Using Seaport Freight Transportation Data to Distribute Heavy Truck Trips on Adjacent Highways

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ABSTRACT
Seaports are important intermodal facilities and accommodating the high traffic they generate is important. Heavy trucks are the main mode for transporting freight in and out of an intermodal facility and therefore important to provide adequate service. A methodology for modeling heavy truck routes on a local road network generated by a Florida seaport's vessel freight activity was evaluated to determine the application to another port. This application testing used a simulation computer package. Port Canaveral, an active intermodal facility on Florida's central east coast, was selected. The model utilizes the intermodal facilities freight operations data including heavy truck traffic and vessel freight data. Almost three months of data from year 2002 were used to successfully calibrate and validate the road network model at the 95% confidence level. Results estimated the access highways (State Road 528 and Interstate 95) served 68.4% of the total port generated trucks during the peak hour. A short term forecast for year 2006 was completed with a port truck trip generation model and the road network model using forecasted vessel freight data. A 24.2% average increase in truck traffic was estimated for the access highways. Eight scenarios were also investigated to evaluate application capabilities such as incident management and security measures. The scenarios examined road closure events on the SR 528 corridor. One lane closure created network delays during the peak hour that exceeded 130 veh-hrs. The use of simulation has proven to be a useful tool for evaluation of an intermodal facility's transportation operations.

Key words: freight data, intermodal, seaport, heavy trucks

INTRODUCTION

Intermodal traffic at seaports must be accommodated and planned for if economic growth is to continue. Seaport vessel freight activity can generate high volumes of daily trucks. Recently, a methodology for modeling heavy truck routes on a road network adjacent to a Florida seaport was developed (*1*). This methodology utilizes a micro simulation computer package to model a defined road network for trucks generated by freight movement activity at an intermodal facility. In order for this methodology to be useful, its application to a seaport different from the one used for the initial development was tested. If the methodology can be successfully applied to a seaport with different characteristics from the one used for initial development, then confirmation of the methodology's functionality can be established. Port Canaveral was selected for this analysis.

The Port of Tampa was used for initial development of the methodology being tested herein. Compared to Tampa, Port Canaveral has unique characteristics. Port Canaveral is a quadramodal port. The port is adjacent to the Kennedy Space Center and therefore has the ability to transport freight by road, rail, air, and into space. The Port of Tampa has 5 access roads whereas Port Canaveral has one main access highway (State Road 528) that connects to both the north and south freight terminals. Tampa handles approximately 45 million tons of freight per year while Port Canaveral is growing at 5 million tons per year (*2*). The Port of Tampa generates about 3700 trucks per day while Port Canaveral averages 300-600 trucks per day, depending upon seasonal traffic. The local area surrounding Port Canaveral is much less urbanized than Tampa. Due to this urbanization, the complexity of the road network for Tampa is much greater than the Port Canaveral network. However, Port Canaveral has a number of industries that receive freight at the port and operate on port property thus generating truck trips based not only on the vessel freight activity, but the economics of the individual businesses as well. Port Canaveral has high storage capacity and tremendous growth potential.

LITERATURE REVIEW

Previous methods for evaluation of freight transportation have lacked resilience in comprehensively examining not only an intermodal facility's internal operations but the road networks that connect them. List and Turnquist indicated the probability that truck flows were likely related to the commodities transported (*3*). The Corradino Group completed some initial examinations of truck drivers at the Port of Miami to identify routes commonly accessed for freight transportation with brief interviews (*4*). Abdelghany and Mahmassani applied a Dynamic Trip Assignment simulation model to a transportation network but did not include truck traffic as a major factor, important for including an intermodal facility in any freight transportation model (*5*).

Al-Deek et al. developed a methodology for modeling truck traffic generated by an intermodal facilities freight activity (*1,6,7*). This methodology utilizes vessel freight data and freight-hauling heavy truck movements to execute a network micro simulation model. This methodology has the ability to utilize the trucks generated at the intermodal facility for use in determining the directions of travel and ultimately examine scenarios for possible application for evaluation of necessary improvements to accommodate changes to the traffic patterns and growth of the facility.

MODEL APPLICATION TO PORT CANAVERAL

The road network connecting to Port Canaveral has been defined based on 1999 Florida Department of Transportation (FDOT) Traffic Data, discussions with local freight industry representatives and field observations. Figure 1 shows the defined network. Most of the links are interstate highways or state roads with high traffic volume capacity due to their geometric design. Table 1 lists the links and nodes for the Port Canaveral road network. Internal nodes are locations identified on the network where traffic can travel from one link to another. These are intersections or interchanges. External nodes are the origin-destination (O-D) points for the network and make up the O-D matrix necessary for input to the computer simulation model to determine vehicular trips on the network.

The Verkehr In Staedten SIMulation (VISSIM) micro simulation model, version 3.5, was selected for this research. VISSIM models traffic networks by creating vehicular trips using a dynamic assignment traffic module. Nodes and edges (links) are defined for a network and the traffic from the O-D matrix is assigned on routes based on shortest travel time.

Data required for building, calibrating and validating the road network model included traffic operations data and peak hour vehicular volumes. Signal timing, turning movements, and geometric design specifications of the links and nodes were necessary for the network coding. The peak hour total vehicular and truck volumes were for the calibration and validation of the network model. The vehicular volumes were also used to construct the initial O-D matrix. The traffic operations data were obtained from local agencies and field observations. This data was necessary for coding an accurate network for the assignment of vehicular trips.

A specific route is selected for every vehicle at the departure time. A route is a trip between a selected pair of external nodes. These route choice decisions of all drivers add up to a dynamic assignment of the given transport demand, thus determining the traffic volumes on the road network. These traffic volumes affect travel times on the network. The volumes and travel times are not constant during the simulation period and therefore the fastest routes will not always be the same because of the incremental loading of traffic volumes to the coded network and the stochastic distribution of traffic using Kirchoff's law (*8*). Drivers however are assumed to have no pre-trip information about the actual travel times in the network. The drivers have empirical knowledge about several routes and the travel times while using these routes during the day.

The traffic volumes for calibration and validation were obtained from actual field data collection using portable traffic classifiers. The port truck traffic was the most important input data to the model because the number of trucks generated at the port from intermodal freight activity was the desired output variable. Approximately 60 days of field data were collected between April and June of year 2002. This data was collected at both the north and south freight terminals and selected network links and nodes. The north terminal data was collected on Grouper Road and the south terminal data was collected on George King Boulevard at a location about a quarter mile north of the State Road (SR) 528 intersection.

Selected network links identified as master links were used for calibration and validation of the network model. A master link is a link with a key location around the port and has a high level of daily truck volumes. The selected master link locations capture the truck traffic generated by the port's freight activity that travel on major highways linked to the defined network that are utilized for long distance interstate and intrastate travel. Interstate 95 (I-95) and SR 528 were identified as major truck routes. Port generated trucks travel these routes to carry freight imported and/or exported at the port by vessel to areas outside the local Cape Canaveral road network.

There are also significant local trips made by the port generated heavy trucks due to the daily business operations of the port tenants. The local trips are defined as a trip generated by the port's freight activity but does not leave the Cape Canaveral area surrounding the network. This is considered to be a trip distance of 10 miles or less. Local attractions include a large cement facility off Industry Road and a rail terminal off highway US 1. Though SR 520 does not carry any significant port generated truck traffic, it has been included as part of the Port Canaveral modeled network for purposes of Intelligent Transportation Systems (ITS) applications such as new security highway access implementation. SR 520 is a possible alternate truck route that could be utilized in the event of a disruption to the SR 528 route. However, SR 520 has many types of impedance such as multiple signalized intersections and a small downtown district in the City of Cocoa that truck drivers would travel through to reach I-95 or another connecting north/south highway to SR 528 for east/west travel.

Node 6 and link numbers 7 and 8 were the locations on the network where field data was collected. Data was also collected at the freight terminals adjacent to the port during the same time period. Node 6 captured the I-95 traffic from collected hourly ramp volumes and the link volumes provided the hourly traffic for SR 528. Analysis of the hourly traffic volumes concluded that the peak hour for the Port Canaveral network was from 4-5 PM.

To develop a successful network model for determining the truck volumes on the road network links generated by the freight activity of an intermodal facility, an accurate O-D matrix must be developed. This is the input data required to model a defined network. The initial O-D matrix was constructed for the external network nodes from FDOT traffic flow data and sample peak hourly Port Canaveral traffic volumes. The O-D matrix required peak hour total traffic volumes. The truck volumes are determined from the model output using predetermined percentages of trucks based on available traffic classification data. This O-D matrix was used to initiate the calibration step.

Due to Port Canaveral's limited access routes, only three master links were identified for the port, all located on SR 528. The master links selected for calibration and validation are Links #7, #8, and #15. Link #7 data included I-95 ramp traffic exiting and entering SR 528 east of I-95. Though no data was collected on Link #15, the through traffic was calculated from the I-95 ramps and Link #7 (SR 528) traffic volumes. Link #15 traffic volumes include only the through volumes on SR 528 just west of I-95. The average number of trucks per day recorded for Master Link #7 were 663 eastbound and 881 westbound. The average number of trucks per day recorded for Master Link #8 were 703 eastbound and 750 westbound. The eastbound direction is inbound to the port and the westbound direction is outbound from the port.

The field data traffic volumes were separated into two sets. Eleven weekdays (Monday-Friday) were selected for validation and the remaining weekday data (24 days) was used to determine average peak hour traffic volumes for calibration. In order to use the remaining days for calculating average volumes, a Scheffe's statistical test between days of the week was performed for a 95% confidence level (*9*). There was no significant difference found between weekdays (Monday-Friday) for the traffic volumes, weekends were excluded. Figure 1 identifies the data collection locations by direction with "stars".

To determine a final calibrated O-D matrix, an absolute percent error of less than 5% between the VISSIM simulated and field traffic volumes was computed. Table 2 displays the VISSIM output results from the final calibrated O-D matrix compared to the field data including the absolute percent error for the master links. The VISSIM simulated traffic volumes were extracted from the model simulations by inserting "check points" on the defined network. A check point is where VISSIM captures traffic operational data and outputs it to a data file. One check point was used to identify a location by direction (inbound or outbound).

The final O-D matrix was then used to test the accuracy of the model against the validation data (actual data collected from the field) for the master links, shown in Table 3. The port inbound and outbound total traffic data from Table 3 was used to create eleven different O-D matrices. The VISSIM model was run for each of the eleven matrices. From this output and the predetermined percentages of trucks on each of the links from the field data, the inbound and outbound truck volumes for the master links were calculated. Figure 3 displays the comparison of the field and VISSIM generated truck volumes by master link location.

The visual analysis showed no significant differences between the field and simulated truck volumes on the master links. A Confidence Interval (C.I.) statistical test was also performed on the truck volumes. The upper and lower C.I. limits for all days and locations included zero, therefore the test concluded there was no significant difference between the simulated and field collected truck volumes. The results of this test are provided in Figure 3.

The final O-D matrices concluded from the calibration are shown in Figure 2. The O-D matrix includes all external nodes as displayed in Table 1. In the matrix, Port identifies the freight terminal traffic volume in the O-D matrix. The traffic at the port not directly associated with the freight activity is included in the matrix as local traffic. Local traffic is all traffic entering and leaving the port on George King Blvd. and SR 401 (access roads for the south and north sides of the port) excluding the port freight terminal traffic.

Of the total trucks during the peak hour (32 trucks) destined to Port Canaveral generated by the port's vessel freight activity, 23.3% use SR 528 (eastbound), 23.3% use I-95 traveling northbound (coming from areas south of SR 528) and 26.7% use I-95 traveling southbound (coming from areas north of SR 528). For trucks originating from Port Canaveral (54 trucks) during the peak hour, 20.6% use SR 528 (westbound), 22.2% use I-95 traveling northbound (going to areas north of SR 528) and 20.6% use I-95 traveling southbound (going to areas south of SR 528).

The network model has also captured port generated local truck trips. 9.5% of the truck traffic generated by the port's freight activity travel to Industry Road and 16.7% of the trucks destined to the port are coming from Industry Road. This Industry Road truck traffic is attributed to the large Rinker cement facility. Also, 6.3% of the trucks were local trips to US1 and 3.3% of the truck trips to the port were from US1. This truck traffic is attributed to the rail terminal located just northwest of SR 528. The remaining percentages of truck trips are other local delivery trips.

This Port Canaveral network simulation model was concluded to be accurate at the 95% confidence level and accurately models the current traffic conditions. Therefore, this model is applicable for short term forecasting with the appropriate Port Canaveral intermodal freight data. A truck trip generation model for the freight terminals can be utilized to produce the data necessary to estimate a forecast of traffic volumes for input to the final O-D matrix.

FORECASTING

In order to utilize the Port Canaveral road network model for a short term forecast of truck trips, forecasted traffic volumes for the port's freight terminals are necessary. The data to compute these volumes can be obtained from executing a truck trip generation model (*1,7*). To determine the trucks generated by an intermodal facility, the model requires daily vessel freight data for input. Artificial Neural Network (ANN) modeling with the MatLab computer package was used to build the model by establishing relationships between daily vessel freight data and heavy truck volumes for both the inbound and outbound directions (*6,7*).

The input data to execute the Canaveral truck trip generation model was derived from historical data and an Auto Regressive Integrated Moving Average (ARIMA) time series model (*1,7*). The Canaveral Port Authority provided historical data records for a period from September 1994 through August 2001. The ARIMA model used the historical data to estimate future expected vessel freight movements for year 2006. From these forecast results, five days of vessel freight data were input to the Canaveral truck trip generation model to obtain the corresponding inbound and outbound daily truck volumes. These daily truck volumes were then converted to peak hour traffic volumes using the truck (T) & peak hour (K) factors derived from the current traffic operations data. A growth rate was calculated based on the annual increase in daily truck traffic from forecasted data between year 2002 and 2006. This growth rate was necessary to estimate the traffic volume increases on the network corresponding to the year of analysis (in this case year 2006).

The T factor was 10% and the K factor for the inbound traffic to the port was 6.53% and the outbound K factor was 14.03%. The annual growth rate from the forecasted data was found to be 5.07% (*1*). The final total traffic matrix, displayed in Figure 2 was adjusted based on the new forecast traffic volume data. The Port O-D pair was changed to reflect year 2006 forecasted traffic volumes. The remaining O-D pair volumes were adjusted to reflect the estimated growth rate. Five separate O-D matrices were created for each of the forecast days.

The forecast results for the Port Canaveral network during the peak hour indicate expected increases on I-95, SR 528, and Industry Road due to forecasted increases of intermodal freight activity. For the eastbound direction (inbound to the port), the truck volumes from I-95 increased by 26.6%. SR 528 showed a 28.6 % increase and Industry Road had a 20% increase in truck traffic. For the westbound direction (outbound from the port), the truck volumes to I-95 increased by 22.2%. For SR 528, the truck volumes increased by 23.1% and the truck volumes destined to Industry Road increased by 16.7%. There were increases for truck traffic northbound on SR 3 and US 1 for outbound trucks but due to the low volumes, this was not considered to be significant. Figure 4 compares current traffic conditions with the year 2006 forecasted total traffic and trucks only peak hour volumes generated by the Port Canaveral's intermodal freight activity.

MODEL APPLICATIONS

A number of scenarios were investigated with the validated Canaveral Road Network Model to evaluate the potential applications to traffic operations management for an intermodal facility. VISSIM allows the user to insert "check points" on a defined network for extracting evaluation parameters such as average individual vehicular delay (sec/veh). From the simulated volumes and individual vehicular delay, a total link or node delay can be calculated. For each scenario, the vehicular delay was calculated for each check point selected. The vehicular delay recorded at a check point includes any queuing delay the vehicles experienced prior to passing the check point. The check points are identified in Table 4. One check point was selected for each direction. The total network delay in vehicle-hours (veh-hrs) was calculated from the 18 checkpoints established on the network in VISSIM. The individual vehicular delays for the base scenario and the change in delay between the base and other scenarios are summarized in Table 4.

A base scenario was completed for comparative purposes. All other scenarios were compared to the base scenario to evaluate selected network links and nodes (check points). The base scenario was completed with the final total traffic volume O-D matrix displayed in Figure 2. All scenarios examined the effects of lane closures on the network.

Scenario 1 examines the effect of closing one lane on SR 528 for Link 8 in the westbound direction. There were significant increases in delay on SR 528 for all westbound links. There were also extremely high delays for vehicles exiting SR 528 westbound onto SR 3. An increase in delay was also observed on SR 520, the alternate route for SR 528. The total network experienced a delay increase of over 98 veh-hrs.

Scenario 2 has a lane closure on SR 528 for Link 1 westbound. There was a significant increase in delay on SR 528 for westbound links downstream of the lane closure. Furthermore, vehicles entering SR 528 westbound from SR 3 experienced some delay. All vehicles passing the lane closure and exiting to US 1 (Node 4) experienced significant delays. Those vehicles exiting to SR 3 (Node 1) also experienced significant delays. This is attributed to the lane closure that is immediately upstream of this node. Vehicles on SR 520 westbound also experienced some delay. The overall network delay increased to 136.3 veh-hrs.

Scenario 3 had a lane closure on SR 528 (Link 18) in the westbound direction. Vehicles passing Check Point 3 on SR 528 (Link 7) downstream of the lane closure experienced significant delays. However, the lane closure no longer seemed to have any significant influence to the traffic volumes of the off-ramps to SR 3 and US 1. The high delays for I-95 northbound (Node 6, Check Point 11) and SR 528 (Link 15, Check Point 16) westbound are attributed to the fact that the port is a significant generator of traffic and the further a vehicle travels to reach the lane closure on the affected routes, the higher delays experienced due to the accumulation of delay as the vehicle traverse through the network. In other words, the longer a vehicle travels the network on links influenced by the lane closure, the higher the delay for that vehicle.

Scenario 4 eliminates the SR 528 off-ramp to SR 3 in the westbound direction (check point 5). The delay decreased on SR 528 near the port (Link 8) for westbound traffic. This is attributed to the elimination of access to the SR 3 off-ramp. The previous influence of vehicles decelerating to exit SR 528 is no longer impeding the flow of traffic. The reduction of delay on SR 520 (check point 9) is attributed at least in part to a reduction to the traffic volume (SR 528/SR 3 volumes that were using SR 520 westbound). The overall network experienced only a slight increase (8.4 veh-hr) in total delay.

Scenario 5 eliminates the SR 528 off-ramp to US 1 in the westbound direction (Node 4, Check Point 7). On SR 528 westbound (Link 8) the reduction in delay when compared to Scenario 4 was higher. This is attributed to the higher volume the US 1 off-ramp serviced (1153 veh/hr) compared to the SR 3 off-ramp (543 veh/hr). More vehicles that previously influenced the traffic operations with deceleration for the ramp exit have been eliminated. This reduction in delay followed through downstream of the US 1 interchange as well. There was a considerable reduction in delay on SR 528 (Link 8, Check Point 3 and Link 15, Check Point 16). The network experienced a 6.5 veh-hr overall reduction in delay. This was the only scenario that produced any significant reduction in delay for the overall network.

Scenario 6 closes both travel lanes southbound on SR 3 (Link 2) just south of the SR 528/SR 3 interchange. There were slight increases in delay for the SR 528 westbound traffic, possibly due to a re-direction of the vehicular trips prohibited on SR 3 southbound. The slight reduction is SR 520 delays may be due to a slight reduction in the traffic volume on Link 3 (Check Point 9). The network experienced a slight increase in delay of 10 veh-hrs.

Scenario 7 closes both travel lanes southbound on US 1 (Link 4) just south of the SR 528/US 1 interchange. There was even less effect to the delay for this scenario. The network experienced almost no change for the overall delay. A few minor delay increases occurred on SR 528 but not significant enough to impact the level of operations to any degree. The assumption here is that due to the low volume of traffic exiting SR 528 to travel south on US 1 (concluded from comparing the base scenario volume to this scenario volume result for Link 4 southbound).

Scenario 8 has a lane closure on SR 528 eastbound (Link 1) just west of the SR 3 interchange. This created delay increases for all vehicles inbound to the port (Link 3, Check Point 2). This lane closure created a total delay increase of 7.4 veh-hrs. No other delay of any significance was recorded on the network.

CONCLUSIONS

An intermodal facilities ability to provide adequate service to freight carriers is only as good as the transportation network connecting to it. If freight cannot be transported in and out of the facility efficiently, then the facility is lacking usefulness as an intermodal hub. In order to reduce or eliminate the possibility of experiencing such a weakness, routine evaluations of the intermodal freight operations, heavy truck volumes generated and the efficiency of the transportation network, including the access roads and connecting road network should be completed.

One way in which to accomplish this task is to apply simulation modeling techniques that utilize intermodal freight data from the facility to be evaluated. Al-Deek et al. developed tools directly applicable to such tasks (*1,6,7*). A truck trip generation model for seaports that utilized vessel freight data to calculate the daily number of heavy trucks generated by the freight data has been created. Al-Deek et al has also successfully built a framework for applying this model with a network modeling methodology to evaluate the trips made by the heavy trucks transporting freight outside the area of port operations.

This entire framework was applied successfully to the Port Canaveral intermodal facility. The port operations, network analysis, forecast of future expected changes to the freight operations and possible applications were successfully accomplished. Eight different network scenarios were investigated to evaluate the applicability of the methodology.

To build the network connecting to Port Canaveral, total traffic and heavy truck volumes at the port and at selected locations on the defined network were collected with portable vehicle classifiers. This actual field data was utilized to calibrate and validate a road network model coded in the VISSIM micro simulation computer software package. The network model was successfully validated at the 95% confidence level using a Confidence Interval test. The major highways identified in the network (State Road 528 and Interstate 95) service the majority of the freight traffic during the peak hour. For inbound truck traffic to the port, 73.3% travel from the major highways and 63.4% of the trucks leaving the port were destined to them. This indicates the significance and importance of having an adequate interstate highway system connecting to intermodal facilities for transportation of imported and exported goods via seagoing vessel.

A truck trip generation model that produces heavy truck trips based on intermodal freight activity (daily vessel freight records) was executed to estimate future expected truck volumes in year 2006. Forecasted vessel freight records for year 2006 were input to the model and from the output, five weekdays of truck volumes were utilized to calculate estimated peak hour total traffic volumes using truck (T) and peak hour (K) factors as well as an annual average growth rate. These total traffic volumes were input to the previously validated total traffic O-D matrix (shown in Figure 2) to evaluate the network operations potential to accommodate growth. The delays for the network increase by almost 50% (from 13.7 to 26 veh-hrs), see Table 4. The truck volumes on I-95 increased by an average of 25%, SR 528 truck volumes increased by 26% and Industry Road increased by 18%.

Of the eight scenarios investigated and compared to the current traffic conditions for year 2002 in the Port Canaveral area, lane closures on SR 528 have the greatest impact. This highway is the main artery to Port Canaveral for transportation of freight. The high delays experienced by only one lane closure during the peak hour (in excess of 120 veh-hrs) provides proof to support the conclusion that it is important to be able to accommodate freight transportation efficiently. SR 528 just west of this intermodal facility, services on the average almost 2200 veh/hr during the peak hour in the outbound (westbound) direction including almost 4% trucks. The westbound direction of SR 528 is also an evacuation route for the Cape Canaveral area for events such as a hurricane or other major disaster.

The ability of an intermodal facility to provide adequate and efficient transportation services to freight transporters by rail, highway, water and air is important to the economy of a region for growth potential. Constricting transportation movements inhibits the possible expansion capabilities of an intermodal facility. Heavy trucks transport the majority freight in and out of intermodal facilities due to their maneuverability for providing door-to-door service (*10*). Therefore, it is of great interest and benefit for these trucks to efficiently and economically access an intermodal facility and ultimately have an adequate road network to travel on.

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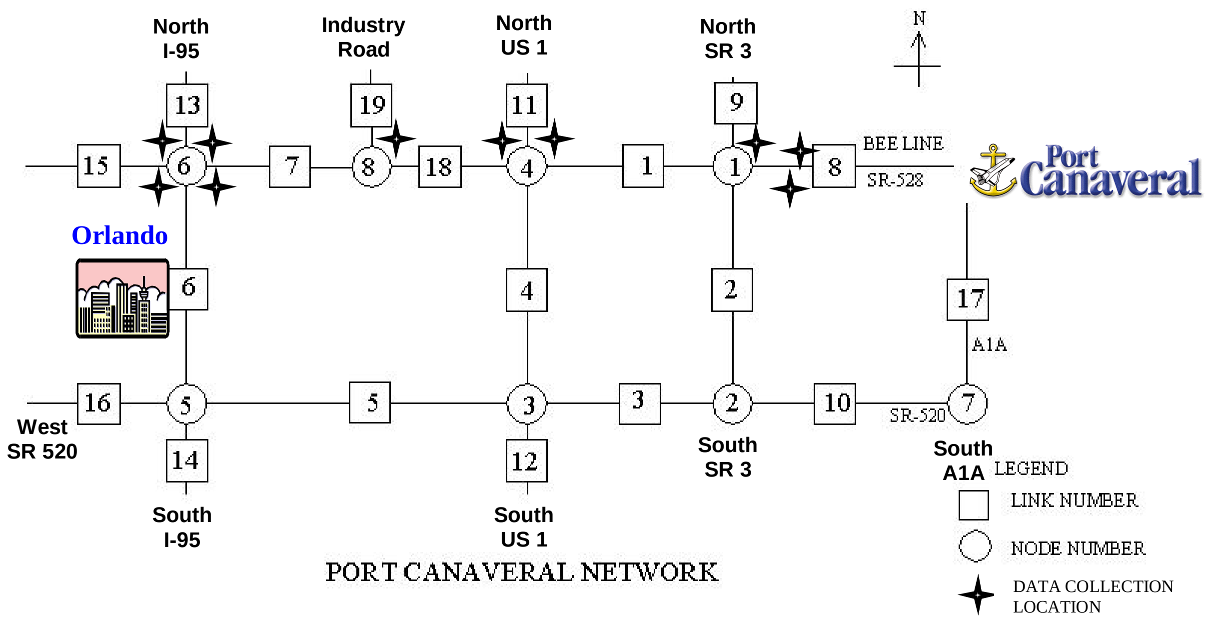

Figure 1: Port Canaveral Truck Route Network

Calibrated Total Traffic O/D Matrix

Total Traffic Volume	Local Traffic	North SR 3	North US 1	North I-95	SR 520 (Orlando)	South US 1	South SR 3	South A1A	Industry Road	SR 528 (Orlando)	South I-95	Port	Prod.
Local Traffic	0	550	1300	650	10	250	250	1500	350	900	100	5	5865
North SR 3	500	0	1500	230	100	400	1500	100	250	500	100	10	5190
North US 1	400	150	0	25	10	1200	10	100	60	50	300	10	2315
North I-95	220	5	5	0	400	10	10	40	40	350	1200	80	2360
SR 520 (Orlando)	10	40	10	500	0	100	200	500	60	10	500	5	1935
South US 1	150	10	1500	10	400	0	400	400	5	80	200	5	3160
South SR 3	150	800	100	100	150	300	0	300	5	20	10	5	1940
South A1A	800	50	300	50	250	400	500	0	5	50	400	10	2815
Industry Road	100	10	10	10	10	10	10	10	0	10	560	50	790
SR 528 (Orlando)	270	250	200	400	10	150	100	10	40	0	400	70	1900
South I-95	170	10	20	1500	600	10	10	500	90	150	0	70	3130
Port	10	40	40	140	10	20	20	20	60	130	130	0	620
Att.	2780	1915	4985	3615	1950	2850	3010	3480	965	2250	3900	320	

Calibrated Trucks Only O/D Matrix

Trucks Only Volume	Local Traffic	North SR 3	North US 1	North I-95	SR 520 (Orlando)	South US 1	South SR 3	South A1A	Industry Road	SR 528 (Orlando)	South I-95	Port	Prod.
Local Traffic	0	5	5	15	1	1	1	2	4	12	4	1	51
North SR 3	1	0	2	15	1	1	6	1	3	11	6	1	48
North US 1	1	2	0	3	0	10	0	1	2	6	10	1	36
North I-95	4	1	1	0	6	0	0	1	6	12	20	8	59
SR 520 (Orlando)	0	1	0	8	0	1	1	4	1	0	8	1	25
South US 1	2	0	10	0	5	0	1	3	0	5	3	1	30
South SR 3	2	8	2	2	2	5	0	3	0	3	0	1	28
South A1A	5	1	5	1	4	6	8	0	0	3	6	1	40
Industry Road	1	0	0	2	2	0	0	0	0	1	20	5	32
SR 528 (Orlando)	2	2	2	10	0	1	1	0	2	0	6	7	34
South I-95	2	0	0	20	10	0	0	8	8	7	0	7	62
Port	1	4	4	14	1	2	2	2	6	13	13	0	62
Att.	22	24	31	89	33	28	21	25	32	73	97	32	

Figure 2: Final Calibrated Port Canaveral O-D Matrices

Figure 3: Port Canaveral Field and VISSIM Truck Volume Validation Results

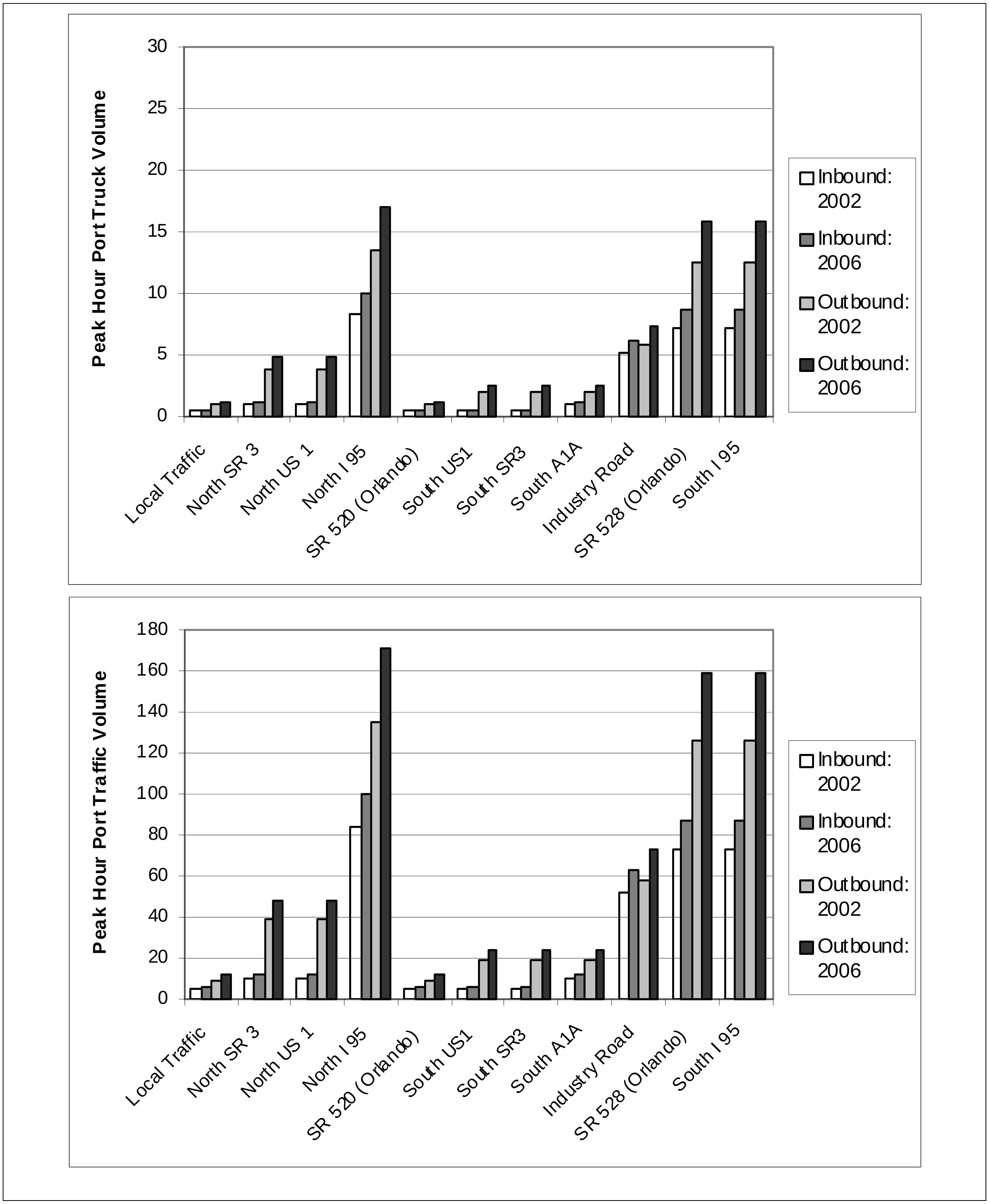

Figure 4: Port Canaveral Current and Forecasted 2006 Vehicle Volumes

Link #	Link Description
1	SR 528 (between SR 3 and US 1)
2	SR 3 (between SR 528 and SR 520)
3	SR 520 (between SR 3 and US 1)
4	US 1 (between SR 528 and SR 520)
5	SR 520 (between US 1 and I 95)
6	I 95 (between SR 528 and SR 520)
7	SR 528 (between Industry Rd and I 95)
8	SR 528 (between Port Canaveral and SR 3)
9	SR 3 (North of SR 528)
10	SR 520 (East of SR 3)
11	US 1 (North of SR 528)
12	US 1 (South of SR 528)
13	I 95 (North of SR 528)
14	I 95 (South of SR 520)
15	SR 528 (between Orlando and I 95)
16	SR 520 (West of I 95)
17	SR A1A (north of SR 520)
18	SR 528 (between US 1 and Industry Rd)
19	Industry Rd (north of SR 528)

Note: Shaded Records indicate Master Links

Node #	Internal Node Description
1	SR 528 and SR 3
2	SR 520 and SR 3
3	SR 520 and US 1
4	SR 528 and US 1
5	SR 520 and I 95
6	SR 528 and I 95
7	SR 520 and SR A1A
8	SR 528 and Industry Rd

External Nodes
West SR 520
South I-95, North I-95
South US 1, North US 1
South SR 3, North SR 3
South A1A
Orlando
Port Canaveral
Industry Road

Table 1: Port Canaveral Network Links and Nodes

Check Point	Link (L) or Node (N)	Link or Node Description	Total Peak Hour Traffic Vol. Actual	VISSIM	% Diff
1	L-8	Westbound (SR528 near port)	2333	2297	1.5%
2	L-8	Eastbound (SR528 near port)	977	964	1.3%
3	L-7	Westbound (SR528 near I95)	1221	1228	0.6%
4	L-7	Eastbound (SR528 near I95)	833	852	2.3%
5	N-1	SR528 (Off ramp to SR3)	545	543	0.4%
7	N-4	SR528 (Off ramp to US1)	1199	1153	3.8%
8	N-4	SR528 (On ramp from US1)	211	211	0.0%
11	N-6	SR528 (Off ramp to I95 North)	365	359	1.6%
12	N-6	SR528 (Off ramp to I95 South)	269	261	3.0%
13	N-6	SR528 (On ramp from I95 North)	110	112	1.8%
14	N-6	SR528 (On ramp from I95 South)	210	216	2.9%
15	N-8	SR528 (Off ramp to Industry Road)	295	293	0.7%
16	L-15	Orlando SR528 West	587	594	1.2%
17	L-15	Orlando SR528 East	513	529	3.1%

Note: Shaded cells indicate Master Links

Table 2: Calibration Results

Total Traffic Volumes

	Inbound							Outbound						
	Port	Link 8		Link 7		Link 15		Port	Link 8		Link 7		Link 15	
Day #	Node	Actual	VISSIM	Actual	VISSIM	Actual	VISSIM	Node	Actual	VISSIM	Actual	VISSIM	Actual	VISSIM
1	270	929	915	758	844	459	522		2197	2267	1120	1183	569	559
2	262	844	925	776	838	473	524		2347	2275	1183	1190	591	572
3	314	891	960	792	837	484	528		2314	2311	1148	1182	591	569
4	375	940	973	763	871	462	535		2361	2294	1181	1207	585	575
5	398	969	982	842	871	493	535		2070	2301	1197	1226	662	583
6	288	837	883	724	831	437	528		2007	2267	1079	1191	557	556
7	306	831	883	728	847	442	528		2092	2257	1052	1142	498	531
8	254	905	904	812	845	495	523		2216	2289	1135	1188	550	565
9	281	858	901	809	847	449	527		2032	2288	1080	1198	550	570
10	339	885	968	850	862	516	528		2387	2283	1193	1198	568	580
11	271	881	908	773	824	461	521		2022	2261	1258	1197	692	563

Truck Volumes

	Inbound							Outbound						
	Port	Link 8		Link 7		Link 15		Port	Link 8		Link 7		Link 15	
Day #	Node	Actual	VISSIM	Actual	VISSIM	Actual	VISSIM	Node	Actual	VISSIM	Actual	VISSIM	Actual	VISSIM
1	27	18	18	29	32	10	11		42	43	55	58	37	36
2	26	21	23	29	31	7	8		43	42	52	52	26	25
3	31	28	30	32	34	13	14		49	49	52	54	29	28
4	38	17	18	29	33	10	12		53	51	46	47	14	14
5	40	13	13	29	30	8	9		41	46	51	52	24	21
6	29	20	21	29	33	11	13		106	120	59	65	39	39
7	31	35	37	35	41	16	19		124	134	55	60	28	30
8	25	36	36	24	25	5	5		130	134	42	44	20	21
9	28	20	21	26	27	9	11		117	132	55	61	30	31
10	34	19	21	25	25	9	9		111	106	67	67	44	45
11	27	19	20	25	27	9	10		111	124	67	64	44	36

Table 3: Port Canaveral Master Link Validation Data

Check Point	Link (L) or Node (N)	Description	Base Scenario*	Year 2006	Scenario (Change in Individual Vehicular Delay (Sec/Veh))							
					One	Two	Three	Four	Five	Six	Seven	Eight
1	L-8	Westbound (SR528 near port)	2.8	3.4	66.7	0.0	0.0	-1.9	-2.3	-1.3	-0.5	0.0
2	L-8	Eastbound (SR528 near port)	0.5	0.5	0.0	2.4	0.0	0.0	0.0	0.2	-0.2	31.1
3	L-7	Westbound (SR528 near I95)	8.3	15.7	88.7	84.2	157.2	9.0	-5.0	11.1	1.0	0.0
4	L-7	Eastbound (SR528 near I95)	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
5	N-1	SR528 (Off ramp to SR3)	5.8	13.2	810.9	226.8	0.0	N/A	-4.0	-1.7	-1.6	0.0
6	N-1	SR528 (On ramp from SR3)	0.0	0.0	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0
7	N-4	SR528 (Off ramp to US1)	9.2	20.0	78.4	164.8	0.3	12.2	N/A	12.9	1.2	0.2
8	N-4	SR528 (On ramp from US1)	0.5	0.7	0.3	0.1	-0.4	0.0	0.4	-0.2	-0.2	0.0
9	L-3	Westbound SR520	1.2	2.6	21.2	21.6	0.0	-0.8	-0.5	-0.9	-0.5	0.0
10	L-3	Eastbound SR520	1.6	1.5	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.2	0.0
11	N-6	SR528 (Off ramp to I95 North)	10.4	21.6	129.3	98.5	239.5	12.0	-6.0	13.9	1.6	-0.1
12	N-6	SR528 (Off ramp to I95 South)	0.7	0.8	-0.6	-0.5	2.0	0.1	-0.1	0.1	0.1	-0.1
13	N-6	SR528 (On ramp from I95 North)	0.5	0.9	0.4	0.0	-0.1	0.3	0.2	0.5	0.1	0.0
14	N-6	SR528 (On ramp from I95 South)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	N-8	SR528 (Off ramp to Industry Road)	9.8	22.3	112.9	151.3	13.1	13.7	-6.5	13.4	0.5	0.2
16	L-15	Orlando SR528 West	10.5	18.9	127.3	127.4	228.1	10.3	-6.5	13.8	1.1	0.0
17	L-15	Orlando SR528 East	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	L-17	A1A South	2.2	2.4	1.6	0.4	0.0	-1.6	-1.8	-1.2	-0.3	0.0
1-18	**Total Network Delay for all Vehicles (Veh.Hr)**		**13.7**	**26.0**	**98.3**	**122.6**	**68.7**	**8.4**	**-6.5**	**10.0**	**-0.1**	**7.4**

*Vehicular delay (in seconds per vehicle) without any modifications to the network

Note: shaded records indicate master links

Table 4: Results for Network Scenarios