MONETIZING TRUCK FREIGHT AND THE COST OF DELAY FOR MAJOR TRUCK ROUTES IN GEORGIA

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MONETIZING TRUCK FREIGHT AND THE COST OF DELAY FOR MAJOR TRUCK ROUTES IN GEORGIA

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LIST OF SYMBOLS

α	A coefficient equal to 0.15
β	An exponent equal to 4
$s_{20XX,\, i}$	Speed for a given link *i*, during a designated year (2007 or 2040)
t	Final link travel time
t_o	Free-flow link travel time
V/C	Volume-to-Capacity ratio

LIST OF ABBREVIATIONS

AADT	Annual Average Daily Traffic
AADTT	Annual Average Daily Truck Traffic
ATR	Automated Traffic Recorder
ATRI	American Transportation Research Institute
CBA	Cost Benefit Analysis
CFS	Commodity Flow Survey
CV	Compensation Variable
FAF^3	Freight Analysis Framework, Version 3
FARS	Fatal Accident Reporting System
FHWA	Federal Highway Administration
FPM	Freight Performance Measure
GDOT	Georgia Department of Transportation
GIS	Geographic Information System
GPS	Global Positioning System
HTS	Highly Time Sensitive
Ktons	Kilotons
LTS	Low Time Sensitive
MOVES	Mobile Vehicle Emission Simulator
MPO	Metropolitan Planning Organization
MTS	Moderately Time Sensitive
NCHRP	National Cooperative Highway Research Program
O-D	Origin-to-Destination
ODCM	Origin-Destination-Commodity-Mode
RFID	Radio Frequency Identification
SCTG	Standard Classification of Transported Goods
STP	Stated Preference Survey
TEF	Truck Equivalency Factor
Tot	Total
VCR	Volume-to-Capacity Ratio
VOD	Value of Delay
WTP	Willingness to Pay

SUMMARY

This research provides an example delay calculation for long-haul single unit and combination trucks on Interstate-75 (I-75) in Georgia. Truck profiles on Georgia interstates are used to calculate the value of freight by truck type and commodity moved. Determining the types of trucks and commodities moved within the state of Georgia allows the researcher to monetize the effect of recurring congestion by location in addition to the cost of lost time.

This research expands on the concepts of performance measures by integrating commodities moved by truck type into cost of delay calculations specifically for I-75 between Macon, GA and the Florida-Georgia border. A more accurate calculation of delay based on truck type and commodity moved will better inform the Georgia Department of Transportation about the performance of Georgia's major truck routes, and its potential effect on the local economy.

A review of past research on this topic found that the calculated cost of delay in previous studies varied widely based on truck and commodity type. The identification of the types of commodities moved can assist in better monetizing the value of truck freight. The growing importance of putting a value on different types of truck freight delay costs are demonstrated by using forecast data on future truck traffic volume increases in the corridor.

1 INTRODUCTION

1.1 Problem Statement

Congestion is becoming a recurring and expected problem among drivers in the United States. With a projected increase in the amount of congestion on highways, there is an expected increase in the cost of traffic delays. With an increase in the cost of delay, the growth in population and economic activity that has been increasing faster in the South and West [1] than anywhere else in the United States may be hindered. For continuous population and economic growth, the issue of congestion needs to be addressed, especially with regard to goods movement.

Ninety-four percent of the goods in Georgia are moved by truck. The efficient movement of goods in the state directly influences the local economy. With the rising influence and effect of congestion on Georgia highways for personal vehicles as well as trucks, being able to more accurately calculate delay is important for highway planning in Georgia, especially with a projected increase in the tons and value of freight being moved. This projected increase in goods movement comes in turn from an increase in demand from decentralized buyers and sellers as well as an increase in demand for just-in-time deliveries. As demand increases, the need for the accurate calculation of delay for trucks increases. Increasing the importance of efficient on-time goods deliveries, many of these goods moved by truck are considered "high value goods". For example, in 2007, over two-thirds of goods moved in the United States were considered high-value, time sensitive goods; by weight, these goods only made up one eighth of the tons moved [2].

Currently, popular delay cost calculations use vehicle- and driver-based costs. However, additional considerations should be made when determining the cost of delay for trucks. This research adds to the existing literature by estimating delay cost per-mile using truck type and commodities carried as well as both vehicle- and driver-based costs. Delay costs are then used to assess the performance on specific high truck volume highways in Georgia. Opportunities for improved performance measurement are also discussed.

1.2 Research Objectives and Purpose

The objective of this research is to more accurately calculate delay costs for trucks through the addition of variables that indicate truck type and the type of commodities carried, in addition to the more commonly used variables related to truck operation costs and driver-based costs. This information can then be used to indicate performance on Georgia's highways by identifying key locations where current or future delays are likely to be costly. New variables are added in the delay cost equation in order to perform a sample calculation on the section of Interstate-75 (I-75) of Georgia from Macon to the Georgia-Florida border as seen in Figure 1. The focus on this corridor is on long-haul, single unit and combination trucks. While the scope of this research is limited to a single major truck corridor and its major freight generators and attractors, the process used to calculate delay costs can be adapted for use on other freight significant corridors.

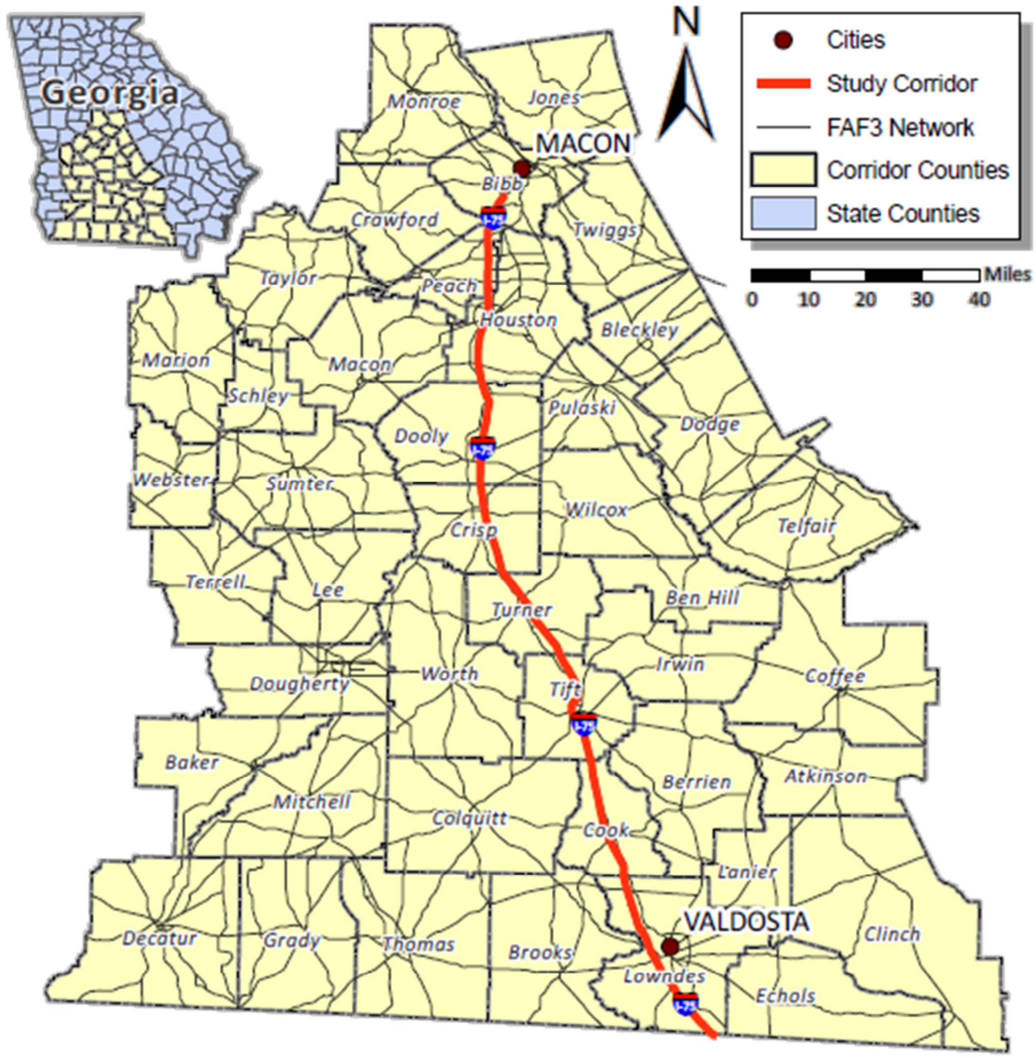

Figure 1—Study Corridor (I-75)

The remainder of this thesis is organized as follows: Chapter 2 describes previous work and findings on the value of travel time for freight and also past work done regarding the cost of commodities. Chapter 3 reviews the data sources used in the empirical analysis, and Chapter 4 describes the study area. Chapter 5 describes how the cost of movement per mile and delay are calculated. Finally, Chapters 6 and 7 present the empirical findings and overall conclusions of the thesis respectively.

2 LITERATURE REVIEW

According to the 2010 "Freight Facts and Figures", freight is traveling farther and is driven by the "geographic distribution of population and economic activity" [1]. Because of projected and expected increases in congestion, Samimi et al. (2011) describe how societal benefits in terms of travel time, fuel use, pollution reduction, and the lessening of other negative consequences associated with surface transportation can result from reducing the over-reliance on the highway transportation network to move goods [3]. In order to determine overuse and overreliance on the surface transportation network, highway performance measures and the costs of delay can be used to quantify and monetize the impacts of congestion. This portion of the thesis reviews and analyzes previous work performed on aspects of travel time, freight value of time, truck freight performance measures, and commodity movement.

2.1 Truck-Freight Value of Time

Currently there is a lack of disaggregate data to help modelers simulate freight behavior [3], and calculate value of time to apply to freight transportation improvements. As noted by Wheeler (2010), the value of time for trucks can range anywhere from $20 per hour to $190 per hour [4]. Similarly, in a report by Small et al. (1999), the value of freight travel time savings in congestion was found to range from $144.22 to $192.83 per hour [5]. The report by Small et al. (1999) conducted a survey on freight carriers in California that represented four industry groups with varying commodity time sensitivities. The survey population was extremely small but yielded informative results that indicate the considerable importance of freight transit time and cost for decision-makers.

Due to the large amount of variability reported in Wheeler's (2010) paper, Southworth and Gillett (2011) conclude that this "suggests considerable value could be derived from associating specific truck movement delay costs…with the type(s) of commodities moving through a corridor" [6]. While the actual percentage effect of including the cost of moving commodities through a corridor as it affects delay cost is unknown, major components of freight value of time come from driver wages and fuel. As described in a paper by Tavasszy (2005), up to 60 percent of transportation costs can come from driver wages creating a link between driver wages and productivity in terms of transportation efficiency [7]. For example, driver wages could also be affected by delay if drivers are paid on an hourly basis.

The direct shipping costs are also described by the American Transportation Research Institute (ATRI). ATRI (2008) performed an analysis of trucking operation costs. Based on the results of the analysis, it was determined that it costs approximately $1.73 for a truck to move one mile on average, and if traveling for one hour, the cost to operate is $83.68. Table 1 shows the variables considered in determining these per-mile and per-hour rates [8]. These ATRI estimates are made in the empirical analysis presented in Chapter 6 below.

Table 1—Truck Operational Costs

Motor Carrier Marginal Expenses	Costs Per Mile	Costs Per Hour
Vehicle-based		
Fuel-Oil Costs	.634	$33.00
Truck/Trailer Lease or Purchase Payments	.206	$10.72
Repair and Maintenance	.092	$4.79
Fuel Taxes	.062	$3.23
Truck Insurance Premiums	.060	$3.12
Tires	.030	$1.56
Licensing and Overweight-Oversize Permits	.024	$1.25
Tolls	.019	$0.99
Driver-based		
Driver Pay*	.441	$16.59
Driver Benefits	.126	$6.56
Driver Bonus Payments	.036	$1.87
Total Marginal Costs	**$1.73**	**$83.68**

*CPH figures are based on respondents' actual driver hourly pay rates

Kawamura (2000) notes deficiencies in the past methods of value of time calculations due to overly conservative estimates that result from using only the travel -time cost-savings method [9]. Where highway project costs and benefits are being evaluated, some planning agencies use labor, operation, cargo handling, and storage costs [8].

In the Georgia Statewide Strategic Transportation Plan three components to a supply chain cost are mentioned: the direct cost of shipping, direct inventory cost, and obsolescence cost (see Table 2). This final component of the supply chain cost is the one that would most directly take into account the value of the commodity in computing delivery delay costs.

Table 2—Components of Supply Chain Costs

Supply Chain Cost	Description
Direct Shipping Cost	The cost directly associated with moving goods from one location to another. These cost can include but are not limited to fuel, the cost of the truck, and driver wages
Direct Inventory Cost	The cost associated with carrying goods on a truck. For example,
Obsolescence Cost	The cost associated with the risk of the goods being carried depreciating while in transit.

Indications of the importance of capturing the obsolescence cost can be found by looking at the results from the National Cooperative Highway Research Program (NCHRP) Report 431 (1999), findings by Miao et al. (2011), and a report by MacroSys Research and Technology (2005) [5, 10, 11]. The conclusions from the stated preference survey (STP) conducted by Small et al. (1999) identified the value of travel time savings ranging from $144.22 to $192.83 per hour [5]. The survey conducted in the report surveyed freight carriers that reflected the varying time sensitivities of commodities moved. Although the response rate for the survey was low, an idea of the large range of time savings, especially when attributed to commodity time sensitivities was seen.

In another report by Miao et al. (2011), the value of delay (VOD) ranged from $33.25 to $56.48 per hour for the entire dataset [10]. To further investigate the perceived value of delay for truckers and carriers, the data was broken down into groups. Some of the grouping methods included the type of carrier, trip length, and salary method. When grouping the values of delay, an even larger range of values appeared. The survey used to identify value of travel time savings for various truck drivers and receivers took into account the type of cargo carried whether it was bulk, average value, high value or other

[10]. Although commodity value and sensitivity are not necessarily correlated, they can be related.

Finally, in the report prepared by MacroSys Research and Technology (2005), three components of logistics costs are described: “inventory-carrying costs, transportation costs, and administrative costs” [11]. The inventory-carrying cost component accounts for 33 percent of the total logistics costs. Sixty-six percent of that is taxes, obsolescence, depreciation, and insurance costs. Obsolescence cost alone accounts for 33 percent of the inventory-carrying cost.

2.2 Freight Performance Measures

In order to provide accountability for road service, the performance of freight significant corridors needs to be tracked on a yearly basis. A report by Southworth and Gillett (2011), “Freight Performance Measures: Trucking in Georgia” describes the importance of tracking performance over time. With a projected growth in truck traffic, being able to accurately measure traffic today as well as evaluate how effectively it is moving is essential. The report contains a review of literature describing freight performance measures that can assist state DOTs in tracking truck performance throughout the state. According to the report, and using the criteria developed by following Schofield and Harrison (2007) , performance measures should be measurable, capture deficiencies, be measured over time, capable of being forecast, and easily understood [6, 12].

The motivation behind performance measures stems from the need for reliable, cost-effective, and safe freight service. Figure 2 captures the motivation behind many of the freight performance measure activities engaged in by state DOTs and Metropolitan

Planning Organization (MPOs) in recent years [6]. The provision of reliable, cost-effective, and safe trucking service requires maintaining the quality of both the truck vehicle fleet and the highway network they move over. This in turn requires adequate highway capacity and connectivity that is managed and maintained over time. Planning agencies need to track and evaluate how well these capacity and connectivity provisions are being met, and these suggest the development and maintenance of a suitable set of truck freight performance measures (FPMs) such as those shown in the right-hand list of Figure 2.

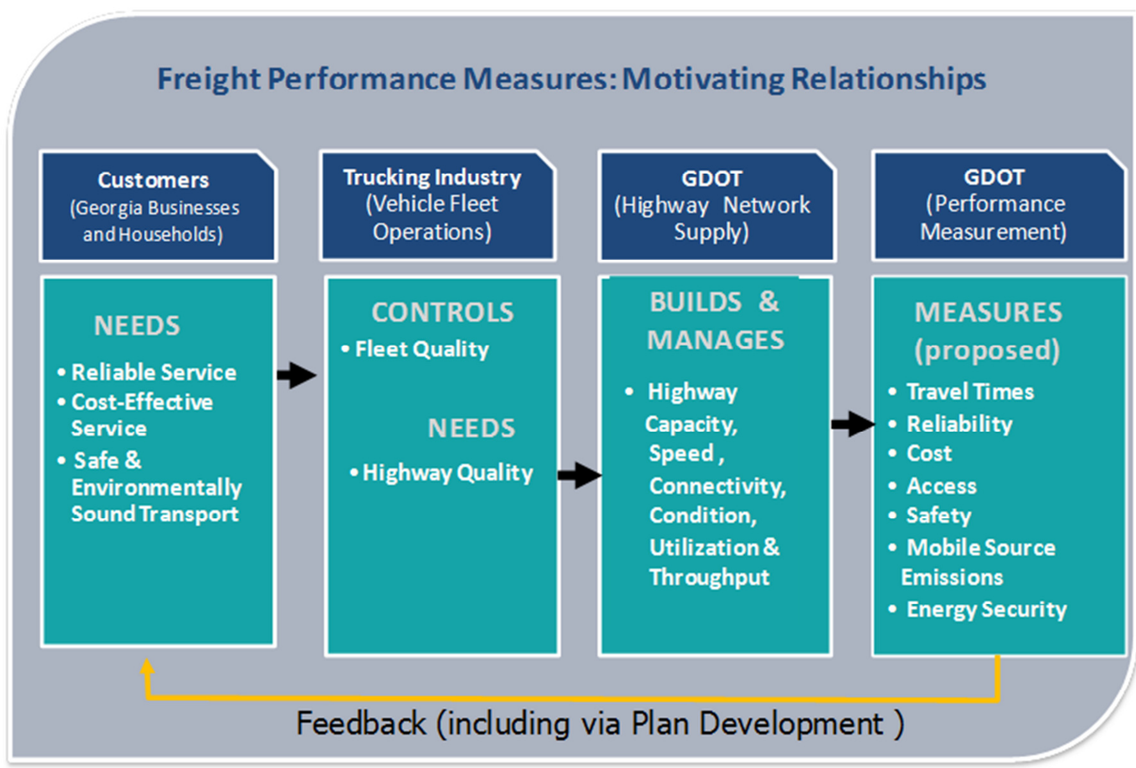

Figure 2—Freight Performance Measures Motivating Relationship

A modification of this general concept lead to seven categories of performance measures described in the report: network supply, travel time, travel safety, energy security, mobile source emissions, monetary travel costs, and regional accessibility [6]. Based on the categories of measures, proposed measures were identified and calculated for a test corridor using a variety of data sources, including FAF[3] (Freight Analysis Framework Version 3), GDOT (Georgia Department of Transportation) traffic volumes, ATRI (American Transportation Research Institute) speeds, along with MOVES (Mobile Vehicle Emission Simulator) reports and FARS (Fatal Accident Report System) data. The data preparation steps used to develop the freight performance measures listed in Table 3 [6] are also used to calculate the delay costs presented later in this thesis as described in Chapter 3 below.

Table 3—Calculated Performance Measures

Performance Measures	
Network Supply	Average Mixed Traffic Volume (AADT) Average Truck Volume (AADTT) Tons of Freight Transported Daily Average Daily Vehicle Miles of Travel
Travel Time	Average Speed Average Travel Time 95^{th} Percentile Travel Time Planning Time Index Buffer Index
Energy Security	Average Daily Fuel Use (Truck-Gallons)
Mobile Source Emissions	Average Daily Emissions (grams)
Travel Cost	Average Daily Dollar Cost of Delay Average Daily Cost of Travel Time Variability Corridor per mile Delay Cost Index
Safety	Number of Heavy Truck-Involved Fatal Crashed Number of Fatal Crashes per million Truck-Miles

With a diverse range of measures, focus will be placed in this thesis on monetary travel costs, specifically those dealing with daily delays costs and a corridor per-mile delay cost index. In doing so, the method described by Southworth and Gillett (2011) was built upon to further refine these trucking delay cost calculations.

2.3 Commodity Valuation

According to a guide prepared by Cambridge Systematics, Inc. et al (2006), the increases in trade and movement of goods will cause increases in capacity and a decrease in travel reliability which will cause "transport and supply chain costs [to] go up, raising prices for U.S. consumers and lowering the competitiveness of U.S. businesses" [13]. Due to the potential detriment to the economy, being able to accurately put a value on commodities moved along a corridor in combination with the cost of delay of those commodities can assist decision-makers in identifying risk areas.

Samimi et al. (2011) use binary and logit models to describe freight mode choice. Though the 2011 report looks at mode choice, some of the indicator variables can still be used to help explain how shippers and receivers choose to move their goods and what determinants are most important. The data model looked at transportation cost, distance traveled, access to intermodal facilities, as well as the weight and value of commodities being moved [3]. Limdep econometrics software was used to analyze the impacts of explanatory variables on mode choice. Of the variables used, the truck-cost-index (represented by $Ln((Truck - Cost)/(Truck - Time * Value))$) proves informative. The study found that truck mode choice is very sensitive to distance (which tends to be an indicator of travel time), weight, and cost, showing that long distance and larger, high cost shipments are more likely to take rail. When looking at the elasticities of truck-time in comparison to rail, it shows that “truck travel time is almost 20 times greater… [showing] that the time is a crucial issue especially when truck is preferred to rail” [3]. For shippers that prefer truck as the mode of transport, looking at the coefficients of time and cost, the main concern is shipping time rather than cost. This apparent insensitivity to cost when choosing the truck mode may be due to the priority being given to on-time arrival of shipments and the increase of just-in-time deliveries. Additional variables that were not necessarily included in the final model were also observed. These variables included one that is directly related to commodities. At the 80 percent confidence level, it was found that mode of transit is dependent on the perishability of the commodity. Summarizing from the study, because rail tends to go through consolidation and distribution centers, commodities with limited transit time flexibility tend to travel by truck which is a much more time-sensitive mode. Another observation of the study is that in general, freight traffic is much less elastic to changes in shipment costs in comparison to passenger traffic. Consequently, for trucks, even with increased fuel prices or increased cost of delay for commodities with higher transit time tolerance, very little variation in volume may result. Therefore, in order to prevent the additional cost accrued from increased freight shipping cost specifically due to delay, corridors displaying large delay costs need to be identified and prioritized for improvement.

Despite the economic recession that began in 2008, and the resulting decrease in the aggregate volume of goods moved nationwide, the volume and also the value of goods trucked within the continental United States is expected to significantly increase in coming decades. Recent and projected commodity value and tonnage trends of goods moved within the U.S. can be seen in Table 4. Not only are total shipments by truck expected to increase significantly, but also the average value per trucked ton is also expected to rise (from an estimated $875 per ton in 2009 to $1,174 per ton in 2040). In 2007 these higher priced goods included machinery, electronics, and motorized vehicles [1].

Table 4—Total Shipment Trends from Freight Facts and Figures 2010

	Total Shipments					
	2007		***2009***		***2040***	
	Weight	*Value*	*Weight*	*Value*	*Weight*	*Value*
All Modes	18,581	16,536	16,122	14,647	27,104	39,294
By Truck	12,766	10,783	10,868	9,511	18,445	21,656
%Truck	68.70%	65.21%	67.41%	64.93%	68.05%	55.11%
	Cost ($/ton)					
All Modes	$890		$909		$1,450	
By Truck	$845		$875		$1,174	
	Percent Change					
	2007-2009		***2007-2040***		***2009-2040***	
	All Modes	*By Truck*	*All Modes*	*By Truck*	*All Modes*	*By Truck*
By Weight	-13.23%	-14.87%	45.87%	44.49%	137.63%	100.83%
By Value	-11.42%	-11.80%	68.12%	69.72%	168.27%	127.69%

2.4 Economic Quantification and Prioritization

In considering the cost associated with delay and value of time for freight, the economic impact should be quantified in an objective, consistent, and transparent method to allow planners and policy makers to assess the net benefits of large-scale transportation projects [13]. Tavasszy (2005) summarizes value-of-time research as well as other sources of economic benefits that arise from time gains in transport. In Tavasszy's paper, a cost-benefit- analysis (CBA) is used to determine the present value of logistics improvements using willingness-to-pay (WTP) as well as a compensation variable (CV) to determine if the necessary criteria are met. To simplify the analysis, logistics costs are broken down into three components: the cost of transportation, “freight”, and other (i.e. damage) [7]. Information regarding a user’s WTP or a compensation variable is not available for the portions of highway examined in this thesis; however trends from contextual stated preference surveys could be used to analyze the potential effect of increases or decreases in delay cost from 2007 to 2040.

After quantifying the economic impact, highway network links need to be prioritized for improvement based on the current and future costs of delay. The most common prioritization method is to rank projects based on some pre-determined criteria [14]. Unfortunately, simply ranking projects tends to cause decision-makers to select from the project list based on a worst-first scenario. According to the *Statewide Strategic Transportation Plan: 2010*-2030, the Georgia DOT is attempting to move away from such a worst-first system [15]. Research performed for this thesis treats the commodities carried by truck as assets and aims to use these asset evaluations to move closer to the development of a strategic and systematic prioritization decision method. The *Pavement Management Guide* (2001) describes seven ranking approaches: prioritization by damage measures, a performance function, a usage weight performance function, composite criteria, first cost, least life-cycle cost, and benefit-cost ratio or cost-effectiveness [14]. Items of interest in the guide refer to the use of a single year prioritization that is not a worst-first scenario; however, to do this, additional benefit and life-cycle costs are required. Using the available data described below, this thesis draws on aspects of various prioritization methods to rank links based on the costs of delay.

3 DATA REVIEW

Data requirements are an important and limiting factor in how performance can be measured and tracked over time. Three different types of data were required for the analysis of presented below: network link specific truck traffic volume data, network link specific truck traffic speed data, and truck mode specific commodity flow data. In addition, data on the volume (tonnage), dollar value, and types of freight being trucked needed to be collected. In the United States the main source of truck and commodity origin-to-destination (O-D) data is the Federal Highway Administration's Freight Analysis Framework, or FAF, dataset (itself based on the quinquennial U.S. Commodity Flow Surveys) [16].

In-the-pavement traffic counters that capture speed and vehicle class as well as traffic are just one type of data source that can be used to collect data. In addition to in-the-pavement traffic counters and loop counters, a number of comparatively new data sources are now being used by state traffic engineers: Global Positioning System (GPS) satellites, cellular telephones, aerial photographs, transponder and active radio frequency identification (RFID) technologies are all now being used for tracking and reporting truck movements (see Table 5).

Table 5—Traffic Data Collection Technologies

Data Technology	Description
Loop Detector	A magnetic loop installed on or in the pavement that detects vehicles based on a disruption in the electromagnetic field. May be used to determine the speed of vehicles on a corridor.
Automatic Traffic Recorder	A permanent, fixed, traffic counter located on major highways and interstates throughout Georgia. Traffic counts are obtained through the Georgia Department of Transportation.
Video Detection System Traffic Camera	Fixed cameras located every third of a mile along major interstates and highways displaying black and white images. VDS cameras can be used to determine corridor density as well as travel time, speed, and vehicle counts. VDS cameras are operated by the Atlanta Transportation Management Center.
Closed Circuit Television Camera	Pan-tilt-zoom cameras that display color feeds on major interstates and highways in Atlanta. CCTV cameras are operated by the Atlanta Transportation Management Center.
Weigh-In-Motion	Weigh-in-motion (WIM) centers can be used to determine truck counts through a corridor. Truck weigh stations are located along interstate highways. As trucks pass through the WIM station trucks fitted with transponders can be tracked and counted, allowing information on travel time to be deduced as successive WIM centers are traversed.
Global Position System	Devices used within trucks. GPS devices can be tracked and used to determine route choice as well as speed and travel time. Data may be difficult to obtain since it usually involves a private-public relationship and contracting of agreements for data usage. ATRI/FHWA provide access to Interstate GPS data for Georgia and U.S.
Radio Frequency Identification Tag	Small plastic identification tags that can be mounted in vehicles. Tags are read by radio frequency as vehicles passes through a collector. Data obtained through RFID tags can be used to determine truck speed along a corridor and the unique ID also allows for identification of route choice across a system.

Three data sources are described in this portion of the report. The data needed to complete this research was obtained from the Freight Analysis Framework Version 3 (FAF^3), the Georgia Department of Transportation (GDOT), and the American

Transportation Research Institute (ATRI). The content of this data is described in the following sections which are organized by data type.

3.1 Truck Traffic Volumes

Both GDOT and FAF^3 were consulted to obtain truck volumes. FAF^3 provides unidirectional 2007 annual average daily traffic (AADT) and annual average daily truck traffic (AADTT) for specific links throughout the nation. Through the integration of data from multiple sources, FAF^3 is able to produce estimated annual or average daily flows for 2007 and a projection of such flows for the year 2040 [16]. For a detailed description of the variables provided in the FAF dataset, the reader is directed to Appendix A which contains the FAF data dictionary.

The considerable value of FAF^3 truck movement data is that it provides a continuous set of link specific truck as well as general traffic volumes throughout the corridor of interest. These FAF^3 estimated truck trip volumes are a synthetic combination of both traffic count data and truck route modeling and are based on an extrapolation of GDOT supplied traffic counts via the FHWA's Highway Performance Monitoring System dataset. Based on the state supplied traffic volume counts, FAF^3 truck volumes are stochastically applied to highway links and routes by means of a user equilibrium traffic assignment software (a TransCad GIS-based transportation planning software). In using the stochastic user equilibrium assignment, FAF O-D flows are summarized into a number of FAF transportation analysis zones and state origin-destinations. The reader is directed to Battelle (2011) [17] for more information.

The Georgia Department of Transportation (GDOT) also collects route specific truck volume data gathered using automated traffic recorders (ATRs) located throughout the state. Traffic counts along the corridor of interest were available by start date and direction of travel (northbound or southbound) for calendar years 2008, 2009, and 2010. Unlike FAF^3 data, GDOT truck traffic counts are only available at a limited number of point locations. The locations of these ATRs are also variable due to some number of them being rotated every three years. Due to this rotation of the counters, a time series of truck traffic volumes could not be obtained and only 2008 GDOT truck volumes were used in the analysis below. The counts obtained for 2008 are also the most consistent with FAF traffic counts, which are extrapolated from state DOTs supplied 2007 and 2008 count data. One significant benefit of using the 2008 GDOT truck traffic counts is that the number of trucks by class could be determined. Specifically, GDOT counters classify each vehicle based on axle spacing into 15 categories which can be seen in Appendix B.

Discussions were held with staff in the Georgia DOT's Office of Transportation Data in Chamblee, GA where a computer run was made to produce the data set used for the test corridor. A listing of the data provided in the computer run is listed in Table 6.

Table 6—Georgia Department of Transportation Data

Traffic Volumes Data	Vehicle Counts	County Name and FIPS Code	Minimum Speed
County Name and FIPS Code	Total Daily Traffic Volume	Route #	Maximum Speed
Route Number	Total Daily Truck Volume	Site #	Average Speed
Site Number	Peak Traffic Hour	Direction of Travel	Description of Counter Location
Date	Description of Counter Location	Vehicle Class Counts	
Direction of Travel	Traffic Speed Data	Number of Observations in speed bins	

The information provided allowed for aggregation of truck types into single unit trucks and combination trucks. Highway speeds were only used to test the reasonableness of the ATRI speed estimates described further in Chapter 3.2 below.

Both the FAF^3 volumes and GDOT volumes have positive and ideal aspects. For FAF^3, the availability of volumes for every link of the corridor is critical in the analysis of the cost of delay. Contrarily, GDOT counters only provide volume information at one location; however, they do offer information on the different vehicle types that traversed the point of interest. Truck volume profiles that run consistently along the length of the entire corridor of interest are the ideal data to work with. Although GDOT and FAF^3 data were not available for the same year, the two data sets were combined to facilitate the analysis of the cost of delay along the corridor. Steps on how the two datasets were combined can be found in Chapter 5.1 below.

3.2 Truck Speeds

Under a "Freight Performance Measurement Initiative" beginning in 2002, average truck speed data is available for most interstate corridors based on a contractual relationship between the Federal Highway Administration (FHWA) and ATRI [18]. This database consists of GPS tracked individual truck speeds. On average, approximately 500,000 trucks equipped with GPS and satellite equipment are tracked as they move along some 25 freight significant corridors. With ATRI permission, a specific pre-processed subset of this speed data can be extracted via its FPMWeb tool[1].

[1] <https://www.freightperformance.org/fpmweb/user_login.aspx>

Speed data is available in three-mile intervals by hour, direction, and day of week throughout the corridor of interest for the year of 2009. ATRI speeds are collected from actual individual truck speeds which are then aggregated and averaged for confidentiality reasons For this ATRI speed data to be useful, the three-mile ATRI speed intervals were conflated (a Geographic Information Systems term meaning matched on the basis of a common spatial location) to the FAF^3 highway network links. This conflation process is described in Chapter 5.1 below.

3.3 Commodity Weight and Value

The final data type needed to more accurately calculate the cost of delay for trucks is commodity data. In addition to speeds and volumes, FAF^3 also provides commodity data. Commodity data is gathered from the 2007 Commodity Flow Survey (CFS). An origin-destination-commodity-mode (ODCM) matrix was used to build a flow matrix of 43 commodities by eight transportation modes between 131 origins and 131 destinations throughout the nation, providing the weight (in thousands of tons) and value (in millions of 2007 dollars) of commodities [19]. The 43 commodities are represented by two-digit Standard Classification of Transported Goods (SCTG) classes.

Commodity origin-to-destination (O-D) data can be extracted using the FAF Data Extraction Tool[2]. "Total flows", which include imported and exported as well as domestically produced goods, are used in this research.

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[2] <http://faf.ornl.gov/fafweb/Extraction1.aspx>

4 STUDY AREA

For this research, the 160-mile corridor shown in Figure 1 was used as the test corridor. This portion of I-75 is mostly rural; however, it does carry a significant portion of freight traffic—an average of over 10 thousand trucks per day, bi-directionally for the entire corridor. Figure 3 shows the volume of freight on the corridor, according to FAF[3]. Also, according to *Freight Story 2008*, the corridor of interest carries more than 50 million tons of freight per year [20].

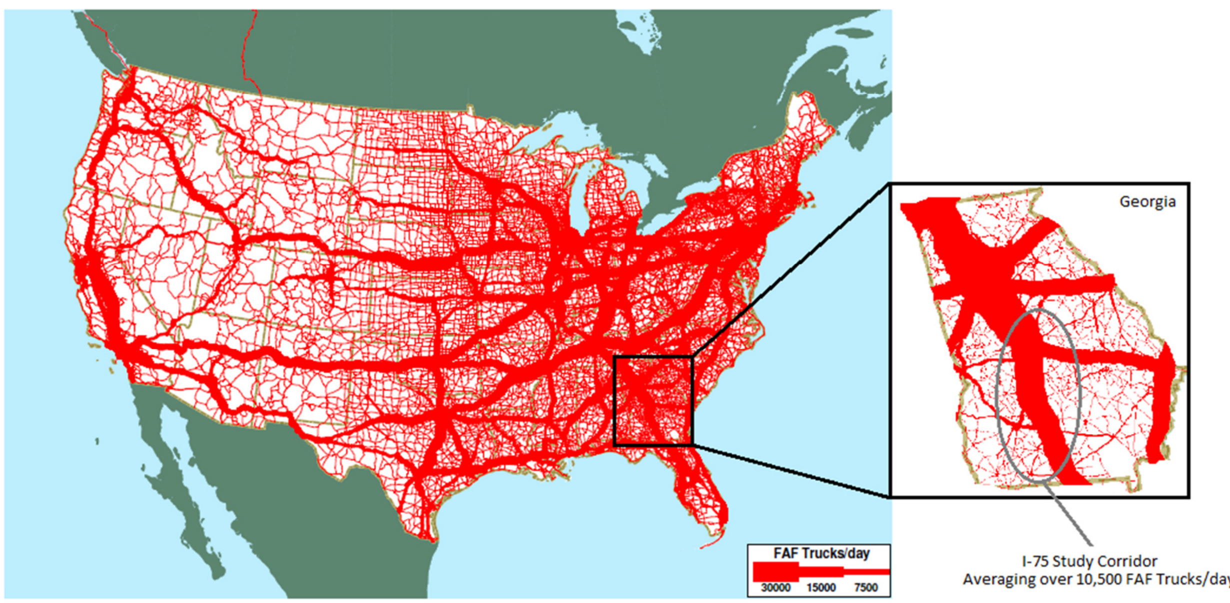

Figure 3—Freight Analysis Framework, Version 3

Twenty-one states, including Georgia, are estimated to interact to move significant amounts of freight goods along a portion or the entire study corridor (see Table 7). Although only 21 states are said to move significant amounts of goods along the corridor of interest, all 50 states in addition to Washington, D.C. move goods to and from Georgia; however, because of the lack of interaction with the study corridor, the origin-destination pairs with the remaining states are not considered.

Table 7—States that Interact with the I-75 Study Corridor

States the Interact with the Study Corridor	
Colorado	Missouri
Florida	Montana
Georgia	Nebraska
Idaho	North Dakota
Illinois	Oklahoma
Indiana	Oregon
Iowa	South Dakota
Kansas	Tennessee
Kentucky	Utah
Michigan	Wyoming
Minnesota	

One additional area of interest along the corridor is the Cordele Intermodal Port. According to GDOT, the purpose of the port was to increase competitiveness in shipping for the neighboring states of Alabama, Florida, Mississippi, and Georgia itself [21]. By connecting multiple Georgia Port Authorities via rail, it is hoped that road congestion and resulting emissions will be reduced [21]. The inland port is located just off of I-75 in Crisp County, Georgia and opened for business during the Fall of 2011. Because of potential increases in goods movement in this area, monitoring performance along the corridor of interest can prove beneficial to maintaining high levels of service to and from this new inland port as well as on the surrounding transportation network.

5 METHODOLOGY—COST AND DELAY CALCULATIONS

Expanding on previous research by Southworth and Gillett (2011), a 160 mile corridor in southern Georgia was identified as the test corridor. A profile of truck types was identified on the corridor along with possible delivery origins and destinations in order to obtain a profile of commodity movement along I-75. This section of the thesis describes how the previously described data was used along the corridor of interest to calculate the cost of delay for trucks. As previously described, the calculation of delay cost is determined by taking into account the speed, volume, and type of truck along with the distance traveled and type of commodity moved. Using this information, delay is calculated both by individual (FAF) link and also for the entire 160 mile corridor.

5.1 Combining Data Sources

In order to obtain the value of freight by truck type and commodity, while also calculating the cost of delay, the previously identified data sources (FAF^3, ATRI Speeds, and GDOT volumes) had to be combined in a coherent and logical manner. A process similar to the one seen in Figure 4 was used to merge various data sets [6]. First, FAF link volumes and ATRI speeds were matched. This was done using the provided ATRI link and node file and joining it with the FAF^3 data using the Maptitude Geographic Information System (GIS). From ATRI, links with speeds were able to be downloaded and mapped using ArcGIS. A link shape file was created in ArcGIS and then opened in Maptitude. Once the file was converted to the Maptitude format, the identified corridor of interest (the southern portion of I-75) was exported into a standard geographic file. A similar extraction process was performed for the FAF^3 data so that only data corresponding to the corridor of interest was exported.

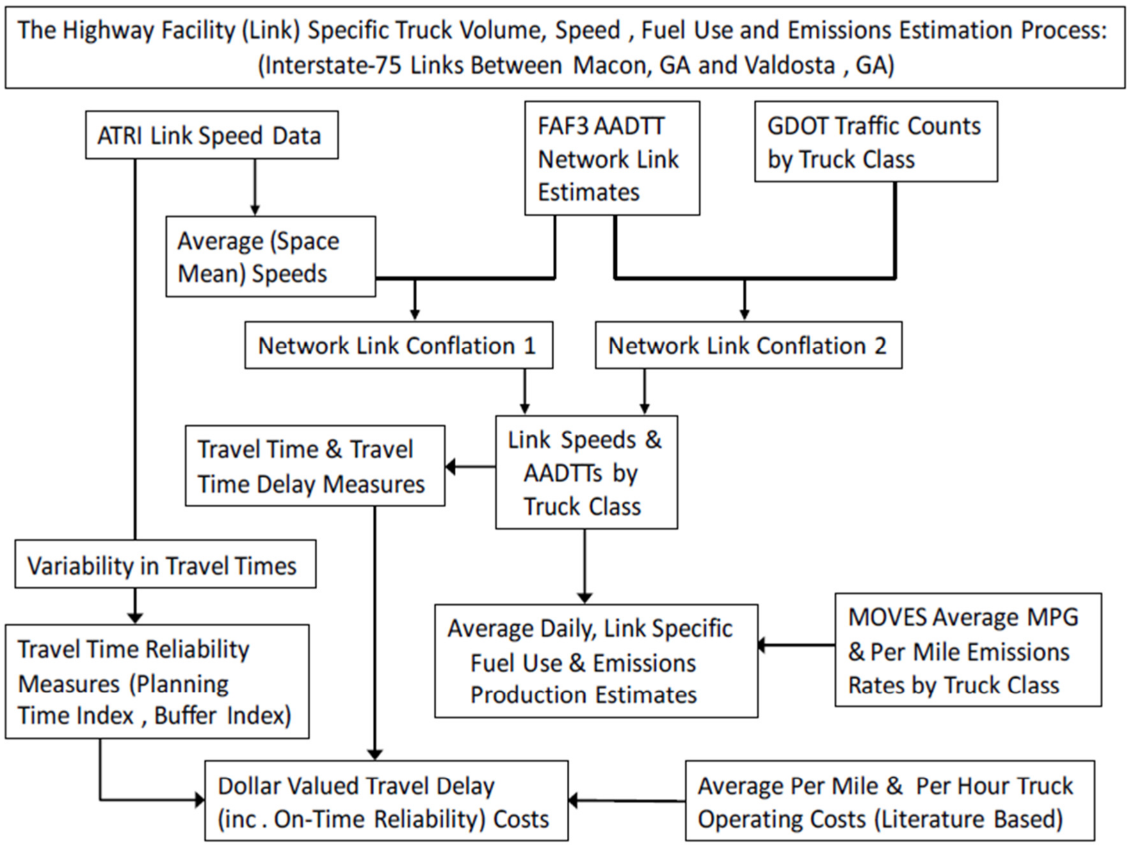

Figure 4—Steps to Create FPMs for the Study Corridor

With separate and condensed data for both volume and speed, each link for both FAF^3 and ATRI needed to be linked so that a volume and corresponding speed could be matched and identified on a per-mile basis. Link information from Maptitude was used to identify each link using the corresponding ID, volume, and length and was then exported to Excel. Once in Excel, the methodology used to combine FAF^3 volumes and ATRI speed per link was to create a matrix that identified a speed and volume for each mile of a link. This was done by aggregating links with the same or similar speeds together and summing up the link volumes. After aggregating link lengths with similar volumes, the “ROUND” feature in Excel was used to either round-up or round-down the mile length of the segment. In order to assess the difference in mileage between the original link lengths and the aggregated and rounded link lengths, the cumulative link distance was calculated and the results was deemed to be appropriate (160 miles instead of 156.88) and still very close to the cumulative ATRI link distance of 159 miles. This information was then displayed in a matrix (which can be seen in Appendix C).

The data provided in the matrix was then converted back to columnar form using a “Matrix Converter” Add-In in Excel. Both data sets were then combined and converted to a pivot table which described the average volume and average speed per mile of the associated link. The combination and aggregation of FAF^3 and ATRI data resulted in a total of 28 corridor links that displayed both FAF^3 data (AADT, AADTT, distance, capacity, volume to capacity ratios, and more) and average ATRI speeds for each associated FAF^3 link.

To more accurately calculate delay, additional variables were needed; one additional variable was truck type. To obtain the truck profiles along the corridor, GDOT counter volume profiles had to be joined and conflated to the new FAF^3-ATRI Excel file. GDOT counter data provided information regarding truck volumes as well as general traffic volumes. Based on the vehicle class types, Class 1 through Class 4 were not considered to be trucks. Class 5 through Class 15 were considered trucks that ranged from two-axle, six tire units to any eight-axle, multi-trailer unit. The 15 vehicle classes were then aggregated into three general categories, as shown in Table 8.

Table 8—Vehicle Class Aggregation

Category	Class Range
Total Volume	Class 1 – Class 15
Single Unit Trucks	Class 5 – Class 7
Combination Trucks	Class 8 – Class 14

To use the aggregated vehicle class profile information with FAF^3 volumes, 2008 GDOT counters at four locations were identified along the corridor of interest. The four counters were located in Macon, Perry, Byron, and Valdosta, Georgia. The counter locations were able to be geographically referenced in ArcMap which allowed for the FAF^3 data and GDOT counter data to be joined spatially. With the spatial join, a new table was created in ArcMap that consisted of the FAF^3 data in addition to GDOT counter data for the counter nearest to each FAF^3 link. With GDOT counter data associated with a FAF^3 link, the FAF^3 volumes were distributed by truck type and direction. To correctly distribute the FAF^3 volumes by direction and by truck type, raw GDOT counter data was used to determine the directional split of volume for each counter as well as the vehicle class ratio per counter. Excel was used to calculate the ratio of volume in one direction over the total volume to determine the directional split for each class of each counter. Then, class shares were determined by dividing the total volume for that class of the specified counter over the sum of volumes for that counter. Next, the FAF^3 truck volumes were multiplied by the directional split and class share in order to determine the type and volume of trucks that were moving in a specific direction along the FAF^3 link. Finally, in Excel all three databases were combined: FAF^3 truck volumes distributed by direction and aggregated by class along with ATRI speeds for each link of the corridor.

5.2 Calculating the Cost of Delay

This section describes the various calculations of delay costs for the corridor of interest. The costs of delay calculated in this section refer to recurring congestion which creates an opportunity cost related to the amount of avoidable time spent on the highway—a nonproductive activity [6]. Congestion in a corridor can cause varying increases in travel costs by commodity type where delay for high-value commodities can cost from $50 to $75 per hour [15]. Over time and over the years this avoidable cost can add up and affect local companies as well as the overall State economy. Table 9 provides a list of the various link delay measures used to monetize truck freight on the corridor of interest:

Table 9—Link Delay Measures

Delay Type	**Equation**
Average Delay (minutes)	= Average Travel Time – Free Flow Travel Time
Average Delay Per Mile (minutes/mile)	= Average Delay/Distance
Total Link Delay (minutes)	= Average Delay *Truck Volume
Delay Time Cost ($)	= VOT*(TotLinkDelay/60) [Daily Dollar Cost of Delay]
Commodity Delay Cost Index	The demurrage cost associated with each minute that a commodity is delayed

The delay measures shown above are used to calculate both link delay as well as delay for the entire corridor for 2007 and 2040. In order to calculate delay for 2040, projected 2040 truck speeds needed to be estimated. This was done by extrapolating from the available 2009 ATRI speeds. To do this, the following equation from the Bureau of Public Roads[3] was used, where:

$$t = t_0 \left[1 + \alpha \left({V}/{C}\right)^{\beta}\right]$$ [4]

And the variable can be defined as follows:

t = final link travel time
t_0 = free-flow link travel time
α = 0.15, a coefficient
(V/C) = link volume-to-capacity ratio
β = exponent typically equal to 4.

Using the 2007 and 2040 volume-to-capacity ratios for each link, the inverse of the ratio of the 2040 to 2007 travel time is multiplied by the current average ATRI speed for the link as identified in the following equation.

$$s_{2040,i} = \left(\frac{1}{{t_{2040,i}}/{t_{2007,i}}} \right) \times s_{2007,i}$$

where *s* represents the speed for a given link *i* during 2007 or 2040. With speed and volume represented for both study years, delay measures are calculated and compared. Delay measures and cost calculations for 2007 can be found in Appendix D.

This is an admittedly approximate method, and also assumes no change in link specific or corridor-wide highway capacity. It does, however, offer a means of capturing the order of magnitude effects of steadily growing truck traffic volumes on congestion and therefore

[3] < http://www.sierrafoot.org/local/gp_notes/BPR_function.html>
[4] Bureau of Public Roads function <http://www.sierrafoot.org/local/gp_notes/BPR_function.html>.

on delay in the corridor should no further road capacity be added. More elaborate formulas relating volume/capacity ratios to space mean speeds might also be used here.

5.3 Commodity Valuation

To assist in valuating commodities moved by truck, three categories of commodity time sensitivities are used: highly time sensitive (HTS), moderately time sensitive (MTS), and low time sensitive (LTS) goods [5]. Each sensitivity category consists of varying types of goods based on their perishability potential and/or use. For the purpose of this research, highly time sensitive goods are those commodities that are at risk of high obsolescence costs due to the shipments perishable nature. Examples of highly time sensitive goods would be any agricultural product or fresh produce [5]. Moderately time sensitive goods are those with lower time sensitivities such as bulk liquids and building materials. Commodities that are considered moderately time sensitive are not at the same risk level to deteriorate in transit, instead, many of the goods moved in this category have higher time sensitivities due to the scheduling sensitivity of the receiver [5]. Finally, the least time sensitive goods tend to be household products or other similar goods [5]. These goods have the lowest time sensitivities and according to a report developed by Small et al. (1999) shipments within the same day of the pre-determined arrival date are still considered to be acceptable. Table 10 shows which types of goods were aggregated into which time sensitivity category noting that other combinations of commodities might be used depending among other things on the level of commodity detail.

The commodity sensitivity aggregations shown in Table 10 display the 43 two-digit Standard Classification of Transported Goods (SCTG) classes that were used by in the

2007 Commodity Flow Survey along with the actual commodity name and a short description of the type of commodities in the sensitivity grouping.

Table 10—Time Sensitivity Grouping

Time Sensitivity	SGTC Class	Commodity	Description
High	01	Life animals/fish	Commodities that are highly time sensitive due to the perishability of the product being moved.
	02	Cereal Grains	
	03	Other agricultural products	
	04	Animal Feed	
	05	Meat/seafood	
	06	Milled grain products	
	07	Other food stuffs	
	43	Mixed freight	
Moderate	08	Alcohol beverages	Commodities with lower time sensitivities. Goods in this category are not necessarily damaged by time delays; however, the recipient tends to have a higher sensitivity to on-time delivery.
	09	Tobacco products	
	10	Building stone	
	11	Natural sands	
	12	Gravel	
	13	Nonmetallic minerals	
	14	Metallic ores	
	15	Coal	
	16	Crude petroleum	
	17	Gasoline	
	18	Fuel Oils	
	19	Coal-n.e.c.	
	20	Basic chemicals	
	21	Pharmaceuticals	
	22	Fertilizers	
	23	Chemical products	
	24	Plastics/rubber	
	25	Logs	
	26	Wood products	
	31	Non-metallic minerals	
	32	Base metals	
	33	Articles-Base metal	
Low	27	Newsprint/paper	The least time sensitive commodities. These commodities tend to be household goods or similar products where if delivered within the same days as previously scheduled, the delivery is still found to be acceptable [5].
	28	Paper articles	
	29	Printed products	
	30	Textiles/leather	
	34	Machinery	
	35	Electronics	
	36	Motorized vehicles	
	37	Transport equipment	
	38	Precision instruments	
	39	Furniture	
	40	Misc. mfg. prods.	
	41	Waste/scrap	
	42	Unknown	

Based on querying O-D pairs using the FAF Data Extraction Tool, the total tons of commodities that travel to, from, and through Georgia could be determined. Because only a portion of Georgia highways are used, the tons of commodities that move throughout the state needed to be converted into number of trucks in order to relate it to the given FAF^3 volumes on the corridor of interest—in essence, tons of commodities were converted to number of trucks. To do this, the tons of commodities being moved needed to be allocated to the type of trucks they were likely to be moved in. Alam (2010) identifies the five truck types listed in Table 11 along with the corresponding truck allocation factors based on distance [22].

Table 11—Truck Allocation Factors

Range		**Truck Type**				
Min	Max	SU	Truck Trailer	Comb Semi	Comb Double	Comb Trip
0	50	0.793201	0.070139	0.130465	0.006179	0.0000167
51	100	0.577445	0.058172	0.344653	0.019608	0
101	200	0.313468	0.045762	0.565269	0.074434	0.000452
201	500	0.142467	0.027288	0.751628	0.075218	0.002031
501	10000	0.06466	0.0149	0.879727	0.034143	0.004225

The truck allocation factors obtained from Battelle (2011) along with the expected amount of commodities moved throughout the corridor of interest were used to convert tons moved to truck volumes by commodity type, using truck equivalency factors (TEFs). Truck equivalency factors are multidimensional and take into account the truck type, body type, and commodity [17]. A listing of truck body types that are taken into consideration can be seen in Table 12.

Table 12—Major Truck Body Types

Major Truck Body Type	Percent of Fleet
Dry Van	37.73%
Flat Bed	24.37%
Bulk	14.73%
Reefer	8.15%
Tank	7.97%
Logging	2.12%
Livestock	1.70%
Automobile	0.91%
Other	2.33%

For this research, the five truck allocation factors used were split up between commodity tons that were moved within Georgia and tons of commodities move to and from Georgia, where trucks that traveled between zero and 200 miles were considered to be moving goods within the state of Georgia while those traveling more than 200 miles were designated commodities that originated in Georgia and were moved out of state, or came from another state into Georgia. For the purpose of this study only the 101 to 200 mile distance truck allocation factor was used as an example. This distance range is also chosen because this truck type breakdown is the most similar to that of the corridor in terms of FAF^3 truck class specific volumes.

Based on the result of the convergence of commodity tons into trucks, the FAF^3 corridor volumes were distributed according to the type of commodity and truck moved. In the case of matching FAF^3 truck volumes and converted kilotons to truck volumes, rates were determined for each of the loaded truck body types and each commodity type. These rates were then applied to the truck volume on the FAF^3 link. For the corridor of interest, the numbers of single unit and combination trucks were already accounted for based on the output from GDOT traffic counters. Because this data was collected and analyzed in-state, commodities by the five general truck body types used to convert tons to volume were aggregated into the two general classes (single unit and combination) to determine the percent commodity moved by each group and not necessarily the percent breakdown by truck type. A more detailed step-by-step description of how tons of commodities are converted to truck volumes can be found in *FAF^3 Freight Traffic Analysis* [17] and further descriptions of how converted volumes were matched to existing FAF^3 can be found in Appendix E.

After converting tons of commodities moved into truck volumes and relating them to existing FAF^3 truck volumes by link, a matrix of the number of trucks along the corridor that carry various commodity types was made. The purpose of this matrix was to then determine the cost of those commodities along the corridor as they are affected by delay. This was determined by aggregating the commodities into the three sensitivity groupings as seen in Table 10. The aggregated commodity sensitivity category volumes were then included in the delay files shown in Appendix F.

The valuation of commodities as they are affected by specific logistical aspects of delay could not be calculated with existing data. Although actual values for the cost of commodity depreciation and/or obsolescence was not able to be determined explicitly, the ranges of value of time savings and value of delay identify that some of the variation in cost can be attributed to the cost of commodities that is not unambiguously being accounted for.

6 RESULTS

Two files were created with delay costs and trucks carrying commodities of various sensitivities for 2007 and one for 2040. In 2007 the average delay for a link was 3.5 minutes. A 3.5 minute delay on a corridor that is 22 miles long can incur a delay cost of almost $23,000 which is based on the value of time for each truck on the link. Also, this link had a FAF^3 calculated volume-to-capacity ratio (VCR) of 0.46 in 2007. The cost of delay presented does not include the demurrage charge that would be associated with the volume of trucks carrying low, moderate, or highly time sensitive goods. In 2040, the VCR is projected to increase to 0.94 for the link—double the ratio in 2007 (assuming no change in highway capacity). Also, the total volume and truck volume is projected to nearly double on that link.

Using this 22-mile link as an example, the importance of considering the cost of carrying commodities by value-of-time sensitivity in the cost of delay calculations can be seen. Table 13 compares the volume (in trucks) of commodities moved along the link and the corresponding effect of delay and delay costs. Assuming that current capacity conditions remain the same along the corridor, with the nearly doubling of volumes and therefore the VCR, the cost of delay will increase as speeds decrease. Although this data does not display it, the consideration that the percent of high value, time sensitive goods are expected to increase can also increase the risk of higher delay costs for carriers.

Table 13—2007 vs. 2040 Link 7 Comparison

		Northbound 2007	Northbound 2040	Southbound 2007	Southbound 2040
Link ID		7		7	
Distance (miles)		22		22	
Total Volume		18,157	36,580	18,018	36,628
Total Trucks		4,359	8,822	4,503	8,905
Single Unit Trucks	*Volume*	*563*	*559*	*559*	*1,248*
	High	81	202	80	179
	Mod	383	956	380	848
	Low	100	248	99	220
Combination Trucks	*Volume*	*3,799*	*3,937*	*3,937*	*7,653*
	High	545	1,063	565	1,098
	Mod	2,582	5,037	2,676	5,202
	Low	671	1,309	696	1,352
Average Speed (mph)		58.22	54.61	58.35	54.72
Volume-to-Capacity Ratio		0.46	0.94	0.46	0.94
Average Delay (minutes) Per Mile		0.173	0.242	0.171	0.239
Total Link Delay (minutes)		16,625	46,892	16,959	46,878
Delay Time Cost		$22,912	$64,625	$23,372	$64,606
Delay Time Cost per Vehicle Mile		$0.06	$0.08	$0.06	$0.08

As previously stated, from 2007 to 2040 there is expected to be an almost 70 percent increase in the value of goods moved in the United States [1]. As the value of the goods increase, it can be assumed that the negative effect of delay associated with moving goods will also increase. Looking at the example presented in Table 13 for Link 7, a decrease in speed of less than four miles per hour results in approximately a 40 percent increase in the average minutes of delay per mile for the link. As a result of the increase delay and increased volume, the delay time cost for the link nearly triples and the delay time cost per vehicle mile increases by 33 percent.

Table 14 compares the overall corridor delay costs for 2007 and 2040. Comparing the cumulative effect of delay on the corridor, Table 14 displays the delay measures for each direction as well as corridor level values for 2007 and 2040 along with the percent increase. The additional volume on the corridor causes significant increases in average daily corridor delay and the associated cost of delay. The projected increase in delay can affect the movement of goods along the corridor, especially those with high time sensitivities.

Table 14—2007 Average Daily Corridor Delay Comparison

Delay Measure	Direction	2007	2040	% Increase
Average Daily Corridor Delay per Mile (minutes)	North	0.148	0.222	50.00%
	South	0.147	0.220	49.66%
Average Daily Corridor Delay (minutes)	North	23.60	35.25	49.36%
	South	23.33	34.96	49.85%
Average Daily Delay Time Cost	North	$156,097	$445,662	185.50%
	South	$160,480	$466,238	190.53%
Average Daily Delay Time Cost per Vehicle-Mile	North	$0.04	$0.06	50.00%
	South	$0.05	$0.07	40.00%

The costs displayed in Table 14 are based on the assumption that a vehicle travels the entire corridor. Looking specifically at links within the corridor, Figure 5 displays the average delay per mile and the 2007 truck volumes by their sensitivity in the northbound and southbound direction for the corridor.

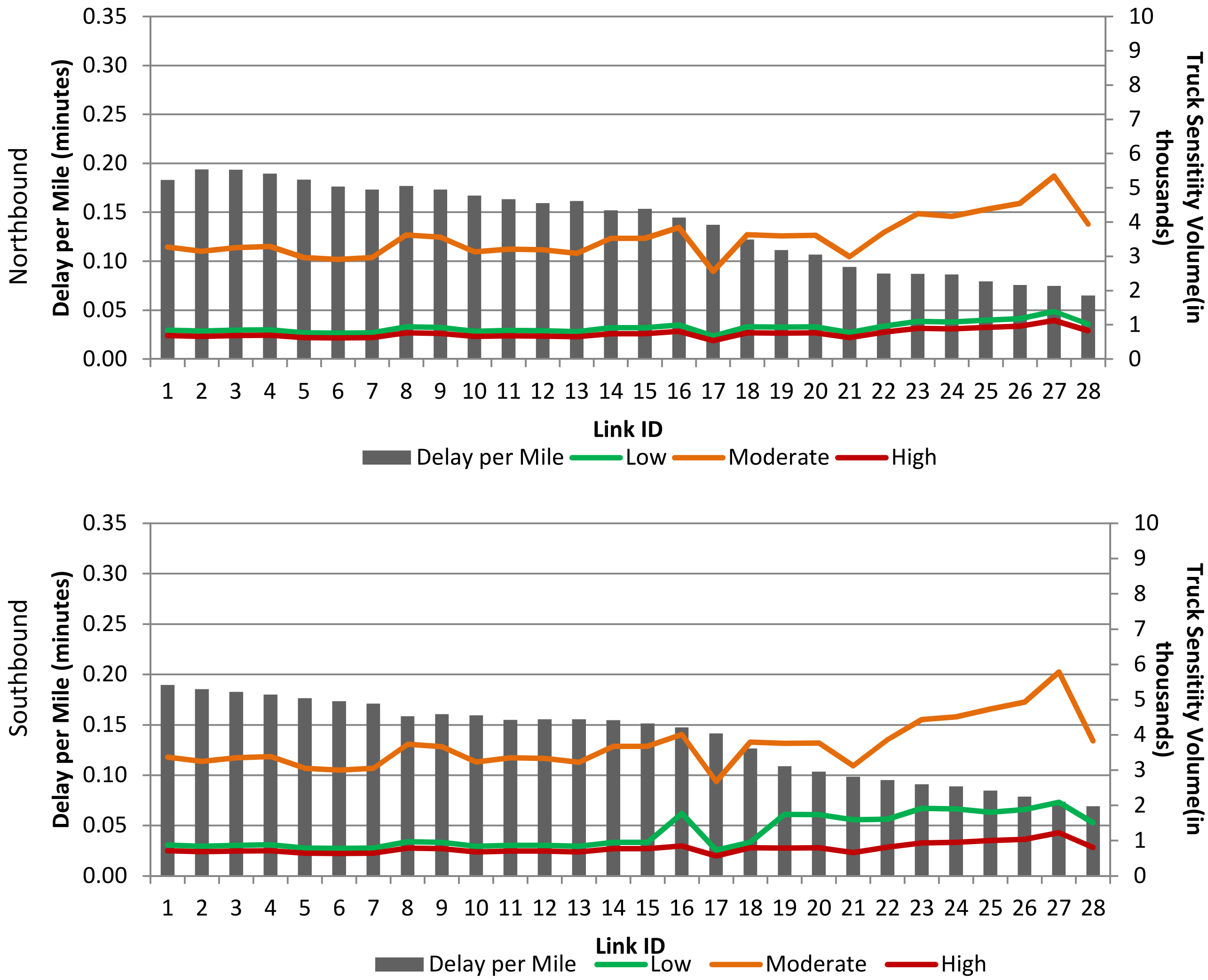

Figure 5—2007 Average Daily Delay and Truck Sensitivity Volume by Link

Based on the equations used to calculate the cost of delay as seen in Table 9, the cost of delay per link is based on the total link delay multiplied by the value of time. As seen in Figure 5, the amount of delay per mile decreases as vehicles approach link 28 (closest to Macon, GA). Although the amount of delay decreases based on the current delay cost calculation, if the type and/or time sensitivity of commodities moved along that portion of the corridor were taken into account, the value of delay per vehicle-mile could increase due to the increased spike in volume, especially for highly and moderately time sensitive truck commodities.

Figure 6 displays the 2040 projection of the average delay per mile and the truck volumes by their sensitivity in the northbound and southbound direction for the corridor. As seen in Figure 6, Links 18 and 19 which had the largest increase in VCR also have one of the largest average daily delays per mile. Percent increase in volume to capacity ratios from 2007 to 2040 can be seen in Figure 7.

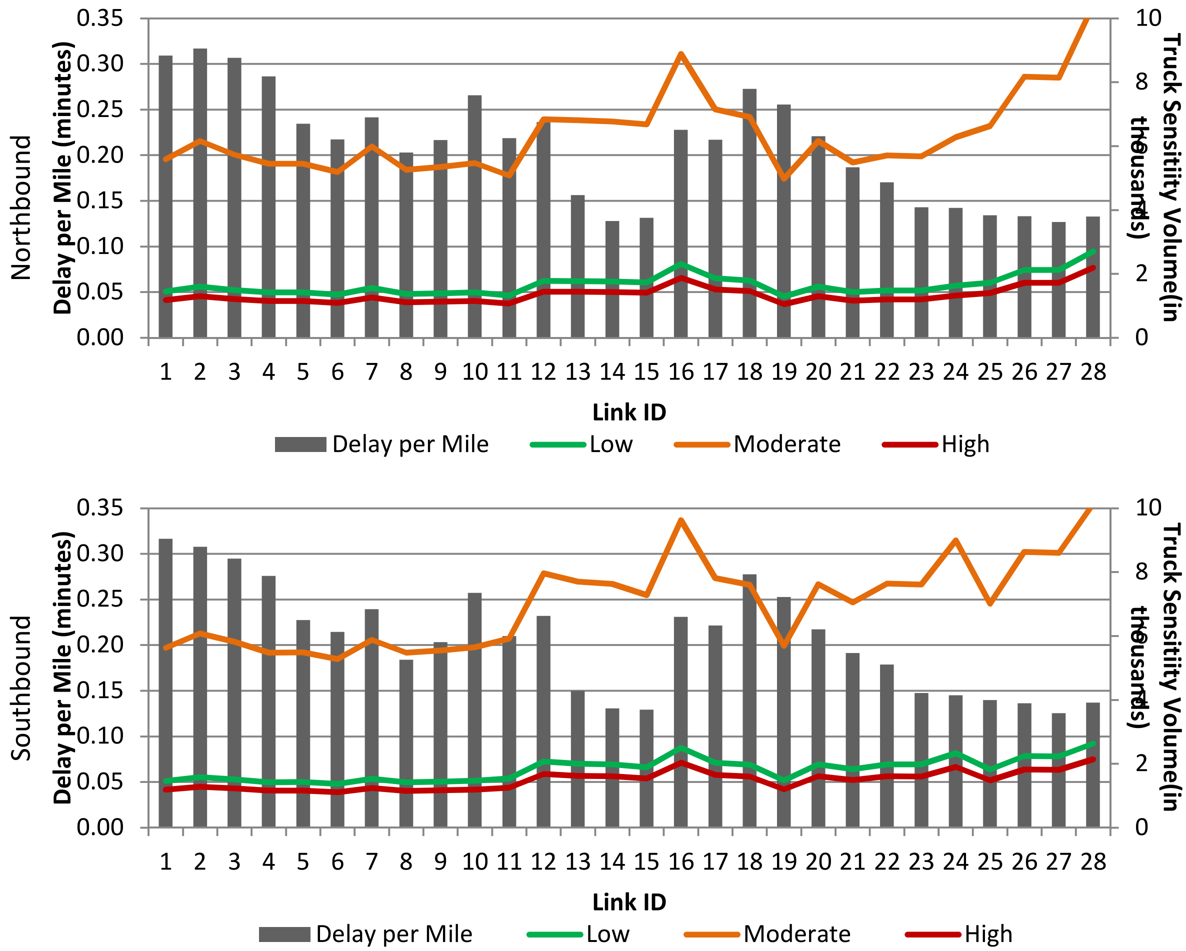

Figure 6—2040 Average Daily Delay and Truck Sensitivity Volume by Link

On average, the volume-to-capacity ratio increased by 119 percent. Based on the predicted increase in VCR, in 2040 Links 18 and 19 could be potential bottlenecks; however, looking at the links with the largest volumes, Link 28 will have the highest vehicular volume. Basing levels of concern on the largest average delay per mile, links closes to the Georgia-Florida border may warrant attention.

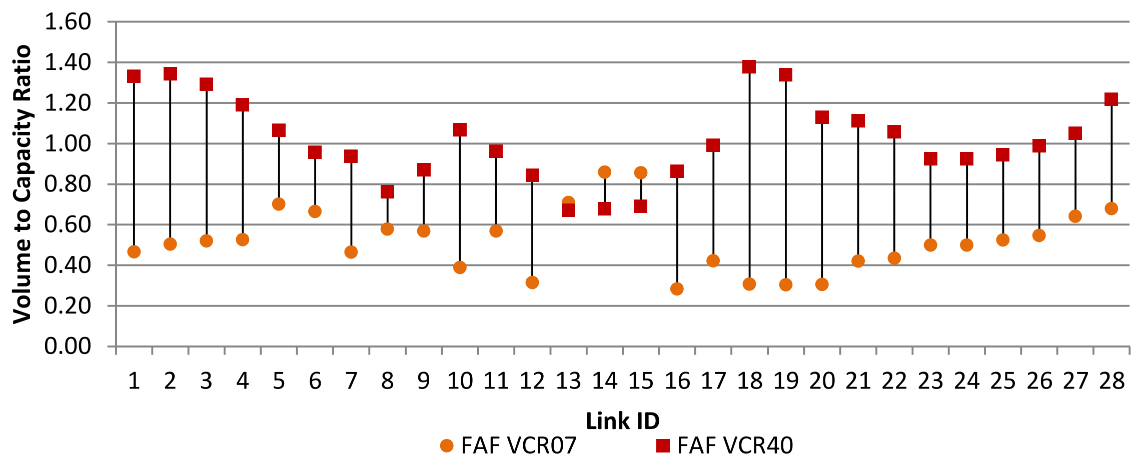

Figure 7—FAF^3 VCR 2007-2040 VCR Comparison

Although the description of potential rankings of links on the corridor needing attention relied solely on worst case scenarios, it is recommended that rankings consider multiple factors including the cost and benefit of any improvements to the user. Low cost improvements are possible which can still limit the mobility constraints on the surface transportation network and cost less than $1 million dollars according to Fekpe (2010) [23]. The low-cost improvements typically take less than one year to implement and are spot or location specific; which is beneficial for a project level analysis such as that performed for the corridor studied in this report [23]. Low costs improvements do not address physical capacity issues directly but can take regulatory, technological, or policy approaches to improving performance for various constraint types, depending on the location and nature of the casualty [23].

Projects that specifically address physical infrastructure capacity, especially for corridors of nation significance, would require larger upfront costs. These larger projects could be new and/or expanded freight corridors, truck right-of-way or priority lanes, or other "capital improvement projects that focus largely on improving the flow and capacity of moving goods" [13]. Unlike low-cost improvements, large-scale projects can cost from tens of millions to billions of dollars.

7 CONCLUSIONS

The current and projected rate of growth for truck-freight demand has already "outpaced the rate of transportation infrastructure capacity expansion and maintenance funding levels" [23]. Current volumes of truck freight already contribute to stresses on the transportation network. The anticipated increase in freight volumes will continue to stress the network as well as "increase the maintenance requirements and threaten system performance" [1] if critical links in the network are not addressed. There are expected increases in both the weight and value of goods moved, especially higher-value time sensitive goods. Identifying and prioritizing links by delay cost can assist in bringing awareness to critical links and remediate impasses in the highway network to make room for future growth. The link between congestion and increases in delay costs are not meant to represent or highlight capacity improvements. Instead, it is meant to bring awareness to critical links (at a local scale) or corridors (on a network scale) of interest that could inhibit future economic growth in the area due to the unattractiveness of current and projected delay and the inability to efficiently and reliably move goods.

Additional factors to take into consideration when determining the effect of growth on the network are increases in the value of travel time reliability. As delay is projected to increase, the value associated with delivering transported good within a certain on-time window can be informative especially when tied into the cost of moving commodities. Also, by measuring travel time reliability, the performance of travel times along a link or corridor can be tracked over time and inform the planning process about the performance of the highway link over time. Travel time reliability measures typically include the Buffer Index (BI) and the Planning Time Index (PTI). The buffer index expresses the amount of extra time needed to be on time 95 percent of the time while the planning time index expresses the total time that should be planned in order to complete a trip in order to arrive on time [24]. Both indices were created to account for varying amounts of recurring delay.

The difficulty in the process of monetizing truck freight and calculating the cost of delay along the identified corridor of interest is typically one of collecting sufficient and sufficiently accurate data and incorporating the results of the subsequent performance measurement procedure into the transportation planning process [24]. Once accurate data is obtained and analyzed, programs such as Highway Economic Requirements System—State Tool (HERS-ST) can be useful in identifying user costs and benefits for links or corridors of interest. Being able to more accurately calculate delay using the available data only sets the stage for true system performance enhancement. Monetizing the costs of truck delay assists in quantifying the effects of surface freight transportation on the network. Accurate representation of what commodities are moving throughout the state along with the risks delay can assist in better informing cost models as well prioritizing links. Links with higher volumes of trucks carrying goods that have a low time sensitivity and those that are of lower values (in dollars per ton) should be distinguished when considering freight corridor improvements because their effect on the local economy vary.

Areas for improvement and future research include the identification of the percent of delay costs associated with the movement of goods along a corridor. This effort may require a survey of freight carriers to determine if they incur a charge for late or damaged goods, and if so what percent or value is that of the overall travel time costs. Through the inclusion of the cost of delay to specific classes of commodities in the estimation of travel time costs, transportation planners will be better able to capture the true cost and value of freight moving along a corridor and relate that cost to its impacts on the local economy.

Although the examples used in the report referred specially to a single Georgia highway, it is hoped that in the future as research continues, the findings may be of value in other states to better inform the planning process and more accurately calculate delay.

APPENDICES

Appendix A—FAF Data Dictionary

Table 15—FAF Data Dictionary

Attribute	Domain Type	Description
ID	Integer	Unique identifier to link with FAF network arc
Version	Character	Used for maintaining consistency across data files containing alternate releases of the FAF.
AADT07	Integer	HPMS annual average daily traffic for year 2007, derived from HPMS 2008 database. Volume/day/route
AADTT07	Integer	Year 2007 Truck Volume estimated using a combination of HPMS 2008 database, State truck percentage, and functional class specific defaults. Volume/day/route
FAF07	Integer	FAF 3.1 long distance truck volume estimated based on the FAF 3.1 Origin-Destination truck tonnage and includes empty trucks. Volume/day/route
NONFAF07	Integer	Local truck traffic that is not part of FAF 3.11 O-D database. Volume/day/route
AADT40	Integer	Year 2040 forecast Annual Average Traffic Volume estimated using the HPMS 20 year growth factors and projected to future using linear growth. Volume/day/route
AADTT40	Integer	Forecast Annual Average Truck Volume estimated using the HPMS 20 year growth factors and projected to future using linear growth. Volume/day/route
FAF40	Integer	Year 2040 FAF 3.1 long distance truck volume estimated based on the forecasted FAF 3.1 Origin-Destination truck tonnage and includes empty trucks. Volume/day/route
NONFAF40	Integer	Year 2040 Local truck traffic that is not part of FAF 3.11 O-D database. Volume/day/route
CAP07	Integer	Link specific peak capacity estimated using the procedures outlined in HCM 2000 and the arc geometry provided in 2008 HPMS database. Volume/hour/route
SF07	Integer	Estimated service flow using the procedures outlined in HCM 2000 and arc geometry, FAF truck, non-FAF truck and passenger volume. Volume/hour/route
VCR07	Real	2007 estimated volume to capacity ratio, estimated by dividing SF07 with CAP07. Unit less
SPEED07	Real	2007 estimated peak period link speed, estimated using the procedures outlined in HCM 2000 and the arc geometry provided in 2008 HPMS database. miles/hour
DELAY07	Real	2007 estimated peak period link delay, estimated using the procedures outlined in HCM 2000 and the arc geometry provided in 2008 HPMS database. In hours
CAP40	Integer	Link specific peak capacity estimated using the procedures outlined in HCM 2000. Volume/hour/route
VCR40	Real	2040 estimated volume to capacity ratio, estimated by dividing SF40 with CAP40. Unit less
SPEED40	Real	2040 estimated peak period link speed, estimated using the procedures outlined in HCM 2000. Miles/hour
DELAY40	Real	2040 estimated peak period link delay, estimated using the procedures outlined in HCM 2000. In hours

Appendix B—Vehicle Classification Chart

Figure 8—Vehicle Classification Chart

Appendix C—FAF^3 Volume Matrix and ATRI Speed Combination

Table 16—FAF^3 Link Data and ATRI Data Matrix

FAF^3 Data				ATRI Data					
	Volume	Distance			Speed			Distance	
Link ID	AADTT07	Aggregate Length	Cumulative Distance	From Measure	Mile 1	Mile 2	Mile 3	Distance	Cumulative Distance
1	9771	11	11	1314	59.10672	59.10672	59.10672	3	3
2	9417	5	16	1311	56.91581	56.91581	56.91581	3	6
3	9712	2	18	1308	56.93693	56.93693	56.93693	3	9
4	9825	4	22	1305	57.79438	57.79438	57.79438	3	12
5	8858	7	29	1302	56.8465	56.8465	56.8465	3	15
6	8697	11	40	1299	57.09941	57.09941	57.09941	3	18
7	8682	22	62	1296	57.27097	57.27097	57.27097	3	21
8	10825	1	63	1293	57.50035	57.50035	57.50035	3	24
9	10630	2	65	1290	57.6606	57.6606	57.6606	3	27
10	9362	14	79	1287	57.85315	57.85315	57.85315	3	30
11	9650	4	83	1284	57.95812	57.95812	57.95812	3	33
12	9599	2	85	1281	58.08277	58.08277	58.08277	3	36
13	9284	15	100	1278	58.22191	58.22191	58.22191	3	39
14	10598	2	102	1275	57.98862	57.98862	57.98862	3	42
15	10603	1	103	1272	58.0475	58.0475	58.0475	3	45
16	11554	8	111	1269	58.31242	58.31242	58.31242	3	48
17	7705	3	114	1266	57.95405	57.95405	57.95405	3	51
18	10936	9	123	1263	58.09272	58.09272	58.09272	3	54
19	10829	1	124	1260	58.25563	58.25563	58.25563	3	57
20	10871	5	129	1257	58.97504	58.97504	58.97504	3	60
21	8983	7	136	1254	58.01919	58.01919	58.01919	3	63
22	11122	1	137	1251	58.2295	58.2295	58.2295	3	66
23	12770	2	139	1248	58.42257	58.42257	58.42257	3	69
24	12780	2	141	1245	58.5807	58.5807	58.5807	3	72
25	13405	4	145	1242	58.65278	58.65278	58.65278	3	75
26	13946	5	150	1239	58.70452	58.70452	58.70452	3	78
27	16374	3	153	1236	58.77195	58.77195	58.77195	3	81
28	11441	6	159	1233	58.8244	58.8244	58.8244	3	84
29	8753	1	160	1230	59.24337	59.24337	59.24337	3	87
				1227	58.55381	58.55381	58.55381	3	90
				1224	58.72151	58.72151	58.72151	3	93
				1221	58.85966	58.85966	58.85966	3	96
				1218	59.00971	59.00971	59.00971	3	99
				1215	59.45908	59.45908	59.45908	3	102
				1212	59.35824	59.35824	59.35824	3	105
				1209	59.80227	59.80227	59.80227	3	108
				1206	60.35263	60.35263	60.35263	3	111
				1203	60.34071	60.34071	60.34071	3	114
				1200	60.90952	60.90952	60.90952	3	117

Table 17—FAF^3 Data Matrix

FAF^3	Mile Segments																					
ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
104631	9771	9771	9771	9771	9771	9771	9771	9771	9771	9771	9771	0	0	0	0	0	0	0	0	0	0	0
204635	9417	9417	9417	9417	9417	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
304639	9712	9712	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
404642	9825	9825	9825	9825	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
504645	8858	8858	8858	8858	8858	8858	8858	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
604649	8697	8697	8697	8697	8697	8697	8697	8697	8697	8697	8697	0	0	0	0	0	0	0	0	0	0	0
709590	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682	8682
804653	10825	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
904659	10630	10630	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1004662	9362	9362	9362	9362	9362	9362	9362	9362	9362	9362	9362	9362	9362	9362	0	0	0	0	0	0	0	0
1104666	9650	9650	9650	9650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1204668	9599	9599	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1304673	9284	9284	9284	9284	9284	9284	9284	9284	9284	9284	9284	9284	9284	9284	9284	0	0	0	0	0	0	0
1404676	10598	10598	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1504680	10603	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1604684	11554	11554	11554	11554	11554	11554	11554	11554	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1705890	7705	7705	7705	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1804691	10936	10936	10936	10936	10936	10936	10936	10936	10936	0	0	0	0	0	0	0	0	0	0	0	0	0
1903691	10829	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003695	10871	10871	10871	10871	10871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2107579	8983	8983	8983	8983	8983	8983	8983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2203699	11122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2303703	12770	12770	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2408794	12780	12780	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2504702	13405	13405	13405	13405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2604698	13946	13946	13946	13946	13946	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2704708	16374	16374	16374	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2804711	11441	11441	11441	11441	11441	11441	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2904712	8753	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix D—2007 Delay Measures

Table 18—2007 Northbound Measures

LinkID	Distance (miles)	Total		Trucks		VCR			Average		Free Flow		Delay (minutes)			Cost (dollars)			
		Volume	Truck	Single Unit	Combination	Calculated	FAF 2007	FAF 2040	Speed (MPH)	Travel Time (minutes)	Speed (MPH)	Travel Time (minutes)	Average	Average (per mile)	Total Link	Direct Travel	Delay Time	Travel Time per Vehicle Mile	Total Travel Time
1	11	18,165	4,806	621	4,189	0.14	0.47	1.33	57.68	11.44	70	9.43	2.01	0.18	9680	$ 91,462	$ 13,341	$ 1.43	$75,793
2	5	19,694	4,632	599	4,037	0.15	0.50	1.34	57.09	5.26	70	4.29	0.97	0.19	4491	$ 40,067	$ 6,189	$ 1.45	$33,548
3	2	20,311	4,777	617	4,163	0.16	0.52	1.29	57.10	2.10	70	1.71	0.39	0.19	1850	$ 16,529	$ 2,550	$ 1.45	$13,836
4	4	20,548	4,833	625	4,212	0.16	0.53	1.19	57.33	4.19	70	3.43	0.76	0.19	3662	$ 33,443	$ 5,047	$ 1.44	$27,883
5	7	18,527	4,357	563	3,797	0.21	0.70	1.07	57.67	7.28	70	6.00	1.28	0.18	5589	$ 52,764	$ 7,703	$ 1.43	$43,732
6	11	17,460	4,278	553	3,728	0.20	0.67	0.96	58.06	11.37	70	9.43	1.94	0.18	8297	$ 81,408	$ 11,435	$ 1.42	$67,022
7	22	18,157	4,359	563	3,799	0.14	0.46	0.94	58.22	22.67	70	18.86	3.81	0.17	16625	$ 165,906	$ 22,912	$ 1.42	$136,197
8	1	22,639	5,325	688	4,641	0.17	0.58	0.76	58.02	1.03	70	0.86	0.18	0.18	942	$ 9,212	$ 1,299	$ 1.43	$7,589
9	2	22,232	5,229	676	4,557	0.17	0.57	0.87	58.23	2.06	70	1.71	0.35	0.17	1812	$ 18,091	$ 2,497	$ 1.42	$14,850
10	14	18,842	4,605	595	4,013	0.22	0.39	1.07	58.58	14.34	70	12.00	2.34	0.17	10776	$ 111,533	$ 14,851	$ 1.41	$91,008
11	4	18,610	4,723	553	4,165	0.21	0.57	0.96	58.80	4.08	70	3.43	0.65	0.16	3085	$ 32,684	$ 4,252	$ 1.41	$26,569
12	2	18,511	4,698	550	4,143	0.21	0.32	0.84	59.03	2.03	70	1.71	0.32	0.16	1496	$ 16,256	$ 2,062	$ 1.40	$13,162
13	15	18,621	4,544	532	4,007	0.21	0.71	0.67	58.89	15.28	70	12.86	2.43	0.16	11019	$ 117,917	$ 15,187	$ 1.40	$95,703
14	2	22,141	5,187	607	4,575	0.26	0.86	0.68	59.46	2.02	70	1.71	0.30	0.15	1576	$ 17,947	$ 2,173	$ 1.39	$14,427
15	1	22,152	5,190	607	4,577	0.26	0.86	0.69	59.36	1.01	70	0.86	0.15	0.15	797	$ 8,978	$ 1,099	$ 1.39	$7,229
16	8	22,281	5,655	662	4,987	0.17	0.28	0.86	59.90	8.01	70	6.86	1.16	0.14	6540	$ 78,266	$ 9,013	$ 1.38	$62,455
17	3	21,464	3,771	441	3,326	0.16	0.42	0.99	60.34	2.98	70	2.57	0.41	0.14	1552	$ 19,572	$ 2,139	$ 1.37	$15,504
18	9	21,089	5,353	626	4,720	0.16	0.31	1.38	61.27	8.81	70	7.71	1.10	0.12	5881	$ 83,339	$ 8,105	$ 1.35	$65,011
19	1	20,883	5,300	620	4,674	0.16	0.30	1.34	61.95	0.97	70	0.86	0.11	0.11	590	$ 9,169	$ 813	$ 1.33	$7,074
20	5	20,964	5,321	623	4,692	0.16	0.31	1.13	62.25	4.82	70	4.29	0.53	0.11	2841	$ 46,024	$ 3,915	$ 1.33	$35,342
21	7	21,449	4,397	514	3,877	0.16	0.42	1.11	63.06	6.66	70	6.00	0.66	0.09	2903	$ 53,244	$ 4,001	$ 1.31	$40,357
22	1	21,449	5,444	637	4,801	0.17	0.44	1.06	63.51	0.94	70	0.86	0.09	0.09	477	$ 9,417	$ 657	$ 1.30	$7,087
23	2	24,627	6,250	731	5,512	0.19	0.50	0.93	63.55	1.89	70	1.71	0.17	0.09	1087	$ 21,626	$ 1,498	$ 1.30	$16,265
24	2	24,233	6,140	1841	4,291	0.19	0.50	0.93	63.59	1.89	70	1.71	0.17	0.09	1061	$ 21,245	$ 1,462	$ 1.30	$15,969
25	4	25,233	6,440	1931	4,500	0.19	0.53	0.95	64.06	3.75	70	3.43	0.32	0.08	2046	$ 44,568	$ 2,819	$ 1.29	$33,252
26	5	26,251	6,700	2009	4,682	0.20	0.55	0.99	64.31	4.66	70	4.29	0.38	0.08	2540	$ 57,959	$ 3,500	$ 1.29	$43,076
27	3	30,822	7,867	2359	5,497	0.24	0.64	1.05	64.38	2.80	70	2.57	0.22	0.07	1765	$ 40,830	$ 2,432	$ 1.28	$30,312
28	6	35,174	5,845	2403	3,397	0.26	0.68	1.22	65.06	5.53	70	5.14	0.39	0.07	2282	$ 60,671	$ 3,146	$ 1.27	$44,573
CORRIDOR	**159**	**21,876**	**5,215**	**870**	**4,341**	**0.19**	**0.53**	**--**	**60.38**	**159.89**	**70.00**	**136.29**	**0.84**	**0.14**	**113265**	**$1,360,126**	**$156,097**	**$ 1.37**	**$1,084,824**

Table 19—2007 Southbound Measures

LinkID	Distance (miles)	Total		Trucks		VCR			Average		Free Flow		Delay (minutes)			Cost (dollars)			
		Volume	Truck	Single Unit	Combination	Calculated	FAF 2007	FAF 2040	Speed (MPH)	Travel Time (minutes)	Speed (MPH)	Travel Time (minutes)	Average	Average (per mile)	Total Link	Direct Travel	Delay Time	Travel Time per Vehicle Mile	Total Travel Time
1	11	18,027	4,965	616	4,341	0.14	0.47	1.33	57.32	11.51	70	9.43	2.09	0.19	10357	$ 94,481	$ 14,274	$ 1.44	$78,788
2	5	19,544	4,785	594	4,184	0.15	0.50	1.34	57.55	5.21	70	4.29	0.93	0.19	4438	$ 41,390	$ 6,117	$ 1.44	$34,379
3	2	20,156	4,935	613	4,315	0.15	0.52	1.29	57.70	2.08	70	1.71	0.37	0.18	1804	$ 17,075	$ 2,486	$ 1.43	$14,145
4	4	20,392	4,992	620	4,365	0.16	0.53	1.19	57.86	4.15	70	3.43	0.72	0.18	3593	$ 34,546	$ 4,951	$ 1.43	$28,540
5	7	18,385	4,501	559	3,935	0.21	0.70	1.07	58.05	7.23	70	6.00	1.23	0.18	5558	$ 54,506	$ 7,660	$ 1.42	$44,879
6	11	17,328	4,419	549	3,864	0.20	0.67	0.96	58.22	11.34	70	9.43	1.91	0.17	8434	$ 84,096	$ 11,624	$ 1.42	$69,046
7	22	18,018	4,503	559	3,937	0.14	0.46	0.94	58.35	22.62	70	18.86	3.77	0.17	16959	$ 171,382	$ 23,372	$ 1.42	$140,396
8	1	22,466	5,500	683	4,809	0.17	0.58	0.76	59.07	1.02	70	0.86	0.16	0.16	872	$ 9,516	$ 1,202	$ 1.40	$7,700
9	2	22,062	5,401	671	4,722	0.17	0.57	0.87	58.95	2.04	70	1.71	0.32	0.16	1736	$ 18,688	$ 2,392	$ 1.40	$15,153
10	14	18,698	4,757	591	4,159	0.21	0.39	1.07	59.02	14.23	70	12.00	2.23	0.16	10623	$ 115,215	$ 14,641	$ 1.40	$93,312
11	4	18,507	4,927	553	4,374	0.21	0.57	0.96	59.29	4.05	70	3.43	0.62	0.15	3053	$ 34,094	$ 4,207	$ 1.39	$27,488
12	2	18,409	4,901	550	4,351	0.21	0.32	0.84	59.25	2.03	70	1.71	0.31	0.16	1524	$ 16,957	$ 2,100	$ 1.40	$13,678
13	15	18,518	4,740	532	4,208	0.21	0.71	0.67	59.25	15.19	70	12.86	2.33	0.16	11053	$ 123,003	$ 15,233	$ 1.40	$99,223
14	2	22,019	5,411	607	4,804	0.26	0.86	0.68	59.30	2.02	70	1.71	0.31	0.15	1674	$ 18,722	$ 2,306	$ 1.39	$15,090
15	1	22,029	5,413	607	4,806	0.25	0.86	0.69	59.49	1.01	70	0.86	0.15	0.15	820	$ 9,365	$ 1,130	$ 1.39	$7,525
16	8	22,158	5,899	662	5,237	0.17	0.28	0.86	59.73	8.04	70	6.86	1.18	0.15	6958	$ 81,642	$ 9,589	$ 1.38	$65,336
17	3	21,346	3,934	441	3,492	0.16	0.42	0.99	60.09	3.00	70	2.57	0.42	0.14	1669	$ 20,417	$ 2,300	$ 1.38	$16,241
18	9	20,973	5,583	626	4,957	0.16	0.31	1.38	61.00	8.85	70	7.71	1.14	0.13	6353	$ 86,934	$ 8,756	$ 1.36	$68,117
19	1	20,767	5,529	620	4,908	0.16	0.30	1.34	62.10	0.97	70	0.86	0.11	0.11	603	$ 9,565	$ 831	$ 1.33	$7,362
20	5	20,848	5,550	623	4,927	0.16	0.31	1.13	62.46	4.80	70	4.29	0.52	0.10	2870	$ 48,010	$ 3,955	$ 1.32	$36,738
21	7	21,331	4,586	515	4,072	0.16	0.42	1.11	62.78	6.69	70	6.00	0.69	0.10	3162	$ 55,540	$ 4,358	$ 1.32	$42,283
22	1	21,331	5,678	637	5,041	0.16	0.44	1.06	63.00	0.95	70	0.86	0.10	0.10	541	$ 9,824	$ 745	$ 1.31	$7,453
23	2	24,490	6,520	731	5,788	0.19	0.50	0.93	63.28	1.90	70	1.71	0.18	0.09	1187	$ 22,559	$ 1,636	$ 1.31	$17,040
24	2	25,283	6,640	1661	4,982	0.20	0.50	0.93	63.41	1.89	70	1.71	0.18	0.09	1182	$ 22,974	$ 1,629	$ 1.30	$17,316
25	4	26,327	6,965	1742	5,225	0.20	0.53	0.95	63.70	3.77	70	3.43	0.34	0.08	2362	$ 48,194	$ 3,255	$ 1.30	$36,164
26	5	27,389	7,246	1812	5,436	0.21	0.55	0.99	64.10	4.68	70	4.29	0.39	0.08	2856	$ 62,674	$ 3,937	$ 1.29	$46,732
27	3	32,158	8,507	2128	6,383	0.25	0.64	1.05	64.46	2.79	70	2.57	0.22	0.07	1879	$ 44,151	$ 2,590	$ 1.28	$32,738
28	6	36,337	5,596	2131	3,508	0.27	0.68	1.22	64.77	5.56	70	5.14	0.41	0.07	2322	$ 58,087	$ 3,200	$ 1.28	$42,863
CORRIDOR	**159**	**21,975**	**5,442**	**4941**	**4,612**	**0.19**	**0.53**	**--**	**60.48**	**159.61**	**70.00**	**136.29**	**0.83**	**0.14**	**116445**	**$1,413,606**	**$160,480**	**$ 1.37**	**$1,125,724**

Appendix E—Linking FAF^3 Volumes to Commodity Tons

Table 20 displays the commodity tonnage moved within the state of Georgia along with the tons allocated to various truck types (see Table 11). Tons of goods moved by the five truck types were determined by multiplying the truck allocation factor for the specified distance and commodity by the number of tons moved for that commodity. The annual loaded truck traffic volumes were then calculated by tons moved by body type by the sum associated truck allocation factors. To determine the percent of trucks moved by each commodity, the sum of truck volumes for that commodity type were divided by the total volume of trucks. This percentage was then applied to the known volume of trucks (total trucks, single unit, and combination) by link on the corridor resulting in a matrix of truck volumes by commodity, link, and truck type (being either single unit or combination trucks). The truck volumes for each commodity were then aggregated by sensitivity type and truck type and were used to display volumes and delay for links on the corridor.

Table 20—Ktons to Volume Conversion for Corridor

	SCGT2	Ktons W/in GA	101-200 miles w/in GA SU	TT	CS	DBL	TPL	Annual Truck Traffic, Loaded SU	TT	CS	DBL	TPL	Annual Truck Traffic, Loaded % SU	TT	CS	DBL	TPL
			0.313468	*0.045762*	*0.565269*	*0.074434*	*0.000452*										
1	Live animals/fish	4,400	1,379	201	2,487	328	2	86,695	23,881	96,437	9,705	0	1.31%	1.31%	1.31%	1.31%	1.31%
2	Cereal grains	5,956	1,867	273	3,367	443	3	68,579	11,227	117,136	11,660	0	1.26%	1.26%	1.26%	1.26%	1.26%
3	Other ag prods.	7,164	2,246	328	4,049	533	3	114,298	26,930	174,405	17,639	0	2.02%	2.02%	2.02%	2.02%	2.02%
4	Animal feed	5,730	1,796	262	3,239	426	3	92,555	22,485	128,520	13,772	0	1.56%	1.56%	1.56%	1.56%	1.56%
5	Meat/seafood	2,306	723	106	1,304	172	1	63,369	24,483	51,067	10,730	0	0.91%	0.91%	0.91%	0.91%	0.91%
6	Milled grain prods.	1,609	505	74	910	120	1	80,764	45,428	37,638	7,047	0	1.04%	1.04%	1.04%	1.04%	1.04%
7	Other foodstuffs	6,147	1,927	281	3,475	458	3	81,888	58,383	213,717	14,142	0	2.23%	2.23%	2.23%	2.23%	2.23%
8	Alcoholic beverages	2,341	734	107	1,323	174	1	17,767	3,167	184,814	10,562	0	1.31%	1.31%	1.31%	1.31%	1.31%
9	Tobacco prods.	65	20	3	37	5	0	2,254	45	1,495	0	0	0.02%	0.02%	0.02%	0.02%	0.02%
10	Building stone	1,103	346	50	623	82	0	11,781	2,952	23,302	2,784	0	0.25%	0.25%	0.25%	0.25%	0.25%
11	Natural sands	8,162	2,558	373	4,614	608	4	79,490	18,899	163,087	14,228	0	1.67%	1.67%	1.67%	1.67%	1.67%
12	Gravel	84,982	26,639	3,889	48,037	6,326	38	700,872	158,007	1,731,270	136,884	943	16.53%	16.53%	16.53%	16.53%	16.53%
13	Nonmetallic minerals	7,290	2,285	334	4,121	543	3	65,106	14,095	140,027	13,902	0	1.41%	1.41%	1.41%	1.41%	1.41%
14	Metallic ores	21	7	1	12	2	0	197	0	423	40	0	0.00%	0.00%	0.00%	0.00%	0.00%
15	Coal	452	142	21	255	34	0	3,230	1,004	8,077	599	0	0.08%	0.08%	0.08%	0.08%	0.08%
16	Crude petroleum	0	0	0	0	0	0	3	0	5	1	0	0.00%	0.00%	0.00%	0.00%	0.00%
17	Gasoline	30,978	9,711	1,418	17,511	2,306	14	508,738	127,188	518,672	109,249	0	7.66%	7.66%	7.66%	7.66%	7.66%
18	Fuel oils	9,972	3,126	456	5,637	742	5	118,091	22,387	167,971	16,359	0	1.97%	1.97%	1.97%	1.97%	1.97%
19	Coal-n.e.c.	10,140	3,178	464	5,732	755	5	194,618	25,595	206,454	21,669	0	2.72%	2.72%	2.72%	2.72%	2.72%
20	Basic chemicals	12,577	3,943	576	7,110	936	6	226,658	27,017	271,655	28,216	0	3.35%	3.35%	3.35%	3.35%	3.35%
21	Pharmaceuticals	297	93	14	168	22	0	10,944	0	7,970	0	0	0.11%	0.11%	0.11%	0.11%	0.11%
22	Fertilizers	2,921	916	134	1,651	217	1	38,756	12,699	64,025	7,270	0	0.74%	0.74%	0.74%	0.74%	0.74%
23	Chemical prods.	3,434	1,076	157	1,941	256	2	59,864	30,498	72,123	5,587	0	1.02%	1.02%	1.02%	1.02%	1.02%
24	Plastics/rubber	2,321	727	106	1,312	173	1	74,725	28,214	55,450	12,397	0	1.03%	1.03%	1.03%	1.03%	1.03%
25	Logs	45,157	14,155	2,066	25,526	3,361	20	606,413	73,339	1,216,309	79,090	0	11.97%	11.97%	11.97%	11.97%	11.97%
26	Wood prods.	12,592	3,947	576	7,118	937	6	247,412	79,619	377,820	27,256	0	4.44%	4.44%	4.44%	4.44%	4.44%
27	Newsprint/paper	3,093	969	142	1,748	230	1	73,325	9,132	61,830	0	0	0.87%	0.87%	0.87%	0.87%	0.87%
28	Paper articles	2,657	833	122	1,502	198	1	59,983	126,624	57,763	8,168	0	1.53%	1.53%	1.53%	1.53%	1.53%
29	Printed prods.	732	229	34	414	54	0	21,754	33,515	16,967	0	0	0.44%	0.44%	0.44%	0.44%	0.44%
30	Textiles/leather	5,417	1,698	248	3,062	403	2	188,386	108,403	107,480	55,616	0	2.79%	2.79%	2.79%	2.79%	2.79%
31	Nonmetal min. prods.	37,300	11,692	1,707	21,084	2,776	17	170,942	87,104	970,307	64,523	368	7.84%	7.84%	7.84%	7.84%	7.84%
32	Base metals	3,679	1,153	168	2,079	274	2	88,711	11,698	273,278	56,855	0	2.61%	2.61%	2.61%	2.61%	2.61%
33	Articles-base metal	2,598	814	119	1,469	193	1	47,582	27,074	123,830	6,556	0	1.24%	1.24%	1.24%	1.24%	1.24%
34	Machinery	3,758	1,178	172	2,124	280	2	87,406	13,488	79,732	12,550	30	1.17%	1.17%	1.17%	1.17%	1.17%
35	Electronics	1,102	345	50	623	82	0	33,513	25,234	24,704	0	0	0.51%	0.51%	0.51%	0.51%	0.51%
36	Motorized vehicles	2,569	805	118	1,452	191	1	12,297	22,961	70,593	12,749	0	0.72%	0.72%	0.72%	0.72%	0.72%
37	Transport equip.	53	17	2	30	4	0	618	232	1,258	113	0	0.01%	0.01%	0.01%	0.01%	0.01%
38	Precision instruments	41	13	2	23	3	0	2,099	941	1,039	360	0	0.03%	0.03%	0.03%	0.03%	0.03%
39	Furniture	768	241	35	434	57	0	29,893	5,171	16,580	1,981	0	0.32%	0.32%	0.32%	0.32%	0.32%
40	Misc. mfg. prods.	1,599	501	73	904	119	1	45,582	7,504	58,097	6,860	0	0.72%	0.72%	0.72%	0.72%	0.72%
41	Waste/scrap	33,334	10,449	1,525	18,843	2,481	15	265,615	160,505	715,640	48,457	0	7.21%	7.21%	7.21%	7.21%	7.21%
42	Unknown	6,303	1,976	288	3,563	469	3	75,697	17,849	130,266	0	0	1.36%	1.36%	1.36%	1.36%	1.36%
43	Mixed freight	10,272	3,220	470	5,807	765	5	315,339	72,308	242,659	33,964	119	4.03%	4.03%	4.03%	4.03%	4.03%
Grand Total		**383,393**	**120,181**	**17,545**	**216,720**	**28,537**	**173**	**5,073,810**	**1,567,286**	**8,981,893**	**879,538**	**1,459**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Appendix F—Delay Measures Including Commodity Sensitivity Volumes

Table 21—2007 Northbound Delay Measures Including Commodity Sensitivity Volumes

LinkID	Distance (miles)	Total		Single Unit Truck				Combination Trucks				FAF³ VCR		Average		Free Flow		Delay (minutes)			Cost (dollars)			
		Volume	Trucks	Volume	High	Mod	Low	Volume	High	Mod	Low	2007	2040	Speed (MPH)	Travel Time (minutes)	Speed (MPH)	Travel Time (minutes)	Average	Average (per mile)	Total Link	Direct Travel	Delay Time	Delay Time per Vehicle Mile	Travel Time per Vehicle Mile
1	11	18,165	4,806	621	89	422	110	4,189	601	2,847	740	0.47	1.33	57.68	11.44	70	9.43	2.014	0.183	9680	$ 91,461.53	$ 13,340.83	$ 0.07	$ 1.43
2	5	19,694	4,632	599	86	407	106	4,037	579	2,744	713	0.50	1.34	57.09	5.26	70	4.29	0.969	0.194	4491	$ 40,067.23	$ 6,188.74	$ 0.06	$ 1.45
3	2	20,311	4,777	617	89	420	109	4,163	598	2,830	736	0.52	1.29	57.10	2.10	70	1.71	0.387	0.194	1850	$ 16,528.96	$ 2,549.95	$ 0.06	$ 1.45
4	4	20,548	4,833	625	90	425	110	4,212	605	2,863	744	0.53	1.19	57.33	4.19	70	3.43	0.758	0.189	3662	$ 33,442.55	$ 5,047.46	$ 0.06	$ 1.44
5	7	18,527	4,357	563	81	383	100	3,797	545	2,581	671	0.70	1.07	57.67	7.28	70	6.00	1.283	0.183	5589	$ 52,764.34	$ 7,703.17	$ 0.06	$ 1.43
6	11	17,460	4,278	553	79	376	98	3,728	535	2,534	659	0.67	0.96	58.06	11.37	70	9.43	1.940	0.176	8297	$ 81,408.35	$ 11,434.68	$ 0.06	$ 1.42
7	22	18,157	4,359	563	81	383	100	3,799	545	2,582	671	0.46	0.94	58.22	22.67	70	18.86	3.814	0.173	16625	$ 165,905.66	$ 22,912.18	$ 0.06	$ 1.42
8	1	22,639	5,325	688	99	468	122	4,641	666	3,154	820	0.58	0.76	58.02	1.03	70	0.86	0.177	0.177	942	$ 9,211.59	$ 1,298.85	$ 0.06	$ 1.43
9	2	22,232	5,229	676	97	459	119	4,557	654	3,098	805	0.57	0.87	58.23	2.06	70	1.71	0.347	0.173	1812	$ 18,091.31	$ 2,497.07	$ 0.06	$ 1.42
10	14	18,842	4,605	595	85	405	105	4,013	576	2,728	709	0.39	1.07	58.58	14.34	70	12.00	2.340	0.167	10776	$ 111,533.02	$ 14,850.75	$ 0.06	$ 1.41
11	4	18,610	4,723	553	79	376	98	4,165	598	2,831	736	0.57	0.96	58.80	4.08	70	3.43	0.653	0.163	3085	$ 32,684.03	$ 4,251.76	$ 0.06	$ 1.41
12	2	18,511	4,698	550	79	374	97	4,143	595	2,816	732	0.32	0.84	59.03	2.03	70	1.71	0.318	0.159	1496	$ 16,255.65	$ 2,061.88	$ 0.06	$ 1.40
13	15	18,621	4,544	532	76	361	94	4,007	575	2,724	708	0.71	0.67	58.89	15.28	70	12.86	2.425	0.162	11019	$ 117,916.53	$ 15,186.70	$ 0.05	$ 1.40
14	2	22,141	5,187	607	87	413	107	4,575	657	3,110	808	0.86	0.68	59.46	2.02	70	1.71	0.304	0.152	1576	$ 17,947.43	$ 2,172.56	$ 0.05	$ 1.39
15	1	22,152	5,190	607	87	413	107	4,577	657	3,111	809	0.86	0.69	59.36	1.01	70	0.86	0.154	0.154	797	$ 8,977.95	$ 1,099.05	$ 0.05	$ 1.39
16	8	22,281	5,655	662	95	450	117	4,987	716	3,390	881	0.28	0.86	59.90	8.01	70	6.86	1.157	0.145	6540	$ 78,265.55	$ 9,013.47	$ 0.05	$ 1.38
17	3	21,464	3,771	441	63	300	78	3,326	477	2,261	588	0.42	0.99	60.34	2.98	70	2.57	0.412	0.137	1552	$ 19,572.32	$ 2,139.37	$ 0.03	$ 1.37
18	9	21,089	5,353	626	90	426	111	4,720	678	3,209	834	0.31	1.38	61.27	8.81	70	7.71	1.099	0.122	5881	$ 83,339.20	$ 8,104.73	$ 0.04	$ 1.35
19	1	20,883	5,300	620	89	422	110	4,674	671	3,177	826	0.30	1.34	61.95	0.97	70	0.86	0.111	0.111	590	$ 9,169.31	$ 813.36	$ 0.04	$ 1.33
20	5	20,964	5,321	623	89	423	110	4,692	674	3,190	829	0.31	1.13	62.25	4.82	70	4.29	0.534	0.107	2841	$ 46,024.37	$ 3,915.32	$ 0.04	$ 1.33
21	7	21,449	4,397	514	74	350	91	3,877	557	2,636	685	0.42	1.11	63.06	6.66	70	6.00	0.660	0.094	2903	$ 53,243.64	$ 4,000.81	$ 0.03	$ 1.31
22	1	21,449	5,444	637	91	433	113	4,801	689	3,263	848	0.44	1.06	63.51	0.94	70	0.86	0.088	0.088	477	$ 9,417.40	$ 656.92	$ 0.03	$ 1.30
23	2	24,627	6,250	731	105	497	129	5,512	791	3,747	974	0.50	0.93	63.55	1.89	70	1.71	0.174	0.087	1087	$ 21,625.65	$ 1,498.32	$ 0.03	$ 1.30
24	2	24,233	6,140	1,841	264	1,252	325	4,291	616	2,916	758	0.50	0.93	63.59	1.89	70	1.71	0.173	0.086	1061	$ 21,245.14	$ 1,461.96	$ 0.03	$ 1.30
25	4	25,233	6,440	1,931	277	1,313	341	4,500	646	3,059	795	0.53	0.95	64.06	3.75	70	3.43	0.318	0.079	2046	$ 44,568.26	$ 2,819.41	$ 0.03	$ 1.29
26	5	26,251	6,700	2,009	288	1,366	355	4,682	672	3,183	827	0.55	0.99	64.31	4.66	70	4.29	0.379	0.076	2540	$ 57,958.68	$ 3,500.34	$ 0.03	$ 1.29
27	3	30,822	7,867	2,359	339	1,603	417	5,497	789	3,737	971	0.64	1.05	64.38	2.80	70	2.57	0.224	0.075	1765	$ 40,829.58	$ 2,432.24	$ 0.03	$ 1.28
28	6	35,174	5,845	2,403	345	1,633	425	3,397	488	2,309	600	0.68	1.22	65.06	5.53	70	5.14	0.390	0.065	2282	$ 60,670.69	$ 3,145.54	$ 0.01	$ 1.27
CORRIDOR	**159**	**21,876**	**5,215**	**870**	**125**	**591**	**154**	**4,341**	**623**	**2,951**	**767**	**0.50**	**0.99**	**60.38**	**159.89**	**70.00**	**136.29**	**0.843**	**0.138**	**113265**	**$ 1,360,125.92**	**$ 156,097.43**	**$ 1.28**	**$ 38.41**

Table 22—2007 Southbound Delay Measures Including Commodity Sensitivity Volumes

LinkID	Distance (miles)	Total		Single Unit Truck				Combination Trucks				FAF^3 VCR		Average		Free Flow		Delay (minutes)			Cost (dollars)			
		Volume	Trucks	Volume	High	Mod	Low	Volume	High	Mod	Low	2007	2040	Speed (MPH)	Travel Time (minutes)	Speed (MPH)	Travel Time (minutes)	Average	Average (per mile)	Total Link	Direct Travel	Delay Time	Delay Time per Vehicle Mile	Travel Time per Vehicle Mile
1	11	18,027	4,965	616	88	419	109	4,341	623	2,951	767	0.47	1.33	57.32	11.515	70	9.429	2.086	0.190	10357	$ 94,480.60	$ 14,274.32	$ 0.07	$ 1.44
2	5	19,544	4,785	594	85	404	105	4,184	601	2,844	739	0.50	1.34	57.55	5.213	70	4.286	0.928	0.186	4438	$ 41,389.82	$ 6,116.66	$ 0.06	$ 1.44
3	2	20,156	4,935	613	88	416	108	4,315	619	2,933	762	0.52	1.29	57.70	2.080	70	1.714	0.366	0.183	1804	$ 17,074.56	$ 2,486.19	$ 0.06	$ 1.43
4	4	20,392	4,992	620	89	421	110	4,365	627	2,967	771	0.53	1.19	57.86	4.148	70	3.429	0.720	0.180	3593	$ 34,546.45	$ 4,951.11	$ 0.06	$ 1.43
5	7	18,385	4,501	559	80	380	99	3,935	565	2,675	695	0.70	1.07	58.05	7.235	70	6.000	1.235	0.176	5558	$ 54,506.04	$ 7,660.47	$ 0.06	$ 1.42
6	11	17,328	4,419	549	79	373	97	3,864	555	2,626	683	0.67	0.96	58.22	11.337	70	9.429	1.909	0.174	8434	$ 84,095.56	$ 11,623.97	$ 0.06	$ 1.42
7	22	18,018	4,503	559	80	380	99	3,937	565	2,676	696	0.46	0.94	58.35	22.623	70	18.857	3.766	0.171	16959	$ 171,382.06	$ 23,371.97	$ 0.06	$ 1.42
8	1	22,466	5,500	683	98	464	121	4,809	690	3,269	850	0.58	0.76	59.07	1.016	70	0.857	0.159	0.159	872	$ 9,515.66	$ 1,202.04	$ 0.05	$ 1.40
9	2	22,062	5,401	671	96	456	118	4,722	678	3,210	835	0.57	0.87	58.95	2.036	70	1.714	0.321	0.161	1736	$ 18,688.49	$ 2,392.26	$ 0.05	$ 1.40
10	14	18,698	4,757	591	85	401	104	4,159	597	2,827	735	0.39	1.07	59.02	14.233	70	12.000	2.233	0.160	10623	$ 115,214.62	$ 14,640.53	$ 0.06	$ 1.40
11	4	18,507	4,927	553	79	376	98	4,374	628	2,973	773	0.57	0.96	59.29	4.048	70	3.429	0.620	0.155	3053	$ 34,093.97	$ 4,207.45	$ 0.06	$ 1.39
12	2	18,409	4,901	550	79	374	97	4,351	625	2,957	769	0.32	0.84	59.25	2.025	70	1.714	0.311	0.155	1524	$ 16,956.89	$ 2,099.75	$ 0.06	$ 1.40
13	15	18,518	4,740	532	76	361	94	4,208	604	2,860	744	0.71	0.67	59.25	15.189	70	12.857	2.332	0.155	11053	$ 123,003.27	$ 15,233.32	$ 0.05	$ 1.40
14	2	22,019	5,411	607	87	413	107	4,804	690	3,265	849	0.86	0.68	59.30	2.024	70	1.714	0.309	0.155	1674	$ 18,721.65	$ 2,306.46	$ 0.05	$ 1.39
15	1	22,029	5,413	607	87	413	107	4,806	690	3,267	849	0.86	0.69	59.49	1.009	70	0.857	0.151	0.151	820	$ 9,365.24	$ 1,130.18	$ 0.05	$ 1.39
16	8	22,158	5,899	662	95	450	849	5,237	752	3,560	925	0.28	0.86	59.73	8.037	70	6.857	1.180	0.147	6958	$ 81,641.81	$ 9,589.30	$ 0.05	$ 1.38
17	3	21,346	3,934	441	63	300	117	3,492	501	2,374	617	0.42	0.99	60.09	2.996	70	2.571	0.424	0.141	1669	$ 20,416.63	$ 2,300.26	$ 0.04	$ 1.38
18	9	20,973	5,583	626	90	426	78	4,957	712	3,369	876	0.31	1.38	61.00	8.852	70	7.714	1.138	0.126	6353	$ 86,934.32	$ 8,755.78	$ 0.05	$ 1.36
19	1	20,767	5,529	620	89	422	876	4,908	705	3,336	867	0.30	1.34	62.10	0.966	70	0.857	0.109	0.109	603	$ 9,564.86	$ 830.97	$ 0.04	$ 1.33
20	5	20,848	5,550	623	89	423	867	4,927	707	3,349	871	0.31	1.13	62.46	4.803	70	4.286	0.517	0.103	2870	$ 48,009.78	$ 3,955.33	$ 0.04	$ 1.32
21	7	21,331	4,586	515	74	350	871	4,072	584	2,768	720	0.42	1.11	62.78	6.690	70	6.000	0.690	0.099	3162	$ 55,540.49	$ 4,358.38	$ 0.03	$ 1.32
22	1	21,331	5,678	637	91	433	720	5,041	724	3,427	891	0.44	1.06	63.00	0.952	70	0.857	0.095	0.095	541	$ 9,823.66	$ 745.44	$ 0.03	$ 1.31
23	2	24,490	6,520	731	105	497	891	5,788	831	3,934	1,023	0.50	0.93	63.28	1.896	70	1.714	0.182	0.091	1187	$ 22,558.55	$ 1,636.24	$ 0.03	$ 1.31
24	2	25,283	6,640	1,661	238	1,129	1,023	4,982	715	3,386	880	0.50	0.93	63.41	1.892	70	1.714	0.178	0.089	1182	$ 22,973.66	$ 1,629.36	$ 0.03	$ 1.30
25	4	26,327	6,965	1,742	250	1,184	880	5,225	750	3,552	923	0.53	0.95	63.70	3.768	70	3.429	0.339	0.085	2362	$ 48,194.34	$ 3,255.46	$ 0.03	$ 1.30
26	5	27,389	7,246	1,812	260	1,232	923	5,436	780	3,695	961	0.55	0.99	64.10	4.680	70	4.286	0.394	0.079	2856	$ 62,674.22	$ 3,936.71	$ 0.03	$ 1.29
27	3	32,158	8,507	2,128	305	1,447	961	6,383	916	4,339	1,128	0.64	1.05	64.46	2.792	70	2.571	0.221	0.074	1879	$ 44,151.48	$ 2,590.19	$ 0.03	$ 1.28
28	6	36,337	5,596	2,131	306	1,449	1,128	3,508	504	2,385	377	0.68	1.22	64.77	5.558	70	5.143	0.415	0.069	2322	$ 58,086.89	$ 3,200.09	$ 0.01	$ 1.28
CORRIDOR	**159**	**21,975**	**5,442**	**830**	**119**	**564**	**420**	**4,612**	**662**	**3,135**	**806**	**0.52**	**1.02**	**60.48**	**159.613**	**70.00**	**136.286**	**0.833**	**0.136**	**116445**	**$ 1,413,605.57**	**$ 160,480.19**	**$ 1.32**	**$ 38.34**

Table 23—2040 Northbound Delay Measures Including Commodity Sensitivity Volumes

LinkID	Distance (miles)	Total		Single Unit Truck				Combination Trucks				FAF[3] VCR		Average		Free Flow		Delay (minutes)			Cost (dollars)			
		Volume	Trucks	Volume	High	Mod	Low	Volume	High	Mod	Low	2007	2040	Speed (MPH)	Travel Time (minutes)	Speed (MPH)	Travel Time (minutes)	Average	Average (per mile)	Total Link	Direct Travel	Delay Time	Delay Time per Vehicle Mile	Travel Time per Vehicle Mile
1	11	34,265	8,230	1,311	188	891	232	6,913	601	2,847	740	0.47	1.33	57.68	11.44	70	9.43	2.014	0.183	16576	$ 156,615.58	$ 22,844.37	$ 0.10	$ 1.43
2	5	35,631	9,060	1,444	207	981	255	7,610	579	2,744	713	0.50	1.34	57.09	5.26	70	4.29	0.969	0.194	8783	$ 78,369.35	$ 12,104.84	$ 0.11	$ 1.45
3	2	35,647	8,429	1,343	193	913	237	7,081	598	2,830	736	0.52	1.29	57.10	2.10	70	1.71	0.387	0.194	3265	$ 29,166.05	$ 4,499.50	$ 0.10	$ 1.45
4	4	36,356	8,023	1,278	183	869	226	6,739	605	2,863	744	0.53	1.19	57.33	4.19	70	3.43	0.758	0.189	6080	$ 55,518.47	$ 8,379.37	$ 0.09	$ 1.44
5	7	36,364	8,026	1,279	184	869	226	6,742	545	2,581	671	0.70	1.07	57.67	7.28	70	6.00	1.283	0.183	10297	$ 97,199.51	$ 14,190.36	$ 0.07	$ 1.43
6	11	36,559	7,633	1,216	175	827	215	6,412	535	2,534	659	0.67	0.96	58.06	11.37	70	9.43	1.940	0.176	14804	$ 145,250.84	$ 20,402.05	$ 0.06	$ 1.42
7	22	36,580	8,822	1,406	202	956	248	7,411	545	2,582	671	0.46	0.94	58.22	22.67	70	18.86	3.814	0.173	33647	$ 335,771.22	$ 46,371.23	$ 0.08	$ 1.42
8	1	36,886	7,744	1,234	177	839	218	6,505	666	3,154	820	0.58	0.76	58.02	1.03	70	0.86	0.177	0.177	1371	$ 13,396.62	$ 1,888.94	$ 0.06	$ 1.43
9	2	38,647	7,869	1,254	180	852	222	6,610	654	3,098	805	0.57	0.87	58.23	2.06	70	1.71	0.347	0.173	2727	$ 27,227.16	$ 3,758.05	$ 0.06	$ 1.42
10	14	39,858	8,048	1,282	184	872	227	6,760	576	2,728	709	0.39	1.07	58.58	14.34	70	12.00	2.340	0.167	18832	$ 194,917.33	$ 25,953.48	$ 0.07	$ 1.41
11	4	40,503	7,481	892	128	606	158	6,577	598	2,831	736	0.57	0.96	58.80	4.08	70	3.43	0.653	0.163	4887	$ 51,771.87	$ 6,734.84	$ 0.06	$ 1.41
12	2	41,206	10,076	1,202	172	817	212	8,859	595	2,816	732	0.32	0.84	59.03	2.03	70	1.71	0.318	0.159	3209	$ 34,864.64	$ 4,422.27	$ 0.08	$ 1.40
13	15	41,366	10,037	1,197	172	814	212	8,824	575	2,724	708	0.71	0.67	58.89	15.28	70	12.86	2.425	0.162	24341	$ 260,469.66	$ 33,546.40	$ 0.05	$ 1.40
14	2	41,613	9,977	1,190	171	809	210	8,771	657	3,110	808	0.86	0.68	59.46	2.02	70	1.71	0.304	0.152	3032	$ 34,520.56	$ 4,178.76	$ 0.04	$ 1.39
15	1	42,323	9,839	1,174	168	798	207	8,650	657	3,111	809	0.86	0.69	59.36	1.01	70	0.86	0.154	0.154	1512	$ 17,022.19	$ 2,083.80	$ 0.04	$ 1.39
16	8	42,353	13,092	1,561	224	1,061	276	11,510	716	3,390	881	0.28	0.86	59.90	8.01	70	6.86	1.157	0.145	15142	$ 181,198.27	$ 20,867.75	$ 0.10	$ 1.38
17	3	43,689	10,532	1,256	180	854	222	9,259	477	2,261	588	0.42	0.99	60.34	2.98	70	2.57	0.412	0.137	4335	$ 54,659.86	$ 5,974.65	$ 0.07	$ 1.37
18	9	43,709	10,175	1,214	174	825	214	8,946	678	3,209	834	0.31	1.38	61.27	8.81	70	7.71	1.099	0.122	11180	$ 158,431.89	$ 15,407.49	$ 0.09	$ 1.35
19	1	43,821	7,328	874	125	594	154	6,442	671	3,177	826	0.30	1.34	61.95	0.97	70	0.86	0.111	0.111	816	$ 12,677.16	$ 1,124.52	$ 0.06	$ 1.33
20	5	43,965	9,071	1,082	155	735	191	7,975	674	3,190	829	0.31	1.13	62.25	4.82	70	4.29	0.534	0.107	4843	$ 78,465.82	$ 6,675.14	$ 0.06	$ 1.33
21	7	44,628	8,089	965	138	656	170	7,112	557	2,636	685	0.42	1.11	63.06	6.66	70	6.00	0.660	0.094	5341	$ 97,963.43	$ 7,361.13	$ 0.05	$ 1.31
22	1	48,593	8,410	1,003	144	682	177	7,394	689	3,263	848	0.44	1.06	63.51	0.94	70	0.86	0.088	0.088	736	$ 14,549.22	$ 1,014.90	$ 0.04	$ 1.30
23	2	48,632	8,370	998	143	679	176	7,358	791	3,747	974	0.50	0.93	63.55	1.89	70	1.71	0.174	0.087	1456	$ 28,959.83	$ 2,006.47	$ 0.03	$ 1.30
24	2	50,368	9,243	2,440	350	1,658	431	6,791	616	2,916	758	0.50	0.93	63.59	1.89	70	1.71	0.173	0.086	1597	$ 31,982.24	$ 2,200.81	$ 0.04	$ 1.30
25	4	52,400	9,773	2,580	370	1,753	456	7,180	646	3,059	795	0.53	0.95	64.06	3.75	70	3.43	0.318	0.079	3104	$ 67,629.03	$ 4,278.24	$ 0.03	$ 1.29
26	5	61,524	12,044	3,179	456	2,161	562	8,848	672	3,183	827	0.55	0.99	64.31	4.66	70	4.29	0.379	0.076	4565	$ 104,176.80	$ 6,291.62	$ 0.04	$ 1.29
27	3	69,857	12,002	3,168	455	2,153	560	8,817	789	3,737	971	0.64	1.05	64.38	2.80	70	2.57	0.224	0.075	2692	$ 62,288.84	$ 3,710.58	$ 0.03	$ 1.28
28	6	71,181	15,415	6,788	974	4,614	1,199	8,519	488	2,309	600	0.68	1.22	65.06	5.53	70	5.14	0.390	0.065	6020	$ 160,012.60	$ 8,296.03	$ 0.04	$ 1.27
CORRIDOR	**159**	**44,233**	**9,387**	**1,636**	**235**	**1,112**	**289**	**7,736**	**623**	**2,951**	**767**	**0.52**	**1.02**	**60.38**	**159.89**	**70.00**	**136.29**	**0.843**	**0.138**	**215190**	**$ 2,585,076.04**	**$ 296,567.56**	**$ 1.76**	**$ 38.41**

Table 24—2040 Southbound Delay Measures Including Commodity Sensitivity Volumes

LinkID	Distance (miles)	Total		Single Unit Truck				Combination Trucks				FAF[3] VCR		Average		Free Flow		Delay (minutes)			Cost (dollars)			
		Volume	Trucks	Volume	High	Mod	Low	Volume	High	Mod	Low	2007	2040	Speed 2007 (MPH)	Speed 2040 (MPH)	Travel Time (minutes)	Speed (MPH)	Travel Time (minutes)	Average	Average (per mile)	Direct Travel	Delay Time	Delay Time per Vehicle Mile	Travel Time per Vehicle Mile
1	11	34,309	8,307	1,164	167	791	206	7,139	1,024	4,852	1,261	0.47	1.33	57.32	51.12	12.911	70	9.429	3.482	0.317	$ 158,083.53	$ 39,866.27	$ 0.11	$ 1.62
2	5	35,677	9,145	1,281	184	871	226	7,859	1,128	5,342	1,389	0.50	1.34	57.55	51.51	5.824	70	4.286	1.538	0.308	$ 79,103.90	$ 19,383.48	$ 0.11	$ 1.61
3	2	35,694	8,509	1,192	171	810	211	7,312	1,049	4,970	1,292	0.52	1.29	57.70	52.09	2.304	70	1.714	0.589	0.295	$ 29,439.43	$ 6,910.76	$ 0.10	$ 1.59
4	4	36,404	8,098	1,134	163	771	200	6,960	999	4,730	1,230	0.53	1.19	57.86	52.95	4.533	70	3.429	1.104	0.276	$ 56,038.85	$ 12,321.01	$ 0.08	$ 1.56
5	7	36,412	8,102	1,135	163	771	201	6,963	999	4,732	1,230	0.70	1.07	58.05	55.32	7.592	70	6.000	1.592	0.227	$ 98,110.57	$ 17,776.39	$ 0.07	$ 1.49
6	11	36,606	7,704	1,079	155	734	191	6,621	950	4,500	1,170	0.67	0.96	58.22	55.99	11.788	70	9.429	2.359	0.214	$ 146,612.27	$ 25,046.73	$ 0.06	$ 1.48
7	22	36,628	8,905	1,248	179	848	220	7,653	1,098	5,202	1,352	0.46	0.94	58.35	54.72	24.121	70	18.857	5.264	0.239	$ 338,918.40	$ 64,605.91	$ 0.08	$ 1.51
8	1	36,935	7,816	1,095	157	744	193	6,717	964	4,566	1,187	0.58	0.76	59.07	57.62	1.041	70	0.857	0.184	0.184	$ 13,522.18	$ 1,983.15	$ 0.05	$ 1.44
9	2	38,698	7,943	1,113	160	756	197	6,826	980	4,640	1,206	0.57	0.87	58.95	56.57	2.121	70	1.714	0.407	0.203	$ 27,482.36	$ 4,454.26	$ 0.06	$ 1.46
10	14	39,910	8,123	1,138	163	774	201	6,981	1,002	4,745	1,234	0.39	1.07	59.02	53.84	15.603	70	12.000	3.603	0.257	$ 196,744.29	$ 40,336.94	$ 0.07	$ 1.54
11	4	40,197	8,393	992	142	674	175	7,404	1,063	5,033	1,308	0.57	0.96	59.29	56.24	4.268	70	3.429	0.839	0.210	$ 58,076.21	$ 9,705.46	$ 0.06	$ 1.47
12	2	40,894	11,304	1,336	192	908	236	9,973	1,431	6,778	1,762	0.32	0.84	59.25	55.09	2.178	70	1.714	0.464	0.232	$ 39,110.16	$ 7,229.34	$ 0.09	$ 1.50
13	15	41,053	11,260	1,331	191	905	235	9,934	1,426	6,752	1,755	0.71	0.67	59.25	59.57	15.108	70	12.857	2.251	0.150	$ 292,187.49	$ 34,930.95	$ 0.06	$ 1.39
14	2	41,299	11,192	1,323	190	899	234	9,874	1,417	6,712	1,745	0.86	0.68	59.30	60.74	1.976	70	1.714	0.261	0.131	$ 38,724.18	$ 4,030.71	$ 0.05	$ 1.36
15	1	42,004	11,038	1,305	187	887	231	9,738	1,397	6,619	1,721	0.86	0.69	59.49	60.83	0.986	70	0.857	0.129	0.129	$ 19,095.02	$ 1,965.69	$ 0.05	$ 1.36
16	8	42,034	14,687	1,736	249	1,180	307	12,957	1,859	8,807	2,290	0.28	0.86	59.73	55.14	8.706	70	6.857	1.849	0.231	$ 203,263.09	$ 37,419.02	$ 0.11	$ 1.50
17	3	43,359	11,814	1,396	200	949	247	10,423	1,496	7,085	1,842	0.42	0.99	60.09	55.62	3.236	70	2.571	0.665	0.222	$ 61,315.88	$ 10,822.07	$ 0.08	$ 1.49
18	9	43,380	11,415	1,349	194	917	238	10,071	1,445	6,845	1,779	0.31	1.38	61.00	52.87	10.213	70	7.714	2.498	0.278	$ 177,724.41	$ 39,304.05	$ 0.10	$ 1.56
19	1	43,491	8,220	972	139	660	172	7,252	1,041	4,929	1,281	0.30	1.34	62.10	54.06	1.110	70	0.857	0.253	0.253	$ 14,220.88	$ 2,863.76	$ 0.07	$ 1.53
20	5	43,633	10,176	1,203	173	817	213	8,978	1,288	6,102	1,586	0.31	1.13	62.46	55.85	5.372	70	4.286	1.086	0.217	$ 88,020.73	$ 15,227.38	$ 0.07	$ 1.48
21	7	44,292	9,075	1,073	154	729	190	8,006	1,149	5,442	1,415	0.42	1.11	62.78	57.22	7.341	70	6.000	1.341	0.192	$ 109,892.61	$ 16,765.51	$ 0.05	$ 1.45
22	1	48,226	9,434	1,115	160	758	197	8,323	1,194	5,657	1,471	0.44	1.06	63.00	57.92	1.036	70	0.857	0.179	0.179	$ 16,320.90	$ 2,323.93	$ 0.05	$ 1.43
23	2	48,264	9,389	1,110	159	754	196	8,284	1,189	5,630	1,464	0.50	0.93	63.28	59.73	2.009	70	1.714	0.295	0.147	$ 32,486.31	$ 3,814.56	$ 0.04	$ 1.38
24	2	51,267	9,748	2,240	321	1,522	396	7,510	1,078	5,105	1,327	0.50	0.93	63.41	59.86	2.005	70	1.714	0.290	0.145	$ 33,726.62	$ 3,901.70	$ 0.04	$ 1.38
25	4	53,335	10,306	2,368	340	1,609	418	7,940	1,139	5,397	1,403	0.53	0.95	63.70	60.18	3.988	70	3.429	0.559	0.140	$ 71,317.65	$ 7,941.63	$ 0.04	$ 1.37
26	5	62,622	12,700	2,918	419	1,983	516	9,785	1,404	6,651	1,729	0.55	0.99	64.10	60.40	4.967	70	4.286	0.681	0.136	$ 109,858.80	$ 11,926.70	$ 0.04	$ 1.37
27	3	71,105	12,656	2,908	417	1,976	514	9,751	1,399	6,628	1,723	0.64	1.05	64.46	61.05	2.948	70	2.571	0.377	0.126	$ 65,686.18	$ 6,573.98	$ 0.03	$ 1.35
28	6	72,606	14,814	5,718	821	3,887	1,010	9,200	1,320	6,253	1,626	0.68	1.22	64.77	60.34	5.966	70	5.143	0.823	0.137	$ 153,764.42	$ 16,807.12	$ 0.04	$ 1.37
CORRIDOR	**159**	**44,298**	**10,010**	**1,570**	**225**	**1,067**	**277**	**8,444**	**1,212**	**5,739**	**1,492**	**0.52**	**1.02**	**60.48**		**171.249**	**70.00**	**136.286**	**1.249**	**0.206**	**$ 2,728,847.32**	**$ 466,238.47**	**$ 1.85**	**1.47**

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