(s) enabled research team to model the container and chassis trucks and assign

[4] NCFRP 11, “Truck Drayage Productivity Guide”, 2011

different processing times for each vehicle type. The literature review didn't reveal a specific distribution of trucks per lane.

Modeling Gate Strategies

The extended gate hours as a strategy to improve port terminal productivity immediately experience resistance from truck drivers and customers (Giuliano et al. 2009). The off-peak gate operation for truckers means that either they would have to extend their work day or reshape their shift schedules. The social impact is that truckers would have to work during night shift. For terminal owner-operators the strategy does not necessarily produces profit. The main reason are labor costs since labor contract provides for differential shift pay, overtime pay, minimum hour guarantees, and minimum size of labor work units. For warehouses, distribution centers, manufacturers and other entities have to be open during off-peak hours for cargo processing as well. Typically this involves additional labor shifts.

Based on the Los Angeles/Long Beach ports experience with PierPass[5] system percent of truck shifting from the AM and PM peaks was very small, but on the other hand, the large shift out of mid-day hours were observed. The implementation of extended gate operations at the Los Angeles/Long Beach ports revealed that from 22 to 40 percent of the truck demand is expected to utilize the appointment system or arrive during extended hours. Thus in this study it was selected that 30% of truck will utilize the appointment system or arrive during extended hours.

SCENARIO DEVELOPMENT

The increasing truck traffic in the vicinity of the terminal gates can have an impact not only in terms of congestion in the vicinity of the terminal but can impact surrounding roadway network causing congestion problems and reducing not only the terminal performance but affecting shipper as well. Since Port Newark right of way is limited, analyzing the impacts of changes in port truck related traffic as a result of arrival of Post-Panamax vessel to the surrounding roadway network becomes more important and more viable than physical capacity expansions.

It is also important to investigate under which conditions increasing truck volume might starts to impact surrounding highway network. Thus "what-if" scenarios involving different combinations and iterations of the growth in freight demand are developed. For each scenario, a set of operating policies is formulated and simulated in order to determine their effectiveness in responding to the changes in freight (container) demand. The analysis in this study was divided in two parts. First, the impacts of gate operational strategies (appointment system and extended hours of operation) on traffic condition within the study area is analyzed.

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[5] http://www.metrans.org.php53-6.dfw1-1.websitetestlink.com/nuf/2007/documents/Giuliano-OBrienPierPASS_000.pdf

The scenarios analyzed are as follows:

- Baseline Scenario: “Current” operating conditions
- Scenario I: Single Post-Panamax vessel Arrival
- Scenario II (Extended Hours): 30 percent of truck demand is shifted from mid-day to off-peak hours.
- Scenario III (Appointment System): 30 percent of truck demand is shifted from mid-day to off-peak hours

Creating an appointment scenario required changes to be made not only to the truck travel patterns but to physical attributes of the gate model as well. This way faster processing of trucks with appointments is assured. The approach adopted in this study is to have dedicated lanes for trucks with appointments. In order to incorporate these strategies into the Vissim simulation model generalized assumptions were made regarding the way truck arrival pattern would change as a result of Post-Panamax vessel arrival and due to implementation of gate appointment system and extended gate hours.

Based on the literature review, it was assumed that a single Post-Panamax vessel will induce demand of 3,000 trucks at the port gates. The truck arrival distribution in each scenario is modified to reflect additional demand. Figure 6 shows the arrival distribution for baseline scenario, Scenario I when single Post-Panamax vessel arrives and demand where 30 % of truck will utilize the appointment system or arrive during extended hours.

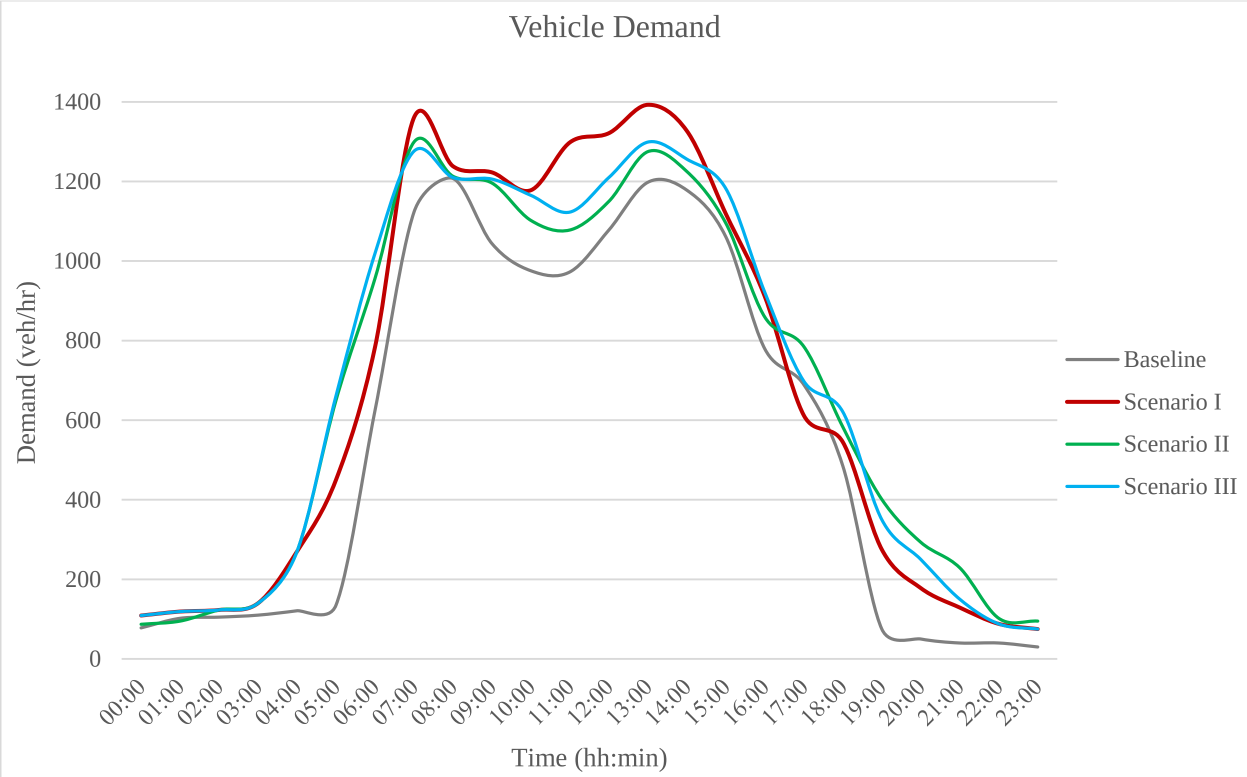

Figure 6. Truck Arrival Distribution

In addition, the sensitivity analysis is developed with a goal of investigating what is the critical demand that will cause a vehicle queue spillover to a surrounding highway The analysis was performed by increasing the baseline truck demand in 10% increments and observing a queue development on both terminal approaches.

RESULTS

As described in the previous sections, the analysis of the impact of one Post-Panamax vessel arrival was analyzed using three scenarios. The arrival of one Post-Panamax vessel is simulated and compared to baseline scenario. Two gate operational strategies are then simulated and their impact of queue formation outside the gates is observed.

Based on the simulation results, it can be observed that the maximum queue length increased from 4274 feet to 6124 feet (43%) due to increased demand in Scenario I (Figure 7). Extending the gate hours had the effect of reducing the average queue length by 5 % and maximum queue length is reduced by 12.9 %. The appointment scenario additionally reduced the average queue length, resulting in 8.4 % and 16.8% reduction in average and maximum queue length respectively compared to the Scenario I.

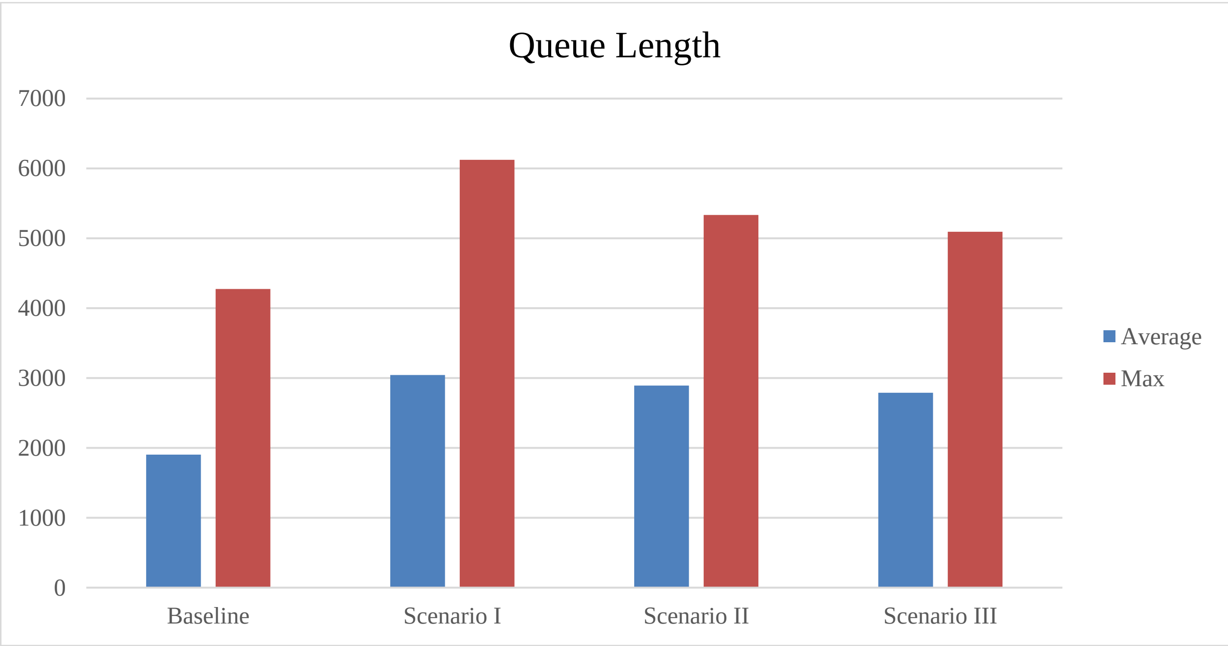

Figure 7. Maximum and Average Queue Length

In Scenario I, the total delay increased by 38% when compared to the Baseline Scenario. The Appointment scenario and Extended Hours scenario reduced the total delay by 12% and 14% respectively. The reason that the appointment scenario outperformed the extended hour scenario is that the delay for appointment trucks had a more significant impact on reducing delays than shifting demand to off-peak hours. A comparison of total delay from the Appointment scenario and Extended Hours scenario to the equivalent value from the Scenario I is shown in Figure 8.

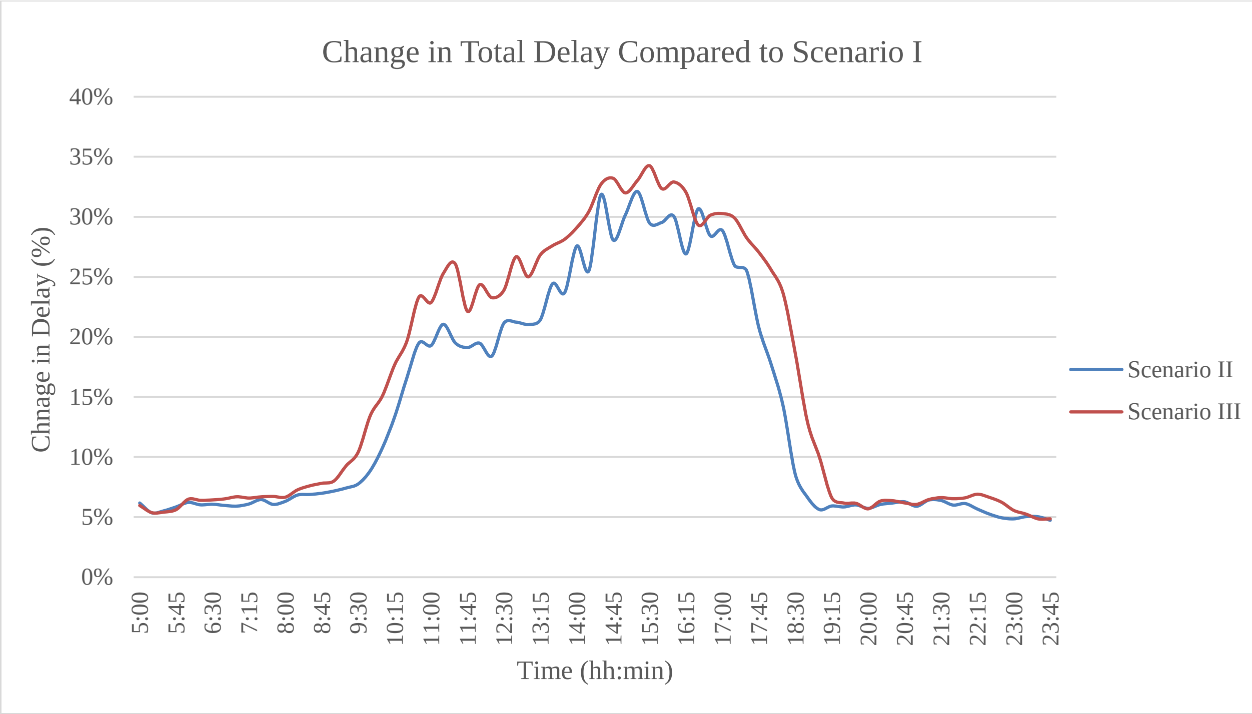

Figure 8. The Gate Strategies Total Delay compared to Scenario I

The next step in this study was to determine the truck volume that affect the highway network i.e. is there a truck a volume that that will cause significant delay within the study area to cause a queue spillover on a highway network. The motivation for this analysis was to investigate what would be the impact of several vessels arriving the container terminals. Since the vessel arrival frequency is unknown, and it is possible that at least two Post-Panamax vessels can be at the berth, the question that arises what would be the critical demand that will result in queues reaching the limits of the study area.

By increasing the truck demand in 10% increments, the impact of the signalized intersection on the truck movement is observed and the length of the queue is recorded. In particular, the thru truck movement progression and queue development at terminal gates is observed. Figure 9 shows the relationship between the change in truck volume and queue formation at the terminal gates.

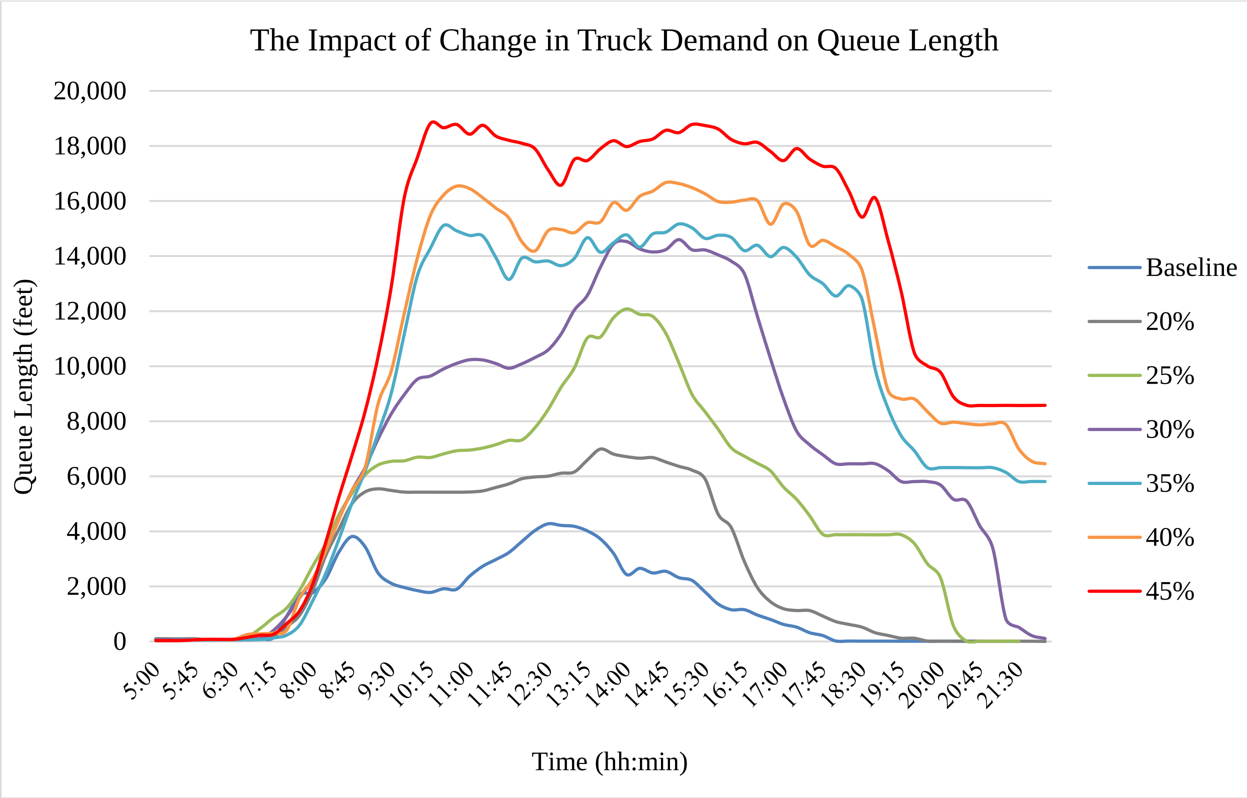

Figure 9. The Impact of Change in Truck Demand on Queue Length

Figure 9 shows as the demand increases the observed queue at terminal gates increases at a rapid rate. The maximum queue length increased from close to 4,000 feet to 18,700 feet if the truck demand is increased by 45 %. The highway exit ramp used by trucks is approximately 3.5 miles or 18,480 feet away from the terminal gates. Thus, increase in demand of 45% causes truck queue spillover to highway network.

Visual observation of the simulations revealed that the significant number of entry and exit points within the study area are imposing additional delays to trucks. It was observed that the signals and turning movements at signals are causing queues formation and obstructing thru vehicle traffic. Thus, the queues at signals and on intersection are restricting access to terminal gates during the peak hours and causing queue to increase at a higher rate.

Figure 10. Observed queues within the Study Area

Figure 10 shows the observed queue at the terminal approach. As stated, it was observed that the terminal gates have sufficient capacity to accommodate additional truck but the signal is imposing additional delays. Also, the default routing parameters within the Vissim model called "the minimum look ahead distance" is increased to ensure that vehicles (especially thru movement vehicles) can "see" the where the queue occurred and consequently change lanes.

CONCLUSION AND RECOMMENDATIONS

A stated, the growth in container volumes is expected to result in substantial increases in congestion. Container terminal operators and State agencies are under pressure to come up with the strategies and infrastructure improvements to accommodate the increasing demand. This study explores the impact of traditional gate operational strategies on queues, delays within the study area. Their impact on queue mitigation and delay reduction is presented.

Since the Post-Panamax vessel arrival frequency is unknown, the study investigates what would be the critical demand that will result in queues reaching the limits of the study area and spilling over to highway network. The result shows that 45 % increase in truck demand could cause the queue spillover on highway network. The visual observations of the simulations reveal that signalized intersection are also contributing to truck delays and restricting access to terminal gates during the peak hours and causing queues to increase at a higher rate.

The simulation model can be improved with the following future research. First, the vehicle counts dataset from which the vehicle distributions is developed can be expanded and latest counts should be used to improve the accuracy the model represents vehicle movements. Implementing the latest efforts of State agencies in improving roadway network, signals and truck logic behind drayage movements between terminals and chassis depot would also improve the functionality of this mode. Specifically, the delays that occur in the chassis depot should be implemented in the model.

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