Evaluating the Effectiveness of Various Truck Lane Restriction Practices in Florida—Phase II

Volume 3—Evaluation of Truck Lane Restriction on Non-Limited Access Urban Arterials

Final Report

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16. Abstract

The commodity pick-up and delivery activities in urban areas have led to an increase in truck traffic on urban roadways raising safety and operational concerns. A number of strategies for managing trucks have primarily been implemented on interstates highways. The perceived success of truck lane restriction on freeways have led to increasing demands from the public for highway agencies to institute similar measures on non-limited access arterial streets. The review of State statutes, policies, and practices have so far revealed that five States—Alabama, Delaware, Florida, Georgia, and New Jersey—have roadway sections on non-limited access highways with truck lane restriction. However, the literature search revealed that the efficacy of truck lane restrictions on non-limited access highways has not been thoroughly studied. The objective of this study was therefore to evaluate the influence of various geometric, traffic, and signalization factors that might affect the effectiveness of truck lane restrictions on non-limited access highways, primarily urban arterial roadways with a significant amount of truck traffic. VISSIM simulation software was used to evaluate operational and safety effects of a truck lane restriction by varying parameters related to the restriction. A 5-mile section of SR 70 in Fort Pierce, Florida was selected for simulation analysis. A network consisting of 22 roadway sections with 121 signalized intersections was simulated. The results of various simulation scenarios showed that restricting trucks to the right lane does not have deleterious effects compared to no restriction. In fact, restricting trucks to the right lane could improve travel speed on the highway corridor, although not by much. However, restricting trucks to the left lane or to the center lane would cause excessive lane changing, reduced travel speed, increased queue lengths, and increased stopped delay. The imposition of a truck lane restriction increases the speed difference between cars and trucks and also increases lane changing maneuvers. This phenomenon is likely to increase vehicular conflicts in real life but the extent to which these operational and safety implications may apply needs to be studied in the field.

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EXECUTIVE SUMMARY

Background

Trucks are heavier, longer, wider, and less maneuverable than passenger cars. While traveling on arterial roadways, trucks pose a number of problems. Large trucks may hinder the visibility of signs and signals for motorists in small vehicles following behind them. Because of the larger physical dimensions, trucks also encroach on adjacent lanes when trying to complete turning maneuvers on narrow intersections. In addition, trucks can create queues when using roadways with fewer and narrower lanes because drivers of passenger cars are less likely to execute passing maneuvers. All these problems have a negative influence on the operational and safety performance of arterial roadways.

The need for a study of truck lane restrictions on non-limited access highways is further heightened by the fact that most studies evaluating truck lane restrictions were conducted on limited access highways. The literature review conducted as part of this research did not find any study that analyzed the efficacy of truck lane restrictions on non-limited access highways. Thus, prior to the implementation of any truck lane restriction strategy on Florida non-limited access highways it is imperative that the likely effects of such decisions be analyzed through a carefully designed simulation study supported by a comprehensive review of theory and practice in other states.

Objectives

The understanding and predictability of the likely operational and safety effects of truck lane restrictions on non-limited access highways require evaluating several lane restriction options—i.e., should trucks be restricted to the outermost left lane, right lane or center lane on roadways with three lanes in one direction? Should trucks be restricted to the left lane or right lane on roadways with two lanes in one direction? Also, on roadways with three lanes in one direction, the issue of how many through lanes should be restricted needs thoughtful evaluation. Furthermore, recommendation of the suitable time of day for restricting trucks to certain lanes requires evaluating various factors that affect traffic operations. These factors include the distribution of the traffic volume between the lanes and the proportion of trucks within the traffic stream. In accordance with the overall goal of the project, the objective of this study was to evaluate the influence of various geometric, traffic, and signalization factors that might affect the efficacy of truck lane restrictions on non-limited access highways, primarily urban arterial roadways with significant truck traffic.

Findings and Conclusions

Consistent with the literature review results which showed that trucks can be restricted to the left or right lanes, four simulation scenarios were identified and analyzed both as a corridor and as a network. The no restriction scenario that currently exists on

SR 70 and three alternative restriction scenarios were built into a VISSIM simulation model. The three restriction scenarios had trucks restricted to the right, center, or left lane in the 3-lane section of SR 70. The results of the corridor analysis indicated restricting trucks to the right lane reduced travel time when compared to the existing scenario of no restriction. The savings in travel time were found to be statistically significant. The results showed the average travel speed of passenger cars increased when trucks were restricted to the right lane. The average truck travel speeds decreased following the restriction, but statistical analysis showed the decrease was not significant. The corridor analysis results further showed restricting trucks to the center lane or to the left lane diminished roadway operational performance. These two restriction scenarios were associated with increased travel time, delay, and reduced travel speed for both passenger cars and trucks. The analysis showed that restricting trucks to the left lane had the most undesirable results due in part to the fact that trucks must access driveways located on the right from the right lane. Thus, they have to change lanes to access these driveways.

The network simulation results mirrored corridor simulation results showing that restricting trucks to the right lane improved intersection performance by reducing queue lengths and total stopped delay. However, when the results were disaggregated to individual roadway segments, the analysis revealed no clear travel time pattern on roadways with or without a lane restriction. This might be attributed to the route choice parameter specified in the dynamic traffic assignment modeling. The network results further showed the average speed of trucks decreased with the imposition of a truck lane restriction. This decrease was especially pronounced at high truck traffic volumes, i.e., over 25 percent of the AADT.

Similar to the corridor analysis, surrogate measures of safety in the network simulation revealed a reduction in the number of lane changes when trucks were restricted to the right lane. An increase in the number of lane changes was noted, however, when trucks were restricted to the left lane or center lane compared to the base simulation scenario of "no restriction". This gain in the surrogate measure of safety is counterbalanced, however, by the increase in the differential speed between cars and trucks, as well as the differential speeds between travel lanes. Detailed analyses of the results showed that the differential speeds between vehicles and between lanes for the "no restriction" scenario were lower than any of the restriction scenarios.

Benefits

The results of this study will assist the Florida Department of Transportation in understanding the consequences associated with the implementation of truck lane restrictions on non-limited access highways. For example, implementing truck lane restrictions on roadways with only two through lanes in each direction and where bottlenecks exist is operationally detrimental and should be avoided. While there might be some benefits associated with trucks being restricted to the right lane, it should be noted that these benefits apply to roadways with sparsely spaced driveways. It should further be understood that restriction of trucks to the left or center lane of arterial roadways should not be considered for implementation. Although field validation of these results is desirable, it is nevertheless possible to use the results of this study in the planning and operational analysis of urban arterial streets.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Unlike passenger cars used to transport people, trucks are primarily used for the bulk movement of goods. In urban areas, trucking activities include the pickup and delivery of goods, supplying home and office needs, trash collection, and delivery of mail and packages. To perform the function of carrying freight, trucks are generally made wider, higher, heavier, and longer than passenger cars. Their larger physical dimensions limit their highway operational abilities, especially in negotiating sharp turns or curves. Also, due to their high weight-to-horsepower ratio, large trucks have lower acceleration/deceleration capabilities and require longer stopping distance compared to passenger cars. The performance and physical characteristics of trucks and the growth of trucks on urban roadways across the nation have given rise to the need for managing truck traffic on these roadways.

Numerous strategies for accommodating trucks on roadways have been implemented in several states in the United States for many years. Some of these strategies include implementing truck lane restrictions, dedicating certain lanes for use by trucks only, and designating truck routes to allow other routes to be rendered inaccessible to large trucks (1). Besides restricting trucks by route or by lane, other restrictions practiced by different states include restriction by a truck's gross weight, by speed, and by time-of-day (2). The review of literature and practice indicated that a truck lane restriction is the most common type of truck traffic management implemented although implementation occurs more on limited access highways than on non-limited access highways. This may be attributed to the fact that limited access highways are designed to higher standards, carry more traffic at higher speeds and serve longer trips compared to non-limited access highways. Some research studies have shown that truck restrictions improve traffic operation and safety, decrease pavement wear, and increase driver comfort (3).

On non-limited access roadways, truck lane restrictions are commonly seen on climbing lanes where truck traveling at crawl speed are separated from regular traffic. Also, on roundabouts with double lanes, trucks are restricted to travel in the outer lane because the inside lane generally does not have large turning path desirable for trucks. Truck lane restrictions can also be found on bridges where it is sometimes desirable to restrict heavier trucks in order to increase bridge life. In addition, truck route restrictions are sometimes placed on arterial and local roads to divert trucks from highly congested urban streets or to limit trucks on roadways with geometry inadequate to accommodate large trucks.

However, review of theory and practice showed that some jurisdictions seem to have implemented truck lane restrictions on arterials and local roads with a significant number of heavy trucks, such as tractor-trailers that have difficulty performing certain types of maneuvers such as U-turns, right turns, and left turns, in order to improve safety and efficiency of traffic operations. The implementation of a truck lane restriction on arterial roadway raises concerns about operations and safety. Some of these concerns include: (1) Where should the restriction be relaxed for turning trucks in the vicinity of an intersection without affecting operations?, (2) Which lanes should be restricted for truck use to improve operations and safety (left lanes, right lanes, or even center lanes)?, and (3) What sign design and locations should be used along the restricted roadway to provide a clear and concise message without causing confusion to through trucks and to facilitate enforcement of the truck restriction?

Florida has truck lane restrictions implemented on both limited access highways and non-limited access roadways. On access limited highways, the practice was first implemented in 1982 on I-95 in Broward County as a one year experimental study on a 25-miles section with six lanes (1, 2, 3). In this study, trucks were prohibited from using the left (inside) lane from 7:00 A.M to 7:00 P.M. The analysis of performance indicated benefits in both safety and operations; hence, the restriction was extended to 24 hours a day in November 2004. Since then, truck lane restrictions on limited access highways in Florida have been extended to sections of I-95, I-75, and the Homestead Extension of Florida's Turnpike (HEFT). On non-limited access roadways, truck lane restriction exists on a 2-mile stretch of US 27, in the City of Havana in north Florida. This restriction, imposed in 1989, requires trucks to use the left lane only in each direction of this four-lane highway. The restriction was imposed to improve pedestrian safety and comfort which was compromised prior to the restriction because of the close proximity of sidewalks and buildings to the roadway.

1.2 Problem Statement

Trucks are heavier, longer, and wider and less maneuverable than passenger cars. While traveling on arterial roadways, trucks pose a number of problems. Large trucks may hinder visibility of signs and signals for motorists in small vehicles following behind. Also, the larger physical dimensions of trucks cause them to encroach on adjacent lanes when trying to complete turning maneuvers. In addition, trucks can create queues when using roadways with narrow lanes because drivers of passenger cars can not or are reluctant to drive parallel or pass them especially during peak hours. These problems have a negative influence on the operational and safety performance of arterial roadways.

The need for a study of truck lane restrictions on non-limited access highways is further supported by the fact that most studies evaluating truck lane restrictions were conducted on limited access highways. The literature review conducted as part of this research did not find any study that analyzed the efficacy of truck lane restrictions on non-limited access highways. Thus, prior to the implementation of any truck restriction strategy on Florida non-limited access highways, it is imperative that the likely effect of such decisions be analyzed through a carefully designed simulation study supported by a comprehensive review of theory and practice in other states.

1.3 Objective of Study

To understand and predict the likely operations and safety implications associated with the implementation of truck lane restriction on non-limited access highways requires evaluating whether trucks should be restricted to the outermost left lane, right lane or center lanes in case of three travel lanes in one direction or restriction to the left lane or right lane of two travel lanes in one direction. Also, in case of roadways with three travel lanes in one direction, the issue of how many through lanes should be restricted needs thoughtful evaluation. Furthermore, recommendation of the suitable time of day for restricting trucks to certain lanes requires evaluating various factors that affect traffic operations such as the distribution of traffic volume and proportion of trucks within the traffic stream. Consistent with the overall goal of the project, the objective of this study was to evaluate the influence of various geometric, traffic, and signalization factors that might influence the efficacy of truck lane restriction on non-limited access highways, primarily on urban arterial roadways with significant amount of truck traffic.

1.4 Study Layout

Following this brief introduction, the remainder of this research report is organized as follows. Chapter Two reviews the theory, practice, and policy related to truck lane restriction on non limited access highways. Also, the review of typical land use, geometrics, and traffic composition on arterial streets is reported in Chapter Two given that these factors will have significant bearing on the design of the simulation plan. Chapter Three describes the methodology used in performing this research study including data acquisition and simulation modeling. Chapter Four discusses model calibration and validation while Chapter Five focuses on the analysis of results for various restriction scenarios. The implications of these study results to the Florida Department of Transportation are discussed in Chapter Six while conclusions and recommendations are presented in Chapter Seven.

Appendix A of this research presents types of commodities shipped in the U.S. Appendix B presents the questionnaire sent to various local and state transportation officials. Appendix C presents the results obtained from the survey questionnaire including the list of respondents. The photograph images acquired from site visits to various locations with a truck lane restriction are presented in Appendix D. Appendix E contains the summary of state statutes related to truck lane restrictions. The signalization data are presented in Appendix F. The field data collected for use in calibrating the simulation model are presented in Appendix G. Appendix H summarizes the simulation outputs for SR 70 and Appendix I presents the summarized simulation outputs for the network.

CHAPTER TWO

LITERATURE REVIEW

2.1 Purpose and Scope

To sufficiently understand and predict the likely operational and safety effects of truck lane restrictions on non-limited access highways, a comprehensive review of literature was conducted. An extensive review of published and unpublished research papers and reports was conducted. The review also involved determining the state of the practice regarding truck lane restrictions on non limited access highways across the country, as well as, reviewing state policies and regulations related to truck lane restrictions on arterial streets. A detailed survey questionnaire was synthesized to solicit information on the policies and practices existing in different states.

Furthermore, the knowledge of truck movements as well as their typical activities in urban areas was vital in understanding the impact of trucks on urban highway operations. Truck movement information was acquired through a comprehensive review of literature and the review of long range transportation plans from around the country, particularly in the St. Lucie and Fort Pierce area. Since the modeling of truck movements in an urban highway network would inevitably involve specifying truck trip generation rates from various land uses, it was important to review the land use characteristics and their influence in generating and attracting truck traffic along a highway corridor. Given that a truck lane restriction is not a panacea, it was important to also review other existing and innovative strategies for managing truck traffic in urban areas.

2.2 Types of Goods Movement in Urban Areas

Freight transportation is essential for the growth of any economy. The increase in truck traffic volume in urban areas is attributed to the increase in commodity flow in these areas. Among land transportation modes, trucks transported 88 percent of all goods traded in North America in 2005 (3). Trucks transport both raw/bulk and processed goods. Raw goods are transported from the farm to industry or from one industry to another, while processed goods are transported from industries to distribution centers like gas stations, supermarkets, and shopping centers. The commodity flow survey summaries these goods into 43 categories as presented in Appendix A (4).

The survey on commodity flow in North America was conducted in 1993, 1997 and 2002 through a study sponsored jointly by the U.S. Department of Transportation, Bureau of Transportation Statistics (BTS), and the U.S. Census Bureau (4). The survey results indicated that in 2004, trucks carried 79.1 percent of total exports to Canada and 81.5 percent to Mexico, whereas trucks carried 56.1 percent of total imports from Canada and 82.2 percent of imports from Mexico. Nationally, the survey concluded that trips resulting from commodity flow were increasing from year to year. It can be hypothesized that some of these truck trips use non-limited access highways located in urban areas.

In the State of Florida, the survey found that trucks carried 79.4 percent of total tonnage of freight originating from Florida. Several commodities were identified as shown in Appendix A, and the data indicates that textiles, leather, and articles of textiles had higher shipment miles followed by tobacco products. Nationally, however, manufactured goods seemed to have higher shipment miles. Even though the survey report did not distinguish between urban and rural commodities, the review of literature suggests interconnectivity of trips between rural and urban commodity flow.

2.3 Type of Land Use along Arterial Streets

Land use can be defined as the way land is developed and used in terms of the types of activities allowed by the local government's zoning laws, i.e., agricultural, residential, industrial, and others. The size of buildings and structures that are permitted to be built along an arterial street also define land use along the street. In any major urbanized areas, truck trips may be through trips or trips originating from or ending at a particular land use on an arterial street. It is clear that each land use generates trips differently and it can be surmised that trips generated per land use is site specific. Thus, a complete understanding of the numerous land uses likely to be located along an arterial street is vital to a study of truck lane restrictions. This includes the trips generated per land use and their variations within the time of day, day of week, and season.

The Institute of Transportation Engineers Manual categorizes land use types into ten groups (5). These groups are further categorized into sub-groups. The number of sub-groups per land use varies widely. However, recreational and retail land uses have a large number of sub-groups, whereas, medical and lodging land uses have the least number of sub-groups. Table 2.1 shows the ten land uses with a few of the existing sub-groups.

Table 2.1: Land uses

Number	Land Use Type	Land Use Sub-Groups
1	Port and Terminal	Truck terminal, commercial airport, water port/marine terminal
2	Industrial	Industrial park, manufacturing, warehousing, utilities
3	Residential	Apartment, mobile home park, condominium, rental townhouse
4	Lodging	All suites hotel, motel, resort hotel, business hotel
5	Recreational	Golf course, live theater, casino, zoo, athletic club
6	Institutional	High school, church, prison, library, cemetery, lodge
7	Medical	Hospital, nursing home, clinic
8	Office	Government office building, office park, US post office
9	Retail	Apparel store, supermarket, nursery (garden center), new car sales, specialty retail center
10	Services	Walk-in bank, drinking place, gasoline/service station

Trips generated are expressed in rates per unit measure. The unit measures of the generated trips can be per acre, per number of employees, per square feet of gross floor area, per parking space, and per storage units. Depending on the land use type, several unit measures can be used per land use. Generally, the review of literature found that trucking and warehousing activities of industrial land uses have the highest truck trip generation rates.

Furthermore, research conducted by FHWA (6) on commercial truck pickup and delivery (PUD) activities in urban areas reviewed trips generated from three land use types. The land uses studied were commercial, office, and industrial derived from various parts of North America. The truck pickup and delivery trip rates reviewed on these three land use types revealed some interesting results relevant to the study reported herein. The research results showed that industrial land uses had more PUD truck trip rates per employee followed by commercial land uses and, thereafter, office land uses.

2.4 Types of Trucks Carrying Urban Freight

A truck is a motor vehicle generally used for transporting goods rather than passengers. Trucks vary in size from automobile-sized pickup trucks, to towering off-road mining trucks, to heavy highway semi-trailer trucks. A truck's definition and categorization depend on the intended use. Some studies define trucks as any commercial vehicle that is not an automobile. Others include any vehicle that has at least two axles and six tires. Still others define trucks based on a minimum vehicle gross weight (7). However, in transportation sectors, trucks are defined and categorized based on axle's configuration, wheels configuration, and/or weight.

The review of literature revealed that the Berkeley Municipal Code (BMC) in California categorizes trucks into four sizes which are further put into various classes depending on the truck gross weight (8). In addition the code further defines the tire and axle configuration of each class. Table 2.2 shows the four truck categories along with their characteristics. The review of literature also showed similar categories were used by the Federal Highway Administration, although the weight categories are slightly different (4). The FHWA categorization has one class under light trucks, four classes under medium trucks, one class under light-heavy trucks, and eight classes under heavy trucks category.

Table 2.2: Truck classification in Berkeley Municipal Code

Descriptive Size	Class	Gross Vehicle Weight (lbs)	Number of Axles	Number of Tires	Representative Vehicles
Light	1	<6,000	2	4	Pick-Up, Van
	2	6,000-10,000	2	4	Step Van, Small Courier Van

Descriptive Size	Class	Gross Vehicle Weight (lbs)	Number of Axles	Number of Tires	Representative Vehicles
Medium	3	10,000-14,000	2	6	Metro Van, Small Tow Truck
	4	14,000-16,000	2	6	Flat Bed
	5	16,000-19,500	2	6	Large Tow Truck, Stake Truck, Package Delivery Van
Light-Heavy	6	19,500-26,000	3	6	Single Unit Truck (30'), Moving Van, Beverage Truck, Home Heating Oil Truck, Armored Car, Mini Bus
Heavy	7	26,000-33,000	3	10	Tractor/Trailer (40'), Moving Truck, Dump Truck, Transit Bus
	8	>33,000	3 3 +	10 10 +	Tractor/Trailer (50'), Moving Truck, Freight Truck, Concrete Truck, Gravel Truck, Articulated Bus, Greyhound Bus

Source: (8)

The review of truck classification in Florida found that like all other states Florida classifies trucks using the Scheme ‘F’ vehicle classification system required by the Federal Highway Administration (FHWA) (9). Three groups derived from Scheme F are presented in Table 2.3. The data in Table 2 .3 shows the 2004 AADT along with each vehicle class volume and percentage at various points of State Route 70 which is classified as an urban principal arterial. The three groups are single unit trucks, combination trucks, and multi-trailer trucks. From Table 2.3 it is evident that each truck type is used to carry urban freight though the proportion of load carried decreases from single unit trucks to multi-trailer trucks. Single unit trucks are a high percentage of the trucks on urban arterials. This phenomenon can be attributed to the high pick-up and delivery trips in urban areas which generally employ single unit trucks (7). Single unit trucks have less weight and dimensions so they are suitable for pick-up and delivery activities.

Table 2.3: Vehicle classification along SR 70

Point of SR70	AADT	Passenger Vehicles		Total Trucks		Single Unit Trucks		Combination Trailer Trucks		Multi Trailer Trucks	
		%	Volume	%	Volume	%	Volume	%	Volume	%	Volume
E. OF SR 9/I-95	28000	83.97	23511.6	16.04	4491.2	8.87	2483.6	6.91	1934.8	0.26	72.8
W. OF SR 9\I-95	27500	79.3	21807.5	20.7	5692.5	9.9	2722.5	10.5	2887.5	0.3	82.5
W. OF SR 91/TPK	7000	81.1	5677	19	1330	12.3	861	6.6	462	0.1	7
SR 713/KINGS HWY	7200	81.88	5895.36	18.11	1303.92	5.9	424.8	11.97	861.84	0.24	17.28
E. OF OKEECHOBEE RD	19800	95	18810	5	990	4.1	811.8	0.9	178.2	0	0
W. OF SR 615 / 25TH ST	22500	93.96	21141	6.04	1359	4.58	1030.5	1.41	317.25	0.05	11.25
E. OF SOUTH 13TH STREET	29000	95.51	27697.9	4.49	1302.1	2.08	603.2	2.31	669.9	0.1	29
E. OF SUNRISE BLVD	29000	94.6	27434	5.4	1566	4.4	1276	0.9	261	0.1	29
W OF SR 5/US1	25000	97.11	24277.5	2.89	722.5	1.78	445	1.11	277.5	0	0

Note: Passenger Vehicles = Vehicle Class 1 - 3   Combination Trailer Trucks = Vehicle Class 8 - 10
Total Trucks = Vehicle Class 4 - 13   Multi Trailer Trucks = Vehicle Class 11 - 13
Single Unit Trucks = Vehicle Class 4 - 7   E-East   W-West

Note: Data extracted from 2004 FDOT Traffic CD

2.5 Characteristics of Truck Movement on Arterial Streets

This section discusses various attributes of truck movement on arterial streets in terms of their volume, trip length, origin and destination, and the time of day trucks operates on these streets. All these truck characteristics are essential since they are likely to be associated with roadway congestion and level of safety prevailing on the roadway. These characteristics are discussed in detail in the following subsections with the aim of understanding how these characteristics can be quantified and modeled in a simulation model to evaluate the efficacy of truck lane restrictions on non-limited access arterial streets.

2.5.1 Volume of Trucks

The trucking industry plays an important role in the national and regional economy. However, trucks are responsible for most of the pavement damage, a sizable portion of the air pollutants from non-stationary sources, and congestion (10). The trucks on American roadways are generally wider, longer, heavier, and less maneuverable than passenger cars. These truck attributes are likely to affect safety and efficiency of highway operations. Hence, the continued growth of truck traffic on surface streets and other transportation facilities requires the consideration of prudent management strategies.

A number of research studies argue that one of the causes leading to the increase in truck traffic over the last decade was the launch of the North American Free Trade Agreement (NAFTA) in 1992 involving Canada, Mexico and the United States. This agreement has caused dramatic changes in the economy and consumer demand in each of these countries with an increase in social and economic activities in urban areas (1, 11, 12). Also, the shift of many freight items from rail and other transportation modes to trucking, the changes in the economy and business practices like just-in-time deliveries of inventory items, population, and employment dispersion have led to the increase in the delivery of goods. In 2005, land-based modes of transportation carried 88 percent of goods traded with NAFTA countries with trucks carrying the highest percentage of freight by value, i.e. 62 percent (13). Research studies show that truck traffic increased by 216 percent in vehicle-miles of travel (VMT) while the population has increased by 33 percent since 1970 (12, 14).

Truck volumes along a roadway are influenced by various factors such as land use types, roadway functional class, and the type of truck restriction imposed on the roadway. Land uses are the main truck trip generators (7). For example, the presence of a truck rental company on a roadway will result in more truck volumes along the roadway than if a truck rental company was located elsewhere. Also, roadways passing through an industrial area will generally have higher truck volumes than roadways servicing residential areas. The functional class of a roadway is mainly related to the traffic carrying ability of the roadway. For example, freeways belong to functional class 1 since they are built to higher standards, carry high traffic volumes and operate at very high speeds compared to local roads of functional class 16. Class 16 roadways are built with geometrics that are inadequate for smooth truck operation (6). Furthermore, the imposition of truck route restrictions on some routes generally leads to more trucks using designated truck routes and increasing the truck volumes on these routes.

2.5.2 Truck Travel by Time of Day

Truck traffic volume along a highway varies greatly depending on what time of day it is. The factors likely to influence variations in truck traffic by time of day include the roadway functional class and land use characteristics along the roadway. The review of literature indicated some freeway sections in Florida experience very high truck volumes at night (3). However, it is quite the opposite on most urban arterial streets since most pick-ups and delivery of services and goods are performed during daylight hours. One study reviewed the distribution of PUD activities by time of day for three land uses. The research study found PUD activities peak between 10:00 a.m. and 11:00 a.m. (6). In addition, truck volumes are higher from 9:00 a.m. to 6:00 p.m. Passenger car volumes peak in the morning, noon, and evening which is between 7:00 a.m to 9:00a.m, 12:00p.m to 2:00 p.m., and 4:00 p.m. to 6:00 p.m. Generally, truck volumes are lower during the morning peak hours, i.e., from 7 a.m. to 9 a.m.

Knowing how truck trips are distributed throughout the day is crucial. This information assists transportation engineers and planners in understanding the variations of truck traffic during peak commuting periods and during off-peak non-commuting periods. The duration of a truck lane restriction—whether to restrict trucks throughout the day or just during the peak periods—will depend on the knowledge of truck traffic peaking characteristics and their interaction with passenger car peaking characteristics. As an example of truck and car volume variation, Figure 2.1 shows the variation of both truck and car traffic volumes by time of day on US 319 in Florida. In producing the figure, trucks were defined as all vehicles with an overall vehicle length of 22 feet or longer. On this section of US 319, truck volume peaks from early to late afternoon, whereas passenger car volume peaks in the morning at 8:00 a.m. and in the evening at 6:00 p.m.

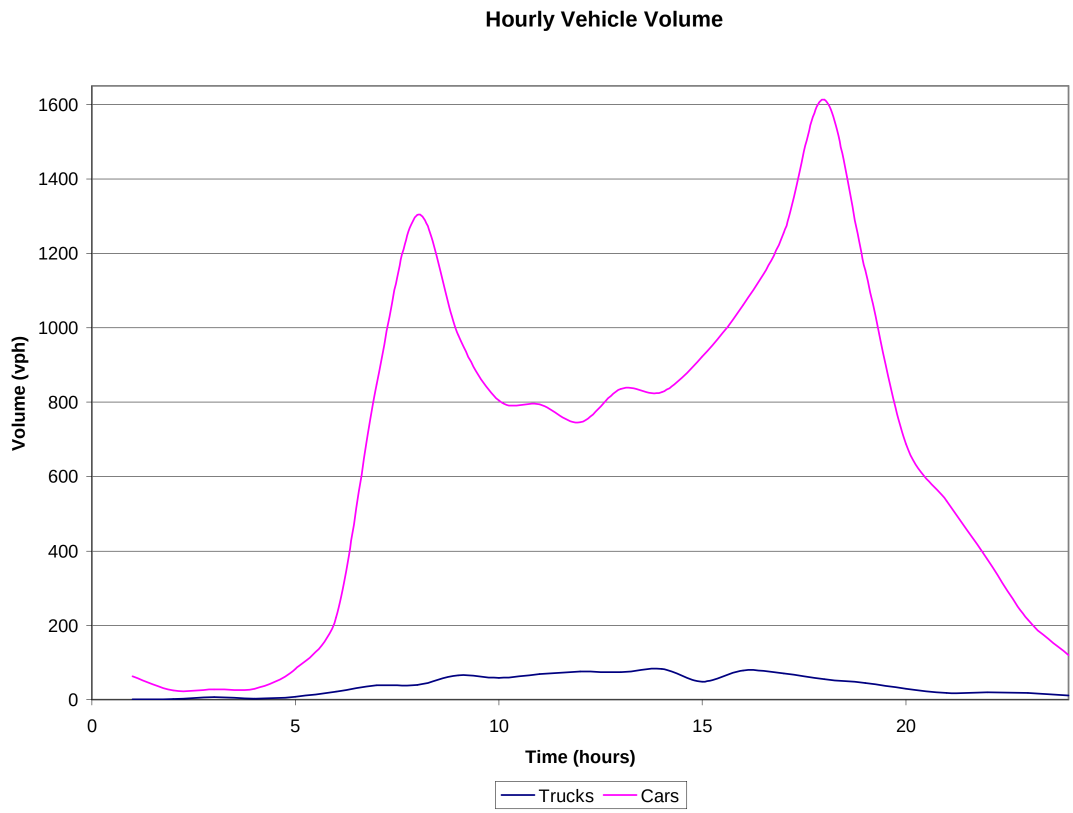


Figure 2.1: Hourly vehicle volumes on US 319

2.5.3 Length of Trip

Trips originate and end in a land use. Trips within the land use, i.e., internal trips, are usually short compared to trips originating in one land use and ending in another land use. Also, trip lengths depend on land use configuration. Thus, sparsely spaced land uses are likely to have longer trip lengths than closely spaced land uses. Truck trips in urban areas are chained together by trips consisting of pick-up, delivery, and mixed pick-up and delivery activities (15). Truck trip lengths are measured as a length or time a truck driver takes to travel from an origin to a single destination and not as the whole trip with multiple destinations.

Individual truck trip lengths are important in determining the total trip chain length and time which can be associated with congestion in urban areas. The review of literature indicates that acquisition of trip length data is of more importance to transportation planners than transportation engineers. Transportation planners use this data in travel demand modeling, intermodal access studies, identification of system operational deficiencies, and evaluation of improvements. Whereas, engineers use the data in site impact analysis, traffic operation studies and street design (7). However, trip generation data for engineering use needs to be very accurate for a wider range of land use types than for planning use. These rates must be accurate at the micro-scale level because they are used to design local streets, designate or revise truck routes, assess traffic impact fees and regulate provision of off-street loading space.

A research study conducted by Slavin (15) to determine an enhanced framework for modeling urban truck trips found that construction activities had longer trip lengths out of the nine reviewed land uses. The research further found that the mining industry had more truck trip rates than other land uses. However, these results might be site specific; therefore, many other factors may be relevant in analyzing truck trip characteristics. For example, the roadway network, roadway capacity constraints, truck activities, and the time windows on deliveries can substantially alter truck trip length. Table 2.4 presents the results obtained by Slavin on truck trip generation and truck trip lengths.

Table 2.4: Truck trip generation and trip lengths

Industry	Trips/ Employee	Average Trip Length (Min.)
Agriculture	3.3	N/A
Mining	6.5	N/A
Construction	1.2	14.35
Manufacturing	0.3	8.24
Transportation/Warehousing	2.1	9.72
Trade	1.3	7.86
Services	0.2	6.75
Government	0.4	7.68

Source (15)

Miguel (16) performed an eight-month truck activity study in the Sydney metropolitan area in Australia. The study found that the shape of the trip length distributions was highly affected by the relative location of major freight generators—that is, large factories, distribution areas, intermodal facilities, etc.—in relation to their service areas. The trip length distribution peaked between 2 and 9 kilometers as shown in Figure 2.2. This is explained by the short trips common in the study area and the local deliveries in other industrial areas surrounding the study area. In addition, the second peak was found to be between 21 and 33 kilometers. These long trips are associated with activity between industrial suburbs in which a trip, for example, originates from a depot and ends at a distribution area. Also, it is worth noting that the average trip length is also influenced by the daily number of customer demand locations. Therefore, average trip lengths in metropolitan areas or regions are generally site dependent.

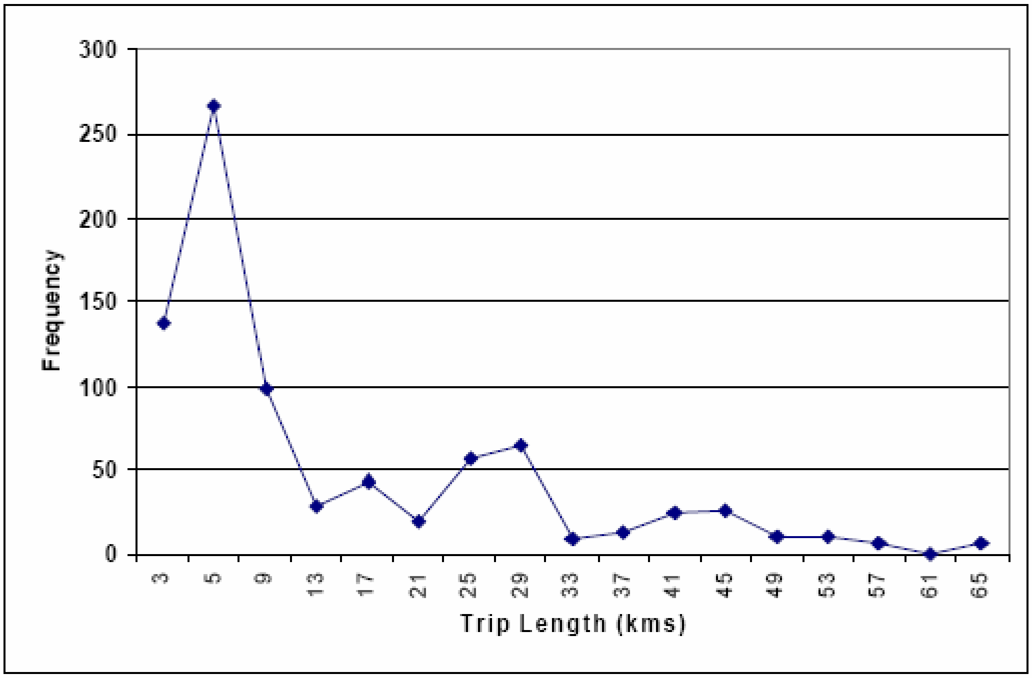


Figure 2.2: Trip length distribution. Source (16)

2.5.4 Trucks Origin - Destination

Trucks play an essential role in the freight transportation system. Trucks provide a high level of transport reliability and enormous flexibility in terms of the origins and destinations served, the commodities carried, and the range of service provided. In addition, they are the key link among most other modes of freight transportation. With increasing use of just-in-time inventory practices, forward positioning of supplies and inventory, and growth in small-package-expedited delivery and e-commerce distribution services, the significance of truck traffic continues to grow (7).

Truck trips originate and end within a land use activity. However, a single truck trip usually has multiple destinations before returning to the original location (16). For example, the research by Miguel (16) found that in Sydney, Australia, one trip may have 6.8 destinations/stops on average whereas in Denver, Colorado there were 5.6 stops and there were 6.2 stops in Amsterdam per trip. Thus, it can be surmised that some truck origin-destination trips are an interconnection of multiple trips.

The review of literature found truck trips are named as inbound and outbound. The inbound trips originate from one land use in a metropolitan area and end at another land use within the same metropolitan area. Whereas, the later refers to truck trips originating from one land use in one metropolitan area and ending at another or the same land use, but in another metropolitan area. Normally, inbound trips are shorter while outbound trips are longer.

2.6 Strategies of Managing Truck Traffic on Arterial Streets

Increasing truck traffic poses safety and operational challenges to agencies that operate and maintain transportation facilities. In recent years, this has been influenced by dramatic changes in the global economy, consumer demand, and logistics practices (12). Operational and safety challenges associated with increased truck traffic include traffic congestion, pavement deterioration, environmental impacts, air and noise pollution, and economic development of certain localities. The review of literature indicated that to cope with truck traffic demands placed on highways, a number of strategies are practiced around the country aimed at managing and preserving the quality of service on these highways.

Improved highway design is one of the strategies many states have implemented. Improving roadway geometrics and structures make more roadways passable for trucks leading to less congestion. Another strategy that has been applied is the introduction of dedicated roadways or lanes for trucks, truck climbing lanes, designated parking, and identification of truck routes. Truck routes and truck climbing lanes are common in most states (12). Truck routes are common in urban areas where trucks are prohibited from roadways with insufficient geometrics for safe and smooth truck operation, and are directed to truck routes that generally have sufficient geometrics to accommodate large trucks. In addition, truck routes detour trucks from highly congested urban highways or detour trucks transporting hazardous materials to minimize safety hazards that may occur if a crash occurs (2). Truck climbing lanes are common on rural roadways with steep upgrades and downgrades where trucks have difficulty maintaining speed.

Operational truck strategies implemented in many states include truck lane restrictions and parking restrictions. A truck lane restriction is a restriction whereby all trucks or trucks of specific size, weight, or axle configuration, are restricted from using specific lanes of the roadway (3, 17). This practice exists in some states on a limited basis. Restriction by time of day means that all trucks or trucks of specific weight, size, or axle configuration are prohibited from specific routes or lanes during specific times of the day, usually during peak hours or late night hours (3). Parking restrictions exist in urbanized areas where trucks are not allowed to park on the streets.

2.7 Survey of Arterial Truck Lane Restriction in the United States

On non-limited access highways, truck lane restrictions are commonly seen on climbing lanes for separating slow moving trucks from other traffic, on double lane roundabouts where the inside lane does not accommodate a large turning path, and on bridges for increasing the bridge life. Also, truck restrictions are placed on arterial and local roads to divert trucks from highly congested urban streets and on certain roadways with inadequate geometrics for smooth operation. However, the survey of policies and practices around the country revealed that some states have implemented truck lane restrictions on arterial and local roads with a significant volume of tractor-trailers. Tractor-trailers generally have difficulties performing maneuvers such as U-turns, right turns, or left turns; therefore, to improve efficiency and safety, trucks are restricted in some fashion.

2.6.1 Questionnaire Design and Mailing

Two survey questionnaires were designed to solicit information from all states on their policy and practice of truck lane restrictions on non-limited access highways. The first questionnaire contained five questions and was aimed at determining whether a particular state had a policy or practice of restricting trucks by lane on non-limited access highways. This questionnaire is shown in Appendix B. The second questionnaire had eight questions and was sent only to those states that responded in the affirmative on the first questionnaire that they have a truck lane restriction policy or practice. Therefore, the second survey questionnaire was aimed at soliciting detailed information regarding the practice and implementation of the policy.

‘For instance, the research team was interested in knowing whether engineering studies were conducted before and/or after the policy was implemented. The basic source of contacts was the American Association of State Highway and Transportation Officials (AASHTO) website where almost all states traffic and operations engineers were listed together with their phone numbers and e-mail addresses. Contact information for county, district, and city traffic and safety engineers was obtained from the entity’s respective websites and through telephone calls to relevant personnel indicated on the entity’s website. A website with the survey questionnaires was created at the FAMU-FSU College of Engineering. An email was sent to the individuals concerned asking them to visit the website and fill in the questionnaire electronically. A database of the responses from each state and jurisdiction was created and analyzed as discussed in the following section.

2.6.2 Analysis of Responses

The results of the survey were quite encouraging; 49 states and one territory responded. Only New Mexico did not respond despite repeated attempts to contact relevant individuals in that state. Of the 50 responding individuals, 45 filled in the questionnaire on the website while five chose to respond by phone. In addition, responses were received from 6 and 11 counties and cities, respectively. All the responses are presented in Appendix C.

Furthermore, through conversations with various people in Florida and in the surrounding states, several non-limited access highway sites with truck lane restrictions were discovered. Site visits were conducted to review the operations and document photographically relevant traffic sign and geometric attributes. The photographs are displayed in Appendix D. Moreover, the research team had follow-up telephone conversations with local engineers and/or officials with jurisdiction at these sites to learn more about the existing truck lane restrictions. The following sections discuss the results obtained from both general and detailed survey questionnaires.

2.6.2.1 Responses to the General Questionnaire

The general questionnaire was sent in two phases. In the first phase, the questionnaire was sent to state traffic professionals. In the second phase, the same questionnaire was sent to traffic professionals in major cities. The survey results of both phases are summarized and presented in the following paragraphs.

Does your agency have a policy on truck lane restriction on arterial streets? If yes, please provide email and/ or phone number of the person we should contact to discuss this issue in more detail.

Fifty-four agencies responded to this question. Richmond District of the Virginia Department of Transportation responded that they have a policy on truck lane restrictions on surface streets and the City of Cleveland, Ohio indicated that they have a policy on truck route restriction. The state and local agencies indicating they have truck lane restriction practices on arterial streets include the State of Washington; City of Seattle, Washington; State of Alabama; and State of Colorado. The City of Seattle specifically said in their response that the practice of restricting trucks from right lanes is practiced on bridges for bridge protection. The response from the State of Alabama indicated that trucks in the City of Dothan are restricted to use the right lane on Ross Clark Circle Road (SR 210) which has two lanes of travel per direction and is 14.4 miles long. Figure 2.3 shows the truck lane restriction in operation on Ross Clark Circle Road in the City of Dothan.

Sign posted on the median

Sign posted on the shoulder

Figure 2.3: Truck lane restriction on Ross Clark Circle Road.

Further correspondence was the Dothan City Traffic Engineer, Mr. Charles E. Metzger, revealed that the restriction was put in place in 2004 although no detailed engineering study was conducted prior to the implementation. Mr. Metzger further indicated that the objective of this restriction was to improve traffic flow since the roadway is serving approximately 35,000 vehicles per day and is highly congested. Asked whether the restriction was being enforced, Mr. Metzger indicated it was almost impossible to enforce the restriction because of the short intersection spacing and difficulty experienced by trucks changing lanes.

Are you aware of the existence of truck lane restriction aimed at large trucks on arterial streets on any roadways other than state–maintained roads in your state? If yes, we will appreciate if you provide the names of the cities or counties that we should contact.

Only three agencies responded to this question— Washington State, the City of Cleveland, Ohio, and the State of Colorado. The respondents indicated they were aware of truck lane restrictions on locally maintained roadways. Washington State responded that truck lane restrictions are placed consistently on locally maintained bridges, just as on state maintained roads. The City Traffic Engineer, Mr. Cross, indicated that in Cleveland people request truck lane restrictions because of perception rather than proven engineering usefulness. The State of Colorado indicated cities and counties follow state statutes to decide on restrictions for roadways under their jurisdiction. Further follow up with Colorado did not reveal any additional information.

Whether or not arterial streets truck lane restriction is practiced in your state, what is your opinion on this issue?

Generally, this question aimed at soliciting the traffic professional's opinions on the subject matter. Responses to this question seem to suggest support for the practice of restricting trucks on a specific lane on arterial streets while 14.8% (8 respondents) were not in favor of truck lane restriction on non limited access highways. Some of the reasons given against the restriction include:

- No high traffic volumes in their state, hence no need for truck lane restrictions.
- Potential disruptions to traffic flow since trucks are usually serving businesses situated on both sides of the roadway.
- Can lead to congestion due to unnecessary lane shifts by motorists forced to move over by the truck behind them.

Figure 2.4 provides a pictorial summary of the views obtained from the respondents.

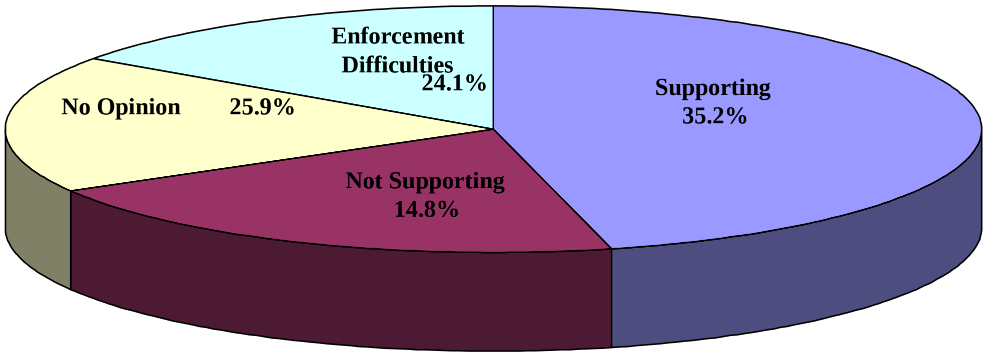


Figure 2.4: Opinions on truck lane restrictions on arterials

2.6.2.2 Responses to the Detailed Questionnaire

The detailed questionnaire was sent to states, districts, cities, and counties identified by the first questionnaire as having truck lane restriction policies in their states and based on the review of literature and practice. A summary of responses to the questionnaire and views expressed by the respondents is presented below. Additional details can be viewed in Appendix C. It should be noted that there were 11 responses to the detailed questionnaire.

Does your agency have a policy on truck lane restriction on arterial streets?

This question was designed to solicit information on the policy of truck lane restriction on arterial streets. The State of New Jersey indicated that Chapter 39, Section 4-88 (e) of the New Jersey State Statutes clearly prohibits trucks weighing 10,000 pounds or more to use the farthest left-lane except when a maneuver is made to change lanes and use a left exit or during emergency conditions (8). Other respondents said they do not have truck lane restrictions written in their state statutes but they nevertheless practice truck lane restrictions using other codes within their state statutes.

What kinds of trucks are targeted by the lane restriction?

This question was aimed at determining which specific truck types are targeted by restrictions. The State of New Jersey indicated their target was the restriction of trucks with a gross weight of 10,000 pounds or more. In the State of Georgia, two truck classifications were indicated, i.e., trucks with gross weight of 10,000 pounds or more and trucks with over six wheels. The responding traffic engineer from the State of Delaware did not provide information regarding the type of trucks targeted by restrictions. However, the State of Delaware respondent did indicate a truck lane restriction was on US 13 and US 113 where the AADT was approximately 60,000 vehicles per day and the percentage of trucks was around eight. The respondent indicated that these roadways were non-limited access highways. It should be noted that the roadway section with a truck lane restriction on US 27 in Havana, Florida does not clearly indicate the type of trucks targeted by the restriction. The posted overhead sign for this restriction simply reads, "*Trucks use this lane.*"

Do you know if engineering studies were conducted prior to implementation of truck restriction on some of these arterial street corridors?

This question was aimed at determining whether engineering studies were conducted prior to implementation and if the studies were available for review thereafter. In response to this question, the survey results showed that:

- In Alabama , Florida, and Georgia the restriction on observed corridors were imposed without conducting any formal engineering study;
- In Delaware, the restriction on US 13 and US 113 were put in place after engineering studies were performed; however, the researchers failed to get a copy of the study;
- In New Jersey, the respondent did not know if an engineering study was conducted prior to implementation of the truck lane restriction.

The totality of the responses to this question suggests the necessity of conducting further study on the effectiveness of truck lane restrictions on non-limited access highways through methods such as a before-and-after study or simulation analysis.

In your opinion, what do you think were the likely reasons for imposing the truck lane restrictions?

More than 50 percent of the respondents gave reasons for imposing truck lane restrictions. These were (1) to improve safety and operations because of public opinion, (2) due to local political issues, and (3) based on engineering judgment. The opinions and reasons by traffic engineers for imposing truck lane restrictions were varied and are summarized in Figure 2.5.

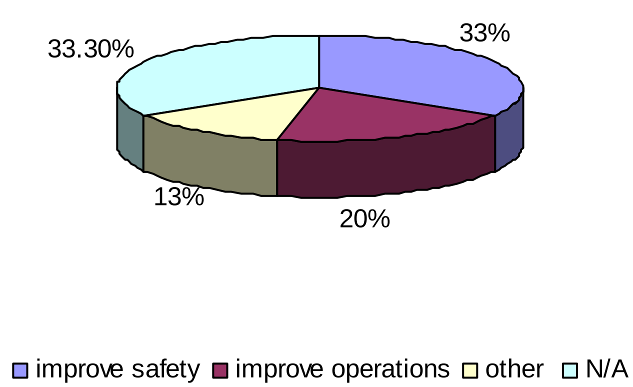


Figure 2.5: Reasons for truck lane restriction on arterials

In Delaware, the restriction was put in place in an attempt to prevent trucks from blocking all lanes at signalized intersections. The restriction in Florida was aimed at keeping trucks as far away as possible from the adjacent sidewalks and buildings to improve the safety of pedestrians who might be affected by the close proximity of a moving truck.

Generally, which lane or lanes are trucks supposed not to use?

There were mixed results relative to which lane trucks are restricted from. In Alabama, trucks were restricted from the left lane on a roadway with two through lanes per direction. In Delaware, trucks were restricted from the left lane on US 13 and US 113 in several urban areas. In Florida, trucks were restricted from the right lane on the roadway with two lanes per direction. In Georgia, trucks were restricted to two right lanes and one right lane on roadways with three through lanes and two through lanes per direction, respectively. In New Jersey, trucks are restricted from using the left lane on any roadway with three or more through lanes per direction. In Washington State, trucks are restricted from the right lane on bridges.

2.6.3 Review of State Statutes

Because the researchers did not get a complete picture of what was happening in the states with regard to truck lane restriction on arterial streets, the research team decided to conduct a review of individual State statutes from all 50 states. Also included in this review were each state's driver's manual and the Uniform Vehicle Code. The results showed that three states—Georgia, New Jersey, and Oregon—have truck lane restrictions coded in their state statutes. Appendix E displays the relevant language found in the statutes. Georgia Statute 40-6-52 states, "*On roads, streets or highways with two lanes allowing for movement in the same direction, it shall be unlawful for any truck to operate in the left-hand lane, except when the truck is actually overtaking and passing another vehicle, preparing for a left turn,*." Some states define the types of trucks to be restricted in terms of number of axles or wheels, while others define the types by weight and by axles or wheels. Most states restrict trucks from the left lanes and the restriction is applicable to highways with three or more travel lanes per direction. However, the Uniform Vehicle Code (UVC) does not define specific traffic for lane designation as shown in Appendix E (19). The Uniform Vehicle Code is a set of traffic laws prepared by the National Committee on Traffic Laws and Ordinances, a private non-profit organization. Most of the members of the committee are officials of state governments and some related organizations. The extent to which the code is used varies by state.

The review of state statutes seem to suggest states fall in four categories in relation to explaining lane specification and designation to a specific type of traffic. The categories include: 1) statutes clearly stipulate truck lane restriction, 2) statutes give authority to jurisdictions to impose truck lane restrictions and consider trucks as slow moving vehicles, 3) statutes designate lanes to specific traffic without stating type of traffic designated, and 4) statutes state neither lane designation nor truck lane restriction. The review of the state statutes showed 22 states adopted the language found in the

Uniform Vehicle Code. The summary of all reviewed state statutes sections pertaining to truck lane restriction is presented in Appendix E. Figure 2.6 shows the distribution of the four categories of State statutes.

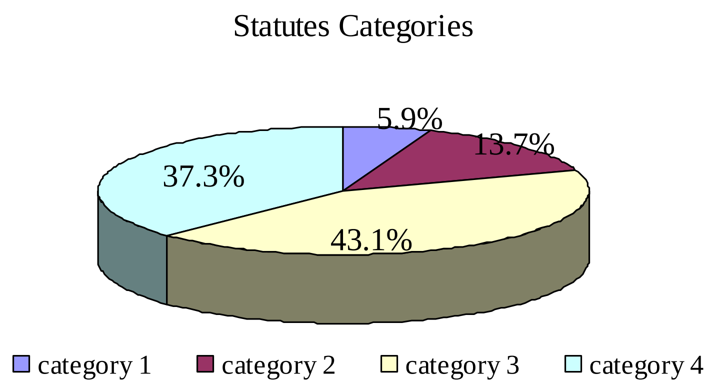


Figure 2.6: State statutes categories

2.6.4 Summary of Survey Results

The purpose of the survey was to solicit information on the state of the practice and policy on truck lane restrictions on arterial streets. Understanding what other states are doing was important in the quest of analyzing the operational and safety efficacy of truck lane restriction on arterial streets. The survey results indicate a wide variation in State statutes, policies, and practices for truck lane restrictions on non-limited access highways. The survey results show only five states out of the 50 states have some semblance of a truck lane restriction on non-limited access highways. Furthermore, the survey results revealed that the imposition of truck lane restrictions on these roadways was aimed at improving roadway operations and safety.

The analysis of survey results indicate that of the five states with a truck lane restriction on a non-limited access highway, only the State of Georgia and the State of New Jersey had a statewide policy on truck lane restrictions on arterial streets. The States of Alabama, Delaware, and Florida do not have a specific policy on restricting trucks on arterial streets. This suggests that these states use other codes in the statutes to give the highway agencies in these states the authority to impose such truck lane restrictions. As for conducting a detailed engineering study prior to implementing a truck lane restriction on a particular roadway, only the State of Delaware indicated they had done so. These results suggest the need for conducting a formal in-depth engineering study when a truck lane restriction is proposed for an arterial street.

The visit to SR 210 in the State of Alabama revealed that on a congested roadway enforcement of and compliance with a truck lane restriction could be difficult. Trucks were observed to be violating the restriction because there was not an ample opportunity to make the necessary lane change. However, visits to the US 27 site in Florida and SR 280 in Georgia revealed a high compliance with the restriction by truck drivers.

The review of state statutes revealed that three states—Georgia, New Jersey, and Oregon—have State statutes that clearly stipulate trucks can be restricted by lane on arterial streets. One definition of trucks that was found used a gross weight of 10,000 pounds or more. Review of the State of California Driving Manual revealed that truck drivers were to drive on the right lane(s); however, this was not stipulated in the California State Statutes. Moreover, in the California State Statutes it is clearly stipulated that trucks should not travel at speeds higher than 55 mph.

From these findings, it is evident that there is an underlying need for more research focusing on this issue since many states indicated truck lane restrictions have been implemented without conducting formal engineering studies. Furthermore, those states with truck lane restrictions implemented on their arterial streets should conduct analysis of before-and-after studies to evaluate the operation and safety benefits associated with these truck lane restrictions.

CHAPTER THREE

STUDY METHODOLOGY

3.1 Overview of the Methodology

The methodology used to accomplish the study objectives consisted of several activities. The first activity involved undertaking a comprehensive review to determine the presence of non-limited access corridors on Florida highways where truck lane restrictions might exist. As was discussed in Section 2.6.2, only one highway corridor in Florida was found to have a truck lane restriction. Despite the existence of this truck lane restriction on State Route 27, it was not considered as a study corridor because of numerous factors such as geometric characteristics, traffic volumes, proportion of trucks, roadway functional class as well as unfavorable abutting land use characteristics. The roadway has two lanes per direction with few abutting land uses since it is a relatively short section of roadway. Further comprehensive review of typical urban non-limited facilities was conducted to provide guidance in selecting a suitable representative corridor with favorable roadway geometrics and traffic characteristics. Also, the functional classification of the roadway together with signalization and other traffic factors were considered in deciding the corridor to pick for evaluation. The detailed discussions of these methods are presented in the following subsections.

3.2 Field Review of Typical Urban Corridors

Increased truck activities in the City of Fort Pierce in St. Lucie County, Florida have raised concerns about the safety and traffic operations particularly in the downtown area due primarily to unfavorable roadway geometrics for the safe and efficient passage of large trucks. A review of the transportation network in the City of Fort Pierce shows several major arterials passing through this city. These include SR 68, SR 615 (Orange Avenue), US 1, SR 70, and SR 713 (King's Highway). Also, Interstate 95 and Florida's Turnpike pass through this area on the western part of the city. All of these roadways can be considered truck corridors since the proportion of trucks in the traffic stream on each of these routes was equal to or greater than 5 percent (20). Table 3.1 below presents these roadways along with their basic characteristics.

To evaluate the effect of truck lane restrictions in this area, SR 70 was chosen because it carries a significantly high traffic volume and high percentage of trucks compared to other major arterials in the study area as indicated in Table 3.1. A preliminary analysis of traffic data from the FDOT database showed this route carries up to 30,000 vehicles per day. The data further showed the percentage of trucks varies significantly across the SR 70 corridor. For example, in St. Lucie County (near Florida's Turnpike and I-95) and in Highland County, truck traffic constitutes about 21% to 30%, respectively.

Table 3.1: Roadways characteristics in Fort Pierce

Roadway	AADT	Truck Percentage (%)	Roadway Functional Class	Maximum Speed (mph)	Number of Lanes per Direction
SR 68	18,100	20.93	14/16/17	35	2
US 1	39,000	8.09	14	40	2
SR 615	23,000	3.1	14	35	2
SR 70	30,500	20.74	2/14	45	2/3
SR 713	9,400	18.11	14	40	1

Key: Roadway Functional Class

2-Rural Principal Arterial-Other

14-Urban Principal Arterial-Other

16-Urban Minor Collector

17-Urban Collector

Source (21)

Figure 3.1 shows SR 70 within the vicinity of the City of Fort Pierce; however, SR 70 runs beyond the city and crosses south Florida from east to west. SR 70 starts in St. Lucie County in the eastern part and ends in Manatee County on the western side of South Florida. The roadway passes through five counties, i.e., St. Lucie, Okeechobee, Highlands, Desoto, and Manatee. The section of SR 70 in St. Lucie County has a length of about 25 miles. This 25-mile stretch consists of 17 miles of two lane highway and 8 miles of four or more lane highway. In the areas close to downtown, there are 4 miles of highway with four lanes and 3.8 miles with six lanes.

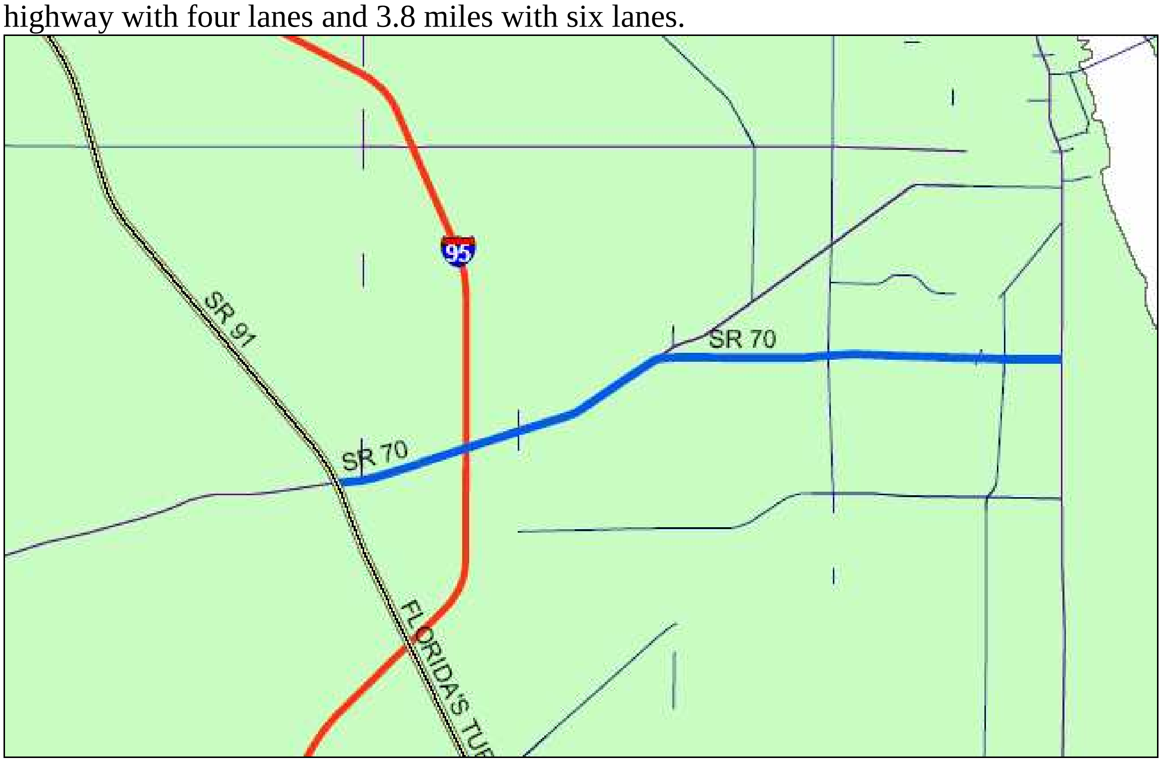


Figure 3.1: Study corridor limits

The review of traffic volume data acquired from the FDOT Traffic CD and the FDOT website indicated that the majority of trucks are generated from Interstate 95 and Florida's Turnpike. Both on and off-ramps on these major limited access highways generate significant truck traffic to and from the City of Fort Pierce. Most of these trucks use SR 70 to travel through the Fort Pierce downtown area. For the purpose of evaluating the impact of restricting trucks to certain lanes in this corridor, a section of about 4.7 miles from US 1 to Florida's Turnpike was selected because it has three lanes of travel per direction as indicated in Figure 3.1.

3.3 Review of Typical Networks

The analysis of the SR 70 discussed above was corridor-based, but it is certainly necessary to equally analyze the effects of truck lane restriction on an area wide basis, i.e., network. The review of typical urban networks involved the identification of typical roadway geometric layouts and land uses in urbanized areas. The review of literature indicated at least eight community development types in which their roadway layout patterns were dependent on history. Other factors affecting community development types include their response to changes in transportation needs and technology, their pattern of society growth, policy, and roadway design (22). The eight community development types are sprawl, urban services area/urban growth areas, mixed use activity centers, neo-traditional town planning, new towns, pre-World War II suburbs, pre-20th century urban centers, and planned unit developments. The results of the analysis of community development types indicated they all result in roadways that typically form a grid network. Therefore, a grid network was chosen for the purpose of evaluating network effects of truck lane restriction on non-limited access highways.

A grid network with roadways spaced as close as ⅛ of a mile in the downtown area and as wide as 2 miles outside of the city center was selected. The network was composed of 11 roadways in the north-south direction and 11 roadways in the east-west direction, resulting in 100 signalized intersections. The number of unsignalized intersections on each roadway link was chosen depending on the link's functional class. Also, the network consisted of 10 six lane roadway links and 12 four lane roadway links per direction. Figure 3.2 shows the schematic representation of the network.

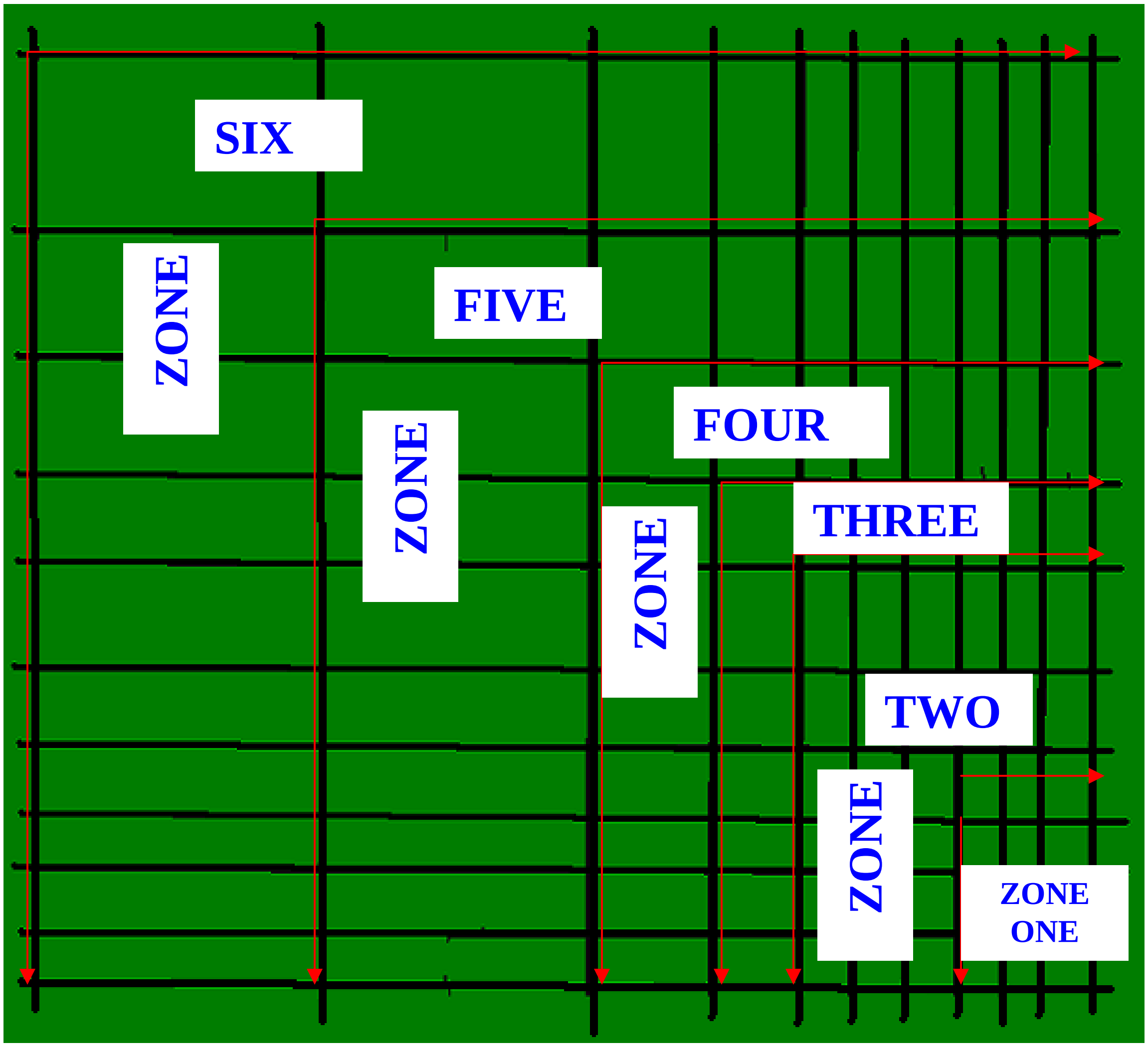


Figure 3.2: Selected typical urban network

3.4 Factors Likely to Affect the Efficacy of Truck Lane Restrictions

Increasing truck traffic continually poses challenges to both transportation engineers and planners. These challenges may include the rapid deterioration of infrastructure, public concerns about truck noise and emissions affecting residential areas, and the loss of productivity due to congestion. Congestion has the effect of increasing costs and affecting manufacturing schedules or shipping deadlines. Several strategies have been researched and implemented in the United States to manage truck traffic (22). A truck lane restriction is one of the strategies whose implementation and effectiveness is affected by various factors. These factors include roadway functional classification, geometric characteristics, traffic volumes, and the distance trucks will be allowed to use all lanes prior to entering a left turn or right turn lane to exit a roadway link. These factors were obtained from various sources and each is discussed in detail in the following subsections.

3.4.1 Roadway Functional Class

Functional classification is the process by which the nation's network of streets and highways are ranked according to the type of service they provide. Any roadway has two competing service functions, that is mobility and access. The travel mobility function tends to decline when a roadway has extensive access points. Roadway functional classification was introduced by the Federal Highway Administration (FHWA) in the late 1960s. FHWA developed guidelines for local governments and planning organizations to use in maintaining the functional classification system in their own jurisdictions. The result was State Departments of Transportation (DOT's) defined guidelines for the classification of both public and private roadways. This provided a demarcation for jurisdiction and maintenance responsibility.

The Florida Department of Transportation (FDOT) adopted the FHWA roadway functional classification system (21). Roadway classes range from unrestricted access to full access control with each functional class divided into design classes. Each class combines the functions of access and mobility and distributes or collects traffic for the adjacent class. All functionally classified arterials and collectors may be found on the State Highway System (SHS), County Road System, and City Street Network. Figure 3.3 illustrates each functional class.

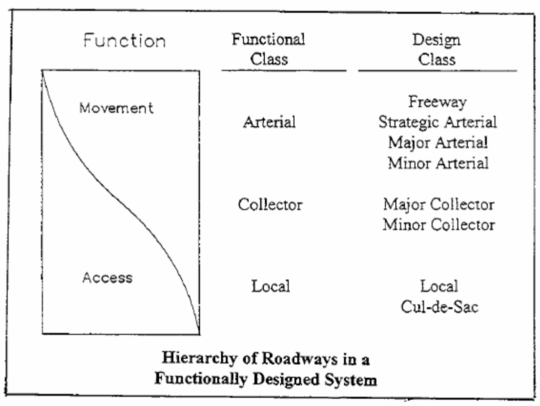


Figure 3.3: Functional classification

Source (23)

The stretch of SR 70 in St. Lucie County is classified into two functional classes; The urban principal arterial stretch which is close to downtown and the rural principal arterial on the rural part. Rural principal arterials have long intersection spacing with few driveways while urban principal arterials have a bit longer intersection spacing with both medial and marginal access.

Rural and urban classifications have fundamentally different characteristics relative to density and the types of land use, travel patterns, and the frequency of streets and highways, as well as, the frequency of signalized intersections and driveways. The rural street system includes principal arterials (interstates and other principal arterials) minor Arterials, major and minor collectors, and local streets. The urban street system has the same categories but does not divide collectors into major and minor categories. In addition, principal arterials in urban areas are defined as interstate, other freeways and expressways, and other principal arterials.

3.4.2 Geometric Factors

Highway geometric design criteria are based on the vehicular characteristics of the largest vehicle likely to use the highway. Usually, trucks and buses are the vehicles used as the design vehicle. Highway geometric design features, whose design is based on vehicular characteristics of the design vehicle, include lane width, sight distance, vertical alignment, acceleration lanes, horizontal alignment, intersection design, and roadside features (12).

Implementing a truck lane restriction on a roadway would require the geometric features discussed above to be adequate and multiple lanes per direction to be present. The inadequacy of these features would hinder the safe operation of large and heavy vehicles. It is worthy mentioning here that SR 70 meets all the criteria that favor safe and efficient operations for trucks. The SR 70 corridor was thus deemed suitable for conducting further study of a truck lane restriction. The analysis of a truck lane restriction on a network level required the specification of typical urban roadway characteristics that were adequate for truck traffic.

3.4.3 Traffic Factors

Traffic data used in the simulation of the SR 70 corridor were extracted from the Florida Traffic Information (FTI) CD and web site maintained by FDOT. Each traffic monitoring site had data on AADT, the proportion of trucks, and directional split factors. In addition, historical AADT data from 1992 with vehicle class proportions were extracted and used in coding vehicular characteristics in the simulation model. Table 3.2 shows a summary of extracted data.

Table 3.2: SR 70 traffic data

From	To	Volume (vph)
Oleander Blvd	US 1	1,376
Sunrise Blvd	Oleander Blvd	1,068
S 13th St	Sunrise Blvd	1,140
S 25th St	S 13th St	1,228
S 35th St	S 25th St	1,548
Okeechobee Rd/ Virginia Ave	S 35th St	1,112
Central Mall Ent	Okeechobee Rd/ Virginia Ave	1,758
West Mall Ent	Central Mall Ent	1,758
McNiel Rd	West Mall Ent	1,827

From	To	Volume (vph)
Jenkins Rd	McNiel Rd	1,848
I-95NB Off Ramp	Jenkins Rd	1,612
I-95SB Off Ramp	I-95NB Off Ramp	1,140
Peters Rd	I-95SB Off Ramp	1,108
Kings Hwy	Peters Rd	1,042

Traffic data used for analyzing the simulated network was based on trips generated from various land uses. The O-D trip matrix was generated for dynamic traffic assignments in the network. Trips were obtained from the ITE Trips Generation Manual for the different land use within the study area. The typical urban land uses were identified and their trips were summed up to give total trips generated from each zone. Subsequently, the distribution of trips from one zone to another zone was estimated using the VISUM transportation planning software. Table 3.3 shows the Origin-Destination (OD) Matrix and the trip distribution in each zone.

Table 3.3: Origin-destination (OD) matrix

Zone	1	2	3	4	5	6
1	2695	2752	3536	3996	3539	3666
2	3245	3943	3191	3281	3121	2429
3	3358	2809	3744	3473	2702	3704
4	2823	3721	2767	3684	2544	3401
5	2514	2937	3945	3396	2500	3769
6	3371	2482	3768	3744	3655	3180

3.4.4 Signalization Factors

Trucks take more time to slow down and make a turning movement due to the limitations imposed by their performance and physical characteristics (12). Depending on the type of movement, large trucks may need longer green or yellow times to safely traverse an intersection. The Manual on Uniform Traffic Control Devices (MUTCD) (24) specifies an interval of 3 seconds to 6 seconds for the yellow change interval at signalized intersections. The MUTCD also specifies that the yellow signal display be followed with an all-red clearance interval. Both yellow and all-red intervals are frequently used at intersections with substantial truck volumes.

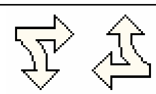
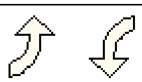
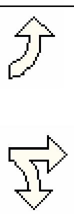
The signalization variables of interest for the corridor and network analysis were offsets, cycle length, and green splits. These variables generally define coordination along a roadway and the amount of green time allocated for through traffic and turning traffic. Signal data for intersections along the study section of SR 70 were obtained from the Fort Pierce Traffic Operation Office and are presented in Table 3.4. The green splits along with phasing and movements details are attached as Appendix F.

Table 3.4: Intersections signal data

Intersection	Cycle length (s)	Phases
US 1	150	4
Oleander Blvd	120	4
Sunrise Blvd	120	4
S 13th St	120	4
S 25th St	120	4
S 35th St	120	3
Okeechobee Rd/ Virginia Ave	110	2
Central Mall Entrance	110	2
West Mall Entrance	110	2
McNeil Rd	90	4
Jenkins Rd	90	4
I-95 NB Off Ramp	90	2
I-95 SB Off Ramp	90	2
Peters Rd	90	4
Kings Hwy	90	4

The cycle length and phasing for the network were decided primarily based on roadway geometrics. The intersection geometrics were varied to represent a variety of real life scenarios. If a left turn lane existed at an intersection, a left turn phase was included unless the three movements (left, through, and right) were serviced by the same phase. This approach was necessary because the traffic volume at intersections was unknown. The green splits, cycle length, and phasing were adjusted to meet traffic volume demands for each movement based on the preview of the simulation animation. The primary signal data used in the study are presented in Table 3.5.

Table 3.5: Network intersections signal data

Movement	Green split (s)	Cycle length (s)	No of Phases
	38	120	4
	16		
	28	120	4

3.4.5 Distance of Restriction Release

The distance measured from the center of an intersection beyond which trucks can be allowed to change lanes in order to reach a desired destination is hereby defined as the "restriction release distance". The restriction release distance has an influence on both the safety and performance of a truck lane restriction. The shorter the distance, the lower the chance of trucks finding gaps in lane changing maneuvers thus increasing the risk of a crash occurrence. The delayed action of truck changing lanes also has an effect of queue building up behind the truck waiting for a gap to change lanes.

The literature search did not reveal recommendations for suitable restriction release distances; subsequently, to analyze restriction release distances, a 2-mile long roadway section was coded in VISSIM. The roadway had two lanes per direction with one intersection. A traffic volume of 1, 910 vph was used to imitate the highest flow rate on a two lane section of SR 70. The speed limit was set as 45 mph. After all the input parameters were coded in the model, the roadway was simulated for one hour and results collected every half hour. The restriction release distances were varied as 500 ft, 700 ft, 1000 ft, and 1500 ft. Truck percentages were varied from 0 percent to 40 percent at the increment of 5 percent. Note that truck percentage is measured as the proportion of the AADT.

The results associated with all restriction release distances were analyzed to reveal any trends. The measures of performance used in the analysis were speed, travel time, delay, queue length, and number of lane changes. It was observed that when truck percentages were low, the restriction release distance had less influence on the simulation results. The results further showed that the impact was significant as truck percentage reached 20 percent or more of the total traffic volume. However, the results for 700 ft, 1,000 ft, and 1,500 ft associated with high truck percentages were not significantly different. Therefore, a release distance of 700 ft was selected for all simulation runs in order to maximize lane restriction length.

3.5 Acquisition of Data for Calibration

The default driver and vehicular characteristics in the model were likely to render simulation results different from those acquired in the field. Therefore, the default parameters coded in the VISSIM model needed to be calibrated. The calibration process involved checking model results against observed field data and adjusting driver and/or vehicular parameters until the simulation model results fell within an acceptable range. Speed, travel time, delay, and capacity are some of the common performance measures used for calibration. Using a floating car technique with a GPS device, average speed and travel time data were collected and used for model calibration as discussed in Section 4.4. Table 3.6 presents summarized field data used for calibration of the simulation model. The raw data used for these purposes are included in this report as Appendix G.

Table 3.6: Field data for calibration

Run Number	Distance Traveled(Miles)	Average Speed (mph)	Travel Time(s)
1	4.69	33.17	549
2	4.68	35.62	481.2
3	4.69	33	540
4	4.7	30.83	583.8
5	4.68	39.84	423
6	4.7	27.76	667.2
7	4.71	29.06	604.2
8	4.73	27.48	655.2
9	4.7	33.06	523.2

CHAPTER FOUR

SIMULATION MODELING

4.1 Software Selection

Microscopic simulation modeling has emerged as a popular and effective tool to perform traffic operations analysis and evaluate new ITS technologies in transportation engineering. Transportation problems that are not easier to study by other means, or where real-world data is unavailable for use in the analysis, can easily be performed with simulation. There are numerous computer simulation models to choose from depending on the intended accuracy of results desired, intended analysis and the knowledge the user has with the simulation model. Through computer simulation of a roadway network, it is possible to predict the operational effects of vehicles traveling on the roadway in terms of capacity, average speeds, delays, vehicle-hours of travel, vehicle-miles of travel, service flow rates, fuel consumption, and pollutant emissions, as well as, analyzing the existing conditions. Simulation is therefore an effective and powerful approach for quantifying the benefits, costs, and limitations of different alternatives which may not currently be evaluated using real world data.

There are several microscopic traffic simulation software packages available on the market capable of modeling truck lane restrictions on non-limited access highways. Some of the most commonly used micro-simulation software include: CORSIM, PARAMICS, SIMTRAFFIC, INTEGRATION, and VISSIM. One of the requirements for the simulation software to be used for evaluation of non-limited access arterials and freeway frontage roads is its capability to model interrupted flow situations (25). A number of criteria were developed and used to screen each simulation software to determine its suitability in modeling truck lane restrictions on non-limited access highways. The selection criteria included the software's ability to model dynamic route assignments, lane closures, modeling of a corridor or network, its interface with external software, and the cost of acquiring the software. It was found from the literature that CORSIM and SIMTRAFFIC software are not capable of dynamic traffic assignment hence they were eliminated first from the list. VISSIM and PARAMICS are both sufficiently capable of modeling truck lane restrictions on non limited access highways. However, VISSIM was finally chosen as the modeling tool in this study over PARAMICS because the cost of purchasing PARAMICS was about ten times that of VISSIM (2, 25).

4.2 VISSIM Model Characteristics

VISSIM is a microscopic, time step and behavior-based simulation model developed to model urban traffic and public transit operations (26, 27, 28). The software can analyze traffic and transit operations under constraints such as lane configuration, traffic composition, traffic signals, and transit stops. This makes VISSIM a useful tool for the evaluation of various alternatives based on desired transportation engineering and planning measures of effectiveness (26).

VISSIM has the capability of modeling geometric and operational characteristics involved with the implementation of a truck lane restriction. The VISSIM through lane closure attribute in link data enables a modeler to restrict a specific vehicle type from using a specific lane. Operationally, VISSIM is capable of collecting various measures of performance like speed, density, travel time and delay for all vehicle types, as well as, for a specific vehicle type. Hence, numerous operational and safety aspects of a truck lane restriction can be analyzed based on the different vehicle types on the road.

For a traffic simulation tool to model traffic and replicate real world data, it must accommodate a lot of parameters. Several traffic parameters incorporated in the simulation software must be validated; for example, generation of vehicles under various traffic conditions, vehicle types with various performance characteristics, drivers with different capabilities, and several others. Some of these parameters for VISSIM traffic simulation software are presented in the following sections.

4.2.1 Traffic Generation Model

The vehicle input in VISSIM is used when at least one vehicle composition is defined (26). Traffic volumes are entered in a specific link and time period via a vehicle input attribute available in VISSIM. Traffic volume can be defined in a time variable but will be generated in vehicles per hour, even if the time period is different from one hour. Thereafter, vehicles are generated from the input point based on a Poisson distribution. Also, if the defined traffic volume exceeds capacity, excess vehicles will be stacked outside the network until space is available in the simulated network. This vehicle input option was adopted for the corridor simulation part of this study.

While in the network simulation, vehicle input (traffic volume) is achieved using an Origin-Destination (OD) matrix in which traffic composition is also defined. OD-matrices cannot be created nor edited directly using VISSIM but rather from a transportation planning software. For this research, the OD-matrix was created on the VISUM transportation planning tool and thereafter imported into VISSIM. In this tool, vehicles are generated via parking lots and the distribution of vehicles entering the network is based on the Poisson distribution model.

4.2.2 Car-Following Theory

The VISSIM model contains a psycho-physical car following model for longitudinal vehicle movement and a rule-based algorithm for lateral movements (26). The model is based on the continued work of Wiedemann (26, 27). The Wiedemann model assumes the driver of the following vehicle decelerates after reaching his/her individual perception threshold relative to a leading vehicle. The basic idea of the Wiedemann model is the assumption that a driver can be in one of four driving modes:

- **Free driving –** in this mode the driver is not influenced by the preceding vehicle. The driver drives at his/her desired speed. In reality, the speed in free driving cannot be kept constant but oscillates around the desired speed due to imperfect throttle control.

- **Approaching –** in the approaching mode the driver is influenced by the preceding vehicle. While approaching, a driver applies a deceleration so the speed difference of the two vehicles is zero the moment he reaches his desired safety distance.

- **Following –** in this driving mode the driver tries to maintain the safety distance. But since he/she cannot accurately determine the speed of the preceding vehicle, the differential speed between the preceding car and the following car always oscillates around zero.

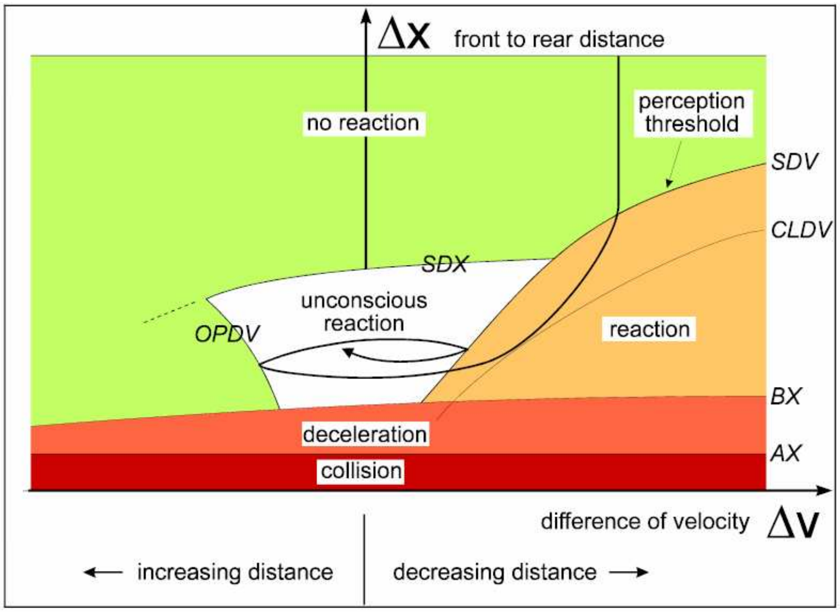
- **Braking –** this driving mode occurs when the preceding vehicle applies brakes abruptly or a driver in an adjacent lane changes to the lane in front of the observed driver. This leads to the observed driver applying high deceleration rates to avoid a crash.

In all four driving modes, the acceleration and deceleration rates are expressed as results of speed, differential speed, distance and the individual characteristics of driver and vehicle. The driver population is diverse with different perception capabilities, desired speed, and safety distance thresholds. Also, driver switches from one mode to another. As soon as he/she reaches a certain threshold, this threshold can be expressed as a combination of speed difference and distance. Because of the combination of psychological aspects and physiological restrictions of the driver's perception, the model described above is commonly referred to as a psycho-physical car-following model (26)

The car-following model parameters vary depending on the type of traffic environment modeled. Wiedemann developed two models mentioned below, one for urban traffic and the other for interurban traffic. The two models have different parameters for vehicle following:

- *Wiedemann 74*: Model mainly suitable for urban traffic,
- *Wiedemann 99*: Model mainly suitable for interurban (motorway) traffic, and
- *No Interaction*: Vehicles do not recognize any other vehicles (can be used for a simplified pedestrian behavior).

The basic concept in the Wiedemann model is that the driver of the faster moving vehicle starts to decelerate when the driver reaches his/her individual perception threshold to a slower moving vehicle. Since a driver cannot exactly determine the speed of the slower moving vehicle, the speed will fall below the speed of the slower moving vehicle. The driver starts accelerating again slightly until another perception threshold is reached. This results in an iterative process of acceleration and deceleration. Stochastic distributions of speed and spacing thresholds replicate individual driver behavior characteristics as illustrated in Figure 4.1.



Car following logic (Wiedemann 1974)

Figure 4.1: Driver behavior model (car-following) in VISSIM

Source: (26).

4.2.3 Lane-Change Algorithm

Lane change in VISSIM is possible where there is more than one lane per direction or one lane per direction, but wide enough to allow passing on the same lane. There are basically two kinds of lane changes in VISSIM:

- free lane change, and
- necessary lane change.

In a free lane change, the driver is not forced to change lanes. Rather, he/she wants to stay in a desired lane. VISSIM checks for the desired safety distance of the trailing vehicle on the new lane, which depends on the speed of the trailing vehicle and the speed of the vehicle that wants to change to that lane. Currently, VISSIM Version 4.1 has no way for the user to change the "aggressiveness" parameter for these lane changes. However, changing the parameters for the desired safety distance, which are used for the vehicle following behavior will affect the free lane changes as well (26).

In a necessary lane change, the driver changes lanes in order to reach a designated route. Driving behavior parameters considered include maximum acceptable deceleration for the vehicle and the trailing vehicle on the new lane with default values of 13.12 ft/s^2 and 9.84 ft/s^2 for the lead vehicle and trailing vehicle, respectively. Minimum headway (front/rear) by default is 1.64 ft and these parameters depend on the distance to the emergency stop position on the next connector of the route.

However, in both free and necessary lane changes, the driver finds a suitable gap (time headway) in the destination flow before making any lane change maneuver. The gap size is dependent on both the speed of the lane changer and the speed of the vehicle that “comes from behind” (on that lane where the lane changer changes to) (26). But in a necessary lane change, the gap size is also dependent on the deceleration values and the level of “aggressiveness”.

Example of necessary lane change

Aggressiveness in a necessary lane change can be defined by using deceleration thresholds. Maximum and minimum thresholds for both the lane changer and trailing vehicles must be defined. Maximum decelerations are different for two vehicles, as presented above, but the minimum (accepted) decelerations are the same with a default value of 3.28 ft/s^2. In addition, a reduction rate is used to reduce the *maximum deceleration* with increasing distance off the emergency stop position (26). An example of a parameter’s specification and the resulting movement graph is shown in Figure 4.2.

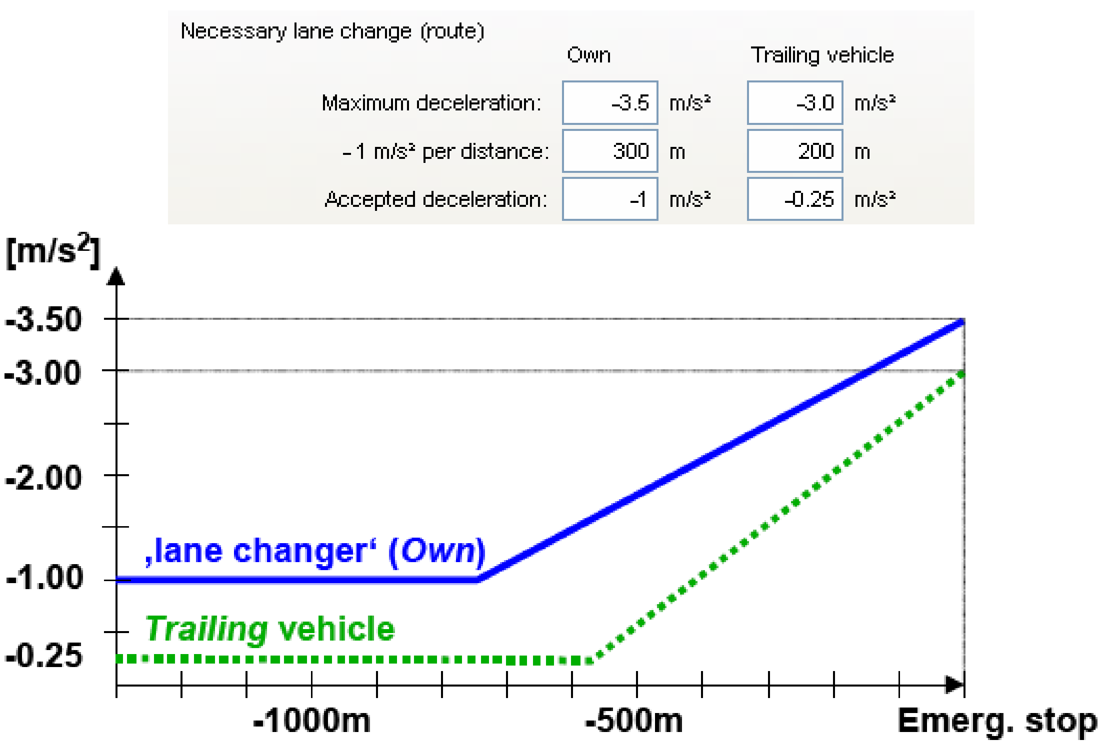


Figure 4.2: VISSIM necessary lane change parameters

Source: (26)

4.2.4 Route Choice Model

VISSIM has two methods of routing traffic in a simulated roadway or network, namely, static route assignment and dynamic assignment. In static route assignment, VISSIM uses routing or direction decisions while dynamic assignment uses an origin-destination (OD) matrix. Both methods were used in this research depending on some influencing factors as will be discussed later. Furthermore, in static routing the user defines the start point and destination along with the proportion of traffic. One starting point can have multiple destinations. This method of routing was adopted in the corridor modeling where the starting point on the major road was inserted before the signalized intersections and destined to various route access and turning points before a new route assignment. Destination points were located after the signalized intersections.

In the dynamic assignment, drivers choose their routes when they start a trip at the origin parking lot. Knowing the destination parking lot and possible routes, drivers will choose the best route characterized by the lowest general cost. However, not all drivers are bound to use the best route although all routes are open for use. The criterion for a best route is general cost which is computed as a weighted sum:

General cost = α*travel time + β*travel distance + γ*financial cost + Σsupplement)

In which the weights α, β, and γ are user-defined. The function used to model discrete choice behavior is the logit function expressing by Kirchhoff distribution formula:

$$p(R_j)= \frac{e^{-k.\log C_j}}{\sum_i e^{-k.\log C_i}}$$

Where $p(R_j)$ is the probability of route j to be chosen, k is the sensitivity of the model, and C_j is the general cost of route j. A very low sensitivity factor would lead to nearly equal distribution while a very high value would lead to all drivers choosing the best routes.

4.3 Simulation Design

Simulation modeling is a useful tool for analyzing systems or strategies that are not amenable to analysis by other methods. It enables planners and engineers to analyze merits and demerits of numerous designs prior to implementation. Achieving a simulation model that replicates what exists in the field involves various tasks. How traffic volume input, signal data, and geometric data are to be managed are some of the tasks that a modeler must perform. Other tasks include validation and calibration. The following sections explain in detail how the mentioned tasks were performed.

4.3.1 Corridor Simulation

Corridor simulation in this research meant simulation of SR 70. After reviewing the literature and analyzing the methodology to be used, the geometrics of SR 70 were then coded in VISSIM. Traffic data, signalization data, vehicle routing, vehicle mix by type and vehicle characteristics were the basic inputs specified in the VISSIM simulation model. The sections below discuss how corridor geometrics were coded in VISSIM including definition of the input parameters.

4.3.1.1 Corridor Coding

Corridor coding refers to the process of capturing and representing the roadway geometry, traffic, and traffic signal characteristics in a computer. A background map of SR 70 was downloaded from Google Earth and imported into VISSIM. The map was scaled followed by tracing the links and connectors on the scaled background map. As was described in Section 2 of Chapter Three, Florida's Turnpike and I-95 off-ramps and on-ramps for the destination SR 70 on the west side. Hence, two link types were created, which are urban (motorized) and freeway to emulate local vehicle and driver characteristics. In addition, the freeway and SR 70 were grade separated while SR 70 grade was 0 percent since this area seemed to have a fairly level terrain. Intersection geometrics, lane width, length of storage and turning bays were verified through video log and site visits.

Video logs show the whole roadway with its side characteristics as well as the mile points. Having a mile point made it easy to measure the length of storage bays while the video helped in showing the number of lanes, location of intersections, and the location of access points.

4.3.1.2 Corridor Simulation Input and Their Levels

In specifying vehicle composition and vehicle characteristics in VISSIM, a modeler can choose to use default values or change them depending on desired simulation objectives. In this study, the vehicle composition and vehicle characteristics parameters were specified based on the results of the field review. For example, there are no tram bus types operating on SR 70 and minimal pedestrian/bike activities. Hence tram, bikes, and pedestrians were not included in the specification of vehicle composition.

A closer examination of VISSIM default vehicle characteristics revealed that they are slightly different from field data collected. The VISSIM default vehicle lengths for passenger cars ranged from 13.48 ft to 15.62 ft while heavy truck lengths were 33.51 ft to represent single unit trucks. Based on previous research studies, the vehicle lengths were changed to 30 ft for passenger cars and 120 ft for heavy trucks (9, 11, 17). The VISSIM default weight of trucks ranged from 6,200 pounds to 88,000 pounds. It seemed that the lower default boundary was a bit high for single unit trucks that are used to haul, pickup, deliver parcels and other activities in urban areas. Thus, the weight range was changed to

3,000 to 80,000 pounds. The power range of large trucks was not changed and was left at the default range of 150 kW to 400 kW.

Traffic volume and signal data presented on Table 3.2 and 3.4, respectively, were used for vehicle and signalization input. Signalization input was achieved by defining cycle length, phasing, and green time splits on signal control attributes in VISSIM. Thereafter, signal control and phase groups were marked on lanes via a signal head which is equivalent to the signal display in real world.

4.3.1.3 Corridor Simulation Scenarios

Following the coding of the corridor and the specification of input parameters, simulation scenarios were specified from which the effect of truck lane restriction could be quantified. Like other researchers (2, 11, 28, 29), a number of factors like truck volume, grade, number of access points per mile and which lane trucks are restricted to, all should be considered in various combinations so that truck lane restriction efficacy can be assessed. Four possible truck lane restriction scenarios were identified. In all scenarios, the traffic volume was kept constant but the percentage of trucks was varied from 0 percent to 40 percent at 5 percent increment.

Traffic data analysis, together with field visits to SR 70 in Fort Pierce revealed that the noon peak had more traffic than the morning and evening peak hours. Therefore traffic volume for the noon peak hour was used in this research. As discussed in Section 3.2 of Chapter Three, the truck percentage in this corridor was as high as 30 percent in Highlands County; hence, the truck percentage was varied from 0 percent to 40 percent.

Roadway grade was assumed to be 0 percent since in this area the terrain was gentle with less than 2 percent grade. At the time of simulation, VISSIM Version 4.1 did not allow a violation rate to be specified to model the percentage of trucks that use the restricted lane(s). Thus, for all simulation scenarios it was assumed that there would be 100 percent compliance rate with the lane restriction. Table 4.1 presents a summary of the simulation scenarios.

Table 4.1: Summary of simulation scenarios

Scenario	Section number of lanes	Trucks restricted to	Truck percentage
1	2	None	0 %– 40%
2	2	Right lane	0 %– 40%
3	2	Left lane	0 %– 40%
4	3	None	0 %– 40%
5	3	Right lane	0 %– 40%
6	3	Center lane	0 %– 40%
7	3	Left lane	0 %– 40%

4.3.1.4 Measures of Operational Performance

Once the simulation scenarios were set, it was necessary to define the measures of operational performance necessary for quantifying the operational effects of truck lane restrictions on non-limited access highways. Like other researchers (2, 11, 29, 30), measures of operational performance selected for the simulated corridor were travel speed, travel time, and delay. The intersection measures of performance selected were delay, total stopped delay, and queue lengths. These intersection performance measures have also been used in the research reported in the literature (31, 32). The following sections explain the efficacy of some of these operational performance measures.

Vehicle Speeds

Vehicle speeds on a roadway are influenced by various factors including roadway geometrics, adjacent land use, interaction between vehicles, and traffic control devices such as signs and signals (30). Interaction among vehicles can be defined by density, vehicle composition (trucks, cars, and buses), and the type of movement the vehicles make like U-turns, left-turns or right-turns. The proportion of trucks in a traffic stream also affects traffic flow performance. For example, the presence of 2 percent trucks in the traffic stream will likely have less effect on average travel speed than the presence of 15 percent trucks (17). Therefore, roadway geometrics and other factors mentioned above affect the operational performance of a roadway making speed a good measure for quantifying the efficacy of truck lane restriction.

Travel Time

Travel time is the average time spent by vehicles traversing a highway segment. The travel time includes running time on a link and control delay at an intersection (30). A successful operational and safety strategy for managing trucks should result in reduced travel time and decreased congestion. Therefore, travel time was selected as a measure of performance of truck lane restriction.

Delay

Delay is the additional travel time experienced by a driver, passenger or pedestrian and is mentioned as a performance measure for intersections (30). VISSIM is capable of collecting total delay and total stopped delay data for an intersection, as well as, roadway segments. These delays result from both control signals and vehicle interaction. VISSIM does not output traffic signal control delay which is usually used to analyze intersection performance. However, in this study the total delay and total stopped delay was used in corridor and intersection analysis, particularly in analyzing the performance of signalized intersections.

Queue Length

Queue length is the un-served traffic demand caused by oversaturation of a traffic control device and is usually measured in length units (30). Queue length in VISSIM is output in units of length, not in a number of cars (26). VISSIM provides several user definable conditions to define a queued vehicle. A vehicle is in queue condition if its speed drops below the begin speed and has not exceeded the end speed yet. The maximum headway defines the maximum distance between two vehicles so the queue is not disrupted, and the maximum length defines the maximum length of the queue.

Default values of the above mentioned conditions were; 3.1 mph (Begin speed), 6.2 mph (End Speed), 65.6 ft (maximum headway), and 1640.4 ft (maximum length). The default values specified by VISSIM were adopted in this study. VISSIM outputs related to queue length output include average queue length, number of vehicle stops within the queue, and maximum queue length. The preliminary analysis of the results indicated plausible values with plausible trends. For instance, the number of stops was increasing with the increase in truck percentage as was the average queue length. The maximum queue length was discarded as a measure because its report defined maximum queue length - even if the actual queue was longer. Therefore, only the average queue length was used as a performance measure.

4.3.1.5 Measures of Safety Performance

Traffic safety and crash occurrences are influenced by many factors including roadway geometry, vehicle characteristics, vehicle performance, driver behavior, environmental conditions, traffic composition, and roadside land use activities. The simulation analysis of safety effects of a truck lane restriction does require analyzing the effects of these parameters on simulated crashes. VISSIM is incapable of simulating a crash and does not allow the user to model relationship between crashes and some of the causative factors mentioned above.

Because of the difficulty of accurately predicting crash rates in a simulated environment, surrogate simulation performance measures were obtained that correspond to the safety level of a transportation facility under various designs (33). The distribution of headways, differences in speeds, and the number of lane changes are some of the surrogate measures that have been used by some researchers in the past (2, 11). For instance, the use of headways as a safety measure is plausible since smaller space headways reduce the space for a following driver to maneuver in case the lead vehicle abruptly applies brakes thus increasing the probability of a rear end collision.

The number of lane changes and differential speed among vehicles on different lanes are considered as measures of the degree of inter-lane vehicle interaction brought about by a truck lane restriction. The increase in inter-lane vehicle interaction increases the potential for crash occurrence because of the frequent lane changes which occur as drivers try to maximize their positions and speeds. Thus, the number of lane changes in a section and average speed differences between adjacent lanes are good predictors of safety characteristics of a transportation facility following the implementation of a truck lane restriction.

VISSIM is capable of recording each vehicle movement along with their desired speeds, desired headways, following distances, desired lane, acceleration and deceleration for every second per individual vehicle or per class of vehicles. As indicated earlier, the number of lane changes and speed differential were used in this research to evaluate the resulting effects of implementing a truck lane restriction on a non-limited access roadway. The number of lane changes was recorded for each individual vehicle while the headway was recorded for each vehicle class. The recording of individual vehicle headways was discarded because just one hour of simulation produced huge data output files that were difficult to summarize for analysis.

4.3.2 Network Simulation

To analyze operational effects and safety indicators associated with the implementation of truck lane restrictions on non-limited access highways on an area wise basis, it was necessary to expand the simulation to a network level. The primary focus of the simulation analysis was in urban areas where land use characteristics and roadside friction factors contribute to increased conflicts between through vehicles and turning vehicles. Therefore, the analysis of an urban roadway network was undertaken to determine the influence of a truck lane restriction on abutting roadways.

A typical network of urban roadways with 121 nodes and 100 links was considered. The network was shown in Figure 3.2 in Chapter Three. However, the simulation analysis will be limited to hypothetical traffic and signalization characteristics since real life data of these characteristics were difficult to obtain. However, a wide range of traffic and signalization conditions typical in most urban areas was simulated. Efforts were made to replicate geometric characteristics of major roads found in Fort Pierce, Florida, which was the test bed for the truck lane simulation analysis. A limited validation effort was conducted using relevant data from Fort Pierce area.

4.3.2.1 Coding of the Network Geometrics

The important geometric input variables likely to affect the efficacy of a truck lane restriction include the layout of the network, number of lanes in a link, lane width, intersection spacing, functional classification of different roadway links, distribution of driveways and unsignalized intersections along a link, and signalized intersection spacing. Necessary input geometrics for the network were identified. Thereafter, a typical grid network was drawn in Microsoft Word showing the grid spacing, number of links as well as link length. The drawing was then converted into “tiff” file format and then imported to VISSIM as a background image. Links and link connectors were then traced on this background image in VISSIM. Having a network skeleton made, the intersection geometrics were coded.

To replicate the real-world, several intersection designs were coded including intersections with and without separate left turn or right turn storage bays. Both signal and stop controlled intersections were employed. The network had 102 intersections with either left, right or both turning storage bays and 19 intersections without storage bays and more than 50 intersections with stop controlled intersections. The network had eleven roadways on each side. In addition, six roadways on one side of the network had two lanes per direction while five roadways had three lanes per direction. Each zone had a different speed limit, with a high speed range of 40 to 55 mph in Zone 6 and a lower speed range of 25 to 30 mph in Zone 1.

4.3.2.2 Simulation Input and Their Levels

In VISSIM, vehicle population is categorized into vehicle types containing vehicles that share common performance attributes. These performance attributes may include weight, power, length, model, and maximum/minimum acceleration and deceleration. Vehicle model and length are user-defined based on probabilistic distributions while all other attributes are preset by VISSIM. Three vehicle types were defined in this study, namely passenger cars, buses, and trucks. Trucks were further divided into subgroups differentiating between light and heavy trucks as presented in Table 4.2.

Table 4.2: Vehicle types

<table>
<tr><td colspan="3">Vehicle type</td><td>Length (ft)</td><td>Weight (lb)</td><td>Percentages</td></tr>
<tr><td colspan="3">Passenger car</td><td>≤ 19</td><td>1700-4400</td><td>100%</td></tr>
<tr><td colspan="3">Buses</td><td>37.87</td><td>8800-26500</td><td>100%</td></tr>
<tr><td rowspan="4">Truck</td><td rowspan="2">SUT’s</td><td>Light</td><td>30- 39</td><td>< 4000</td><td>40%</td></tr>
<tr><td>Heavy</td><td>39.5-45</td><td>50000-65000</td><td>40%</td></tr>
<tr><td rowspan="2">Tractor trailers</td><td>Light</td><td>45.5-55</td><td>80000-99000</td><td>15%</td></tr>
<tr><td>Heavy</td><td>55-120</td><td>80000-100000</td><td>5%</td></tr>
</table>

The default values suggested by VISSIM for passenger cars and buses vehicle characteristics were adopted while length and weight of trucks were adjusted to represent what exists in some urban areas. The corridor and network simulation did not consider the presence of pedestrian and cyclists in order to reduce the level of post-simulation data processing.

Traffic demands in VISSIM can be input in two different forms as was discussed in Section 4.2.1. The dynamic assignment method was chosen in which vehicle input is achieved through the OD-matrix, which contains the number of trips for every pair of planning zones for a given time interval (26). Therefore, it was necessary to determine the number of trips generated per zone.

The network was partitioned into six zones where the first zone had closely spaced intersections representing downtown characteristics. The sixth zone had sparsely spaced intersections representing rural or sub urban areas. Numerous land uses likely to be found in urban areas were identified and their trip generation characteristics reviewed. The Institute of Transportation Engineers (ITE) trip generation manuals (5) were the basic sources of information on trip rates per land use along with other sources. Each zone was assigned a number of trips based on the type of land use likely to be found in that zone, e.g., a raw food processing company was not expected to be found in Zone 1, downtown area but rather in Zone 6 representing a rural or suburban area.

In VISSIM, vehicles originate from or are destined to a parking lot. A zone can have several parking lots in which traffic outflow or inflow depends on the user-defined proportion of parking lots available in each zone. The drivers choose the destination parking lot in a discrete manner. The choice is based on a utility function which account for factors like parking time fee per hour and parking lot open hours (26).

Signalization data obtained from the City Fort Pierce had a maximum cycle length of 120 seconds as presented in Appendix F; therefore, a default cycle length of 120 seconds was set in VISSIM while green splits and phasing were set based on the intersection geometrics found in the simulated network. Following animation review of the simulated trial runs, signal timing data were adjusted to reduce congestion on various intersections and to equalize traffic flow in different parts of the network.

4.3.2.3 Network Simulation Scenarios

VISSIM is capable of modeling a truck lane restriction through the option of a "lane closure" in which a lane can be closed to a specified vehicle type. Therefore, following this VISSIM capacity, four scenarios were identified, simulated and evaluated. Trucks were restricted to the left lane in the first scenario, then restricted from the right lane in the second scenario, and restricted to the center lane for roadways with three lanes in the third scenario. The existing condition of "no restriction" was the fourth scenario. Also, the truck proportion was varied from 0 to 0.4 at an increment of 0.05 in all simulation scenarios. All scenarios were simulated and analyzed to document the effects of truck lane restrictions on non limited access highways.

Furthermore, the same OD-matrix was used under all scenarios to reduce bias in the results arising from various traffic conditions in different scenarios. The edited signal timing resulted in most intersections having a cycle length lower than 110 seconds. These edited signal timings were used in simulation scenarios.

4.3.2.4 Network Measures of Performance

From the review of literature, operational performance measures include speed, delay, travel time, queue length and level of service. Four performance measures were used in comparing the effect of the truck lane restriction in the various scenarios. The average speed a vehicle can maintain on each link and the average speed for the whole network were the selected performance measures. Both average travel times per roadway and network, as a whole, were considered in this research. Also, delay times resulting from both control devices and vehicle interactions were taken into account as well as queue length. In addition, delay and queue length were used to analyze the influence of truck lane restriction on intersection performance.

4.3.2.4 Network Measures of Safety

This section, discusses simulation outputs that quantify the safety effects of a truck lane restriction and those that give surrogate indicators of the likely safety impacts of the truck lane restriction. Following a comprehensive literature review, safety performance measures identified were speed differential, headways and the number of lane changes. The speed difference among vehicle types or lanes has been used as a surrogate measure in assessing the impact of a truck lane restriction (2, 30). An increase in the differential speed will, theoretically, increase the probability of a crash occurrence.

Apart from speed differential, lane change frequency is used to evaluate the safety level of a transportation facility. The higher the lane change frequency, the higher the probability of a crash occurrence because of the vehicle interaction. A truck lane restriction is expected to lower the lane changing frequency since trucks are restricted to designated lane unless they make a turning movement. However, this might not be valid based on location and the density of the access point which might necessitate a truck to cross several lanes to exit. In addition, the lower the headway, the higher the opportunity for crash occurrence. This research limits itself to speed differential and the number of lane changes as safety measures since headway data collection resulted in a large, unmanageable file. These safety measures were analyzed for each scenario and used to compare the results of all four simulated scenarios.

4.4 Model Calibration and Validation

Traffic flow characteristics vary from one place to another depending on traffic volume, roadway geometry, environmental conditions and driving behavior. Therefore, these parameters are sometimes site specific. It was therefore necessary to calibrate the model to replicate what exists in the field. Calibration refers to model parameters adjustment for output results that compare with observed field data. Validation occurs when the output of the model is statistically comparable to observed field data (30). Calibration and validation methodologies adopted in this research are similar to those found in other studies (2, 30, 34, 35).

4.4.1 The Corridor

Guidelines for model calibration and validation provided by the Federal Highway Administration (FHWA) and Highway Capacity Manual (HCM) were adopted in this research (30,34). Numerous test simulation runs were performed using VISSIM default values of minimum headway, maximum and minimum deceleration of all vehicle types, look ahead and look back distance, probability of temporary lack of attention as well as driving behavior parameters. In the test runs, speed and travel time outputs were analyzed and compared with field data. Also, animation review was performed which assisted in revealing coding errors like vehicles running red traffic signals which results when a signal head is located at an overlap of a link and a connector. There were observed differences between VISSIM outputs and field data, hence each calibration simulation run was adjusted by fine tuning the driving behavior parameters. The iterative calibration process resulted in a model that fairly represented the observed field conditions.

In addition, speed-density-flow relationships resulting from the simulation modeling were compared to the field data values. As shown in Figure 4.3 below, the simulated data matched well with field data. The slight differences in Figure 4.3 might be a result in different measuring procedures. VISSIM records each vehicle data every one tenth of a second but point measure and single floating car were used in the field data collection.

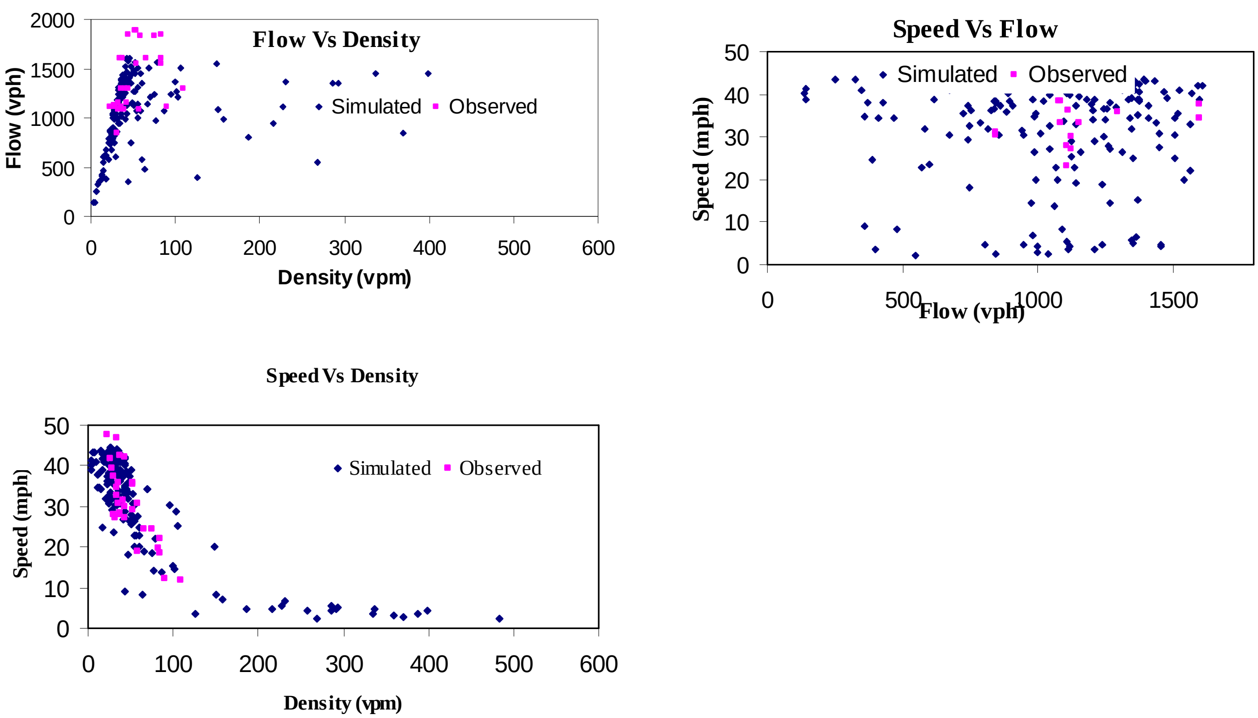


Figure 4.3: Traffic flow diagrams

The model was further validated by statistically comparing the calibrated model results with field observed data (30). The analysis of variance (ANOVA) was used to test differences between simulated speed with field speed, and results indicated no statistical difference at an α-level of 0.01. The *p*-value is higher than 0.01 as seen in Table 4.3 below.

Table 4.3: ANOVA summary

Groups	*Count*	*Sum*	*Average*	*Variance*		
Observed Speed	9	289.82	32.20222	15.76437		
Simulated speed	9	278.4976	30.94417	8.278708		
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.122104	1	7.122104	0.592445	0.45269	8.530947
Within Groups	192.3446	16	12.02154			
Total	199.4667	17				

4.4.2 The Network

The hypothetical network was not calibrated using the guidelines and procedures used in some past studies (30, 34). Rather, calibration was made using realistic input data, as much as possible, and observing the animation of any coding errors. Animation helped in visualizing coding errors like full destination parking lots. Such errors were resolved by changing from an abstract parking lot to a zone connector. The capacity of an abstract parking lot is user-defined, while the capacity of a zone connector is not user-defined and can cope with only 700 vph per lane. Also, this problem can be resolved by setting parameters that compute a new route or parking lot if a vehicle-assigned parking lot is full. In addition, unusual queues at intersections were resolved by changing intersection geometrics, especially at input points on network boundaries and at intersections by adjusting signal timing.

CHAPTER FIVE

ANALYSIS OF RESULTS

This chapter discusses the simulation results of truck lane restrictions on arterial streets for the four restriction scenarios that were discussed in detail in Chapter Four. The VISSIM outputs that measure the influence of truck lane restriction on safety and operation performance of a roadway were analyzed for each simulated scenario. The results discussed in this chapter are for both corridor and network simulations. The measures of performance and surrogate measures for safety were derived for both the sections and the intersections that were coded in VISSIM.

5.1 Effect of Restriction on Operation

A number of performance measures were selected for the purpose of quantifying the effect of a truck lane restriction on the operation of the SR 70 corridor and the network. The performance measures for both the corridor and the network link analysis were travel time and speed. Generally, the presence of intersections along a corridor affects the operational performance of the corridor. Thus, it was important to account for the influence of intersections on the performance of a corridor or network by analyzing measures of effectiveness (MOEs) related to intersection operations—that is, delay, stopped delay, and queue length. The following subsections discuss the trend of these performance measures for both the SR 70 corridor and the network under all simulated scenarios.

5.1.1 Travel Time

Table 5.1 shows the travel time for all four restriction scenarios. Only through vehicles that traversed the study section from the beginning to the end were used in the travel time data aggregation. The no restriction scenario was compared to the three hypothetical restriction scenarios. The results indicate that restricting trucks to the right lane is relatively beneficial compared to the “no restriction” scenario. In addition, the results in Table 5.1 indicate that neither a restriction of trucks to the left lane only, nor a restriction of trucks to the center lane only, is a better alternative compared to “no restriction” or “restriction to the right lane only” alternatives. They both have negative impacts on roadway performance by increasing travel time. These results might be attributed to the fact that the simulated corridor had a raised median with fewer left-turn driveways compared to right-turn driveways. It is worth noting that in Table 5.1 travel time increases with an increase in truck percentage regardless of which lane trucks are restricted from.

Table 5.1: SR 70 travel time

Truck Percentage	Travel time in seconds			
	No Restriction	Trucks use right lane only	Trucks use left lane only	Trucks use center lane only
0%	590.7	558.3	590.7	590.6
5%	599.9	569.8	602.8	602.2
10%	615.5	577.2	617.6	616.4
15%	628.9	584.2	631.0	632.3
20%	646.7	596.3	660.4	655.8
25%	665.0	611.1	685.0	682.2
30%	699.3	632.0	730.0	719.1
35%	741.1	650.7	766.6	757.4
40%	761.4	679.2	794.9	779.4

5.1.2 Average Speed

The average speed was analyzed for each vehicle type as well as in combination (all vehicle types) as shown in Table 5.2. The results show that passenger cars have a higher average speed compared to trucks in all simulated scenarios. Restricting trucks to the right lane has advantages for both passenger cars and trucks. They both operate at higher speeds with the truck restriction than without it. However, the results also show that passenger cars tend to gain more average speed with increased truck percentages when trucks are restricted to the right lanes.

The results indicate that restricting trucks to the left lane only aggravates the operational performance of the roadway when compared to other restriction scenarios and to the "no restriction" scenario. Furthermore, average vehicle speeds decrease with an increase in truck percentages regardless of the type of truck lane restriction scenario imposed. Through these simulation results, it can generally be said that the restriction of trucks to the right lane is beneficial to the operational performance of a roadway. However, the gain in average speed was not statistically significant. A statistical analysis conducted on the difference between the right lane only restriction and the "no restriction" produced a *p*-value greater than 0.05.

Table 5.2: SR 70 average speed per vehicle type

Truck Percentage	Average Speed (in miles per hour)					
	No Restriction			Trucks use right lane		
	Car	Trucks	All Vehicle	Car	Trucks	All Vehicle
0%	34.6	0.0	34.6	34.9	0.0	34.9
5%	34.2	29.8	33.9	34.2	29.5	34.0
10%	33.3	28.8	32.8	34.0	29.0	33.4
15%	33.1	28.9	32.4	33.5	28.4	32.6
20%	32.2	28.1	31.3	33.1	27.9	32.0
25%	31.4	27.1	30.2	33.0	27.4	31.4
30%	31.2	26.9	29.8	31.9	26.3	30.0
35%	28.9	25.2	27.4	30.8	25.5	28.6
40%	27.8	23.9	26.1	30.3	24.7	27.9
Truck Percentage	Trucks use left lane			Trucks use center lane		
	Car	Trucks	All Vehicle	Car	Trucks	All Vehicle
0%	34.6	0.0	34.6	34.7	0	34.7
5%	33.9	29.3	33.6	34.0	29.5	33.7
10%	33.5	28.4	32.8	33.5	28.4	32.9
15%	32.9	28.1	32.1	32.9	28.1	32.1
20%	32.5	27.4	31.4	32.0	27.2	30.9
25%	31.7	26.7	30.3	32.3	26.9	30.8
30%	30.1	25.2	28.4	30.8	25.6	29.0
35%	28.2	23.6	26.1	28.2	23.7	26.4
40%	27.3	22.7	25.4	28.0	23.4	25.9

The results of the average speed analysis for the simulated network do not indicate a clear speed difference among the four scenarios of interest as shown in Table 5.3. This might be attributed to the fact that only four out of 22 roadways in the simulated network had a truck lane restriction. However, the results in Table 5.3 show a clear trend of average speed decreasing with the increase in truck percentage for all four scenarios. Closer examination of Table 5.3 further shows that passenger cars travel with higher speed than trucks and the difference in speed between passenger cars and trucks increases with the increase in truck percentage. It can be surmised, therefore, that imposition of a truck lane restriction affects average truck speeds negatively when the truck percentage is higher on a particular roadway.

Table 5.3: Network average speed per vehicle type

Truck Percentage	Average Speed in miles per hour					
	No restriction			Trucks use right lane		
	Car	Trucks	All Vehicles	Car	Trucks	All Vehicles
0%	32.9	0	32.9	32.9	0.0	32.9
5%	32.5	32.3	32.5	32.7	30.6	32.6
10%	32.7	32.2	32.5	32.4	30.3	32.2
15%	32.5	31.9	32.3	32.4	30.2	32.2
20%	32.7	32.0	32.4	32.5	30.2	32.3
25%	32.1	31.3	31.8	32.2	29.4	31.8
30%	32.2	31.9	31.9	32.3	29.5	31.9
35%	32.3	31.5	31.9	32.0	28.9	31.4
40%	31.9	31.2	31.4	32.2	28.8	31.6
	Trucks use Left lane			Trucks use Center lane		
Truck Percentage	Car	Trucks	All Vehicles	Car	Trucks	All Vehicles
0%	32.8	0	32.7	32.9	0	32.9
5%	32.7	31.0	32.6	32.7	31.0	32.6
10%	32.6	30.3	32.4	32.6	31.0	32.3
15%	32.7	30.1	32.4	32.6	30.8	32.3
20%	32.7	30.1	32.2	32.8	30.6	32.3
25%	32.2	29.6	31.8	32.3	29.9	31.6
30%	32.6	29.9	32.1	32.3	30.4	31.8
35%	32.4	29.4	31.8	32.3	29.7	31.5
40%	32.2	29.2	31.5	32.2	28.0	31.3

5.1.3 Delay

Delay is a measure of intersection performance chosen to demonstrate the influence of a truck lane restriction on intersection operations. Table 5.4 shows the intersection delay experienced by vehicles for all four scenarios and for the nine truck percentage levels used in the simulation. The results in Table 5.4 show that "no restriction" scenario, restriction to the left lane, and restriction to the center lane resulted in less delay at low truck percentages—that is, up to 10 percent—but increased substantially as the percentage of trucks increased. However, different results are observed when the restriction is to the right lane only. The delay is higher at low truck percentages compared with delay recorded from other scenarios and increases slightly with the increase in truck percentage. It can thus be inferred from these results that restriction to the right lane only is a better alternative for improving intersection performance.

Table 5.4: Corridor intersection delay

Truck Percentage	Delay in seconds			
	No Restriction	Trucks use right lane only	Trucks use left lane only	Trucks use center lane only
0%	40.6	42.0	40.6	40.6
5%	43.4	44.4	43.4	43.4
10%	46.6	46.3	46.6	46.4
15%	49.6	49.0	49.6	49.8
20%	54.2	52.1	54.2	53.5
25%	57.7	55.7	57.7	57. 5
30%	63.5	59.5	63.5	62.2
35%	68.1	62.1	68.1	66. 5
40%	70.5	64.9	70.5	69.9

Table 5.5 presents the results of the intersection delay at a network level analysis. The delay for each truck percentage is the weighted average of the delay measured from all signalized intersections. The introduction of a lane use restriction for trucks slightly reduces intersection delay when compared to the "no restriction" scenario. However, the results do not give a clear indication of which lane trucks should be restricted to in order to obtain a significant reduction in intersection delay. Regardless of the restriction scenario, the results in Table 5.5 show that intersection delay increases with the increase in truck percentage. In addition, it is noteworthy that the results of a restriction to the right lanes or to the left lanes present effects on four roadways out of the 22 roadways in the network. However, restriction to the center lane presents effects on only two roadways out of 22 roadways in the network. Thus, effects of restriction in reducing intersection delay might have been higher if more roadways had truck lane restriction within the network.

Table 5.5: Network intersection delay

Truck Percentage	Delay in Seconds			
	No restriction	Trucks use right lane	Trucks use left lane	Trucks use center lane
0%	47.3	39.1	36.9	37.3
5%	41.1	40.0	39.8	39.7
10%	42.9	41.5	41.9	41.9
15%	44.5	43.4	43.5	43.5
20%	46.4	45.4	45.3	45.6
25%	47.4	47.1	47.2	46.8
30%	48.9	48.4	48.2	48.5
35%	50.1	49.6	49.7	49.8
40%	51.7	51.2	51.13	50.7

5.1.4 Total Stopped Delay

Total stopped delay is another VISSIM intersection output that was used to analyze the influence of a truck lane restriction on intersection operations. The stopped delay data were aggregated to measure the influence of a truck lane restriction on roadway intersection performance. The results in Table 5.6 show similar trends to the delay results discussed earlier. There is no clear indication of which scenario is better in reducing total stopped delay at an intersection. The results in Table 5.6 show that generally restricting trucks to the right lane only minimizes total stopped delay at higher truck percentages than at lower truck percentages. Since delay is a measure of congestion (31), restricting trucks to the right lane may be beneficial only on congested intersections.

Table 5.6: Corridor intersection total stopped delay

Truck Percentage	Total Stopped Delay in seconds			
	No Restriction	Trucks use right lane	Trucks use left lane	Trucks use center lane
0%	29.6	31.2	29.6	29.6
5%	30.8	32.3	31.1	31.1
10%	32.6	33.3	33.0	32.8
15%	34.4	34.9	34.8	34.8
20%	36.5	37.0	37.6	37.2
25%	38.6	39.1	39.8	39.6
30%	41.6	41.5	43.6	42.5
35%	44.1	43.1	46.6	45.1
40%	45.8	44.8	47.8	47.3

The results of the intersection total stopped delay for the network had similar trends to those recorded in the corridor analysis. The results in Table 5.7 suggest that none of the analyzed scenarios seem to be better in reducing intersection total stopped delay. A closer look of the results in Table 5.7 indicates that there is an increase in total stopped delay with the increase in truck percentage regardless of the scenario being considered. Further analysis of individual intersections on roadways with truck lane restriction and roadways without truck lane restriction revealed no clear pattern in the difference between recorded total stopped delays. This can be explained by the fact that once a vehicle changes a route it is not necessary for the vehicle to use the nearby roadway over the shortest route. Thus, intersections on the new shortest route will be affected more than the intersections on restricted roadways or abutting roadways.

Table 5.7: Network intersection total stopped delay

Truck Percentage	Total Stopped Delay in Seconds			
	No restriction	Trucks use right lane	Trucks use left lane	Trucks use center lane
0%	33.0	26. 5	24.9	25.2
5%	27.8	27.0	26.8	26.7
10%	28.9	27.8	28.0	28.1
15%	29.9	29.0	29.0	29.1
20%	31.0	30.3	30.1	30.4
25%	31.5	31.3	31.2	31.0
30%	32. 5	32.0	31.8	32.0
35%	33.2	32.7	32.7	32.9
40%	34.1	33. 8	33.6	33.3

5.1.5 Queue Length

VISSIM groups the results of the intersection analysis by turning movements. Also, VISSIM gives the average queue length of all analyzed intersections. The analysis reported herein used the average queue length, as well as, the individual intersections' queue lengths. For both the network and the SR 70 corridor, ten simulation runs were performed using various random number seeds. Therefore, the SR 70 and network queue length results presented in Table 5.8 and Table 5.9 respectively are the weighted average of the ten simulation runs. The results show that the average queue length is slightly higher for the existing conditions (no restriction) than queue length associated with trucks being restricted to the right lane only. Restricting trucks to the center lane or left lane increases queue length more than the "no restriction" scenario at higher truck percentages of about 20 percent or higher. However, it can be observed in Table 5.8 that as the percentage of trucks increases, intersection queue length increases under all scenarios. However, these differences were not statistically significant.

Table 5.8: Corridor intersection queue length

Truck Percentage	Queue Length in Feet			
	No Restriction	Trucks use right lane	Trunks use left lane	Trucks use center lane
0%	139.7	138.6	139.8	140.0
5%	150.8	148. 7	150.8	150.4
10%	160.1	156.1	160.1	160. 6
15%	169.3	164.5	169.3	172.4
20%	185.7	175.1	185.7	186.1

Truck Percentage	Queue Length in Feet			
	No Restriction	Trucks use right lane	Trunks use left lane	Trucks use center lane
25%	203.2	185.8	203.2	204.5
30%	232.3	200.8	232.3	232.8
35%	254.8	213. 9	254.8	255.0
40%	269.4	226.1	269.4	267.3

Table 5.9 presents the weighted average queue length of all intersection in the simulated network. These average queue length results have similar trends to those of the corridor analysis presented above. The effects of truck lane restriction on the four roadways in the network that had a restriction still indicate that restricting trucks to the right lane only reduces queue lengths at intersections. Further analysis of individual intersections in the network revealed no clear pattern of average intersection queue length among different simulation scenarios.

Table 5.9: Network intersection queue length

Truck Percentage	Queue Length in Feet			
	No restriction	Trucks use right lane	Trucks use left lane	Trucks use center lane
0%	110.3	97.3	93.3	93.5
5%	99.4	96.5	97.2	96.8
10%	101.9	98.7	100.7	100.0
15%	104.6	101.9	103.1	102.3
20%	107.6	104.6	106.1	105.8
25%	109.2	108.3	109.2	108. 7
30%	111.5	110.6	111.3	111.3
35%	113.9	113.3	114.0	113.7
40%	116.7	115. 6	116.8	115.6

5.2 Effect of Restriction on Safety

As mentioned in Chapter Four, the frequency that drivers change lanes and the differential speed were used as surrogate safety measures as was mentioned in Chapter Four. These same safety measures were used for both the SR 70 corridor analysis and the network level analysis. Data on the number of lane changes were collected for all vehicle types whereas differential speed was collected as the speed difference between the two vehicle types and among lanes. Each safety measure is discussed in detail in the following sections.

5.2.1 Number of Lane Changes

Number of lane changes, or lane change frequency, was used as a surrogate measure of safety in this study. The results in Table 5.10 show that restricting trucks to the right lane reduces the frequency of drivers changing lanes thus reducing their exposure to a crash occurrence. Restricting trucks to the left lane and to the center lane increases the number of lane changes when compared to "no restriction". These results suggest that the probability of a crash occurrence is elevated when a left and center lane restriction is used as a truck management strategy on an arterial street. However, in all scenarios the number of lane changes decreases with the increase in truck percentage. Therefore, since the number of lane changes is a good indicator of the potential for vehicular conflicts that could result in traffic crashes, the reduction in the number of lane changes at high percent of trucks may suggest that traffic crashes are less likely to occur under congested conditions with high truck percentages. Similar results were found in the review of literature (2, 11).

Table 5.10: Number of lane changes on SR 70

Truck Percentage	Number of Lane Changes			
	No Restriction	Trucks use right lane	Trucks use left lane	Trucks use center lane
0%	47726	44230	48904	49177
5%	50831	47345	52820	52835
10%	53804	49345	54552	54643
15%	55521	51223	56337	55565
20%	56863	52693	57183	56917
25%	57765	52550	58386	57628
30%	57107	53229	58548	57928
35%	56544	53649	57669	57311
40%	56446	52997	57448	56931

Data analysis at the network level revealed that the number of lane changes decreases with the increase in truck traffic volume regardless of the scenario in effect. A closer look at the results in Table 5.11 indicates that restricting trucks to the center lane or the left lane increases the number of lane changes more than when restriction is to the right lane or when there is no restriction. It can thus be surmised from the results displayed in Table 5.11 that restriction of trucks to the right lane or going with "no restriction" seem to be better options.

Table 5.11: Network number of lane changes

Truck Percentage	Number of Lane Changes			
	No restriction	Trucks use right lane only	Trucks use left lane only	Trucks use center lane only
0%	290207	290864	296110	292396
5%	283621	283168	287141	288079
10%	276508	275516	279828	278313
15%	271060	273151	273100	273888
20%	264325	267483	265730	266057
25%	256933	258077	263878	258495
30%	253235	250441	255152	253985
35%	246568	244217	247651	248106
40%	241451	242096	241810	240740

5.2.2 Speed Differences Among Vehicles and Lanes

Speed differences among vehicles and lanes were used as safety surrogate measures. Table 5.12 presents the speed difference among vehicles resulting from each scenario. The speed difference among vehicles is statistically significant with or without truck lane restriction at an alpha value of 0.05. Moreover, a speed difference among vehicles within the same lane on roadways without a truck lane restriction was significant indicating some vehicles were traveling at higher speeds than other vehicles. However, the difference in speed among vehicle types in the same lane on roadways with truck lane restriction was statistically significant. This fact indicates that the theoretical safety benefits resulting from reduced lane change frequency might be outweighed with increased speed differential between cars and trucks.

Table 5.12: Speed difference among vehicles on SR 70

Truck Percentage	Speed Difference (in miles per hour)					
	No Restriction			Trucks use right lane		
	lane 1	lane 2	lane 3	lane 1	lane 2	lane 3
0%	34.0	33.6	33.3	34.0	33.5	35.5
5%	4.4	3.8	4.1	4.8	4.4	6.5
10%	4.0	4.2	4.0	4.3	5.0	7.1
15%	3.9	3.9	4.0	5.0	5.3	7.2
20%	4.2	4.0	3.6	4.8	4.8	6.8
25%	4.1	4.1	3.8	5.7	5.5	7.1
30%	3.8	3.8	3.3	4.9	4.9	6.5
35%	3.7	3.9	3.3	5.5	4.9	5.6

Truck Percentage	Speed Difference (in miles per hour)					
	No Restriction			Trucks use right lane		
	lane 1	lane 2	lane 3	lane 1	lane 2	lane 3
40%	3.6	3.5	3.3	4.1	4.5	5.5
Truck Percentage	Trucks use left lane			Trucks use center lane		
	lane 1	lane 2	lane 3	lane 1	lane 2	lane 3
0%	34.0	33.5	33.3	34.1	33.5	33.4
5%	6.1	4.2	3.9	5.9	4.1	5.7
10%	5.3	4.1	4.2	4.5	4.3	5.2
15%	5.5	4.7	4.1	5.0	3.8	4.6
20%	5.5	4.6	3.8	4.8	4.5	5.0
25%	5.2	4.5	4.1	4.8	4.3	5.1
30%	5.0	4.2	4.0	4.5	4.2	4.3
35%	4.5	4.0	3.8	4.9	4.2	4.0
40%	4.9	4.0	3.6	4.2	4.0	4.2

Speed difference among vehicle types for the network seems to increase with the imposition of a truck lane restriction more so than without a truck lane restriction as Table 5.13 indicates. Furthermore, the differential speed increases with an increase in truck traffic volume. Thus, imposition of truck lane restriction increases vehicle interaction which in turn increases the probability of crash occurrence.

Table 5.13: Speed difference among vehicles on the network

Speed Difference Within the Lane in miles per hour						
Truck Percentage	No restriction			Trucks use right lane only		
	lane 1	lane 2	lane 3	lane 1	lane 2	lane 3
0%	32.6	33.3	32.8	32.7	33.3	32.5
5%	0.8	0.9	-1.1	1.2	3.4	11.2
10%	0.4	1.0	0.3	0.6	3.7	10.8
15%	0.5	1.0	0.4	1.2	3.4	11.1
20%	0.8	0.7	0.9	1.6	4.3	9.5
25%	0.3	1.2	1.2	1.0	4.9	10.8
30%	0.4	0.5	0.1	1.9	4.6	10.7
35%	1.0	0.7	1.0	1.8	5.0	10.4
40%	1.1	0.8	0.9	1.9	5.3	10.2

Truck Percentage	Trucks use left lane only			Trucks use center lane		
	lane 1	lane 2	lane 3	lane 1	lane 2	lane 3
0%	32.6	33.2	31.7	31.1	31.1	23.3
5%	2.0	1.6	1.6	-1.3	0.6	-1.5
10%	2.6	2.6	1.1	0.1	0.0	2.1
15%	3.1	2.7	2.1	1.0	-0.6	1.7
20%	2.4	2.6	2.1	0.8	-0.1	1.8
25%	3.2	2.7	1.5	0.2	-0.1	0.0
30%	2.8	2.5	2.5	1.1	-0.7	0.9
35%	3.2	2.9	2.7	0.4	0.1	0.8
40%	3.5	2.6	3.1	0.4	0.2	0.4

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this research was to evaluate the efficacy of truck lane restriction on non-limited access highways, particularly on urban arterial streets. The desire to restrict trucks from using certain lanes on surface streets is predicated on the ubiquity of such restrictions on limited access highways. It is hypothesized that extending such restrictions on non-limited access highways will result in safety and operational benefits. Given that the literature search did not reveal any study proving or disapproving this and related hypotheses, the research reported herein evaluated operational and safety implications resulting from truck lane restriction on non-limited access highways. VISSIM simulation software was used in the evaluation following a field review which showed a lack of sufficient roadway sections with a truck lane restriction on which to collect data and conduct a comprehensive analysis.

The corridor selected for study was SR 70 running through the City of Fort Pierce in Florida. A 5-mile section located between US 1 to the east and Florida's Turnpike to the west was coded in VISSIM. This section has two to three travel lanes of travel in each direction separated by a raised median. It has a speed limit of 45 mph which was considered a suitable representative corridor as it has an average of 30,000 vehicles per day with a large number of trucks on weekdays, i.e., approximately 20 percent of AADT.

To analyze the area-wide effect of a truck lane restriction, a hypothetical network was simulated. The network was coded with various urban and suburban characteristics including 100 roadway sections with lengths ranging from 1/8-mile to 2 miles. The network had a total of 121 signalized intersections and more than 50 unsignalized intersections to represent typical urban and suburban geometric characteristics. To further represent an urban roadway configuration, three roadway types were specified: one way streets, two-way streets with two travel lanes per direction, and two-way streets with three travel lanes per direction.

Consistent with the literature review which showed that trucks can be restricted to the left or to the right lanes, four simulation scenarios were identified and analyzed in both corridor and network setups. The no restriction scenario that currently exists on SR 70 and three alternative restriction scenarios were built into a VISSIM simulation model. Three restriction scenarios were simulated -- restriction to the right, center, and left lane in the 3-lane section of SR 70. Review of traffic data provided by FDOT revealed that the noon peak period had higher traffic compared to the morning and evening peak periods; hence, all simulation scenarios were analyzed based on noon traffic volumes.

6.1 State Route 70 Corridor Analysis Conclusions

The analysis of operational measures resulting from the simulation indicated that restricting trucks to the right lane reduced travel time when compared to the existing scenario of no restriction. The savings in travel time were found to be statistically significant. The results showed that the average travel speed of passenger cars increased when trucks were restricted to the right lane. The average truck travel speeds decreased following the restriction but statistical analysis showed that the decrease was not significant.

The results further showed that restricting trucks to the center lane and to the left lane diminished roadway operational performance as revealed by various VISSIM simulation outputs. These two restriction scenarios were associated with increased travel time, delay, and reduce travel speed for both passenger cars and trucks. The results showed that restricting trucks to the left lane had the most undesirable results given that on a divided roadway with a median. Trucks tended to access driveways located on the right through the right lane thus they had to change lanes frequently to access these driveways.

Furthermore, analysis of individual intersection performance measures indicated similar trends in which restricting trucks to the right lane reduced queue lengths at these intersections. Interestingly, reduction in queue lengths was more pronounced as the truck percentage was varied higher in the simulation. At low truck percentages, up to 25 percent, there was no improvement in intersection stopped delay when restriction to the right was compared to no restriction at all. Similar to section analysis, restricting trucks to the center lane or to the left lane resulted in a degraded intersection performance as revealed by increased queue lengths, stopped delay, and overall delay for all vehicles.

Speed differential among vehicles and the frequency of lane changes were considered as surrogate measures of safety related to a truck lane restriction. The results showed that the number of lane changes decreased when trucks were restricted to the right lane compared to no restriction at all. This signifies there might be safety benefits associated with restricting trucks to the right lane on 6-lane divided urban non-limited access roadways. The speed difference between trucks and passenger cars was somewhat higher when trucks were restricted to the right lane more so than with any other scenario. The general conclusion that can be made is that restricting trucks to the center or left lane exacerbates traffic operations and safety problems whereas restricting trucks to the right lane has some measurable advantages.

6.2 Network Simulation Conclusions

The network simulation results mirrored corridor simulation results in that restricting trucks to the right lane improved intersection performance by reducing queue lengths and total stopped delay. However, when the results were disaggregated to individual roadway segments, the analysis revealed no clear travel time pattern on both roadways with restriction and without restriction. This might be attributed to the route choice parameter that was specified in the dynamic traffic assignment modeling. The network results further showed the average speed of trucks decreased with the imposition of a truck lane restriction; the decrease was especially pronounced at high truck traffic volumes, i.e., over 25 percent of AADT.

Similar to corridor analysis, surrogate measures of safety in the network simulation revealed a reduction in the number of lane changes when trucks were restricted to the right lane but an increase in the number of lane changes was noted when trucks were restricted to the left lane or center lane compared to the base simulation scenario of no restriction. However, this gain in surrogate measure of safety is counterbalanced by the increase in differential speed between cars and trucks, as well as, differential speeds among the travel lanes. Closer analysis of the results showed that differential speed between vehicles and among lanes for the no restriction scenario was lower than any of the other three restriction scenarios.

6.3 Recommendations

The simulation analysis of truck lane restriction on non-limited access roadways revealed some interesting points. First, implementing truck lane restrictions on roadways with only two through lanes in each direction and where bottlenecks exist is relatively infeasible. It is recommended that truck lane restrictions in such situations be avoided. This recommendation is based on the simulation results observed during simulation animation indicating that areas with lane drops and shorter spaced intersections experienced excessive vehicle queues that lowered travel speeds appreciably.

The results of both corridor and network simulation revealed some operational and safety advantages associated with trucks being restricted to the right lane. These results apply to sparsely spaced driveways and on urban roadways with frontage roads where driveway entrance or exit is not directly from the right lane where trucks are restricted. In addition, spacing of signalized intersections is crucial and must be carefully evaluated in the field. In areas with signalized intersections spaced closer than 1/8-mile, a truck lane restriction to the right lane might not be feasible since trucks may not have sufficient roadway length required to safely execute a lane change.

Implementation of truck lane restrictions on arterial streets would also required careful consideration of the design and placement of signs related to the restriction. Highly urbanized roadways are already clogged with signs placed on the shoulder and medians; thus, adding more signage on these roadways could be problematic. The success of enforcement of truck lane restrictions on arterial streets will depend on careful design and placement of signs warning drivers of the existing restriction and informing truckers of the release distances in the vicinity of the intersections. Therefore, it is recommended that a comprehensive analysis of sign-related issues should be conducted prior to the implementation of a truck lane restriction on an arterial streets.

It is further recommended that the restriction of trucks to the left or center lane of arterial streets should not be considered for implementation. The results arising from the simulation of these scenarios clearly indicated that such restrictions will have deleterious effects on safety and operational wellbeing of the streets. Although it might be argued that these simulation results were not backed by field validation, it is not a stretch to foretell the negative consequences that might result from implementing left or center lane restriction based on the fact that on divided roadways, driveways are located on the right and trucks will need to be in the right lane to access these driveways or side streets.

The analysis of the truck lane restriction at a network level can be improved by coding a real existing network with its prevailing traffic and signalization data. Both congested and un-congested flow conditions can be simulated to determine whether truck lane restriction should be time-based—that is, restricting trucks during particular times such as peak commuting periods. Given that in a typical metropolitan area some routes are designated as truck routes, further study should be conducted to determine the number of roadways that should have either a truck lane restriction or a total restriction of trucks.

APPENDIX A: Types of Commodities Shipped In U.S

TABLE A.1: Value, Tons, and Ton-Miles of Freight Shipments within the United States by Domestic Establishments, 2002[P0]

SCTG		Value ($billions)	Percent	Tons (millions)	Percent	Ton-miles[b] (billions)	Percent	Value per ton ($)	Average miles per shipment
01	Live animals and live fish	7.2	0.1	6.5	0.1	2.0	0.1	1,099	534
02	Cereal grains	55.9	0.7	578.6	5.0	263.7	8.2	97	125
03	Other agricultural products	129.9	1.5	277.5	2.4	122.1	3.8	468	477
04	Animal feed and products of animal origin (NEC)	55.3	0.7	240.0	2.1	77.5	2.4	230	141
05	Meat, fish, seafood, and their preparations	204.9	2.4	85.0	0.7	41.8	1.3	2,410	192
06	Milled grain products, preparations, and bakery products	119.7	1.4	116.0	1.0	51.4	1.6	1,032	265
07	Other prepared foodstuffs and fats and oils	362.3	4.3	463.4	4.0	171.2	5.3	782	206
08	Alcoholic beverages	115.8	1.4	93.7	0.8	25.6	0.8	1,236	56
09	Tobacco products	77.2	0.9	5.8	0.1	1.3	0.0	13,320	414
10	Monumental or building stone	2.5	0.0	16.9	0.1	1.3	0.0	145	170
11	Natural sands	4.6	0.1	466.3	4.0	34.0	1.1	10	57
12	Gravel and crushed stone	12.6	0.1	1,775.2	15.3	104.6	3.3	7	33

TABLE A.1 Continue									
SCTG		**Value ($billions)**	**Percent**	**Tons (millions)**	**Percent**	**Ton-miles[b] (billions)**	**Percent**	**Value per ton ($)**	**Average miles per shipment**
13	Nonmetallic minerals (NEC)	12.7	0.1	186.3	1.6	57.0	1.8	68	214
14	Metallic ores and concentrates	15.7	0.2	116.1	1.0	59.4	1.9	136	465
15	Coal	24.1	0.3	1,255.1	10.8	562.5	17.6	19	112
17	Gasoline and aviation turbine fuel	233.6	2.8	840.4	7.3	130.2	4.1	278	103
18	Fuel oils	109.6	1.3	507.5	4.4	108.9	3.4	216	81
19	Coal and petroleum products (NEC)	74.7	0.9	431.3	3.7	96.0	3.0	173	125
20	Basic chemicals	152.1	1.8	497.0	4.3	173.9	5.4	306	516
21	Pharmaceutical products	426.8	5.0	22.8	0.2	12.1	0.4	18,697	722
22	Fertilizers	34.1	0.4	214.2	1.9	74.4	2.3	159	150
23	Chemical products and preparations (NEC)	234.4	2.8	109.8	0.9	54.8	1.7	2,134	409
24	Plastics and rubber	343.4	4.0	147.0	1.3	83.9	2.6	2,335	430
25	Logs and other wood in the rough	5.2	0.1	86.3	0.7	8.9	0.3	60	108
26	Wood products	140.0	1.7	321.1	2.8	114.0	3.6	436	250
27	Pulp, newsprint, paper, and paperboard	102.4	1.2	139.9	1.2	82.6	2.6	732	233

TABLE A.1 Continued									
SCTG		**Value ($billions)**	**Percent**	**Tons (millions)**	**Percent**	**Ton-miles[b] (billions)**	**Percent**	**Value per ton ($)**	**Average miles per shipment**
28	Paper or paperboard articles	105.9	1.2	72.5	0.6	25.5	0.8	1,460	282
29	Printed products	136.9	1.6	34.4	0.3	17.4	0.5	3,977	903
30	Textiles, leather, and articles of textiles or leather	507.0	6.0	53.3	0.5	34.6	1.1	9,511	967
31	Nonmetallic mineral products	143.1	1.7	910.3	7.9	120.3	3.8	157	388
32	Base metal in primary or semi-finished forms and in finished basic shapes	253.7	3.0	326.0	2.8	121.6	3.8	778	275
33	Articles of base metal	234.9	2.8	115.7	1.0	44.4	1.4	2,031	396
34	Machinery	509.5	6.0	62.9	0.5	34.7	1.1	8,094	413
35	Electronic and other electrical equipment and components and office equipment	948.0	11.2	53.8	0.5	32.9	1.0	17,625	747
36	Motorized and other vehicles (including parts)	735.7	8.7	133.7	1.2	59.1	1.8	5,504	401
37	Transportation equipment (NEC)	163.0	1.9	10.3	0.1	6.2	0.2	15,871	1,003
38	Precision instruments and apparatus	222.0	2.6	15.2	0.1	3.4	0.1	14,600	986

TABLE A.1 Continued									
SCTG		**Value ($billions)**	**Percent**	**Tons (millions)**	**Percent**	**Ton-miles[b] (billions)**	**Percent**	**Value per ton ($)**	**Average miles per shipment**
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs	135.0	1.6	30.9	0.3	13.3	0.4	4,373	564
40	Miscellaneous manufactured products	404.7	4.8	90.6	0.8	37.1	1.2	4,467	1,003
41	Waste and scrap	49.3	0.6	305.6	2.6	71.1	2.2	161	163
43	Mixed freight	858.3	10.1	332.2	2.9	57.8	1.8	2,584	434
	Commodity unknown	19.6	0.2	25.5	0.2	10.1	0.3	769	585
	All commodities[a]	**8,483.1**	**100.0**	**11,572.8**	**100.0**	**3,204.4**	**100.0**	**733**	**589**

KEY: NEC = not elsewhere classified; P = preliminary; SCTG = Standard Classification of Transported Goods.

[a] Estimates exclude shipments of crude petroleum (SCTG 16).

[b] Ton-miles estimates are based on estimated distances traveled along a modeled transportation network.

NOTE

Estimates are preliminary and may be revised. Coverage for the 2002 Commodity Flow Survey (CFS) differs from previous surveys due to a change from the 1987 Standard Industrial Classification system to the 1997 North American Industry Classification System and other survey improvements. Therefore, data users are urged to use caution when comparing 2002 CFS estimates with estimates from prior years. Final 2002 CFS available January 2005.

SOURCE

U.S. Department of Transportation, Bureau of Transportation Statistics, U.S. Department of Commerce, Census Bureau, *2002 Commodity Flow Survey: United States (Preliminary)* (Washington, DC: December 2003), table 3a.

APPENDIX B: Survey Questionnaires

Questionnaire: Survey on Truck Lane Restriction on Arterial Streets

The Florida Department of Transportation (FDOT) is interested to learn from your state the efficacy of restricting trucks on multilane arterial streets in urban and rural areas. Truck lane restrictions are very common on interstate freeways and frequently FDOT has to respond to local agencies requesting the practice be extended to multilane surface streets in their localities. We would like you to answer the following questions to assist FDOT in developing a uniform statewide policy on this issue.

1. Does your agency have a policy on truck lane restriction on arterial streets?

☐ **Yes**
☐ **No**

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2. If yes, please provide email and/or phone number of the person we should contact to discuss this issue in more detail.

3.Are you aware of the existence of truck lane restriction on arterial streets on any roadways other than state-maintained roads in your state?

☐ **Yes** ☐ **No**

4.If yes, we will appreciate if you provide the names of the cities or counties that we should contact.

---

5. Whether or not arterial streets truck lane restriction is practiced in your state, what is your opinion on this issue?

6. Please provide us with your name, title, and contact information.

Name:

Title:

Contact Info.:

Submit

Detailed Questionnaire: Survey on Truck Lane Restriction on Arterial Streets

The Florida Department of Transportation (FDOT) is interested to learn from your state the efficacy of restricting trucks on multilane arterial streets in urban and rural areas. Truck lane restrictions are very common on interstate freeways and frequently FDOT has to respond to local agencies requesting the practice be extended to multilane surface streets in their localities. We would like you to answer the following questions to assist FDOT in developing a uniform statewide policy on this issue.

1. Does your agency have a policy on truck lane restriction on arterial streets? **Yes** **No**

2. What kind of trucks are targeted by the lane restriction?

- Tractor trailers only
- Tractor trailers and all other vehicles pulling trailers
- All trucks
- Other (explain)

3. How widespread is truck lane restriction on arterial streets in your city or county?
Approximately how many corridors are you aware of?

4. Do you know if engineering studies were conducted prior to implementing truck restriction on some of these arterial street corridors? **Yes** **No**

5. In your opinion, what do you think were the likely reasons for imposing the truck lane restrictions?

- To improve safety **Yes** **No**
- To improve traffic operations **Yes** **No**
- Other reasons (explain)

6. Generally, which lane or lanes are trucks supposed not to use? Left lane Right lane

7. Besides your city or county, are you aware of any other streets with truck lane restriction your state?
Yes **No**

8. If yes, we will appreciate if you provide the names of the cities or counties that we should contact.

Please provide us with your name, title, and contact information.

Name:	
Title:	
Contact Info.:	

Submit

We appreciate you time and help on this matter. If you have additional information, documents, photographs, etc.

APPENDIX C: Questionnaire Responses

TABLE 3.1: General Questionnaire Responses

State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Alabama (Dothan city)	Charles E. Metzger	cemetzger@dothan.org	No	Yes	There is restriction on Ross Clark circle (R.C.C) road (14.4miles).no tickets have been written in regards to the restriction signage. The signs may be helping on the east side of the R.C.C where traffic is lighter.
Alaska	Kurtis J Smith	Kurt_smith@dot.state.ak.us	No	No	Truck lane restrictions that keep the left lanes clear of truck traffic are helpful.
Arizona	Mike Manthey	mmanthey@azdot.gov	No	No	No opinion
Arkansas	Tony Sullivan Staff Traffic Engineer	Tony.sullivan@arkansashighways.co.us	No	No	No opinion
California (san Diego)	SAM	by phone 619-533-3198	No	No	They have truck route restriction

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Colorado	Dwayne Wilkinson PEII -	Dwayne.Wilkinson@dot.state.co.us	No	Yes	-The cities and counties by state statute decide on restrictions on their facilities. CDOT has jurisdiction on state highways. If a city or county wants to make a restriction on a state highway facility it must be approved by CDOT as per the state statutes. If it is not a state highway, CDOT would not need to approve. - The state highways are designed to carry truck traffic thus there is typically no restriction on this traffic on these facilities. This would be the case even if the facility is functioning as an arterial.
Georgia	Carla W. Holmes	Carla.holmes@dot.state.ga.us	No	No	I think it would be difficult to restrict trucks to certain lanes on arterials since trucks need access to properties on both sides of the roadway, and for right and left turns, and thus may need to be in any lane at any time. Compliance and enforcement would be very difficult. Also, since there is much more signage on arterials already, the presence of more signage for this purpose could be problematic
Illinois Naperville	Steve Cope	copes@naperville.il.us	No	No	I'm proponent.

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Indiana	Carl T. Tuttle	ctuttle@indot.in.us	No	No	We do have TRUCK LANE restrictions on a few locations on the State Highway system. At these locations, the truck lane restrictions are necessary for the progression of the majority of traffic. They work well because the local police enforce the restrictions pretty rigorously.
Idaho	Pat Williams	Pat.williams@itd.idaho.gov	No	No	No opinion
Iowa	Timothy D. Crouch	tcrouch@dot.state.ia.us	No	No	The use of lane restrictions should be kept to a minimum. They should only be used when there is a safety concern or other engineering reasons for the restriction
Kansas	David A. Church P E	church@ksdot.org	No	No	There are a number of communities that have designated "truck routes" for drivers so that trucks are not traveling through the heart of their cities. Feel free to contact the cities of Leavenworth, El Dorado, Garden City, Dodge City and there are probably others. I think that trucks need to be given "reasonable access" to the use of roadways to move goods and services. However, if there are width / weight limitations or there is a safety issue, a truck route should be designated.
Louisiana	Charles Adams	By phone	No	No	No opinion

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Maine	Bruce ibarguen	Bruce.ibarguen@maine.gov	No	No	Maine does not have traffic volumes or highway density to require this approach. Therefore, I have no experience on which to base an opinion.
Maryland	Tom Hicks	thicks@sha.state.md.us	No	No	- OK for steep hills — Trucks generally need the use of all lanes — OK for roadways structural reasons — OK to avoid bikes or low tree limbs — OK for where specific safety reasons suggest such restrictions
Mississippi	Wes Dean	wdean@mdot.state.ms.us	No	No	I don't have an opinion on it at this time. We just haven't had to address this issue in Mississippi
Missouri	John Schaefer	john.schaeferjr@modot.mo.gov	No	No	-Although I do not know of any restrictions, you may call the City of St. Louis. I do not have any contact information for them. -This is my personal opinion and may not represent the state or Missouri DOT. It may be practical to restrict trucks based on height/width/length/weight restrictions on certain routes.
Montana	Duane Williams	duwilliams@mt.gov	No	No	There may be times when it would be good to restrict trucks to one lane. For example, on an arterial with double lane roundabouts where the inside lane does not accommodate the turning path.

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Nebraska	Randall D. Peters	rpeters@dor.state.ne.us	No	No	It is often a challenge to sign the regulatory restrictions effectively.
Nevada	Scott L. Thorson	sthorson@dot.state.nv.us	No	No	I don't think that lane restrictions on Arterials would work very well. Especially if there are a lot of cross streets. Vehicles want to preposition early for making turns off of the arterial. We have restricted trucks to certain lanes on freeways though
New hemisphere	William Lambert	wlambert@dot.state.nh.us	No	No	Truck traffic is a given means of delivering goods in a market oriented society. Lane restrictions on truck traffic can lead to congestion in lanes allowing trucks, with available capacity in adjacent, truck restricted lanes. From observation, that can lead to unnecessary lane shifts by motorists forced (or encouraged?) to move over by the trucker behind them.
North Carolina	Ken Ivey, P.E.	kwivey@dot.state.nc.us	No	No	It would be difficult to enforce due to turning movements, entering traffic, etc. I would question the benefits of truck lane restrictions for arterial streets
North Dakota	Allan L.Covlin	acolvlin@state.nd.us	No	No	A restriction may be difficult to enforce along a corridor with numerous accesses.
Ohio	Dave Holstein	Dave.hilstein@dot.state.oh.us	No	No	I am unaware of this practice anywhere in Ohio. About the only thing close would be bus only lanes.

TABLE C.1Continued

State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Ohio Cleveland City	Andrew R. Cross	across@city.cleveland.oh.us	Yes	Yes	This issue is probably more political than engineering in nature. People tend to request truck restrictions on major arterials in Cleveland more often than you would expect (even on designated truck routes). I believe that truck restrictions are over used.
Oklahoma	Harold Smart	hsmart@odot.org	No	No	Not in place even on freeways because of deterioration
Oregon	Edward L. Fischer P.E	Ed.l.fischer@odot.state.or.us	No	No	Compliance and enforcement issues will probably make it difficult to realize benefits. If the purpose is to prevent pavement damage a total ban on trucks from certain streets may be better. If the purpose is one of traffic efficiency, the benefits may not actually accrue.
Pennsylvania	Kenneth F. Williams		No	No	Truck lane restrictions are a useful application when justified by a properly conducted study. Local input is very important.
Rhode island	Robert RocchioP.E	brocchio@dot.state.ri.us	No	No	I would need to see it in practice prior to having an opinion.
South Carolina	Richard B. Werts	wertsrb@dot.state.sc.us	No	No	No opinion
South Dakota	John Adler	John.adler@state.sd.us	No	No	If done, there should be good justification for it. I'm not sure what that would be. Large trucks cause obstructions to the view for other drivers no matter which lane they are located within.

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Tennessee	Michael L. Tugwell	Mike.tugwell@state.tn.us	No	No	Seems impractical and creates much stopping and starting due to right turn traffic
Texas	Margaret A. Moore	mmoore1@dot.state.tx.us	No	No	We do not believe restrictions should be established on non-controlled access roadways.
Vermont	Amy L. Gamble, PE	amy.gamble@state.vt.us	No	No	Vermont has very few multi-lane arterial streets, and none with more than two through lanes per direction. All of our interstates are 4 lanes (2 each direction.) Truck lane restriction would not be practical.
Virginia	Michael D. Nichols	Michael.nichols@vdot.virginia.org	No	No	We have generally not been in favor of restricting trucks to specific lanes on arterial streets due to the potential disruptions to traffic flow as trucks are usually serving businesses situated on both sides of the roadway.
Virginia (Richmond District)	Travis Bridewell	Travis.bridewell@vdot.virginia.gov	Yes	No	As long as this need is documented via a traffic engineering investigation including measuring the possible impacts on restricting trucks and the state law allows the restriction I am fine with restrictions on non-arterial streets.
Virginia (Hampton District)	Andrew McLaughlin	Andrew.mclaughlin@vdot.virginia.gov	No	No	I am in agreement with truck lane restrictions on arterial streets.

Table C.1 Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Virginia (Bristol District)	Ronnie Mack Hubble	Ronnie.hubble@vdot.virginia.gov	No	No	I believe that separating truck and passenger vehicles will become an even hotter safety issue and the practice of truck lane restrictions will migrate. My opinion is that in some situations that will be a justified solution.
Washington State(Seattle City)	Wayne Wentz		No	No	No opinion
	Eric Widstrand	eric.widstrand@seattle.gov	No	Yes	-There are spot locations where trucks are restricted to the curb lane due to weight limits on bridges - There is safety and operational reasons why it makes sense to restrict truck usage in some instances.
Washington DC	William McGuirk	william.mcguirk@dc.gov	No	No	I suppose they would be beneficial on lanes with height restrictions or substandard pavement conditions. Washington, DC has never given much thought to this specific issue. We would be interested in knowing more about the subject and its potential applicability.
	Douglas E. Noble	Douglas.noble@dc.gov	No	No	Where appropriate due to clearance or pavement structure conditions it could be applicable. Most truck routes in our jurisdiction are also city bus routes so a lane restriction really doesn't make sense for us. We would look at restricting the entire street if appropriate.

TABLE C.1Continued

State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Washington State	Theodore Trepanier	trepant@wsdot.wa.gov	No	Yes	There are many cities within Washington with truck restrictions on local arterials. Spokane and Seattle (cities) are samples.
West Virginia	Charles R. Lewis	rlewis@dot.state.wv.us	No	No	The only justification for such a restriction would be to overcome some geometric constraint that could not be addressed by other means. Even in such an instance, enforcement may be difficult.
Wisconsin	David I. Vieth	david.vieth@dot.state.wi.us	No	No	There may be some benefit in such a restriction for arterial streets, especially where the arterial serves longer trips. The impact of trucks on traffic flow through signalized intersections, and the longer acceleration/deceleration times does have significant impacts on traffic flow. Enforcement would be difficult, but not impossible, as use of the left lane(s) would generally be necessary for access. That would be similar to access provisions for longer commercial vehicles; enforcement would need to reach a conclusion as to whether the access need was legitimate. Another down side would be the signing needed to accomplish this restriction and the added complexity or confusion for all drivers

TABLE C.1Continued

State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Wyoming	Michael N. Gostovich	Mike.gostovich@dot.state.wy.us	No	No	❖ WYDOT does not restrict any vehicles from using any of our street system—as long as they meet height and weight criteria. However, we will allow local jurisdictions to restrict trucks if they set up a truck route and have a means of allowing delivery trucks into the restricted areas. ❖ It can be beneficial in certain situations.
Arizona, Mesa City	Alan Sanderson	alan.sanderson@cityofmesa.org	No	No	It doesn't seem appropriate or necessary on the arterial streets in our city.
Florida, City of Jacksonville	Don Fullerton	don@coj.net	No	No	I can see the use on arterials that are connections (lengthy) between developed areas (cities) where speeds would be higher. Not within metropolitan areas and shorter arterials.
Ohio, Columbus	Bill Lewis	walewis@columbus.gov	No	No	Restricting trucks to the curb lane could interfere with pedestrian and bike movements as well as parked cars and transit operations. I would willing to consider under the right circumstances. I am familiar with the I-95 truck restrictions in South Florida. Will the research results be available to the public?

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Indiana, Indianapolis	Ron Brand	rbrand@indygov.org	No	No	I can see it could help traffic flow.
Oregon, Portland	Peter Mason, PE	Peter.Mason@pdxtrans.org	No	No	It is not clear to me how restricting trucks to a particular lane would be enforced, given the need to make left turns.
Texas, Dallas	Andy Oberlander, P.E.	aoberla@dot.state.tx.us	No	No	Texas has truck lane restrictions on the highway system were trucks can be restricted from the left lane given that certain conditions apply. I support this kind of operation. My opinion is that restricting trucks on certain lanes on arterials will be a significant challenge to make operational and enforce based on restricting a truck from a lane directly impacts where trucks can turn right and left. If the restriction is on the left lane, that restriction for all practical purposes restricts trucks from turning left along that corridor. The same can be said for right lane restrictions. The same challenges are faced when trucks turn onto a facility that has lane restrictions. I would think that with the significantly large number of access points on an arterial (as compared to a control access highway) proper notification to support enforcement will be a challenge.

TABLE C.1Continued					
State	Name	e-address	Have policy	Have truck lane restriction	Opinion
Pennsylvania, Philadelphia	Louis Belmonte PE	lbelmonte@state.pa.us	No	No	It could have an application, but only on facilities at least three lanes wide (one direction) and where there are non-standard left turns (such as jug handles).
California, Oakland	Peter Chun	pfchun@oaklandnet.com	No	No	The City of Oakland is densely populated with a dense network or streets. Truckers typically avoid local streets and try to access State freeways as soon as possible. Therefore we have few roads where trucks and vehicles interact over long distances. The few arterials we have with heavy truck mix are designed to access or exit freeways by making a right turn which lends truckers to stay in the right lane during trips to and from the freeways.
Kentucky, Louisville-Jefferson	A. Dan Curtis, AICP	dan.curtis@louisvilleky.gov	No	No	I believe they can be useful
Tennessee, Memphis	Ken Johnson	ken.johnson@memphistn.gov	No	No	No real need has arisen yet on any of the areas arterials that I am aware of. Enforcement of truck restrictions on certain streets is already tough enough. Targeting enforcement of lane restrictions, I think, may even prove more difficult.

TABLE C.2: Detailed Questionnaire Responses

State	Name	e-address	Have policy	Have lane restriction	Types of trucks restricted	Have lane restriction	Opinion
California (Sacramento)	Casey Robb	casey_robb@dot.ca.gov	No	No	N/A	No	-Local truck restrictions are a local matter and is not under California DOT jurisdiction - We only know about state routes, not local roads
Delaware	Adam S. Weiser, E.I.T.	Adam.Weiser@state.de.us	No	Yes		Yes	These restrictions are applied based on engineering judgement -2 roads have restriction but not the entire corridors are restricted -Left Lane
Hawaii	Alvin Takeshita	Alvin.takeshita@hawaii.gov	No policy	No		No	Not applicable
Kentucky	Duane Thomas	Duane.thomas@ky.gov	No	No		No	No opinion
Minnesota	Bernard J. Arseneau, PE,	bernie.arseneau@dot.state.mn.us	No	No		No	No opinion

TABLE C.2 Continued							
State	Name	e-address	Have policy	Have lane restriction	Types of trucks restricted	Have lane restriction	Opinion
New Jersey	Timothy J. Szwedo	Tim.szwedo@dot.state.nj.us	Yes	Yes		Yes	In general our state motor vehicle code prohibits all trucks from using the left lane when there are 3 or more lanes in the same direction
	Douglas R. Bartlett	Douglas.bartlett@dot.state.nj.us	Yes	Yes		Yes	-all vehicles over 10,000 pounds (type of trucks restricted) -any road having 3 or more lanes in one direction - Left Lane
Puerto Rico	SAMUEL FORESTIER	sforestier@act.dtop.gov.pr	No	No		No	Restrict on left lane
Utah	Robert Hull	rhull@utah.gov	No	No		No	No opinion

APPENDIX D: Truck Lane Restriction Sites Photo’s

TABLE D.1: Photos

State	Photos
Florida (Havana City)	 

TABLE D.1 Continued	
State	**Photos**
Alabama (Dothan City)	
	

TABLE D.1 Continued	
State	**Photos**
Georgia (Stewart County)	 

APPENDIX E: State's Statutes

TABLE E.1: Statute Sections

State	Section	Section explanations
Alabama	32-5A-88	(3) Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the direction of every such device.
Alaska	13 AAC 02.085. 13 AAC 03.085.	(b) Upon a roadway which is divided into three lanes and provides for two-way movement of traffic, no vehicle may be driven in the center lane, except when overtaking and passing another vehicle traveling in the same direction when the center lane is clear of traffic for a safe distance, in preparation for making or completing a left turn, or where the center lane is at the time allocated exclusively to traffic moving in the direction that the vehicle is proceeding. (b) Upon a roadway that is divided into three lanes and provides for two-way movement of traffic, a commercial motor vehicle may not be driven in the center lane, except (3) when the center lane is allocated exclusively to traffic moving in the direction that the vehicle is proceeding.
Arizona	28-736.	A. If the department or a local authority determines on the basis of an engineering and traffic investigation of a highway under its jurisdiction that the designation of a specific lane or lanes for travel of the vehicles prescribed in subsection B of this section would facilitate the safe and orderly movement of traffic, the department or local authority may designate a specific lane or lanes for the travel of those vehicles and shall erect signs at reasonable intervals giving notice of those lanes. B. The following vehicles shall be driven in the lane or lanes designated pursuant to subsection A of this section if signs are erected giving notice of that designation:

TABLE E.1 Continued		
State	Section	Section explanations
Arizona	28-736.	1. A motor vehicle or vehicle combination with a declared gross weight of more than twenty-six thousand pounds, excluding a motor vehicle designed for carrying sixteen or more passengers, including the driver. For the purposes of this paragraph, “declared gross weight” and “vehicle combination” have the same meaning prescribed in section 28-5431. 2. A vehicle that is drawing a pole trailer that weighs six thousand or more pounds. C. This section does not apply to a driver who is preparing for a left-hand or right-hand turn, who is entering or exiting a highway or who must necessarily drive in a lane other than the designated lane to continue on the driver’s intended route.
Arkansas	27-51-302.	(2) Official signs may be erected directing slower-moving traffic to use a designated lane or allocating specified lanes to traffic moving in the same direction, and drivers of vehicles shall obey the directions of every such sign.
California	§ 4122 § 4114.	(3) Traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, and drivers of vehicles shall obey the directions of every such traffic-control device. **Driver Manual: Towing Vehicles, Buses, or Large Trucks; When you tow a vehicle or trailer, or drive a bus or three- or more axle truck, you must drive in the right-hand lane or in a lane specially marked for slower vehicles. If no lanes are marked and there are four lanes or more in your direction, you may only drive in either of the two lanes closest to the right edge of the road.**

TABLE E.1 Continued		
State	Section	Section explanations
California	21655.	(a) Whenever the Department of Transportation or local authorities with respect to highways under their respective jurisdictions determines upon the basis of an engineering and traffic investigation that the designation of a specific lane or lanes for the travel of vehicles required to travel at reduced speeds would facilitate the safe and orderly movement of traffic, the department or local authority may designate a specific lane or lanes for the travel of vehicles which are subject to the provisions of Section 22406 and shall erect signs at reasonable intervals giving notice thereof.
	22406.	No person may drive any of the following vehicles on a highway at a speed in excess of 55 miles per hour: (a) A motortruck or truck tractor having three or more axles or any motortruck or truck tractor drawing any other vehicle. (b) A passenger vehicle or bus drawing any other vehicle. (c) A schoolbus transporting any school pupil. (d) A farm labor vehicle when transporting passengers. (e) A vehicle transporting explosives. (f) A trailer bus, as defined in Section 636.
Colorado	42-4-1007	I Official traffic control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, and drivers of vehicles shall obey the directions of every such device.

TABLE E.1 Continued

State	Section	Section explanations
Connecticut	14-248-14-236	When any highway has been divided into two or more clearly marked lanes for traffic, (1) a vehicle shall be driven as nearly as practicable entirely within a single lane and shall not be moved from such lane until the driver has ascertained that such movement can be made with safety and (2) the State Traffic Commission may erect, on state highways, and local traffic authorities, in accordance with standards approved by the State Traffic Commission, may erect on highways under their jurisdiction, signs directing slow-moving traffic to use a designated lane or, with signs, signals or markings, may designate those lanes to be used by traffic moving in a particular direction regardless of the center of the highway, and drivers of vehicles shall obey the directions of each such sign, signal or marking. Violation of subdivision (1) of this section shall be an infraction.
Delaware	21-41- 4122	(3) Traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, and drivers of vehicles shall obey the directions of every such traffic-control device.
District of Columbia		
Florida	**316.089**	(3) Official traffic control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway; and drivers of vehicles shall obey the directions of every such device.
Georgia	Code 40-6-52.	c) On roads, streets, or highways with three or more lanes allowing for movement in the same direction, it shall be unlawful for any truck to operate in any lanes other than the two most right-hand lanes, except when the truck is preparing for a left turn or as otherwise provided by subsection (d) of this Code section.

TABLE E.1 Continued		
State	Section	Section explanations
Georgia	Code 40-6-52.	d) On roads, streets, or highways with two lanes allowing for movement in the same direction, it shall be unlawful for any truck to operate in the left-hand lane, except when the truck is actually overtaking and passing another vehicle, preparing for a left turn, or as otherwise provided by subsection (d) of this Code section.
Hawaii	291c-49	(3) Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such sign.
Idaho	49-637	(3) Traffic-control devices may be erected directing specified traffic to use a designated lane, or designate those lanes to be used by traffic moving in a particular direction, regardless of the center of the highway and drivers of vehicles shall obey the directions of every device.
Illinois	625 ILCS 5/11-709	I Official traffic control devices may be erected directing specific traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device. On multi-lane controlled access highways with 3 or more lanes in one direction or on any multi-laned highway with 2 or more lanes in one direction, the Department may designate lanes of traffic to be used by different types of motor vehicles. Drivers must obey lane designation signing except when it is necessary to use a different lane to make a turning maneuver.
Indiana	**IC 9-21-8-3**	**Lane use restrictions** Sec. 3. (a) The Indiana department of transportation may adopt rules to restrict the operation of a truck to a certain lane or lanes of a state maintained highway and to a certain lane or lanes of a street of a city or town that is a part

TABLE E.1 Continued		
State	Section	Section explanations
Indiana	**IC 9-21-8-3**	of the state highway system and is maintained by the state. **For interstate highways** Sec. 13. Except when entering or leaving a highway or where a special hazard exists that requires, for safety reasons, the use of an alternate lane, a person may not operate a truck, truck tractor, road tractor, trailer, semi trailer, or pole trailer on an interstate highway consisting of at least three (3) lanes in one (1) direction in any lane other than the two (2) far right lanes.
Iowa	321.306	Official signs may be erected directing slow-moving traffic to use a designated lane or allocating specified lanes to traffic moving in the same direction and drivers of vehicles shall obey the directions of every such sign. Vehicles moving in a lane designated for slow-moving traffic shall yield the right of way to vehicles moving in the same direction in a lane not so designated when such lanes merge to form a single lane. A portion of a highway provided with a lane for slow-moving vehicles does not become a roadway marked for three lanes of traffic.
Kansas	**8-1521.** **8-1522.**	(a) The secretary of transportation and local authorities with respect to highways under their respective jurisdictions may designate any highway, roadway, part of a roadway or specific lanes upon which vehicular traffic shall proceed in one (1) direction at all or such times as shall be indicated by official traffic-control devices. I Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device.
Kentucky	**189.340** **8(b)**	The operator of any motor truck, semi trailer truck, bus, or heavy construction equipment unit, when traveling upon a highway outside of a business or residential district, shall not follow within two hundred fifty (250) feet of another such vehicle or equipment unit. This subsection shall not prevent

TABLE E.1 Continued		
State	Section	Section explanations
Kentucky	**189.340** **8(b)**	overtaking and passing, nor shall it apply to any lane specially designated for use of motor trucks or semi trailer trucks, buses or heavy construction equipment units.
Louisiana	**32:79**	(2) The department may erect signs directing slow moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction, and drivers of vehicles shall obey the directions of such signs.
Maine	29-19- **2051**	**3. Signs.** An operator shall obey an official sign or traffic control device: A. Directing slowly moving traffic to use a designated lane B. Designating a lane to be used by turning traffic or traffic moving in a particular direction regardless of the center of the way; or
Maryland	**§ 21-309.**	(d) *Obedience to traffic control devices.* — The driver of a vehicle shall obey the directions of each traffic control device that directs specified traffic to use a designated lane or that designates those lanes to be used by traffic moving in a particular direction, regardless of the center of the roadway. (f) *Same — Trucks, truck tractors, trailers, or buses.*- On a roadway that has two or more lanes for traffic moving in the same direction, the driver of any truck, truck tractor, trailer, or bus shall obey the directions of each traffic control device that requires the vehicle to be driven in a certain lane.
Massachusetts		**(Driver Manual)**In the accompanying three-lane diagram, the far left travel lane is reserved for buses or high-occupancy vehicles (HOVs), like those used in carpools.

TABLE E.1 Continued		
State	Section	Section explanations
Massachusetts		**Driving Too Slowly**—On a multiple-lane highway, trucks and buses are restricted to driving in the two right-hand lanes. They use the far right lane for normal travel and the second lane as a passing lane. If you are traveling in the second lane, stay with the flow of traffic and avoid driving below the speed limit.
Michigan	**257.634** **257.642**	(3) This section shall not be construed to prohibit a vehicle traveling in the appropriate direction from traveling in any lane of a freeway having 3 or more lanes for travel in the same direction. However, a city, village, township, or county may not enact an ordinance which regulates the same subject matter as any provision of this subsection. The driver of a truck with a gross weight of more than 10,000 pounds, a truck tractor, or a combination of a vehicle and trailer or semi trailer shall drive the vehicle or combination of vehicles only in either of the 2 lanes farthest to the right, except for a reasonable distance when making a left turn or where a special hazard exists that requires the use of an alternative lane for safety reasons. I Official traffic control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of the traffic-control device.
Minnesota	**169.18**	Subd. 10. **Slow-moving vehicle.** Upon all roadways any vehicle proceeding at less than the normal speed of traffic at the time and place and under the conditions then existing shall be driven in the right-hand lane then available for traffic, or as close as practicable to the right-hand curb or edge of the roadway, except when overtaking and passing another vehicle proceeding in the same direction, or when preparing for a left turn at an intersection or into a private road or driveway, or when a specific lane is designated and posted for a specific type of traffic.

TABLE E.1 Continued		
State	Section	Section explanations
Minnesota	**169.18**	I Official signs may be erected directing slow-moving traffic to use a designated lane or allocating specified lanes to traffic moving in the same direction, and drivers of vehicles shall obey the directions of every such sign.
Mississippi	**SEC. 63-3-603.**	I Official signs may be erected directing slow-moving traffic to use a designated lane or allocating specified lanes to traffic moving in the same direction, and drivers of vehicles shall obey the directions of every such sign.
Missouri	**Chapter 304. 015**	(4) Official signs may be erected by the highways and transportation commission or the highway patrol may place temporary signs directing slow-moving traffic to use a designated lane or allocating specified lanes to traffic moving in the same direction and drivers of vehicles shall obey the directions of every such sign;
Montana	**61-8-328**	(3) Official traffic control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway. Operators of vehicles shall obey the directions of every official traffic control device that designates use of specific lanes.
Nebraska	**60-681** 60-6,139	Local authorities may also, by ordinance or resolution, prohibit the operation of trucks or other commercial vehicles or impose limitations as to the weight thereof on designated highways, which prohibitions and limitations shall be designated by appropriate signs placed on such highways. 3) Traffic control devices may be erected by the Department of Roads or local authorities to direct specified traffic to use a designated lane or to designate those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device; and

TABLE 5.1 Continued		
State	Section	Section explanations
Nevada	**NRS 484.305**	(3) Upon a highway which has been divided into three clearly marked lanes, a vehicle must not be driven in the extreme left lane at any time. A vehicle on such a highway must not be driven in the center lane except: (a) When overtaking and passing another vehicle where the highway is clearly visible and the center lane is clear of traffic for a safe distance; (b) In preparation for a left turn; or I When the center lane is allocated exclusively to traffic moving in the direction in which the vehicle is proceeding and a sign is posted to give notice of such allocation.
New Hampshire	XXI-265:24	III. Official traffic control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such sign;
New Jersey	39:4-88.	f) When such roadway had been divided in such a manner that there are 3 or more lanes for traffic in any one direction, no truck of 10,000 pounds registered gross weight or over shall be driven in the farthest left-hand lane, except when and to the extent necessary to prepare for a left turn, or when necessary to enter or leave such roadway by entrance or exit to or from the left lane or when reasonably necessary in response to emergency conditions.
New Mexico	**66-7-317**	C. official signs may be erected directing slow-moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such sign.

TABLE E.1 Continued		
State	Section	Section explanations
New York	**VAT 7.25.1128**	I When official traffic-control devices direct slow-moving traffic, trucks, buses or specified types of vehicles to use a designated lane or designate those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, drivers of vehicles shall obey the directions of every such sign, signal or marking.
North Carolina	20-146.	(3) Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the street and drivers of vehicles shall obey the direction of every such device.
North Dakota	**39-10-17.**	3. Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device.
Ohio	**4511.33.**	(3) Official signs may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, or restricting the use of a particular lane to only buses during certain hours or during all hours, and drivers of vehicles and trackless trolleys shall obey the directions of such signs.
Oklahoma	§47-11-309	(4) Official signs may be erected directing slow-moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such sign.

TABLE E.1 Continued		
State	Section	Section explanations
Oregon	**811.325**	(1) A person commits the offense of failure to keep a camper, trailer or truck in the right lane if the person is operating any of the vehicles described in this subsection and the person does not drive in the right lane of all roadways having two or more lanes for traffic proceeding in a single direction. This subsection applies to all of the following vehicles: (a) Any camper. (b) Any vehicle with a trailer. I Any vehicle with a registration weight of 10,000 pounds or more.
Pennsylvania	75-III-33-3309	3. Lanes limited to specific use.-Official traffic-control devices may be erected to restrict the use of specified lanes to specified classes or types of traffic or vehicles, including multi-occupant vehicles or car pools, and drivers of vehicles shall obey the directions of every such device.
Puerto Rico		
Rhode island	**31.15.(2-11)**	2: slow traffic to right 11: Official signs may be erected directing slow-moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, and drivers of vehicles shall obey the directions of the sign.
South Carolina	**56-5-1900**	I Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device.
South Dakota	32-26-8.	Designation of lane for slow-moving traffic—Violation as misdemeanor. Official signs may be erected on a roadway divided into lanes directing slow-

TABLE E.1 Continued		
State	Section	Section explanations
South Dakota	32-26-8.	moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such sign.
Tennessee	**55-8-123**	(3) Official signs may be erected directing slow-moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, and drivers of vehicles shall obey the directions of every such sign; and
Texas	§ 544.011.	LANE USE SIGNS. If, on a highway having more than one lane with vehicles traveling in the same direction, the Texas Department of Transportation or a local authority places a sign that directs slower traffic to travel in a lane other than the farthest left lane, the sign must read "left lane for passing only."
Utah	41-6a-703	(2) On a freeway or section of a freeway which has three or more general purpose lanes in the same direction, a person may not operate a vehicle in the left most general purpose lane if the person's: (a) vehicle is drawing a trailer or semitrailer regardless of size; or (b) vehicle or combination of vehicles has a gross vehicle weight of 12,001 or more pounds (4) (a) A highway authority may designate a specific lane or lanes of travel for any type of vehicle on a highway or portion of a highway under its jurisdiction for the: (i) safety of the public; (ii) efficient maintenance of a highway; or (iii) use of high occupancy vehicles.

TABLE E.1 Continued		
State	Section	Section explanations
Utah	41-6a-703	(b) The lane designation under Subsection (4)(a) is effective when appropriate signs giving notice are erected on the highway or portion of the highway
Vermont	23-13-1038	(3) Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway, and drivers of vehicles shall obey the directions of the signs.
Virginia	46.2-803.1. 46.2-809. 46.2-804.	Except where the posted speed limit is less than 65 miles per hour, no person shall drive any commercial motor vehicle, as defined in § 46.2-341.4, on the left-most lane of any interstate highway having more than two lanes in each direction. Truck route: The Commonwealth Transportation Board, or its designee, in response to a formal request by a local governing body, after such body has held public hearings, may, after due notice and a proper hearing, prohibit or restrict the use by through traffic of any part of a primary or secondary highway if a reasonable alternate route is provided. The Board, or its designee, shall act upon any such formal request within nine months of its receipt, unless good cause is shown. Such restriction may apply to any truck or truck and trailer or semi trailer combination, except a pickup or panel truck, as may be necessary to promote the health, safety, and welfare of the citizens of the Commonwealth. Nothing in this section shall affect the validity of any city charter provision or city ordinance heretofore adopted. Slow traffic: 4. The Commonwealth Transportation Board, or local authorities in their respective jurisdictions, may designate right lanes for slow-moving vehicles;
Washington State	46.61.140	(3) Official traffic-control devices may be erected directing slow moving or other specified traffic to use a designated lane or designating those lanes to be

TABLE E.1 Continued		
State	Section	Section explanations
Washington State	46.61.140	used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device.
West Virginia	**17C-7-9.**	(3) Official signs may be erected directing slow-moving traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such sign.
Wisconsin	**346.13**	(5) Notwithstanding sub. (2), when lanes have been marked or posted for traffic moving in a particular direction or at designated speeds, the operator of a vehicle shall drive in the lane designated.
Wyoming		Laned for traffic: (iii) Official traffic-control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device;
Uniform Vehicle Code	11-309	(c) official traffic control devices may be erected directing specified traffic to use a designated lane or designating those lanes to be used by traffic moving in a particular direction regardless of the center of the roadway and drivers of vehicles shall obey the directions of every such device.

APPENDIX F: Signalization Data

TABLE F.1: Virginia_Avenue at Oleander Blvd

INTERSECTION #: 5
SYSTEM #: 6
SECTION #:

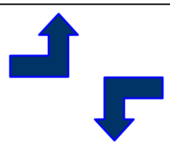
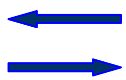
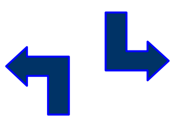
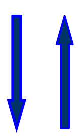
CYCLE #/ SPLIT #		C1S1	C2S1	C2S2	. C1S2	C1S3	C1S4	C1S1	C2S1	C2S2	C1S2	C1S3	C1S4
PHASE/ MOVEMENT	CYCLE	110	120	120	110	110	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	8.9	10.3	10.3	8.9	7.8	7.8	8.1%	8.6%	8.6%	8.1%	7.1%	7.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	15.4	16.8	16.8	15.4	14.3	14.3	14.0%	14.0%	14.0%	14.0%	13.0%	13.0%
	GREEN	33.1	33.1	46.3	40.8	47.4	47.4	30.1%	27.6%	38.6%	37.1%	43.1%	43.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	39.6	39.6	52.8	47.3	53.9	53.9	36.0%	33.0%	44.0%	43.0%	49.0%	49.0%
	GREEN	8.9	10.3	9.1	7.8	8.9	8.9	8.1%	8.6%	7.6%	7.1%	8.1%	8.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	15.4	16.8	15.6	14.3	15.4	15.4	14.0%	14.0%	13.0%	13.0%	14.0%	14.0%
	GREEN	33.1	40.3	28.3	26.5	19.9	19.9	30.1%	33.6%	23.6%	24.1%	18.1%	18.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	39.6	46.8	34.8	33	26.4	26.4	36.0%	39.0%	29.0%	30.0%	24.0%	24.0%
	OFFSET	108	118	6	39	106	110	98.0%	98.0%	5.0%	35.0%	96.0%	100.0%

TABLE F.2: Virginia Avenue at Sunrise Blvd

INTERSECTION #: 4

SYSTEM #: 6

SECTION #:

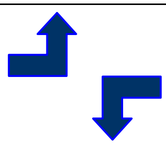
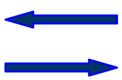
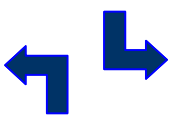
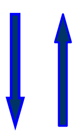
CYCLE #/ SPLIT #		C1S1	C2S1	C2S2	C1S2	C1S3	C1S4	C1S1	C2S1	C2S2	C1S2	C1S3	C1S4
PHASE/ MOVEMENT	CYCLE	110	120	120	110	110	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKN D	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	17.1	25.2	24.0	21.5	16.0	13.8	15.5%	21.0%	20.0%	19.5%	14.5%	12.5%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2	2	2	2	2	2	1.8%	1.7%	1.7%	1.8%	1.8%	1.8%
	TOTAL	23.1	31.2	30.0	27.5	22.0	19.8	21.0%	26.0%	25.0%	25.0%	20.0%	18.0%
	GREEN	41.3	43.2	44.4	33.6	47.9	46.8	37.5%	36.0%	37.0%	30.5%	43.5%	42.5%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2	2	2	2	2	2	1.8%	1.7%	1.7%	1.8%	1.8%	1.8%
	TOTAL	47.3	49.2	50.4	39.6	53.9	52.8	43.0%	41.0%	42.0%	36.0%	49.0%	48.0%
	GREEN	8.9	10.3	9.1	8.9	8.9	8.9	8.1%	8.6%	7.6%	8.1%	8.1%	8.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	15.4	16.8	15.6	15.4	15.4	15.4	14.0%	14.0%	13.0%	14.0%	14.0%	14.0%
	GREEN	17.7	16.3	17.5	21.0	12.2	15.5	16.1%	13.6%	14.6%	19.1%	11.1%	14.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	24.2	22.8	24.0	27.5	18.7	22.0	22.0%	19.0%	20.0%	25.0%	17.0%	20.0%
	OFFSET	108	10	12	61	9	9	98.0%	8.0%	10.0%	'55.0%	8.0%	8.0%

TABLE F.3: Virginia Avenue at S 13th St

INTERSECTION #: 3

SYSTEM #: 6

SECTION #:

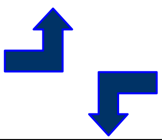
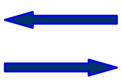
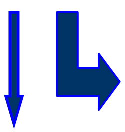
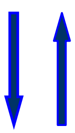
CYCLE #/ SPLIT #		C1S1	C2S1	C2S2	C1S2	C1S3	C1S4	C1S1	C2S1	C2S2	C1S2	C1S3	C1S4
PHASE/ MOVEMENT	CYCLE	110	120	120	110	110	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	7.8	7.9	7.9	7.8	7.8	7.8	7.1%	6.6%	6.6%	7.1%	7.1%	7.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	14.3	14.4	14.4	14.3	14.3	14.3	13.0%	12.0%	12.0%	13.0%	13.0%	13.0%
	GREEN	52.9	49.9	54.7	47.4	51.8	52.9	48.1%	41.6%	45.6%	43.1%	47.1%	48.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	59.4	56.4	61.2	53.9	58.3	59.4	54.0%	47.0%	51.0%	49.0%	53.0%	54.0%
	GREEN	11.1	24.7	19.9	16.6	12.2	11.1	10.1%	20.6%	16.6%	15.1%	11.1%	10.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	17.6	31.2	26.4	23.1	18.7	17.6	16.0%	26.0%	22.0%	21.0%	17.0%	16.0%
	GREEN	12.2	11.5	11.5	12.2	12.2	12.2	11.1%	9.6%	9.6%	11.1%	11.1%	11.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	18.7	18.0	18.0	18.7	18.7	18.7	17.0%	15.0%	15.0%	17.0%	17.0%	17.0%
	OFFSET	108	120	14	64	6	2	98.0%	100.0%	12.0%	58.0%	5.0%	2.0%

TABLE F.4: Virginia Avenue at S 25th St

INTERSECTION #: 2

SYSTEM #: 6

SECTION #:

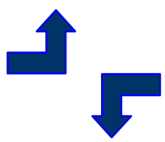
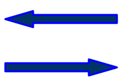
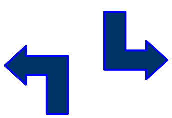
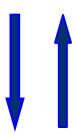
CYCLE #/ SPLIT #		C1S1	C2S1	C2S2	. C1S2	C1S3	C1S4	C1S1	C2S1	C2S2	C1S2	C1S3	C1S4
I PHASE/ MOVEMENT	CYCLE	110	120	120	110	110	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	7.8	7.9	7.9	8.9	7.8	7.8	7.1%	6.6%	6.6%	8.1%	7.1%	7.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	,2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	14.3	14.4	14.4	15.4	14.3	14.3	13.0%	12.0%	12.0%	14.0%	13.0%	13.0%
	GREEN	24.3	39.1	37.9	25.4	44.1	43.0	22.1%	32.6%	31.6%	23.1%	40.1%	39.1%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	2.3%	2.1%	2.1%	2.3%	2.3%	2.3%
	TOTAL	30.8	45.6	44.4	31.9	50.6	49.5	28.0%	38.0%	37.0%	29.0%	46.0%	45.0%
	GREEN	7.3	15.8	15.8	7.3	8.4	9.5	6.6%	13.2%	13.2%	6.6%	7.6%	8.6%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	3	3	3	3	3	3	2.7%	2.5%	2.5%	2.7%	2.7%	2.7%
	TOTAL	14.3	22.8	22.8	14.3	15.4	16.5	13.0%	19.0%	19.0%	13.0%	14.0%	15.0%
	GREEN	43.6	30.2	31.4	41.4	22.7	22.7	39.6%	25.2%	26.2%	37.6%	20.6%	20.6%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	3	3	3	3	3	3	2.7%	2.5%	2.5%	2.7%	2.7%	2.7%
	TOTAL	50.6	37.2	38.4	48.4	29.7	29.7	46.0%	31.0%	32.0%	44.0%	27.0%	27.0%
	OFFSET	19	58	66	91	55	49	17.0%	48.0%	55.0%	83.0%	50.0%	45.0%

TABLE F.5: Virginia Avenue at S 35th St

INTERSECTION #: 1

SYSTEM #: 6

SECTION #:

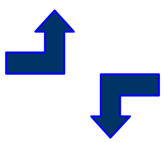
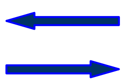
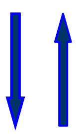
CYCLE #/ SPLIT #		C1S1	C2S1	C2S2	. C1S2	C1S3	C1S4	C1S1	C2S1	C2S2	C1S2	C1S3	C1S4
I PHASE/ MOVEMENT	CYCLE	110	120	120	110	110	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	7.2	7.2	7.2	7.2	7.2	7.2	6.5%	6.0%	6.0%	6.5%	6.5%	6.5%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2	2	2	2	2	2	1.8%	.1.7%	1.7%	1.8%	1.8%	1.8%
	TOTAL	13.2	13.2	13.2	13.2	13.2	13.2	12.0%	11.0%	11.0%	12.0%	12.0%	12.0%
	GREEN	71.0	69.6	68.4	56.7	56.7	74.3	64.5%	58.0%	57.0%	51.5%	51.5%	67.5%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2	2	2	2	2	2	1.8%	1.7%	1.7%	1.8%	1.8%	1.8%
	TOTAL	77.0	75.6	74.4	62.7	62.7	80.3	70.0%	63.0%	62.0%	57.0%	57.0%	73.0%
	GREEN	13.8	25.2	26.4	28.1	28.1	10.5	12.5%	21.0%	22.0%	25.5%	25.5%	9.5%
	AMBER	4	4	4	4	4	4	3.6%	3.3%	3.3%	3.6%	3.6%	3.6%
	ALL RED	2	2	2	2	2	2	1.8%	1.7%	1.7%	1.8%	1.8%	1.8%
	TOTAL	19.8	31.2	32.4	34.1	34.1	16.5	18.0%	26.0%	27.0%	31.0%	31.0%	15.0%
	OFFSET	15	12	22	27	8	6	14.0%	10.0%	18.0%	25.0%	7.0%	5.0%

TABLE F.6: Okeechobee Rd at Virginia Ave

INTERSECTION #:

SYSTEM #: 5

SECTION #:

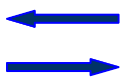
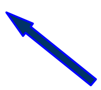
CYCLE #/ SPLIT #		C4S1	C1S1	C2S1	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	84.0	47.0	53.0	53.5	47.0	64.5	60.0%	52.2%	53.0%	48.6%	52.2%	58.6%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	3	3	3	3	3	3	2.1%	3.3%	3.0%	2.7%	3.3%	2.7%
	TOTAL	91.0	54.0	60.0	60.5	54.0	71.5	65.0%	60.0%	60.0%	55.0%	60.0%	65.0%
	GREEN	42.5	29.5	33.5	43.0	29.5	32.0	30.4%	32.8%	33.5%	39.1%	32.8%	29.1%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	1.8%	2.8%	2.5%	2.3%	2.8%	2.3%
	TOTAL	49.0	36.0	40.0	49.5	36.0	38.5	35.0%	40.0%	40.0%	45.0%	40.0%	35.0%
		99	28	90	108	82	110	71.0%	31.0%	90.0%	98.0%	91.0%	100.0%

TABLE F.7: Okeechobee Rd at Central Mall Entrance

INTERSECTION #: 7

SYSTEM #: 5

SECTION #:

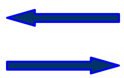
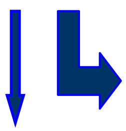
CYCLE #/ SPLIT #		C4S1	C1S1	C2S1	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
I PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	117.2	67.8	78.0	87.5	67.8	87.5	83.7%	75.3%	78.0%	79.5%	75.3%	79.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	123.2	73.8	84.0	93.5	73.8	93.5	88.0%	82.0%	84.0%	85.0%	82.0%	85.0%
	GREEN	10.8	10.2	10.0	10.5	10.2	10.5	7.7%	11.3%	10.0%	9.5%	11.3%	9.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	16.8	16.2	16.0	16.5	16.2	16.5	12.0%	18.0%	16.0%	15.0%	18.0%	15.0%
	OFFSET	80	2	38	103	34	106	57.0%	2.0%	38.0%	94.0%	38.0%	96.0%

TABLE F.8: Okeechobee Rd at West Mall Entrance

INTERSECTION #: 6

SYSTEM #: 5

SECTION #:

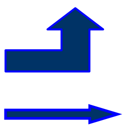
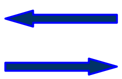
CYCLE #/ SPLIT #		C4S1	C1S1	C2S1	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	8.0	7.5	7.0	12.7	7.5	8.3	5.7%	8.3%	7.0%	11.5%	8.3%	7.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	14.0	13.5	13.0	18.7	13.5	14.3	10.0%	'15.0%	13.0%	17.0%	15.0%	13.0%
	GREEN	120.0	70.5	81.0	85.3	71.4	89.7	85.7%	78.3%	81.0%	77.5%	79.3%	81.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	126.0	76.5	87.0	91.3	77.4	95.7	90.0%	85.0%	87.0%	83.0%	86.0%	87.0%
	OFFSET	99	46	7	10	66	14	71.0%	51.0%	7.0%	9.0%	73.0%	13.0%

TABLE F.9: Okeechobee Rd at McNeil Rd

INTERSECTION #: 5
SYSTEM #: 5
SECTION #:

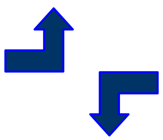
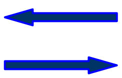
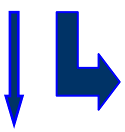
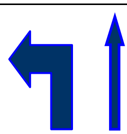
CYCLE #/ SPLIT #		C4S1	C1S1	C2S1.	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	7.5	7.9	7.5	7.8	7.9	7.8	5.4%	8.8%	7.5%	7.1%	8.8%	7.1%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	1.8%	2.8%	2.5%	2.3%	2.8%	2.3%
	TOTAL	14.0	14.4	14.0	14.3	14.4	14.3	10.0%	16.0%	14.0%	13.0%	16.0%	13.0%
	GREEN	84.5	32.2	40.5	49.6	35.8	46.3	60.4%	35.8%	40.5%	45.1%	39.8%	42.1%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2.5	2.5	2.5	2.5	2.5	2.5	1.8%	2.8%	2.5%	2.3%	2.8%	2.3%
	TOTAL	91.0	38.7	47.0	56.1	42.3	52.8	65.0%	43.0%	47.0%	51.0%	47.0%	48.0%
	GREEN	12.2	14.7	16.0	16.0	11.1	19.3	8.7%	16.3%	16.0%	14.5%	12.3%	17.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	18.2	20.7	22.0	22.0	17.1	25.3	13.0%	23.0%	22.0%	20.0%	19.0%	23.0%
	GREEN	10.8	10.2	11.0	11.6	10.2	11.6	7.7%	11.3%	11.0%	10.5%	11.3%	10.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	16.8	16.2	17	17.6	16.2	17.6	12.0%	18.0%	17.0%	16.0%	18.0%	16.0%
	OFFICE	45	30	70	76	60	78	32.0%	33.0%	70.0%	69.0%	67.0%	71.0%

TABLE F.10: Okeechobee Rd at Kings Hwy

INTERSECTION #: 10

SYSTEM #: 5

SECTION #:

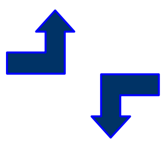
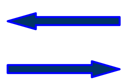
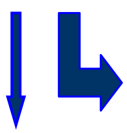
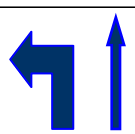
CYCLE #/ SPLIT #		C4S1	C1S1	C2S1	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
I PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOO	AM	NOON	OFF	PM	NIGHT	WKN D	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	24.8	17.4	22.0	25.9	14.7	40.2	17.7%	19.3%	22.0%	23.5%	16.3%	36.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	30.8	23.4	28.0	31.9	20.7	46.2	22.0%	26.0%	28.0%	29.0%	23.0%	42.0%
	GREEN	51.4	17.4	20.0	24.8	26.4	17.1	36.7%	19.3%	20.0%	22.5%	29.3%	15.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	57.4	23.4	26.0	30.8	32.4	23.1	41.0%	26.0%	26.0%	28.0%	36.0%	21.0%
	GREEN	26.2	21.9	24.0	24.8	15.6	18.2	18.7%	24.3%	24.0%	22.5%	17.3%	16.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	32.2	27.9	30.0	30.8	21.6	24.2	23.0%	31.0%	30.0%	28.0%	24.0%	22.0%
	GREEN	13.6	9.3	10.0	10.5	9.3	10.5	9.7%	10.3%	10.0%	9.5%	10.3%	9.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	19.6	15.3	16	16.5	15.3	16.5	14.0%	17.0%	16.0%	15.0%	17.0%	15.0%
	OFFICE	45	52	42	29	90	40	32.0%	58.0%	42.0%	26.0%	100.0%	36.0%

TABLE F.11: Okeechobee Rd at 1-95 NB Off Ramp

INTERSECTION #: 3

SYSTEM #: 5

SECTION #:

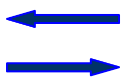
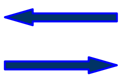
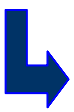
CYCLE #/ SPLIT #		C4S1	C1S1	C2S1	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGH T	WKN D	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	83.6	54.3	58.0	64.4	58.8	72.1	59.7%	60.3%	58.0%	58.5%	65.3%	65.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	89.6	60.3	64.0	70.4	64.8	78.1	64.0%	.67.0%	64.0%	64.0%	72.0%	71.0%
	GREEN	44.9	24.2	30.5	34.1	19.7	26.4	32.1%	26.9%	30.5%	31.0%	21.9%	24.0%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	1.5	1.5	1.5	1.5	1.5	1.5	1.1%	1.7%	1.5%	1.4%	1.7%	1.4%
	TOTAL	50.4	29.7	36.0	39.6	25.2	31.9	36.0%	33.0%	36.0%	36.0%	28.0%	29.0%
	OFFSET	113	90	32	25	14	17	81.0%	100.0%	32.0%	23.0%	16.0%	15.0%

TABLE F.12: Okeechobee Rd at 1-95 SB Off Ramp

INTERSECTION #: 2

SYSTEM #: 5

SECTION #:

CYCLE #/ SPLIT #		C4S1	C1S1	C2S1	C3S1	C1S2	C3S2	C4S1	C1S1	C2S1	C3S1	C1S2	C3S2
PHASE/ MOVEMENT	CYCLE	140	90	100	110	90	110	100%	100%	100%	100%	100%	100%
	TOD	AM	NOON	OFF	PM	NIGHT	WKND	AM	NOON	OFF	PM	NIGHT	WKND
	GREEN	92.5	62.9	72.5	77.0	62.9	82.5	66.1%	69.9%	72.5%	70.0%	69.9%	75.0%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	1.5	1.5	1.5	1.5	1.5	1.5	1.1%	1.7%	1.5%	1.4%	1.7%	1.4%
	TOTAL	98.0	68.4	78.0	82.5	68.4	88.0	70.0%	76.0%	78.0%	75.0%	76.0%	80.0%
	GREEN	36.0	15.6	16.0	21.5	15.6	16.0	25.7%	17.3%	16.0%	19.5%	17.3%	14.5%
	AMBER	4	4	4	4	4	4	2.9%	4.4%	4.0%	3.6%	4.4%	3.6%
	ALL RED	2	2	2	2	2	2	1.4%	2.2%	2.0%	1.8%	2.2%	1.8%
	TOTAL	42.0	21.6	22.0	27.5	21.6	22.0	30.0%	24.0%	22.0%	25.0%	24.0%	20.0%
	OFFSET	15	88	41	32	34	34	11.0%	98.0%	41.0%	29.0%	38.0%	31.0%

APPENDIX G: Field Travel Time and Speed Data

TABLE G.1: Field Data

Admin Time: 06/09/06 10:49:24
Device ID: UNIT ID | Idle Speed: 6 km/hr | GPS Sample Rate: 1 sec | GPS Powered: At Power-On | App: Travel Time/Congestion Mgmt Survey
Source: PDA | Idle Time: 30 sec | Analog Sample Rate: 0 sec | PDA Powered: At Power-On | Micro Version:
Idle Sample Rate: 30 sec | GPS Type: Standard | PDA Version: 1.110702tc

				Number of Enroute GPS Records			Enroute			Number of Intersection / Delay GPS Records			Intersection/Delay		
Chain Number	Route Number	Departure Time	Arrival Time	Bad	Good	Speed > Idle	Distance (miles)	Duration (min)	Avg Speed	Bad	Good	Speed > Idle	Distance (miles)	Duration (min)	Avg Speed
		06/09/06 10:50:38	**06/09/06 11:38:40**	**1**	**2577**	**2020**	**20.92**	**48.01**		**0**	**0**	**0**	**0**	**0**	
		06/09/06 10:50:38	06/09/06 10:53:25	1	147	75	0.38	2.78	9.1						
		06/09/06 10:53:25	06/09/06 11:02:34	0	502	412	4.69	9.15	33.17						
		06/09/06 11:02:34	06/09/06 11:05:01	0	128	96	0.65	2.45	17.15						
		06/09/06 11:05:01	06/09/06 11:13:02	0	468	417	4.68	8.02	35.62						
1	1	06/09/06 11:13:02	06/09/06 11:14:49	0	68	37	0.3	1.78	13.76						
		06/09/06 11:14:50	06/09/06 11:23:50	0	504	391	4.69	9	33						
		06/09/06 11:23:50	06/09/06 11:27:57	0	160	103	0.64	4.12	14.02						
		06/09/06 11:27:57	06/09/06 11:37:41	0	543	450	4.7	9.73	30.83						
		06/09/06 11:37:41	06/09/06 11:38:40	0	57	39	0.19	0.98	8.83						
		06/09/06 12:02:45	**06/09/06 13:06:23**	**10**	**3274**	**2544**	**25.08**	**62.57**		**0**	**0**	**0**	**0**	**0**	
		06/09/06 12:02:45	06/09/06 12:02:48	0	0	0	0	0.05	0						
		06/09/06 12:02:48	06/09/06 12:06:51	10	120	49	0.24	4.05	6.79						
		06/09/06 12:06:51	06/09/06 12:13:54	0	418	388	4.68	7.05	39.84						
		06/09/06 12:13:55	06/09/06 12:19:05	0	210	103	0.52	5.17	8.17						
		06/09/06 12:19:06	06/09/06 12:30:13	0	600	462	4.7	11.12	27.76						
		06/09/06 12:30:13	06/09/06 12:32:21	0	80	49	0.29	2.13	12.31						
2	2	06/09/06 12:32:21	06/09/06 12:42:25	0	578	458	4.71	10.07	29.06						
		06/09/06 12:42:26	06/09/06 12:44:43	0	93	54	0.23	2.28	7.86						
		06/09/06 12:44:43	06/09/06 12:55:38	0	612	471	4.73	10.92	27.48						
		06/09/06 12:55:38	06/09/06 12:56:34	0	54	42	0.26	0.93	16.7						
		06/09/06 12:56:35	06/09/06 12:56:35	0	0	0	0	0	0						
		06/09/06 12:56:35	06/09/06 12:56:36	0	0	0	0	0.02	0						
		06/09/06 12:57:36	06/09/06 12:57:37	0	0	0	0	0.02	0						
		06/09/06 12:57:37	06/09/06 13:06:18	0	507	466	4.7	8.68	33.06						
		06/09/06 13:06:18	06/09/06 13:06:23	0	2	2	0.02	0.08	14.88						

APPENDIX H: SR 70 Simulation Results

TABLE H.1: Corridor Analysis												
No Restriction Scenario on SR 70												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
	travel time	605.608	591.204	591.842	597.026	576.249	566.616	593.175	600.489	587.628	596.973	590.681
0%	speed	18.318	18.365	18.295	18.097	18.762	18.719	18.305	18.271	18.24	18.251	18.3623
	delay	125.463	122.848	124.855	126.209	118.762	118.628	125.213	124.287	124.429	125.114	123.5808
	travel time	609	603.326	595.724	602.819	584.61	583.957	601.684	613.882	594.04	610.318	599.936
5%	speed	17.754	17.754	17.781	17.619	18.304	17.997	17.701	17.525	17.792	17.652	17.7879
	delay	131.651	129.662	129.763	131.832	123.879	126.628	132.113	132.766	129.433	132.176	129.9903
	travel time	623.071	619.677	603.964	618.633	603.711	598.83	628.079	621.701	604.009	632.857	615.4532
10%	speed	17.059	16.825	17.218	16.869	17.51	17.118	16.639	16.973	17.304	16.884	17.0399
	delay	139.284	140.133	136.192	141.097	133.08	136.35	144.009	138.913	135.151	141.84	138.6049
	travel time	631.928	636.379	608.136	631.711	619.034	613.724	646.691	635.096	622.424	644.319	628.9442
15%	speed	16.568	16.213	16.741	16.146	16.753	16.557	15.809	16.192	16.455	16.025	16.3459
	delay	145.032	148.119	141.656	149.605	141.554	144.101	154.011	148.091	145.3	151.713	146.9182
	travel time	655.569	644.047	626.92	646.569	638.671	632.91	666.828	656.382	645.814	653.548	646.7258
20%	speed	15.516	15.489	15.977	15.362	15.852	15.716	14.57	15.359	15.44	15.349	15.463
	delay	158.61	156.867	150.611	159.331	153.161	154.022	170.068	158.441	157.458	159.654	157.8223
	travel time	693.901	650.829	654.937	665.487	665.97	666.958	667.673	656.174	661.504	666.444	664.9877
25%	speed	14.143	14.812	14.876	14.46	14.836	14.646	14.469	14.892	14.699	14.636	14.6469
	delay	179.084	164.95	165.687	172.28	166.464	169.503	172.174	163.897	168.158	170.169	169.2366
	travel time	699.651	713.831	693.543	683.385	704.485	747.717	696.24	690.247	692.832	670.908	699.2839

TABLE H.1 Continued												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
30%	speed	13.831	13.239	13.606	13.691	13.574	12.65	13.189	13.678	13.602	14.23	13.529
	delay	183.915	191.713	184.936	183.558	186.601	202.938	192.167	182.058	185.142	176.148	186.9176
	travel time	734.899	744.453	758.424	731.185	754.633	778.086	729.448	704.545	751.884	723.039	741.0596
35%	speed	12.726	12.339	12.005	12.417	12.216	11.749	12.309	12.809	12.264	12.705	12.3539
	delay	203.803	208.223	214.567	205.223	211.84	222.305	208.28	197.122	210.987	202.175	208.4525
	travel time	753.393	756.83	757.496	744.398	773.323	774.672	752.444	760.128	753.161	779.858	761.3678
40%	speed	12.115	11.82	11.783	11.962	11.593	11.483	11.554	11.411	11.823	11.403	11.648
	delay	215.988	219.732	219.745	216.059	225.117	227.157	223.531	226.48	218.523	229.647	222.8879
Trucks Use Right lane Scenario on SR 70												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
	travel time	570.705	561	561.909	564.658	547.016	534.268	554.058	567.23	555.896	566.086	558.2826
0%	speed	17.965	17.811	17.711	17.644	18.327	18.164	17.969	17.705	17.77	17.805	17.8871
	delay	120.226	119.709	121.742	121.834	115.087	115.036	118.636	120.958	120.202	121.145	119.4575
	travel time	611.128	571.954	561.011	568.233	557.732	547.405	566.885	575.317	558.589	579.408	569.7662
5%	speed	17.781	17.271	17.33	17.172	17.785	17.513	17.215	17.177	17.397	17.246	17.3887
	delay	131.095	126.096	125.278	127.323	120.839	121.625	126.714	126.995	124.426	127.75	125.8141
	travel time	619.413	590.266	557.849	568.749	573.34	556.166	572.765	577.602	565.762	589.899	577.1811
10%	speed	17.129	16.277	17.135	16.863	17.068	16.792	16.718	16.749	17.035	16.761	16.8527
	delay	138.146	137.269	126.67	130.653	129.292	129.069	132.211	131.524	128.498	133.634	131.6966
	travel time	592.55	598.214	560.466	573.725	582.318	566.569	595.153	595.598	575.534	602.246	584.2373

TABLE H.1 Continued												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
15%	speed	16.358	15.699	16.632	16.334	16.437	16.252	15.861	15.889	16.409	15.831	16.1702
	delay	137.997	144.002	131.991	136.781	135.905	136.197	142.198	141.249	135.441	143.286	138.5047
	travel time	602.108	594.332	577.832	581.46	608.428	584.285	612.319	593.721	600.108	608.405	596.2998
20%	speed	15.586	15.313	15.882	15.801	15.257	15.508	14.738	15.49	15.235	15.136	15.3946
	delay	146.579	147.144	140.68	142.633	150.521	144.924	156.108	144.511	149.278	151.082	147.346
	travel time	621.204	609.202	609.021	596.293	646.538	602.498	599.044	609.764	599.525	618.085	611.1174
25%	speed	14.629	14.382	14.748	14.894	14.047	14.767	14.609	14.584	14.832	14.594	14.6086
	delay	159.26	158.241	155.284	153.547	166.599	154.133	155.794	156.223	153.937	159.179	157.2197
	travel time	632.98	631.042	632.913	611.25	659.496	662.027	622.499	608.676	617.036	642.056	631.9975
30%	speed	14.119	13.579	13.703	14.186	13.351	13.106	13.645	14.128	13.982	13.58	13.7379
	delay	166.587	170.98	170.482	162.813	177.084	179.672	170.943	160.489	165.446	173.935	169.8431
	travel time	631.016	663.144	667.565	622.969	670.838	680.849	644.372	625.577	636.454	664.583	650.7367
35%	speed	13.709	12.609	12.598	13.369	12.641	12.306	12.815	13.221	13.257	12.799	12.9324
	delay	172.074	186.892	188.187	173.643	188.246	193.239	182.907	173.576	177.246	186.807	182.2817
	travel time	677.129	671.339	682.982	667.74	691.179	684.946	659.818	652.072	695.305	709.818	679.2328
40%	speed	12.304	12.247	12.031	12.211	11.913	11.917	12.266	12.364	11.727	11.514	12.0494
	delay	195.559	193.693	198.815	194.869	202.344	200.195	192.653	189.732	204.701	210.823	198.3384
Trucks Use Center lane Scenario on SR 70												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
	travel time	602.525	592.973	591.182	595.803	575.935	568.768	593.007	601.475	588.901	595.847	590.6416
0%	speed	18.412	18.29	18.293	18.156	18.732	18.587	18.33	18.142	18.23	18.327	18.3499

TABLE H.1 Continued												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
	delay	124.378	123.996	124.89	125.519	118.882	119.724	124.93	125.392	124.814	124.293	123.6818
	travel time	612.755	602.713	595.221	603.741	591.057	584.405	610.617	612.28	595.829	612.864	602.1482
5%	speed	17.75	17.736	17.755	17.597	18.116	17.957	17.457	17.529	17.742	17.649	17.7288
	delay	131.69	129.809	130.151	132.176	125.842	126.79	134.59	132.39	130.231	132.269	130.5938
	travel time	621.545	624.984	604.924	615.017	606.289	608.668	627.1	618.283	605.683	631.176	616.3669
10%	speed	17.194	16.794	17.17	16.97	17.453	16.944	16.617	17.021	17.227	16.842	17.0232
	delay	138.001	140.838	136.424	139.715	133.811	138.667	144.281	138.489	135.39	141.672	138.7288
	travel time	639.034	639.621	610.196	620.716	635.567	617.208	649.941	642.023	630.94	637.301	632.2547
15%	speed	16.297	16.069	16.625	16.396	16.078	16.465	15.745	15.98	16.146	16.163	16.1964
	delay	148.526	149.626	142.809	146.481	148.65	144.892	154.929	150.562	148.511	149.42	148.4406
	travel time	663.751	648.761	630.181	667.052	650.205	678.738	656.544	655.459	654.491	652.727	655.7909
20%	speed	15.265	15.222	15.8	14.866	15.64	14.616	15.015	15.305	15.172	15.378	15.2279
	delay	162.05	159.287	152.772	166.315	156.066	169.611	164.445	158.517	161.373	159.562	160.9998
	travel time	693.29	676.761	686.318	684.991	689.048	680.669	682.55	679.167	690.652	658.794	682.224
25%	speed	14.18	14.26	14.174	14.09	14.293	14.263	13.989	14.19	13.962	14.933	14.2334
	delay	178.282	173.932	176.123	177.831	175.185	174.263	178.656	173.908	179.786	166.048	175.4014
	travel time	735.62	716.322	727.385	694.749	743.969	770.62	703.661	708.058	704.804	685.44	719.0628
30%	speed	13.115	13.127	12.885	13.428	12.823	12.162	13.159	13.234	13.303	13.875	13.1111
	delay	196.971	193.514	197.983	187.667	200.531	212.145	193.107	189.569	189.708	182.303	194.3498
	travel time	742.024	764.256	767.033	730.298	797.815	785.032	738.148	748.926	749.247	750.897	757.3676
35%	speed	12.626	11.959	11.914	12.356	11.585	11.655	12.222	11.928	12.137	12.207	12.0589
	delay	205.964	215.345	217.091	206.749	226.023	224.455	210.86	215.126	212.143	212.223	214.5979
	travel time	782.664	775.97	800.053	775.537	795.689	793.288	779.807	740.413	765.556	784.747	779.3724

TABLE H.1 Continued

Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
40%	speed	11.527	11.368	11.121	11.314	11.242	11.026	11.089	11.731	11.619	11.438	11.3475
	delay	227.76	228.324	235.275	229.613	233.297	237.85	234.231	219.227	223.534	229.459	229.857
Trucks Use Left lane Scenario on SR 70												
Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
	travel time	603.671	591.498	591.691	595.314	576.158	569.086	594.703	600.959	587.165	597.117	590.7362
0	speed	18.353	18.365	18.265	18.158	18.759	18.648	18.308	18.23	18.272	18.286	18.3644
	delay	125.148	123.078	125.17	125.371	118.757	119.325	125.299	124.585	124.086	124.61	123.5429
	travel time	611.019	604.179	594.895	610.357	589.519	583.104	614.24	611.826	595.323	613.146	602.7608
5%	speed	17.744	17.748	17.724	17.268	18.195	18	17.293	17.562	17.801	17.58	17.6915
	delay	131.485	129.933	130.466	136.239	125.208	126.549	136.262	132.489	129.794	133.203	131.1628
	travel time	626.927	622.311	605.41	614.182	609.214	602.227	626.709	629.074	607.063	632.831	617.5948
10%	speed	17.013	16.857	16.975	17.023	17.333	17.096	16.645	16.582	17.285	16.852	16.9661
	delay	140.077	140.004	138.377	139.25	135.084	136.657	144.115	143.032	135.663	142.062	139.4321
	travel time	637.026	641.52	610.72	633.03	625.032	613.603	645.504	643.365	620.441	639.712	630.9953
15%	speed	16.453	15.951	16.467	16.006	16.624	16.34	15.82	15.772	16.612	16.15	16.2195
	delay	146.993	151.349	144.862	152.067	142.7	146.62	154.116	153.344	143.302	149.79	148.5143
	travel time	669.512	667.354	647.633	658.487	657.698	674.421	664.068	653.64	660.309	651.219	660.4341
20%	speed	15.176	14.914	15.17	15.105	15.353	14.51	14.845	15.317	15.023	15.388	15.0801
	delay	163.288	164.491	161.809	164.071	159.724	171.514	166.679	158.266	163.522	159.087	163.2451
	travel time	696.35	665.032	675.216	682.585	715.303	684.227	661.373	689.938	717.73	661.976	684.973
25%	speed	14.209	14.489	14.227	14.012	13.776	14.163	14.496	13.906	13.349	14.807	14.1434

TABLE H.1 Continued

Simulation seed Number		1	2	3	4	5	6	7	8	9	10	Average
	delay	178.047	169.311	174.632	178.608	183.246	176.923	170.971	178.66	190.729	168.04	176.9167
	travel time	765.367	736.439	704.609	702.648	772.492	758.128	719.814	714.184	724.496	702.232	730.0409
30%	speed	12.542	12.639	13.199	13.294	12.051	12.357	12.829	13.162	12.945	13.475	12.8493
	delay	207.073	201.036	191.929	191.107	214.809	208.551	199.792	190.667	197.941	188.421	199.1326
	travel time	759.395	753.622	776.359	765.514	808.836	807.08	738.472	737.786	766.213	753.157	766.6434
35%	speed	12.283	11.954	11.414	11.63	11.287	11.229	12.117	12.153	11.584	11.869	11.752
	delay	212.627	214.05	227.435	221.256	231.919	234.656	212.178	209.15	222.006	217.724	220.3001
	travel time	799.218	842.245	820.663	792.329	803.992	800.022	785.068	751.884	776.496	777.326	794.9243
40%	speed	11.411	10.588	10.411	10.82	11.02	10.919	11.043	11.516	11.242	11.438	11.0408
	delay	230.626	249.675	251.061	241.194	238.501	239.824	236.694	224.735	231.197	228.265	237.1772

TABLE H.2: INTERSECTION ANALYSIS

No Restriction Scenario of SR 70									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	137.1	41.3	30	153	43.3	31	158.7	46.5	32.8
2	141.4	41.3	30.3	148.9	44.1	31.8	159.6	47.2	33.6
3	143.2	40.5	29.6	149.1	42.5	30.5	158.4	45.2	32
4	145.7	40.9	29.8	155.4	43.6	31.4	168.4	47.3	33.4
5	129.1	39.2	28.5	139.5	41.1	29.3	152.6	44.9	31.7
6	128.4	39.1	28.6	145.3	42.2	30.4	156.4	46	32.8
7	140.4	41	29.8	154.3	43.5	31	176.4	45.9	32.4

TABLE H.2 Continued									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
8	147.6	40.7	29.7	154.1	44.2	31.8	162.7	45.9	32.5
9	144.9	40.5	29.6	150.7	42.6	30.4	158.5	45.6	32.3
10	139.2	41.1	29.9	151.4	42.9	30.7	158.3	46.1	32.6
Average	139.7	40.56	29.58	**149.8556**	**42.96667**	**30.81111**	**161.2556**	**46.01111**	**32.58889**
	15%			20%			25%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	166.7	48.7	33.8	176.4	52.3	36.1	202	59.1	40.7
2	163.1	48.5	34.1	171.8	52	36.2	186.9	55.5	38.5
3	165.2	47.2	33	171.6	50.5	34.8	187.5	54.7	37.6
4	183	51	35.6	191.6	53.8	37.4	199.9	56.4	38.8
5	167.9	47.1	32.9	176.6	50.4	35	194.5	55.9	38.6
6	167	49.1	34.4	177.4	52	36.2	206.4	55.6	38.4
7	184.4	50.6	35.5	207.3	54.1	37.7	211	55.8	38.5
8	177	48.6	34.3	190.5	52.3	36.7	201.1	53.7	37.1
9	168.4	50.1	35.4	182.6	54.3	38	201	57.1	39.8
10	163.2	49.5	35	175.4	52.4	36.6	201.1	55.6	38.4
Average	170.59	49.04	34.4	182.12	52.41	36.47	199.14	55.94	38.64
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)

TABLE H.2 Continued									
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	223.2	60.1	41.1	242	65.1	44.4	261.2	66	44.4
2	230.5	62.1	42.7	248.1	64.3	43.7	260.3	65.1	44.2
3	216.3	58.9	40.3	245.4	62.4	42.6	258.4	66	45
4	224.1	59.8	40.8	248.9	64.9	44	258	65.7	44.5
5	229.9	61.1	41.6	254.9	65.1	44.1	262	68.2	46.2
6	246.5	65	44.2	261.6	67.8	46.3	267.6	68.5	46.5
7	233.6	61.5	42.2	247	66.5	45.5	259.4	69.7	47.8
8	223.6	58.5	40.7	244	61.9	42.5	263.2	70	48.2
9	214.7	61.3	42.2	250.9	65.4	44.4	258.7	66.9	45.5
10	205.2	58.4	40.1	240.8	64.2	43.4	261.3	67.5	46
Average	224.76	60.67	41.59	248.36	64.76	44.09	261.01	67.36	45.83
Trucks Use Right lane Scenario on SR 70									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	146.5	42.4	31.3						
2	135.4	42.3	31.1	149	45.7	33.3	159.1	48.8	35.3
3	141.2	43	31.7	148.7	44	32	152.9	44.6	32
4	142.8	42.5	31.4	154.9	45	32.8	160.2	46.5	33.5
5	145.3	42.5	31.2	138.7	43.3	31.4	150.5	46.8	33.5
6	129.1	40.5	29.7	144	43.6	31.8	152	46.6	33.7
7	127.6	40.9	30.3	151.1	45.3	32.8	161.3	46	33

TABLE H.2 Continued									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
8	136.1	41.8	30.7	152	45.1	32.9	159.7	45.5	32.9
9	143.9	41.8	31	149.6	43.5	31.5	154.8	45.6	32.8
10	138	42.3	31.2	150	44.3	32.2	154.8	45.9	32.9
Average	138.59	42	30.96	148.6667	44.42222	32.3	156.1444	46.25556	33.28889
	15%			20%			25%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	163.1	49.1	34.8	170.1	51.9	36.6	183.6	56.4	39.5
2	162.7	49.5	35.3	167.8	51.2	36.3	183.3	56	39.3
3	158.5	46.6	33.2	176.5	50	35.4	178.8	54.3	37.8
4	171.9	48.9	34.9	178.3	50.9	35.9	186.5	53.9	37.7
5	161.3	48.4	34.4	175	52.5	37.4	189.4	58.2	40.8
6	162.2	49.5	35.3	170.6	52.2	37.2	187.9	55.4	38.9
7	172.2	49.9	35.7	187.7	54.9	39	190.3	56.6	39.7
8	171.7	49.3	35.4	175.5	50.9	36.3	186.2	55.3	39.3
9	160.8	49.3	35.4	180.5	53.4	38.1	188.2	54.7	38.6
10	160.3	49	34.8	168.8	53.3	37.6	184	56.3	39.4
Average	164.47	48.95	34.92	175.08	52.12	36.98	185.82	55.71	39.1
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)

TABLE H.2 Continued									
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	194.4	59.1	41.1	210	59.6	41.1	223.9	64.9	44.5
2	203.8	60.2	41.9	217.3	64.5	44.8	225.1	63.3	43.4
3	199.6	58.2	40.5	215.3	59.5	41.1	224	62.9	43.3
4	196.9	57.2	39.7	208.3	59.2	41	224.4	64.5	44.4
5	204.9	61.2	42.5	219.1	63.3	43.6	228.8	66.2	45.6
6	207.5	62.9	44	223.2	65	45.4	228	65.6	45.4
7	201.7	58.8	41.1	213.9	65	45.5	224.9	65.4	45.4
8	196	57.5	40.3	209.2	61.7	43.2	221	63.6	44.2
9	199.8	58.8	41.2	208.4	59.1	40.9	229.9	65.5	45.7
10	203.4	61.4	42.5	214.2	64.1	44.1	230.8	67.2	46.1
Average	200.8	59.53	41.48	213.89	62.1	43.07	226.08	64.91	44.8
Trucks Use Center lane Scenario on SR 70									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	136.7	40.9	29.7	152.5	43.6	31.3	159.1	46.2	32.7
2	142	41.7	30.5	148.7	44	31.8	159.3	47.5	33.7
3	143.2	40.6	29.6	150.1	42.8	30.7	158.8	45.6	32.2
4	145.5	40.6	29.5	154.6	43.7	31.4	165	47.5	33.7
5	129.7	39.4	28.6	140.7	42.4	30.4	154.5	44.8	31.5
6	129.1	39.7	29.1	145.8	42.3	30.4	156.8	47.5	33.7
7	138.8	41.2	30	155.3	44.9	32	173.8	47.1	33.4

TABLE H.2 Continued									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
8	147.8	41.1	30	154.2	44.2	31.7	161.8	45.6	32.4
9	145.1	40.6	29.7	151.3	43.1	30.9	157.9	45.9	32.4
10	138.5	40.7	29.6	150.5	42.7	30.4	158.6	46.3	32.7
Average	139.97	40.62	29.62	150.37	43.37	31.1	160.56	46.4	32.84
	15%			20%			25%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	167.7	50.5	35.1	179.9	54.1	37.3	199	57.2	39.3
2	164.1	49.6	34.7	174.5	53.6	37.3	199.4	58.6	40.7
3	165.8	47.9	33.5	173.8	50.9	35.2	194.1	55.8	38.3
4	177.2	49.8	34.9	199.2	55	38	214.2	56.1	38.5
5	176.6	49.9	35.1	179.8	52.2	36.4	196.3	60.1	41.5
6	167.2	50.1	35	200.3	55.7	38.7	204.6	57.5	39.7
7	186.2	50.8	35.4	196.1	53.4	37.3	219.5	58.8	40.4
8	179.5	50.1	35.2	196.1	52.1	36.3	213.6	56.3	39
9	177.2	50.8	35.7	184.2	55	38.6	213.2	59.4	41.2
10	162.1	48.3	33.8	177.1	52.5	36.4	191.1	54.7	37.7
Average	172.36	49.78	34.84	186.1	53.45	37.15	204.5	57.45	39.63
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)

TABLE H.2 Continued									
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	227.9	61.3	41.6	243.6	62.8	42.7	267.3	68.9	46.4
2	229.7	63	43.4	261.3	67.4	45.6	269	70.2	47.6
3	228.1	60.1	40.9	259.2	63.3	43	267.5	68.1	45.9
4	233.9	59.6	40.6	251.7	65.2	44.1	270.7	68.7	46.4
5	245.2	65	44.1	263.4	68.6	46.5	269.5	70.3	47.1
6	250.8	68	46.5	262.7	69.7	47.5	272.4	73.1	50
7	233.5	61.9	42.2	248.1	68.5	46.4	268.5	73.2	49.9
8	236.6	61.4	42.1	257.2	67.9	46.3	261	68	46.3
9	223.7	62.3	42.9	260.3	65.8	44.7	264.2	68.6	46.5
10	218.2	59.8	40.9	242.6	65.3	44.3	262.9	69.5	46.9
Average	**232.76**	**62.24**	**42.52**	**255.01**	**66.45**	**45.11**	**267.3**	**69.86**	**47.3**
Trucks Use Left lane Scenario on SR 70									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	137.4	41.3	30	152.3	43.4	31	159.5	47.1	33.3
2	141.1	41.2	30.2	149.5	44.2	31.8	159.1	47.4	33.7
3	143.3	40.6	29.6	150.1	42.6	30.7	157.8	45.5	32.2
4	145.8	40.5	29.6	155.7	44.5	32.1	163.6	46.5	33.1
5	129.8	39.3	28.5	140.4	41.9	30	153.8	45.7	32.2
6	129.5	39.6	29	145.3	42	30.3	155.9	46.7	33.1
7	139.1	41.2	30	157.9	45.6	32.5	171.1	47.5	33.5

TABLE H.2 Continued									
	0%			5%			10%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
8	148.3	40.9	29.9	154.4	43.8	31.5	164.1	47.9	34.2
9	144.4	40.4	29.5	151	42.6	30.3	159	45.6	32.3
10	139.4	41.1	29.8	151.3	43.2	31	157.5	45.8	32.5
Average	139.81	40.61	29.61	150.79	43.38	31.12	160.14	46.57	33.01
	15%			20%			25%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	167.5	49.7	34.4	179.5	53.8	37.1	199.5	57.8	39.6
2	164.9	49.6	34.9	177.3	54.8	38.1	190	57.3	39.5
3	164.4	47.7	33.5	174.9	53.6	37.2	189.3	54.9	37.6
4	178.8	50.9	35.9	194.2	53.8	37.3	211	55.6	38.1
5	166	48.4	33.9	181.1	53.5	37.1	203.7	60.4	41.7
6	162.5	49.7	34.8	193	56.7	39.4	205.5	58.8	40.6
7	182.6	51	35.7	204	54.6	37.8	205.5	56.7	39.1
8	177.2	50.4	35.8	188.4	52.7	36.8	212.3	58.3	40.6
9	167.4	49.6	35	191.4	55.5	38.9	219.4	61.8	43.3
10	161.6	48.5	33.9	172.7	52.5	36.6	195.8	55	38
Average	169.29	49.55	34.78	185.65	54.15	37.63	203.2	57.66	39.81
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)

TABLE H.2 Continued									
	30%			35%			40%		
Seed Number	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)	aveQueue	Delay(All)	tStopd(All)
1	235.7	63.7	43.4	258.5	64.2	43.6	269.6	68.6	45.9
2	234.3	62.6	43.1	256	68.4	46.6	278.1	70.8	47.7
3	216.1	60.7	41.5	254.6	66.9	45.9	270.6	71.1	48.8
4	228.6	60.8	41.6	258.1	69	47.3	273.1	71.9	49
5	244.2	66.2	45.6	261	69	46.8	272.9	70.2	47.2
6	246.8	66.4	45.5	267	73.8	50.9	272.3	71.8	48.7
7	237	64.2	43.7	248.5	68.7	46.8	270.8	74.4	50.6
8	227.7	63.1	43.8	247.8	65.1	44.6	261.1	68.9	47.1
9	227	65	45	252.9	67.6	46.7	266.4	68.8	47
10	225.6	62.2	42.5	243.7	68.4	47	259	68	46.2
Average	232.3	63.49	43.57	254.81	68.11	46.62	269.39	70.45	47.82

TABLE H.3: Speed, Volume, and Density Data

No Restriction					
Truck Percentage	**Car Speed (mph)**	**Trucks Speed (mph)**	**Volume (vph)**	**Density (vpm)**	**Speed all vehicle types (mph)**
0%	34.618061	0	1284.5555	60.39119077	34.6180614
5%	34.180831	29.798903	1275.5401	61.41562996	33.92022312
10%	33.306698	28.781757	1269.1451	63.8543244	32.79809485
15%	33.090483	28.941657	1229.3496	62.99287921	32.4189912
20%	32.212299	28.066101	1193.0231	64.13165128	31.29515166
25%	31.404502	27.11482	1163.7401	66.297889	30.18504376
30%	31.200528	26.877961	1139.2354	66.13490902	29.76478174
35%	28.937547	25.199149	1091.0205	80.55967948	27.44399528
40%	27.759461	23.896869	1059.1359	87.05000896	26.05320726
Trucks use Right Lane Scenario on SR 70					
Truck Percentage	**Car Speed (mph)**	**Trucks Speed (mph)**	**Volume (vph)**	**Density (vpm)**	**Speed all vehicle types (mph)**
0%	34.85	0.00	1138.80	56.01	34.85
5%	34.24	29.48	1135.40	57.42	33.98
10%	33.97	29.04	1127.50	57.96	33.44
15%	33.47	28.44	1088.58	57.18	32.60
20%	33.10	27.92	1050.53	58.18	31.95
25%	32.95	27.38	1031.79	58.66	31.38
30%	31.88	26.28	993.37	61.68	30.00
35%	30.79	25.45	967.50	65.43	28.62
40%	30.31	24.68	918.89	69.40	27.88
Trucks use Center Lane Scenario on SR 70					
Truck Percentage	**Car Speed (mph)**	**Trucks Speed (mph)**	**Volume (vph)**	**Density (vpm)**	**Speed all vehicle types (mph)**
0%	34.73	0	1286.385	60.141664	34.72510866
5%	33.97	29.49	1278.2412	62.17036548	33.71511769
10%	33.49	28.39	1262.2788	63.83478172	32.92410814
15%	32.87	28.09	1224.7048	63.44121613	32.10016859
20%	32.02	27.17	1195.3858	65.4314308	30.9295195
25%	32.27	26.86	1174.0673	64.47520264	30.74544525
30%	30.75	25.60	1136.8833	70.41586498	29.04408606
35%	28.19	23.67	1091.31	82.0437437	26.37432615
40%	28.02	23.35	1067.8868	88.14969518	25.93418879

TABLE H.3 Continued					
Trucks use Left Lane Scenario on SR 70					
Truck Percentage	**Car Speed (mph)**	**Trucks Speed (mph)**	**Volume (vph)**	**Density (vpm)**	**Speed all vehicle types (mph)**
0%	34.613617	0	1286.5075	60.65504996	34.6136171
5%	33.899696	29.340676	1276.3353	62.10921365	33.57629091
10%	33.44551	28.391593	1269.6217	63.60024749	32.82460025
15%	32.863634	28.098417	1228.4888	63.50644722	32.0702322
20%	32.538562	27.437913	1192.06	64.11387858	31.39360985
25%	31.676658	26.701315	1168.1596	66.46279219	30.27248624
30%	30.05839	25.245472	1125.9784	74.983603	28.40333087
35%	28.166006	23.582555	1056.4573	86.82457264	26.10008476
40%	27.267708	22.738805	1059.6215	86.70576823	25.40101558

APPENDIX I: Network Simulation Results

TABLE I.1: Network Analysis

No Restriction Scenario of the Network												
Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	**average**
	travel time	4803.565	4491.582	4500.266	4364.8	4295.902	4213.628	4255.96	4193.836	4192.49	4231.15	4354.32
0%	speed	7.465	10.496	11.296	12.414	13.089	13.968	14.15	14.335	14.59	14.579	12.6382
	delay	3760.211	3120.529	3029.222	2791.926	2660.834	2503.712	2502.34	2442.984	2414.74	2438.48	2766.5
	travel time	4024.787	4051.019	3973.655	3988.439	4010.501	4048.074	4081.35	4017.4	3960.15	4043.96	4019.93
5%	speed	14.401	14.313	14.788	14.612	14.699	14.642	14.472	14.737	14.962	14.681	14.6307
	delay	2336.84	2360.489	2268.181	2295.04	2296.181	2323.236	2360.79	2291.731	2237.01	2319.51	2308.9
	travel time	3937.955	3977.836	3954.501	3939.495	3938.288	3936.453	3989.16	3868.88	3989.47	3909.71	3944.17
10%	speed	14.007	14.088	14.495	14.373	14.23	14.372	14.393	14.512	14.326	14.436	14.3232
	delay	2332.721	2345.512	2289.207	2291.697	2307.667	2290.376	2317.57	2235.108	2324.84	2266.01	2300.07
	travel time	3908.86	3916.228	3901.991	3819.751	3907.197	3833.155	3904.22	3862.911	3911.35	3882.14	3884.78
15%	speed	13.637	13.911	14.005	14.103	13.792	14.003	13.996	14.142	13.762	14.001	13.9352
	delay	2355.715	2328.15	2313.297	2255.788	2338.021	2270.048	2311.5	2270.167	2346.69	2298.58	2308.8
	travel time	3779.513	3866.671	3804.675	3836.205	3825.551	3847.484	3858.25	3866.319	3835.99	3840.4	3836.11
20%	speed	13.604	13.577	13.827	13.654	13.679	13.521	13.721	13.36	13.532	13.582	13.6057
	delay	2280.963	2335.985	2275.13	2315.471	2304.006	2333.503	2316.21	2363.815	2325.87	2323.58	2317.45
	travel time	3737.273	3826.973	3775.266	3778.177		3829.536	3754.43	3742.017	3782.71	3832.9	3784.36
25%	speed	13.411	13.269	13.474	13.358		13.111	13.43	13.47	13.358	13.191	13.3413

TABLE I.1 Continue												
Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	**average**
25%	delay	2276.343	2345.824	2296.619	2308.242		2368.925	2284.15	2271.887	2310.26	2360.25	2313.61
	travel time	3682.113	3793.349	3723.958	3706.816	3712.241	3731.457	3691.52	3738.38	3722.17	3796.13	3729.81
30%	speed	13.022	12.883	13.157	13.117	13.117	13.017	13.144	12.997	13.045	12.859	13.0358
	delay	2283.604	2368.645	2296.11	2290.236	2295.623	2317.845	2277.74	2323.368	2304.98	2373.16	2313.13
	travel time	3638.692	3717.438	3679.354	3688.85	3658.773	3755.629	3687.5	3647.014	3707.93	3723.11	3690.43
35%	speed	12.824	12.813	12.628	12.756	12.768	12.442	12.948	12.987	12.757	12.803	12.7726
	delay	2277.459	2328.922	2328.463	2318.984	2299.547	2393.428	2296.71	2266.494	2329.05	2333.82	2317.29
	travel time	3671.374	3590.835	3700.932	3582.714	3633.14	3641.801	3715.1	3655.492	3670.29	3681.38	3654.31
40%	speed	12.368	12.535	12.368	12.608	12.263	12.391	12.336	12.517	12.429	12.551	12.4366
	delay	2346.019	2279.761	2368.914	2266.44	2334.473	2327.828	2379.13	2322.404	2338.94	2334.76	2329.87
Trucks Use Right Lane Scenario of the Network												
Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	average
	travel time	4291.857	4195.786	4190	4164.479	4147.848	4103.656	4160.93	4113.063	4073.5	4186.77	4162.79
0%	speed	12.666	14.489	14.79	14.911	15.132	15.348	15.422	15.516	15.561	15.416	14.9251
	delay	2702.851	2420.41	2384.954	2356.799	2321.273	2271.379	2292.08	2253.783	2226.53	2309.45	2353.95
	travel time	3967.631	4013.706	4002.938	3993.221	4002.584	4030.518	4074.17	3944.912	4047.09	3991.94	4006.87
5%	speed	15.039	15.013	15.021	14.999	14.911	14.939	14.911	15.297	15.012	15.218	15.036
	delay	2231.359	2256.443	2254.327	2253.976	2263.916	2277.564	2306.5	2188.028	2278.25	2225.58	2253.59
	travel time	3917.305	3947.659	3890.623	3870.78	3880.371	3914.402	3890.91	3894.614	3922.36	3955.29	3908.43

TABLE I.1 Continue

Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	average
10%	speed	14.653	14.556	14.784	14.901	14.783	14.6	14.962	14.75	14.727	14.373	14.7089
	delay	2247.804	2273.848	2218.357	2192.683	2208.78	2250.434	2192.88	2221.165	2238.9	2304.59	2234.94
	travel time	3843.734	3894.274	3828.1	3814.59	3881.062	3896.15	3929.36	3837.208	3835.71	3865.82	3862.6
15%	speed	14.19	14.071	14.318	14.39	14.193	14.038	14.078	14.272	14.44	14.441	14.2431
	delay	2256.18	2297.074	2232.92	2219.756	2277.123	2305.146	2316.3	2241.984	2221.83	2241.23	2260.95
	travel time	3768.208	3847.576	3816.341	3808.272	3727.761	3770.558	3813.69	3806.564	3831.34	3875.28	3806.56
20%	speed	13.739	13.771	13.938	13.956	14.028	13.916	13.844	13.893	13.7	13.7	13.8485
	delay	2260.358	2305.966	2266.626	2264.462	2206.33	2244.078	2276.19	2262.493	2304.51	2330.12	2272.11
	travel time	3738.176	3854.518	3737.902	3785.244	3784.439	3810.057	3804.19	3752.222	3781.75	3750.98	3779.95
25%	speed	13.642	13.282	13.604	13.426	13.321	13.277	13.247	13.583	13.461	13.496	13.4339
	delay	2250.259	2363.074	2256.137	2307.053	2316.256	2338.348	2335.83	2265.15	2298.67	2274.94	2300.57
	travel time	3700.681	3732.299	3693.642	3743.699	3708.836	3735.905	3755.77	3690.938	3700.67	3776.1	3723.85
30%	speed	13.075	13.117	13.263	13.195	13.2	13.08	12.993	13.345	13.149	12.902	13.1319
	delay	2289.405	2305.175	2268.302	2308.316	2284.714	2313.385	2332.97	2257.198	2281.53	2356.26	2299.73
	travel time	3663.114	3712.916	3699.091	3652.702	3681.093	3718.551	3742.42	3702.187	3629.29	3699.37	3690.07
35%	speed	12.941	12.714	12.872	12.961	12.863	12.645	12.854	12.865	13.075	12.71	12.85
	delay	2280.346	2333.748	2312.246	2275.821	2302.578	2348.941	2340.05	2314.087	2246.08	2331.06	2308.5
	travel time	3638.41	3625.916	3615.598	3645.843	3633.542	3658.517	3703.88	3564.28	3616.93	3653.3	3635.62
40%	speed	12.618	12.629	12.741	12.488	12.491	12.356	12.468	12.869	12.627	12.695	12.5982
	delay	2298.973	2290.566	2274.3	2322.169	2311.676	2341.23	2356.61	2226.016	2285.48	2300.56	2300.76

TABLE I.1 Continued

Trucks Use Left Lane Scenario of the Network

Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	average
0%	travel time	3998.309	4059.358	4059.219	3996.957	4111.985	4038.216	4076.26	4030.355	4060.56	4141.5	4057.27
	speed	15.778	15.934	15.891	15.986	15.718	15.949	15.796	15.817	15.871	15.666	15.8406
	delay	2168.141	2182.139	2188.582	2142.843	2237.595	2170.58	2204.04	2178.652	2190.06	2260.29	2192.29
5%	travel time	3946.322	3944.202	3952.764	3951.074	4006.24	3965.106	4006.53	3974.182	4046.48	3966.53	3975.94
	speed	15.202	15.329	15.346	15.452	15.122	15.34	15.03	15.216	15.032	15.417	15.2486
	delay	2203.946	2189.286	2198.813	2179.854	2247.716	2198.176	2259.01	2221.075	2285.87	2194.95	2217.87
10%	travel time	3956.444	3945.762	3871.795	3852.265	3945.974	3906.7	3931.95	3895.17	3970.94	3946.54	3922.35
	speed	14.46	14.55	15.044	15.018	14.625	14.9	14.653	14.824	14.911	14.642	14.7627
	delay	2293.63	2277.272	2184.089	2174.112	2271.575	2219.445	2257.58	2221.225	2254.99	2271.03	2242.5
15%	travel time	3835.988	3883.952	3836.109	3753.106	3841.494	3815.169	3869.01	3833.255	3856.01	3883.01	3840.71
	speed	14.183	14.297	14.368	14.727	14.301	14.138	14.299	14.329	14.317	14.361	14.332
	delay	2258.153	2272.644	2241.797	2152.802	2249.059	2250.915	2260.07	2239.318	2256.88	2265.63	2244.73
20%	travel time	3809.263	3840.054	3784.023	3740.849	3800.559	3791.865	3759.11	3775.262	3797.35	3766.01	3786.43
	speed	13.676	13.919	13.913	14.137	14.099	13.984	13.948	13.965	13.998	13.976	13.9615
	delay	2295.713	2287.014	2256.76	2207.593	2247.485	2253.562	2236.39	2241.225	2254.11	2239.9	2251.97
25%	travel time	3719.379	3806.052	3755.002	3687.26	3736.081	3806.603	3726.19	3750.574	3714.89	3794.47	3749.65
	speed	13.555	13.26	13.66	13.875	13.441	13.271	13.726	13.287	13.774	13.53	13.5379
	delay	2255.673	2340.465	2266.791	2204.67	2279.102	2341.116	2243	2303.389	2228.21	2304.96	2276.74

TABLE I.1 Continued												
Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	average
30%	travel time	3666.772	3699.005	3655.926	3675.65	3636.258	3700.776	3720.57	3694.252	3715.19	3775.15	3693.95
	speed	13.142	13.383	13.601	13.129	13.103	13.27	13.173	13.253	13.185	13.01	13.2249
	delay	2264.411	2261.068	2213.644	2274.426	2256.894	2275.152	2296.59	2270.899	2291.95	2350.54	2275.56
35%	travel time	3642.393	3604.044	3681.1	3615.053	3624.931	3720.744	3607.08	3677.951	3658.3	3734.51	3656.61
	speed	12.831	13.134	12.779	13.081	13.016	12.572	12.976	12.984	12.916	12.633	12.8922
	delay	2283.695	2226.754	2314.952	2240.488	2256.789	2362.226	2248.42	2290.191	2286.65	2364.11	2287.43
40%	travel time	3568.267	3650.502	3593.105	3613.78	3596.375	3683.122	3613.02	3587.876	3608.21	3648.46	3616.27
	speed	12.566	12.582	12.743	12.621	12.628	12.205	12.478	12.728	12.771	12.576	12.5898
	delay	2264.956	2316.746	2265.202	2288.991	2279.419	2377.197	2301.68	2263.985	2268.66	2315.72	2294.26
Trucks Use Center Lane Scenario of the Network												
Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	average
0%	travel time	4109.489	4116.193	4081.215	4126.315	4125.523	2411.784	4128.4	4089.948	4082.76	4120.37	3939.2
	speed	15.364	15.494	15.724	15.575	15.479	16.427	15.497	15.615	15.707	15.496	15.6378
	delay	2271.035	2257.831	2213.081	2256.962	2264.623	1260.281	2264.94	2229.147	2217.07	2264.73	2149.97
5%	travel time	3977.163	3992.856	3999.902	3985.079	4029.793	4010.518	4046.75	4008.307	4074.39	4015.49	4014.02
	speed	15.119	15.15	15.212	15.21	15.008	15.09	14.978	14.978	14.858	15.238	15.0841
	delay	2224.961	2231.68	2229.527	2224.85	2268.664	2247.503	2281.53	2259.795	2313.18	2236.26	2251.8
10%	travel time	3879.289	3962.617	3932.685	3920.623	3932.438	3970.465	3970.43	3976.477	3930.74	3938.05	3941.38
	speed	14.796	14.609	14.749	14.679	14.656	14.638	14.578	14.371	14.763	14.649	14.6488

TABLE I.1 Continued												
Truck Percentage	Seed Number	10	11	12	13	14	15	16	17	18	19	average
	delay	2207.385	2277.946	2248.59	2246.78	2253.698	2279.817	2282.81	2313.286	2237.11	2260.37	2260.78
15%	travel time	3875.966	3927	3867.645	3809.839	3832.447	3913.067	3856.67	3832.742	3846.41	3938.25	3870
	speed	14.261	14.053	14.329	14.456	14.389	14.004	14.374	14.321	14.467	14.106	14.276
	delay	2265.536	2318.802	2253.284	2209.438	2225.494	2315.717	2239.64	2235.074	2227.24	2322.15	2261.24
20%	travel time	3790.76	3892.553	3823.662	3774.938	3811.672	3873.02	3777.57	3823.809	3826.23	3842.84	3823.71
	speed	13.705	13.654	13.946	13.944	13.873	13.662	14	13.869	13.884	13.855	13.8392
	delay	2278.875	2344.92	2272.122	2244.594	2271.445	2333.011	2234.26	2277.859	2279.03	2293.45	2282.96
25%	travel time	3702.981	3782.964	3741.293	3718.393	3764.828	3752.179	3687.08	3728.944	3724.43	3764.04	3736.71
	speed	13.65	13.519	13.653	13.673	13.355	13.349	13.597	13.414	13.71	13.505	13.5425
	delay	2234.2	2299.373	2261.678	2242.695	2306.888	2299.749	2231.58	2275.088	2240.8	2290.24	2268.23
30%	travel time	3737.315	3669.278	3646.306	3693.413	3745.704	3683.53	3682.79	3721.974	3746.02	3676.43	3700.28
	speed	13.199	13.478	13.426	13.148	13.001	13.285	13.256	13.167	13.099	13.328	13.2387
	delay	2305.097	2233.265	2224.833	2284.168	2332.042	2258.546	2263.78	2297.927	2322.13	2252.63	2277.44
35%	travel time	3658.615	3682.143	3673.027	3578.485	3624.158	3667.908	3660.44	3642.44	3646.86	3722.27	3655.63
	speed	12.853	12.789	12.768	13.229	12.931	12.718	12.875	12.935	12.88	12.806	12.8784
	delay	2290.727	2312.994	2312.888	2201.504	2263.697	2316.085	2289.52	2275.184	2282.46	2338.65	2288.37
40%	travel time	3610.553	3598.158	3624.456	3595.68	3593.26	3591.999	3590.19	3649.933	3626.94		3609.02
	speed	12.519	12.708	12.77	12.604	12.703	12.482	12.773	12.672	12.658		12.6543
	delay	2294.707	2268.972	2281.863	2280.881	2268.377	2290.935	2257.97	2305.254	2294.6		2282.62

TABLE I.2: Intersection Analysis

No Restriction Scenario of the Network												
	0%				5%				10%			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)
1	66.7	48.1	132.2	64577	41.9	28.4	101.2	114494	43.6	29.4	104	109171
2	53.4	37.9	118	87196	42	28.6	101.5	114286	43.1	29	102.4	110827
3	51.7	36.3	119.6	94917	40	27.1	98.3	115389	42.6	28.7	101.1	112807
4	47.5	32.9	112.2	104126	40.5	27.4	97.7	114835	42.5	28.6	102	110976
5	45	31.2	109.2	109304	40.6	27.4	98.3	116678	43.5	29.3	102.6	110275
6	42.4	29.1	105.1	114544	41.5	28.1	100.4	116766	42.8	28.9	101.8	111600
7	42.5	29.3	104	118060	41.8	28.4	101.3	116217	42.7	28.8	102.4	113162
8	42.2	28.9	100.9	117749	41.3	28	99.6	116217	43.1	29.1	99.5	110603
9	41	28	101.9	120542	40.2	27.2	97	116421	42.8	28.7	102.8	112773
10	40.7	27.9	99.8	121135	40.7	27.6	99	117404	42.2	28.5	100.8	112123
average	**47.31**	**32.96**	**110.29**	**105215**	**41.05**	**27.82**	**99.43**	**115871**	**42.89**	**28.9**	**101.94**	**111432**
	15%				20%				25%			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)
1	44.9	30.2	107.3	105913	46.1	30.9	107	101578	47.3	31.5	108.5	99307
2	44.4	29.8	105.5	107435	46.8	31.3	108.1	103864	47.2	31.5	109.7	100165
3	44	29.6	104.7	107251	45.3	30.2	103.9	103721	47.3	31.5	107.6	99749
4	43.7	29.3	102.1	106095	46.4	30.9	107.9	102986	46.5	31	108	99647
5	45	30.2	105.2	106855	46	30.8	106.5	102677				
6	45.3	30.5	103	105188	46.6	31.1	107.8	102437	48.6	32.3	111	99052

TABLE I.2 Continued												
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)
7	44.1	29.5	105	107847	46	30.9	108	104848	47	31.4	108.2	100215
8	44.4	29.9	103.3	107917	47.4	31.8	109.9	101556	47.3	31.3	108.4	99279
9	45.2	30.3	106.1	106349	46.9	31.3	109.5	102350	46.7	30.9	109.5	100134
10	43.7	29.5	104	107576	46.2	30.9	107.1	103513	48.5	32.3	111.9	99568
average	**44.47**	**29.88**	**104.62**	**106843**	**46.37**	**31.01**	**107.57**	**102953**	**47.3778**	**31.522**	**109.2**	**99680**
	30%				35%				40%			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay(All)	tStopd(All)	aveQueue	Veh(All)
1	48.2	32	110.8	94834	50	33	113.3	92399	52	34.4	117.2	89789
2	49.1	32.5	113.6	96896	50.2	33.1	114	94499	50.2	33	114.4	89632
3	48.5	32.2	109.9	96422	50.2	33.4	112.7	92187	52.5	34.5	118.9	89838
4	48.4	32.2	110.6	95835	50	33.2	114.1	92736	51.3	34	114	89183
5	48.8	32.4	110.8	95899	50	33.1	112.9	91969	52.3	34.6	116.4	87991
6	49.3	32.7	112.4	95001	50.8	33.7	116.6	92450	52.2	34.5	116.6	89404
7	48.3	32.1	110.3	96130	49.9	33	112.9	94030	52.4	34.7	119.5	90670
8	49.5	32.9	110.9	95249	49.9	32.8	112.4	93280	50.4	33.3	115.4	90156
9	48.8	32.4	111.4	95832	50.2	33.1	115.4	93630	51.2	33.8	116.5	89877
10	49.8	33.1	114.2	96297	50.2	33.2	114.3	94118	52.3	34.5	117.6	90969
average	**48.87**	**32.45**	**111.49**	**95839.5**	**50.14**	**33.16**	**113.86**	**93130**	**51.68**	**34.13**	**116.65**	**89751**
Trucks Use Right Lane Scenario of the Network												
	0%				**5%**				**10%**			

TABLE I.2 Continued

Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	43.5	29.8	108.6	106690	40.4	27.3	96.9	117826	41.9	28	101	113507
2	40.1	27	99.7	120266	40	27	95.9	118374	41.9	28.1	101	113635
3	39.3	26.7	97.4	121324	39.5	26.7	96.2	118669	41.3	27.8	97.1	113239
4	39	26.5	97.4	121696	40.3	27.2	96.9	117942	40.4	27.1	96.4	113403
5	39	26.4	95.9	123657	39.5	26.7	95.9	117655	41.2	27.5	97.5	113754
6	38.2	25.7	95.4	124548	41	27.7	97.4	118482	42	28.2	99.8	112679
7	38	25.7	95.8	127020	40.3	27.1	98.4	119578	40.3	26.9	97.5	114405
8	38.1	25.8	94.2	125605	39.2	26.4	93.9	119078	41.9	28.1	99.4	113046
9	37.4	25.2	93.5	124986	40.3	27.1	98.2	119801	41.4	27.7	97.2	114494
10	37.9	25.7	95	127256	39.2	26.5	95.3	119870	42.4	28.6	100.2	112283
Average	39.05	26.45	97.29	122305	39.97	26.97	96.5	118728	41.47	27.8	98.71	113445

	15%				**20%**				**25%**			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	43.8	29.2	103.7	107707	46.1	30.8	105.4	102387	46.6	30.8	107.4	100749
2	43.6	28.9	103.7	108755	45.5	30.3	104.9	104635	48.1	32	111	101517
3	43.1	29	100.1	108507	44.9	29.9	104.1	105037	46.5	30.8	106.5	99656
4	43.1	28.9	100.4	108108	45.5	30.3	104.8	105611	46.6	31	108.9	100183
5	43.3	29	101.9	108638	44.4	29.7	101.6	103380	47.3	31.5	108.2	99341
6	44.8	29.9	103.2	107517	45.2	30.1	103.7	103504	47.9	31.9	109.2	99905
7	43.9	29.3	103.4	108876	45.6	30.6	104.4	104477	47.5	31.6	109.7	99928

TABLE I.2 Continued												
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
8	43.7	29.3	101.6	107928	45.2	30.1	104.7	103960	47.2	31.4	107.3	100279
9	42.1	27.9	100.1	109866	45.1	29.9	106.2	103600	46.9	31.2	108.1	100500
10	42.9	28.6	101	110930	46.3	30.9	106.3	104965	46.8	31.1	107.1	100992
Average	43.43	29	101.91	108683	45.38	30.26	104.61	104156	47.14	31.33	108.34	100305
	30%				**35%**				**40%**			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	48.5	32.1	111.5	95526	50	33.1	113.1	93677	50.5	33.1	115.7	91028
2	47.7	31.6	111.7	96658	50	33.1	113.1	93677	50.4	33.2	115.5	91007
3	47.8	31.7	109.1	96388	49.3	32.4	113.8	93696	50.6	33.4	112.7	90849
4	48.7	32.2	109.9	97043	49.3	32.7	112.5	93210	51.3	34	115.1	90070
5	48.8	32.4	110.5	96256	49.1	32.2	111.8	93638	51.1	33.7	114.7	89297
6	48.4	31.9	110.8	96670	51.1	33.8	115.5	92710	52.2	34.4	116.6	89464
7	48.2	32	111.5	96187	48.8	32.3	114	94813	51.2	33.8	117.8	91059
8	48.3	32.1	108.7	97152	50	32.9	112.8	93830	49.9	32.9	111.5	90247
9	47.5	31.4	109.2	96526	48.9	32.2	110.6	93769	50.1	33	113.8	90138
10	49.6	33	113.3	96435	50.2	33	114.8	93338	50.3	33.2	115	92032
Average	48.35	32.04	110.62	96484.1	49.67	32.77	113.2	93636	50.76	33.47	114.84	90519
Trucks Use Left Lane Scenario of the Network												
	0%				**5%**				**10%**			

TABLE I.2 Continued

Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	37	24.9	91.5	124032	40.3	27.1	97.4	118559	43.2	28.8	103.6	113352
2	36.4	24.4	92.2	127887	39.4	26.4	96.8	119930	42.6	28.6	101.4	113567
3	36.8	24.9	93.6	126995	38.4	25.8	94.4	119088	40.7	27.3	98.4	114524
4	36.3	24.4	91.4	125981	39.6	26.6	96.7	120507	40.6	27	98.1	114366
5	37.2	25.1	94.6	127721	40	27	97.5	119683	42.2	28.4	101.8	113694
6	37	24.9	93.2	126980	39.5	26.6	96.8	119892	41.8	28	99.8	114648
7	37.5	25.3	94.3	127018	40.7	27.4	99.2	118797	41.5	27.8	100.6	113638
8	37.2	25.1	92.8	125861	40	26.9	98	119014	42.2	28.2	100.9	113868
9	36.6	24.5	94.7	126882	40.3	27.1	99.8	119620	41.4	27.5	101.2	116773
10	37.3	25.2	94.6	127834	39.5	26.6	95.8	120172	42.3	28.4	101	114053
average	36.93	24.87	93.29	126719	39.77	26.75	97.24	119526	41.85	28	100.68	114248
	15%				**20%**				**25%**			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	44.2	29.5	103.9	107322	46.8	31.1	109.1	102966	46.9	30.9	109.4	99873
2	43.8	29.1	104.4	109447	44.9	29.9	106.8	105612	47.2	31.4	110.9	99822
3	43.7	29.2	103.5	108525	45.3	30.3	104.7	103873	47.3	31.3	109.1	100767
4	41.6	27.7	98.9	109058	44	29.1	104.4	103999	45.9	30.3	104.8	100873
5	43.2	28.8	102.7	108277	45.2	30	105.8	105489	47.5	31.6	109	98659
6	44.3	29.6	103.9	106256	45.9	30.6	107.3	104477	48.4	32	112.3	99210
7	43.5	29.1	103.3	109275	45.1	30	106.4	103217	46.8	31	107.9	100214

TABLE I.2 Continued												
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
8	43.9	29.3	104	108085	45.3	30	105.6	103852	47.9	31.7	110.4	98202
9	43.4	28.8	103.9	108901	45	29.8	105.8	104858	46.4	30.5	106.8	101016
10	43.3	28.8	102.9	109663	45.2	30.1	105.3	104093	47.2	31.2	111.4	101623
average	43.49	28.99	103.14	108481	45.27	30.09	106.12	104244	47.15	31.19	109.2	100026
	30%				**35%**				**40%**			
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	48.3	31.8	111.9	95695	50	32.9	114.9	92321	51.7	34.1	115.6	88951
2	47.6	31.3	111.1	97703	48.6	32	110.7	93946	51.4	33.8	118.8	90814
3	46.9	30.8	107.7	98118	49.6	32.7	115.5	92520	50.6	33.3	115	90524
4	48.8	32.2	112.1	94623	49.8	32.9	112.7	93070	51.1	33.5	117.4	89645
5	48.5	32.1	109.2	93874	48.6	31.9	110.9	93424	50.5	33.1	114	89842
6	48.8	32.2	111.9	96803	51.1	33.5	117	92106	53.2	35	120.8	88458
7	47.4	31.2	111.9	96961	48.9	32.3	111.9	93036	51.1	33.7	118.1	88928
8	48.7	32.2	111.3	95998	49.9	33.1	113.9	93935	50.4	33.2	115.5	89541
9	48.2	31.9	111.8	96612	49.6	32.5	113.9	93031	50.6	33.1	115.3	91091
10	49.1	32.4	114.5	97168	50.4	33.3	118.4	93177	50.7	33.3	117.9	91022
average	48.23	31.81	111.34	96355.5	49.65	32.71	113.98	93057	51.13	33.61	116.84	89882
Trucks Use Center Lane Scenario of the Network												
			0%				**5%**				**10%**	

TABLE I.2 Continued

Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	37.4	25.2	94.3	124796	39.7	26.7	96.2	118297	41.6	27.9	98.8	113674
2	37.5	25.2	94.4	126321	39.9	26.8	96.2	119737	42.1	28.3	100.7	114390
3	36.8	24.9	91.6	126342	39.2	26.4	95.6	120003	41.2	27.7	98	114487
4	37.4	25.3	93	126529	38.7	25.9	95.2	119238	41.5	27.6	100	113352
5	37.4	25.2	94.3	126075	39.4	26.6	96.6	119930	41.5	27.8	99.8	114178
6					40.2	27	97.3	119230	43.2	29	101.7	114074
7	37.2	25.1	94.3	126538	40	27	97.9	120334	42.2	28.2	101.5	114204
8	38.5	26.2	93.9	125816	40.3	27.2	97.5	118405	42.4	28.5	102.2	112196
9	36.1	24.3	93.2	126412	40.2	26.9	99.2	118960	41.1	27.5	98.8	114967
10	37.3	25.2	92.7	125929	39.2	26.4	95.8	120999	41.7	28	98.4	114285
Average	37.29	25.18	93.52	126174	39.925	26.875	97.6	119675	41.85	28.05	100.23	113913
			15%				**20%**				**25%**	
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	43.4	28.9	102.9	109438	45.9	30.6	106.7	102870	45.9	30.2	107.9	100020
2	44.4	29.6	105	109320	45.9	30.6	107.6	105098	47.1	31.3	109.6	100929
3	42.8	28.7	101.2	108970	45.2	30.2	103.4	104961	46.7	31.1	108.9	100228
4	42.7	28.5	100.5	108838	45.4	30.2	105.3	104452	46.5	30.9	107.6	100067
5	42.3	28.2	100.8	109207	45.6	30.4	105.7	104394	47.3	31.5	108.9	99203
6	44.9	30	103.7	108000	46.1	30.8	107.9	103994	47.7	31.6	110.3	98965
7	43.4	29	101	109500	45.1	30.1	103.9	104653	46.2	30.6	106.8	99237

TABLE I.2 Continued												
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
8	43.6	29.1	101.5	108465	45.8	30.5	107.1	104892	47.2	31.2	109.6	99005
9	42.7	28.5	101.2	110280	45.5	30.3	105.2	104722	45.6	30.1	107.6	100667
10	44.4	29.6	105	109826	45.6	30.6	104.9	104685	47.3	31.5	109.5	100490
Average	43.46	29.01	102.28	109184	45.61	30.43	105.77	104472	46.75	31	108.67	99881
			30%				**35%**				**40%**	
Seed Number	Delay(All)	tStopd(All)	aveQueue	Veh(All)	Delay (All)	tStopd (All)	aveQueue	Veh(All)	Delay(All)	tStopd (All)	average Queue	Veh(All)
1	48.5	31.9	111.3	96928	50	33	114.2	92713	50.7	33.2	117.1	89643
2	48.1	31.8	113.3	97826	50.2	32.9	114.3	93623	50.2	33	114.8	90668
3	48.6	32.2	109.3	97193	49.7	32.8	113.7	91932	51.2	33.7	115	90995
4	47.6	31.3	109.1	96461	48.6	31.9	109.2	93489	51	33.7	116.3	89798
5	48.7	32.3	110.1	95592	48.7	32.1	111.4	92544	50.9	33.4	114.7	90081
6	49.9	32.9	113.6	95719	51.1	33.8	114.9	92054	52.5	34.5	117.7	88382
7	47.3	31.3	110.6	96707	50.2	33.3	113.8	93208	50.2	33.3	113.8	93208
8	48.4	31.9	110.5	96239	50	33	113.3	92500	49	32.2	113.6	90545
9	48.5	32	112.2	96433	49.2	32.4	114.6	92462	50.7	33.2	117.1	91265
10	49	32.4	113.2	97251	50.7	33.4	117.2	93993	50.5	33.1	116.1	90822
Average	48.46	32	111.32	96634.9	49.84	32.86	113.66	92852	50.69	33.33	115.62	90541

TABLE I.3: Speed, Volume, and Density Data

No Restriction Scenario of the Network					
	Car Speed	Truck Speed	Volume (vphpl)	All Vehicle Speed	Density (vpmpl)
0%	32.867	0.000	320.062	32.853	13.023
5%	32.528	32.270	311.693	32.453	13.700
10%	32.653	32.170	296.259	32.507	13.151
15%	32.469	31.934	276.897	32.301	12.870
20%	32.659	32.025	263.736	32.423	12.237
25%	32.106	31.318	256.789	31.811	13.012
30%	32.182	31.948	253.823	31.922	12.345
35%	32.270	31.491	246.643	31.897	12.012
40%	31.896	31.175	234.761	31.431	12.790
Trucks Use Right Lane Scenario of the Network					
	Car Speed	Truck Speed	Volume (vphpl)	All Vehicle Speed	Density (vpmpl)
0%	32.854	0.000	313.808	32.845	12.814
5%	32.685	30.567	312.804	32.602	13.525
10%	32.364	30.343	292.908	32.227	13.567
15%	32.444	30.202	275.150	32.214	12.736
20%	32.546	30.186	260.568	32.267	12.293
25%	32.233	29.441	256.172	31.795	12.921
30%	32.269	29.540	249.804	31.881	12.218
35%	32.034	28.865	246.013	31.404	12.718
40%	32.225	28.840	240.552	31.586	12.606
Trucks Use Left Lane Scenario of the Network					
Truck Percentage	Car Speed	Truck Speed	Volume (vphpl)	All Vehicle Speed	Density (vpmpl)
0%	32.748	0.000	334.484	32.743	12.722
5%	32.720	31.025	313.449	32.628	12.652
10%	32.594	30.326	285.731	32.432	12.052
15%	32.691	30.060	297.596	32.398	12.387
20%	32.561	30.130	280.111	32.229	12.779
25%	32.199	29.579	259.947	31.820	11.725

TABLE I.3 Continued					
Truck Percentage	**Car Speed**	**Truck Speed**	**Volume (vphpl)**	**All Vehicle Speed**	**Density (vpmpl)**
30%	32.609	29.900	256.742	32.117	11.054
35%	32.412	29.410	252.745	31.779	11.437
40%	32.240	29.200	241.939	31.522	11.085
Trucks Use Center Lane Scenario of the Network					
Truck Percentage	**Car Speed**	**Truck Speed**	**Volume (vphpl)**	**All Vehicle Speed**	**Density (vpmpl)**
0%	32.880	0.000	311.136	32.866	12.830
5%	32.681	30.988	310.985	32.556	13.430
10%	32.560	31.042	295.229	32.328	13.074
15%	32.575	30.793	276.388	32.277	12.638
20%	32.764	30.618	259.962	32.331	12.217
25%	32.265	29.899	258.789	31.628	13.109
30%	32.320	30.367	258.433	31.823	12.434
35%	32.258	29.710	239.265	31.460	12.566
40%	32.204	27.983	235.877	31.313	13.110

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