Source Book Calculations Documentation

Prepared for

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Introduction

The Florida Multimodal Mobility Performance Measures Source Book, hereafter referred to as the Source Book, is intended to be an easy-to-use compendium of current and historical mobility data on Florida's transportation systems. The objective of this technical memorandum is to present a comprehensive introduction of the methodology used to calculate the Mobility Performance Measures (MPMs) in the 2014 version of the Source Book.

Florida's Mobility Performance Measures (MPM) program defines mobility as the movement of people and goods. The definition emphasizes mobility from the user's perspective. Florida's mobility performance measures describe the following primary dimensions of mobility:

- The **quantity** of the travel (reflects the magnitude of the use of a facility or service);
- The **quality** of travel (describes user's experiences with travel conditions);
- The **accessibility** provided by the transportation system (describes the ease with which people can engage in activities); and,
- The **utilization** of a facility or service (indicates whether or not a transportation system is adequately sized and the ability to accommodate growth).

Estimation of mobility performance measures in the Source Book is based on a combination of measured (field data) and modeled results. Most of the data are obtained from existing sources such as the Department's Roadway Characteristics Inventory (RCI) and Traffic Characteristics Inventory (TCI). These data sources provide information on the roadway geometry (such as the number of lanes, design speed, and access control) and demand for the roadway (traffic volume and vehicle classification). Extensive implementation of Florida's latest Generalized Service Volume Tables, national research, and Florida travel demand models were also components of the 2014 Source Book. The full list of the MPMs is shown in Figure 1.

Multimodal Mobility Performance Measures Matrix (Reported in 2014 Source Book)

	MODE	QUANTITY	QUALITY	ACCESSIBILITY	UTILIZATION
People	Auto/Truck	**Vehicle Miles Traveled** Person Miles Traveled	**% Travel Meeting LOS Criteria** % Miles Meeting LOS Criteria **Travel Time Reliability** Travel Time Variability **Vehicle Hours of Delay** Person Hours of Delay Average Travel Speed		**% Miles Severely Congested** % Travel Severely Congested Hours Severely Congested Vehicles Per Lane Mile
	Transit	Passenger Miles Traveled Passenger Trips	Average Headway		
	Pedestrian		*Level of Service (LOS)*	% Sidewalk Coverage	
	Bicycle		*Level of Service (LOS)*	% Bike Lane/Shoulder Coverage	
	Aviation	Passengers	Departure Reliability	*Highway Adequacy (LOS)*	*Demand to Capacity Ratios*
	Rail	Passengers	*Departure Reliability*		
	Seaports	Passengers		*Highway Adequacy (LOS)*	
Freight	Truck	**Combination Truck Miles Traveled** Truck Miles Traveled *Combination Truck Tonnage* *Combination Truck Ton Miles Traveled*	**Travel Time Reliability** Travel Time Variability **Combination Truck Hours of Delay** Combination Truck Average Travel Speed		**% Miles Severely Congested** Vehicles Per Lane Mile *Combination Truck Backhaul Tonnage*
	Aviation	Tonnage		*Highway Adequacy (LOS)*	
	Rail	Tonnage		*Highway Adequacy (LOS)* *Active Rail Access*	
	Seaports	Tonnage Twenty-Foot Equivalent Units		*Highway Adequacy (LOS)* *Active Rail Access*	

Reporting Periods: Peak Hour Peak Period Daily Yearly **Bold = FDOT MAP-21 Recommended Measure** *Italicized Text = Measures Added 2014*

Figure 14. List of Mobility Performance Measures in the 2014 Source Book

All the calculated MPMs listed above are calculated from 2004 to 2013 or from 2005 to 2013 using the methodologies discussed in this memorandum. A summary of the calculations for the 2014 version of Source Book is provided in Table 1: Source Book Calculations.

Table 14: Source Book Calculations

Quantity Mobility Performance Measures				
MPM	Methodology	Calculation	Report Period	Sources
Vehicle-Miles Traveled	Determined using vehicle traffic volume and segment length	$\sum(\text{Segment Length} \times \text{Volume})$	Daily and Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (feature 111)
Person-Miles Traveled	Determined using vehicle traffic volume, segment length, & average vehicle occupancy for highway motor vehicles	$\sum \begin{matrix}\text{Segment Length x Volume x} \\ \text{Average Vehicle Occupancy}\end{matrix}$	Daily and Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (feature 111) • 2009 National Household Travel Survey – Florida Add-On
Truck-Miles Traveled	Determined using truck traffic volume and segment length	$\sum(\text{Segment Length x Volume x T Factor})$	Daily and Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (feature 111)
Combination Truck-Miles Traveled	Determined using combination truck traffic volume and segment length. Combination truck is defined as FHWA 8-13.	$\sum(\text{Segment Length x Combination Truck Volume})$	Daily	• FDOT Statistics Office HPMS data collection program
Travel Time Reliability	Travel Time Reliability is defined as the percentage of travel that is greater than or equal to the speed limit for freeways.	$\frac{\sum(\text{VMT} \mid \text{Travel Speed} \geq \text{Speed Limit})}{\sum(\text{VMT})} \times 100$	Daily and Peak Period for 7 largest counties. Daily and Peak Hour for all others	• Traffic Characteristics Inventory • Level of Service Database and FDOT CARS • Reliability model developed by University of Florida
Travel Time Variability – 95th Percentile Travel Time Index	Travel Time Variability is defined as 95th percentile travel time index.	$\frac{\text{Travel Time}_{\text{95th percentile}}}{\text{Travel Time}_{\text{free-flow}}}$	Daily and Peak Period for 7 largest counties. Daily and Peak Hour for all others	• Traffic Characteristics Inventory • Level of Service Database and FDOT CARS • Reliability model developed by University of Florida
Combination Truck Tonnage	Combination truck tonnage represents the amount of freight being transported along the SHS by combination trucks	Tonnage_{2013}= Tonage_{2012}*(AvgLoad_{2013}/AvgLoad_{2012})*(CTMT_{2013}/CTMT_{2012})	Yearly	• Freight Analysis Framework • FDOT Weigh-In-Motion

Combination Truck Ton Miles Traveled	Combination Truck Ton Miles Traveled is determined by multiplying the annual average combination truck load by the combination truck miles traveled.	$Combination\ Truck\ Miles\ Traveled\ \times Average\ Truck\ Load$	Yearly	• FDOT Weigh-In-Motion • Traffic Characteristics Inventory • Roadway Characteristics Inventory
Transit Passenger Miles Traveled	This number provides a measure of the total number of passenger miles of transportation service consumed, and is typically derived based on sampling.	Passengers $\times$ (Σ Highway Miles $\div$ Σ Trips)	Yearly	• FDOT Transit Office
Transit Passenger Trips	This is the annual number of passenger boardings on the transit vehicles. A trip is counted each time a passenger boards a transit vehicle. Thus, if a passenger has to transfer between buses to reach a destination, the passenger is counted as making two passenger trips.	Σ Passenger Boardings	Yearly	• FDOT Transit Office
Aviation Passengers	The total number of revenue passengers boarding aircraft, includes both originating and connecting passengers.	Σ Commercial Service Enplanements	Yearly	• Florida Aviation System Plan 2025
Rail Passengers	This represents the annual number of revenue paying rail passengers.	Σ Amtrak Passengers	Yearly	• Amtrak Factsheet: Florida
Seaport Passengers	This represents the annual number of passengers embarking on cruise ships at Florida ports.	Σ Cruise Passengers	Yearly	• Florida Ports Council
Aviation Tonnage	All cargo landed at public airports, this includes the weight of the plane.	Σ Tons Landed at Qualifying Cargo Airports	Yearly	• FAA Air Carrier Activity Information System (ACAIS)

Rail Tonnage	Tons of freight carried by rail mode originated or terminated in Florida	Σ Rail Tonnage	Yearly	• U.S. DOT Surface Transportation Board, Florida Rail Waybill Data
Seaport Tonnage	International and domestic waterborne tons of cargo handled at both public and private terminals in port areas of Florida	Σ Waterborne Tonnage	Yearly	• Florida Ports Council Five year Seaport Mission Plan
Twenty-foot Equivalent Units	International and domestic waterborne containers handled at both public and private terminals in port areas of Florida	Σ Twenty-foot Equivalent Units	Yearly	• Florida Ports Council Five year Seaport Mission Plan
Quality Mobility Performance Measures				
MPM	Methodology	Calculation	Report Period	Sources
Vehicle Hours of Delay	Calculated as the product of directional hourly volume and the difference between travel time at "threshold" speeds and travel time at the average speed. The thresholds have been updated to be based on LOS B. Delay estimation considers unserved demand from the preceding hours for the time periods between 7 AM and 10 AM and between 4 PM and 7 PM. During oversaturation, the undischarged queue—the difference between demand and capacity—from an oversaturated hour is added to the next hour. The process is repeated until demand (including that from previous hour(s)) is less than capacity.	Sum of both auto and trucks: $\sum(\text{Daily or peak period/hour travel time} - \text{Travel time at LOS B})$	Yearly, Daily, and Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation (Moses et al.) • Greater Treasure Coast Regional Planning Model

Person Hours of Delay	Calculated as the product of average vehicle occupancy, directional hourly volume, and the difference between travel time at "threshold" speeds and travel time at the average speed. Delay estimation considers unserved demand from the preceding hours for the time periods between 7 AM and 10 AM and between 4 PM and 7 PM.	The product of average vehicle occupancy and vehicle hours of delay: $\sum \text{Avg. Veh. Occupancy} \times \text{Veh. Hours of Delay}$	Yearly, Daily, and Peak Hour	• 2009 National Household Travel Survey – Florida Add-On • Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation (Moses et al.) • Greater Treasure Coast Regional Planning Model
Average Travel Speed	The Average Travel Speed calculations use the HCM 2010 methods and the latest FDOT Generalized Service Volumes Tables for roadways operating below capacity ($v/c \leq 1$). Because the Generalized Service Volumes Tables lack speed information for over capacity conditions ($v/c > 1$), speed-volume curves were used to provide improved accuracy in congested regimes. Speed estimation also accounts for reduced speed due to unserved demand from the preceding hours same as above performance measure.	Average travel speeds on various segments are weighted by VMT to arrive at a single average travel speed: $\frac{\sum(\text{VMT} \times \text{Average Travel Speed})}{\sum(\text{VMT})}$	Peak Period for 7 largest counties. Peak Hour for all others.	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation (Moses et al.) • Greater Treasure Coast Regional Planning Model • 2012 Generalized Service Volume Tables

Pedestrian Level of Service	Pedestrian LOS measures a roadway's quality of service to pedestrians with LOS A being the highest quality, and LOS F the lowest quality. Pedestrian LOS was analyzed using the FDOT Pedestrian LOS Model.	Σ Miles of Each LOS Letter Grade	Peak Period for 7 largest counties with more than 1 million of population and Peak Hour for all others	• FDOT Pedestrian LOS Model • Traffic Characteristics Inventory • Roadway Characteristics Inventory
% of Travel Meeting Generally Acceptable Operating Conditions	The percentage of travel meeting generally acceptable operating conditions is determined by summing the Vehicle Miles Traveled on roadway operating acceptably and then dividing by the total system Vehicle Miles Traveled. "Acceptably" is defined as LOS D (two-hour peak) for the 7 largest counties, LOS D (one-hour peak) for other urbanized areas, and LOS C (one-hour peak) everywhere else.	$\dfrac{\sum \begin{matrix}(\text{VMT}\mid\text{Peak Hour Volumes } < \\ \text{Acceptable LOS Volume Threshold})\end{matrix}}{\sum(\text{VMT})} \times 100$	Peak Period and Daily for 7 largest counties with more than 1 million of population. Daily and Peak Hour for all others.	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • 2012 Generalized Service Volume Tables
% of Miles Meeting Generally Acceptable Operating Conditions	The percentage of miles meeting generally acceptable operating conditions is determined by summing the centerline miles of roadway operating acceptably and then dividing by the total system centerline miles. "Acceptably" is defined above.	$\dfrac{\sum \begin{matrix}(\text{Segment Length}\mid\text{Peak Hour Volumes } < \\ \text{Acceptable LOS Volume Threshold})\end{matrix}}{\sum(\text{Segment Length})} \times 100$	Peak Period for 7 largest counties with more than 1 million of population. Peak Hour for all others.	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • 2012 Generalized Service Volume Tables
Travel Time Reliability (Freight)	Freight Travel Time Reliability measures the entire traffic stream's condition for freeway only. The free flow truck speed is assumed to be equal to the speed limit.	$\dfrac{\sum \begin{matrix}(\text{VMT} \mid \text{Combination Truck Travel Speed} \\ \geq \text{Speed Limit})\end{matrix}}{\sum(\text{VMT})}$	Daily and Peak Period for 7 largest counties. Daily and Peak Hour for all others	• Traffic Characteristics Inventory • Level of Service Database and FDOT CARS • Reliability model developed by University of Florida

Rail Departure Reliability	Rail departure reliability captures the on-time performance of three rails systems: Amtrak, Miami Dade Metrorail, and South Florida Regional Transportation Authority Tri-Rail. A train is considered on time if it arrives within a given temporal buffer.	Σ (On-Time Arrivals ÷ Σ Arrivals) × 100	Yearly	• Amtrak • Miami Dade County • South Florida Regional Transportation Authority
Aviation Departure Reliability	Departure reliability at Florida airports is defined as "on time" if the flight departs less than 15 minutes after the scheduled time shown in the carriers' Computerized Reservations Systems.	Σ (Departures < 15 Minutes of Schedule ÷ Σ Departures) × 100	Yearly	• U.S. DOT Air Travel Consumer Report
Travel Time Variability – 95th Percentile Travel Time Index (Freight)	Freight Travel Time Variability measures use entire traffic stream's condition for freeways only. The free flow truck speed is assumed to be equal to the speed limit for the freeway.	$\frac{\text{Travel Time}_{\text{95th percentile}}}{\text{Travel Time}_{\text{free-flow}}}$	Daily and Peak Period for 7 largest counties. Daily and Peak Hour for all others	• Traffic Characteristics Inventory • Level of Service Database and FDOT CARS • Reliability model developed by University of Florida
Combination Truck Delay	The Combination Truck Hours of Delay measure is based on truck speed. The free flow truck speed is assumed to be equal to the speed limit. Similar to Vehicle Hours of Delay, delay is calculated as the product of directional hourly volume and the difference between travel time at "threshold" speeds (at LOS B) and travel time at the average speed. The "threshold" speeds used for Combination Truck Hours of Delay are identical to the "threshold" speeds used for Vehicle Hours of Delay.	For Combination Truck only: $\sum(\text{Daily Combination Truck Travel Time} - \text{Travel Time at LOS B})$	Daily	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • 2012 Generalized Service Volume Tables • Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation (Moses et al.) • Greater Treasure Coast Regional Planning Model

	Delay estimation considers unserved demand from the preceding hours for the time periods between 7 AM and 10 AM and between 4 PM and 7 PM..			
Combination Truck Average Travel Speed	The calculation of Combination Truck Average Travel Speeds is identical to the methodology for (passenger) vehicle's average travel speed, except that combination trucks are assumed to have a lower free flow speed. The free flow truck speed is assumed to be equal to the speed limit.	$\frac{\sum(\text{CTMT} \times \text{Combination Truck Average Travel Speed})}{\sum(\text{CTMT})}$	Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • 2012 Generalized Service Volume Tables • Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation (Moses et al.) • Greater Treasure Coast Regional Planning Model •
Bicycle Level of Service	Bicycle LOS measures a roadway's quality of service to bicyclists with LOS A being the highest quality, and LOS F the lowest quality.	Σ Miles of Each LOS Letter Grade	Peak Period for 7 largest counties with more than 1 million of population and Peak Hour for all others	• FDOT Bike LOS Model • Traffic Characteristics Inventory • Roadway Characteristics Inventory

Utilization Mobility Performance Measures				
MPM	Methodology	Calculation	Report Period	Sources
% Miles Severely Congested	The percentage of miles severely congested is determined by summing the miles of roadway operating at LOS F in the peak hour and then dividing by the total system miles.	$\frac{\sum \begin{array}{c}(\text{Segment Length}\mid\text{Peak Hour Volumes} > \\ \text{LOS E Volume Threshold})\end{array}}{\sum(\text{Segment Length})} \times 100$	Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • 2012 Generalized Service Volume Tables
Aviation Demand to Capacity Ratio	The ratio of the annual operational demand to annual service volume. Annual service volume is determined by the quantity of airports' runways and taxiways.	$(\Sigma \text{ Operations} \div \Sigma \text{ Airport Service Volume}) \times 100$	Yearly	• FDOT, Avaiation d/c May 26, 2012
% Travel Severely Congested	The percentage of travel severely congested is determined by summing the vehicle-miles of travel on roadways operating at LOS F and then dividing by the total system vehicle-miles of travel.	$\frac{\sum(\text{VMT}\mid\text{Peak Hour Volumes} > \text{LOS E Volume Threshold})}{\sum(\text{VMT})}$	Peak Hour and Daily	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • 2012 Generalized Service Volume Tables

Hours Severely Congested	The Hours Severely Congested is estimated as the average number of hours in which segments operate at LOS F, weighted by lane-miles. During oversaturation, the undischarged queue—the difference between demand and capacity—from an oversaturated hour is added to the next hour for the time periods between 7 AM and 10 AM and between 4 PM and 7 PM... The process is repeated until demand (including that from previous hour(s)) is less than capacity. The yearly duration of congestion is the total number of hours experiencing congestion.	On a single segment: $\text{Daily Hours Severely Congested}_i = \sum_{t=1}^{24} 1 \mid \text{Hourly Volume} > \text{LOS E Threshold}$ $\text{Yearly Hours Severely Congested}_i = 365 \times \sum_{t=1}^{24} 1 \mid \text{Hourly Volume} > \text{LOS E Threshold}$ Aggregating multiple segments : $\text{Daily Hours Severely Congested} = \frac{\sum \text{Lane} \times \text{Length} \times \text{Hours Severely Congested}}{\sum \text{Lane} \times \text{Length}}$	Daily and Yearly	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • 2012 Generalized Service Volume Tables
Vehicles Per Lane Mile	Vehicle per lane mile is calculated as the summation of each roadway segment's peak hour volume divided by the number of lane miles.	Aggregating multiple segments : $\frac{\sum(\frac{\text{Volume}}{\text{Number of Lanes}}) \times (\text{Lane Miles})}{\sum(\text{Lane Miles})}$	Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (feature 111)
% Miles Severely Congested (Freight)	The freight percentage of miles severely congested is determined by summing the centerline miles of roadway operating at LOS F in the peak hour and then dividing by the total system centerline miles.	$\frac{\sum(\text{Segment Length} \mid \text{Peak Hour Volumes} > \text{LOS E Volume Threshold})}{\sum(\text{Segment Length})}$ Note: If the truck factor on the segment is zero, the corresponding freight percentage of miles severely congested is zero.	Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (features 111, 121, 124, 212 and 311) • Level of Service Database (LOS Area Type, LOS Facility Type and LOS Adjustment Factor) • HCM 2010 • 2012 Generalized Service Volume Tables
Vehicles Per Lane Mile (Freight)	Vehicle per lane mile (freight) is identical to the general traffic's vehicles per lane mile measure.	Aggregating multiple segments : $\frac{\sum(\frac{\text{Volume}}{\text{Number of Lanes}}) \times (\text{Lane Miles})}{\sum(\text{Lane Miles})}$	Peak Hour	• Traffic Characteristics Inventory • Roadway Characteristics Inventory (feature 111)

Combination Truck Backhaul Tonnage	This represents the amount of available freight cargo space moving throughout Florida. Combination Truck Backhaul Tonnage is represented by the difference between incoming and outgoing loads and interpolated using average load factor and combination truck miles traveled ratios	Σ Combination Truck Backhaul Tonnage	Yearly	• FDOT Weigh-in-Motion data • Freight Analysis Framework
Accessibility Mobility Performance Measures				
MPM	Methodology	Calculation	Report Period	• Sources
Percent Sidewalk Coverage	This is the percentage of centerline miles of SHS (nonfreeway) facilities in urban areas (5,000+ population) that have sidewalks and/or shared pathways available to pedestrians.	(Sidewalk Miles in Urban Areas $\div$ Centerline Miles in Urban Areas) $\times$ 100	Yearly	• Roadway Characteristics Inventory
Percent Bike Lane/Shoulder Coverage	This is the percentage of centerline miles of SHS (nonfreeway) facilities that have bike lanes, paved shoulders, or shared pathways available to bicyclists.	(Bike Lane/Shoulder Miles in Urban Areas $\div$ Centerline Miles in Urban Areas) $\times$ 100	Yearly	• Roadway Characteristics Inventory
SIS/NHS Hub Highway Adequacy	This measure reports on the accessibility provided to critical Florida hubs, it is determined by evaluating the LOS for each highway connector.	$\text{Connector Highway Adequacy} = \sum \text{Facility Travel Times}$	Yearly	• Traffic Characteristics Inventory • Aerial Images
Active Rail Access	Active rail access accounts for active rail serving intermodal logistic centers and seaports.	Hubs with Active Rail ÷ Σ Hubs	Yearly	• FDOT Rail Office

INTERMEDIATE CALCULATION ROUTINES IN THE 2014 SOURCE BOOK

There are several intermediate calculation routines required by multiple performance measures in the Source Book. They are discussed in the sections below.

Hourly Factors

The FDOT Transportation Statistics Office compiled 2012 Florida continuous traffic data for many roadway facility types and segments. These data were categorized and hourly factors (i.e., the ratio of hourly volumes to daily volumes) were calculated for the eight facility types below:

1. Freeway core (FRC)
2. Freeway urbanized (FRU)
3. Freeway transitioning (FRT)
4. Freeway rural (FRR)
5. Arterial urbanized (AU)
6. Arterial non urbanized (ANU)
7. Two lane highway rural (2HY)
8. Multilane highway rural (MHY)

Due to the sensitivity of the Source Book results relative to the hourly factors used, comparisons and smoothing were performed with the hourly factors used in previous versions and with hourly factors derived for national research projects, namely SHRP2 L08 – Incorporating Travel Time Reliability into the Highway Capacity Manual - and NCHRP 387 - Planning Techniques to Estimate Speeds and Service Volumes for Planning Applications.

In addition, a new set of weekend hourly factors are used to better represent traffic volumes on Saturday and Sunday (see section below). Appendix A-1 contains the updated weekday hourly factors and the new weekend factors used in the 2014 Source Book.

Day of Week Variance

The continuous traffic data also enabled a comparison of daily traffic between weekdays, Saturdays, and Sundays. It was expected that roadways would show higher daily traffic in weekdays, lower traffic on Saturdays and Sundays. While some variations from this pattern were observed (e.g., high traffic on Fridays in rural roads), the hypothesis was generally supported by the data. Therefore, day of week variance factors were developed for weekdays, Saturdays, and Sundays, allowing for a more precise representation of overall traffic conditions. Table 15 summarizes the day of week variance on daily traffic assumed in the 2014 Source Book.

Table 15. Day of Week Variance Factors

Weekday	Saturday	Sunday
105%	90%	85%

The application of day of week variance factors does not change the annual average daily traffic (i.e., the weighted-average of factors is equal to 100%).

For peak hour and peak period performance measures, only the weekday traffic volumes and results are used. For measures reported on a daily basis, a seven-day average is calculated by weighting the weekday (5x), Saturday (1x), and Sunday (1x) results. Performance measures that are reported daily and weighted by VMT (e.g., average travel speed) give additional importance to weekday results and less importance to weekend ones, as there are not only more weekdays than weekend days but traffic volumes (and thus, VMT) are higher on weekdays. A-2 presents a flowchart of the day of week variance calculation routine used in the 2014 Source Book database.

Vehicle Occupancies

Vehicle occupancies are used to estimate the number of person-miles traveled (PMT) from vehicle-miles of travel (VMT). In the 2014 Source Book, the vehicle occupancies are taken from the Florida's 2009 National Household Travel Survey (NHTS) Add-on dataset. The NHTS Add-on dataset contains data for all 150,147 completed households in the sample including household, person, vehicle and daily (travel day) trip level data. In addition to the households selected as part of the national survey, this dataset includes the data collected from the twenty *Add-on* program regions, including the State of Florida. Average vehicle occupancies for the 2014 Source Book were derived from the Florida NHTS Add-on, which targeted 14,000 households. Data extracted from the NHTS are only for the trips where it was indicated that the respondent drove the vehicle. In other words, passenger trips by the respondent were excluded. Occupancies were calculated from driver trip data and reported occupancies. Occupancy averages are weighted by trip lengths to develop factors that can directly convert VMT to PMT.

Speed-Volume functions

Speed-volume functions have been applied as follows:

Freeway travel speeds are calculated using the Modified Davidson curve for both under-saturated and over-saturated conditions. A comparison of the performance of different speed-flow functions in the Orlando Urban Area Transportation Study (OUATS) travel demand model suggests that the modified Davidson equation had the highest average coefficient of determination (R^2) out of the study functions.

Arterial speeds are calculated using different methodologies for under-saturated and over-saturated conditions. For under-saturated conditions (demand less than capacity), operating speeds are calculated based on Florida's latest set of Generalized Service Volume Tables (December 2012). For over-saturated conditions (demand greater than capacity), a BPR curve (with Greater Treasure Coast Regional Planning Model parameters) is used to determine average travel speed given vehicle volume and segment capacity. The BPR curve was calibrated such that the v/c = 1.0 speed matches the Generalized Service Volume Tables LOS E speed for a Class II arterial (e.g., 10 mph in an Urbanized Area). The v/c >= 2.0 speed was set at a minimum of 7 mph.

Two-lane highway travel speeds are calculated assuming a linear relationship between speed and flow according to the 2010 Highway Capacity Manual (HCM). Chapter 15:

Two-Lane Highways of the HCM provides guidance on estimating average speeds on two-lane highways.

Delay Calculations for Saturated Flow

Delay calculations have been revised to take into account queuing that occurs under saturated flow conditions. For each hour between 7 AM and 10 AM and between 4 PM and 7 PM where saturated conditions exist, it is assumed that the unserved part of the queue will spill back to the next hour. This unserved demand is added to the volume of the next hour and this total volume is used to calculate speed. More detail on the volume spill-back adjustment can be found under the Hours Severely Congested section.

Auto Level of Service

The process described below calculates the peak hour auto level of service for each facility in the MPM database. The auto level of service is an input to several of the MPMs, including travel or miles meeting LOS criteria and travel or miles severely congested.

Step 1: Obtain Hourly Directional Vehicle Volume

The hourly directional volume is the product of the AADT, hourly factor (see Appendix A-2:), and directional factor. For the determination of auto LOS, volumes between 7 AM and 10 AM and between 4 PM and 7 PM are adjusted to account for unmet demand in the previous hour.

Step 2: Identify Appropriate Level of Service Threshold Set

Threshold volumes from the Generalized Service Volume Tables must be carefully selected from the several available tables, as presented below in Table 16. In the 2014 Source Book, Generalized Service Volume Tables 7 through 9 are used for LOS reporting.

The Generalized Tables present maximum service volumes, the highest numbers of vehicles for a given LOS. Any number greater than the value shown in a table for a roadway with a given number of lanes would drop the LOS to the next letter grade. The full set of Generalized Service Volume Tables can be accessed online[1].

Table 16. Generalized Service Volume Tables

Generalized Service Volume Table	Area Type	Time Period	Direction
Table 1	Urbanized Areas	Daily	Two-Way
Table 2	Transitioning Areas and Areas over 5,000 Not in Urbanized Areas	Daily	Two-Way
Table 3	Rural Undeveloped Areas and Developed Areas less than 5,000 Population	Daily	Two-Way
Table 4	Urbanized Areas	Peak Hour	Two-Way
Table 5	Transitioning Areas and Areas over 5,000 Not in Urbanized Areas	Peak Hour	Two-Way
Table 6	Rural Undeveloped Areas and Developed Areas less than 5,000	Peak Hour	Two-Way

[1] http://www.dot.state.fl.us/planning/systems/sm/los/

	Population		
Table 7	Urbanized Areas	Peak Hour	One-Way
Table 8	Transitioning Areas and Areas over 5,000 Not in Urbanized Areas	Peak Hour	One-Way
Table 9	Rural Undeveloped Areas and Developed Areas less than 5,000 Population	Peak Hour	One-Way

Step 3: Obtain Level of Service

A comparison of the vehicle volumes obtained in Step 1 and the thresholds obtained from Step 2 yields the auto LOS for a given roadway segment.

CALCULATION METHODOLOGY FOR THE 2014 SOURCE BOOK

The calculation methodology for each individual performance measure is presented below.

VEHICLE MILES TRAVELED, PERSON MILES TRAVELED, TRUCK MILES TRAVELED, AND COMBINATION TRUCK MILES TRAVELED

Vehicle Miles Traveled, Person Miles Traveled, Truck Miles Traveled, and Combination Truck Miles Traveled are important measures of the quantity of travel performed. Person Miles Traveled, unlike the Vehicle Miles Traveled measure, captures the effect of vehicle occupancy on a roadway's mobility. The following steps describe the process used to obtain Vehicle Miles, Truck Miles, Combination Truck Miles, and Person Miles Traveled on a single segment.

Step 1: Obtain Daily and Peak Hour Vehicle Volume

Daily vehicle volume is directly obtained from Annual Average Daily Traffic (AADT), while the peak hour volume is the product of the AADT and the highest hourly factor.

Step 2: Obtain Vehicle Miles Traveled (VMT)

VMT is determined using vehicle traffic volume and segment length. The number of vehicle-miles traveled is based on data obtained from traffic monitoring sites and FDOT's Roadway Characteristics Inventory (RCI) feature 111 data. These monitoring sites collect count data on an hourly basis, while the RCI's data are updated annually on December 31 (SHS and NHS roads) and September 30 (city and county roads). Vehicle Miles Traveled is equal to the product of the daily or hourly volume and the roadway's length in miles:

(Equation 1)

$$\text{VMT} = \sum (\text{Segment Length} \times \text{Volume})$$

Step 3: Convert to Person Miles Traveled (PMT)

Person Miles Traveled is computed by multiplying VMT by the average vehicle occupancy. Average vehicle occupancies in the Source Book are provided on a county-by-county basis (see Table 17). PMT is computed as follows:

(Equation 2)

$$\text{PMT} = \sum \text{Segment Length} \times \text{Volume} \times \text{Average Vehicle Occupancy}$$

Table 17. Recommended Average Vehicle Occupancies. Source: NHTS 2009 Florida Add--On

County	Occupancy	County	Occupancy	County	Occupancy
Alachua	1.77	Hardee	1.81	Okeechobee	1.79
Baker	1.72	Hendry	1.81	Orange	1.70

County	Occupancy	County	Occupancy	County	Occupancy
Bay	1.52	Hernando	1.62	Osceola	1.60
Bradford	1.72	Highlands	1.81	Palm Beach	1.55
Brevard	1.58	Hillsborough	1.69	Pasco	1.57
Broward	1.55	Holmes	1.77	Pinellas	1.44
Calhoun	1.53	Indian River	1.79	Polk	1.73
Charlotte	1.55	Jackson	1.77	Putnam	1.71
Citrus	1.63	Jefferson	1.53	Saint Johns	1.84
Clay	1.27	Lafayette	1.68	Saint Lucie	1.47
Collier	1.59	Lake	1.48	Santa Rosa	1.51
Columbia	1.72	Lee	1.48	Sarasota	1.46
DeSoto	1.81	Leon	1.57	Seminole	1.64
Dixie	1.68	Levy	1.68	Sumter	1.63
Duval	1.61	Liberty	1.53	Suwannee	1.68
Escambia	1.90	Madison	1.53	Taylor	1.53
Flagler	1.71	Manatee	1.73	Union	1.72
Franklin	1.53	Marion	1.75	Volusia	1.66
Gadsden	1.29	Martin	1.92	Wakulla	1.53
Gilchrist	1.68	Miami-Dade	1.76	Walton	1.77
Glades	1.81	Monroe	1.76	Washington	1.77
Gulf	1.53	Nassau	1.78	FLORIDA	1.63
Hamilton	1.68	Okaloosa	1.60		

Step 4: Convert to Truck Miles Traveled (TMT)

Truck Miles Traveled is computed by multiplying VMT by a truck factor, also known as the heavy vehicle percentage or T Factor. The truck factor for each roadway segment is provided in the RCI database. Truck Miles Traveled is then computed as follows:

(Equation 3)

$$\text{TMT} = \sum \text{Segment Length} \times \text{Volume} \times \text{T Factor}$$

Step 5: Convert to Combination Truck Miles Traveled (CTMT)

Combination Truck Miles Traveled is computed by multiplying VMT by the T factor and a combination truck factor. The combination truck factor is provided on a county-by-county basis and represents the proportion of trucks that are combination trucks. Combination Truck Miles Traveled is then computed as follows:

(Equation 4)

$$\text{CTMT} = \sum \text{Segment Length} \times \text{Volume} \times \text{T Factor} \times \text{Combo Truck Factor}$$

PERCENT OF TRAVEL OR MILES MEETING LOS CRITERIA

The Percent of Travel or Percent of Miles Meeting Generally Acceptable Operating Conditions is determined by summing the Vehicle Miles Traveled (for Percent of Travel) or the centerline miles of roadway (for Percent of Miles) operating acceptably and then dividing by the total system VMT or centerline miles. "Acceptably" is defined as LOS D (two-hour peak) for the 7 largest counties, LOS D (one-hour peak) for urbanized areas, and LOS C (one-hour peak) everywhere else.

The generally acceptable thresholds are described in Table 18. The measure is reported daily and for the peak period for the 7 largest counties, and reported daily and for the peak hour for all other area types.

Table 18. Generally Acceptable Conditions Thresholds

Area Type	Time Period	Generally Acceptable Threshold
7 Largest Counties	Peak Period (two-hours)*	LOS D
Urbanized Areas	Peak Hour**	LOS D
All Others	Peak Hour**	LOS C

* 4pm to 6pm for all areas.
** 5pm to 6pm for all areas.

Step 1: Obtain Peak Period and Peak Hour Directional Vehicle Volume

Peak hour directional volume is the product of the AADT, directional factor, and the highest hourly factor. Similarly, peak period volume is equal to the product of AADT , directional factor, and the sum of the hourly factors from 4 to 5 PM and 5 to 6 PM.

Step 2: Compute Auto Level of Service

Compute auto LOS in the peak hour and daily time periods for each road segment, as specified in the Auto Level of Service section of this memorandum.

Step 3: Compare Auto Level of Service to LOS Criteria Thresholds

In the 2014 version of Source Book, generally acceptable LOS criteria will be considered to be those instances where:

- Peak period LOS is D or better (7 largest counties), or
- Peak hour LOS is D or better (in urbanized areas outside the 7 largest counties), or
- Peak hour LOS is C or better everywhere else.

When one direction does not meet LOS criteria during a peak hour, the entire segment would be considered as not meeting LOS criteria. When calculating the percentage of travel meeting LOS criteria, each hour of the peak period is evaluated separately. However, when calculating the percentage of miles meeting LOS criteria, if any hour within the peak period does not meet LOS criteria, then the entire peak period does not meet LOS criteria.

Step 4: Sum VMT or Centerline Miles Meeting LOS Criteria

The following equations will be used to compute a single percent of travel or miles meeting LOS criteria. Although these equations represent a peak hour-based calculation of travel or miles meeting LOS criteria, they can be extended to other time periods by simply changing the inputs.

(Equation 5)

$$\%\ \text{Travel Meeting LOS Criteria} = \frac{\sum(\text{VMT}|\text{Peak Hour Volumes} < \text{Acceptable LOS Volume Threshold})}{\sum(\text{VMT})} \times 100$$

(Equation 6)

$$\%\ \text{Miles Meeting LOS Criteria} = \frac{\sum(\text{Segment Length}|\text{Peak Hour Volumes} < \text{Acceptable LOS Volume Threshold})}{\sum(\text{Segment Length})} \times 100$$

TRAVEL TIME RELIABILITY AND VARIABILITY

The 2014 version of Source Book reports Travel Time Reliability as follows:
Travel Time Reliability (TTR) is the percent of VMT for which the travel speed is greater than or equal to the roadway's speed limit.
Travel Time Variability, or Travel Time Index (TTI) is the ratio of the 95th percentile travel time to the free-flow travel time.
These are defined by the following equations:

(Equation 7)

$$\text{Travel Time Reliability (All Vehicles)} = \frac{\sum(\text{VMT}|\text{Travel Speed} \geq \text{Speed Limit})}{\sum(\text{VMT})} \times 100$$

(Equation 8)

$$\text{Travel Time Reliability (Freight)} = \frac{\sum(\text{VMT}|\text{Combination Truck Travel Speed} \geq \text{Speed Limit})}{\sum(\text{VMT})} \times 100$$

(Equation 9)

$$\text{Travel Time Index}_{95} = \frac{\text{Travel Time}_{\text{95th percentile}}}{\text{Travel Time}_{\text{freeflow}}}$$

Travel Time Reliability and Travel Time Variability are reported for both vehicles and freight. The calculation procedure is summarized as follows.

Step 1: Compute Travel Time Reliability

Travel speeds were calculated based on the FDOT reliability model[2]. Summing the VMT for all segments whose travel speed is greater than or equal to the speed limit and dividing by total VMT yields the TTR measure defined for the 2014 version of the Source Book.

Step 2: Set Travel Time Variability as 95th Percentile Travel Time Index

Travel speeds were calculated based on FDOT's reliability model. The 95th percentile travel time for each segment is equated to the Travel Time Variability measure. The 95th percentile TTI is also defined as the planning time index (PTI).

HOURS OF DELAY

In the 2014 version of Source Book, Vehicle Hours of Delay, Person Hours of Delay, and Combination Truck Hours of Delay are estimated on an hourly basis by determining the difference between delay threshold travel time and actual travel time along a facility. Delay threshold travel time/speed is considered the additional travel time experienced by a motorist in addition to what would be experienced under normal conditions. The definition of "normal" conditions is defined as level of service "B". The delay threshold speed for the 2014 version of the Source Book is provided in Table 19 below.

Delay estimation considers unserved demand from the preceding hours for the time periods between 7 AM and 10 AM and between 4 PM and 7 PM. During oversaturation, the undischarged queue—the difference between demand and capacity—from an oversaturated hour is added to the next hour. The process is repeated until demand (including that from previous hour(s)) is less than the capacity.

Table 19. Summary of Delay Threshold Speeds

Facility	The 2014 version of Source Book	
	Delay Threshold Speed[1] (mph)	Basis
Urban Freeway	~68	Modified Davidson curve with LOS B to C threshold volume
Rural Freeway	~74	Modified Davidson curve with LOS B to C threshold volume
Arterial	31 (Class I or Rural Arterial) / 22 (Class II)	Generalized LOS Table LOS with LOS B to C threshold volume
Multilane Highway	~58	Modified Davidson curve with LOS B to C threshold volume
Two-lane Highway	~54	HCM 2010 methodology with LOS B to C threshold volume

[2] http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_PL/FDOT_BDK77_977-10_rpt.pdf (accessed 09/05/2013)

[1]Delay threshold speeds are not fixed to a particular value, but rather calculated based on the LOS B volume threshold. Therefore, the values provided in this table are averages of the entire data set. For a particular roadway, delay threshold speed may be lower or greater than what is reported here.

The following description summarizes the technique to calculate the Vehicle Hours of Delay. The calculations for obtaining Person Hours of Delay and Combination Truck Hours of Delay are similar to the ones for obtaining all vehicles' delay, with the exception of multiplying by the average vehicle occupancy rate in the former and using the combination truck average travel speed in the latter.

Step 1: Obtain Hourly Directional Vehicle Volumes

For purposes of estimating speed, AADT must first be converted to hourly directional volumes, based on the hourly and directional factors. Hourly directional volumes used for delay calculation are adjusted for queue spill-back under over-saturation conditions for the time periods between 7 AM and 10 AM and between 4 PM and 7 PM.

Step 2: Obtain Delay Threshold Travel Time

A segment's delay threshold travel time is obtained by dividing the segment length by the threshold speeds presented above.

Step 3: Compute Hourly Directional Total Vehicle Delay

Average vehicle delay (in time units per vehicle) is computed as the difference between the actual travel time and the delay threshold travel time. It should be noted that when the actual travel time is less than the delay threshold travel time, there is no delay on the roadway segment. Total vehicle hours of delay (in vehicle-time units) is the product of average vehicle delay and the vehicle volume. The actual travel time is computed based on the output of the average travel speed model described in the previous section. On a single segment and for a single hour, the delay calculation will be as presented in the following equations.

(Equation 10)

$$\text{Vehicle Hours of Delay} = \sum (\text{Daily or Peak Period/Hour Travel Time} - \text{Travel Time at LOS B})$$

(Equation 11)

$$\text{Person Hours of Delay} = \sum \text{Average Vehicle Occupancy} \times \text{Vehicle Hours of Delay}$$

(Equation 12)

$$\text{Combination Truck Hours of Delay} = \sum (\text{Daily Combination Truck Travel Time} - \text{Travel Time at LOS B})$$

Step 4: Obtain Daily Total Delay

The daily total hours of delay is equal to the sum of the hourly total delays. For example, the vehicle hours of delay are calculated as shown below.

(Equation 13)

$$\text{Daily Vehicle Delay} = \sum_{t=1}^{24} \text{Total Hourly Vehicle Delay}_t$$

AVERAGE TRAVEL SPEED

Average Travel Speeds are calculated using data such as traffic volume, truck percentage, speed limit, number of lanes, facility type, and area type. The calculation of average daily operating speed requires the determination of operating speeds during each hour of the day. The average travel speed calculations use the latest FDOT Generalized Service Volumes Tables which implement HCM 2010 methods for roadways operating below capacity (v/c ≤ 1). Because the Generalized Service Volumes Tables lack speed information for over capacity conditions (v/c > 1), speed-volume curves were used to provide improved accuracy in congested regimes. Speed estimation also accounts for reduced speed due to unserved demand from the preceding hours. During oversaturation, the undischarged queue—the difference between demand and capacity—from an oversaturated hour is added to the next hour. The process is repeated until demand (including that from previous hour(s)) is less than the capacity. These hourly operating speeds are weighted by hourly traffic volume and averaged to determine the average daily operating speed on each segment.

The calculation of Combination Truck Average Travel Speeds is identical to the methodology for (passenger) vehicle average travel speed, except that combination trucks are assumed to have a lower free flow speed. For automobiles, free flow speed is set as the posted speed limit plus five miles per hour for all facility types and area types. For combination trucks, the free flow speed is simply the posted speed limit.

Operating speeds are calculated using different methodologies for different facility types:

- For freeways and multilane highways, operating speeds are calculated using the Modified Davidson Curve in Appendix A-4. Modified Davidson parameters applicable to Florida conditions were obtained from FDOT.

- For arterials, different methodologies are used for under-saturated and over-saturated conditions. For under-saturated conditions (demand less than capacity), operating speeds are calculated based on the latest set of Generalized Service Volume Tables (December 2012). For over-saturated conditions (demand greater than capacity), a BPR curve (with Greater Treasure Coast Regional Planning Model parameters) is used to determine average travel speed given vehicle volume and segment capacity. The BPR curve was calibrated such that the v/c = 1.0 speed matches the Generalized Service Volume Tables LOS E speed for a Class II arterial (e.g., 10 mph in an Urbanized Area). The v/c >= 2.0 speed was set at a minimum of 7 mph.

- For two-lane highways, the 2010 HCM base relationship between flow and average travel speed are used to calculate operating speeds.

- A minimum speed of 7 mph is set for conditions when v/c >= 2.0 for all facility types.

The following description summarizes the speed estimation technique.

Step 1: Obtain Hourly Directional Vehicle Volume

Daily volume is obtained directly from Annual Average Daily Traffic (AADT). For purposes of estimating speed, AADT must first be converted to hourly directional volumes, based on the updated hourly factors presented in Appendix A-1: 2014 Source Book Hourly Factors and directional factors.

Step 2: Adjust for Spillback

Hourly vehicle volumes calculated from Step 1 are adjusted to take into account queuing that occurs under saturated flow conditions. For each hour between 7 AM and 10 AM and between 4 PM and 7 PM where saturated conditions exist, the additional traffic over the capacity obtained from the Generalized Service Volume Tables is added to the following hour and used to calculate speeds.

Step 3: Determine whether Undersaturated or Oversaturated Conditions Prevail

The adjusted hourly volumes computed in Step 2 are compared with capacities obtained from Florida's Generalized Service Volume Tables in Appendix A-3. If volume is greater than the capacity, oversaturated condition is assumed.

Step 4: Select Appropriate Travel Speed Estimation Technique

A speed estimation technique is then chosen based on the facility type and the prevailing regime (i.e., undersaturated or oversaturated).
Figure 15. Average Travel Speed Estimation Techniques provides a summary of the estimation techniques that were used in the 2014 version of Source Book.

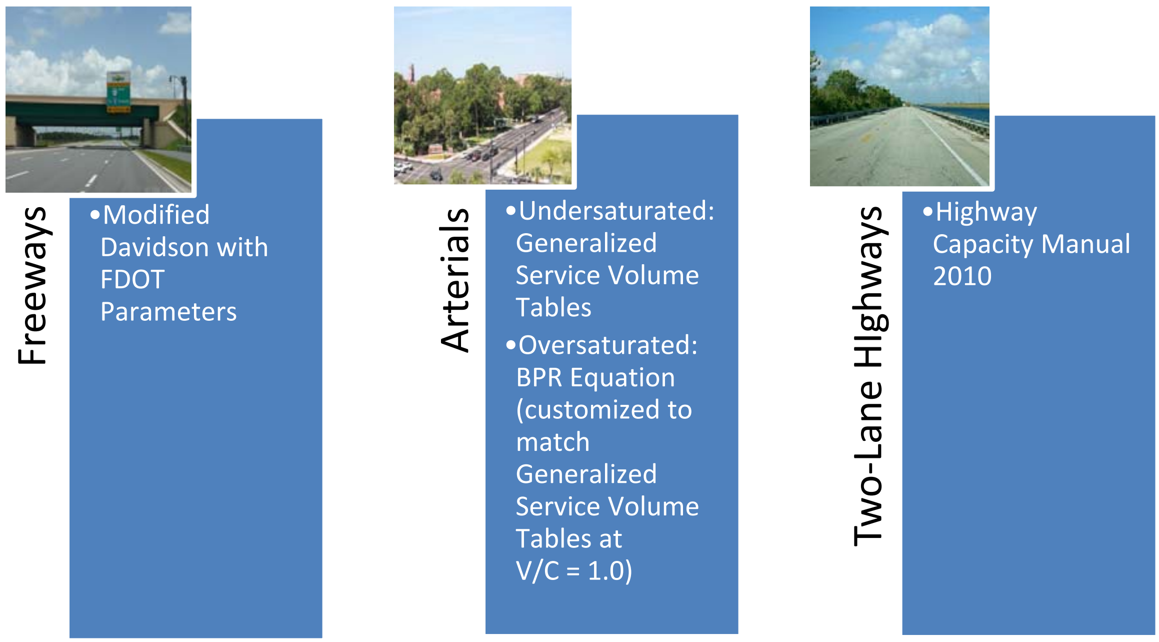


Figure 15. Average Travel Speed Estimation Techniques

Step 5: Compute Average Travel Speed

Once the applicable speed estimation technique has been identified, the next step is to compute average travel speed. Figure 16, Figure 17, and Figure 18 present flowcharts for freeways, arterials, and two-lane highways, respectively.

The minimum travel speed for any facility type is set at 7 mph. More details on the review are included in Appendix A-4: Freeway Speed Model, Appendix A-5: Arterial Speed Model, and Appendix A-6: Two-Lane Highway Speed for freeways, arterials, and two-lane highways, respectively.

As shown in the equation below, average travel speeds on various segments are weighted by VMT to arrive at a single average travel speed.

(Equation 14)

$$\text{Average Travel Speed} = \frac{\sum(\text{VMT} \times \text{Average Travel Speed})}{\sum(\text{VMT})}$$

(Equation 15)

$$\text{Combination Truck Average Travel Speed} = \frac{\sum(\text{CTMT} \times \text{Combination Truck Average Travel Speed})}{\sum(\text{CTMT})}$$

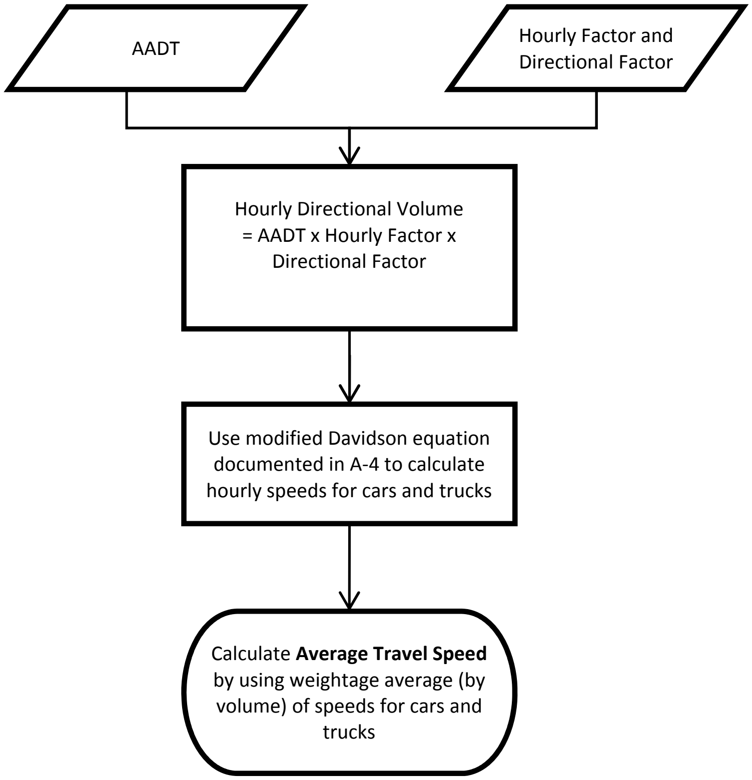


Figure 16. Estimation of Average Travel Speed on Freeways (Flowchart)

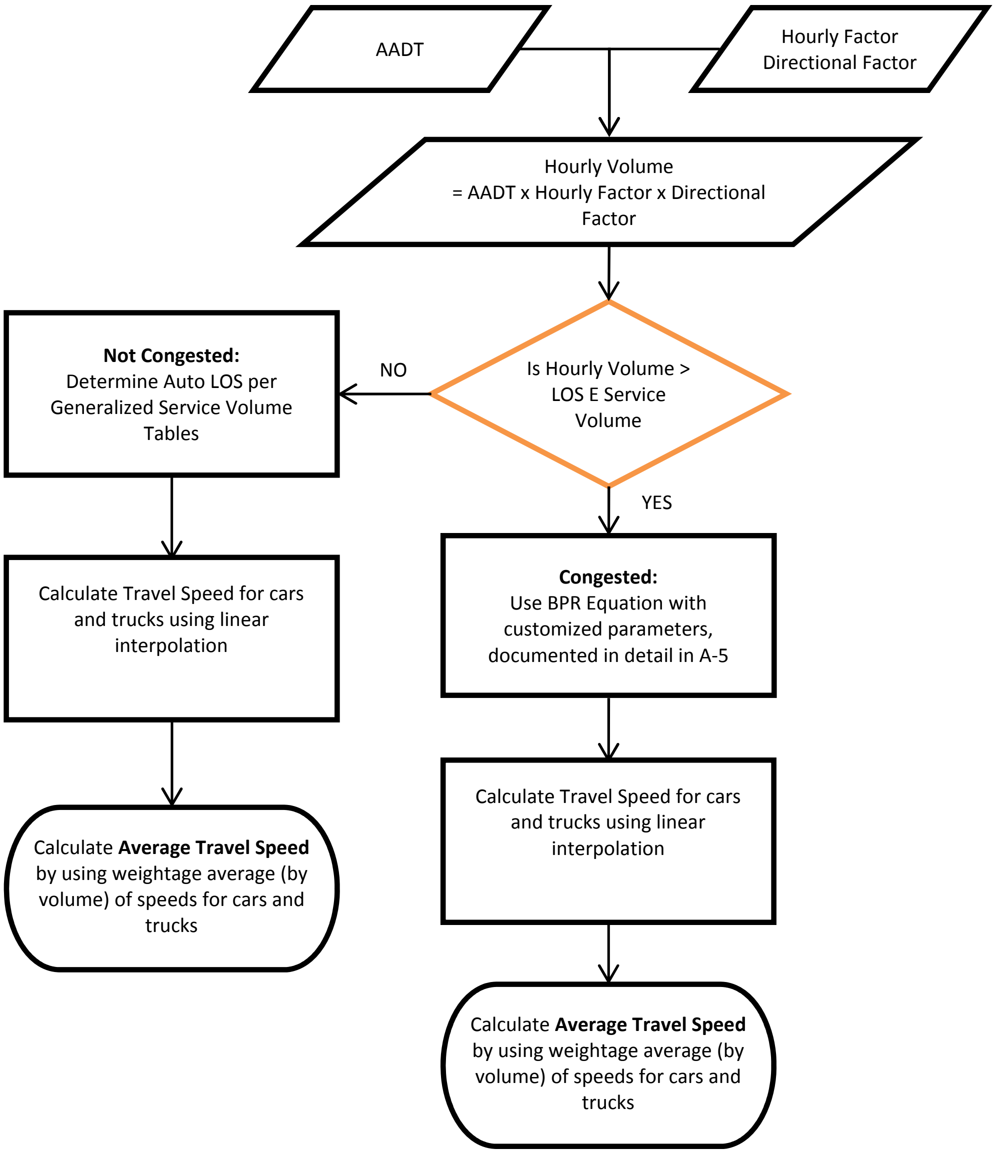


Figure 17. Estimation of Average Travel Speed on Arterials (Flowchart)

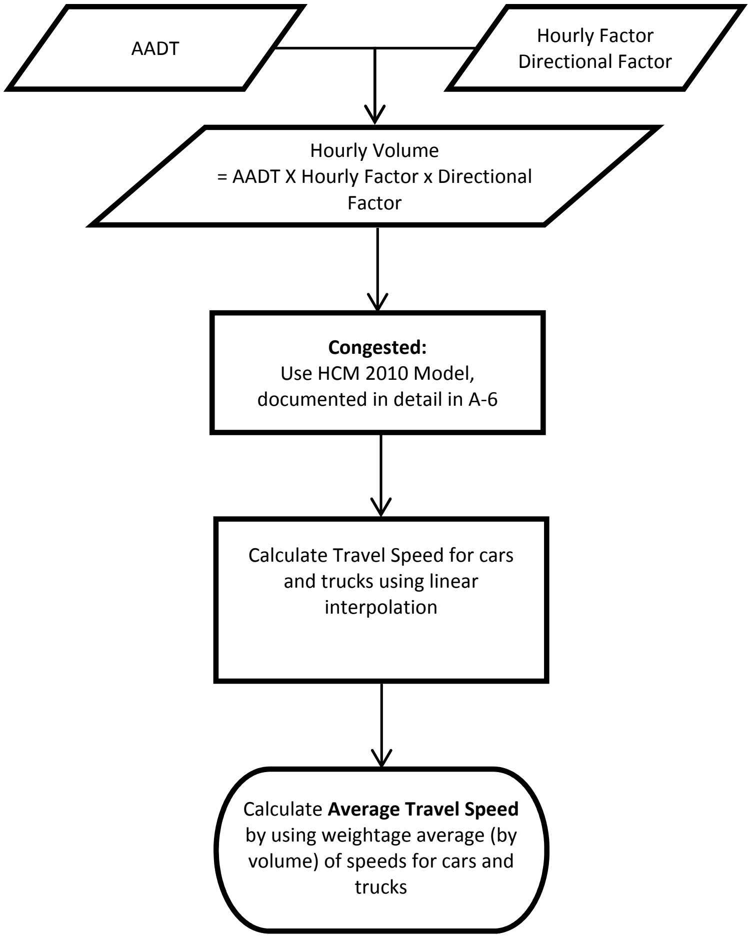


Figure 18. Estimation of Average Travel Speed on Two-Lane Highways (Flowchart)

PERCENT OF MILES SEVERELY CONGESTED

The Percent of Miles Severely Congested for all vehicles and for freight is determined by summing the miles of roadway operating at LOS F and then dividing by the total system miles. The Percent of Miles Severely Congested is assumed to be the same for freight and all vehicles, except when no trucks exist on a roadway segment.

Step 1: Compute Peak Hour Auto Level of Service

Compute auto LOS for each road segment as specified in the Auto Level of Service section.

Step 2: Compare Auto Level of Service to Severe Congestion Threshold

In the 2014 version of Source Book, severely congested conditions will be considered to be those instances where volume exceeds the LOS E service volume. Therefore, the appropriate LOS E thresholds from Florida's Generalized Service Volume Tables in Appendix A-3 will be used to classify segments as congested or not.

When one direction is classified as severely congested during an hour, the entire segment (including both directions) would be considered as severely congested.

Step 3: Sum Centerline Miles in Severely Congested Conditions

The following equation will be used to compute a single percent of miles congested.

(Equation 16)

$$\%\ \text{Miles Severely Congested} = \frac{\sum(\text{Segment Length}|\text{Peak Hour Volumes} > \text{LOS E Volume Threshold})}{\sum(\text{Segment Length})} \times 100$$

PERCENT OF TRAVEL SEVERELY CONGESTED

The Percentage of Travel Severely Congested is determined by summing the vehicle-miles traveled on roadways operating at LOS F and then dividing by the total system vehicle-miles traveled (see calculation of vehicle-miles traveled in the Vehicle Miles Traveled, Person Miles Traveled, Truck Miles Traveled section). This measure will be reported for both the peak hour and daily time periods.

Step 1: Compute Auto Level of Service

Compute auto LOS for each road segment, as specified in the Auto Level of Service section.

Step 2: Compare Auto Level of Service to Severe Congestion Threshold

Similar to the Percent of Miles severely Congested measure, the appropriate LOS E thresholds from the Generalized Service Volume Tables will be used to classify segments as congested or not. When one direction is classified as severely congested during an hour, the entire segment (including both directions) would be considered as congested.

Step 3: Sum Vehicle-Miles Traveled in Severely Congested Conditions

(Equation 17)

$$\%\ \text{Travel Severely Congested} = \frac{\sum(\text{VMT}|\text{Peak Hour Volumes} > \text{LOS E Volume Threshold})}{\sum(\text{VMT})} \times 100$$

HOURS SEVERELY CONGESTED

Hours Severely Congested is an indication of the average amount of time in which severely congested conditions occur on a system. It is estimated as the average number of hours in which segments operate at LOS F, weighted by lane-miles.

Step 1: Compute Weekday Hourly Directional Volumes

Weekday hourly factors and directional factors will be used to convert AADT to hourly directional volumes.

Step 2: Compute the Number of Hours in Congested Conditions

A comparison between the hourly directional volumes obtained from Step 1 and the threshold volumes in the FDOT's Generalized Service Volumes Table will yield the number of hours in a congested state (i.e., LOS F).

Step 3: Iteratively Adjust for Queue Spillover

An algorithm to allow for queue spillover from one time interval to the next is implemented in this Source Book. During oversaturation, the undischarged queue—the difference between demand and capacity—from an oversaturated hour between 7 AM and 10 AM and between 4 PM and 7 PM is added to the next hour. The process is repeated until demand (including that from previous hour(s)) is less than the capacity. Figure 19 presents the algorithm in a graphical form.

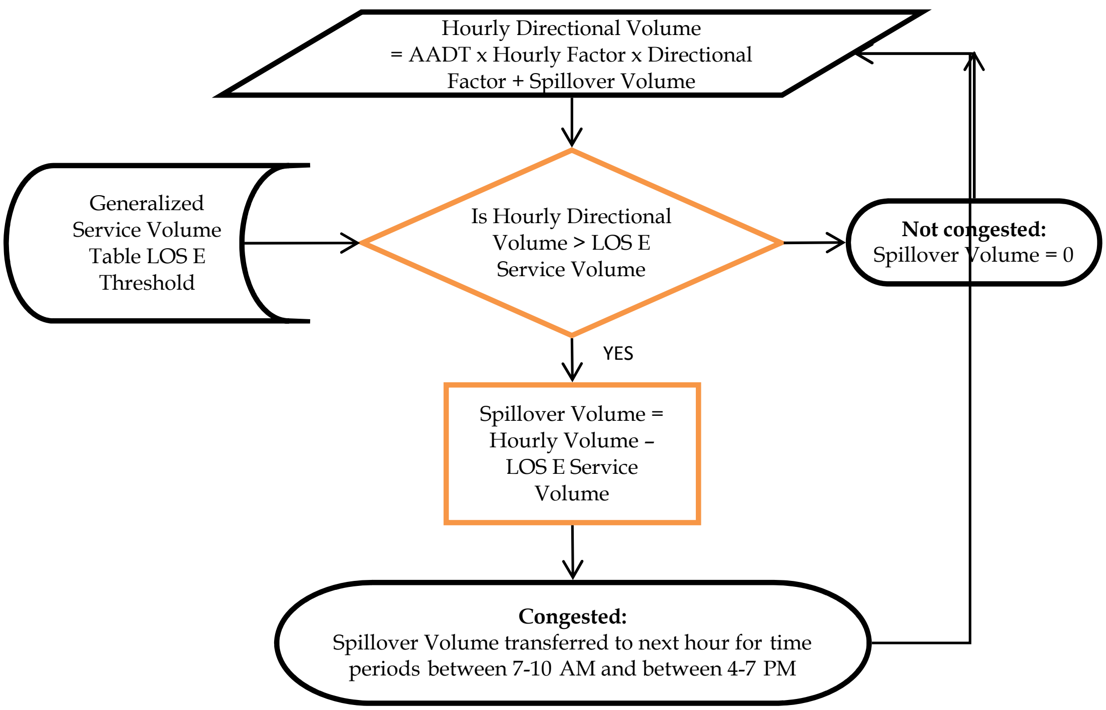


Figure 19. Queue Spillover Algorithm (Flowchart)

Step 4: Weight by Lane-Miles

To report a single duration of congestion metric, severe congestion durations from multiple roadways are weighted by the roadways' lane miles:

(Equation 18)

$$\text{Daily Hours Severely Congested} = \sum_{t=1}^{24} 1|\text{Hourly Volume} > \text{LOS E Threshold}$$

$$\text{Yearly Hours Severely Congested} = 365 \times \sum_{t=1}^{24} 1|\text{Hourly Volume} > \text{LOS E Threshold}$$

VEHICLES PER LANE MILE

The most commonly used mobility performance measure to describe utilization is Vehicles per Lane Mile, which represents the average density on a roadway. It is calculated as the summation of each roadway segment's peak hour vehicle miles traveled divided by the number of lane miles. Vehicle miles of travel is used in the aggregation of this measure rather than average annual daily traffic, since vehicle miles of travel describes the volume across a segment and is more suitable to the segmentation used for Florida's highway systems. Vehicle per lane miles is reported only for peak hour.

Step 1: Obtain Peak Hour Vehicle Volume and Number of Lanes

Peak hour volume is the product of the AADT and the highest hourly factor. Total number of lanes (in both directions) is obtained by summing the number of lanes on the right and left sides of the roadway segment, which are obtained directly from the RCI database.

Step 2: Obtain Vehicles per Lane Mile

Vehicle per lane mile is calculated as:

(Equation 19)

$$\text{Vehicles per Lane Mile} = \frac{\sum\left(\frac{\text{Volume}}{\text{Number of Lanes}} \times \text{Lane Miles}\right)}{\sum(\text{Lane Miles})}$$

TRUCK AND COMBINATION TRUCK MILES TRAVELED

The Truck Miles Traveled and Combination Truck Miles Traveled performance measures are intended to describe the quantity of travel done by trucks and combination trucks, respectively. In the Source Book, combination trucks are those vehicles that fall under the FHWA Class 8 through 13.

Step 1: Obtain Daily Truck or Combination Truck Volume

Daily combination truck volume is obtained by multiplying the Annual Average Daily Traffic (AADT) by the percent of trucks (also referred to as "%HV", which includes FHWA Classes 4 through 13) and by a combination truck factor. The combination truck factor represents the proportion of trucks that are combination trucks.

(Equation 20)

$$\text{Truck ADT} = \text{AADT} \times \%\text{HV}$$

$$\text{Combination Truck ADT} = \text{AADT} \times \%\text{HV} \times \text{Combination Truck Factor}$$

Combination truck factors were based on truck VMT data obtained from the FDOT Transportation Statistics Office.

Step 2: Obtain Truck or Combination Truck Miles Traveled

Daily Truck or Combination Truck Miles Traveled is the product of the daily truck or combination truck volume and the segment length. Miles traveled can be directly summed to obtain an aggregate measure (e.g., Combination Truck Miles Traveled on all freeways). On a group of segments, the equations would be as follows:

(Equation 21)

$$\text{Truck Miles Traveled} = \sum \text{Segment Length} \times \text{Truck ADT}$$

$$\text{Combination Truck Miles Traveled} = \sum \text{Segment Length} \times \text{Combination Truck ADT}$$

FREIGHT VEHICLES PER LANE MILE

The Trucks per Lane Mile is calculated and reported for the peak hour. This measure represents the density of vehicles that trucks would experience on roadways, and the calculation is identical to the general traffic's vehicles per lane mile measure.

Step 1: Obtain Peak Hour Volume and Number of Lanes

Peak hour volume is the product of the AADT and the highest hourly factor.

Step 2: Obtain Vehicles per Lane Mile

The following equation can be used to obtain average freight vehicles per lane mile over *N* segments. The numerator represents freight vehicle volume and the denominator is equal to the sum of lane-miles.

(Equation 22)

$$\text{Freight Vehicles per Lane Mile} = \frac{\sum \left(\frac{\text{Volume}}{\text{Number of Lanes}} \times \text{Lane Miles}\right)}{\sum(\text{Lane Miles})}$$

SIS/NHS HUB HIGHWAY ADEQUACY (LOS)

Highway adequacy was evaluated on all SIS and NHS highway connectors. These facilities connect airports, bus terminals, railyards, seaports, and space ports to SIS and NHS corridors. This measure reports on the accessibility provided to critical Florida hubs, it is determined by evaluating the LOS for each highway connector. To obtain the LOS aerial imagery and TCI data was used.

Step 1: Compute Auto Level of Service

Automobile LOS is calculated using LOSPLAN software suite, for arterials the ARTPLAN application was used to analyze LOS. The procedure is repeated for each facility within the connector.

Step 2: Combine Facility LOS into Connector LOS

Combine travel times for each facility to determine amount of time to travel the entire connector.

(Equation 233)

$$\text{Connector Highway Adequacy} = \sum \text{Facility Travel Times}$$

COMBINATION TRUCK TONNAGE

Combination truck tonnage represents the amount of freight being transported along the SHS by combination trucks. FHWA defines combination trucks as classes 8 thru 13. Combination Truck Tonnage is determined using the tonnage value for the year and interpolated using average load factor and combination truck miles traveled ratios.

Step 1: Compute Combination Truck Tonnage for Years 2004 thru 2007

Obtain 2007 tonnage value from Freight Analysis Framework (FAF) and apply adjustment factors to account for historic trends in CTMT and average load.

(Equation 24)

$$\text{Tonnage}_{2006} = \text{Tonnage}_{2007}*(\text{AvgLoad}_{2006}/\text{AvgLoad}_{2007})*(\text{CTMT}_{2006}/\text{CTMT}_{2007})$$

Step 2: Compute Combination Truck Tonnage for Years 2008 thru 2011

Obtain 2007 and 2012 tonnage values from Freight Analysis Framework (FAF) and apply adjustment factors to account for historic trends in CTMT and average load.

(Equation 25)

$$\textbf{Tonnage}_{\mathbf{2008}} = ((\text{Tonage}_{2007}*(\text{AvgLoad}_{2008}/\text{AvgLoad}_{2007})*(\text{CTMT}_{2008}/\text{CTMT}_{2007})$$

$$+ \text{Tonnage}_{2012}*(\text{AvgLoad}_{2011}/\text{AvgLoad}_{2012})*(\text{CTMT}_{2011}/\text{CTMT}_{2012}))/2$$

Step 3: Compute Combination Truck Tonnage for Years 2012 and 2013

Obtain 2012 tonnage value from Freight Analysis Framework (FAF) and apply adjustment factors to account for future trends in CTMT and average load

(Equation 26)

$$\textbf{Tonnage}_{2013} = \text{Tonage}_{2012} * (\text{AvgLoad}_{2013}/\text{AvgLoad}_{2012}) * (\text{CTMT}_{2013}/\text{CTMT}_{2012})$$

COMBINATION TRUCK TON MILES TRAVELED

Combination Truck Ton Miles Traveled is determined by multiplying the annual average combination truck load by the combination truck miles traveled.

(Equation 27)

$$Combination\ Truck\ Miles\ Traveled\ \times Average\ Truck\ Load$$

COMBINATION TRUCK BACKHAUL TONNAGE

One indicator of available freight carrying capacity is backhaul tonnage. This represents the amount of available freight cargo space moving throughout Florida. Combination Truck Backhaul Tonnage is represented by the difference between incoming and outgoing loads and interpolated using average load factor and combination truck miles traveled ratios.

Step 1: Compute Combination Truck Backhaul Tonnage for Years 2004 thru 2007

Obtain 2007 tonnage value from Freight Analysis Framework (FAF) and apply adjustment factors to account for historic trends in CTMT and average load.

(Equation 28)

$$\text{Backhaul Tonnage}_{2006} = \text{Backhaul Tonnage}_{2007} * (\text{AvgLoad}_{2006}/\text{AvgLoad}_{2007}) * (\text{CTMT}_{2006}/\text{CTMT}_{2007})$$

Step 2: Compute Combination Truck Tonnage for Years 2008 thru 2011

Obtain 2007 and 2012 tonnage values from Freight Analysis Framework (FAF) and apply adjustment factors to account for historic trends in CTMT and average load.

(Equation 29)

$$\textbf{Backhaul Tonnage}_{2008} = ((\text{Backhaul Tonnage}_{2007} * (\text{AvgLoad}_{2008}/\text{AvgLoad}_{2007}) * (\text{CTMT}_{2008}/\text{CTMT}_{2007})$$

$$+ \text{Backhaul Tonnage}_{2012} * (\text{AvgLoad}_{2011}/\text{AvgLoad}_{2012}) * (\text{CTMT}_{2011}/\text{CTMT}_{2012}))/2$$

Step 3: Compute Combination Truck Tonnage for Years 2012 and 2013

Obtain 2012 tonnage value from Freight Analysis Framework (FAF) and apply adjustment factors to account for future trends in CTMT and average load

(Equation 30)

$$\textbf{Backhaul Tonnage}_{2013} = \text{Backhaul Tonnage}_{2012} * (\text{AvgLoad}_{2013}/\text{AvgLoad}_{2012}) * (\text{CTMT}_{2013}/\text{CTMT}_{2012}$$

NON-AUTOMOBILE MEASURES

Data for all the non-highway MPMs included in the 2014 version of Source Book were obtained from multiple sources responsible for monitoring the different travel modes.

AVIATION

AVIATION PASSENGERS

The total number of revenue passengers boarding aircraft, includes both originating and connecting passengers. This information was collected from the 2025 Florida Aviation System Plan.

Calculation: Σ Commercial Service Enplanements **(Equation 31)**

AVIATION TONNAGE

All cargo landed at public airports, this includes the weight of the plane. This data was collected from the Federal Aviation Administration (FAA) Air Carrier Activity Information System (ACAIS) Database.

Calculation: Σ Tons Landed at Qualifying Cargo Airports **(Equation 32)**

AVIATION DEPARTURE RELIABILITY

Departure reliability at Florida airports is defined as "on time" if the flight departs less than 15 minutes after the scheduled time shown in the carriers' Computerized Reservations Systems. This data was collected from the US DOT Air Travel Consumer Report.

Calculation: Σ (Departures < 15 Minutes of Schedule ÷ Σ Departures) × 100 **(Equation 33)**

AVIATION DEMAND TO CAPACITY RATIO

The ratio of the annual operational demand to annual service volume. Annual service volume is determined by the quantity of airports' runways and taxiways.

Calculation: (Σ Operations ÷ Σ Airport Service Volume) × 100 **(Equation 34)**

RAIL

RAIL PASSENGERS

This represents the annual number of revenue paying rail passengers. The data was collected from the Amtrak Fact Sheet for Florida.

Calculation: Σ Amtrak Passengers **(Equation 35)**

RAIL TONNAGE

This figure represents tons of freight carried by rail mode originated or terminated in Florida. The data came from the U.S. DOT Surface Transportation Board, Florida Rail Waybill Data.

Calculation: Σ Rail Tonnage **(Equation 36)**

RAIL DEPARTURE RELIABILITY

Rail departure reliability captures the on-time performance of three rails systems: Amtrak, Miami Dade Metrorail, and South Florida Regional Transportation Authority Tri-Rail. A train is considered on time if it arrives within a given temporal buffer. On time performance information was collected from Amtrak, Miami Dade County, and South Florida Regional Transportation Authority.

Calculation: Σ (On-Time Arrivals ÷ Σ Arrivals) × 100 **(Equation 37)**

ACTIVE RAIL ACCESS

Active rail access accounts for functioning rail lines serving intermodal logistic centers and seaports.

Calculation: Hubs with Active Rail ÷ Σ Hubs **(Equation 38)**

SEAPORT

SEAPORT PASSENGERS

This represents the annual number of passengers embarking on cruise ships at Florida ports. The source of the data is the Florida Ports Council

Calculation: Σ Cruise Passengers **(Equation 39)**

SEAPORT TONNAGE

This is the international and domestic waterborne tons of cargo handled at both public and private terminals in port areas of Florida. The source of the data is the Florida Ports Council Five Year Seaport Mission Plan

Calculation: Σ Waterborne Tonnage **(Equation 40)**

SEAPORT TWENTY-FOOT EQUIVALENT UNITS

This includes international and domestic waterborne cargo handled at both public and private terminals in port areas of Florida. The source of the data is the Florida Ports Council Five Year Seaport Mission Plan.

Calculation: Σ Twenty-foot Equivalent Units **(Equation 41)**

TRANSIT

TRANSIT PASSENGER MILES TRAVELED

This number provides a measure of the total number of passenger miles of transportation service consumed, and is typically derived based on sampling. The source of the data is the FDOT Transit Office. To calculate Transit Passenger Miles Traveled take the number of annual passenger trips and multiply by the highways' average trip length (in miles).

Calculation: Passengers × (Σ Highway Miles ÷ Σ Trips) **(Equation 42)**

TRANSIT PASSENGER TRIPS

This is the annual number of passenger boardings on the transit vehicles. A trip is counted each time a passenger boards a transit vehicle. Thus, if a passenger has to transfer between buses to reach a destination, the passenger is counted as making two passenger trips. The source of the data is the FDOT Transit Office

Calculation: Σ Passenger Boardings **(Equation 43)**

TRANSIT AVERAGE HEADWAY

This represents the measure of time between operating transit vehicles. The source of the data is the FDOT Transit Office.

Calculation: (Route Miles/Speed) ÷ (Peak Hour Vehicles × 60) **(Equation 44)**

PEDESTRIAN

PERCENT SIDEWALK COVERAGE

This is the percentage of centerline miles of SHS (nonfreeway) facilities in urban areas (5,000+ population) that have sidewalks and/or shared pathways available to pedestrians. The Source is the FDOT Roadway Characteristics Inventory.

Calculation: (Sidewalk Miles in Urban Areas ÷ Centerline Miles in Urban Areas) × 100 **(Equation 45)**

PEDESTRIAN LEVEL OF SERVICE

Pedestrian LOS measures a roadway's quality of service to pedestrians with LOS A being the highest quality, and LOS F the lowest quality. Pedestrian LOS was analyzed using the FDOT Pedestrian LOS Model with data from the Roadway Characteristics Inventory and the Traffic Characteristics Inventory.

Calculation: Σ Miles of Each LOS Letter Grade **(Equation 46)**

BICYCLE

PERCENT BIKE LANE COVERAGE

This is the percentage of centerline miles of SHS (nonfreeway) facilities that have bike lanes, paved shoulders, or shared pathways available to bicyclists. The source is the FDOT Roadway Characteristics Inventory.

Calculation: (Bike Lane/Shuolder Miles in Urban Areas ÷ Centerline Miles in Urban Areas) × 100 **(Equation 47)**

BICYCLE LEVEL OF SERVICE

Bicycle LOS measures a roadway's quality of service to bicyclists with LOS A being the highest quality, and LOS F the lowest quality. Bicycle LOS was analyzed using the FDOT Bicycle LOS Model with data from the Roadway Characteristics Inventory and the Traffic Characteristics Inventory.

Calculation: Σ Miles of Each LOS Letter Grade **(Equation 48)**

APPENDIX A-1: 2014 SOURCE BOOK HOURLY FACTORS

Table 20. Hourly Factors Used in 2014 Source Book

		Freeway Core FRC		Freeway Urbanized FRU		Freeway Transitioning FRT		Freeway Rural FRR	
Starting Hour	Ending Hour	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
12:00 AM	1:00 AM	0.95%	2.42%	0.95%	1.47%	0.93%	1.41%	1.36%	1.33%
1:00 AM	2:00 AM	0.57%	1.67%	0.65%	1.02%	0.65%	0.93%	1.07%	1.03%
2:00 AM	3:00 AM	0.44%	1.28%	0.55%	0.80%	0.57%	0.71%	0.94%	0.85%
3:00 AM	4:00 AM	0.48%	1.21%	0.61%	0.71%	0.70%	0.68%	0.97%	0.81%
4:00 AM	5:00 AM	0.74%	1.06%	0.89%	0.83%	1.16%	0.82%	1.22%	0.92%
5:00 AM	6:00 AM	1.90%	1.34%	1.92%	1.23%	2.49%	1.36%	2.04%	1.26%
6:00 AM	7:00 AM	5.16%	2.16%	4.60%	2.01%	5.17%	2.34%	3.76%	1.93%
7:00 AM	8:00 AM	7.00%	2.91%	6.97%	3.01%	6.98%	3.32%	5.04%	2.96%
8:00 AM	9:00 AM	6.65%	3.73%	6.64%	4.17%	6.00%	4.34%	5.26%	4.31%
9:00 AM	10:00 AM	5.54%	4.69%	5.57%	5.51%	5.29%	5.42%	5.58%	5.82%
10:00 AM	11:00 AM	5.10%	5.53%	5.39%	6.63%	5.48%	6.56%	5.98%	7.06%
11:00 AM	12:00 PM	5.06%	6.05%	5.47%	7.18%	5.57%	7.13%	6.16%	7.61%
12:00 PM	1:00 PM	5.17%	6.49%	5.53%	7.47%	5.55%	7.11%	6.15%	7.71%
1:00 PM	2:00 PM	5.32%	6.65%	5.65%	7.52%	5.75%	7.09%	6.29%	7.83%
2:00 PM	3:00 PM	5.74%	6.69%	6.05%	7.54%	6.24%	7.11%	6.58%	7.95%
3:00 PM	4:00 PM	6.66%	6.63%	6.85%	7.43%	6.88%	7.14%	6.93%	7.66%
4:00 PM	5:00 PM	7.53%	6.55%	7.62%	7.10%	7.58%	7.16%	7.14%	7.06%
5:00 PM	6:00 PM	8.12%	6.41%	7.98%	6.55%	7.97%	6.71%	6.88%	6.27%
6:00 PM	7:00 PM	6.64%	6.16%	6.06%	5.67%	5.74%	5.91%	5.56%	5.31%
7:00 PM	8:00 PM	4.67%	5.38%	4.25%	4.70%	4.04%	4.95%	4.32%	4.33%
8:00 PM	9:00 PM	3.48%	4.62%	3.27%	3.88%	3.17%	4.10%	3.53%	3.51%
9:00 PM	10:00 PM	2.98%	4.03%	2.77%	3.22%	2.60%	3.29%	2.97%	2.77%
10:00 PM	11:00 PM	2.40%	3.53%	2.18%	2.51%	2.01%	2.58%	2.40%	2.15%
11:00 PM	12:00 AM	1.70%	2.81%	1.57%	1.83%	1.47%	1.85%	1.86%	1.57%

Table 20. Hourly Factors Used in 2014 Source Book (cont'd)

		Arterial Urbanized AU		Arterial Non Urbanized ANU		Two Lane Highway Rural 2HY		Multilane Highway Rural MHY	
Starting Hour	Ending Hour	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
12:00 AM	1:00 AM	0.66%	1.25%	0.66%	1.12%	0.50%	1.14%	0.74%	1.23%
1:00 AM	2:00 AM	0.43%	0.85%	0.43%	0.70%	0.33%	0.62%	0.55%	0.85%
2:00 AM	3:00 AM	0.36%	0.59%	0.36%	0.56%	0.29%	0.43%	0.53%	0.69%
3:00 AM	4:00 AM	0.39%	0.46%	0.39%	0.40%	0.45%	0.36%	0.61%	0.60%
4:00 AM	5:00 AM	0.69%	0.47%	0.69%	0.42%	0.96%	0.55%	1.06%	0.69%
5:00 AM	6:00 AM	1.76%	0.86%	1.76%	0.89%	2.18%	1.10%	2.54%	1.27%
6:00 AM	7:00 AM	4.27%	1.68%	4.27%	1.57%	4.40%	1.99%	5.28%	2.14%
7:00 AM	8:00 AM	6.42%	2.88%	6.42%	2.59%	6.46%	3.14%	6.48%	2.94%
8:00 AM	9:00 AM	5.92%	4.63%	5.92%	3.78%	5.58%	4.67%	5.67%	4.19%
9:00 AM	10:00 AM	5.51%	5.85%	5.51%	5.44%	5.67%	6.55%	5.45%	5.63%
10:00 AM	11:00 AM	5.70%	7.20%	5.70%	6.59%	6.06%	7.46%	5.64%	6.72%
11:00 AM	12:00 PM	6.10%	7.99%	6.10%	6.96%	6.25%	7.69%	5.89%	7.23%
12:00 PM	1:00 PM	6.41%	8.71%	6.41%	8.03%	6.33%	7.93%	6.07%	7.61%
1:00 PM	2:00 PM	6.38%	7.97%	6.38%	7.73%	6.46%	7.69%	6.29%	7.74%
2:00 PM	3:00 PM	6.72%	7.63%	6.72%	7.65%	7.00%	7.51%	6.60%	7.70%
3:00 PM	4:00 PM	7.41%	7.52%	7.41%	7.58%	7.43%	7.49%	7.22%	7.76%
4:00 PM	5:00 PM	7.77%	7.05%	7.77%	7.40%	7.81%	7.20%	7.76%	7.34%
5:00 PM	6:00 PM	7.92%	6.59%	7.92%	7.20%	7.76%	6.78%	7.96%	6.81%
6:00 PM	7:00 PM	5.90%	5.44%	5.90%	6.60%	5.80%	5.66%	5.74%	5.85%
7:00 PM	8:00 PM	4.23%	4.65%	4.23%	5.42%	4.03%	4.58%	3.87%	4.74%
8:00 PM	9:00 PM	3.27%	3.43%	3.27%	4.41%	3.10%	3.45%	2.89%	3.74%
9:00 PM	10:00 PM	2.63%	2.76%	2.63%	3.27%	2.33%	2.61%	2.27%	2.88%
10:00 PM	11:00 PM	1.90%	2.05%	1.90%	2.23%	1.64%	1.90%	1.68%	2.14%
11:00 PM	12:00 AM	1.27%	1.46%	1.27%	1.48%	1.17%	1.48%	1.23%	1.51%

APPENDIX A-2: DAY OF WEEK CALCULATION ROUTINE

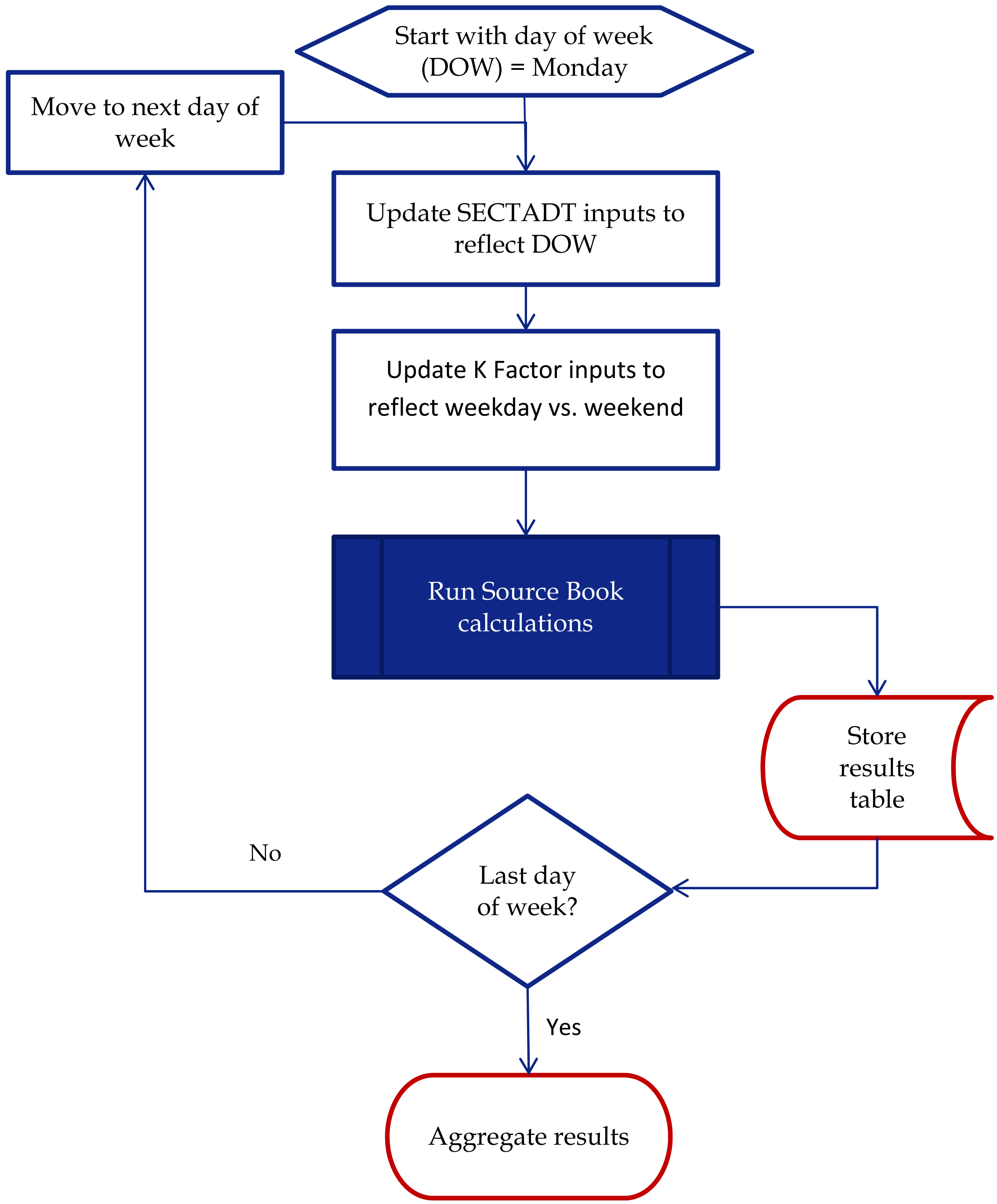


Figure 7 Day of Week Calculation Routine

APPENDIX A-3: 2012 GENERALIZED SERVICE VOLUME TABLES

TABLE 7

Generalized **Peak Hour Directional** Volumes for Florida's **Urbanized Areas**[1]

12/18/12

INTERRUPTED FLOW FACILITIES

STATE SIGNALIZED ARTERIALS

Class I (40 mph or higher posted speed limit)

Lanes	Median	B	C	D	E
1	Undivided	*	830	880	**
2	Divided	*	1,910	2,000	**
3	Divided	*	2,940	3,020	**
4	Divided	*	3,970	4,040	**

Class II (35 mph or slower posted speed limit)

Lanes	Median	B	C	D	E
1	Undivided	*	370	750	800
2	Divided	*	730	1,630	1,700
3	Divided	*	1,170	2,520	2,560
4	Divided	*	1,610	3,390	3,420

Non-State Signalized Roadway Adjustments
(Alter corresponding state volumes by the indicated percent.)
Non-State Signalized Roadways - 10%

Median & Turn Lane Adjustments

Lanes	Median	Exclusive Left Lanes	Exclusive Right Lanes	Adjustment Factors
1	Divided	Yes	No	+5%
1	Undivided	No	No	-20%
Multi	Undivided	Yes	No	-5%
Multi	Undivided	No	No	-25%
–	–	–	Yes	+ 5%

One-Way Facility Adjustment
Multiply the corresponding directional volumes in this table by 1.2

BICYCLE MODE[2]

(Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Paved Shoulder/Bicycle Lane Coverage	B	C	D	E
0-49%	*	150	390	1,000
50-84%	110	340	1,000	>1,000
85-100%	470	1,000	>1,000	**

PEDESTRIAN MODE[2]

(Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Sidewalk Coverage	B	C	D	E
0-49%	*	*	140	480
50-84%	*	80	440	800
85-100%	200	540	880	>1,000

BUS MODE (Scheduled Fixed Route)[3]

(Buses in peak hour in peak direction)

Sidewalk Coverage	B	C	D	E
0-84%	> 5	≥ 4	≥ 3	≥ 2
85-100%	> 4	≥ 3	≥ 2	≥ 1

UNINTERRUPTED FLOW FACILITIES

FREEWAYS

Lanes	B	C	D	E
2	2,260	3,020	3,660	3,940
3	3,360	4,580	5,500	6,080
4	4,500	6,080	7,320	8,220
5	5,660	7,680	9,220	10,360
6	7,900	10,320	12,060	12,500

Freeway Adjustments

Auxiliary Lane	Ramp Metering
+ 1,000	+ 5%

UNINTERRUPTED FLOW HIGHWAYS

Lanes	Median	B	C	D	E
1	Undivided	420	840	1,190	1,640
2	Divided	1,810	2,560	3,240	3,590
3	Divided	2,720	3,840	4,860	5,380

Uninterrupted Flow Highway Adjustments

Lanes	Median	Exclusive left lanes	Adjustment factors
1	Divided	Yes	+5%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

[1] Values shown are presented as peak hour directional volumes for levels of service and are for the automobile/truck modes unless specifically stated. This table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Calculations are based on planning applications of the Highway Capacity Manual and the Transit Capacity and Quality of Service Manual.

[2] Level of service for the bicycle and pedestrian modes in this table is based on number of motorized vehicles, not number of bicyclists or pedestrians using the facility.

[3] Buses per hour shown are only for the peak hour in the single direction of the higher traffic flow.

* Cannot be achieved using table input value defaults.

** Not applicable for that level of service letter grade. For the automobile mode, volumes greater than level of service D become F because intersection capacities have been reached. For the bicycle mode, the level of service letter grade (including F) is not achievable because there is no maximum vehicle volume threshold using table input value defaults.

Source:
Florida Department of Transportation
Systems Planning Office
www.dot.state.fl.us/planning/systems/sm/los/default.shtm

2012 FDOT QUALITY/LEVEL OF SERVICE HANDBOOK TABLES

Figure 8 Generalized Service Volume Tables

TABLE 7
(continued)

Generalized **Peak Hour Directional** Volumes for Florida's **Urbanized Areas**

12/18/12

INPUT VALUE ASSUMPTIONS	Uninterrupted Flow Facilities			Interrupted Flow Facilities					
				State Arterials				Class I	
	Freeways	Highways		Class I		Class II		Bicycle	Pedestrian
ROADWAY CHARACTERISTICS									
Area type (lu, u)	lu	u	u	u	u	u	u	u	u
Number of through lanes (both dir.)	4-12	2	4-6	2	4-8	2	4-8	4	4
Posted speed (mph)	70	50	50	45	50	30	30	45	45
Free flow speed (mph)	75	55	55	50	55	35	35	50	50
Auxiliary lanes (n,y)	n								
Median (n, nr, r)		n	r	n	r	n	r	r	r
Terrain (l,r)	1	1	1	1	1	1	1	1	1
% no passing zone		80							
Exclusive left turn lane impact (n, y)		[n]	y	y	y	y	y	y	y
Exclusive right turn lanes (n, y)				n	n	n	n	n	n
Facility length (mi)	4	5	5	2	2	1.9	1.8	2	2
Number of basic segments	4								
TRAFFIC CHARACTERISTICS									
Planning analysis hour factor (K)	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
Directional distribution factor (D)	0.547	0.550	0.550	0.550	0.560	0.565	0.560	0.565	0.565
Peak hour factor (PHF)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Base saturation flow rate (pcphpl)		1,700	2,100	1,950	1,950	1,950	1,950	1,950	1,950
Heavy vehicle percent	4.0	2.0	2.0	1.0	1.0	1.0	1.0	2.5	2.0
Local adjustment factor	0.91	0.97	0.98						
% left turns				12	12	12	12	12	12
% right turns				12	12	12	12	12	12
CONTROL CHARACTERISTICS									
Number of signals				4	4	10	10	4	6
Arrival type (1-6)				3	3	4	4	4	4
Signal type (a, c, p)				c	c	c	c	c	c
Cycle length (C)				120	150	120	120	120	120
Effective green ratio (g/C)				0.44	0.45	0.44	0.44	0.44	0.44
MULTIMODAL CHARACTERISTICS									
Paved shoulder/bicycle lane (n, y)								n, 50%, y	n
Outside lane width (n, t, w)								t	t
Pavement condition (d, t, w)								t	
On-street parking (n, y)								n	n
Sidewalk (n, y)									n, 50%, y
Sidewalk/roadway separation (a, t, w)									t
Sidewalk protective barrier (n, y)									n

LEVEL OF SERVICE THRESHOLDS

Level of Service	Freeways	Highways		Arterials		Bicycle	Ped	Bus
	Density	Two-Lane	Multilane	Class I	Class II	Score	Score	Buses/hr.
		%ffs	Density	ats	ats			
B	≤ 17	> 83.3	≤ 17	> 31 mph	> 22 mph	≤ 2.75	≤ 2.75	≤ 6
C	≤ 24	> 75.0	≤ 24	> 23 mph	> 17 mph	≤ 3.50	≤ 3.50	≤ 4
D	≤ 31	> 66.7	≤ 31	> 18 mph	> 13 mph	≤ 4.25	≤ 4.25	< 3
E	≤ 39	> 58.3	≤ 35	> 15 mph	> 10 mph	≤ 5.00	≤ 5.00	< 2

% ffs = Percent free flow speed ats = Average travel speed

TABLE 8

Generalized **Peak Hour Directional** Volumes for Florida's **Transitioning** and **Areas Over 5,000 Not In Urbanized Areas**[1]

12/18/12

INTERRUPTED FLOW FACILITIES

STATE SIGNALIZED ARTERIALS

Class I (40 mph or higher posted speed limit)

Lanes	Median	B	C	D	E
1	Undivided	*	710	800	**
2	Divided	*	1,740	1,820	**
3	Divided	*	2,670	2,740	**

Class II (35 mph or slower posted speed limit)

Lanes	Median	B	C	D	E
1	Undivided	*	330	680	720
2	Divided	*	500	1,460	1,600
3	Divided	*	810	2,280	2,420

Non-State Signalized Roadway Adjustments

(Alter corresponding state volumes by the indicated percent.)

Non-State Signalized Roadways - 10%

Median & Turn Lane Adjustments

Lanes	Median	Exclusive Left Lanes	Exclusive Right Lanes	Adjustment Factors
1	Divided	Yes	No	+5%
2	Undivided	No	No	-20%
Multi	Undivided	Yes	No	-5%
Multi	Undivided	No	No	-25%
–	–	–	Yes	+ 5%

One-Way Facility Adjustment

Multiply the corresponding directional volumes in this table by 1.2

BICYCLE MODE[2]

(Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Paved Shoulder/Bicycle Lane Coverage	B	C	D	E
0-49%	*	140	320	1,000
50-84%	100	280	940	>1,000
85-100%	380	1,000	>1,000	**

PEDESTRIAN MODE[2]

(Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Sidewalk Coverage	B	C	D	E
0-49%	*	*	140	480
50-84%	*	80	440	800
85-100%	200	540	880	>1,000

BUS MODE (Scheduled Fixed Route)[3]

(Buses in peak hour in peak direction)

Sidewalk Coverage	B	C	D	E
0-84%	> 5	≥ 4	≥ 3	≥ 2
85-100%	> 4	≥ 3	≥ 2	≥ 1

UNINTERRUPTED FLOW FACILITIES

FREEWAYS

Lanes	B	C	D	E
2	2,200	2,880	3,440	3,580
3	3,260	4,280	5,100	5,540
4	4,260	5,680	6,760	7,500
5	5,300	7,080	8,440	9,440

Freeway Adjustments

Auxiliary Lane	Ramp Metering
+ 1,000	+ 5%

UNINTERRUPTED FLOW HIGHWAYS

Lanes	Median	B	C	D	E
1	Undivided	450	850	1,200	1,640
2	Divided	1,740	2,450	3,110	3,440
3	Divided	2,610	3,680	4,660	5,170

Uninterrupted Flow Highway Adjustments

Lanes	Median	Exclusive left lanes	Adjustment factors
1	Divided	Yes	+5%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

[1] Values shown are presented as peak hour directional volumes for levels of service and are for the automobile/truck modes unless specifically stated. This table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Calculations are based on planning applications of the Highway Capacity Manual and the Transit Capacity and Quality of Service Manual.

[2] Level of service for the bicycle and pedestrian modes in this table is based on number of motorized vehicles, not number of bicyclists or pedestrians using the facility.

[3] Buses per hour shown are only for the peak hour in the single direction of the higher traffic flow.

* Cannot be achieved using table input value defaults.

** Not applicable for that level of service letter grade. For the automobile mode, volumes greater than level of service D become F because intersection capacities have been reached. For the bicycle mode, the level of service letter grade (including F) is not achievable because there is no maximum vehicle volume threshold using table input value defaults.

Source:
Florida Department of Transportation
Systems Planning Office
www.dot.state.fl.us/planning/systems/sm/los/default.shtm

TABLE 8
(continued)

Generalized **Peak Hour Directional** Volumes for Florida's **Transitioning** and **Areas Over 5,000 Not In Urbanized Areas**

12/18/12

INPUT VALUE ASSUMPTIONS	Uninterrupted Flow Facilities			Interrupted Flow Facilities					
				State Arterials				Class I	
	Freeways	Highways		Class I		Class II		Bicycle	Pedestrian
ROADWAY CHARACTERISTICS									
Area type (t,uo)	t	t	t	t	t	t	t	t	t
Number of through lanes (both dir.)	4-10	2	4-6	2	4-6	2	4-6	4	4
Posted speed (mph)	70	50	50	45	50	30	30	45	45
Free flow speed (mph)	75	55	55	50	55	35	35	50	50
Auxiliary lanes (n,y)	n	n	n						
Median (n, nr, r)		n	r	n	y	n	y	r	r
Terrain (l,r)	l	l	l	l	l	l	l	l	l
% no passing zone		60							
Exclusive left turn lane impact (n, y)		[n]	y	y	y	y	y	y	y
Exclusive right turn lanes (n, y)				n	n	n	n	n	n
Facility length (mi)	8	5	5	1.8	2	2	2	2	2
Number of basic segments	4								
TRAFFIC CHARACTERISTICS									
Planning analysis hour factor (K)	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
Directional distribution factor (D)	0.555	0.550	0.550	0.550	0.570	0.570	0.565	0.570	0.570
Peak hour factor (PHF)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Base saturation flow rate (pcphpl)		1,700	2,100	1,950	1,950	1,950	1,950	1,950	1,950
Heavy vehicle percent	9.0	4.0	4.0	2.0	3.0	2.0	3.0	3.0	3.0
Local adjustment factor	0.85	0.97	0.95						
% left turns				12	12	12	12	12	12
% right turns				12	12	12	12	12	12
CONTROL CHARACTERISTICS									
Number of signals				5	4	10	10	4	6
Arrival type (1-6)				4	3	4	4	4	4
Signal type (a, c, p)				c	c	c	c	c	c
Cycle length (C)				120	150	120	150	120	120
Effective green ratio (g/C)				0.44	0.45	0.44	0.45	0.44	0.44
CONTROL CHARACTERISTICS									
Paved shoulder/bicycle lane (n, y)								n, 50%, y	n
Outside lane width (n, t, w)								t	t
Pavement condition (d, t, u)								t	
On-street parking (n, y)								n	n
Sidewalk (n, y)									n, 50%, y
Sidewalk/roadway separation (a, t, w)									t
Sidewalk protective barrier (n, y)									n

LEVEL OF SERVICE THRESHOLDS

Level of Service	Freeways	Highways		Arterials		Bicycle	Ped	Bus
	Density	Two-Lane	Multilane	Class I	Class II	Score	Score	Buses/hr.
		%ffs	Density	ats	ats			
B	≤ 17	> 83.3	≤ 17	> 31 mph	> 22 mph	≤ 2.75	≤ 2.75	≤ 6
C	≤ 24	> 75.0	≤ 24	> 23 mph	> 17 mph	≤ 3.50	≤ 3.50	≤ 4
D	≤ 31	> 66.7	≤ 31	> 18 mph	> 13 mph	≤ 4.25	≤ 4.25	< 3
E	≤ 39	> 58.3	≤ 35	> 15 mph	> 10 mph	≤ 5.00	≤ 5.00	< 2

% ffs = Percent free flow speed ats = Average travel speed

TABLE 9

Generalized **Peak Hour Directional** Volumes for Florida's **Rural Undeveloped Areas** and **Developed Areas Less Than 5,000 Population**[1]

12/18/12

INTERRUPTED FLOW FACILITIES

STATE SIGNALIZED ARTERIALS

Lanes	Median	B	C	D	E
1	Undivided	*	670	740	**
2	Divided	*	1,530	1,580	**
3	Divided	*	2,360	2,400	**

Non-State Signalized Roadway Adjustments
(Alter corresponding state volumes by the indicated percent.)
Non-State Signalized Roadways - 10%

Median & Turn Lane Adjustments

Lanes	Median	Exclusive Left Lanes	Exclusive Right Lanes	Adjustment Factors
1	Divided	Yes	No	+5%
1	Undivided	No	No	-20%
Multi	Undivided	Yes	No	-5%
Multi	Undivided	No	No	-25%
–	–	–	Yes	+ 5%

One-Way Facility Adjustment
Multiply the corresponding directional volumes in this table by 1.2

BICYCLE MODE[2]

(Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Rural Undeveloped

Paved Shoulder/Bicycle Lane Coverage	B	C	D	E
0-49%	*	70	110	170
50-84%	60	120	180	580
85-100%	140	210	1,000	>1,000

Developed Areas

Paved Shoulder/Bicycle Lane Coverage	B	C	D	E
0-49%	*	120	260	840
50-84%	100	240	720	1,000
85-100%	320	1,000	>1,000	**

PEDESTRIAN MODE[2]

(Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Sidewalk Coverage	B	C	D	E
0-49%	*	*	120	460
50-84%	*	80	430	770
85-100%	180	520	860	>1,000

UNINTERRUPTED FLOW FACILITIES

FREEWAYS

Lanes	B	C	D	E
2	1,680	2,500	3,040	3,500
3	2,500	3,720	4,560	5,400
4	3,360	4,980	6,080	7,200

Freeway Adjustments
Auxiliary Lanes Present in Both Directions
+ 1,000

UNINTERRUPTED FLOW HIGHWAYS

Rural Undeveloped

Lanes	Median	B	C	D	E
1	Undivided	240	430	740	1,490
2	Divided	1,340	2,100	2,660	3,020
3	Divided	2,020	3,150	4,000	4,530

Developed Areas

Lanes	Median	B	C	D	E
1	Undivided	450	850	1,200	1,640
2	Divided	1,350	2,120	2,730	3,110
3	Divided	2,020	3,180	4,090	4,670

Passing Lane Adjustments
Alter LOS B-D volumes in proportion to the passing lane length to the highway segment length

Uninterrupted Flow Highway Adjustments

Lanes	Median	Exclusive left lanes	Adjustment factors
1	Divided	Yes	+5%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

[1] Values shown are presented as peak hour directional volumes for levels of service and are for the automobile/truck modes unless specifically stated. This table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Calculations are based on planning applications of the Highway Capacity Manual and the Transit Capacity and Quality of Service Manual.

[2] Level of service for the bicycle and pedestrian modes in this table is based on number of motorized vehicles, not number of bicyclists or pedestrians using the facility.

* Cannot be achieved using table input value defaults.

** Not applicable for that level of service letter grade. For the automobile mode, volumes greater than level of service D become F because intersection capacities have been reached. For the bicycle mode, the level of service letter grade (including F) is not achievable because there is no maximum vehicle volume threshold using table input value defaults.

Source:

Florida Department of Transportation
Systems Planning Office
www.dot.state.fl.us/planning/systems/sm/los/default.shtm

TABLE 9
(continued)

Generalized **Peak Hour Directional** Volumes for Florida's
Rural Undeveloped Areas and
Developed Areas Less Than 5,000 Population

12/18/12

INPUT VALUE ASSUMPTIONS	Uninterrupted Flow Facilities					Interrupted Flow Facilities				
	Freeways	Highways				Arterials		Bicycle		Pedestrian
ROADWAY CHARACTERISTICS										
Area type (ru, rd)	rural	ru	ru	rd	rd	rd	rd	ru	rd	rd
Number of through lanes (both dir.)	4-8	2	4-6	2	4-6	2	4-6	4	4	2
Posted speed (mph)	70	55	65	50	55	45	45	55	45	45
Free flow speed (mph)	75	60	70	55	60	50	50	60	50	50
Auxiliary lanes (n,y)	n									
Median (n, nr, r)		n	r	n	r	n	r	r	r	n
Terrain (l,r)	l	l	l	l	l	l	l	l	l	l
% no passing zone		20		60						
Exclusive left turn lanes (n, y)		[n]	y	[n]	y	y	y	y	y	y
Exclusive right turn lanes (n, y)						n	n	n	n	n
Facility length (mi)	14	10	10	5	5	1.9	2.2	4	2	2
Number of basic segments	4									
TRAFFIC CHARACTERISTICS										
Planning analysis hour factor (K)	0.105	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
Directional distribution factor (D)	0.555	0.550	0.550	0.550	0.550	0.550	0.550	0.570	0.570	0.550
Peak hour factor (PHF)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Base saturation flow rate (pcphpl)		1,700	2,300	1,700	2,200	1,950	1,950	1,950	1,950	1,950
Heavy vehicle percent	12.0	5.0	12.0	4.0	4.0	3.0	3.0	6.0	3.5	3.0
Local adjustment factor	0.84	0.88	0.73	0.97	0.82					
% left turns						12	12		12	12
% right turns						12	12		12	12
CONTROL CHARACTERISTICS										
Number of signals						5	6	2	4	4
Arrival type (1-6)						3	3	3	3	3
Signal type (a, c, p)						c	c	a	a	a
Cycle length (C)						90	90	60	90	90
Effective green ratio (g/C)						0.44	0.44	0.37	0.44	0.44
MULTIMODAL CHARACTERISTICS										
Paved shoulder/bicycle lane (n, y)								n,50%,y	n,50%,y	n
Outside lane width (n, t, w)								t	t	t
Pavement condition (d, t, u)								t	t	
Sidewalk (n, y)										n,50%,y
Sidewalk/roadway separation(a, t,w)										t
Sidewalk protective barrier (n, y)										n

LEVEL OF SERVICE THRESHOLDS

Level of Service	Freeways	Highways				
		Two-Lane ru		Two-Lane rd	Multilane ru	Multilane rd
	Density	%tsf	ats	%ffs	Density	Density
B	≤ 14	≤ 50	≤ 55	> 83.3	≤ 14	≤ 14
C	≤ 22	≤ 65	≤ 50	> 75.0	≤ 22	≤ 22
D	≤ 29	≤ 80	≤ 45	> 66.7	≤ 29	≤ 29
E	≤ 36	> 80	≤ 40	> 58.3	≤ 34	≤ 34

Level of Service	Arterials	Bicycle	Pedestrian
	Major City/Co.(ats)	Score	Score
B	> 31 mph	≤ 2.75	≤ 2.75
C	> 23 mph	≤ 3.50	≤ 3.50
D	> 18 mph	≤ 4.25	≤ 4.25
E	> 15 mph	≤ 5.00	≤ 5.00

%tsf = Percent time spent following %ffs = Percent of free flow speed ats = Average travel speed ru = Rural undeveloped rd = Rural developed

APPENDIX A-4: FREEWAY SPEED MODEL

Table 21. Candidate speed-volume functions

Functional Form	Example	Comments
Linear	$y = -a\,x + b$	Not acceptable. Reaches zero speed at high v/c.
Logarithmic	$y = -a \ln x + b$	Not acceptable. Has no value at x = 0 (the logarithm of "x" approaches negative infinity).
Exponential	$y = a\, s_0 \exp(-bx)$	Has all required traits for equilibrium assignment.
Power	$y = a\ /x^b$	Not acceptable. It goes to infinity at v/c = x = 0.
Polynomial	$y = -ax^2 - bx + c$	Not acceptable. It reaches zero speed at high v/c.
Conical	$y = a - b(1-x) + [a(1-x)^2+c^2]^{0.5}$	Less steep than either BPR or Akçelik. In use at SACOG.
BPR	$y = s_0/(1+a\,(cx)^b)$	Has all required traits for equilibrium assignment.
Akçelik	$y = l/[l/\ s_0+0.25\{(cx-1)+\{(cx-1)^2+16acx\}\}^{½}]$	Has all required traits for equilibrium assignment.

y = predicted speed — x = volume/capacity ratio

a,b,c = global parameters for equation.

l = link length — s_0 = Link free-volume speed.

Akçelik Curve

The Akçelik curves have a sharp drop in predicted speeds at v/c ratios of 1.0, causing very low speed estimates at v/c ratios above 1.0 that are appropriate for modeling traffic diversion but that often fail to replicate field-measured speeds.

Research by Dowling, Singh, and Cheng into the Akçelik speed-volume model demonstrated that the Akçelik model provides more accurate speed estimates overall than the HCM 1994 equations and does not adversely affect model computation times. [3] The Akçelik link congestion function has the added advantage of better simulating link travel times for oversaturated conditions. **Error! Reference source not found.** includes Akçelik delay parameters obtained through Dowling et al.'s research.

$$t = t_0 + \{0.25T \left[(x-1) + \left\{ (x-1)^2 + \frac{8J_a x}{QT} \right\}^{0.5} \right] \}$$

Where:

t	= Average travel time per unit distance (hours/mile)
t_0	= Free-flow travel time per unit distance (hours/mile)
T	= Time period: the time interval in hours during which an average arrival (demand) flow rate, v, persists
Q	= Capacity (passenger car equivalents/lane/hour)
x	= Degree of saturation (i.e., v/c ratio) (dimensionless)
J_a	= Delay parameter (dimensionless)

[3] *Improved Speed-volume Relationships: Application to Transportation Planning Models*. Skabardonis, A., R. Dowling, (2002).

Bureau of Public Roads Function

Traditionally, the BPR function has been used in planning models. This curve was based on the 1965 HCM speed-volume relationship—which was parabolic in shape—and its speed estimates were fairly sensitive to increasing flows. The BPR curve is as follows:

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

Where:

t	= Average travel time per unit distance (hours/mile)
t_0	= Free-volume travel time per unit distance (hours/mile)
V	= Assigned traffic volume (passenger car equivalents per hour)
C	= Link capacity (passenger car equivalents per hour)
α	= Alpha coefficient (typically set at 0.15)
β	= Beta coefficient (typically set at 4.0)

The simplicity of the BPR function has made it the most common way of deriving travel time and/or delay from planning-level volume forecasts. Table 24, **Error! Reference source not found.**, and **Error! Reference source not found.** present BPR alpha and beta parameters obtained through different studies.

Modified Davidson Equation

The travel time function proposed by Davidson (1966, 1978) for transport planning purposes has been subject to much discussion and efforts of calibration and improvement including some controversy over the meaning of its parameters. A new travel time function was proposed by Akçelik[4] as an alternative to Davidson's function to overcome the conceptual and calibration problems. The time-dependent form of the modified Davidson equation is presented below.

$$t = t_0 \times \{1 + 0.25 r_f \left[z + \left(z^2 + \frac{8 J_D x}{r_f}\right)^{0.5}\right]\}$$

Where:

t	= average travel time per unit distance (e.g. in seconds per km),
t_o	= minimum (zero-flow) travel time per unit distance (e.g. in seconds per km),
J_D	= a delay parameter,
z	= x - 1,
x	= q / Q =degree of saturation,
q	= demand (arrival) flow rate (in veh/h),
Q	= capacity (in veh/h),
r_f	= T_f / t_o, i.e. ratio of flow (analysis) period to minimum travel time (T_f and t_o must be in the same units)

In a presentation on the *Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation*, Moses et al. (December 5, 2012) presented a piecewise modified Davidson volume-delay function for use in a study of SR 9/I-95 data in Pompano Beach, Florida. Table 24 contains modified Davidson parameters applicable to freeways in Florida.

[4] *Travel time functions for transport planning purposes: Davidson's function, its time-dependent form and an alternative travel time function*. Akçelik (December 2000)

$$S = \begin{cases} \dfrac{S_0}{1+\dfrac{J_D\left(\frac{V}{C}\right)}{1-\frac{V}{C}}} & for\ \dfrac{V}{C} \le \mu \\ \dfrac{S_0}{1+\dfrac{J_D \times \mu}{1-\mu}+\dfrac{J_D\left(\frac{V}{C}-\mu\right)}{(1-\mu)^2}} & for\ \dfrac{V}{C} > \mu \end{cases}$$

Where:

S	= predicted travel speed (mph)
S_o	= free-flow speed (mph)
J_D	= a delay parameter,
V	= volume (veh/h)
C	= capacity (veh/h)
μ	= saturation threshold parameter

Conical Speed Function

The SACOG SACMET01 regional travel model uses a conical function for its speed-volume curves.

$$T_C = T_0 + \min\left\{\epsilon - \alpha(1-\rho x) + \sqrt{\alpha(1-\rho x)^2 + \beta^2}, max(T_C)\right\}$$

Where:

X	= v/c ratio
T_C	= Congested travel time
T_0	= Free- flow travel time
A	= User-specified parameter
ß	= (2α-1)/(2α-2)
E	= 2 – ß
ρ	= v/c ratio factor adjusted so that T_C = 1.5 when x = 1.0
max(T_C)	= μ+vx

Highway Capacity Manual 2010

The HCM 2010 method for undersaturated conditions (Chapter 11-Basic Freeway Segments) is based on two volume regimes. Below a certain "breakpoint" volume, vehicles travel at the free-flow speed. Once that breakpoint volume is exceeded, speeds are gradually reduced depending on the freeway's free flow speed.

Table 22. HCM 2010 Undersaturated Freeway Speed-Volume Curves

Free Flow Speed (mi/h)	Breakpoint (pc/h/ln)	Speed if Volume ≤ Breakpoint	Speed if Volume ≥ Breakpoint and ≤ Capacity
75	1,000	75	$75 - 0.00001107\ (V_p - 1{,}000)^2$
70	1,200	70	$70 - 0.0000116\ (V_p - 1{,}200)^2$
65	1,400	65	$65 - 0.00001418\ (V_p - 1{,}400)^2$
60	1,600	60	$60 - 0.00001816\ (V_p - 1{,}600)^2$
55	1,800	55	$55 - 0.00002469\ (V_p - 1{,}800)^2$

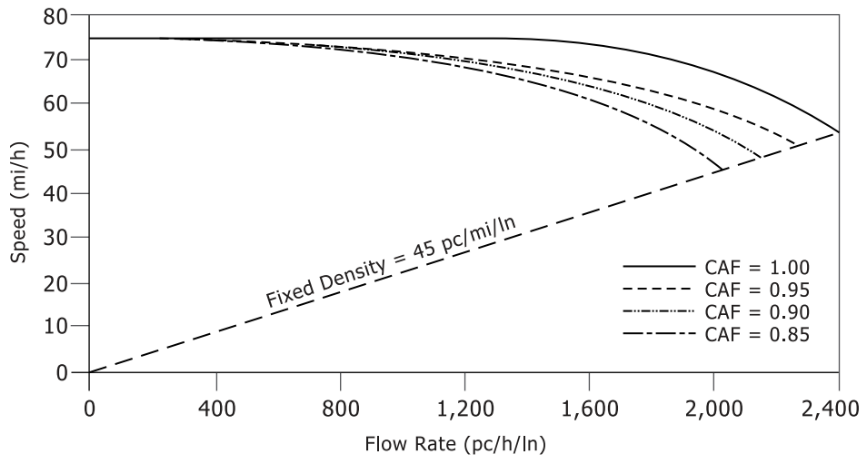
The HCM 2010 method for oversaturated conditions (Chapter 25-Freeway Facilities: Supplemental) is based on concepts of traffic flow theory and the assumption that speed and flow are linearly related for densities greater than 45 passenger cars per mile per lane. The HCM warns that this relationship has not been extensively calibrated for field observations.

The HCM equation (Equation 25-1) also allows for the input of a Capacity Adjustment Factor (CAF), which may be used to model incidents, work zones, or any other capacity-affecting phenomena:

$$S = FFS + [1 - e^{\ln\left(FFS+1-\left(C*\frac{CAF}{45}\right)\right)*\frac{v_p}{C*CAF}}]$$

Where:

S	= Segment speed (miles/hour)
FFS	= Free-volume segment speed (miles/hour)
C	= Original segment capacity
CAF	= Capacity adjustment factor (dimensionless)
v_p	= Segment flow rate (passenger cars per hour per lane)



Note: Free-flow speed = 75 mi/h (base conditions); *CAF* = capacity adjustment factor (proportion of available capacity).

Exhibit 25-2
Alternative Speed–Flow Curves for Indicated Capacity Adjustment Factors

Figure9. HCM 2010 speed-volume relationships

SPEED-VOLUME FUNCTIONS IN PRACTICE

FDOT

FDOT tested a number of different speed-volume functions against data from state monitoring stations.[5] Volume data were converted to passenger-car equivalents (PCE) and the 99th percentile hourly PCE volume was considered to be the practical capacity of the freeway segment. Recommended practical capacities are shown in the table below.

Table 23. FDOT Recommended Practical Capacities

Area type	Number of lanes	Recommended default capacity volume (PCE/lane/hr)
Urban	2	2,100
	3	2,100
	4	1.800
	5	1,600
Residential	2	2,100
	3	2,100
	4	2,100
	5	1,800
Rural	2	1,800
	3	1,800

[5] Moses, Ren et al. Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation. Presentation to MTF Advanced Traffic Assignment Subcommittee. December 5, 2012.

Speed-volume curves were developed as follows:

- Plot the raw field data
- Remove outliers
- Handle conditions where v/c > 1.0
- Assess relevant volume-delay functions
- Fit VDF to field data
- Determine VDF parameter values for further analysis

VDFs tested were the following:

- Standard BPR
- Fitted BPR
- Modified Davidson
- Conical
- Akçelik

Fitted values are shown in the table below.

Table 24. FDOT Parameter Values for Fitted Speed-Volume Functions

Function	Parameter	Urban, speed limit up to 60 mph	Urban, 60 <speed limit <= 65 mph	Urban, 65 < speed limit <= 70 mph
Fitted BPR	α	0.2630	0.1890	0.2580
	β	6.6890	5.3990	5.6100
Modified Davidson	J_D	0.0090	0.0092	0.0099
	μ	0.9500	0.9490	0.9510
Conical	α	1.0290	1.0320	1.0680
	β	18.3900	16.6340	8.3440
Akçelik	J	0.1000	0.1000	0.0990

Comparisons of the fitted functions to field data from SR-9/I-95 in Pompano Beach are shown in the figure below.

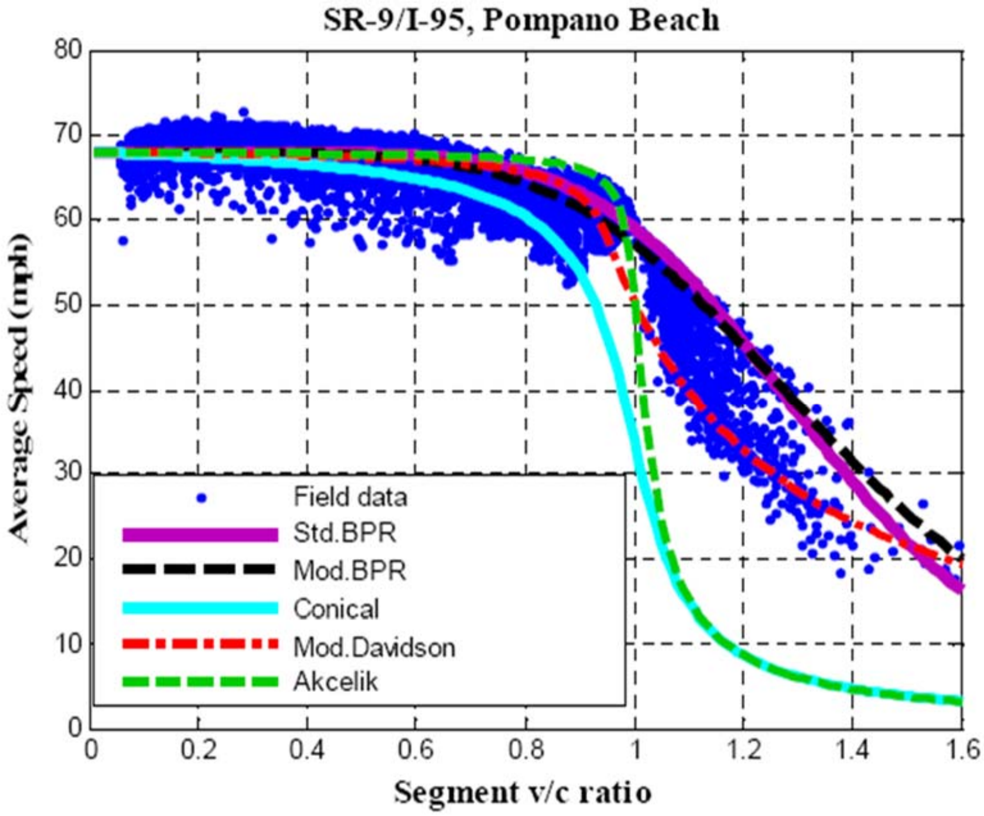
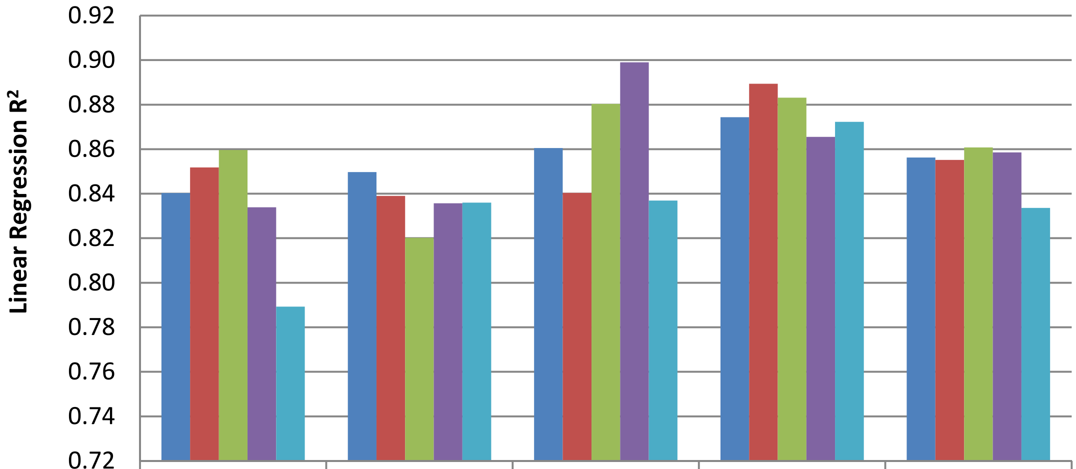


Figure 200. Comparison of Modeled and Observed Speeds

In general:

- All functions except the conical appear to fit the data well in the non-congested regime up to v/c ratios of about 0.8
- The conical and Akçelik functions show a sharp drop off in speeds for v/c > 1.0. The drop off in speeds produced by these functions is much greater than the observed speed drop off.
- The standard and fitted BPR functions estimate speeds higher than those observed for the congested regime
- The modified Davidson function appears to estimate speeds somewhat lower than those observed for the congested regime.

A comparison of the performance of different speed-flow functions in the Orlando Urban Area Transportation Study (OUATS) travel demand model suggests that the modified Davidson equation had the highest average coefficient of determination (R^2) out of the study functions. Figure 21 presents the R^2 for the study functions by time of day.



	7-8 AM	8-9 AM	4-5 PM	5-6 PM	Average
Standard BPR	0.84030	0.84970	0.86050	0.87440	0.85623
Fitted BPR	0.85180	0.83900	0.84040	0.88940	0.85515
Modified Davidson	0.85960	0.82020	0.88030	0.88310	0.86080
Conical	0.83390	0.83570	0.89900	0.86550	0.85853
Akcelik	0.78930	0.83600	0.83690	0.87230	0.83363

Figure 21. Comparison of Linear Regression Coefficient of Determination (R^2) in the OUATS Model

Conical function parameters for different functional classes are presented in the table below.

SUMMARY

This section has presented a discussion of several types of speed-volume relationships from the literature and from experience in the field. It should be remembered that the speed-volume relationships presented here are used primarily for the purposes of obtaining good traffic assignments and speeds in the outputs from regional travel models. Although the functions discussed here produce results for v/c ratios greater than one, in practice v/c ratios greater than one occur only in the model and are never observed in the real world. Hence, actual speeds in the field are likely to differ from the estimates produced from these functions.

In general,

- No one speed-volume function performs best across all v/c regimes.
- From the empirical work by FDOT:
  - The standard BPR and modified Davidson functions appear to fit the data most closely for v/c less than 1.0, although near v/c = 1.0 the modified Davidson function appears to slightly underestimate speeds.
  - For v/c > 1.0 the standard and modified BPR curves slightly overestimate speeds while the modified Davidson function slightly underestimates speeds. The Akçelik and conical functions appear to significantly underestimate speeds for v/c > 1.0.

For the 2014 version of Source book, freeway speed calculations use modified Davidson equation.

APPENDIX A-5: ARTERIAL SPEED MODEL

The following sections describe the derivation of procedures for obtaining more accurate estimates of free-flow speed and capacity inputs.

Equation 24. BPR Equation

$$S = \frac{S_f}{1 + a\left(\frac{V}{C}\right)^b}$$

Where:

S = predicted mean speed

S_f = free flow speed

V = volume

C = capacity,

a = alpha parameter

b = beta parameter

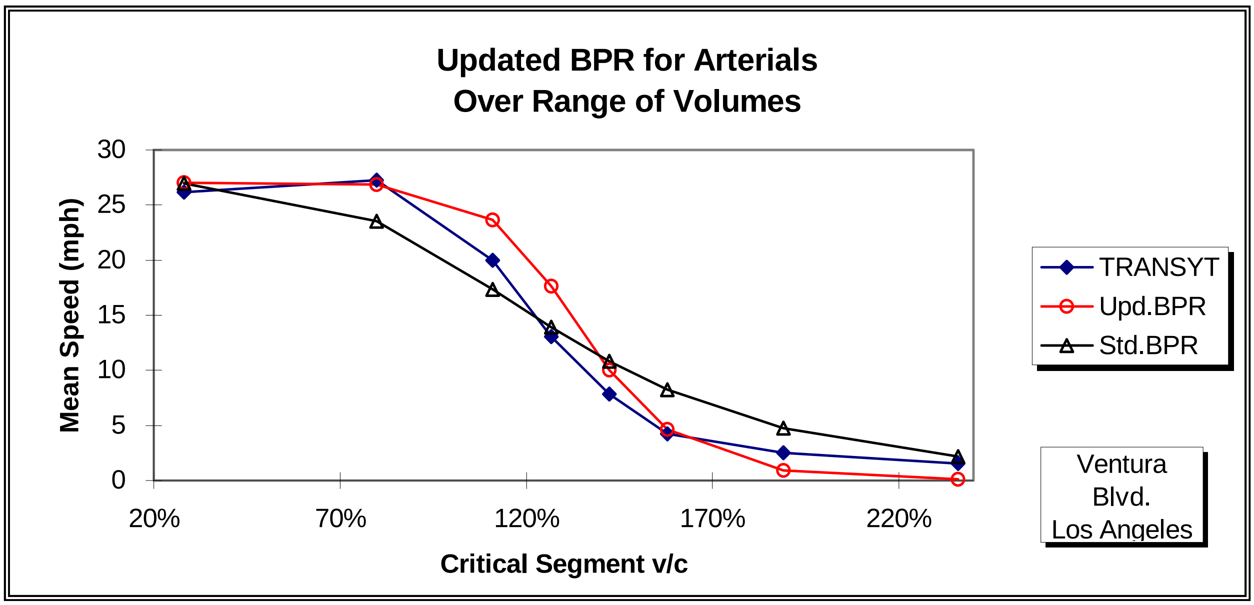


Figure 12. Comparison of Standard BPR, Updated BPR, and TRANSYT-7F Microsimulation

A comparison of potential alpha and beta parameters for the 2014 version of Source Book is presented in Table 25, including two sets from Florida travel demand models.

The updated BPR curve presented in NCHRP Report 387—also shown in Figure —is flatter than the original BPR curve for v/c ratios less than 0.70 and then drops much faster in the vicinity of capacity (v/c = 1.00). On the other hand, BPR curves using parameters developed in Florida drop at lower v/c ratios and then drop more modestly as v/c increases. A comparison of the BPR curves is provided in Figure 3 and Figure 14 for LOS C-based capacities and in Figure 225 and Figure 16 for LOS E-based capacities.

Table 252. BPR Parameters

Source	High Speed Arterial[2]		Low Speed Arterial[2]	
	Alpha	Beta	Alpha	Beta
Southeast Regional Planning Model (SERPM)[1]	0.55	5.05	0.35	4.05
Greater Treasure Coast Regional Planning Model (GTCRPM III)	0.71	2.1	0.83	5.5
NHCRP Report 387	0.05	10	0.05	10

[1]The SERPM uses an LOS C-based capacity. To convert to LOS E capacity, a conversion factor of 0.90 is used by the model (i.e., LOS C Capacity= LOS E Capacity × 0.90)

[2]The SERPM distinguishes between High Speed Arterials and Low Speed Collectors. The GTCRPM III distinguishes between FSUTMS type 2x (Divided Arterial) and type 4x (Collectors).

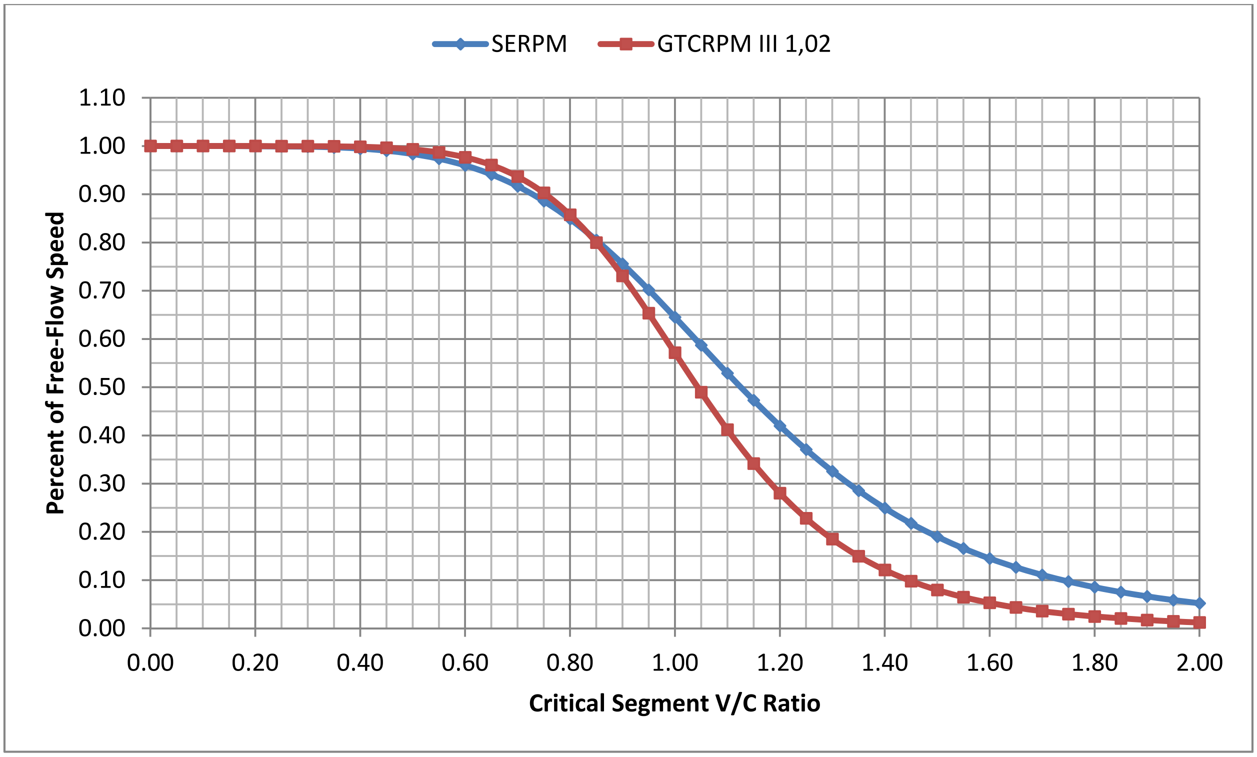


Figure 13. High Speed Arterial BPR Comparison (LOS C-based)

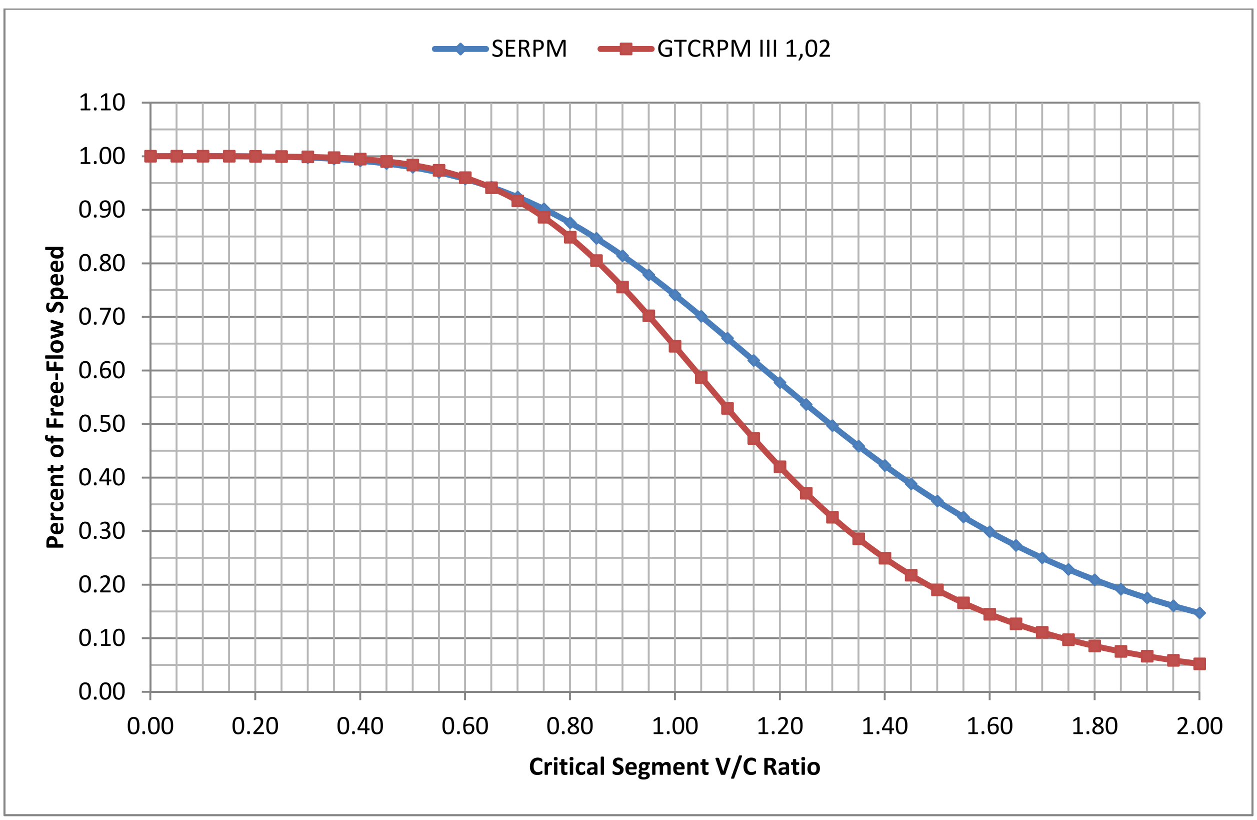
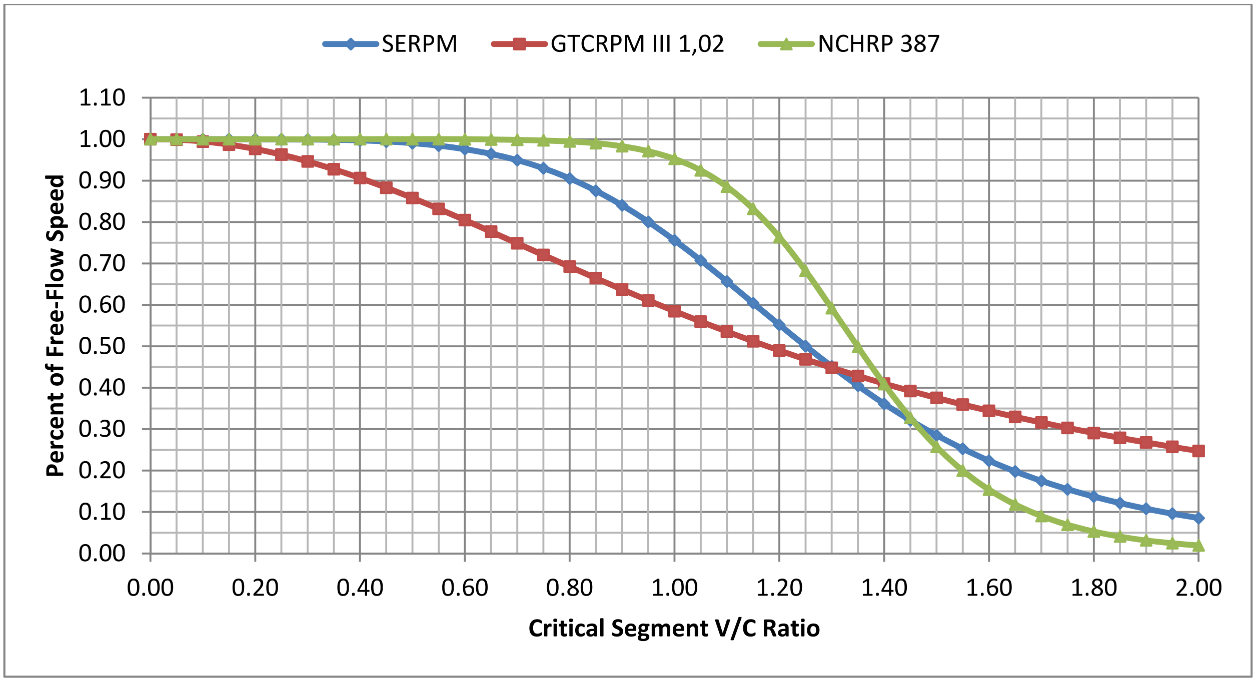


Figure 14. Low Speed Arterial BPR Comparison (LOS C-based)



The Southeast Regional Planning Model (SERPM) BPR equation was converted to LOS E for direct comparison with the other BPR equations.

Figure 22. High Speed Arterial BPR Comparison (LOS E-based)

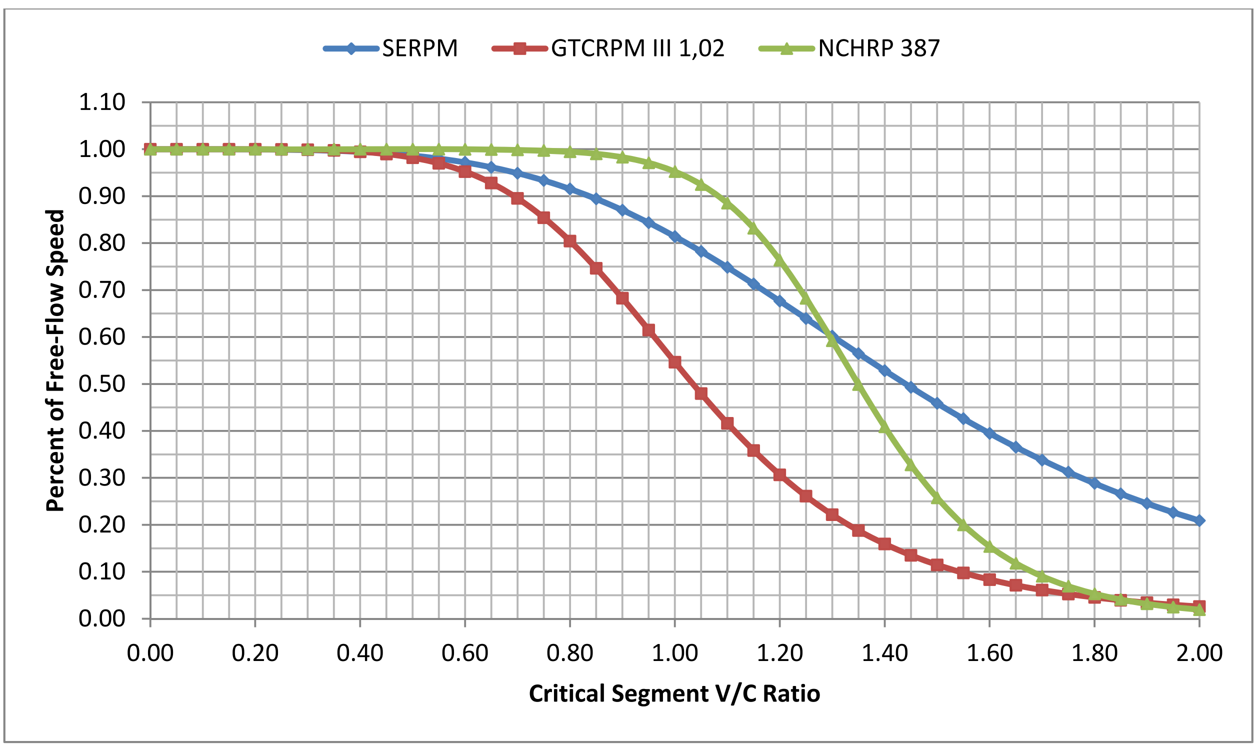


Figure 1623. Low Speed Arterial BPR Comparison (LOS E-based)

FREE-FLOW SPEED ESTIMATION

Spot speed studies conducted in urban areas collect data at mid-block locations away from the influence of upstream and downstream signals. Consequently, the free-flow speeds estimated from these studies will give an average mid-block speed for an urban street, but not the average speed along the street, including signal delays (which occur even at low volumes). Thus it is necessary to adjust an estimated mid-block free-flow speed for the estimated signal delay at low volumes to obtain an accurate estimate of free-flow speed over the length of an urban street.

The adjustment consists of adding the product of the number of signals and the average delay at a signal to the midblock travel time. Average delay at a signal can be computed using the Highway Capacity Manual (HCM) 2010 Chapter 18: Signalized Intersections equations.

We can obtain the signal delay for low-flow conditions by setting the volume to zero in the HCM equations. The incremental delay (d_2) term drops out and we are left with a simple equation for uniform delay (d_1) as follows:

Equation 25. Uniform Delay at a Signalized Intersection (low v/c). Adapted from HCM 2010 Eq. 18-20

$$d_1 = 0.5C\left(1 - \frac{g}{C}\right)^2$$

Where:

C = Signal cycle length in seconds. Assume 120 seconds if unknown.

g/C = Effective green time to cycle length ratio. Assume 0.45 if unknown.

Therefore, motorists would incur an average delay of 18 seconds at a signal with default C and g/C values, even with negligible traffic.

As an added refinement, it is recommended that uniform delay be adjusted to account for signal progression on the arterial. The HCM 2010 provides a table with platoon ratios and their corresponding progression setting (see Table 13 below)

Table 13. Relationship between Arrival Type and Progression Quality

Platoon Ratio (R_p)	Arrival Type	Progression Quality
0.33	1	Very poor
0.67	2	Unfavorable
1.00	3	Random arrivals
1.33	4	Favorable
1.67	5	Highly favorable
2.00	6	Exceptionally favorable

Adapted from HCM 2010 Exhibit 18-8

HCM 2010 Equation 18-2 relates the platoon ratio to the proportion of vehicles arriving during the green indication and the signal's g/C ratio, as follows:

$$R_p = \frac{P}{\frac{g}{C}}$$

Where:
R_p = platoon ratio,

P = proportion of vehicles arriving during the green indication (decimal), and

g/C = Effective green time to cycle length ratio. Assume 0.45 if unknown.

Because vehicles arriving on green do not incur any delay at the signal in low-volume conditions, the uniform delay obtained through Equation 25 may be reduced in proportion to P. For example, a signal with exceptionally favorable progression quality (i.e., Arrival Type = 6) has an Rp of 2.00. Assuming the default g/C ratio of 0.45, an estimated 90% of vehicles would arrive on the green indication. In this case, delay would be adjusted from the d1 result of 18 seconds per vehicle to 1.8 seconds per vehicle. Equation 26 presents the equation to compute the adjusted average signal delay.

Equation 26. Average Signal Delay

$$Average\ Signal\ Delay = d_1(1-P) = d_1(1 - R_p \times \left(\frac{g}{C}\right))$$

Where the variables are the same as defined above.

Once the average signal delay is known, estimating the free-flow speed on an arterial segment is straightforward. The calculation requires the mid-block free-flow speed, the facility length, and the signal spacing.

Equation 27. Free Flow Speed for Urban Arterial

$$Free\ Flow\ Speed\ for\ Urban\ Arterial = \frac{L}{\left(\frac{L}{S_{mb}}\right) + \left(\frac{L}{s_{sig}}\right) \times \left(\frac{D}{3600}\right)}$$

Where:

L = Facility length (miles);

S_{mb} = Mid-block free-flow speed (mph), may be assumed to be equal to the speed limit or 5 mph over the speed limit;

s_{sig} = Average signalized intersection spacing (miles); and

D = Average delay per signal per Equation 26 (sec).

CAPACITY ESTIMATION

The recommended capacity of urban interrupted flow facilities is derived from the 2012 FDOT Generalized Service Volumes Tables[6], assuming the LOS E maximum service volume is the roadway's capacity. (If LOS E cannot be achieved, LOS D maximum service volumes should be

[6] http://www.dot.state.fl.us/planning/systems/sm/los/

used.) Several factors affect capacity in the Generalized Service Volume Tables, including number of lanes, median type, and area type.

To arrive at a directional hourly capacity, the peak-hour directional maximum service volumes in Table 7 through Table 9 (see Appendix A-3) should be obtained and adjusted according to the roadway's characteristics (i.e., number of lanes, median type, and presence of exclusive left or right-turn lanes).

Example

The free-flow speed estimation methodology presented above can be applied to a typical Class I state arterial—as defined in the Generalized Service Volume Tables input value assumptions (see Appendix A-3: Generalized Service Volume Tables).

The results can then be directly compared to the "average travel speed" values presented at the bottom of each Generalized Service Volume Table. Note that the terminology of NCHRP Report 387 report and FDOT differ, but they both refer to a speed that is inclusive of signal delay.

This example uses the following input value assumptions from the Generalized Service Volume Tables:

Class I State Arterial

Area Type = Urbanized Areas

Number of lanes (both directions) = 2

Posted Speed = 45 mph

Free-flow (Midblock) Speed = 50 mph

Median Type = none

Facility Length = 2 miles

Number of signals = 4

Arrival Type = 3

Cycle Length = 120 seconds

g/C = 0.44

From Equation 25, a d1 of 18.82 seconds is obtained as the uniform delay at each signal. An Arrival Type of 3 is equivalent to a 1.00 platoon ratio, yielding a 0.44 proportion of vehicles arriving on green (see HCM 2010 Equation 18-2). Equation 26 adjusts the uniform delay based on the roadway's progression and results in an average signal delay of 10.53 seconds.

Finally, Equation 27 calculates the free-flow speed through the arterial (i.e., including signal delay) given the average signal delay and other roadway characteristics:

$$Free\ Flow\ Speed\ for\ Urban\ Arterial = \frac{2.0\text{ mi}}{\left(\frac{2.0\text{ mi}}{50\text{ mph}}\right) + (4) \times \left(\frac{10.53}{3600}\right)}$$

$$Free\ Flow\ Speed\ for\ Urban\ Arterial = 38.68\text{ mph}$$

This value is consistent with the Generalized Service Volume Table example, which specifies an average travel speed of >31 mph for LOS B. This example calculation was repeated for all the arterial types in the Generalized Service Volume Tables. As shown in Figure, the NCHRP Report 387 free-flow speed ("average travel speed" in the Generalized Service Volume Tables) was found to be generally 4-7 mph below the posted speed limit. The data used to produce Figure7 are included as Table 4.

u = Urbanized, t = Transitioning, rd = Rural Developed, ru = Rural Undeveloped

*The **ru, 4 lanes** arterial type has a NCHRP Report 387 free-flow speed (56.5 mph) that is higher than the posted speed limit (55 mph).

Figure17. Comparison of Free-Flow Speed, Posted Speed, and NCHRP Report 387 Free-Flow Speed (Average Travel Speed)

Table 14. Calculation of NCHRP Report 387 Free-Flow Speed (Average Travel Speed) for Generalized Service Volume Tables

Roadway Characteristic	Urbanized Area				Transitioning				Rural				
Area type (u,lu)	u	u	u	u	t	t	t	t	rd	rd	ru	rd	rd
Number of through lanes (both dir.)	2	4-8	2	4-8	2	4-6	2	4-6	2	4-6	4	4	2
Posted speed (mph)	45	50	30	30	45	50	30	30	45	45	55	45	45
(Midblock) Free flow speed (mph)	50	55	35	35	50	55	35	35	50	50	60	50	50
Auxiliary Lanes (n,y)													
Median (n, nr, r)	n	r	n	r	n	y	n	y	n	r	r	r	n
Terrain (l,r)	l	l	l	l	l	l	l	l	l	l	l	l	l
% no passing zone													
Exclusive left turn lane impact (n, y)	y	y	y	y	y	y	y	y	y	y	y	y	y
Exclusive right turn lanes (n, y)	n	n	n	n	n	n	n	n	n	n	n	n	n
Facility length (mi)	2	2	1.9	1.8	1.8	2	2	2	1.9	2.2	4	2	2
Number of basic segments													
Planning analysis hour factor (K)	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.095	0.095	0.095	0.095	0.095
Directional distribution factor (D)	0.550	0.560	0.565	0.560	0.550	0.570	0.570	0.565	0.550	0.550	0.570	0.570	0.550
Peak hour factor (PHF)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Base saturation flow rate (pcphpl)	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950
Heavy vehicle percent	1.0	1.0	1.0	1.0	2.0	3.0	2.0	3.0	3.0	3.0	6.0	3.5	3.0
Local adjustment factor													
% left turns	12	12	12	12	12	12	12	12	12	12		12	12
% right turns	12	12	12	12	12	12	12	12	12	12		12	12
Number of signals	4	4	10	10	5	4	10	10	5	6	2	4	4
Arrival type (1-6)	3	3	4	4	4	3	4	4	3	3	3	3	3
Signal type (a, c, p)	c	c	c	c	c	c	c	c	c	c	a	a	a
Cycle length (C)	120	150	120	120	120	150	120	150	90	90	60	90	90
Effective green ratio (g/C)	0.44	0.45	0.44	0.44	0.44	0.45	0.44	0.45	0.44	0.44	0.37	0.44	0.44
d_1 (Uniform Delay) per intersection	18.82	22.69	18.82	18.82	18.82	22.69	18.82	22.69	14.11	14.11	11.91	14.11	14.11
Average Intersection Delay (adjusted for progression)	10.54	12.48	7.80	7.80	7.80	12.48	7.80	9.11	7.90	7.90	7.50	7.90	7.90
NCHRP Report 387 Free-Flow Speed (mph)	38.68	39.82	25.01	24.62	38.43	39.82	25.37	24.26	38.79	38.48	56.47	41.00	41.00

u = Urbanized, t = Transitioning, rd = Rural Developed, ru = Rural Undeveloped

An example to show how to calculate speed on an Arterial when v/c > 1.
Assume the roadway segment belongs to Arterial Class I. From the Peak hour Directional Generalized Table in Urbanized Area, the capacity speed (v/c=1) is 15 mph. The threshold speed is assumed to be at 7 mph when (v/c>=2).
In the previous memo, the values of the BPR parameters were found from the GTCRPM model. For Arterial Class I, alpha=0.71, beta=2.1, assume free flow speed=45 mph (speed limit =40 mph) for this sample, using equation S=Sf(1+Alpha(v/c)^Beta) in the memo, the following table was got:

Table 265. Predicted Speed by the BPR function

v/c	Predicted Speed by BPR
1	26.32
1.1	24.10
1.2	22.05
1.3	20.16
1.4	18.45
1.5	16.89
1.6	15.49
1.7	14.22
1.8	13.08
1.9	12.05
2	11.13

Factors were used to force the predicted speeds equal to 15 mph when v/c=1, 7 mph when v/c=2, shown in Table 16.

Table 16. Interpolated Speed

v/c	Predicted Speed By BPR	Interpolated Speed
1	26.32	15.00
1.1	24.10	13.83
1.2	22.05	12.75
1.3	20.16	11.76
1.4	18.45	10.86
1.5	16.89	10.04
1.6	15.49	9.30
1.7	14.22	8.63
1.8	13.08	8.03
1.9	12.05	7.49
2	11.13	7.00

The comparison of predicted speeds by BPR and interpolated speeds is shown in Figure 18.

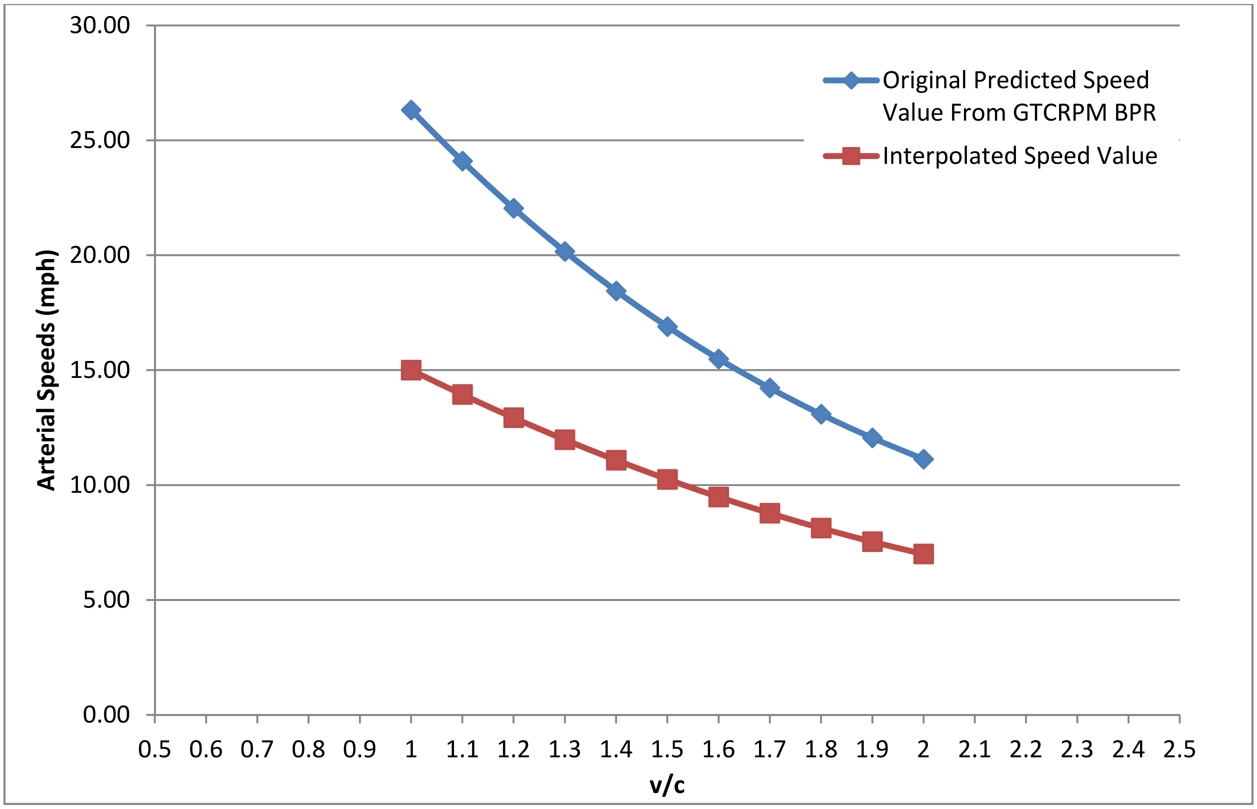
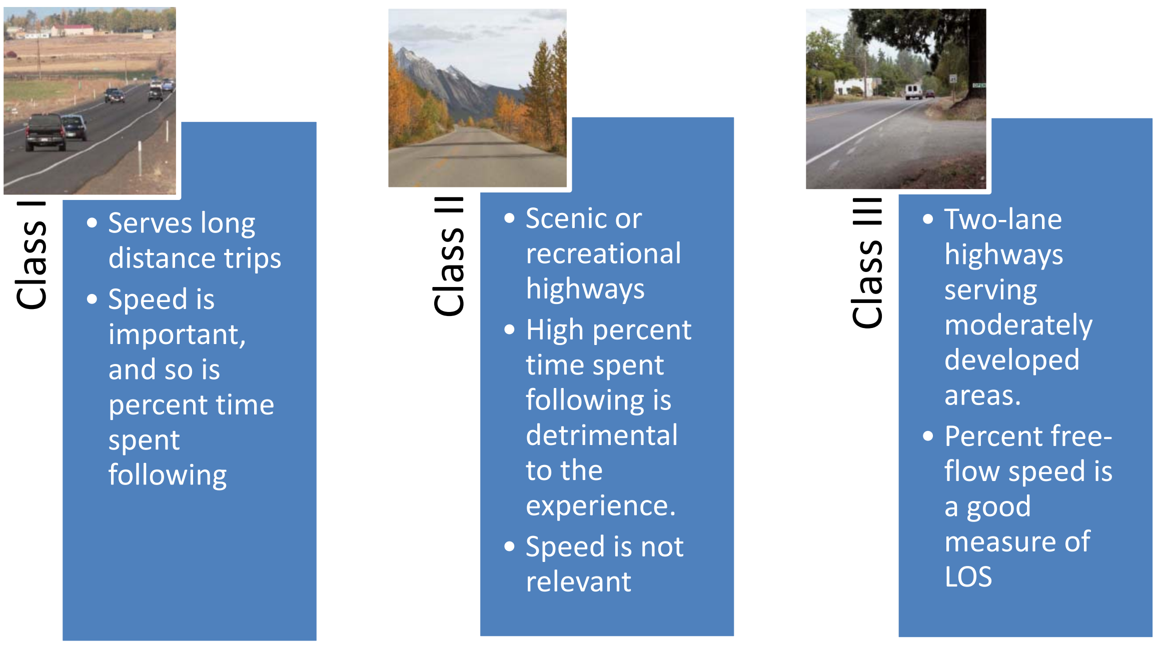


Figure 18. Predicted and Interpolated Speed

APPENDIX A-6: TWO-LANE HIGHWAY SPEED

CLASSIFICATION OF TWO-LANE HIGHWAYS

Because two-lane highways are versatile roadways that can serve a multitude of purposes, the HCM has subdivided this type of facility into three distinct classes: Class I, Class II, and Class III. A brief discussion of the different classes is relevant to the Source Book project, as they have different methodologies for calculating performance measures.



Source: Derived from HCM 2010: Chapter 15: Two-Lane Highways

Figure 1924. Two-Lane Highway Classification

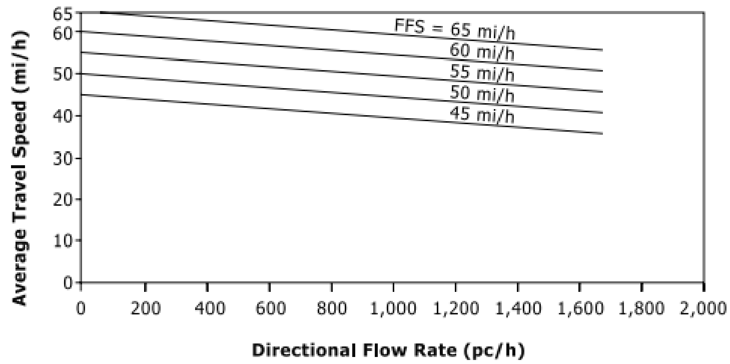
BASIC RELATIONSHIP

Figure 20 presents the basic relationship between flow, average travel speed, and percent time spent following for two-lane highways in "base conditions". Base conditions are defined by the HCM as the absence of restrictive geometric, traffic, or environmental factors. Therefore, base conditions are not to be confused with typical or default conditions: they more closely resemble ideal conditions.

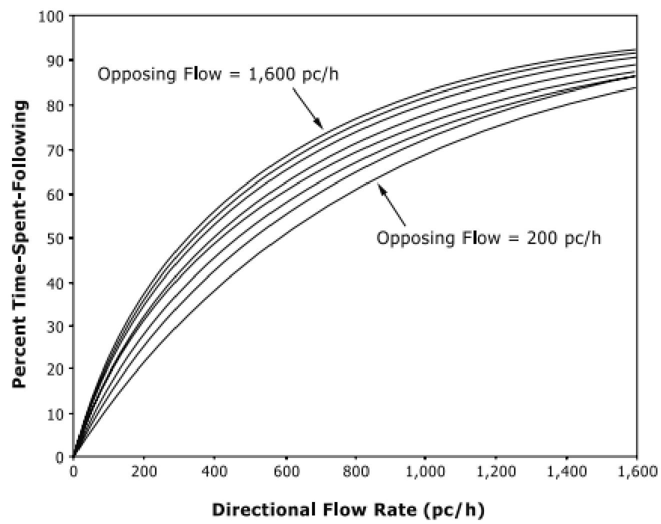
When a more detailed analysis is desired, the analyst may forgo the use of the speed-flow curves in Figure 20 and instead use the methodology described in the rest of this document.

For the 2014 version of Source book, the two-lane highway speed calculations are based on Speed-flow relationships with base conditions (Exhibit 15-2 of HCM 2010).

Exhibit 15-2
Speed–Flow and PTSF Relationships for Directional Segments with Base Conditions



(a) ATS Versus Directional Flow Rate



(b) PTSF Versus Directional Flow Rate

Figure 250. Base (Ideal) Speed-Flow Relationship in Two-Lane Highways. Source: HCM 2010, Chapter 15