Traffic Analysis Handbook

Systems Implementation Office

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FLORIDA DEPARTMENT OF TRANSPORTATION

TRAFFIC ANALYSIS HANDBOOK

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List of Abbreviations

3D	Three-dimensional
AADT	Annual Average Daily Traffic
AOI	Area of Influence
APAC	Aerial Photography Archive Collection
CADD	Computer Aided Drafting and Design
CAF	Capacity Adjustment Factor
CBD	Central Business District
CFI	Continuous Flow Intersection
CORSIM	CORridor SIMulation
D	Directional Distribution
DDI	Diverging Diamond Interchange
DOS	Degree of Saturation
DLT	Displaced Left Turn
DRI	Development of Regional Impact
DSD	Desired Speed Decision
EDTT	Extra Distance Travel Time
ELToD	Express Lane Time of Day
ETT	Experienced Travel Time
FDM	FDOT Design Manual
FDOT	Florida Department of Transportation
FFS	Free Flow Speed
FGDL	Florida Geographic Data Library
FHWA	Federal Highway Administration
FTE	Florida's Turnpike Enterprise
FTO	Florida Traffic Online
GEH	Geoffrey E. Havers
GIS	Geographic Information System
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
IAR	Interchange Access Request

IARUG	Interchange Access Request User's Guide
ICE	Intersection Control Evaluation
ICU	Intersection Capacity Utilization
ITS	Intelligent Transportation System
K	K Factor (Proportion of Daily Traffic Volume in the Peak Hour)
LGCIP	Local Government Capital Improvement Plans
LOS	Level of Service
LRTP	Long Range Transportation Plans
MLOU	Methodology Letter of Understanding
MOEs	Measures of Effectiveness
MOT	Maintenance of Traffic
MPO/TPO	Metropolitan Planning Organization/Transportation Planning Organization
MRM	Multiple Resolution Modeling
MUT	Median U-Turn
MUTCD	Manual on Uniform Traffic Control Devices
MUTS	Manual on Uniform Traffic Studies
MVDS	Microwave Vehicle Detection System
NCHRP	National Cooperative Highway Research Program
O-D	Origin-Destination
ODME	O-D Matrix Estimation
OEM	Office of Environmental Management
PD&E	Project Development and Environment
PHF	Peak Hour Factor
QA/QC	Quality Assurance/Quality Control
RBC	Ring Barrier Controller
RCI	Roadway Characteristics Inventory
RCUT	Restricted Crossing U-Turn
RITIS	Regional Integrated Transportation Information System
RSA	Reduced Speed Area
RTMC	Regional Transportation Management Center
SAF	Safety Adjustment Factor
SHS	State Highway System

SIDRA	Signalized & Unsignalized Intersection Design and Research Aid
SIRC	State Interchange Review Coordinator
SLD	Straight-Line Diagram
T	Heavy Vehicles Percentage
TD	Traffic Density
TDM	Travel Demand Model
TEM	Traffic Engineering Manual
TMCs	Turning Movement Counts
TSM&O	Transportation System Management and Operation
V/C	Volume to Capacity Ratio
VAP	Vehicle Actuated Programming
Vissim	Verkehr In Staedten SIMulation
VMT	Vehicle-Miles Traveled
VTTS	Value of Travel Time Savings

Chapter 1
Introduction

Traffic analysis is the process of evaluating the effect of traffic demand and supply on the performance of a transportation facility in relation to meeting goals and objectives of the facility. Demand is the amount of traffic load that intends to use the facility while supply is the capacity of the facility to handle the demand. The goals and objectives not only provide guidance to the transportation planning process, but also are used to evaluate the implementation and operation of the facility. The goals can be categorized as related to mobility, reliability, accessibility, safety, economy or environmental preservation.

There are different levels of traffic analysis which can be grouped as:

- Generalized (sketch-level) planning analysis.
- Preliminary engineering and Design analysis.
- Operational analysis.

Traffic analysis tools are procedures, methodologies and computer models used to carry out traffic analyses. These tools differ in their computational capabilities, input requirements and output measures. Consequently, proper application of each tool to solve traffic problems is a challenge to the transportation practitioners and decision-makers in obtaining reasonable traffic analysis results for the projects. This challenge eventually affects the cost and time to perform transportation projects. Guidance on the uniform and consistent application of the traffic analysis tools is therefore needed to overcome this challenge.

Since safety of a transportation facility is correlated with the traffic demand, safety consideration is as important as operational (mobility, reliability and accessibility) efficiency of the system. As such, safety must be integrated as appropriate in all traffic analysis levels to address safety issues for all users, including pedestrians and bicyclists. This can be achieved by incorporating relevant safety performance measures early in the analysis process.

1.1 Purpose

This handbook provides guidance and general requirements for the uniform application of traffic analysis tools on roadway corridors, interchange and intersection analyses. The techniques and accepted procedures for analyzing project traffic within the Florida State Highway System (SHS) are documented in this handbook. Additionally, the handbook guides traffic analysts, reviewers and decision-makers through development of documentation and deliverables necessary to complete the traffic analysis process.

This handbook provides guidance and general requirements for the uniform application of traffic analysis tools on roadway corridors, interchange and intersection analyses.

Specifically, this handbook:

- Provides guidelines for a consistent and unified approach to the traffic analysis process for the Florida Department of Transportation (FDOT) projects.
- Guides the traffic analyst to select appropriate traffic analysis tool(s) and comparable performance measures of effectiveness (MOEs).
- Documents FDOT's requirements for traffic analyses.
- Provides a streamlined review process for accepting and approving traffic analysis and making informed decisions regarding the existing and proposed transportation investments.

This guidance was prepared with a consideration that not all traffic analyses are the same. As such, the handbook is not intended to be prescriptive, and its application can be adjusted based on the context and size of the project as well as capabilities of the Districts and reviewing entities. To obtain reasonable traffic analysis results there should always be a balance between project complexity, its goals and objectives; time and budget available; and measures of system performance that will be used to assess the project.

1.2 Goals

It is expected that the information contained in this handbook when used and adapted to site specific conditions will:

- Improve consistency and effectiveness of the traffic analysis process.
- Streamline selection and application of analytical tools and traffic simulation models around the state.
- Improve documentations and transparency of the assumptions, input values, calibrated parameters and outputs from traffic analyses.
- Facilitate portability of microscopic traffic simulation models from one (1) phase of the project development to another.
- Streamline the project delivery process.

1.3 Intended Use

The primary intended users of this handbook are the transportation practitioners preparing traffic analyses which are to be accepted or approved by FDOT or Federal Highway Administration (FHWA) and reviewers of such efforts. Applicable traffic analyses to this handbook include corridor studies, interchange access requests (IARs) and project development and environment (PD&E) studies. For traffic studies that are not covered by this handbook which include but not limited to traffic signal warrant studies, travel time studies and speed studies, the analyst should refer the FDOT Manual on Uniform Traffic Studies (MUTS). For guidance on conducting traffic impact studies, the analyst should refer to the FDOT Transportation Site Impact Handbook. For guidance on sketch-level planning analysis, the analyst should refer to the FDOT Quality/Level of Service Handbook.

The scope of this handbook covers traffic analysis methods, tools and documentation. Safety analysis tools and methods are not covered in this handbook. It is recommended that the analyst perform safety analysis depending on the project type. For IARs, the IARUG Safety Analysis Guidance available on FDOT Systems Management website should be followed. For safety analysis in PD&E projects, the analyst should refer the Safety Analysis Guidebook for PD&E Studies on FDOT Office of Environmental Management (OEM) website. Other safety guidance and material can also be found on the FDOT Safety Office website.

This handbook does not constitute a training manual. Rather, it assumes the user has sufficient knowledge, experience and expertise in traffic analysis and is familiar with relevant traffic analysis tools available in the industry. Additionally, when the standards, methods or procedures are documented elsewhere, the handbook refers to those publications.

Users of this handbook should have sufficient knowledge, experience and expertise in traffic analysis and be familiar with relevant traffic analysis tools available in the industry.

Guidelines provided in this handbook do not cover multiple resolution modeling (MRM) approaches. MRM concept integrates regional travel demand models (TDM) and microscopic simulation (microsimulation) models to perform time-dependent traffic assignments.

1.4 Handbook Organization

The chapters of the handbook give guidance on conducting traffic analysis as follows:

- **Chapter 1: Introduction** – contains an overview of the handbook including purpose, goals and intended use.
- **Chapter 2: Traffic Analysis Methodology** – provides guidelines to prepare methodology to conduct the traffic analysis.
- **Chapter 3: Analysis Area Boundary Limits** – provides guidance on establishing the limits of traffic analysis.
- **Chapter 4: Analysis Tools Selection** – contains general guidelines on selecting proper traffic analysis tools.
- **Chapter 5: Data Collection** – provides guidance on data requirements, resources, collection techniques and procedure.
- **Chapter 6: Traffic Analysis using Analytical Tools** – contains additional guidelines on the use of deterministic tools that are used to perform traffic analysis.
- **Chapter 7: Microsimulation Analysis** – provides guidance of the use of traffic microsimulation tools, specifically CORSIM and Vissim. Key steps that are to be followed when performing microsimulation are also provided.
- **Chapter 8: Express Lanes Analysis** – contains guidance and key steps to be followed for analyzing express lanes facilities.
- **Chapter 9: Performance Measures of Effectiveness** – contains guidance on which MOEs should be produced and appropriate documentation of MOEs for traffic analysis.

- **Chapter 10: Traffic Report** – contains guidelines for preparing traffic reports.
- **Appendices** – contains a list of technical references that were used to prepare this handbook and Tool Selection Worksheet.

1.5 Distribution, Updates and Contact

This document is available online at: FDOT Systems Implementation Office website. For updates and questions regarding this Handbook, please contact:

Florida Department of Transportation
Systems Implementation Office, Mail Station 19
605 Suwannee Street
Tallahassee, Florida 32399
ATTN: State Interchange Review Coordinator

Users of this handbook are encouraged to submit questions and requests for modifications to the Systems Implementation Office at the above address. Users of this handbook are encouraged to check the website prior to use to obtain any latest process and technical requirements.

Chapter 2
Traffic Analysis Methodology

The traffic analysis component of a project can be substantial in terms of time, resources and complexity. To streamline proper use of analysis approach and tools for the project the methodology of the traffic analysis should be prepared. Methodology elements discussed in this chapter include elements of the technical analysis approach memos or methodology letters of understanding (MLOUs) that are prepared by the analyst and approved by the reviewing entity prior to beginning the analysis. These elements can also be incorporated in the project scope by project managers. The analysis methodology is used to document how the analysis will be accomplished to meet project goals. A properly prepared methodology provides the base for the entire analysis process by identifying the issues to be solved, data requirements, identification of analysis tools, performance measures, schedule and analysis deliverables. The content of the analysis methodology should be tailored to the context and complexity of the project. The methodology elements discussed in this chapter can also be used by project managers to prepare the scope of traffic analysis. The reviewers of the traffic analysis report may use the methodology development process as an opportunity to raise critical issues and concerns so they can be resolved and incorporated in the analysis.

The methodology elements listed below represent general requirements of any traffic analysis. The analyst should refer to the applicable handbooks and manuals depending on the type of study for which the analysis is performed.

2.1 Methodology Elements

The methodology of the traffic analysis effort should include:

- Project description
- Traffic analysis objective
- Analysis boundary limit
- Analysis tool(s) selection and analysis approach
- Data requirements and data collection plan
- Project traffic forecasting
- Performance MOEs
- Project alternatives analysis
- Traffic analysis report and technical documentation
- Estimation of level of effort

Very early at the project onset, the traffic analysis methodology should be discussed and agreed upon between the lead agency, FDOT, the analyst and other project stakeholders. A pre-analysis field review is essential to become familiar with the analysis location. However, the field review may not be necessary for sketch-level planning analyses where lower levels of effort and details are desired. Additionally, meetings such as analysis scoping meeting may be required to reach full agreement and to clearly define and document every aspect of the traffic analysis methodology.

Traffic analysis methodology should be discussed and agreed upon between the lead agency, FDOT, the analyst and other project stakeholders.

Prior to completing the methodology document the analyst should determine the schedule and budgetary constraints for the analysis effort.

2.2 Project Description

The project description is used to introduce the project. It includes general context and background information. The project location map should be included in the project description.

2.3 Traffic Analysis Objective

Traffic analysis objective(s) should clearly identify the following:

- The performance problem or goal which the analysis seeks to answer.
- The intended use and decision-makers of the traffic analysis results.

The objectives should be clear, specific, measurable and realistic, considering the resources and time that are available for their achievement. It is important to establish specific and measurable objectives that are directly tied to traffic operational and safety performance measures. Broad analysis objectives should be avoided as they tend to obscure the project needs and negatively impact decision-making. Additionally, the traffic analysis objectives should be in conformity with the project purpose and need statement.

The objectives of a project's traffic analysis should be clear, specific, measurable and realistic.

2.4 Analysis Boundary Limit

The analysis boundary limit defines the traffic study in both space and time domains (spatial and temporal limits). The space dimension is affected by the physical characteristics of the project while the time dimension is affected by hourly variation of the traffic on the project. Analyst's knowledge of the location and operation of the existing facility or proposed improvement is requisite for defining proper analysis boundary limit. Therefore, prior to defining the analysis boundary, the analyst should review and understand both spatial and temporal characteristics of the facility.

In determining the analysis boundary limit, the following should be considered:

- Characteristics of the project and the required level of analysis.
- Geographic location of network being studied.
- Size and topology of the network and availability of multiple routes.
- Classifications of the roadways forming the network being studied.
- Existing traffic controls and traffic management strategies.
- Future network conditions that are being planned in the long range transportation plans (LRTP), local government capital improvement plans (LGCIP) or approved Development of Regional Impact (DRI) within the vicinity of project.
- Hourly variations of traffic in the project area.
- Bottleneck (capacity constraints) locations, their activation and dissipation periods and queue extents caused by them.

Residual queues can have a significant effect on the results of the analysis. As such, the analyst should make sure that the analysis incorporates any residual queues observed in the field to the extent possible. If it is impossible to collect an initial queue estimate, the analysis time period should be extended to start on the period with demand less than capacity and no residual queue. Incorporating residual queues may require multi-hour analyses.

The analyst is responsible to determine and incorporate any improvements beyond the project area in the analysis boundary limit if they impact the project. Failure to consider such impacts may affect analysis results.

To streamline the review process, the analyst should coordinate with the traffic analysis reviewing and approving entities when establishing limits of the analysis. Guidance on establishing the boundary limits of traffic analysis is further provided in **Chapter 3**. Guidance on boundary limits for new express lanes system and expansion of existing express lanes system is provided in **Chapter 8.**

2.5 Traffic Analysis Tool and Analysis Approach Selection

Traffic analysis tools can be categorized as deterministic or stochastic (or non-deterministic). Deterministic tools are tools in which no randomness is applied in their computational methods. These tools are also called analytical tools. Most of the analytical tools are based on Highway Capacity Manual (HCM) methodologies. Stochastic tools employ randomness in their computational methods to model real world traffic conditions. Microsimulation tools are stochastic and thus they are effective in evaluating heavily congested conditions, complex geometric configurations and system-level impacts of transportation improvements that are beyond the limitations of deterministic tools.

Proper selection of analysis tool and approach determines the success of any traffic analysis effort. The analyst should possess sufficient traffic analysis knowledge including understanding of the strengths and weaknesses of the traffic analysis tools in order to select proper analysis tools that meet the project needs. The analyst should be aware that no single tool can analyze or model all project conditions. It is recommended that the analysis effort correlate the project complexity, traffic analysis level and magnitude of the traffic problem being analyzed. Thus, use of very sophisticated tools and approaches should match the complexity of the problem being solved. The following factors are normally considered when selecting analysis approach and tools to carry out the analysis:

- Type of the project and level of analysis.
- Required performance MOEs.
- Traffic operating conditions such as queue formation and degree of saturation (DOS).
- Facility type and geographic context of the analysis.
- Assumptions and limitation of the available analytical tools.
- Presence of traffic management strategies, specialized traffic control and intelligent transportation system (ITS) features.
- Interoperability with other analysis software or traffic management strategies.
- Resources and budgetary constraints.

Projects on urban arterials that require signal optimization would require signal optimization tools to determine optimal signal settings.

The analyst should determine appropriate analysis tools and their versions based on the above-mentioned factors. Additional guidance on selecting appropriate analysis tools is provided in **Chapter 4**. The reasons for selecting such tools should be justified and stated clearly in the analysis methodology.

Reasons for selecting such tools should be justified and stated clearly in the analysis methodology.

2.6 Data Requirements and Data Collection

Data requirements for any traffic analysis depend on the analysis level of detail, analysis type, analysis tool and targeted performance measures. Variables affecting operation of the system (the vehicle, the environment and the driver) should be assessed and collected as appropriate to meet the analysis objective. At minimum, assumptions, input data and calibration data (when simulation is proposed) must be identified.

Required data should be categorized as available from existing sources or field-measured with appropriate collection means outlined. The quality of the existing data should be verified to determine its fitness to the analysis method. Such verification can involve checking recent aerial images, maps or drawings. Additionally, sample data may be collected during field reviews to verify the accuracy of the existing data.

Existing data should represent a typical day (Tuesday, Wednesday or Thursday) of the week. However, data can be collected from other days of the week that are known to have highest volumes depending on the use of the facility or purpose of the project. The data should be screened for and exclude those days where weather, incidents and holidays influence the traffic.

The most recent existing data preferably collected within the last 12 months should be used whenever possible. If older data is used, then it should be validated and checked for reasonableness. Traffic validation guidelines for both existing and future traffic along with the traffic validation template can be obtained from State Interchange Review Coordinator (SIRC). Historic traffic growth and latest adopted travel demand model are good sources for use in the traffic validation effort. If the traffic validation exercise reveals that the existing counts available are not valid anymore, then a methodology should be developed to update the traffic.

When microsimulation analysis is proposed, the methodology should identify calibration performance data along with their collection requirements. Key locations where calibration data is to be collected should be included so that the analyst and reviewers can agree on the simulation scenarios and calibration data needs. It is important to note that local knowledge and field observations of the traffic operating characteristics is requisite in establishing calibration locations.

Clear identification of the data required to support the analysis methodology helps to minimize project costs. Specific budgetary items should be included in the project plan to fund data collection. Regardless of the level and type of the analysis, data collection plan should be designed carefully. Data collection requirements are discussed in detail in **Chapter 5**.

2.7 Project Traffic Demand Forecasting

The project traffic analysis methodology should include the demand forecasting procedure for future year analysis. Also included in the analysis methodology are the design year, interim year and opening year for traffic analysis.

Development of demand volume projections should follow the guidelines and techniques published in the FDOT Project Traffic Forecasting Handbook and the FDOT's Project Traffic Forecasting Procedure Topic No. 525-030-120. The analysis should identify the adopted regional Metropolitan Planning Organization/Transportation Planning Organization (MPO/TPO) TDM to be used in the analysis along with its version, base year and planning (horizon) year.

2.8 Performance Measures of Effectiveness

Numerical outputs from the traffic analysis are the MOEs which are metrics used to assess the performance of a system. MOEs are also used to compare and contrast the system performance under various design or improvement alternates. The analyst should be aware of and able to identify any limitations of the MOEs to the measurement of performance of the system being evaluated.

The methodology should identify all operations and safety MOEs that will be used to measure the performance of the system to fulfill the objective of the analysis and alternatives being evaluated. It is important to describe the MOEs as field-measured or analytically established. Additional project-related MOEs to be used in the alternatives analysis can be obtained from relevant local and regional agency guidelines.

The methodology should identify all operations and safety MOEs that will be used to measure the performance of the system to fulfill the objective of the analysis and alternatives being evaluated.

Level of Service (LOS) is a readily recognizable qualitative indicator of traffic operations and has been widely used by different agencies when evaluating the traffic operations performance of facilities. However, LOS alone does not necessarily give insight about the overall performance of the facility. Thus, additional quantifiable measures should be included in the analysis to better assess the performance of the system or network being analyzed. It is recommended that the analyst seek input from project stakeholders when establishing MOEs for the project. Guidance on selecting MOEs for freeways and arterials and their documentation is provided in **Chapter 9**.

LOS targets for projects on the SHS are to be selected based on the FDOT LOS policy (FDOT procedure No. 000-525-006). Projects on local agency facilities may use the agency's LOS target. In some instances, local governments may have adopted LOS standards for state roads and/or local facilities that do not match LOS targets in FDOT's policy.

When the proposed analysis approach requires calibration, the methodology should outline how calibration process will be performed and what calibration performance measures will be used. All calibration and validation parameters and the locations where they will be checked should be identified. The analysis methodology should also identify the desired calibration margins of error or tolerances that will be met. Guidance on calibration and validation of microsimulation models is provided in **Chapter 7.**

2.9 Project Alternatives

All alternative improvements that have been developed for the project and will require traffic analysis should be described in the analysis methodology. Discussion of how (and why) the alternatives will be developed should be brief, yet clear. The number of details provided should be commensurate with the proposed level of analysis. Graphical illustrations of all alternatives considered should be provided when alternatives are known. The “no-build” alternative must be considered as one (1) of the project alternatives. No-build alternatives include existing conditions plus committed improvements with programmed funding to the analysis location. A description of how the alternatives will be evaluated and screened should be included.

2.10 Traffic Analysis Report and Technical Documentation

Documentation requirements for traffic analysis should be established as part of the traffic analysis methodology and should describe how the results will be presented to the intended audience such as policy makers and the public. Documentation is also necessary to enable a reviewer to independently confirm analysis assumptions, analysis methodology, input data, outputs and, if necessary, reproduce the same results presented by the analyst. As such, the methodology should include check points to provide for interim technical reviews and approval of the analysis efforts. The number of check points and interim documents necessary to support traffic analysis should be proportional to the size of the project and complexity of the analysis. Specific documentation requirements for traffic reports and an example outline are provided in **Chapter 10**.

2.11 Estimation of the Level of Effort

The methodology of the traffic analysis may include an estimate of the work effort required to meet project objectives. The estimate of work effort should identify both personnel, budget and scheduling requirements which include key milestones and decision points required to deliver a traffic analysis report. When microsimulation approach is proposed, the methodology may include the model development proposal which could help project stakeholders comprehend the realistic level of effort to carry out the analysis.

Efforts that involve modeling of complex areas with extreme congestion should be carefully estimated. Such efforts have to include the time and resources required to test and validate the analysis results. Generally, for most projects involving deterministic and analytical tools, the traffic analysis could be completed in less than three (3) months. Time to complete traffic analyses that require microsimulation tools could be longer than three (3) months depending on the complexity of the project, number of alternatives being evaluated and project schedule. Ideally, one (1) analyst at a time can code, calibrate and run the microsimulation on the computer. However, there are some situations where a skeleton (master network) model may be built and later split into subarea models that could be coded by different analysts. The subarea models can then be pasted back into the skeleton network. As such, ability of the software package to split the network should be explored prior to coding the model.

Additionally, since calibration of microsimulation tools is a time consuming process, its staffing requirements, budget and schedule should be set properly to meet project time and money constraints. Level of effort estimates for microsimulation should include time and resources for error checking (model verification) for alternative analysis. Estimates of level of effort should also include time for reviews of the analysis methodology, preliminary data, analysis outputs and analysis reports.

2.12 Traffic Analysis Methodology Checklist

A checklist of the traffic analysis methodology development content is shown in **Table 2-1**. This checklist is a guidance that should be used by the analyst when preparing the methodology memorandum. The checklist may also be used by project managers when preparing scope for the traffic analysis. Following of this checklist does not guarantee acceptance of the analysis methodology and/or results.

Table 2-1 Traffic Analysis Methodology Content Checklist

Financial Project ID: _________________ Federal Aid Number:_________________

Project Name: ____

State Road Number: _________________ Co./Sec./Sub. ________________ Begin Project MP: _________________ End Project MP: ________________

Item	**Description**	**Check**	**Remarks**
Traffic analysis objective	Discuss briefly and concisely objective, purpose and need. Include location map.	☐	
Technical Guidance and Standards	Describe technical standards, procedures and guideline to be followed to conduct analysis. Include quality assurance/control commitment.	☐	
Analysis area boundary limit	Describe both spatial and temporal boundary limits. Include a legible and scaled area map showing all study intersections and interchanges.	☐	
Analysis tool(s) selection and analysis approach	Describe the approach to be used to perform traffic analysis. List analysis tool(s) to be used along with their versions.	☐	
Data requirements and data collection plan	Describe data collection plan, include methodology, sources, techniques, schedule and quality assurance plan. Identify calibration and validation data requirements and include calibration data collection means.	☐	
Project traffic forecasting	Summarize methodology for projecting traffic forecast. List model base year, design year/planning horizon, opening and interim years.	☐	
Performance Measures of Effectiveness	Describe performance measures of effectives (MOEs) that will be evaluated. Explain how the selected approach and tools will report the MOEs. If calibration and validation are required, briefly explain approach and MOEs as well as locations to be calibrated and targets for acceptance.	☐	
Project alternatives	Describe existing/no-build conditions and improvement (build) alternatives to the extent possible. Use graphics to illustrate build alternatives. Describe alternative screening criteria.	☐	
Traffic analysis report and technical documentation	Describe required documentation requirements commensurate with the complexity of the analysis.	☐	
Estimate of work effort	Include an estimate of the level of analysis effort.	☐	

Preparer's Name:____________________________________ Date:_________________ Reviewer's Name:____________________________________ Date:_________________

Chapter 3
Analysis Area Boundary Limits

Boundary limits for the analysis area are established to accurately capture the prevailing traffic operating characteristics. This chapter provides guidance on establishing both spatial and temporal boundary limits of the traffic analysis without express lanes. Please refer to **Chapter 8** for additional guidance on determining boundary limits for express lanes system and expansion of existing express lanes system projects.

This chapter provides guidance on establishing both spatial and temporal boundary limits of the traffic analysis without express lanes.

Spatial boundary limit is derived from an area of influence (AOI) or study area which is the geographic breadth of the traffic analysis. The AOI depends on the type and location of the project type and the prevailing traffic operating characteristics. Proper identification of the AOI increases the level of accuracy of the traffic analysis tool in replicating real world traffic characteristics. The analyst should initially conduct a field reconnaissance to determine an extent of the problem and identify any hidden bottlenecks. The presence of a traffic bottleneck can affect the spatial boundary limit. Hidden bottlenecks are formed when the existing demand at a segment or point is constrained by upstream bottlenecks. In such conditions, correction of upstream bottleneck by the improvement would normally shift the bottleneck to a downstream capacity constrained location.

The presence of a traffic bottleneck can affect the spatial boundary limit.

For IARs, the analyst should consult the FDOT IARUG and prepare an MLOU defining the AOI for the project. Coordination with the approving agency of the analysis is strongly recommended when establishing the analysis boundary limits.

The AOI for the analysis performed in urban areas using analytical traffic analysis tools typically includes at least the first adjacent interchange or signalized intersection. The variation of operating characteristics observed in urban areas can necessitate the extension of the AOI. When traffic congestion is prevalent, the location, type, magnitude and causes of congestion should be determined prior to establishing the AOI for the analysis. The establishment of the spatial boundary limits of analysis should therefore consider factors that would affect traffic operational and safety performance of the project such as:

- Bottleneck (capacity constraint) that affects traffic flow into or out of the AOI in both existing and future conditions.
- Queues that extend beyond the predefined AOI.
- Major systems interchange that affect the lane-changing behavior (merge/diverge or weaving operations) through the AOI.
- Adjacent intersections that affect formation of vehicle platoons in the AOI. For

example, presence of a coordinated signal system.
- DRIs in the vicinity of the project area to determine its inclusion within the AOI.

AOI for projects located in rural areas is established on a case-by-case basis depending on their degree of isolation from other segments or facilities.

The following general guidelines may also be considered when identifying the AOI for projects involving microsimulation:

<u>Freeway Projects</u> – Projects involving freeways in urban areas may require a longer AOI due to variations in the network topology, land use characteristics and driving behaviors. Existing or proposed traffic conditions downstream and upstream of the AOI may affect the outcome of the analysis of the study area. As such, the analyst should examine and consider the following as appropriate to replicate existing operating characteristics:

- Extent of congestion (or queuing) upstream or downstream of the analysis AOI.
- Ramp connections that affect weaving within the AOI.
- Areas where traffic flow entering the AOI is metered by toll plazas, ramp meters and upstream traffic signals.
- Other relevant operational situations as evidenced by data or field observations.

<u>Express Lanes Projects</u> – Guidelines for projects involving analysis of express lanes are provided in **Chapter 8**. The analyst should refer to those guidelines to determine the AOI of express lanes projects.

<u>Arterial Projects</u> – The AOI for arterial roadways and other surface streets depends upon the road network configuration, frequency of traffic signals and the level of congestion within the project area. The following guidelines should be considered when establishing the AOI:

- Boundaries should extend far outside the project location enough to replicate existing traffic conditions within the AOI. Inclusion of at least one (1) signalized intersection beyond the AOI is typically necessary to increase accuracy of the model in replicating existing operating characteristics.
- Boundaries should be located at logical points in the road network from the existing traffic operations perspectives, such as on a section of road with approximately random or uniform traffic arrivals. For instance, the random arrivals might be due to a distant (0.5 miles or more) upstream signalized intersection, while the uniform arrivals might be due to heavy traffic turning onto the arterial from the upstream signalized intersection or intervening unsignalized streets and driveways, resulting in traffic uniformly arriving at the traffic signal throughout the cycle. If the project is within an arterial with signal coordinated system, the analysis boundary should be extended to include the effect of coordinated signals.
- Boundaries should not be extended unnecessarily, as this would increase analysis

efforts and may reduce attention to the project location.

3.1 Temporal Boundary Limits

Temporal boundary limit is the length of the traffic analysis period. Analysis period is selected such that the effect of traffic demand variation is captured and included in the analysis. Capacity analyses typically focus on the peak hour where demand to use the facility is high. Typically, hourly volumes are higher prior to the onset of the peak hour than during the peak hour in oversaturated traffic conditions. As such, peaking characteristics of the facility should be examined before establishing the analysis period. Peaking characteristics can be obtained from examining hourly and daily variations of the traffic demand. The analyst should consult local permanent count station data to gain an understanding of the traffic demand variations. Additional field observations and queue analysis may be conducted to confirm the demand variations. Knowledge of variability in traffic demand is needed to properly determine temporal boundary limits.

Knowledge of variability in traffic demand is needed to properly determine temporal boundary limits.

The traffic operating characteristics in undersaturated conditions are homogenous and thus 15-minute analysis period is used consistent with HCM methodology. As such, extending the analysis period beyond 15 minutes in undersaturated conditions will not affect the performance measure significantly. Traffic flow during the analysis period is deemed undersaturated when all the following assumptions hold:

a) the arrival flow rate is less than the capacity of the facility.
b) no residual queue present from a previous breakdown of the facility.
c) downstream conditions do not affect the traffic flow.
d) speeds remain at or near the posted speed limit.

If any of these conditions is violated, the traffic flow is considered oversaturated. In many cases, a study area can be undersaturated under existing conditions but may be oversaturated in future years. This change should be considered when selecting the temporal boundary limits for future years analyses.

For locations where traffic flow is oversaturated, a single 15-minute traffic analysis period is typically not sufficient. A multiple-period analysis is required under these conditions to capture the effect of demand that is not served by the facility from one (1) 15-minute to the next. It is important to note that the first and last periods of the multiple-period analysis should be undersaturated. Microsimulation analysis should be conducted to analyze oversaturated conditions extending beyond peak hour. Three (3) to four (4) hours of peak period are common when performing microsimulation analysis. Additional guidance on determining temporal boundary limits for new express lanes system and for expansion of existing express lanes system is provided in **Chapter 8.**

Analysis period on congested facilities can be more than one (1) hour when demand to use the facility exceeds the capacity over a period longer than one (1) hour. This condition is called peak spreading. Peak spreading typically occurs when congestion is very severe. Existing 24-hour traffic volume profiles should be evaluated to determine the periods in which peak demand spreads over multiple hours. Directional volumes should be analyzed because of the possibility to have volume in one (1) direction at capacity while volume in the opposite direction well below capacity. When the peak traffic spreads out, the analysis period must include duration of traffic congestion as well as uncongested periods before (congestion build-up) and after (congestion dissipation) the peak period. Inclusion of uncongested periods is essential to capture the effects of traffic breakdown as the result of congestion spread beyond the time during which the demand exceeds capacity. The analyses of peak hour spreading requires the use of microsimulation tools.

When unmet demand is observed, the analyst should extend the analysis period to include uncongested periods before and after the period where demand exceeds capacity. In case of urbanized areas, where this approach does not provide required results, then other methods to address the unmet demand should be followed. Guidance on how to address the unmet demand in analysis is provided in **Chapter 7**.

Chapter 4
Analysis Tools Selection

Traffic analysis tools have different computational capabilities and assumptions. As such, to obtain cost-effective, yet reasonable analysis results at a desired level of confidence, guidance for selecting proper analysis tools is provided in this chapter. Guidance on reporting MOEs from these tools is provided in **Chapter 9.** The following items are covered in this chapter:

1. Traffic Analysis Tools
2. Appropriate Tool for the Project

4.1 Traffic Analysis Tools

The following are tools that are commonly used to perform traffic analysis in Florida:

- *Florida's Generalized Service Volume Tables*

Florida's Generalized Service Volume Tables are sketch-planning level tools developed to provide a quick review of capacity and LOS of the transportation system. The Generalized Service Volume Tables, found at the end of the FDOT Quality/Level of Service Handbook, present maximum service volumes or the highest number of vehicles for a given LOS.

Generalized Service Volume Tables are intended to provide an estimate of the LOS of an existing facility or provide quick estimation of the number of lanes of a proposed facility. This tool should not be used for evaluating or developing detailed improvement plans or operational analysis.

- *HCM/Highway Capacity Software (HCS)*

The HCM is the most widely used document in the transportation industry that contains a set of methodologies and application procedures for evaluating the capacity and quality of service of various transportation facilities. It is a tool for analyzing existing facilities and for the planning and design of future systems. HCM is built from more than 60 years of research work and represents a body of expert transportation consensus. HCS is a computer program that implements the HCM methodologies. Both HCM and HCS analyze capacity and LOS for uninterrupted-flow and interrupted-flow roadways.

- *SIDRA INTERSECTION*

SIDRA (which stands for Signalized & unsignalized Intersection Design and Research Aid) INTERSECTION is an analytical model mostly used to analyze roundabout operations in the United States. Unlike HCM which uses lane group concept in intersection analysis, SIDRA has the capability of performing lane-by-lane analysis at the intersection. Additionally, SIDRA can be used to evaluate the effect of metering signals on roundabout performance.

- *Synchro/SimTraffic*

Synchro is a macroscopic analysis tool which is used to design, model and analyze signalized and unsignalized intersections. Synchro is also used to model arterial segments. The software optimizes traffic signal timings for an isolated intersection, an arterial or a network. It uses three (3) methods to analyze signalized intersections: Intersection Capacity Utilization (ICU), HCM Signalized Method and Synchro Percentile Delay. SimTraffic is a microsimulation tool which models individual vehicles interactions and provides animation of the model in a network. SimTraffic uses direct input from Synchro to perform microscopic traffic simulation. SimTraffic can model signalized and unsignalized intersections and urban arterial segments. Additionally, Synchro has capability of building input files for detailed microsimulation analysis.

- *CORSIM*

CORSIM stands for CORridor SIMulation. It is a microscopic traffic simulation tool. CORSIM models individual vehicle movements using car-following and lane-changing logics in a time-step simulation. Time-step simulation enables each vehicle to be individually tracked through the network and MOEs to be collected on every vehicle. Driver behavior characteristics are assigned to each vehicle. Random processes are introduced to reflect real world operating conditions. The variation of each vehicle's behavior is simulated in a manner reflecting real world operations. Driver behavior parameters can be calibrated to simulate local existing conditions. CORSIM comes pre-configured with TRAFED and TRAFVU tools. TRAFED is a graphical user interface-based editor used to create and edit traffic networks while TRAFVU is the visualization utility that displays the network and animates simulated traffic flow. An arterial system modeled using Synchro can be imported into CORSIM.

- *Vissim*

Vissim stands for the German words "Verkehr In Staedten SIMulation". It is a microsimulation tool that is used to analyze and model vehicular traffic, transit and pedestrian flows. Vissim has an option of recording videos of simulation runs in three-dimensional (3D) mode. Vissim can be applied to analyze different transportation conditions such as signal prioritization and optimization; dynamic traffic assignments; freeway operations; managed lanes analysis, traffic management strategies; pedestrian flows; and interaction of different transportation modes. It simulates the traffic flow by moving the driver-vehicle units. It also uses a car-following and lane-changing logic which allows drivers from multiple lanes to react to each other. This software provides a number of calibration parameters that allow for model calibration to better match local conditions. Additionally, Vissim has a module which can build models from Synchro by directly importing Synchro's geometry, volumes and signalization data.

Table 4-1 provides a summary of the applications of these tools in different levels of analysis.

Table 4-1 Uses of Traffic Analysis Tools

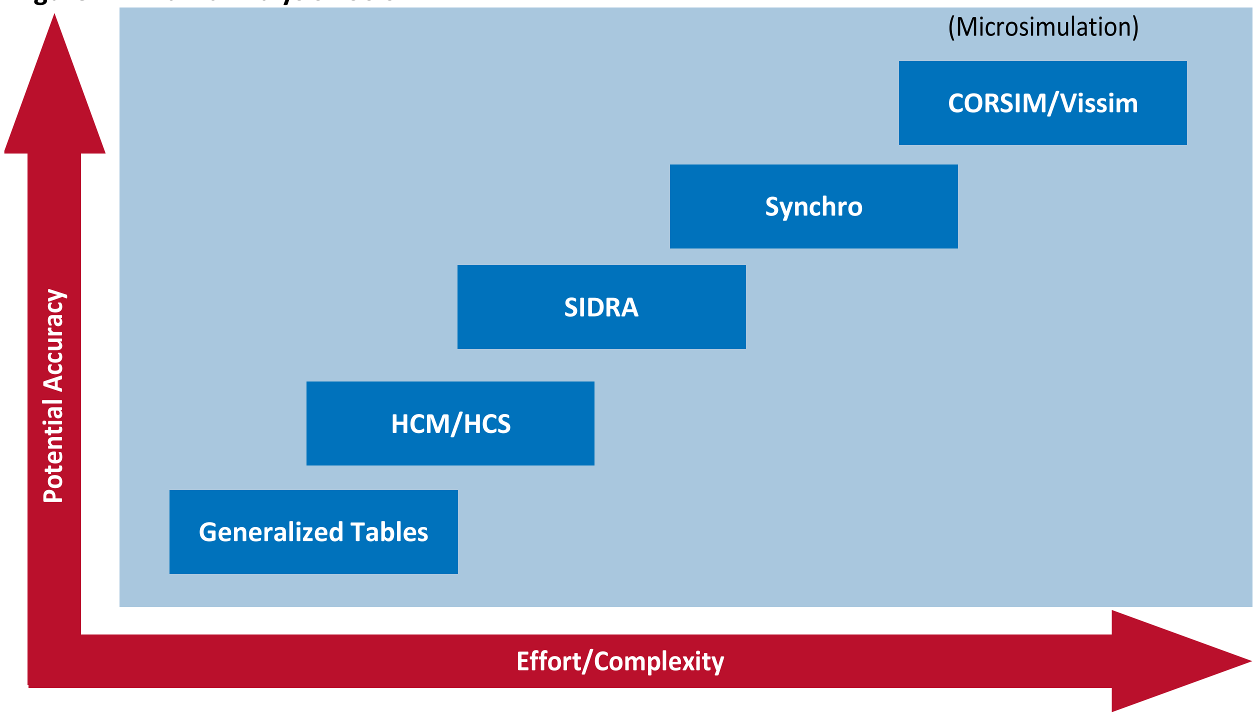
Analysis Type	Level of Detail	Level of Analysis	Analysis Tool
Sketch Planning	Analyzing system elements to obtain general order-of-magnitude estimates of performance based on capacity constraints and operational control	Generalized Planning	Generalized Service Volume Tables, HCS
Deterministic	Analyzing broad criteria and system performance based on geometric and physical capacity constraints; operational systems such as traffic control and land use	Preliminary Engineering; Design; Operation	HCS, Synchro, SIDRA
Microscopic Simulation	Analyzing system performance based on detailed individual user interactions; geometry and operational elements	Preliminary Engineering; Design; Operation	CORSIM, Vissim, SimTraffic

4.2 Which Tool is Appropriate?

At the initiation of the traffic analysis methodology development process, determination of the tool which satisfies the project traffic analysis objectives to the maximum extent possible should be made. In making such determination, the analyst should be aware of the required level of analysis effort, degree of detail and limitations of all tools in performing such analysis. However, the analyst should refrain from selecting a simple analysis tool (solely based on familiarity or lack of resources) that may not fit the analysis objective. **Figure 4-1** demonstrates the relation between the levels of analysis, effort and degree of accuracy among different traffic analysis tools used by FDOT.

At the initiation of the traffic analysis methodology development process, determination of the tool which satisfies the project traffic analysis objectives to the maximum extent possible should be made.

Figure 4-1 Traffic Analysis Tools



It is recommended that microsimulation tools be used for preliminary engineering, design and operation analyses only when HCM-based tools are not appropriate. Prior to selecting microsimulation tools, the analyst should thoroughly review existing conditions to justify their use. At least one (1) of the following conditions must be valid for the analyst to consider microsimulation:

- Conditions that violate or limit the basic assumptions of analytical tools such as higher levels of saturation and complexity of the network or corridor.
- Conditions that are not covered by analytical tools such as traffic routing, queues that overflow to the system analyzed or prolonged congestion periods.
- When analysis objective requires evaluation of vehicle performance, user behavior, multiple what-if scenarios, effect of application of a technology or an operational strategy like managed lanes and ramp metering.

Analysis of an isolated point or segment where influence from adjacent segments is marginal and congestion is not prevalent should always be performed by deterministic tools such as HCS or Synchro. Additionally, where congestion does not exist (typically LOS D or better), HCM should be used to analyze freeway facilities (basic segments, weaving area, ramp merge/diverge areas) and urban street facilities (combination of automobile, pedestrian, transit and bicycle) from a complete corridor perspective.

Analysis of an isolated point or segment where influence from adjacent segments is marginal and congestion is not prevalent should always be performed by deterministic tools such as HCS or Synchro.

Table 4-2 presents a summary list of example applications of traffic analysis software to analyze the performance of different facilities. A tool category selection worksheet that can be used in the tool selection process is provided in **Appendix B**. **Chapter 9** provides detailed guidance on the MOEs and their presentation from these tools.

Table 4-2 Traffic Analysis Software by System Element

Facility	Level of Analysis	Project Need	Software
Limited Access	Generalized Planning	Determining a need for additional capacity	Generalized Service Volume Tables
	Preliminary Engineering and Design	Determining how the facility will operate	HCS, CORSIM, Vissim
	Operational	Determining how well the facility operates	HCS, CORSIM, Vissim
		Express lanes analysis	Vissim
Interchanges	Generalized Planning	Determining capacity of the weaving segment	HCS
	Preliminary Engineering and Design	Determining capacity of the weaving segment or ramp merge/diverge	HCS
		Evaluating effect of a queue backup from the ramp terminal to the weaving operation	Synchro, CORSIM, Vissim
		Analyzing weaving from ramp terminal to the nearest signalized intersection	CORSIM, Vissim
		Evaluating the operation of the entire interchange	CORSIM, Vissim
	Operational	Evaluating weaving operation	HCS, CORSIM, Vissim
Urban Arterials	Generalized Planning	Determining a need for additional capacity	Generalized Service Volume Tables
	Preliminary Engineering and Design	Determining how the facility will operate	HCS, CORSIM, Vissim
		Optimizing signals	Synchro/SimTraffic
	Operational	Coordinating traffic signals	HCS, Synchro/SimTraffic
		Evaluating existing signal timing plans	HCS, Synchro/SimTraffic
		Checking the effect of technology application or traffic demand management strategy	Synchro/SimTraffic, CORSIM, Vissim
Rural two-lane highways and Multilane highways	Generalized Planning	Determining a need for additional capacity	Generalized Service Volume Tables
	Preliminary Engineering and Design	Determining how the facility will operate	HCS
	Operational	Determining how well the facility operates	HCS

Facility	Level of Analysis	Project Need	Software
Intersections	Generalized Planning	Determining a need for additional intersection capacity	HCS
	Preliminary Engineering and Design	Designing isolated intersection	HCS, Synchro
		Analyzing closely spaced intersections	Synchro/SimTraffic
		Analyzing unconventional (or complex) intersection	CORSIM, Vissim
		Analyzing multimodal interactions	HCS, Vissim
	Operational	Evaluating the performance of signalized intersections	HCS, Synchro, CORSIM, Vissim
Roundabouts	Generalized Planning	Evaluating the need for roundabout	HCS, SIDRA
	Preliminary Engineering and Design	Analyzing roundabout	HCS, SIDRA
	Operational	Evaluating the performance of roundabout	HCS, SIDRA
Networks & Systems	Generalized Planning	Forecasting system-wide future demand	Generalized Service Volume Tables, HCS
	Preliminary Engineering and Design	Evaluating the performance of the entire network/system	Synchro/SimTraffic, CORSIM, Vissim
	Operational	Evaluating the performance of the entire network/system	Synchro/SimTraffic, CORSIM, Vissim
Multimodal Transportation District	Planning	Planning level assessment of different modes	Generalized Service Volume Tables, HCS
	Design and operational	Evaluate alternative multimodal improvements	Vissim
		Assessing quality of service on a multimodal corridor	HCS, Vissim

If simulation is required, the simulation tool should be selected carefully. It should be noted that that there is no single microsimulation tool that can perfectly analyze all types of traffic problems. Each microsimulation tool that is available in the market has strengths and limitations. Microsimulation tools such as CORSIM and Vissim should be appropriately used to perform traffic microscopic analysis on interstate and freeway corridors. SimTraffic can be used on urban arterials analysis. Factors that can be considered when deciding to use CORSIM or Vissim for traffic microsimulation may include:

- Prior applications and available data
- Network size limitations
- Simulation time period limitations
- Suitability of the software package to simulate the special phenomenon that is to be investigated, e.g., express lanes, pedestrian movements, transit, signal preemption, railroad crossing etc.
- Knowledge of calibration and validation parameters from previous completed projects
- Visualization capabilities and input data formats
- User interface control and flexibility of coding network

- Compatibility and integration with other traffic modeling tools, e.g., TDMs
- Special conditions such as complex weaves (**Chapter 8**)

This list is not exhaustive, and it remains responsibility of the analyst to use good engineering and planning judgment when selecting microscopic traffic simulation tools to analyze traffic. While this handbook provides guidelines on selecting and using appropriate traffic analysis tools on different analysis levels, use of alternative tools other than those discussed in this handbook may be necessary depending on the project local circumstances, software limitations and scale of analysis. When alternative tools are proposed, the analyst should provide adequate documentation to enable the reviewer to understand the model development process to independently confirm model inputs and outputs and verify calibration process. **Appendix B** contains a Tool Selection Worksheet that can be used as part of the documentation to explain the use of alternative tools.

Chapter 5
Data Collection

This chapter provides guidance on the data requirements, data resources and data collection procedures. Data collection and quality assurance procedures are also described in this chapter. The following topics are covered in this chapter. Each of these topics are discussed in detail in subsequent sections.

1. Field Observations
2. Required Data
3. Input Parameters Default Values
4. Data Collection Plan
5. Existing Data Sources
6. Data Collection Schedule
7. Calibration and Validation Data
8. Quality Assurance

Additional guidance on data requirements for express lanes projects is provided in **Chapter 8.**

5.1 Field Observations

Field observations (or field inspections) are a requisite to obtain accurate traffic analysis results. Field observations enable the analyst to become familiar with the general traffic operating characteristics and the surrounding environment in the analysis area. Desktop review of data through aerial photographs, video logs or online street view applications should not replace physical field observations.

5.2 Required Data

The reliability of traffic analysis results depends on the accuracy and quality of data. As such, a thought-out traffic data collection plan is necessary before collecting data. Data requirements and assumptions depend on the analysis type and level of analysis. For instance, generalized planning analysis requires less data (in term of both quantity and quality) compared to operational analysis which are performed at a higher degree of detail and accuracy. To minimize project costs existing data should be used as much as possible.

Data for traffic analysis can be grouped as traffic operations and control, traffic characteristics and facility characteristics. Data needs for various traffic analysis tools are summarized in **Table 5-1.** Not all data listed below are input parameters of the traffic analysis tools. Some of the data are collected or analytically computed to evaluate the existing traffic problem or support justification for improvements utilizing other quantitative or qualitative approaches.

Table 5-1 Typical Input Data for Different Analysis Types

Input Data Category	Traffic Analysis Tools					
	Generalized Service Volume Tables	HCM/ HCS	SIDRA	Synchro/ SimTraffic	CORSIM	Vissim
Traffic Operations and Control Characteristics						
☐ Average Speed		x	x	x	x	x
☐ Speed Limit or Free Flow Speed (FFS)	x	x	x	x	x	x
☐ Driver Behavior					x	x
☐ Parking		x	x	x		x
☐ Signs			x		x	x
☐ Signal Timing and Phasing Plans		x	x	x	x	x
☐ Detector types and their location		x		x	x	x
☐ Intersection control type	x	x	x	x	x	x
☐ Right/left turn treatment	x	x	x	x	x	x
☐ Railroad Crossing				x		x
☐ Lane Restriction					x	x
☐ Toll Facility					x	x
☐ Ramp Metering					x	x
☐ School zone					x	x
Traffic Characteristics						
☐ Driver behavior characteristics (e.g. aggressiveness, age) and their composition		x			x	x
☐ Demand (AADT, T %, TMC, O-D, spatial and temporal variation)	x	x	x	x	x	x
☐ Queue length		x	x	x	x	x
☐ Capacity/ Saturation Flow		x		x	x	x
☐ Pedestrian Counts		x	x	x		x

An "x" indicates a data category is used as an input to the analysis tool. A blank cell indicates the corresponding data is not needed.

Input Data Category	Traffic Analysis Tools					
	Generalized Service Volume Tables	HCM/ HCS	SIDRA	Synchro/ SimTraffic	CORSIM	Vissim
Traffic Characteristics						
☐ Bicycle counts		x	x			x
☐ Bus & Transit stops		x		x		x
☐ Fleet Characteristics		x	x	x	x	x
☐ Vehicle occupancy					x	x
☐ Major traffic generators					x	x
Facility Characteristics						
☐ Road Classification	x	x	x	x		
☐ Cross Section elements	x	x	x	x	x	x
☐ Geometry	x	x	x	x	x	x
☐ Access Control	x	x			x	x
☐ Access Density		x				
☐ Parking			x	x		x
☐ Aerial images		x		x	x	x

An “x” indicates a data category is used as an input to the analysis tool. A blank cell indicates the corresponding data is not needed.

5.3 Input Parameters Default Values

It is recommended to field-measure input parameters. However, there are circumstances which permit use of default values for input parameters. For instance, default values are mostly used in planning level analyses in which case data is not readily available or cannot be field measured because future geometric and operational characteristics of the proposed facilities are unknown. Additionally, default values may be used when past experience and research have shown such input parameters have negligible effect on the outcome of the results.

Contrary to planning level analysis, design and operational analyses are more detailed and thus require use of accurate field-measured data. In some instances, design and operational analyses utilize locally adapted default values for some input parameters when field data are yet to be collected or when field data collection is not practical.

5.4 Data Collection Plan

After the traffic analysis methodology is known, a data collection plan should be prepared and agreed upon with the reviewing entity. The data collection plan is prepared to document data needs for the traffic analysis and the procedures for collecting the data. Refer to FDOT (MUTS) for further guidance on field data collection.

5.4.1 Data Collection Checklist

Prior to developing the data collection plan, the analyst should understand what to collect, when to collect, how long to collect, where to collect and how to manage the data. Additional questions that the analyst should answer include:

- What is the level of analysis?
- Can the use of published default values fulfill the objectives of analysis?
- What type of traffic data is available?
- How old is the existing data? What format?
- What is the traffic analysis procedure (tool and approach)?
- What performance measures will be evaluated?
- What degree of accuracy (confidence level) of the results is required?
- What are the project alternatives to be analyzed? Will the alternatives require additional data?
- Is the existing data sufficient enough to support the project objectives?
- Does the data (to be collected) adequately support the objectives?
- Are there any data collection assumptions?

5.4.2 Data Collection Plan Format

At a minimum, the format of data collection plan consists of the following elements:

- Objectives of the analysis.
- Data required to meet objectives and performance measures used for evaluation.
- Desired level of accuracy of the data dependent on the level of analysis.
- Data collection, duration, method and data sources.
- Data storage.
- Schedule and resources requirements.
- Budget.

5.5 Existing Data Sources

Existing data should be used as much as possible to streamline the project and minimize the cost of the project. As such, existing data resources should be explored before new data is planned to be collected from the field. The following is the list of data resources that the analyst should explore:

- Florida Traffic Online (FTO) which is a web-based mapping application that provides current and historical traffic count data.
- FDOT Transportation Data and Analytics (TDA) Roadway Characteristics Inventory (RCI) which is a database of roadway descriptive characteristics within Florida.
- Straight-Line Diagrams (SLD) which are graphical linear representation of selected RCI data reported for individual roadways.
- Florida Geographic Data Library (FGDL) which is an online portal for distributing spatial

data throughout the state of Florida.

- Florida Aerial Photography Archive Collection (APAC) which is the Florida's largest collection or inventory of aerial photography.
- Traffic counts from local agency databases.
- Regional Integrated Transportation Information System (RITIS) which is an automated real time and archiving system for sharing among the various transportation data and performance measures.
- FDOT's eTraffic which is a web-based mapping application maintained by FDOT's Traffic Engineering and Operations Office and provides traffic, roadway and signal data.
- State and local governments' crash databases.
- State and local governments' signal timing data bases.

Even when existing data is deemed sufficient to meet the analysis objective, field observations should be conducted to verify and confirm key traffic and roadway data (such as roadway geometric, traffic control, driver behavior) that would impact traffic operating characteristics in the analysis location. The findings from site observations should be documented and included in the existing conditions report or analysis report, as appropriate. A field inspection is compulsory in any traffic analysis to confirm existing characteristics.

A field inspection is compulsory in any traffic analysis to confirm existing characteristics.

It is normally difficult to measure the true traffic demand when oversaturated traffic conditions exist because automatic data recorders do not account for demand caused by queuing. Under these conditions, the demand should be estimated, based on the FDOT's 200th Highest Hour Traffic Count Reports using data for unconstrained sites with similar roadway and geometric characteristics. The 200th Highest Hour reports are published in the FTO. Alternatively, counting arrival volume upstream of the bottleneck would help to capture the true demand.

5.6 Data Collection Schedule

Once the data collection technique is determined and analysis approach has been determined, the data collection schedule should be developed and integrated into the scope of the project. The data collection schedule may show the resources (manpower and equipment) and time required for completing data collection effort. When a new collection technique or technology is proposed, a pilot data collection may be conducted before the actual data collection starts to understand the accuracy of the data collected by the new technology.

The field traffic data collection and its key requirements are listed below:

- Traffic volume data (mainline, ramps and turning movement volumes) should be collected during typical weekdays, excluding weeks that contain holidays. Refer to FDOT (MUTS) for further guidance on field data collection.

- Traffic volumes must also be collected in 15-minute increments for the entire study period.
- If feasible, traffic volumes should be collected on the same day throughout the entire study area and should coincide with other data collection and field observations (e.g., vehicle speeds and queuing).
- The vehicle classification data should be collected, at a minimum, at one (1) location within the study area, which should be determined through coordination with FDOT during the scoping process.
- When turning movement counts (TMCs) and daily traffic counts are to be collected, they should be scheduled to occur simultaneously so that the turning counts can be used to validate the daily counts.
- The standard traffic counts collected should be 48–72-hour bi-directional volume counts for all approaches of a freeway or an intersection.
- TMCs should be collected for four (4) consecutive hours in each peak period in urban area. If peak spreading does not exist or the analysis is in rural location, then two (2) to three (3) hours of TMCs can be used.
- In addition to the data identified above, Origin-Destination (O-D) counts may be needed for complex microsimulation projects. The scope and acceptable tolerances of the O-D counts should be discussed and approved by the FDOT.

When microsimulation approach is proposed, the data collection schedule should include additional field reviews during model calibration process to review traffic operating characteristics and compare with model outputs. Alternatively, the analyst may videotape the analysis area as vehicle behavior data is needed to visually verify the simulation models.

5.7 Calibration and Validation Data

Usually, calibration and validation data are required only when a microsimulation approach is used. In this case, the scope of the data collection must include calibration (and validation) data. The importance of the accuracy of traffic counts and other field measured data for model calibration and validation emphasizes the need for careful planning and diligence of a data collection plan. It is strongly recommended, wherever possible that calibration and validation data be collected simultaneously with demand data to maintain consistency with the simulation demand inputs. This would help to compare field-measurements and simulation output and eventually streamline the calibration process.

It is strongly recommended, wherever possible that calibration and validation data be collected simultaneously with demand data to maintain consistency with the simulation demand inputs.

The following data may be collected to calibrate and validate the simulation model with real world conditions.

- Traffic Volume / Throughput
- Travel speeds
- Travel times and delay
- Queue lengths
- O-D data
- Bottleneck locations
- Weaving and lane changing observations
- Field observations

Table 5-2 summarizes the various calibration data with their sources and microsimulation model element it is used to calibrate. Calibration and validation guidelines for microsimulation tools are provided in **Chapter 7.**

Table 5-2 Summary of Calibration Data with Sources and Usage

Calibration Data	Potential Data Source	Calibration Data Usage
☐ **Traffic Volume/ Throughput**	Machine counts, TMCs, FTO, Previous projects	Freeway, Ramps, Arterial
☐ **Travel Speeds**	RITIS, INRIX, Probe vehicle	Freeway, Arterial
☐ **Travel Time and Delay**	Travel time runs, Probe vehicle	Freeway, Arterial
☐ **Queue Lengths**	Field review, Aerial survey, Local area knowledge	Freeway, Ramps, Arterial
☐ **O-D Data**	Bluetooth data, Mobile source data	Freeway, Arterial
☐ **Bottleneck Locations**	Field observations, Aerial survey, Local area knowledge	Freeway, Arterial
☐ **Field Review**	Field observations	Freeway, Ramps, Arterial

5.8 Quality Assurance

> Regardless of the tool used, the outputs from the traffic analysis will be no better than the accuracy of the data used in the analysis.

Data collection plans must emphasize on the quality of data since use of good data can lead to good analysis results and poor data yields bad results. Regardless of the tool used, the outputs from the traffic analysis will be no better than the accuracy of the data used in the analysis. One (1) general rule of obtaining good data is to incorporate and follow quality control protocols throughout the data collection process. Thus, checking data collected for completeness, accuracy and reasonableness is strongly recommended. It is prudent to verify the reliability of the data collected by examining their trends and descriptive statistics. These statistics such as mean and standard deviation are useful in assessing the accuracy and precision of the measurements. Trend analysis would help to determine variation of data in time and space domain.

Moreover, all data collected should be properly handled by documenting data attributes such as source, collection time and condition and any other information that might have affected the data collection process. To streamline the process, the analyst should use adequate data management strategies which is understandable by the data collection personnel.

A good practice is to use a second analyst who was not involved in collecting data to check the reasonableness of the data. Verification should include checking that weather, incidents or construction did not influence the data collected. Checking variation of the data (in both space and time), data discrepancy or missing data to determine any abnormalities or outliers (based on historical data, local knowledge, or experience) and determining their probable causes is necessary to understand the accuracy of the data collected.

Additionally, maximum traffic count should be compared with the capacity of the facility and travel time data should be compared with the operating speeds at the time of data collection. A difference of more than 10% should necessitate a second look at the calculations and field measurements to determine the cause of the discrepancy.

When an error found in the data collected is caused by equipment malfunction or human error, the data should be recollected.

Quality assurance of the data collection also includes checking and verifying hourly traffic volumes are balanced within the analysis boundary limit. Traffic counts will have to be checked by starting at the beginning or perimeter of the system and adding or subtracting entering and exiting traffic, respectively. When volume imbalances are detected, the cause of such discrepancies should be determined, reconciled and documented in the data collection summary or narrative. A 10% difference between upstream and downstream counts for location with no known traffic sources or sinks (such as driveways or parking garage) is considered acceptable.

A 10% difference between upstream and downstream counts for location with no known traffic sources or sinks (such as driveways or parking garage) is considered acceptable.

When microsimulation approaches are proposed the analyst must collect the data that is as precise as possible. Small errors in input data used in the microsimulation could lead to amplification errors which create large errors in the simulation results that cannot be calibrated. Such errors have a tremendous negative effect on the performance of the simulation model. As such, the quality assurance reviewer should verify that data used for model calibration and validation is not only correct but also was collected or measured at the same time and location as the data that was used to code the model.

Chapter 6
Traffic Analysis Using Analytical Tools

This chapter provides guidance on analytical tools that are used to perform traffic analysis. When the context of the project does not justify the use of microscopic traffic simulations, analytical (deterministic) tools should be used. Users of this handbook are advised to consult each specific tool's User Guides and Manuals for details of the analytical procedures. The following topics are covered in this chapter. Each of these topics is discussed in detail in subsequent sections.

1. Generalized Service Volume Tables
2. HCM and HCS
3. SIDRA Intersection
4. Synchro and SimTraffic

6.1 Generalized Service Volume Tables

Generalized planning makes extensive use of default values and is intended for broad applications, such as initial problem identification (e.g., deficiency and needs analyses, geographic influence areas), statewide analyses (e.g., statewide calculation of delay) and future year analyses (e.g., 10-year planning horizon). Generalized Service Volume Tables are the primary tools for conducting generalized planning analysis. The Generalized Service Volume Tables, found at the end of the FDOT Quality/Level of Service Handbook, present maximum service volumes, or the highest numbers of vehicles for a given LOS. FDOT's Generalized Service Volume Tables consist of three (3) area types grouped into three (3) tables listed below:

- Annual Average Daily Service Volume
- Peak Hour Two-Way Service Volume
- Peak Hour Directional Service Volume

Generalized Service Volume Tables must be appropriately applied using the right area type and facility type designations and interpreted by selecting the right values from the tables. The adjustment factors must be applied, as appropriate. The Generalized Service Volume Tables cannot be relied upon when approaching LOS E and LOS F thresholds, because of operational fluctuations at the thresholds. The Generalized Service Volume Tables are not detailed enough for PD&E traffic analysis, final design or operational analysis work and should not be used for those purposes.

6.2 HCM and HCS

HCM is the most widely used document in the transportation industry that contains a set of methodologies and application procedures for evaluating the capacity and quality of service of various transportation facilities. HCS is a computer program that implements the HCM methodologies. Both HCM and HCS analyze capacity and LOS for uninterrupted-flow and interrupted-flow roadways and other travel modes including pedestrian, bicycle and transit. HCM procedures are suitable for analyzing undersaturated conditions and have limitations of analyzing oversaturated conditions and time-varying demand. Methodology limitations for each system element analysis are further identified and discussed throughout HCM.

The HCM methodologies contain default values which represent nationally accepted values. Since typical conditions within the state of Florida may be different from national values, the analyst may be required to change some of the default parameters to Florida based values. When HCM default values or assumptions are changed, justification for such should be documented.

Irrespective of the tool used in preliminary engineering, design or operational analyses, input parameters that represent basic segment, intersection geometry and demand flow rates should always be measured in the field or drawn from the best available evidence. The analyst should refrain from using “rules of thumb estimates” to obtain the values of these parameters because such methods usually produce incorrect estimates of the performance measures.

Special considerations should be given to the following parameters:

- *Peak Hour Factor (PHF)*

  HCM methodologies use demand flow rates for the 15 minutes peak period. If flow rates have been measured from the field, the flow rates for the worst 15 minutes should be used in operational analyses. PHF is used to calculate the equivalent hourly flow rate.

  In the absence of field measurements of the PHF, design analyses may use a default PHF of 0.95 on urban freeway facilities and urban arterials. A PHF value of 0.92 may be used on facilities in transitioning areas; however, data shows that PHF increases as demand volume increases. Lower PHF signifies greater variability of flow while higher PHF signifies less flow variation within the analysis hour. Rural areas tend to have slightly lower PHF values than urban areas. A PHF value of 0.88 may be used on rural facilities. A PHF higher than 0.95 may be used on urban areas if justified by traffic conditions. It is recommended that the analyst obtain concurrence with the reviewing and approving entity (of the analysis results) prior to using default PHF values in the analysis.

PHF is not needed in multiple analysis periods where 15-minute traffic demand measurements are directly used. This approach tends to account for residual queues from one (1) 15-minute period to another.

It is recommended that the analyst obtain concurrence with the reviewing and approving entity (of the analysis) results prior to using default PHF values in the analysis.

- *Free Flow Speed (FFS)*

FFS is field measured under low volume conditions, when drivers are not constrained by other vehicles, roadway geometry or traffic control. In the absence of field data, FFS can be estimated at five (5) mph above the posted speed limit.

- *Saturation Flow Rates and Capacities*

The HCM saturation flow rates and capacities were developed based on national research. These values can be changed if Florida specific maximum generally acceptable volumes are available for the project. Coordination with the reviewing entity or lead agency is required before overriding these values.

- *Signalized Intersection Parameters*

It is recommended to obtain input values for intersection signal parameters (such as signal control type, sequence of operation and controller settings) from the agencies that maintain the signals. However, planning analyses may use the HCM quick estimation methodology to estimate a reasonable signal timing plan.

- *Speed Adjustment Factor (SAF) and Capacity Adjustment Factor (CAF)*

The SAF is used to adjust the speed of a facility based on a combination of sources, including weather and construction work zone effects. The SAF may also be used to calibrate the estimated free-flow speed for local conditions or other effects that contribute to a reduction in free-flow speed. The CAF is used to adjust the capacity of a facility for reduced-capacity situations or to match field measurements. The capacity can be reduced to represent situations such as construction and maintenance activities, adverse weather, traffic incidents, and vehicle breakdowns. Reference the HCM for the recommended SAF and CAF based on level of driver familiarity.

6.3 SIDRA INTERSECTION

SIDRA INTERSECTION's Standard and HCM models can be used to analyze various roundabout geometries such as raindrop design, strip islands (between lanes), wide splitter island, slip/bypass lane and roundabouts with more than two (2) lanes.

Special considerations should be given to the following parameters:

- *LOS and Geometric Delay*

Geometric delay is the delay caused by vehicles slowing down when entering, negotiating and exiting the roundabout. This delay is very important when comparing operations of different intersection alternatives. SIDRA considers geometric delay when calculating roundabout LOS. HCM roundabout LOS does not consider geometric delay.

- *Practical Degree of Saturation (DOS)*

Practical DOS is the maximum volume to capacity (V/C) ratio or DOS that corresponds to an acceptable level of performance. A DOS of 0.85 is desired for roundabouts without metered signals. For DOS above 0.85, the analyst is encouraged to perform sensitivity analysis to determine the influence of volume on roundabout delay and queues.

- *Environmental Factor*

Since research conducted in the United States (e.g. NCHRP Report 572 and NCHRP Report 672) found lower capacity values at United States roundabouts compared with European and Australian ones, the following Environmental Factors are recommended depending on the lane configuration of the roundabout.

An Environmental Factor of 1.2 is suggested for multi-lane (both approach road and circulating road have two or more lanes) roundabouts for the existing conditions. An Environmental Factor of 1.1 is suggested for multi-lane roundabouts for future years analysis. An Environmental Factor of 1.05 is suggested for roundabouts that have both single-lane and multi-lane approaches for the existing conditions analysis. An Environmental Factor of 1.0 is suggested for roundabouts that have both single-lane and multi-lane approaches for future years analysis.

- *Number of Circulatory Lanes*

The number of lanes in the circulatory roadway should provide lane continuity through the roundabout. The number of lanes is a function of the sum of the entering and conflict volumes. The maximum number of circulatory lanes should be two (2).

- *Pedestrians*

Pedestrian walking speed should be set to 3.5 ft/sec based on the current guidance in the MUTCD.

- *Extra Bunching*

This parameter is used to model the effect of platoon arrivals from the upstream signals on the capacity of roundabouts. Platooned arrivals are not important at roundabouts that are spaced at least a half-mile from a signalized intersection. Values for Extra Bunching are provided in the SIDRA INTERSECTION User's Manual.

- *Mode*

  SIDRA offers SIDRA Standard, HCM 6, and HCM 2010. FDM states that HCM mode is consistent with HCM Methodology so this is the FDOT preferred mode. HCM 6 is the most up to date mode to be used for roundabout analysis as it assumes a better driver familiarity.

6.4 Synchro and SimTraffic

Synchro is used to analyze traffic on urban streets where adjacent signalized intersections influence each other and signal optimization or simulation may be required. Synchro is also used for operational analysis projects which include signal re-timing, corridor operational assessments and capacity analysis of individual intersections (signalized, unsignalized or roundabout). Synchro has a capability of performing traffic analysis and producing reports based on HCM 2000, HCM 2010 and HCM 6th Edition methodologies.

Analysis results from Synchro can be reported based on the Synchro methodology or HCM methodology. The Department's primary source for highway capacity and LOS analysis methodologies is the HCM. Synchro LOS are approximations based on several procedures included in the program. The analyst, client and approving authorities should agree and document the reporting methodology at the beginning of the study. If HCM based results are reported from Synchro, the latest available version of HCM should be selected.

The analyst, client and approving authorities should agree and document the reporting methodology at the beginning of the study. If HCM based results are reported from Synchro, the latest available version of HCM should be selected.

Synchro does not have capability to analyze freeways, multilane highways and two-lane rural roads. For freeway analyses that include evaluation of crossing arterials and local roads, Synchro is used to develop optimized signal timing plans which are then used as input to the freeway analysis tools such as CORSIM or Vissim.

The analyst should be aware that Synchro does not accurately model oversaturated traffic conditions. Under such conditions, microsimulation tools such as CORSIM or Vissim can be used. SimTraffic uses direct input from Synchro to perform microscopic traffic simulation but has limitations and is therefore not commonly used for microsimulation analysis. Like Synchro, SimTraffic does not have capability to simulate freeway corridors including ramp junctions, weaving areas and traffic management strategies such as managed lanes and ramp metering. Since SimTraffic is associated with Synchro and cannot simulate freeway elements, it is discussed in this chapter with along other analytical tools.

A SimTraffic model is created by importing a Synchro model. Therefore, any Synchro coding error or warning should be reviewed and corrected before initiating SimTraffic.

6.4.1 Inputs for Synchro/SimTraffic

Basic inputs for Synchro are identified in **Table 5-1** in **Chapter 5**. To obtain reasonable results, the analyst should use existing (or field-measured) data as much as possible. The following specific input guidelines should be followed when preparing Synchro traffic models:

- *Nodes*

Numbering of nodes in logical order along the main street is recommended to enhance the review of the results.

- *Traffic Demand*

Hourly volumes should be used. Volumes and heavy vehicle percentages (T) should be calculated based on the existing Turning Movement Counts (TMCs) data. In absence of count data, guidelines provided in the HCM-based Tools should be used.

- *Lane Utilization Factor*

This parameter only affects Synchro's saturation flow rate, it is not used by SimTraffic. Default lane utilization factors should be overridden with field measurements when more vehicles use one (1) lane group than the other. Additionally, as demand approaches capacity, lane utilization factors that are closer to 1.0 may be used to override default values.

- *PHF*

The Synchro default PHF is 0.92. Refer to PHF guidelines provided in **Section 6.2**.

- *Signal Timing*

Signal timing plans including offsets, cycle lengths, interconnection and phasing plan should be obtained from the district traffic operations offices or local agencies maintaining the signals. For future analyses that require signal retiming, timing data should be calculated based on the Manual on Uniform Traffic Control Devices (MUTCD) requirements and the guidelines published in the FDOT Traffic Engineering Manual (TEM).

- *Bends and Short Links*

When coding the street network, excessive bends and short links should be avoided as they impair performance of the SimTraffic model or other models when built from Synchro. It is recommended to use curved links as much as possible instead of bend nodes.

- *Intersection and Street Geometry*

These parameters include number of lanes, turn lanes, storage lengths and grade. Data for existing analysis should be obtained from field measurements or as-built (record) drawings. Future analyses should be based on proposed design plans. In absence of field measurements or design plans, the analyst should consult HCM, FDOT Design Manual (FDM), FDOT Design Standards, or FDOT TEM for selection of standards and other project parameters that are specific for a project and would require deviations from the standards. The analyst is required to document justification for any deviations from the standards that will help the development of the design exception/variation process.

- *Link Speeds*

Link speeds coded in the Synchro network should match the posted speed limit or actual operating speed of the roadway.

6.4.2 Calibration of Synchro and SimTraffic

The following guidelines are provided for Synchro model:

- Lost time adjustment factor should be adjusted to replicate field observed queue lengths.
- In urbanized areas, default gap acceptance factor should be checked and modified to replicate field conditions.
- To calculate reasonable queuing in the model, all link terminals should extend at least 1,000 feet from the last node.
- 95th percentile queue lengths that are tagged with "#" or "m" should be examined for the extent of queuing problems. The "#" indicates that the volume for the 95th percentile cycle exceeds capacity. The "m" indicates that volume for the 95th percentile queue is metered by an upstream signal.

SimTraffic simulation model requires calibration to simulate the existing traffic operating conditions. Before adjusting SimTraffic calibration parameters, it is advised that the analyst verify the Synchro input parameters such as lane assignments, demand and PHF are coded correctly.

SimTraffic simulation model requires calibration to simulate the existing traffic operating conditions.

At a minimum, simulation report should include vehicles exited, 95th percentile queues and travel times/speeds. The analyst should verify the number of vehicles exiting the intersection is within 5% of the input volumes. Calibration target for queues, speeds and travel time should follow the guidance outlined in **Chapter 7**.

SimTraffic calibration parameters are:

- Headway factor
- Driver reaction time
- Lane usage

Headway factor adjusts headways on a per movement basis. It is used to calibrate the saturation flow rates. When calibrating saturation flow rates, the link turning speeds should be coded as realistically as possible.

Driver reaction time can be field calibrated by observing the level of aggressiveness of the drivers as they cross the intersection—a typical urban core area driver is more aggressive than a rural area driver.

Lane usage or lane choice in SimTraffic is controlled by Positioning/Mandatory Distance parameters. Prior to changing these parameters, it is advised the analyst should review the simulation for any unbalanced lane utilizations or unbalanced queue and compare with the existing conditions to determine the cause of the problem.

Additional calibration guidance that is provided by Trafficware, developers of Synchro and SimTraffic, is summarized in **Table 6-1**. The order of adjustment preference is 1, 2, 3.

SimTraffic takes direct input from Synchro network and is not as robust as the other microsimulation programs such as CORSIM and Vissim. Therefore, SimTraffic based simulation can be used to screen alternatives at the planning stage but its use is not recommended for projects requiring operational analysis such as design and IARs.

SimTraffic takes direct input from Synchro network and is not as robust as the other microsimulation programs such as CORSIM and Vissim.

Table 6-1 Guidance for Calibrating SimTraffic Model

Traffic Flow Issues in the Model	SimTraffic Calibration Parameters								
	Link-Based Parameters (Synchro Simulation Settings)				Global Parameters - Model (SimTraffic Drivers and Internal Settings)				
	Lane Alignment	Mand. & Pos. Dis.	Turning Speed	Headway Factor	Speed Factor (%) Alignment	Headway @ 0, 20, 50, & 80-mph	Gap Accpt.	Mand. & Pos. Dist Adjust (%)	PHF Adjust & Anti PHF Adjust
Vehicles too slow when making a left or right turn			1						
Queuing seems too short/long (assuming no upstream bottle-necks)	1						2		3
Travel time seems too low/high					1				
Lanes not utilized properly - unbalanced queues		1						2	
Volume simulated too low			1	2		3			

Mand. & Pos. Dist. = Mandatory and Positioning Distance
Gap Accpt. = Gap Acceptance

Chapter 7
Microsimulation Analysis

Microsimulation programs involve the application of car-following and lane-changing models to replicate traffic flow on the transportation facility. Microsimulation traffic models use input information (e.g., traffic volume, facility type, vehicle-driver characteristics) to move traffic using simple acceleration, gap acceptance and lane change rules on a split second (time step) basis. Microsimulation models cannot optimize traffic signals but rather have strong ability to examine complex congested traffic conditions in urban areas. Typical outputs of the microsimulation model are given per individual vehicle in form of text reports and visual animations.

This chapter provides guidance on the traffic microsimulation analysis by highlighting key steps to be followed when performing microsimulation analysis. Emphasis is given to the base model inputs, quality control checks and calibration process. The guidelines contained in this chapter are intended for CORSIM and Vissim models. This guidance is not applicable to multimodal alternative analysis studies.

This chapter provides guidance on the traffic microsimulation analysis by highlighting key steps to be followed when performing microsimulation analysis.

Additional guidance is provided in **Chapter 8** for microsimulation analysis of express lanes. Guidance for SimTraffic simulation is provided along with Synchro guidance in **Chapter 6** because SimTraffic takes direct input from Synchro network.

The following topics are covered in this chapter. Each of these topics are covered in detail in subsequent sections.

1. Base Model Development using CORSIM and Vissim Microsimulation software.
2. Model Verification/Error Checking for CORSIM and Vissim Microsimulation software.
3. Model Calibration and Validation using CORSIM and Vissim Microsimulation software.
4. Correcting Effects of Unmet Demand in CORSIM and Vissim Microsimulation models.
5. Future Year Model Verification.
6. Calibration and Validation Report.
7. Model Calibration Reviewer’s Checklist.
8. Maintenance of Traffic (MOT) Analysis using Microsimulation Models.
9. Animation
10. Model Manual

7.1 Base Model Development

A base-year model (base model) is a simulation model of the existing (or current) conditions which serves as the foundation from which other project modeling alternatives are built. Development of an accurate and verifiable base model is essential to simulate the existing traffic characteristics.

Before starting to code the base model, the analyst may review previous microsimulation projects within the region. The review would help the analyst to understand modeling issues and calibration parameters.

To increase modeling efficiency, the base model for one (1) analysis period should be fully developed, calibrated and functional before creating other analysis period scenarios. The goal of the calibration effort is to develop a set of calibration parameters that reflects the operating conditions of both the AM and PM peak periods. If this cannot be achieved, documentation must be provided to justify multiple sets of calibration parameters for the base model. Calibration parameters in the base model are carried forward in all subsequent models. Base model development guidelines for CORSIM and Vissim are provided in this section.

To increase modeling efficiency, the base model for one (1) analysis period should be fully developed, calibrated and functional before creating other analysis period scenarios.

7.1.1 CORSIM Modeling Guidelines

A step-by-step procedure to develop a CORSIM model is presented in the FHWA Traffic Analysis Toolbox Volume IV. Key issues and specific input requirements are highlighted in the following subsections.

Coding

When coding a CORSIM model, the analyst should adhere to the following general guidelines:

- Use base map (orthorectified aerial image and computer aided drafting and design (CADD) drawing) to create link-node diagram. A simulation model built from a base map with the real world coordinate system would be easily transferable from one (1) phase of the project to another or easily merged to another project. Thus, developing a link-node diagram using real world coordinates is recommended. Lane schematics should also be prepared using CADD, Microsoft Excel or any other graphic design program. Examples of a link-node diagram and lane schematics showing node numbering scheme are shown in **Figure 7-1** and **Figure 7-2**, respectively.
- Use different sets of numbers of nodes to represent different areas of the network. For example, use 1000s for a freeway and 100s for the arterial segments. The node numbering scheme depicted in **Table 7-1**, which is adapted from the FHWA Traffic Analysis Toolbox Volume IV, is recommended. A standardized node numbering scheme can assure the quality of the model by reducing modeling mistakes.

Additionally, use of the standardized numbering system would not only simplify the model review process but also minimize efforts that would be required to reuse the model with a different design or operational condition.

- The node numbering begins upstream of the facility and increases sequentially to the end of the facility. The node numbering should include gaps between nodes to accommodate future or revised access points.

Figure 7-1 Link-Node Diagram

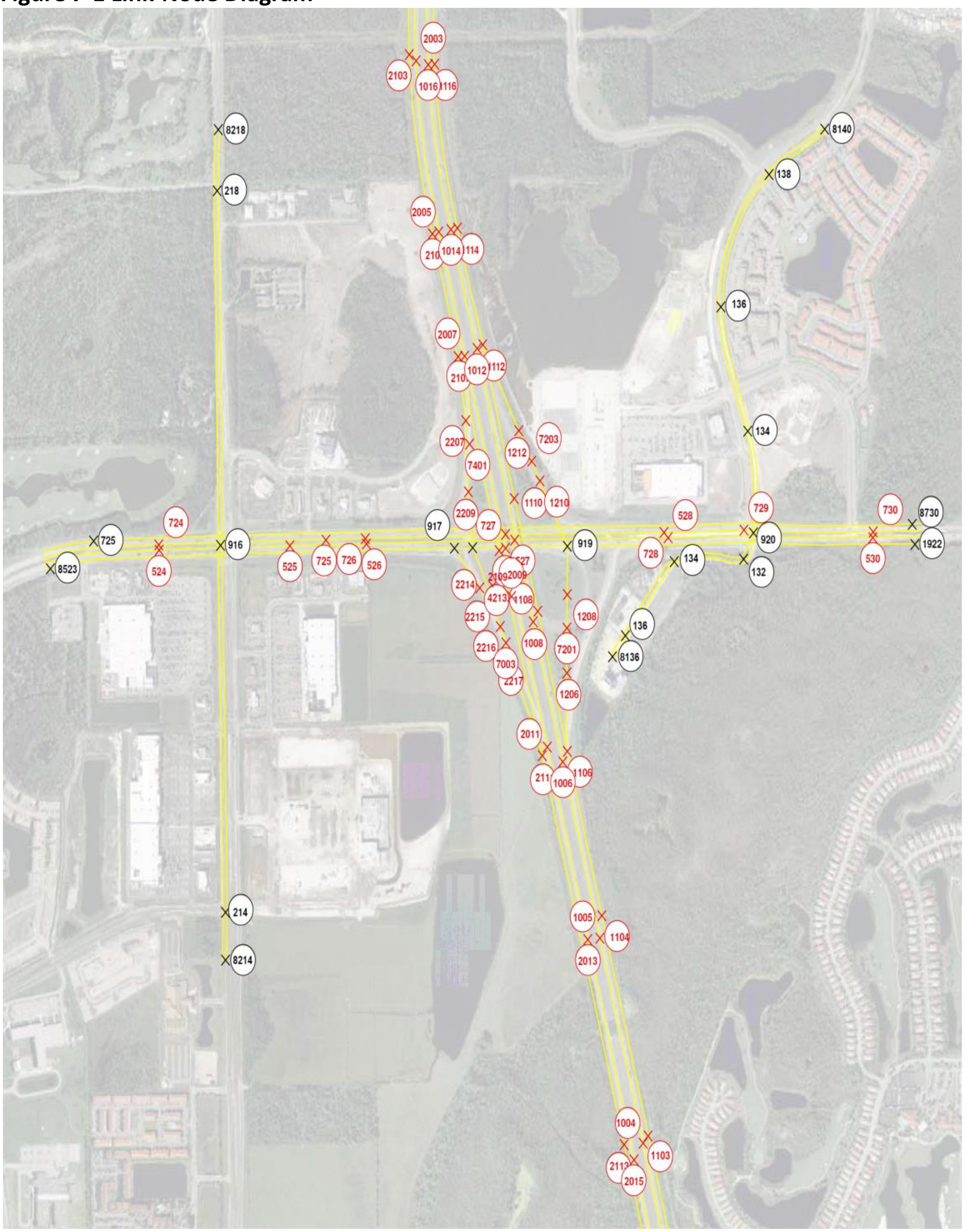


Figure 7-2 Lane Schematics Showing Node Numbering Scheme

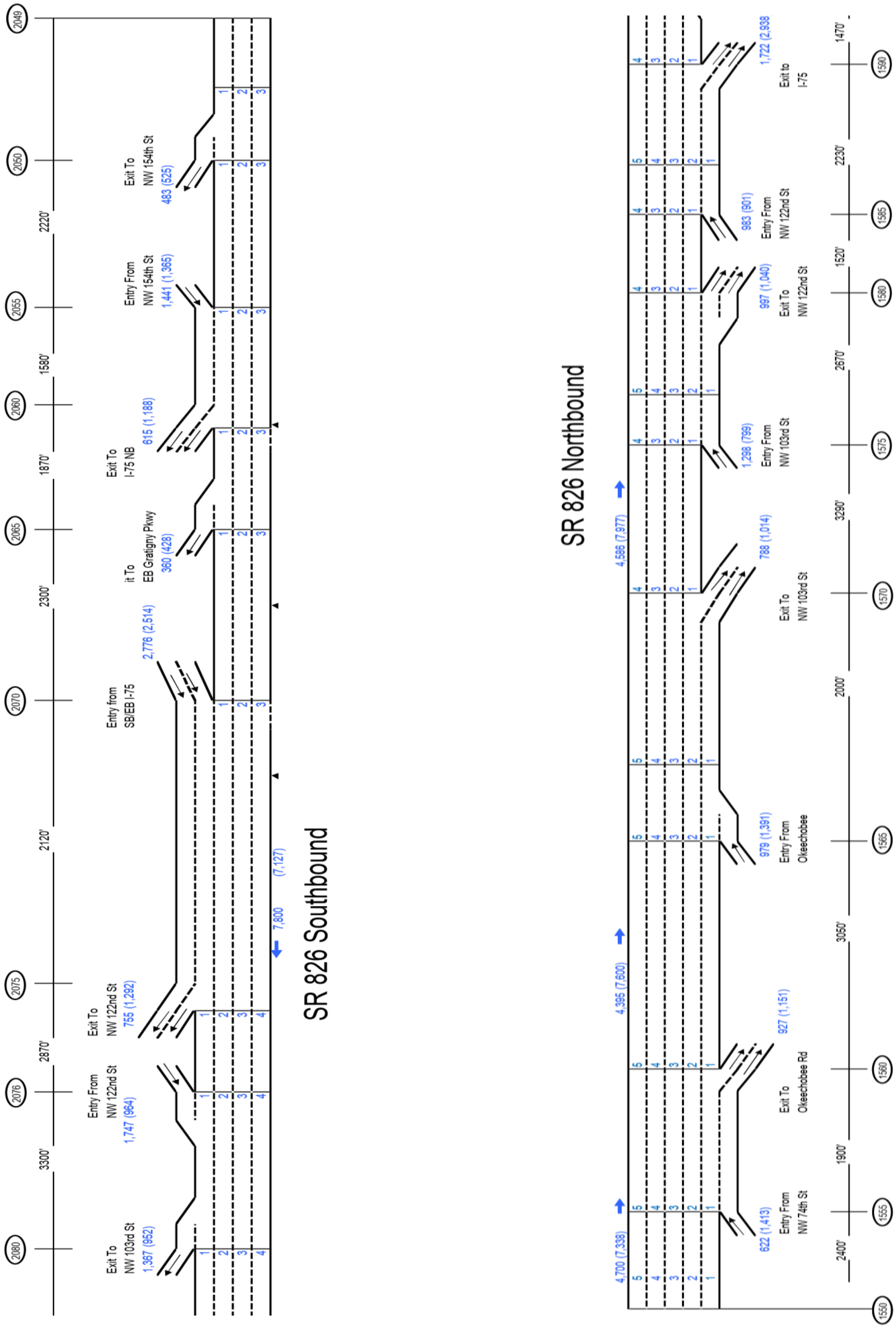


Table 7-1 Node Numbering Scheme

Range		Description
From	To	
1	999	Surface Street
1000	1199	Northbound Freeway Mainline
1200	1299	Northbound Freeway Ramps
2000	2199	Southbound Freeway Mainline
2200	2199	Southbound Freeway Ramps
3000	3199	Eastbound Freeway Mainline
3200	3299	Eastbound Freeway Ramps
4000	4199	Westbound Freeway Mainline
4200	4299	Westbound Freeway Ramps
5000	5999	East-West Arterials
6000	6999	North-South Arterials
7000	7999	Interface Nodes
8000	8999	Network Entry Nodes

Source: FHWA Traffic Analysis Toolbox Volume IV

- Node values in the range between one (1) and 999 should be assigned on surface streets. The lowest range of node numbers is recommended for surface streets as the Synchro software is often used to create a preliminary surface street network for CORSIM. Nodes created by Synchro start at number one (1).
- Split the links and place nodes consistent with the HCM definition of Analysis Segments for a Ramp Configuration as documented in the HCM Freeway Facilities Chapter. For instance, to correlate the CORSIM model to the LOS criteria for ramp junctions, a node should be placed 1,500 feet away from the ramp junction.
- Code curves on freeway and ramp alignments only when the radius of the curve is less than 2,500 feet.
- Space nodes at an average of 2,000 feet or less throughout the freeway network to facilitate the review of MOEs. Multiple nodes should be considered on long stretch of basic segments. The 1,500 feet rule on ramp influence areas should be applied as much as possible consistent with the HCM definition of the merge and diverge density.
- Code a node at a ramp meter location in ramp-metered operations.
- Code 15-minute volumes that are derived from a profile of the balanced hourly traffic throughout the study period. The onset, presence and dissipation of congestion are incorporated by varying the input volumes over multiple time periods.
- Code sink/source nodes at significant traffic generators to account for volume imbalances.
- Review and correct any errors when Synchro network is transferred into CORSIM.
- Document all assumptions made during the model development process to aid the reviewer and potential future modeler to understand the analyst’s intent.
- Perform cursory reviews of the network at multiple steps in the development of the

base model to catch and correct any errors as early as possible in the coding process.
- Place nodes feeding the approaches to the intersection far enough away so that storage lanes can be accommodated. It is recommended to place entry/exit nodes at the center of adjacent intersections.
- Place interface nodes closer to the freeway mainline at exit ramps and closer to the arterial street at entrance ramps.

Coding O-D data

Often O-D tables created by CORSIM are inaccurate. The inaccuracies are most prevalent when the model includes both surface streets and freeways. Therefore, it is highly recommended that the analyst develop and code full O-D tables before testing the model. This approach would contribute to significant time savings. When O-D tables are used, the analyst should develop a spreadsheet to estimate (and balance) entry volumes and exit percentages based on O-D data.

An O-D table can be developed by utilizing select link analysis output from the TDM. Alternatively, O-D table can be created by assigning weaving movements before estimating the remaining O-D percentages. Using this approach, the analyst must use balanced entry and exit volumes.

Coding Vehicle Data

CORSIM has four (4) different vehicle fleets (Passenger Car, Truck, Bus and Carpool) and defaults to nine (9) vehicle types as shown in **Table 7-2**. Equivalent FHWA Classification Scheme F classes are also shown in **Table 7-2**.

Table 7-2 Default CORSIM Vehicle Fleet Specifications

Vehicle Fleet	Vehicle Type	Type Description	Default % NET/FRE	Length (ft)	Occupancy	FHWA Scheme "F" Class
Passenger Car	FRESIM 1- NETSIM 5	Low-performance car	25/25	14	1.3	1 - 3
	FRESIM 2 – NETSIM 1	High-performance passenger car	75/75	16	1.3	
Truck	FRESIM 3 –NETSIM 2	Single unit truck	100/31	35	1.2	5 -7
	FRESIM 4 – NETSIM 6	Semi-trailer with medium load	0/36	53	1.2	8- 10
	FRESIM 5 – NETSIM 7	Semi-trailer with medium load	0/24	53	1.2	
	FRESIM 6 – NETSIM 8	Double-bottom trailer	0/9	64	1.2	11- 12
Bus	FRESIM 7 – NETSIM 4	Conventional	100/100	40	25.0	4
Carpool	FRESIM 8 – NETSIM 9	Low-performance Carpool	0/25	14	2.5	1-3
	FRESIM 9 – NETSIM 3	High-performance Carpool	100/75	16	2.5	

Scheme F classification counts are obtained from the Florida's continuous traffic monitoring sites. By default, 25% of passenger cars have a length of 14 feet and 75% of passenger cars have a length of 16 feet. When there is no possibility of queue spillover or queue spillback, vehicle length would have no significant effect on the simulation results. It may be necessary to evaluate vehicle composition/length of cars within the study area when no other adjustments to modeling parameters provide accurate results. These adjustments should have supporting justifications.

7.1.2 CORSIM Model Input Parameters

Table 7-3 provides specific guidance to CORSIM input data. The default values or range of values were created based on the experiences of developing CORSIM models throughout the state of Florida. The table should be used by both analysts and reviewers. Additional default values are listed in **Table 7-11**. When different values are coded, justification for these values should be provided.

Table 7-3 Guidance to CORSIM Model Input Parameters

Input	Guidance
Vehicle entry headway	☐ Erlang distribution with parameter "a" set to 1 for networks with FRESIM dominance ☐ Normal distribution for networks with arterial dominance
Time periods	☐ Use approved temporal limit of analysis; One (1) time period is 900 seconds ☐ Time interval duration is typically 60 seconds
Node IDs	☐ Confirm to node numbering scheme
Freeway geometry	☐ Enter lane numbers, lane types, ramp positions, lane add/drops per approved spatial limit of analysis ☐ Enter correct link lengths per lane schematics ☐ Enter correct warning sign location for anticipatory lane change, exit ramps
Arterial geometry	☐ Enter number of lanes, storage lanes, lane drop/add locations ☐ Enter correct link lengths per lane schematics ☐ Network length should match approved spatial limit of analysis
Grade	☐ Code grades ≥ 4% if longer than 2600 ft
Freeway radius	☐ Code curves on mainline and ramps only when their radii are less than 2,500 feet
FFS	☐ Use field-measured FFS
Off-ramp reaction points	☐ Code an actual measured point if known, default is 2,500 feet
Traffic demand	☐ Enter entry volume (vehicles per hour) explicitly for each time period if proportion of turning vehicles is relatively stable over the analysis period ☐ Enter turn percentages for the first time period only ☐ Enter percentage of trucks and carpool for each time period
O-D data	☐ Enter O-D data for each time period when required ☐ Pay attention to the O-D within weaving areas
Minimum separation for generation of vehicles	☐ 1.6 seconds
Lane distribution	☐ Enter percentages based on field data (FRESIM only)
Freeway ramp exit volumes	☐ Enter for the time period for first period only
Intersection control types	☐ Code pre-timed versus actuated as per approved methodology ☐ In consultation with traffic operations and signal system engineers, exercise caution in changing the parameters
Traffic control	☐ Code all freeway and arterial control parameters correctly and as per confirmed methodology
Traffic management	☐ Code all types of operations and management data that exist on the system

*Additional input default values are listed in **Table 7-11.**

7.1.3 Vissim Modeling Guidelines

For a step-by-step procedure used to develop Vissim models, the analyst should refer to the PTV's Vissim User Manual. Key issues and specific input requirements are only highlighted in the following subsections.

Coding

When coding a Vissim model, the analyst should adhere to the following general guidelines:

- General:
  - Prepare lane geometry and network configuration with balanced demand volumes.
  - Create a scaled base model from an orthorectified aerial image, CADD drawing or other scaled background images.
  - Minimize the number of connectors as much as possible by avoiding unnecessary segmentation along the corridor sections with similar geometry.
  - Minimize or eliminate links and connectors overlap since overlaps tend to affect traffic flow in the network.
  - Differentiate display types for overlaps between freeway elements and arterial streets.
  - Identify areas where planned improvements (in the proposed model) are likely to change the initial coding to accommodate future splitting of links and addition of connectors.
  - Code data collection points, travel time sections and queue counters or use node evaluation to collect delay and queue length. Increase the default Upstream Start of Delay Segment parameter, in the Node Evaluation settings, to capture queue delay.
  - Code external links (where vehicles enter the network) such that all vehicles (demand volume) can be loaded into the model within the analysis time period.
  - Vehicle Compositions, Vehicle Inputs and Vehicle Routing Decisions work together to determine what Vehicle Types are simulated and what Desired Speed Distributions are used on external links (Compositions), how many vehicles are simulated (Inputs) and where those vehicles go in the network (Routings). These three (3) networks parameters are closely related and should be considered together when developing a Vissim network.
  - Desired Speed Decisions (DSD) permanently update the Desired Speed of a vehicle. Once a vehicle encounters a DSD, the Desired Speed will be updated according to the Desired Speed Distribution associated with that DSD for that Vehicle Class.
  - Reduced Speed Areas (RSA) assign a temporary reduction in speed to a vehicle while that vehicle is within the defined RSA, after leaving the RSA the vehicle continues to travel at the Desired Speed from before it encountered the RSA. For loop ramps, it is recommended to use RSA to code the reduction in speed.
  - Identify initial locations for Conflict Areas and Priority Rules, such as permissive left turns, right-turns-on-red, minimizing excessive intersection congestion, etc.

- Freeway:
  - Freeway facilities should be coded using the default freeway link behavior type (based on the Wiedemann 1999 car-following model). Modifications are typically made to create custom driving behaviors during the model calibration process.
  - Prepare lane schematics for the network. Freeway links in the Vissim model should be split based on the HCM Freeway Facilities definitions (Merge / Diverge / Weave / Basic Freeway).
  - The parallel type of merge/diverge section can be coded as a single link with the number of lanes equal to the mainline plus auxiliary lanes. For taper type merge/diverge section, code as a connector separating from the freeway or a single link with the number of lanes equal to the mainline plus a short auxiliary lane.
  - Separate Merge/Weaving Parameter Set from Freeway (free lane selection). However, the number of additional link types should be minimized to the extent possible.
  - Default lane change distance used in Vissim should be increased for Freeway off-ramps and merges. It is recommended to use the 'per lane' option to avoid using excessively long lane change distances. It is recommended to use 1000 feet per lane change distance when ‘per lane’ option is selected.
  - Desired Speed is the FFS of the facility. It is solely dependent on the roadway design and driver aggression and is not affected by weather, congestion, incidents, or any other impedances. Desired Speed measurements in field should be taken during free-flow time of day and should be exhibited as a distribution of existing FFS along the corridor. Field speed data collected in peak hour does not represent FFS and is impacted by multiple variables. Field measured peak hour speed represent actual speed of the corridor which should be replicated in the calibrated model during simulation using Desired Speed or FFS as an input. Desired Speed can also be obtained through existing ITS devices (vehicle detectors or SunPass readers).

- Arterial:
  - Arterial facilities should be coded using the default urban link behavior type (based on the Wiedemann 1974 car following behavior). Modifications are typically made to create custom Driving Behaviors during the model calibration process.
  - Code driveway links between major intersections to reflect significant volume gains or losses between the intersections (e.g., a volume sink/source).
  - Code intersections turn bays as separate links. Code turning movements and weaving movements to occur across connectors.
  - Define all critical intersections as nodes for evaluation purposes.
  - Increase the default maximum queue length parameter to capture longest queue possible.
  - Code special use lanes as part of multilane link using lane closures ('Blocked Vehicle Classes' and 'No Lane Change Left/Right' link settings).
  - Combine Static Routing Decisions option for locations in which vehicles may need more time to react to closely spaced intersections.

Vissim simulation model development guidelines are provided in **Table 7-4** below to streamline coding and model review process. Additional default input values are provided in **Table 7-12**.

Table 7-4 Guidance to Vissim Model Development

Item	Guidance
Simulation parameters	☐ Set simulation period to be equal to the approved temporal limit of analysis plus a warm-up time. ☐ The warmup time should be at least equal to twice the time it takes for a vehicle to fully traverse the network. ☐ Simulation resolution has a significant impact on the capacity. Simulation resolution of 10-time steps/simulation second is recommended. For a large network 5-time steps/simulation second is also acceptable. In very large planning studies, a time step of up to one (1) second can be used.
Desired speed	☐ Use FFS distribution from field measurements, through existing ITS devices (vehicle detectors or SunPass readers) or previous studies at similar locations based on guideline provided in **Section 7.1.3**
Route decision and O-D data	☐ Use O-D tables from adopted (and validated) regional model or O-D data collected during data collection. When traffic assignment is used over a model, it should be calibrated and validated. ☐ Freeway lane change distance on freeways should be located on per lane basis. Code location of routing decision points to match sign location or field observations and user demographics to allow for accurate weaving and/or merging and lane utilization. ☐ For closely spaced intersections, Combine Routes tool should be used to combine static routes. ☐ Vehicle routes should be coded in 15-minute or hourly demand increments. ☐ Dynamic traffic assignment is preferred on large networks or when actual route behavior is of interest to solve the problem. ☐ Routing decision must be reviewed to verify correct route paths have been defined accurately in the network.
Traffic demand	☐ Input balanced demand (15-minute) volumes including traffic composition for all links entering the network. ☐ Default vehicles in the North American Default.inpx should be used instead of Vissim standard default.
Traffic control and management	☐ Conflict areas are preferred over priority rules to control permissive movements in signalized intersections and all movements in unsignalized intersections. In other situations, priority rules are preferred. ☐ Ring Barrier Controller (RBC) should be used whenever possible and the vehicle actuated programming (VAP) module can be used to model unique and complex traffic controls that RBC cannot model. ☐ Code all types of operations (Right Turn on Red, Protected/Permissive left turn movements, and Overlap Phases) and management data that exist on the system. ☐ Code signal heads, stop bars and detectors at proper locations. ☐ In consultation with traffic operations and signal system engineers, exercise caution in changing the parameters
Assumptions	☐ Document all assumptions made during network coding to streamline the review process.

*Additional default input parameters are listed in **Table 7-12.**

Coding O-D data

For complex networks, that have multiple routes or paths, coding of O-D data using dynamic assignment is preferred over static route assignment because it predicts travel behavior more realistically. Dynamic assignment has a potential to capture temporal interactions of the transportation demand and supply, congestion build-up and dissipation and the effect of traffic controls such as ramp metering, traffic signals and ITS technologies. Dynamic assignment allows Vissim to assign traffic to the network using O-D tables (time and vehicle class-dependent) and travel cost function. O-D matrices can be obtained from TDMs. Each O-D table is related to a user-supplied traffic composition and to a 15-minute period of the simulation.

When Dynamic assignment method is used, it is recommended to check convergence of the model using "Travel Time on Paths" criteria. The two (2) other options should be left unchecked. Convergence will be assumed to be satisfactorily met (and hence stable model) when 95% of travel time on all paths change by less than 20% for at least four (4) consecutive iterations for each peak time interval.

7.2 Model Verification/Error Checking

Before proceeding to calibration, the base model has to be examined for completeness and accuracy. The objective of the model verification step is to confirm the model building process is complete and the model contains no errors in its implementation. A verified simulation model does not necessarily meet the performance goal of the analysis. When an error-free model is prepared and accurately measured data is entered, the calibration process would be more efficient. The model verification is conducted by reviewing software error messages (including warnings), input data and model animation. The verified simulation model after completing the peer review should be used for calibration process.

A verified simulation model does not necessarily meet the performance goal of the analysis.

7.2.1 Base Model Verification Checklist

Checklists for verifying the accuracy of the base model coded using CORSIM and Vissim are provided as **Table 7-5** and **Table 7-6**, respectively.

The following strategies can be used to increase the effectiveness of the verification process:

- Use the latest version and "patch" or "service pack" of the software to ensure latest known bugs are corrected by software developers. Additionally, a review of the software and user group websites would help to understand workarounds for some known software problems.
- If a software error (computational limitation) is suspected, code simple test problems (such as a single link or intersection) or sub-network where the solution can be

computed manually and compare the manually computed solutions to the model output. It is essential to fix errors in the order they are listed.

- Use color codes to identify links by the specific attribute being checked (for example: links might be color coded by FFS range, facility type, lanes, etc.). Out of range attributes or breaks in continuity can be identified quickly if given a particular color.
- Review intersection attributes.
- Load 50% or less of the existing demand and observe vehicle behavior as the vehicles move through the network. Look for congestion that shows up at unrealistically low demand levels. Such congestion is often due to coding errors.
- Load the network with 100% demand and review MOEs such as speeds and processed volumes. Any substantial difference from the field measurements could indicate a modeling error.
- Follow or trace a single vehicle through the network (possibly at very low demand levels) and look for unexpected braking and/or lane changes. Repeat for other O-D pairs.
- Look for network gridlock and consistent traffic conflicts (vehicle-vehicle, vehicle-pedestrian/bike) which may indicate coding errors.
- Visual inspection should be performed to ensure the model replicates field observations. When the model animation shows unusual traffic behavior, the behavior should be verified in the field.

Table 7-5 CORSIM Model Verification (Error Checking) Process Checklist

Project Name: ____
State Road Number: _______________ **Co./Sec./Sub.** _______________

Error Type	Description	Check
Software	☐ Verify no runtime error existing in the network	☐
	☐ Verify runtime warning messages do not affect network operation	☐
Model run parameters	☐ Verify number of time periods against temporal boundary limit	☐
	☐ Verify fill time is large enough to load network with vehicles	☐
	☐ Check the output data to verify equilibrium has been reached	☐
Network	☐ Verify spatial boundary limit against link-node diagram	☐
	☐ Check basic network connectivity. Are all connections present?	☐
	☐ Verify if the link-node diagram has been created, and a base map was created in real world coordinates	☐
	☐ Verify lane schematics and check link geometry (lengths, number of lanes, FFS, facility type, etc.)	☐
	☐ Check for prohibited turns, lane closures and lane restrictions at intersections and on links	☐
Demand	☐ Verify coded volumes and against counts	☐
	☐ Check vehicle mix proportions	☐
	☐ Check identified sources and sinks for traffic. Verify sink volumes against traffic counts	☐
	☐ Check lane distributions	☐
	☐ Check turn percentages	☐
	☐ Verify O-D on the network when coded	☐
Control	☐ Check intersection control types and data	☐
	☐ Check ramp meter control types and data	☐
Traffic operations and management data	☐ Verify bus operations—routes, dwell time	☐
	☐ Check parking operations	☐
	☐ Verify pedestrian operations and delays	☐
Driver behavior and vehicle characteristics	☐ Check and revise, as necessary, the default vehicle types properties and performance specifications	☐
	☐ Check and revise, as necessary, the driver behavior specifications	☐
Animation	☐ Review network animation with the model run at extremely low demand levels-check for unrealistic operational characteristics	☐
	☐ Review network animation with 50% demand levels	☐

Table 7-6 Vissim Model Verification (Error Checking) Process Checklist

Project Name: ______________________________

State Road Number: ________________ **Co./Sec./Sub.** ________________

Error Type	Description	Check
Software	☐ Verify no runtime or syntax error occurs in the Protocol Window	☐
	☐ Review the error file (.err) for any errors or runtime warnings that affect simulation results	☐
	☐ Review RBC errors or warnings	☐
Model run parameters	☐ Review temporal boundary limit to confirm it matches the approved methodology	☐
	☐ Verify initialization period is at least equal to twice the time to travel the entire network	☐
Network	☐ Verify spatial boundary limit against approved methodology	☐
	☐ Check basic network connectivity.	☐
	☐ Verify the background image has been properly scaled	☐
	☐ Verify link geometry matches lane schematics	☐
	☐ Check link types for appropriate behavior parameters	☐
	☐ Check for prohibited turns, lane closures and lane restrictions at intersections and on links	☐
	☐ Check and verify traffic characteristics on special use lanes against general use lanes	☐
	☐ Check default vehicles have been updated to those in the North American Default.inpx and ensure trucks are updated to reflect typical sizes found within project area	☐
Demand and routing	☐ Verify coded volume and vehicle mix/traffic composition	☐
	☐ Check HOV vehicle type and occupancy distribution as appropriate	☐
	☐ Check routing decision including lane change distances	☐
	☐ Verify O-D matrices and their placement in the network	☐
Control	☐ Check and verify intersection control type and data are properly coded. Verify no error messages or warnings exists in signal control window that affect simulation results. Verify vehicles are reacting properly to the controls	☐
	☐ Check ramp meter control type and data	☐
	☐ Check conflict area settings	☐
Traffic operations and management data	☐ Verify bus operations—routes, dwell time	☐
	☐ Check parking operations	☐
	☐ Verify transit operations behave as expected and do not deviate from expected operation lanes	☐
	☐ Verify pedestrian operations and delays	☐
Driver and vehicle characteristics	☐ Check if driver behavior adjustments are necessary in saturated conditions	☐
	☐ Verify no lane changes occur in unrealistic locations and vehicles make necessary lane changes upstream in appropriate location	☐
	☐ Verify average travel speed reasonably match field conditions	☐
Animation	☐ Review network animation with the model run at low demand levels—check for unrealistic operational characteristics such as congestion and erratic vehicle behaviors	☐
	☐ Review reasonableness of the model against data coding, route assignment and lane utilization	☐

	☐ Compare model animation to field characteristics	☐
	☐ Verify all turn bays are fully utilized and they are not blocked by through vehicles	☐
	☐ Verify there are no vehicles turning at inappropriate time or locations	☐
	☐ Verify vehicles respond appropriately to all modeled traffic controls	☐

7.3 Model Calibration and Validation

Model calibration and validation is the most important, yet challenging step of developing a realistic microsimulation model.

- Calibration is an iterative process whereby the model parameters are adjusted until simulation MOEs reasonably match the field measured MOEs. Calibration requires both software expertise and knowledge of existing traffic conditions.
- Model validation is the process of testing the performance of the calibrated model using an independent data set (not previously used in the calibration). Validation is an additional check to confirm that a model has been correctly calibrated and closely match the existing conditions.

Calibration is performed for all base models prior to their applications to reduce prediction errors. When AM peak and PM peak models are prepared, both models must be coded with the guidance provided in the Base Model Development Section of this chapter. Calibrated parameters from the base model are to be carried forward without being changed in the future year (proposed) models unless adequate justification is provided (e.g., changes in geometry). It is important to note that calibration includes modifying model parameters that control driving behavior to replicate the field conditions. Calibration parameters should be distinguished from model input parameters such as number of vehicles, number of lanes, vehicle mix, network terrain, etc., which are field collected. The accuracy of the model input parameters is checked during the model verification/error-checking stage as outlined in the previous section.

It is important to note that calibration includes modifying model parameters that control driving behavior to replicate the field conditions.

Default values for the model calibration parameters are provided as a starting point to model real world traffic conditions and do not necessarily represent the analysis area characteristics. The initial step of calibration is to compare graphically and visually the simulation performance data based on default parameters with the field data. The field data collection locations should match the data collection points in the simulation network to obtain comparable results. Only under very rare conditions will the model be able to replicate the

The field data collection locations should match the data collection points in the simulation network to obtain comparable results.

existing conditions using default values. As such, calibration of these parameters is essential to replicate the reality to a high degree of confidence.

The analyst should refrain from using default or calibrated values from other software models because their computational algorithms are different.

7.3.1 Model Calibration Process

Simulation model calibration process involves iteratively changing default parameters, simulating the model and comparing calibration MOEs with field measured MOEs. If the residual errors between simulated and field measured MOEs are within an acceptable margin of error, the model is calibrated; otherwise, model parameters are modified until all MOEs residual errors are within the acceptable range. The modified values of the calibrated parameters should be reasonable and realistic. The calibration process involves the following and each of these are discussed in subsequent sections:

- Defining the objectives of calibration.
- Determining a calibration strategy to achieve the objectives.
- Determining the minimum required number of simulation runs.
- Performing calibration and validation to obtain an acceptable field match.

The model calibration process should place a high emphasis on matching the MOEs at critical locations on the network such as bottlenecks and areas where improvements are proposed.

In addition to evaluating calibration MOEs, a qualitative evaluation of the model must be performed by visual inspection of the animation of the calibrated base model against field observations to determine the degree of reasonableness that the model replicates reality.

7.3.2 Calibration Objectives

The objective of the calibration process is to minimize the difference between simulation MOEs and the field measured MOEs by iteratively adjusting calibration parameters. To properly calibrate a microsimulation model, calibration locations on the simulation network and their MOEs should be known when data collection plan is devised. This would enable collection of adequate and relevant data that is used to test the performance of the simulation model in replicating real world traffic operating conditions.

A minimum of two (2) performance MOEs in addition to capacity and traffic volumes should be selected for calibration. When modeling limited access facilities, at least one (1) of the MOEs must be associated with surface streets modeled within the analysis limits. The system performance MOEs include travel time, speed, delay and queue length.

A minimum of two (2) performance MOEs in addition to capacity and traffic volumes should be selected for calibration.

7.3.3 Model Calibration Strategy

Since model calibration is an iterative process, the analyst should develop a practical strategy for achieving the objectives of calibration. A good practice is to divide the calibration parameters into two (2) basic categories that must be dealt with separately:

- *Parameters that the analyst is certain about and does not wish to adjust.*

  The values of these parameters are measured directly from the field and input in the model (e.g., vehicle length). Parameter values which can be taken from previous analyses and are applicable to the problem being analyzed also belong in this category. Also included in this category are parameters which do not have strong influence on the calibration MOEs.

- *Parameters that the analyst is less certain about and is willing to adjust.*

  Included in this category are parameters that have high to medium levels of sensitivity to the calibration MOEs.

Thus, it is worthwhile to focus more on calibrating parameters that are appropriate to the problem being solved and have strong influence on the calibration MOEs. Working on parameters that influence the calibration MOEs reduces the amount of time to adjust and calibrate the model. It is also important to divide adjustable parameters into those that directly affect capacity and those that impact route choice.

> It is worthwhile to focus more on calibrating parameters that are appropriate to the problem being solved and have strong influence on the calibration MOEs.

Parameters to be adjusted should be divided into global and local parameters. Global parameters affect all elements of the simulated network while local parameters affect individual links or points in the network. Global parameters should be adjusted prior to local parameters.

The following strategy can be followed to improve the efficiency of the calibration effort:

1. *Bottleneck calibration* – this involves extracting a sub-network containing the bottleneck from the verified simulation network from which capacity calibration is performed. Prior to calibrating the bottleneck, the analyst should determine its causal and contributing factors which could include roadway geometrics, traffic control or regulatory constraints. If the source of congestion is located outside the model network, then calibration steps need to be applied within the model to reduce speeds on external links. Applying slower speeds limits to match congestion travel times may be employed, as can "dummy" stop signs or traffic signals, designed to replicate real world queuing behavior. If an extension of the study microsimulation model is not feasible, then post-processing of the model’s results should be done to accurately replicate the field conditions. It is recommended that the selected technique be discussed with FDOT for approval prior to use.

2. *Route choice calibration* – route choice parameters are calibrated when the simulation model involves parallel streets. It involves adjusting route choice algorithm parameters such as drivers' familiarity with the area. The parameters that were previously calibrated in the capacity calibration stage are not subject to adjustment during route choice calibration.
3. *System performance calibration* – this involves fine tuning the model parameters to enhance the overall model performance with respect to speed, travel times and queues.

7.3.4 Number of Multiple Simulation Runs

Simulation models are run multiple times with different random number seeds to minimize the impact of the stochastic nature of the model on the results. Averages and variances of the results from multiple runs are reported. Ten (10) simulation runs with different random numbers are usually adequate. However, the number of simulation runs that is required to achieve a certain confidence level about the mean of the performance measure can be computed mathematically as:

$$\boldsymbol{n} = \left(\frac{\mathbf{s} * \mathbf{t}_{\propto/2}}{\mu * \boldsymbol{\varepsilon}}\right)^{2}$$

Where:

n is the required number of simulation runs.

s is the standard deviation of the system performance measure based on previously conduced simulation runs.

$t_{\alpha/2}$ is the critical value of a two-sided Student's t-statistic at the confidence level of α and *n-1* degrees of freedom. An α of 5% is typical.

μ is the mean of the system performance measure.

ε is the tolerable error, specified as a fraction of μ. A 10% error is desired.

The CORSIM output processor can automatically calculate the required number of simulation runs necessary to achieve results that are within the tolerable error. For Vissim, the analyst needs to assume an initial number of runs and apply the method to calculate the required number of runs using the network-wide total travel time. It should be noted that this is an iterative process and due to the time constraints, the methodology is limited to a maximum of 30 runs.

7.3.5 Calibration Targets

Proper calibration requires an assessment of the degree of closeness of the calibration MOEs to the field measured MOEs. The assessment involves measuring the magnitude and variability of simulation errors in replicating existing traffic conditions. Since the process of adjusting calibration parameters is iterative, calibration tolerances or targets are set to curtail the process.

Calibration targets are set depending on the objectives of the traffic analysis as well as the types of the decisions that will be made from the analysis. Prior to proceeding with the calibration effort, the reviewing entity or lead agency of the project must concur with the calibration targets during methodology development stage of the traffic analysis.

The calibration targets are presented in **Table 7-7** and were originally developed by Wisconsin DOT for their freeway modeling program. The analyst is encouraged to coordinate with the reviewing entity on using these targets before proceeding with the calibration effort.

Table 7-7 Classical Model Calibration Targets

Calibration item	Calibration Target/Goal
Capacity	Simulated capacity to be within 10% of the field measurements.
Traffic Volume	Simulated and measured link volumes for more than 85% of links to be: ▪ Within 100 vph for volumes less than 700 vph ▪ Within 15% for volumes between 700 vph and 2700 vph ▪ Within 400 vph, for volumes greater than 2700 vph.
	Simulated and measured link volumes for more than 85% of links to have a GEH* statistic value of five (5) or lower.
	Sum of link volumes within calibration area to be within 5%.
	Sum of link volumes to have a GEH* statistic value of five (5) or lower.
Travel Time (includes Transit)	Simulated travel time within ±1 minute for routes with observed travel times less than seven (7) minutes for all routes identified in the data collection plan.
	Simulated travel time within ±15% for routes with observed travel times greater than seven (7) minutes for all routes identified in the data collection plan.
Speed	Modeled average link speeds to be within the ±10 mph of field-measured speeds on at least 85% of all network links.
Intersection Delay	Simulated and field-measured link delay times to be within 15% for more than 85% of cases.
Queue Length	Difference between simulated and observed queue lengths to be within 20%.
Visualization	Check consistency with field conditions of the following: on- and off-ramp queuing; weaving maneuvers; patterns and extent of queue at intersection and congested links; lane utilization/choice; location of bottlenecks; etc.
	Verify no unrealistic U-turns or vehicle exiting and reentering the network.

*GEH is an empirical formula expressed as $\sqrt{2 * (M - C)^2/(M + C)}$ where M is the simulation model volume and C is the field counted volume.

Table 7-8 presents an example of traffic volume calibration with demand and simulated volume comparison with Geoffrey E. Havers (GEH) statistic calculation.

Table 7-8 Traffic Volume Calibration with Demand and Simulated Volume Comparison with GEH Statistic Calculation

Segment							Calibration Targets			
No.	Location	Input Volume Hourly	Simulated Volume Hourly	Difference Volume	Difference Abs. %	GEH Volume	GEH (< 5)	Flow < 700 vph (± 100 vph)	700 < Flow <2,700 (± 15%)	Flow > 2700 vph (± 400 vph)
100	I-95 Northbound	8,846	8,839	-7	0.1%	0.1	Yes	-	-	Yes
101	I-95 Northbound	8,846	8,837	-9	0.1%	0.1	Yes	-	-	Yes
102	I-95 Northbound	8,846	8,839	-7	0.1%	0.1	Yes	-	-	Yes
103	I-95 Northbound	8,846	8,844	-2	0.0%	0.0	Yes	-	-	Yes
104	I-95 Northbound	8,846	8,843	-3	0.0%	0.0	Yes	-	-	Yes
105	I-95 Northbound	8,846	8,848	2	0.0%	0.0	Yes	-	-	Yes
106	I-95 Northbound	8,846	8,850	4	0.0%	0.0	Yes	-	-	Yes
107	I-95 Northbound	8,846	8,853	7	0.1%	0.1	Yes	-	-	Yes
108	Diverge to Old St. Augustine Road	8,846	8,857	11	0.1%	0.1	Yes	-	-	Yes
109	I-95 Northbound	7,855	7,849	-6	0.1%	0.1	Yes	-	-	Yes
110	Merge from Old St. Augustine Road	11,875	11,796	-79	0.7%	0.7	Yes	-	-	Yes
111	I-95 Northbound	11,875	11,793	-82	0.7%	0.8	Yes	-	-	Yes
112	I-95 Northbound	11,875	11,799	-76	0.6%	0.7	Yes	-	-	Yes
113	I-95 Northbound	11,875	11,800	-75	0.6%	0.7	Yes	-	-	Yes
114	Diverge to I-295	11,875	11,801	-74	0.6%	0.7	Yes	-	-	Yes
115	I-95 Northbound	5,471	5,450	-21	0.4%	0.3	Yes	-	-	Yes
116	I-95 Northbound	5,471	5,452	-19	0.3%	0.3	Yes	-	-	Yes
117	Merge from I-295 Westbound	6,095	6,045	-50	0.8%	0.6	Yes	-	-	Yes
118	I-95 Northbound	6,095	6,046	-49	0.8%	0.6	Yes	-	-	Yes
119	Merge from I-295 Eastbound	10,750	10,711	-39	0.4%	0.4	Yes	-	-	Yes
120	Diverge to Philips Highway	10,750	10,716	-34	0.3%	0.3	Yes	-	-	Yes
121	I-95 Northbound	9,306	9,290	-16	0.2%	0.2	Yes	-	-	Yes
122	Merge from Philips Highway	11,943	11,844	-99	0.8%	0.9	Yes	-	-	Yes
123	I-95 Northbound	11,943	11,845	-98	0.8%	0.9	Yes	-	-	Yes
124	Diverge to Southside Boulevard	11,943	11,849	-94	0.8%	0.9	Yes	-	-	Yes
125	I-95 Northbound	9,333	9,224	-109	1.2%	1.1	Yes	-	-	Yes
126	I-95 Northbound	9,333	9,227	-106	1.1%	1.1	Yes	-	-	Yes
127	I-95 Northbound	9,333	9,230	-103	1.1%	1.1	Yes	-	-	Yes
128	I-95 Northbound	9,333	9,229	-104	1.1%	1.1	Yes	-	-	Yes
129	Diverge to Baymeadows Road	9,333	9,235	-98	1.1%	1.0	Yes	-	-	Yes
130	I-95 Northbound	8,050	7,953	-97	1.2%	1.1	Yes	-	-	Yes
131	I-95 Northbound	8,050	7,956	-94	1.2%	1.1	Yes	-	-	Yes
132	Merge from Baymeadows Road	12,742	12,583	-159	1.3%	1.4	Yes	-	-	Yes

Total Input Volume	Total Simulated Volume	Volume Difference	Percent Difference
1,041,149	1,039,892	-1,257	-0.1%

GEH	Flow < 700 vph (± 100 vph)	700 < Flow <2,700 (± 15%)	Flow > 2700 vph (± 400 vph)
100.0%	0.0%	0.0%	98.7%
76	0	0	75
0	0	0	1

Table 7-9 presents an example of comparison for simulated travel time and observed travel times for different routes.

Table 7-9 Comparison of Simulated Travel Time and Observed Travel Times

Direction	Total Distance (Miles)	Average Total Travel Time (Minutes)	±1.0 Range (s)		Modeled Average Travel Time (Minutes)	Threshold Met?
			Lower Limit	Upper Limit		
Corkscrew Road Eastbound (West of Three Oaks Pkwy. to East of Ben Hill Griffin Pkwy.)	1.92	4.03	3.03	5.03	4.20	Yes
Corkscrew Road Westbound (East of Ben Hill Griffin Pkwy. to West of Three Oaks Pkwy.)	1.92	4.67	3.67	5.67	4.65	Yes

Figure 7-3 presents an example of speed profile showing a comparison of simulated speeds with field measured speed/travel time runs during hour 1 of the multiple time period simulation.

Figure 7-3 Speed Profile Showing Comparisons between the Simulated Speed and Field Measured Speed

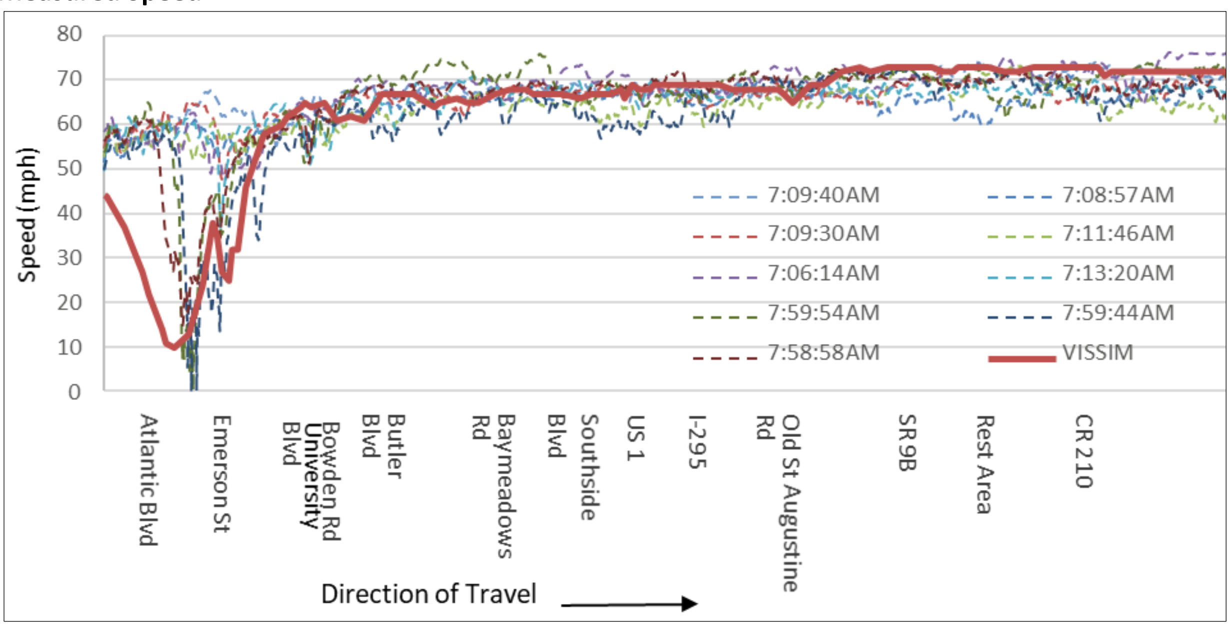


Table 7-10 presents an example of comparisons between the simulated speed and observed speed from RITIS in 15-minute interval.

Table 7-10 Comparisons between the Simulated Speed and Observed Speed from RITIS

			Fifteen Minute Interval				Peak Hour
			07:30:00	07:45:00	08:00:00	08:15:00	
Zone	**VISSIM ID**	**Location**	**AM - WB AVG Speeds - (VISSIM)**				
4030	2000	I-4 WB btw SR 434 & Lake Mary	70.0	70.0	70.4	70.2	70.1
4063	2020	I-4 WB West of US 17/92	67.7	67.0	67.4	68.1	67.5
3808	2030	I-4 WB West of Lake Mary	68.9	67.9	68.1	68.5	68.3
3440	2040	I-4 WB North of Saxon	63.9	63.4	63.2	63.6	63.5
Zone	**VISSIM ID**	**Location**	**AM - WB AVG Speeds - (RITIS)**				
4030	2000	I-4 WB btw SR 434 & Lake Mary	67.3	66.6	66.1	66.6	66.6
4063	2020	I-4 WB West of US 17/92	67.0	63.2	63.7	64.2	64.5
3808	2030	I-4 WB West of Lake Mary	73.1	73.2	73.6	73.2	73.3
3440	2040	I-4 WB North of Saxon	60.1	59.9	60.6	62.7	60.8
Zone	**VISSIM ID**	**Location**	**AM - WB Speed Difference**				
4030	2000	I-4 WB btw SR 434 & Lake Mary	-2.6	-3.4	-4.3	-3.7	3.5
4063	2020	I-4 WB West of US 17/92	-0.7	-3.8	-3.6	-3.9	3.0
3808	2030	I-4 WB West of Lake Mary	4.3	5.3	5.5	4.7	-5.0
3440	2040	I-4 WB North of Saxon	-3.8	-3.6	-2.6	-0.9	2.7

7.3.6 CORSIM Model Calibration Process

A summary of guidance on CORSIM model calibration parameters for freeways and surface streets is presented in **Table 7-11**. The calibration process should concentrate on parameters that have substantial effects on the model's performance—these parameters are labeled with high to medium sensitivity levels in **Table 7-11**. The default values can be found in CORSIM User's Guide and Minnesota CORSIM Manual. Changes made to these parameters should be documented in the calibration report and become part of the simulation model documentation.

> The calibration process should concentrate on parameters that have substantial effects on the model's performance.

Table 7-11 CORSIM Calibration Parameters

Calibration Parameter	Sensitivity Level	Default Value	Remarks
FREESIM			
Lag acceleration and deceleration time	Medium	0.3 s	
Pitt car following constant	Medium	10 ft	
Time to complete a lane change	Medium	2.0 s	
Maximum non-emergency deceleration	Medium	8 ft/s^2	13 ft/s^2 (cars), 10 ft/s^2 (trucks)
Maximum emergency deceleration	Medium	15 ft/s^2	
Leader's maximum deceleration perceived by its follower	Medium	15 ft/s^2	
Car following sensitivity multiplier	High	100%	50% - 200% based on traffic volume
Warning sign locations	Medium	2500 feet (Exit) 1500 feet (Lane add/drop) 5280 feet (HOT/HOV lane)	Field-measured or add 1,000 ft for each lane greater than two lanes
Anticipatory lane changes speed	Medium	2/3 FFS	
Anticipatory lane changes distance	Medium	1500 ft	Field-measured
Mean FFS	High	Field-measured	Field-measured
NETSIM			
Acceptable gap in oncoming traffic (left and right turns)	Medium	7.8 s for timid drivers to 2.7 s for aggressive drivers, with a mean value of 5.0 s	
Cross-street acceptable gap distribution (near and far side)	Medium	5.0 s for timid drivers to 2.0 s for aggressive drivers, with a mean value of 3.8 s	
Time to react to sudden deceleration of lead vehicle	High	1.0 s	
Minimum deceleration for a lane change	Medium	5 ft/s^2	
Spillback probabilities	Medium	100%, 81%,69% and 40% for 1st, 2nd, 3rd and 4th vehicle, respectively	
Mean discharge headway	High	1.8 s	
Mean start-up delay	High	2.0 s	
Mean FFS	High	Field-measured	Field-measured
Deceleration of lead vehicle	Medium	12 ft/s^2	
Deceleration of following vehicle	Medium	12 ft/s^2	
Max. allowable left turn speed	Medium	22 fps	
Max. allowable right turn speed	Medium	13 fps	

Source: FHWA Publication Number: FHWA-HRT-04-131

7.3.7 Notes Regarding CORSIM Calibration Process

- Oversaturated conditions require multi-period simulation to allow all input volumes to be served. In such modeling conditions, the beginning of the first time period and the final time period should be undersaturated.
- Global FFS parameter (FFS multiplier) should not be modified.
- Global car following sensitivity factor should not be modified.
- Mean start-up delay at the global scale (start-up delay multiplier) should not be modified.
- Mean discharge headway at the global scale (discharge headway multiplier) should not be modified.
- Warning sign locations (reaction points) are not locations of actual signs on the highway. Thus, reactions points should be coded in the base model based on actual field observations to the extent possible.
- Off-ramp (exit) warning signs should always be placed downstream of a lane drop.
- If undesirable FFSs are obtained, presence of curvature, superelevation and friction in the model should be checked to determine whether they affect speeds.
- If undesirable high speeds are obtained when volume is higher than a certain level contrary to the traditional traffic engineering theory, car-following sensitivity factors in FRESIM should be adjusted per segment.
- When the capacity and performance of permissive left turners is an important issue, it may be preferable to “zero out” or at least reduce the percentage of left-turn jumpers. By default, 38% of permissive left turners at the front of the queue will discharge before the opposing queue has begun movement—a phenomenon referred to as Left-turn “jumpers” in NETSIM.
- At intersections (or intersection approaches) where saturation flow rate is measured or estimated to be lower than normal, excluding reductions caused by permissive left-turn and right-turn effects, the mean discharge headway should be increased for a more accurate model. Mean discharge headway is closely correlated with, and inversely proportional to, the HCM saturation flow rate. Typical reasons for a lower-than-normal saturation flow rate include narrow lane widths, parking maneuvers, bus blockage, pedestrian/bike interference, heavy vehicles and grade.
- If the simulated average phase durations (for actuated controllers) do not closely match field-measured average phase durations, the analyst should make corrections to the simulation input parameters to realize a more accurate model. If the simulated average phase durations do not fluctuate (i.e., behavior of a pre-timed controller) but the field-measured phase durations fluctuate significantly, the analyst should make corrections to the simulation input parameters.

7.3.8 Vissim Model Calibration Process

Calibration of Vissim models involves adjusting default driver behavior (lane changing and car-following) parameters. Default network parameters that may also be adjusted include priority rules/conflict areas, gap parameters, reduce speed areas, connector lane change distance, turning speed, routing decision point locations. Prior to adjusting these parameters, the analyst should check and confirm field-measured data for vehicle types, traffic composition and speed have been correctly coded in the model. The use of field-measured data is vital to a successful calibration process.

A summary of guidance on Vissim model calibration parameters for freeways and surface streets is presented in **Table 7-12**. The values of these calibration parameters should be considered as a starting point for the calibration process. The values were obtained from Oregon Vissim Manual and the PTV's Vissim User Manual. Adjustments made to these parameters should be documented in the simulation model calibration report and become part of the simulation model manual. Additionally, these parameters may be specific to a vehicle class or area (link) in the network or a combination of values per vehicle class and area within the same link in the network.

7.3.9 Notes Regarding Vissim Calibration Process

- Weaving, merge and diverge areas' driver behavior parameters values are different from the basic freeway parameters. Thus, weaving, merge and diverge areas link behavior types could be separated from basic freeway (free lane selection) behavior type.
- Standstill distance (CC0), headway time (CC1) and following variation (CC2) have strong influences on model results. CC0 and CC1 control most of the driver following behavior.

CCO, CC1 and CC2 have strong influences on the model results.

- Negative and positive 'following' thresholds (CC4 and CC5) are other means of calibrating break-down conditions.
- Standstill acceleration (CC8) is a useful parameter for calibration of the recovery from breakdown conditions.
- Default values for maximum acceleration functions can be used since Vissim driver's acceleration decisions are influenced by the car following algorithm.
- Connector Lane Change Distance for freeway diverge segment connectors should be increased above the default (which is set to be appropriate for arterial operations) to replicate field observation. In the absence of field data, it is recommended to use "per-lane" option when multiple lanes are being traversed.
- Connector Lane Change Distance for freeway lane drop and merge segment connectors may need to be adjusted from default values to the length of the acceleration lane or more to allow vehicles to begin making lane changes once the lane drop/on-ramp merges onto the mainline.
- Speed distributions representing posted speed limits should be established such that the maximum speed should be capped to 10 mph above the posted speed limit unless field data suggest another value.
- The default truck characteristics (such as lengths) used in Vissim do not represent trucks found on Florida highways. Thus, use of truck dimensions from vehicle mix in North America Default.inpx, representative of at least 2-axle single unit trucks (Class

5-7) and 5-axle tractor-semi trailers (Class 4, 8-13) is needed to accurately calibrate capacity and queue lengths.

- Waiting time before diffusion value should only be adjusted if there is field data to warrant the additional time to wait before diffusing a vehicle. It should not be used as a primary calibration attribute as diffused vehicles are often a sign of coding errors.
- Driver Error Parameter 'Temporary lack of attention during following' can be adjusted to assist in replicating field measured conditions, especially in urban areas, where many drivers temporarily look at their phones which slows their reaction times.
- Saturation Flow Rate in Vissim is affected by a combination of driving parameters. The additive part of desired safety distance and the multiplicative part of safety distance have major effect on the saturation flow rate for the Wiedemann 74 model. In the Wiedemann 99 model, CC1 has a major effect on the saturation flow rate. Other field-measured data such as desired speed and truck volume also affect the saturation flow rate significantly.
- Adjusting network objects like DSD and RSAs to replicate congestion is not a preferred method for calibration. However, in situations where bottlenecks exist completely outside of the study area and congestion from this bottleneck spills back into the study area, adjusting DSD and RSA can be employed. This strategy should be discussed with FDOT. It is important to verify whether these bottlenecks outside of the project area and capacity constraints are expected to be resolved with planned projects in the future year analyses and adjust future models accordingly.

Table 7-12 Vissim Model Calibration Parameters

Calibration Parameter	Default Value	Suggested Range	
		Basic Segment	Weaving/Merge/ Diverge
Freeway Car Following (Wiedemann 99)			
CCO Standstill distance	4.92 ft	>4.00 ft	>4.92 ft
CC1 Headway time	0.9 s	0.70 to 3.00 s	0.9 to 3.0s
CC2 'Following' variation	13.12 ft	6.56 to 22.97 ft	13.12 to 39.37ft
CC3 Threshold for entering 'following'	-8	use default	
CC4 Negative 'following' threshold	-0.35	use default	
CC5 Positive 'following' threshold	0.35	use default	
CC6 Speed Dependency of oscillation	11.44	use default	
CC7 Oscillation acceleration	0.82 ft/s^2	use default	
CC8 Standstill acceleration	11.48 ft/s^2	use default	
CC9 Acceleration at 50 mph	4.92 ft/s^2	use default	
Arterial Car Following (Wiedemann 74)			
Average standstill distance	6.56 ft	>3.28 ft	
Additive part of safety distance	2.00	1 to 3.5[i]	
Multiplicative part of safety distance	3.00	2.00 to 4.500[i]	
Lane Change			
Maximum deceleration	-13.12 ft/s^2 (Own) -9.84 ft/s^2 (Trail)	-15 to -12 ft/s^2 -12 to -8 ft/s^2	
-1 ft/s^2 per distance	200 ft (Freeway) 100 ft (Arterial)	>100 ft >50 ft	
Accepted deceleration	-3.28 ft/s^2 (Own) -1.64 ft/s^2 (Trail)	-2.5 to -4 ft/s^2 -1.5 to -2.5 ft/s^2	
Waiting time before diffusion	60 s	Should not be decreased from default 60 seconds but can be increased based on field observations	
Min. headway (front/rear)	1.64 ft	1.5 to 6 ft	
Safety distance reduction factor	0.6	0.1 to 0.9	
Max. dec. for cooperative braking	-9.84 ft/s^2	-32.2 to -3 ft/s^2	
Overtake RSAs	Depends on field observations		
Advanced Merging	Checked		
Emergency stop	16.4 ft	Depends on field observations	
Lane change	656.2 ft	Depends on field observations. Recommended to use "per-lane" option for freeway diverge segments, Adjust to the length of the acceleration lane or more for freeway merge and lane drop segments	
Reduction factor for changing lanes before signal	0.6	Default	
Cooperative lane change	Unchecked	Checked especially for freeway merge/diverge areas	
Vehicle routing decisions look ahead	Unchecked	Checked. If this option is checked, the option "Combine static routing decisions" (under attributes of static vehicle routing decisions) must be selected.	

[i] The relationship should be based on the User Manual i.e., Multiplicative = Additive+1

7.4 Correcting Effects of Unmet Demand in the Model

Unmet demand or latent demand is defined as the number of vehicles unable to enter the network at the end of the simulation time period. Latent demand occurs mainly due to insufficient capacity in the network. The following conditions should prevail for a model to reasonably replicate real world traffic operating characteristics:

- Simulated congestion should not extend beyond the boundary limits of the analysis.
- Vehicles should not be blocked from entering (or being generated) the network in any simulation time step.

Ideally, time periods for microsimulation models should be selected such that the first and last simulation periods are undersaturated. The residual queues accumulate during the "middle" time periods and dissipate before the end of the final simulation time period. If residual queues do not dissipate before the end of the final time period, performance measurement reported at the end of simulation may not be accurate. The residual queues are also referred to as unmet demand or latent demand. Presence of unmet demand in the model may contribute to erroneous or misleading output.

Existing conditions models should be able to process the service volumes (counts) and thus there should not be any "latent demand" if properly calibrated.

Latent demand can occur in future conditions when capacity constraints within the roadway network under no-build conditions can restrict traffic from entering the network. Additional roadway capacity under build conditions may allow more traffic to be processed within the network, reducing the extent of latent demand. However, increased throughput may lead to shifting of bottlenecks or reduced travel speed areas. Simulating different volumes between no-build and build conditions may also lead to misleading results if latent demand occurs. Latent demand can impact other network performance results, deliver misleading results and, therefore, should be accounted for in the results and comparison of alternatives.

- The latent demand should be documented for each model to accurately represent the results. This can be documented for entire simulation period or each interval.
- Generally, build scenario microsimulation models latent demand should be lower than the no-build alternative microsimulation models due to the benefit of the project improvements.
- In some complex scenarios, different demand volumes may be utilized between the no-build and build scenarios. If the resulting build latent demand is greater than the no-build latent demand, then the total network demand (the combination of simulated volume throughput and latent demand) should be compared so the alternative providing the greatest operational benefit can be recommended.

In cases where latent demand is observed in the existing or future conditions, the following steps should be followed:

> Correction of unmet demand is achieved by first extending the model's spatial and temporal limits.

- Correction of unmet demand is achieved by extending the model's spatial and temporal limits to include the maximum back of queue or congestion buildup and congestion dissipation periods. However, in some cases, it may be impossible to extend spatial limits of analysis due to nature of the project, physical or software limitations and unmet demand still exists.
- The analysis output should be adjusted to account for unreported congestion. When the extension of spatial and temporal limits fails to simulate the latent demand, documentation should be provided to indicate that boundary limit expansion did not eliminate the unmet demand error and maximum queues due to latent demand replicates congestion extent in the field. Outstanding queues from the entrances with latent demand can be visualized by multiplying the latent demand (vehicles) with the length of an average vehicle. The resulting queue length from this calculation should be examined and confirmed from field data for accurate calibration of the network.

The following methods can be used to account for the effect of unmet demand from **CORSIM** in the performance of the network.

1. Adding blocked vehicles delay to the software reported delay for each simulation run. Blocked vehicle delay is obtained from multiplying the total number of blocked vehicles (reported by the software) for each time step by the length of each time step (hours).
2. Quantifying the amount of unreported residual delay (D') due to queues (Q) that are present at the end of the simulation run as: $D' = Q^2/2C$. Where C is the bottleneck capacity in vehicles per hour.

The following methods can be used to account for the effect of unmet demand from **Vissim** in the performance of the network.

- In Vissim, under network performance results, the number of vehicles that could not be deployed in the network are reported as latent demand and the total waiting time for the vehicles that since the beginning of the simulation were not able to enter the network from each origin as latent delay. Latent demand can be used to estimate queue length that extend beyond network boundaries as discussed above.

7.5 Future-Year Model Verification

After the base model is successfully calibrated, coding of the future-year models may begin. The future-year models are only checked for errors and reasonableness. The input parameter values of the calibrated model are carried forward to the future-year models without any adjustment or modification. However, future conditions of the proposed facility may dictate fine tuning of some of the calibration parameters. When modification of calibrated parameters is necessary, the reasons should be provided and documented.

Check of reasonableness includes verifying the future-year model volumes match TDM forecasts. Any significant volume differences should be reconciled by coordinating with the demand modelers before finalizing the analysis as the problem may be caused by the microsimulation model, demand forecasting model or both.

7.6 Calibration and Validation Report

Documenting how calibration was carried out is essential to streamline the review of the traffic model. As such, a good practice and recommended approach is to submit the base model (that has been calibrated) to the reviewing entity for concurrence prior to proceeding with alternative analyses. The base model should be supported with a model calibration and validation report to document the model development process. At minimum, the report should include a summary of the model verification process, assumptions and modeling issues, a detailed calibration process with all calibration parameters and calibration targets, site observations and how they have been accounted for in the model and a history of model development. Calibration report should be submitted for review before proceeding with alternative analysis.

Calibration report should be submitted for review before proceeding with alternative analysis.

Both calibrated and validated model results should be tabulated or graphed and compared with the field-measured data for each calibration periods. Any discrepancies between the model and local traffic conditions should be noted and discussed in the report. Review of the reasonableness of the calibrated model will rely on information presented in the report.

Due to stochastic nature of the microsimulation tools, higher probability of coding errors and rationale for modeling judgments, this report should be well organized to elaborate all decisions and assumptions made in the process of developing and calibrating the model. As such, the calibration report should address the following information in detail:

Introduction

This section includes background of the project and methodology of traffic analysis; location; and type and version of the software that will be used.

Data Collection

This section contains a summary of the existing data that is used to generate microsimulation model. Descriptions of key calibration locations based on field observations are included in this section. Speed-contour plots or similar contour plots are prepared and presented to show existing congestion patterns along the corridor.

A summary of the calibration and validation data is provided in this section.

Important issues to be addressed through the calibration process are also described in conjunction with each calibration location. The issues will aid the understanding of the derivation of appropriate calibration measures and will be used as a guide when adjusting default parameters.

Base Model Development and Verification

This section consists of the following items:

- Coding of network geometry, traffic demands and traffic control.
- Model Verification/Error Checking—this includes both quantitative and qualitative evaluation of the model. The results of the simulated model with 50% and 100% demand loaded to determine there are no coding errors are summarized in this section. Any demand violation issues such as unrealized or blocked vehicles that cannot be processed by the model are discussed. Additionally, summary of the comparison of animation and real world traffic conditions is presented.
- Specific assumptions made to the model development.

Model Calibration and Validation

This section includes the following key items:

- Calibration MOEs and key calibration locations.
- Calibration goals or acceptance tolerances.
- Calibration method and strategy.
- Default calibration parameter values that will be adjusted to meet calibration goals. Adjusted input parameter values can be categorized as global and local parameters. Additionally, links used for local parameters calibration can be grouped into categories with similar local characteristics. For instance, categorization by location includes freeway mainline segments, ramps merge/diverge and weaving areas, intersection, or arterial segments while categorization by traffic conditions include congestion levels such as oversaturated and undersaturated conditions per V/C ratios.

Model Calibration Results

This section contains the following:

- Calculation of the minimum number of simulation runs.
- Detailed documentation for justifications or reasons for changing default input parameter values. Each parameter changed should be discussed in this section along with supportive statistics/MOEs or site characteristics that trigger the change.
- Results of the calibration model should be presented in graphical and tabular format in this section. Refer to tables (**Table 7-8** to **Table 7-10**) and figures (**Figure 7-3** and **Figure 7-4**) provided in **Section 7.4.5.**
- Validation results of the calibration model using an independent data set (data that was not used for calibration).

Summary or Conclusions

This section contains a summary of the calibration report.

7.7 Model Calibration Reviewer’s Checklist

Table 7-13 presents the list that the reviewer can use to check the reasonableness of the base model in replicating the existing traffic characteristics. The reviewer should check all items that apply to the project otherwise indicate the item(s) is not applicable to the project.

Table 7-13 Model Calibration Reviewer's Checklist

Financial Project ID: ________________________ **Federal Aid Number:** ________________________

Project Name: ____

State Road Number: _________________ **Co./Sec./Sub.**: ________________ **Project MP:** ________

Item to Check	Description	Check
Model errors	☐ Simulation model contains no errors	☐
	☐ Simulation model was accurately verified	☐
MOEs	☐ All calibration MOEs are listed	☐
	☐ Calibration targets/goals have been outlined	☐
	☐ Calibration and validation data is sufficient to meet the targets	☐
	☐ Bottlenecks and areas of congestion are clearly identified	☐
Calibration process	☐ Calibration process is documented with all relevant calibration data, assumptions and include a history of base model development	☐
	☐ Calibration effort cover both AM and PM peak periods	☐
	☐ Sufficient length of the simulation and warm up period is covered	☐
	☐ Default calibration parameters were changed and documented for freeway	☐
	☐ Default calibration parameters were changed and documented for arterial	☐
	☐ Model animation matches expected driver behavior and conditions observed in the field	☐
	☐ Model replicates real world bottleneck(s) and lane utilization	☐
Calibration targets	☐ Calibration results are based on at least 10 simulation runs with different random seeds	☐
	☐ Model output volumes satisfy volume calibration requirements	☐
	☐ Model link capacities satisfy capacity calibration requirements	☐
	☐ Model link speeds meet speed calibration requirements	☐
	☐ Model link travel time meet calibration requirements	☐
	☐ Model intersection delay results meet calibration requirements	☐
	☐ Model queuing replicates real world conditions	☐
	☐ Two (2) calibration targets outside the volume and capacity are met	☐
Calibration documentation	☐ Speed profile plots depicting field speed/ travel time and simulated speed are provided	☐
	☐ Tables depicting field speed/ travel time and simulated speed are provided	☐
	☐ Table documenting total latent demand and latent demand as a percentage of overall demand volume	☐
	☐ Tables depicting demand volume and simulated volume comparison with GEH calculation is provided for the entire simulation period	☐

Comments:
Reviewer's Name: ____
Date:_________________

7.8 Maintenance of Traffic Analysis using Microsimulation Models

Typically, microsimulation models are calibrated to normal traffic conditions so they can be used to test alternatives in future years. MOT is a temporary occurrence during construction and mostly lasts for a short period. There is no special calibration required for these projects. However, a calibrated existing condition model can be used to replicate and analyze MOT scenarios. The calibrated model replicating normal traffic conditions can then be used as a base to modify geometry, volume and traffic control for MOT purpose. For large corridor projects where construction takes place in multiple phases, the Opening Year or Design Year models could be used as base to modify geometry, volume and traffic control in order to analyze the MOT scenarios.

7.9 Animation

One (1) of the advantages of microsimulation over analytical tools is its ability to describe or demonstrate the problem and potential solutions by animating the individual vehicles trajectories from the model. Animation can be a very effective tool to present traffic analysis results to non-technical audience such as elected officials, policy makers and the public. Like graphical summaries, animation is an excellent visual tool to identify and compare the effects of each improvement alternative on traffic operations.

It is possible to record animation from the analyzed system in the video format and present the video in various public information platforms such as public meetings and project websites. The animation prepared for public presentation or forum should support the goal of the project and audience characteristics. In which case the animation should be created from parts of simulation results that exhibit the findings of the analysis.

If it is desired to show a comparative analysis of two (2) alternatives, a side-by-side display of animations with same traffic loadings should be prepared. Screen shots of animation of critical locations can also be prepared and presented to the public as still images.

Animation is used in the traffic analysis report to complement the results presented in tabular or graphical displays only because of the following challenges:

- Time constraints to review animation in the whole time-space domain.
- Animation provides only a qualitative assessment of the overall performance of an alternative.
- Animation outputs are produced from a single simulation run while MOEs are reported from the averages of multiple runs.

In the report, the animation results maybe presented in the form of screen shots of the animation system with supporting description of the animation.

7.10 Model Manual

Model manual (or model development report) is prepared to support and document the analyses performed on complex systems using microsimulation tools. The preparation of model manual is optional, especially if a calibration report is prepared. Simple analyses such as analysis of isolated locations do not require preparation of separate analysis development reports. An example of the analysis development report is the simulation model manual which documents input data, field observations, model verification, calibration and outputs. Also included in the model manual are all electronic input files used in the analysis process. The purpose of the model manual is to:

- Provide sufficient materials to review and verify the accuracy of the model against real world conditions.
- Enable an independent analysis to be conducted.
- Maximize the return on the considerable resources expended in developing the model by making the model available to use on other phases of the projects.
- Document lessons learned and best practices for the benefit of future applications.

Different model manuals can be prepared for the base model and for each alternative simulated. A typical model manual should include all the documentation pertaining to the model development, including the following:

- Description of existing site conditions including all field observations notes.
- Traffic volume data (flow rates, traffic volumes, O-D data)
- Geometric data (link-node diagrams, lane schematics)
- Traffic control data
- Data sources
- Model parameters and inputs
- Model calibration and validation
- Model outputs and analysis results
- Model/analysis assumptions

The recommended outline of the model manual is shown in **Figure 7-4**.

Figure 7-4 Model Manual Outline

1. **Overview**

   Contains a brief statement of the purpose of the study, study area map, existing conditions narrative with discussion of driver behavior, location of physical constraints and a discussion of the study approach (tools used, method, rationale).

2. **Data Collection**

   Contains a summary of the data collection methods and sources of data; input data such as link-node diagrams, lane schematics, arterial TMCs—raw and balanced, freeway and ramp volumes, O-D tables, traffic control data, transit and multimodal data, field observation. It should also address calibration data such as travel speeds, travel times, queues, and intersection delay. If signal optimization software was used, then its input and output files should be included in this section.

3. **Base Model**

   Contains model assumptions, all model input and output files and model verification documentation including all checklists used in the Quality Assurance/Quality Control (QA/QC) process. Coding techniques for complex or unconventional geometrics or operations are included here.

4. **Error Checking**

   Contains error checking process, QA/QC process and results.

5. **Base Model Calibration and Validation**

   Contains calibration and validation process narrative, which include calibration targets, MOEs and documentation supporting evidence of changing default parameters.

6. **Alternatives Analysis**

   Contains input and output data (electronic files), signal optimization files and MOE summaries, QA/QC documents each future year model analyzed. This section may be divided into subsections covering input data and output data for each analyzed alternative.

Chapter 8
Express Lanes Analysis

8.1 Introduction to Managed Lanes

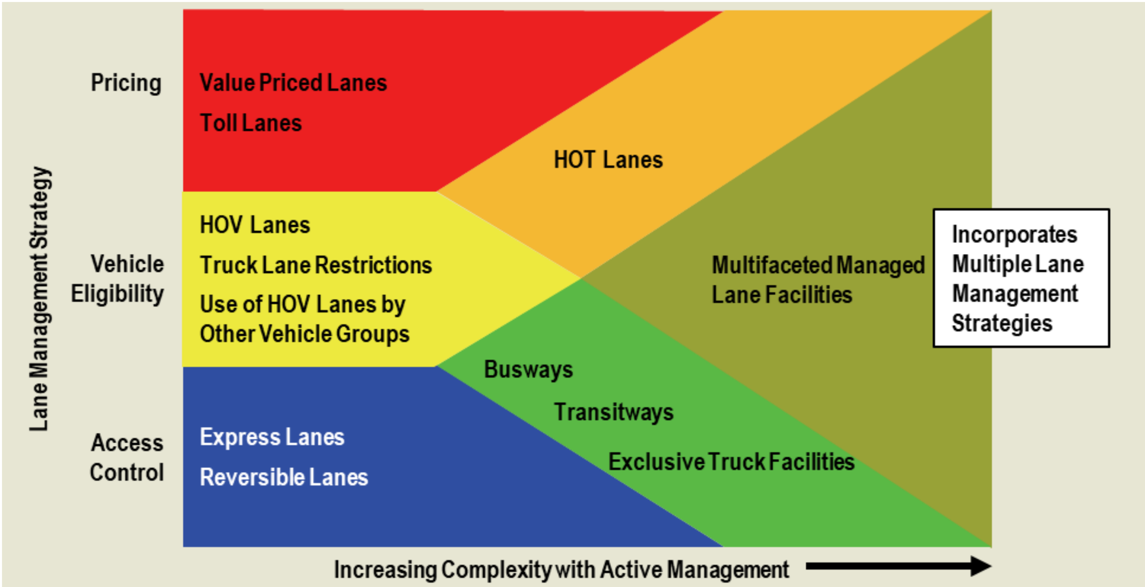
Managed lanes are a TSM&O solution in which operational management strategies are used for highway facilities, or sets of lanes within a highway facility, to proactively relieve congestion and improve safety in response to changing conditions. Managed lane strategies are being increasingly implemented, especially in situations where the options for constructing new capacity are limited. Managed lanes could refer to any dedicated and restricted lane that is not a general use lane. The three (3) primary management strategies are access control, vehicle eligibility and pricing (tolling). The FDOT adopted Policy No: 000-525-045 is to employ managed lanes on appropriate facilities that currently or are expected, in the future, to experience significant congestion. Every corridor or facility is different with its own unique operating characteristics therefore, FDOT operates managed lanes in a manner individually designed to maximize throughput on the specific facility. FDOT prioritizes congestion management and maximize throughput on these key facilities through managed lane vehicle eligibility standards, access control, pricing, incentives and other available techniques.

Figure 8-1 illustrates the different lane management strategies that fall into this broad definition of managed lanes. Access control, vehicle eligibility and pricing are on the left of the diagram and more complex and blended strategies of managed lane facilities are to the right.

If the managed lanes do not incorporate tolling, then this chapter is not applicable. The term “managed lanes” or “priced managed lanes” used in this chapter hereafter refers only to express lanes.

If the managed lanes do not incorporate tolling, then this chapter is not applicable.

Figure 8-1 Managed Lane Strategies and Complexity



Source: FHWA Managed Lanes Primer

8.1.1 What is an Express Lane?

Express lanes are defined as a travel lane or lanes delineated or physically separated from a general use lane or general toll lane within a roadway corridor in which tolls are set based on traffic conditions. In other words, a managed lane for which tolling is an option, whether immediately or in the future, is an express lane. Express lanes have multifaceted aspects of operations that require well-defined procedures and policies to meet operational expectations. Tolling is utilized to maintain and promote FFS.

A managed lane for which tolling is an option, whether immediately or in the future, is an express lane.

The three (3) types of tolling approved for use on Florida's express lanes are static, time of day and dynamic tolling to manage congestion and these may vary based on traffic conditions. With static tolling, the toll rate in the express lanes is set to a fixed amount that does not change. With time of day tolling (pricing), the express lanes' toll rate is adjusted throughout the day according to an established schedule for each type of day. When dynamic tolling is used, the express lanes' toll rate increases as traffic builds in the express lanes and decreases as traffic reduces.

8.2 Purpose and Intended Use

The purpose of this chapter is to provide guidance and key steps to be followed for analyzing express lanes facilities, to aid in the consistent and verifiable application of express lanes analysis methodologies using microsimulation models and to assist project managers to prepare the scope of traffic analysis for express lanes projects. Depending on the project-specific purpose and need and project scope, methodology elements described in this chapter may be enhanced or adapted to support the project.

The guidelines contained in this chapter are intended only for the implementation of express lanes on freeways or controlled access highways. This guidance does not apply to implementation of express lanes on arterial roadways or for multimodal alternative analysis studies. This chapter must be used in conjunction with other chapters of this handbook. This chapter does not cover existing conditions calibration process of microsimulation models. The analyst should follow guidelines provided in **Chapter 7** of this handbook for the microsimulation model calibration and validation process. The following items are covered in this chapter:

The guidelines contained in this chapter are intended only for the implementation of express lanes on freeways or controlled access highways.

1. Project scope: recommendations and guidance for project scoping a new express lanes facility and expanding a facility that has express lanes in operation within the AOI, including spatial and temporal boundaries.
2. Data collection: primary and secondary data sources and types of data.
3. Travel demand forecasting: methodologies and selection criteria for forecasting traffic for express lanes projects and an initial traffic assignment.
4. Traffic assignment methods: static and dynamic assignment methods for express lanes.
5. Express lanes modeling: criteria, guidelines and computational procedures for different methods of modeling express lanes using microsimulation, including final operational assessment.
6. Complex weave: analysis methodology.

The express lanes analysis modeling process in this chapter references information in the following publications:

- Priced Managed Lane Guide prepared by the FHWA.
- 2019 Project Traffic Forecasting Handbook prepared by FDOT.
- PTV Vissim User Manual.
- Vissim Managed Lanes Facilities Module User Guideline.
- PTV Visum User Manual.
- An Application of Microscopic Dynamic Lane Choice Assignment for Express Lanes prepared by FTE.
- Managed Lanes: A Primer, prepared by FHWA.

8.3 Project Scope

Long-distance trips are one (1) of the key components of express lanes planning. Each express lane corridor is different, with its own planning and operating challenges and characteristics. The effectiveness of the traffic analysis methodology depends on addressing the characteristics of the study corridor. Effective application of express lanes along a corridor may require that the express lanes extend beyond District boundaries and may overlap multiple jurisdictions. Scoping the limits of express lanes projects and determining their logical termini requires coordination between FDOT districts and all the jurisdictions involved.

8.3.1 AOI and Spatial Boundary

Chapter 3 provides guidance for identifying the AOI and spatial boundaries for microsimulation projects. Guidelines presented in **Chapter 3**, combined with the FDOT IARUG, should be used to determine the project's AOI. The guidance in this chapter assists the analyst in determining the appropriate spatial limits for express lanes microsimulation analysis. It does not replace or supersede the AOI requirements in the IARUG for IARs.

This chapter does not replace or supersede the AOI requirements in the IARUG for IARs.

i) New Express Lanes System

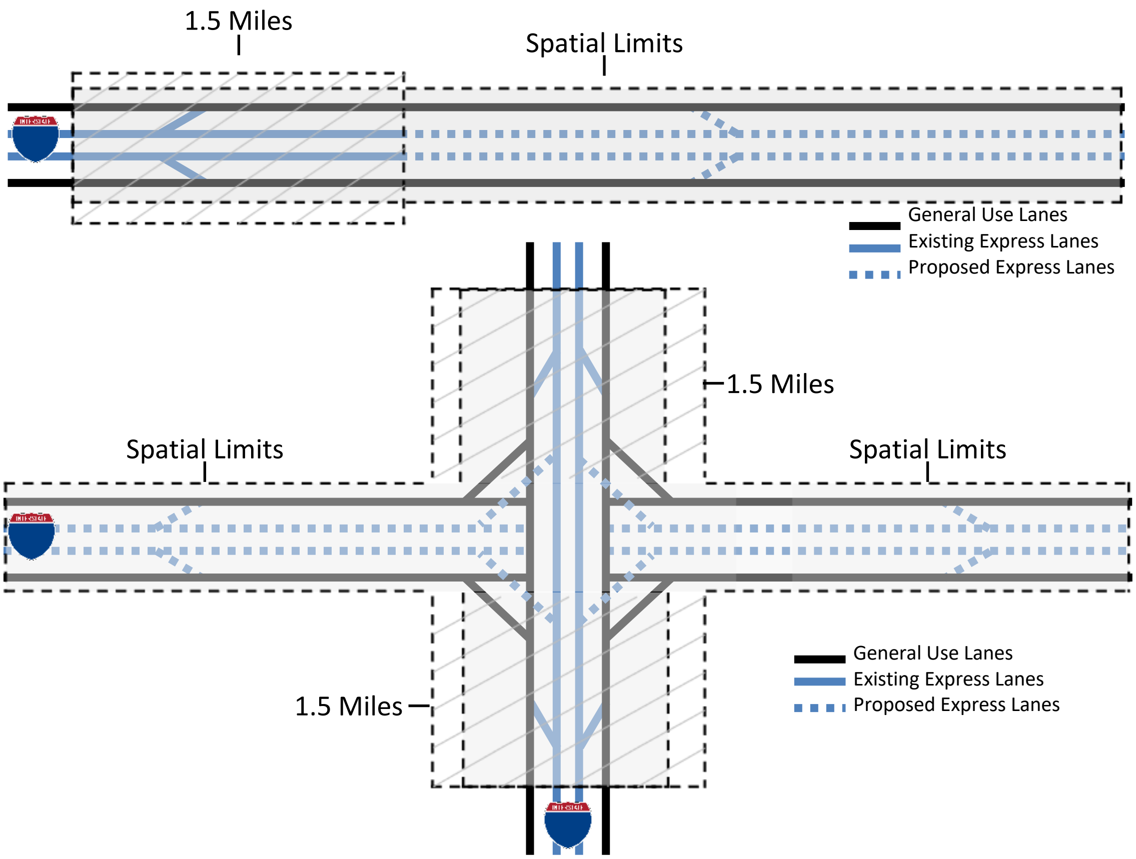
For a new express lanes system, the AOI is defined as the area that is anticipated to experience changes in traffic patterns and operations because of the proposed express lanes and access locations. The spatial limits of the microsimulation model for the analysis of a new express lanes system should extend at least 1.5 miles upstream of the begin point and 1.5 miles downstream of the end point of the express lanes. This is to allow adequate distance and reaction time for the microsimulation model to better replicate the traffic characteristics and operations upstream and downstream of the proposed express lanes facility. Interchanges within this distance of 1.5 miles should be considered for inclusion in the analysis, based on the project characteristics and discussions with FDOT.

ii) Expansion of Existing Express Lanes System

FDOT has been implementing express lane networks since 2008 to provide drivers with an option to bypass the heavily congested urban areas. There are several express lanes projects under construction or in planning to extend these existing express lanes to reduce traffic congestion and provide a reliable travel time for travelers within the region. If an existing express lanes system is being extended, then the spatial limits of the microsimulation model for the new project should be extended at least 1.5 miles to include the ingress and egress locations of the existing express lanes. If the ingress point of the existing express lanes facility does not fall within 1.5 miles, then the model limits should be extended to include the ingress point for simulation analysis purposes. This will allow the traffic from existing express lanes system to enter the project area of the study. If the study area includes an intersecting freeway that has existing express lanes, then the spatial limits of the microsimulation model should extend at least 1.5 miles along the intersecting freeway in both directions from the study freeway. Any known bottlenecks should be considered and included, as needed, in the spatial limits of the microsimulation model.

A dummy ingress should be created in situations when nearest ingress of an existing express lanes is further than 1.5 miles. Examples of the spatial limits of express lanes in microsimulation analysis are provided in **Figure 8-2**.

Figure 8-2 Recommended Spatial Limits of Express Lanes in Microsimulation



Note: Distances shown in this figure indicate the minimum extents of roadway segments to be included in microsimulation of express lanes. The FDOT IARUG should be used to determine the AOI for IARs.

8.3.2 Determination of Temporal Boundary

A temporal boundary limit as defined in **Chapter 3** of this handbook is the length of the traffic analysis period.

i) Analysis Time Period

The analysis time period selected should capture the effect of traffic demand variation rather than the capacity of the corridor. Express Lanes are typically considered for congested corridors. To properly evaluate the potential effects of express lanes on a corridor and how the express lanes will affect existing congestion patterns, the analysis time period selected needs to capture the effect of traffic demand variation on the corridor, including the buildup and dissipation of traffic congestion and not just study the period in which the corridor is over capacity. Therefore, microsimulation models used to evaluate express lanes projects should evaluate peak periods of at least three (3) hours, in addition to the required seed time, during both the morning and evening peak periods. The hours selected for each peak shall be based on existing conditions congestion data. Each peak period shall begin before congested conditions have developed and end after congested conditions have been relieved.

The microsimulation models used to evaluate express lanes projects must evaluate peak periods of at least three (3) hours, in addition to the required seed time, during both the morning and evening peak periods.

ii) Duration and Extent of Congestion

The duration of congestion is the time between the start of the breakdown and the clearance of congestion. The duration of congestion can be longer than one (1) hour, when the demand to use the facility exceeds the capacity over a period longer than one (1) hour. Existing 24-hour traffic volume profiles should be prepared to determine the periods in which peak demand spreads over multiple hours.

The extent of the congestion (or queuing) could be due to a bottleneck outside the study project limits. This is a common occurrence in urban areas where the extent of congestion extends well beyond project scope limits or originates outside the project scope area and affects the study corridor’s operations. The analyst should attempt to encompass as much of the congestion as feasible within the microsimulation model. Roadway congestion needs to be considered within the microsimulation model to obtain reasonable results. If the source of congestion is located outside the model network, then calibration steps need to be applied within the model to reduce speeds on external links. Applying slower speeds to match congestion travel times may be employed, as can "dummy" stop signs or traffic signals, designed to replicate real world queuing behavior. If an extension of the study microsimulation model is not feasible, then post-processing of the model’s results should be done to accurately replicate the field conditions. It is recommended that the selected technique be discussed with FDOT for approval prior to use.

8.4 Data Collection for Express Lanes

Chapter 5 provides guidance regarding data collection needs for microsimulation projects. This chapter provides guidance on collecting data for express lanes projects and should be used in conjunction with the guidance provided in **Chapter 5**.

The data requirements should be evaluated in the beginning stages of a project to get an early estimate of the effort required, and a data collection plan should be designed, carefully keeping in mind the project requirements. The data collection plan should be developed per the project-specific needs. Traffic volumes, O-D data, corridor speed and knowledge of congested areas (queue lengths) are required for all express lanes project analysis. The following sections describe the primary and secondary sources of required data identified for express lane projects.

8.4.1 Primary Data Types/Sources

i) Traffic Volume

The basic demand data needed for analysis by most simulation software is the entry volumes entering the study area at different points and turning movement volumes.

When collecting traffic volume data in congested networks, data collection and observation locations must consider how to capture vehicle throughput as well as vehicle demand. For locations where major bottlenecks or queuing occurs, the data collection upstream of the bottleneck should record actual demand levels to accurately replicate the level of congestion and queuing observed in the field. Traffic counts along the mainline should be collected at the less congested points upstream of the bottleneck to record the vehicle demand profile, instead of metering the volume data only to what can be delivered through the bottleneck. Traffic counts at the ramps and at the intersections should also be collected for assigning percentage of traffic to various routes. Balancing traffic counts collected on either side of a known bottleneck location should be avoided.

Balancing traffic counts collected on either side of a known bottleneck location should be avoided.

The vehicle classification data should be collected, at a minimum, at one (1) location within the study area, which should be determined through coordination with FDOT during the scoping process.

- Field Data Collection
  The field traffic data collection and its key requirements are listed below:
  - Traffic volume data (mainline, ramps and turning movement volumes) should be collected during typical weekdays, excluding weeks that contain holidays. Refer to FDOT (MUTS) for further guidance on field data collection.
  - Traffic volumes must also be collected in 15-minute increments for the entire study period.
  - If feasible, traffic volumes should be collected on the same day throughout the entire study area and should coincide with other data collection and field observations (e.g., vehicle speeds and queuing).

- Florida Traffic Online (FTO)
  FTO is a web-based mapping application that provides current and historical traffic count data. This data is obtained from Florida's traffic monitoring sites.

  The data available in the FTO ranges from AADT, daily truck volume, daily volumes in 15-minute intervals, vehicle classification counts and other traffic information. Archived data from FTO can also be used to obtain an understanding of traffic data variation.

- Previous Studies

  In addition to collecting new traffic volume counts, traffic counts collected as part of other recently completed projects may be used to supplement the data collected. Traffic volume data from previous projects should be checked for reasonableness and adjusted, as needed, to reflect the current project area's conditions. Traffic validation guidelines for both existing and future traffic along with the traffic validation template can be obtained from SIRC. Historic traffic growth and latest adopted travel demand model are good sources for use in the traffic validation effort. If the traffic validation exercise reveals that the existing or future traffic from previous studies are not valid anymore, then a methodology should be developed to update the traffic.

ii) Origin-Destination (O-D)

O-D information is critical to accurately model express lanes in microsimulation models. O-D data is important for accurately modeling the lane changing, weaving and other related driver behavior types upstream and downstream of express lanes access and at access locations along general use lanes. In addition, the O-D data is valuable in determining the express lane access points and assists in the express lane utilization.

The different methods for collecting O-D data are described below. These methods vary in accuracy, cost and post-processing requirements. The analyst should select the data collection method best suited to satisfy the project needs.

- Bluetooth Studies

  Bluetooth studies have been widely used for sampling O-D travel patterns between multiple gateways and preparing an estimate of travel time. This method can be expensive and requires a large sample size. If O-D data collected using Bluetooth studies is available for the project area, it can be used in analysis after checking the data for reasonableness.

- Mobile/Location Source Data

  Mobile information, extracted from mobile phones and in vehicle devices (such as navigational systems, commercial fleet management systems etc.), have gained popularity in recent years. Mobile data is used to identify O-D patterns and extract matrices, along with travel time data and other information. Mobile data can provide travel patterns with accurate locations and times and create reliable information that can be used for high-quality, O-D matrices, which are better than traditional, synthetic O-D matrices or any other sources listed here. The data can be extracted for different times of the year and by vehicle type and can identify trip time, length, speed and trip purpose. This method is suitable for application in planning, PD&E and design projects.

- Other Methods

  TDM trip tables based on field counts can also provide general O-D patterns, which can be utilized after verification and with some post-processing. This is generally a cost-effective option and is suitable for application in planning and PD&E projects.

iii) Corridor Speed Data

Corridor speed and travel time data is collected to replicate corridor operating speeds in microsimulation models. This data is important for accurately modeling the duration and distance of congestion, identifying bottlenecks locations, activation and dissipation times. This data is also important for comparing field measured speed to that estimated by the model on a section of freeway for existing conditions calibration.

Two (2) different methods for collecting speed and travel time data are described below. It is recommended to use only one (1) data set, either speed or travel time runs and keep the other data source for validation.

- RITIS Speed Data

  The RITIS is a web-based mapping application that provides corridor speed information collected by multiple agencies and third parties from roadway sensors that include inductive loops, side-fired sensors (acoustic, microwave, etc.), radar and video. The data is available for the entire year for segments and individual lanes, depending on the location. The data granularity varies from five (5) minutes to one (1) hour, depending on the corridor location. The analyst should confirm that data collection detectors are available at major bottlenecks, system-to-system interchanges and preferably, at each interchange to ensure that data gaps do not exist. Where feasible, microsimulation models should be developed to provide travel speed outputs for segments that match the segments available in RITIS, to allow for comparison between observed corridor speeds and microsimulation model speeds. RITIS data is real world data and is available for comparison against microsimulation outputs for various studies but it cannot predict operations under concept or proposed conditions.

  If express lanes facilities exist within the study corridor's AOI, speed data is typically available from Microwave Vehicle Detection System (MVDS) or other sources. MVDS sensors measure spot speeds, volume and occupancy of the express lanes, the general use lanes and the on ramps that include ramp metering. The monthly quantities of malfunctions of these devices and their corresponding "up time" or availability should be verified before using this data.

  RITIS data is also available for general use lanes and express lanes. This can vary, depending on the FDOT district or express lanes corridor and should be investigated before using RITIS data in projects. RITIS data is very reliable for existing facilities; however, it should be used with caution for new or recently opened facilities. RITIS data can be used to analyze express lanes in planning, PD&E and design projects.

  > RITIS data can be used to analyze express lanes in planning, PD&E and design projects.

- Field Travel Time Runs
  Field travel time runs may be conducted for one (1) or multiple days using probe vehicles with GPS in accordance with FDOT's MUTS. Field travel time runs should be performed during the entire peak period to be analyzed, using multiple vehicles where necessary. It is important to conduct adequate number of travel time runs during the peak period. It is recommended to conduct at least six (6) travel time runs during each hour in each direction. If this is not feasible for larger study networks, then several days of travel time runs should be collected, typically Tuesday to Thursday for two (2) weeks. If express lanes facilities exist within the study corridor's AOI, travel time runs should be conducted separately for general use lanes and express lanes. This method can be used for all planning, PD&E and design projects.

iv) Extent and Duration of Queues and Congestion

Collecting extent and duration of queues and congestion is critical for corridor performance assessment. This data is critical for visual information of corridor operations and can highlight geometric and operational constraints, key bottlenecks and effect of these bottlenecks during the analysis period. In oversaturated conditions, the entire extent of the queue should be observed and documented, even if the queue extends past project AOI.

Three (3) different methods for collecting extent and duration of queues and congestion are described below. These methods vary in costs and size of the project.

- Regional Transportation Management Center (RTMC)
  FDOT has taken a leadership role in the deployment of ITS infrastructure throughout the State and has established RTMC in all seven (7) FDOT districts and FTE. RTMCs are an effective source for traffic monitoring in major metropolitan areas. Most interstate and major highway congestion can be monitored from the center or using the web. This can be utilized to determine the congestion's extent and duration along the corridor. Published data from RTMCs can also be used. This is generally a cost-effective option.

- Aerial Congestion Survey
  Aerial congestion surveys are used when collecting visual information for large and congested networks is challenging. These areas cannot be monitored using stationary cameras, and the back of the queue cannot be estimated using conventional methods. Aerial congestion surveys are conducted using manned or unmanned aircraft, including drones, to obtain vital information for the corridor and can be expensive.

- Field Observation
  Conducting field reviews during peak periods to assess the safety and operational conditions of the corridor is the most widely used and cost-effective method to determine the corridor's congestion. Field reviews may be performed under various conditions to gain insight into the project or existing road and identify areas of

operational concerns. This information is generally used to appropriately calibrate the existing condition's microsimulation model.

The types of data described above are required to analyze express lanes for planning, PD&E and design projects and must be obtained from the primary sources. These data allow the analyst to understand the existing conditions within the study area, provide the basis for calibration of microsimulation models and allow for comparison of operational outputs between the existing and proposed conditions. The methodology used to obtain this data can be determined by the analyst, depending on the project's purpose and study area characteristics. Coordination should be done with FDOT to obtain approval prior to performing data collection.

The types of data described above are required to analyze express lanes for planning, PD&E and design projects and must be obtained from the primary sources.

8.4.2 Secondary Data Sources

Secondary data sources can be used to verify or supplement information from the primary sources but are not required with the submittal of the project document. Information obtained from secondary sources cannot be used in lieu of or to replace the primary data sources.

Information obtained from secondary sources cannot be used in lieu of or to replace the primary data sources.

- <u>Google Speed and Congestion Data</u>
  Google speed or speed from Google Maps, is indicative of travel speed and general operations along the corridor. It incorporates data from crowdsourced apps (e.g., Waze) and devices that have the Google Maps app. Google Maps do not provide speed threshold information. They may be used to verify or gain an understanding of the congestion extent and queues along the corridor, but it is not acceptable to use Google Maps as a primary data source for calibrating existing or new express lanes.

- <u>Stated Preference Survey Methods</u>
  Stated preference survey methods have been used in the past, to research travel behavior and establish travel time savings for toll facilities. The stated preference survey provides reliable information and was a widely used method before the evolution of Bluetooth data and mobile source data. This method has become outdated, expensive and has not been used for recent express lanes projects in Florida. Stated preference survey can be used to derive Value of Travel Time Savings (VTTS) for express lanes.

8.4.3 Existing Express Lanes Within Study Area

Data for existing express lanes can be used as a sample for modeling proposed express lanes in nearby segments. If express lanes exist within the study area, then the following data may be collected to understand traffic and pricing characteristics:

- Volume
  The average peak period volume in existing express lanes during morning and evening peak periods.

- Speed
  The peak period speed of the existing express lanes during morning and evening peak periods and the posted and minimum speed required in priced managed lanes along the existing express lanes facility.

- Tolling Policy and Toll Rates
  The tolling policy in place for the existing express lanes facility that identifies dynamic pricing, time-of-day pricing, static pricing and toll rates applied. Efforts should be made to emulate these policies for the extension of the existing facility or new express lanes corridor within the AOI.

- Value of Travel Time Savings (VTTS)
  VTTS represents the monetary equivalent of travel time savings. VTTS is derived from Stated Preference Survey and can vary for each region. VTTS is used to determine the time coefficient used as an input in Vissim managed lanes module.

8.5 Travel Demand Forecasting for Express Lanes

Determining the feasibility of an express lanes project and evaluating express lanes alternatives require a travel demand forecasting tool that can assess the impact of tolling on traffic volumes and travel patterns. The travel demand forecasting method for express lanes volumes should be chosen depending on the project's complexity and development phase. In most cases, a comprehensive TDM is needed to forecast the level of demand for the express lanes, the impacts of pricing on the corridor and regional travel, as well as the impacts of tolling on different groups of travelers.

While the total mainline volume (general use lanes plus express lanes) may be established by applying the K and directional factors (D), express lanes traffic should not be forecasted using a typical project traffic forecasting procedure that applies standard K and D factors to annual average daily traffic (AADT). **Chapter 8** of the FDOT Project Traffic Forecasting Handbook provides a discussion on the express lanes project development process and offers guidance on the methodologies and procedures for project traffic development. There are four (4) methods described in the FDOT Project Traffic Forecasting Handbook to estimate express lanes volumes:

1. Manual estimation using peak hour O-D.
2. Regional TDM with dynamic toll function or VTTS curve assignment.
3. Regional TDM with express lane time of day (ELToD) static assignment model.

4. Microsimulation model express lanes assignment.

The first three (3) project traffic forecasting methods are covered in detail in **Chapter 8** of the Project Traffic Forecasting Handbook. This chapter focuses on the microsimulation model express lanes assignment method. The following sections discuss the initial traffic assignment and express lanes traffic modeling techniques for use in microsimulation.

8.6 Traffic Assignment Methods

An initial traffic assignment is performed to input the total project demand that is expected to enter the microsimulation model network. There are two (2) methods for assigning the initial traffic in microsimulation models: static traffic assignment and dynamic traffic assignment. These methods determine how vehicles will travel within the simulation network. The static traffic assignment can be performed using manual static routes or static routes created using O-D matrix estimation (ODME). The determination of the appropriate methodology is dependent on many variables, such as project need, project type and available data. The selection of the initial traffic assignment methodology should be made on a project-by-project basis, considering these variables. Depending on the project characteristics, it is acceptable to use a combination of the manual static routes and ODME techniques for an initial traffic assignment.

> An initial traffic assignment is performed to input the total project demand that is expected to enter the microsimulation model network.

The differences between the two (2) initial traffic assignment methods and selection criteria are described in the following sections.

8.6.1 Static Traffic Assignment

The static traffic assignment method specifies traffic demand in the form of vehicle inputs and manual routing decisions. This method assumes that the link flow remains constant between the user-defined begin and end points. The traffic entering the network and its path is predetermined and manually assigned in the microsimulation model. The static traffic assignment can cover the entire study area, several interchanges or a single interchange. Once the initial traffic assignment of the microsimulation model is complete, then the express lanes assignment step is conducted. Even if the initial traffic assignment is performed using the static method, the express lanes assignment can still be performed using the dynamic express lanes assignment described in **Section 8.7** if the freeway routes are coded or combined for all on-ramps and off-ramps.

> Even if the initial traffic assignment is performed using the static method, the express lanes assignment can still be performed using the dynamic express lanes assignment.

The static traffic assignment can be performed using manual static routes or ODME techniques, as described below.

i) Manual Static Routes

The manual static routes for the microsimulation network are created manually using peak period demand determined by the project traffic forecasting methodologies in **Section 8.5**. The traffic volume split between express lanes and general use lanes can be determined with a manual estimation of traffic, regional TDM with dynamic toll function or from the ELToD static assignment model. This estimated traffic is assigned in microsimulation model using manual static routes with predetermined turn-by-turn assignment.

A disadvantage of the manual static routes method is that it can be cumbersome to use for projects with larger networks or multiple, closely spaced interchanges, because the manual entry of the routes can take time and be prone to errors. The application of the manual static routes is appropriate for smaller projects or projects in which the corridor or interchange study areas are extracted from a larger network and traffic was determined by a previous project effort. Another disadvantage of this method is that it does not allow for the rerouting of traffic due to congestion in express lanes.

i) Static Routes Created from ODME

The static routes created from the ODME method specifies traffic demand in the form of one (1) or more O-D matrices. This method is efficient for larger networks and closely spaced interchanges, because the roadway network can be simulated without manually creating routes and entering vehicle inputs. The O-D matrices specify the start and end points of trips and the number of trips between these locations. This process requires using Vissim and Visum software. Visum's traffic assignment can be performed using the ODME process with volume targets, seed O-D matrices and Visum's TFlowFuzzy procedure. In the Vissim network, nodes are created at the entrances, exits and intersections and the network is exported to Visum. The skim matrix is generated and edited to create an initial seed matrix for the ODME process. The ODME assignment and demand matrix correction is done after loading the target peak hour volume. This process assigns the volume to the study area's links and nodes. The vehicles' routes are generated in Visum and checked for any illogical movements. These routes are exported to Vissim as static routes. This process eliminates manually entering vehicle routing decisions and inputs.

8.6.2 Dynamic Traffic Assignment Using ODME

The dynamic traffic assignment can also be performed using O-D matrices within Vissim. In Vissim, the dynamic assignment is done by an iterative application of the traffic flow simulation. This approach is particularly beneficial for freeway projects that have parallel facilities. However, this method may encounter issues when the demand exceeds the capacity of the network, where the network may not be able to fully simulate the entire demand. This method has not been used much in express lanes projects in Florida and should be used with caution. This method is not recommended for express lanes projects where the corridor demand exceeds the capacity in existing or future years.

8.7 Express Lane Traffic Modeling in Microsimulation

There are two (2) methods for express lane traffic assignment in microsimulation: static and dynamic. The proposed traffic assignment method for each express lane project should be identified at the beginning of the project in coordination with FDOT. Each of these methods is described in detail in the subsequent sections.

8.7.1 Static Express Lanes Traffic Assignment

This method assigns predetermined traffic flow in express lanes, regardless of the congestion in the general use lanes. In this approach, a portion of the total traffic in the project corridor is shifted to express lanes. Reasonableness checks are required to compare the traffic shifted to the express lanes with potential eligible trips. Also, the express lanes volumes can be iteratively adjusted based on simulation to ensure realistic or required operations. Truck proportions in the general use lanes should be adjusted to account for shifted traffic. Traffic volumes used in the static assignment method can be derived directly from a TDM with the built-in tolling algorithm, the ELToD model or from previous studies.

8.7.1.1 Split from Travel Demand Model with Built-In Tolling Algorithm

Some Florida regional TDMs have tolling algorithms built-in and the capability to provide separate general use lanes and express lanes traffic volumes for peak periods. The volume split between general use lanes and express lanes from these models can be applied to the microsimulation model peak period volumes and used as predetermined or static volume in express lanes. TDMs without peak periods should not be used to estimate the split between general use and express lanes. Express lanes static volume assignments using this method can be used for planning and PD&E projects. It is not recommended for use in IARs, even if these are prepared in conjunction with the PD&E.

8.7.1.2 ELToD Output

ELToD is a standalone subarea assignment model. The ELToD model is used with a regional TDM to determine traffic split between express lanes and general use lanes. The ELToD toll choice model uses travel time savings, costs, reliability and trip distance to calculate the percentage of travelers expected to choose express lanes. The ELToD estimates the volume of traffic by predefined time period on the general use and express lanes using a highway trip table from any TDM. In addition, it estimates the express lane dynamic toll and congested speeds by hour and V/C ratios based on traffic conditions.

The express lane traffic volume forecast from ELToD or the general use lane and express lane splits can be applied on the peak period volumes and used as a predetermined static volume input in express lanes. The ELToD model application is valuable for projects with alternative express lane access or ingress/egress scenario tests and with multiple scenarios to eliminate undesirable alternatives through comparison. Express lane static volume assignments using the ELToD model can be used for all planning, PD&E projects and IARs. Dynamic express lane assignment using the ELToD output can also be considered for IARs if a more detailed analysis is required.

8.7.1.3 Manual Methods Based on Previous Studies

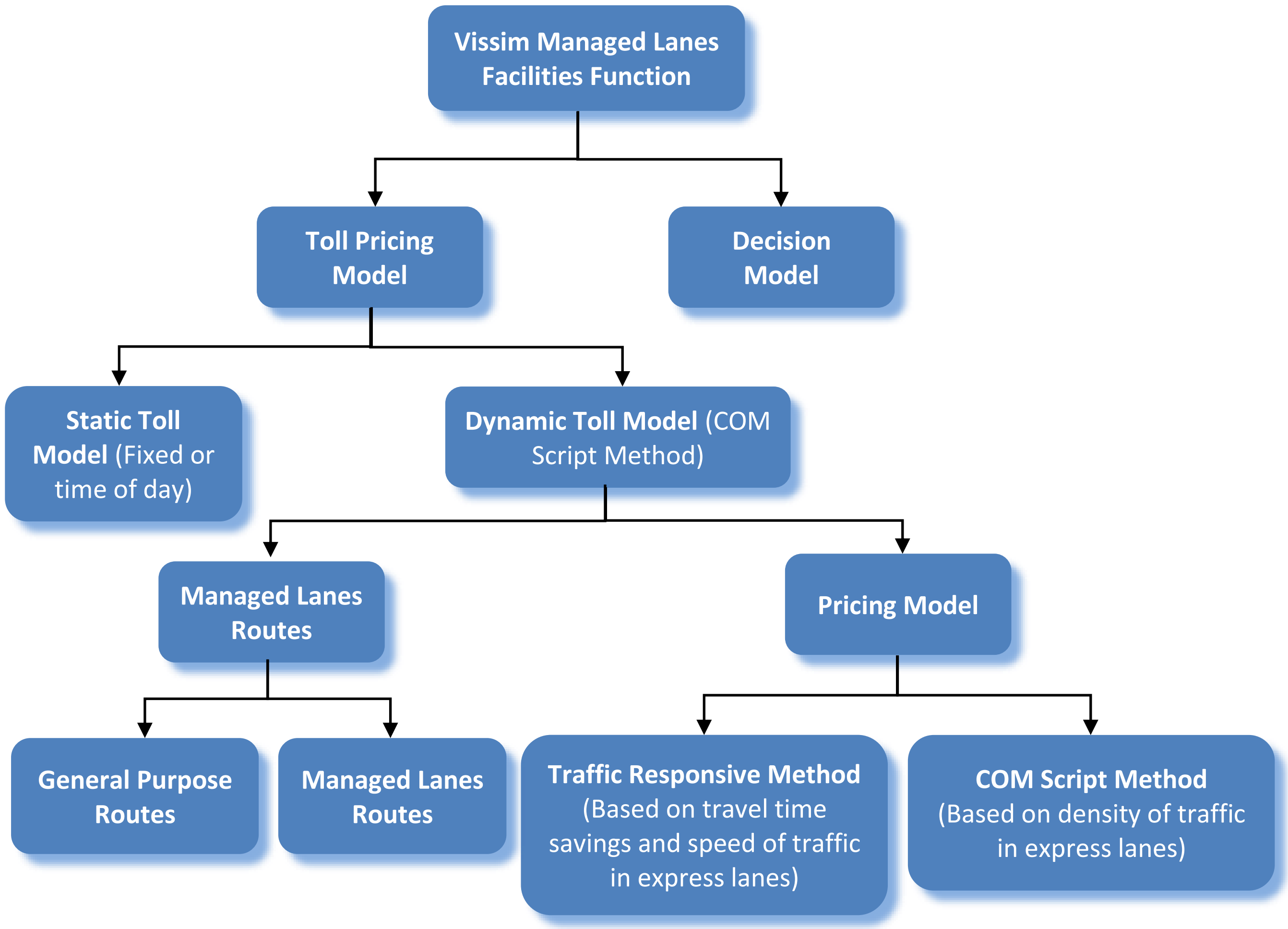
If a project with a small corridor or an interchange are extracted from a larger network for which traffic was already determined during the previous project's effort, the static volume assignment can be done utilizing the already approved express lanes volumes. This approach can be applied for planning, PD&E and design projects.

8.7.2 Dynamic Express Lane Assignment

This method dynamically assigns traffic in express lanes based on the driver's perception of congestion in general use lanes and potential travel time savings by using express lanes. This method uses the Managed Lane Facilities function within Vissim's microscopic simulation software to dynamically assign traffic to the express lanes.

Microsimulation models use a pricing component to estimate the toll amount based on measured conditions such as density. This is a more detailed and time-consuming effort compared to the static express lane traffic assignment. This approach is applicable for PD&E and design projects as well as IARs, for which a more detailed analysis is required. **Figure 8-3** shows the flow diagram explaining the dynamic express lane assignment using the Vissim Managed Lanes Facilities function.

Figure 8-3 Flow Diagram for Vissim Managed Lanes Facilities Function



There are three (3) main components of the Vissim Managed Lanes Facilities function: Managed Lanes Routes, Toll Pricing Model and Decision Model. These components are explained in the following sections.

8.7.2.1 Managed Lanes Routes

Express lanes routes in Vissim are created using the managed lane routing decision. Managed lane routes are temporary routes within the defined static routes. The managed lane route consists of two (2) parallel paths: a general-purpose path and a managed lane path. Managed lane routes are assigned to a managed lanes facility, which has a toll pricing model and a decision model, described in detail in later sections. The managed lane routes do not replace static routes but are in addition to the static routes. The beginning of the managed lane routing decision point should be placed at an adequate distance upstream to allow vehicles adequate distance to make lane changes to access express lane ingress and downstream of the corresponding static routing decision. The destination of the managed lane routing decision should be placed after the express lanes egress. When vehicles cross the beginning of the managed lane decision point of the managed lane route, they use predefined decision model to determine whether they are to use general purpose path or managed path. Vehicles eligible for the longest managed lane route should bypass all subsequent managed lane decisions once assigned to the general-purpose lane or managed lane portions of the first route. The managed lane routes do not require volume assignment. A dummy ingress should be created in situations when nearest ingress of an existing express lanes is further than 1.5 miles which is required spatial limits of express lanes discussed in **Section 8.3.**

8.7.2.2 Toll Pricing Calculation Model

The toll pricing calculation model determines when and how the express lane facility calculates the toll charge. Each toll pricing calculation model contains a pricing model. The toll charge is calculated according to the selected toll pricing calculation model for each express lane facility and is valid until the next update. The Vissim toll pricing methodology can be configured to simulate a static toll (flat rate or time of day method) and dynamic toll (traffic responsive method and COM script method). Each of these pricing calculation models are described in subsequent sections. It is suggested to follow the general guidelines listed below, regardless of the method used:

- The express lanes speed should be maintained at 45 mph or greater.
- The frequency of toll rates updates at every 15 minutes.
- The toll should be consistent with the most recent FDOT toll policies.

Static Toll Method
The static toll method of express lanes applies a fixed toll to express lanes to manage congestion in the network. A fixed toll price is assumed for operations during specified times of the analysis, in conjunction with the decision model parameters. The toll price can be fixed for the entire duration of the analysis or vary by time-of-day. No pricing model is required for this method. This method is applicable for planning and PD&E projects, dependent on the agency’s pricing policy.

Dynamic Toll Method
The dynamic toll method is a more complex and advanced method of simulating express lane operations. This approach can allow the user to maximize throughput while maintaining free-flow conditions in the express lanes. This method typically uses density information from the express lanes and updates it at a predefined time to control the traffic flow entering the express lanes to maintain acceptable conditions. The two (2) primary dynamic toll methods used for analyzing express lanes are:

- <u>The Traffic Responsive Method</u>
  The traffic responsive method should be used with caution, keeping in mind that it does not account for congestion in the express lanes by using density limits to confirm that the express lanes are operating at an acceptable level. In some scenarios, the speed thresholds may not drive the traffic out of the price-managed lanes and can result in degraded express lane operations.

- <u>The COM Script Method</u>

  The Managed Lanes Facilities function with the COM script traditionally uses average densities in the express lanes to calculate the toll rate, in combination with the decision model, to calculate the dynamic volume to be shifted from the general use lanes to the express lanes. COM scripts allow the user to set the value of the toll in express lane toll based on the current and change in traffic density (TD) which is tied to the LOS and toll rate for the express lanes' value. The toll, for express lanes, increases as density increases, and the toll decreases as density decreases. High tolls because of high traffic densities restrict traffic entering the express lanes and avoids situations in which the express lanes become unrealistically congested.

  The Vissim Managed Lane Facilities Module user guidelines developed in coordination with PTV are recommended for use. This COM script-assisted facility module reflects the toll-pricing algorithm used on 95 Express and all other statewide express lanes projects. It is available for use for all future projects in Florida. This method can simulate more realistic express lane operations because it is based on the TD of the express lane. The two (2) main elements of this method are change in TD and LOS settings. Toll rates are calculated in the script and updated in Vissim when the script sets the values based on the calculated toll amount. The steps for calculating the current toll are described below (Source: 95 Express Toll Facility Operations Manual and An Application of Microscopic Dynamic Lane Choice Assignment for Express Lanes).

Step 1: Calculate ΔTD

$$\Delta TD = TD_t - TD_{t-1}$$

Step 2: Find ΔR based on ΔTD and TD_t

$$Refer\ to\ Delta\ Settings\ Table\ (Table\ 8-3)\ or\ (Table\ 8-4)$$

Step 3: Calculate R_t

$$R_t = R_{t-1} + \Delta R$$

Step 4: Decide Final Rt

$$R_t = Max, if\ R_t > Max\ \ (Table\ 8-1)\ or\ (Table\ 8-2)$$
$$R_t = Min, if\ R_t < Min\ \ (Table\ 8-1)\ or\ (Table\ 8-2)$$
$$R_t,\ \ otherwise$$

Where:

R_t – Current toll

R_{t-1} – Previous toll
TD_t – Current TD
TD_{t-1} – Previous TD
ΔTD – Change in TD
ΔR – Toll adjustment
Max – Maximum toll at an LOS
Min – Minimum toll at an LOS

The toll change is added or subtracted to the previous toll to determine the current toll. The current toll is compared with the Minimum and Maximum LOS settings. If the current toll falls outside the Minimum or Maximum toll range for the corresponding TD, then the Minimum or Maximum tolls are applied, respectively. If the current toll falls within the Minimum or Maximum toll range, then the current toll is applied.

Tables 8-1 and **8-2** show proposed default LOS and toll settings for interstate facilities for express lanes segments less than and greater than three (3) miles, respectively. **Tables 8-3** and **8-4** show proposed default delta density settings for express lanes segments less than and greater than three (3) miles, respectively. These tables are based on the following constraints.

- Minimum of $0.50 per segment
- Maximum of $3.00 per segment for segments less than three (3) miles
- Maximum of $5.00 per segment for segments greater than three (3) miles

COM script with this tolling algorithm can be obtained from FTE. The most recent FDOT tolling policies should be investigated and discussed with FDOT in the beginning of the express lanes project.

Table 8-1 Proposed Default LOS and Toll Settings for Interstate Facilities (Segment < 3 miles)

LOS	TD		Rate	
	Min	Max	Min	Max
A	0	11	$0.50	$0.50
B	12	18	$0.50	$0.50
C	19	26	$0.50	$0.75
D	27	35	$0.75	$2.00
E	36	45	$2.00	$3.00
F	46	60	$3.00	$3.00

Table 8-2 Proposed Default LOS and Toll Settings for Interstate Facilities (Segment > 3 miles)

LOS	TD		Rate	
	Min	Max	Min	Max
A	0	11	$0.50	$0.50
B	12	18	$0.50	$0.50
C	19	26	$0.50	$1.00
D	27	35	$1.00	$3.00
E	36	45	$3.00	$5.00
F	46	60	$5.00	$5.00

Table 8-3 Default Delta Density Settings for Interstate Facilities (Segment < 3 Miles)

LOS	Current Density	Delta (Change in Density)																		
		Δ0	Δ1	Δ2	Δ3	Δ4	Δ5	Δ6	Δ7	Δ8	Δ9	Δ10	Δ11	Δ12	Δ13	Δ14	Δ15	Δ16	Δ17	Δ18
	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
A	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	7	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	8	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	9	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	10	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	11	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	12	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	13	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	14	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
B	15	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	16	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	17	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	18	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	19	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	20	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	21	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
C	22	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	23	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	24	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	25	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	26	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	27	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	28	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	29	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	30	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
D	31	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	32	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	33	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	34	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	35	$0.00	$0.25	$0.25	$0.25	$0.50	$0.50	$0.50	$0.75	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.25	$1.50	$1.50	$1.50	$1.50
	36	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	37	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	38	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	39	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
E	40	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	41	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	42	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	43	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	44	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	45	$0.00	$0.25	$0.25	$0.50	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.25	$1.50	$1.50	$1.75	$1.75	$2.00	$2.00	$2.25	$2.25
	46	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	47	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	48	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	49	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	50	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	51	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	52	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
F	53	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	54	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	55	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	56	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	57	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	58	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	59	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	60	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

Table 8-4 Default Delta Density Settings for Interstate Facilities (Segment > 3 Miles)

LOS	Current Density	Delta (Change in Density)																		
		Δ0	Δ1	Δ2	Δ3	Δ4	Δ5	Δ6	Δ7	Δ8	Δ9	Δ10	Δ11	Δ12	Δ13	Δ14	Δ15	Δ16	Δ17	Δ18
	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
A	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	7	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	8	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	9	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	10	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	11	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	12	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	13	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	14	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
B	15	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	16	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	17	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	18	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	19	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	20	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	21	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
C	22	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	23	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	24	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	25	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	26	$0.00	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
	27	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	28	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	29	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	30	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
D	31	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	32	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	33	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	34	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	35	$0.00	$0.25	$0.25	$0.50	$0.75	$0.75	$1.00	$1.00	$1.25	$1.50	$1.50	$1.75	$2.00	$2.00	$2.25	$2.25	$2.50	$2.50	$2.50
	36	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	37	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	38	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	39	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
E	40	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	41	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	42	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	43	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	44	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	45	$0.00	$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.00	$3.25	$3.50	$3.75	$4.00
	46	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	47	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	48	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	49	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	50	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	51	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	52	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
F	53	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	54	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	55	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	56	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	57	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	58	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	59	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	60	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

8.7.2.3 Decision Model

Vissim's Managed Lanes Facilities function includes an embedded decision model that determines the probability of vehicles to use the express lanes, based on travel time savings and toll costs. This decision model is a discrete choice model with attributes of cost coefficient, time coefficient and base utility (intercept/toll constant).

The managed lane's utility (U) is calculated using **Equation 8-1**:

Equation 8-1

$$U_{Toll} = cost\ coefficient \times toll\ rate + time\ coefficient \times time\ gain + base\ utility$$

In the equation above, the time gain is the difference between the travel time on the general use lane and the travel time on the express lanes, determined during the last update interval (typically 15 minutes). The utility of the general use lanes is always zero, because there is neither a toll nor time gain, when compared to itself.

The probability of using the managed lane is calculated using a Logit model, provided in **Equation 8-2**:

Equation 8-2

$$P_{(Toll)} = 1 - \frac{e^{a \times U_{Toll-free}}}{e^{a \times U_{Toll-free}} + e^{a \times U_{Toll}}} = 1 - \frac{1}{1 + e^{a \times U_{Toll}}}$$

Where,
$a =$ alpha value and
$U_{Toll} =$ utility of managed lane

The decision model parameters in the above **Equations 8-1** and **8-2** depend on the project area. To determine the probability of managed lane users, stated preference surveys can be performed for the express lane project. Stated preference surveys are typically conducted as part of a Traffic and Revenue Study and can be obtained from the FTE. The results of these stated preference surveys should be used in finalizing project-specific decision model parameters. In the absence of a survey in the project study area, the values from the existing express lane projects within the region can be used. The Vissim decision model parameters were calibrated using 95 Express Phase 1 data and have been used for multiple projects throughout the state. As part of the calibration for 95 Express Phase 1, the decision model parameters were adjusted to reflect the ELToD choice model as best as possible. The decision model in Vissim can be customized to replicate ELToD directly through additional programming or COM scripts. **Table 8-5** provides proposed ranges for decision model parameters for use in **Equations 8-1** and **8-2**.

Table 8-5 Proposed Ranges for Decision Model Parameters

Decision Model Parameters	Proposed Ranges
Alpha value or scale factor	0.5 to 1
Cost coefficient	-0.61
Time coefficient	Equation 8-3
Intercept/ Base utility	-0.8 to 1.0

Time Coefficient

The time coefficient can be obtained from **Equation 8-3.** The coefficient is derived from the VTTS in dollars per hour obtained from a stated preference survey. Based on previous calibration efforts for 95 Express Phase 1, the VTTS should be factored by 3.5 to account for actual time savings compared to the toll charged. This VTTS factor has been used for Vissim managed lane projects in the state and has proven to provide reasonable results.

Equation 8-3

$$VTTS = 60 \times \frac{time\ coefficient}{cost\ coefficient}$$

An example calculation of the time coefficient is as follows. The VTTS for a corridor was measured as $13.50 per hour from the stated preference survey. By keeping cost coefficient at -0.61 according to **Table 8-5**, the time coefficient using **Equation 8-3** is calculated as 0.137 (($13.50 x -0.61)/60). Applying a factor of 3.5 yields a final time coefficient of 0.48.

Table 8-6 provides an example of a probability matrix with an alpha value, a cost coefficient, a time coefficient and a base utility as 1, -0.61, 0.48 and -0.4, respectively.

Table 8-6 Example of Probability Matrix

Travel Time Savings (minutes)	Toll: $0.5	$1.0	$2.0	$3.0	$4.0	$5.0	$6.0	$7.0	$8.0	$9.0	$10.0
0	33%	27%	17%	10%	6%	3%	2%	1%	1%	0%	0%
1	45%	37%	24%	15%	9%	5%	3%	2%	1%	0%	0%
2	57%	49%	35%	22%	13%	8%	4%	2%	1%	1%	0%
3	68%	61%	46%	32%	20%	12%	7%	4%	2%	1%	1%
4	78%	72%	58%	43%	29%	18%	11%	6%	3%	2%	1%
5	85%	81%	70%	55%	40%	27%	17%	10%	6%	3%	2%
6	90%	87%	79%	67%	52%	38%	25%	15%	9%	5%	3%
7	94%	92%	86%	77%	64%	50%	35%	22%	14%	8%	4%
8	96%	95%	91%	84%	75%	62%	47%	32%	20%	12%	7%
9	98%	97%	94%	90%	83%	72%	59%	44%	30%	19%	11%
10	99%	98%	96%	94%	89%	81%	70%	56%	41%	27%	17%

8.7.3 Summary

Static express lane assignment approach designates a predetermined traffic flow in express lanes, regardless of the congestion in general use lanes, and, therefore, there is no pricing model defined for this approach. The dynamic volume assignment method dynamically appoints traffic in express lanes based on the driver's perception of congestion in general use lanes and the potential travel time savings by using express lanes.

Table 8-7 summarizes express lane modeling with the pros, cons and applicability for each method.

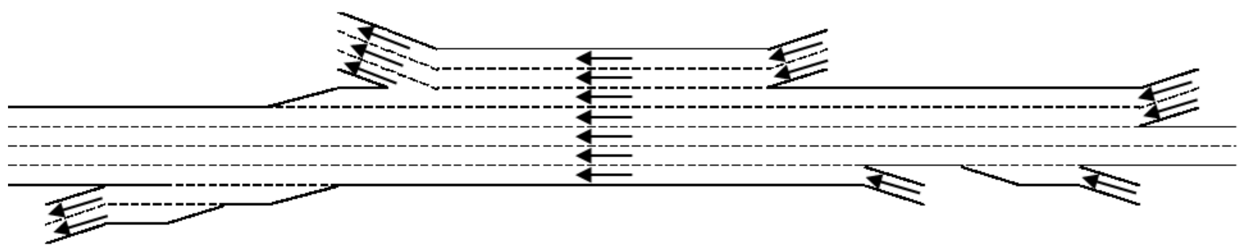
Table 8-7 Express Lanes Traffic Modeling

Express Lanes Assignment	Express Lanes Demand Volume Source	Pricing Model and Decision Model	Pros	Cons	Applicability
Static	Split from TDM with built-in tolling algorithm. TDMs without peak periods should not be used for the split between general use and express lanes.	No pricing model or decision model required.	- Peak period demand directly from TDM without needing to use another model - Easier to use for systemwide evaluation	- Does not expressly consider queue accumulation and dissipation. - May result in degraded operations for express lanes if congestion exists at express lanes access points or anywhere in the network and affect express lanes operations.	Planning and PD&E projects. Not preferred for IARs
	ELToD output		- Quick turnaround time for alternatives testing - Consistent results in controlled environment - Peak hour demand volume available		IARs, Planning and PD&E projects.
	Previous studies in the study area		Express lanes volume is already determined		For re-evaluation of Planning, PD&E and design projects
Dynamic	TDM with or without built-in tolling algorithm, ELToD output	- Pricing model can be static for the time of day or dynamic - Decision model parameters development needed	- Pricing model customized to match the statewide express lanes software tolling algorithm - Accounts for congestion build up and dissipation - Does not require manual assignment of express lanes traffic for all ingress/egress locations - Results may be more defendable than manual assignment	- Extensive time and effort - Requires customized scripting and other inputs using Vissim Managed Lanes Facilities functionality - Alternatives or ingress/egress testing can be cumbersome	PD&E and design projects. Preferred for IARs

8.8 Complex Weave Analysis

Complex or multiple weave segments are formed by a series of closely spaced merge and diverge areas creating overlapping, weaving movements between different merge-diverge pairs that share the same roadway segment. In Florida, complex or multiple weave segments are primarily formed by the left-side access from express lanes to general use lanes, when it has a proximity to another service or system-to-system interchange. These often create operation and safety concerns. **Figure 8-4** shows an example of a complex weave segment.

Figure 8-4 Complex Weave Segment



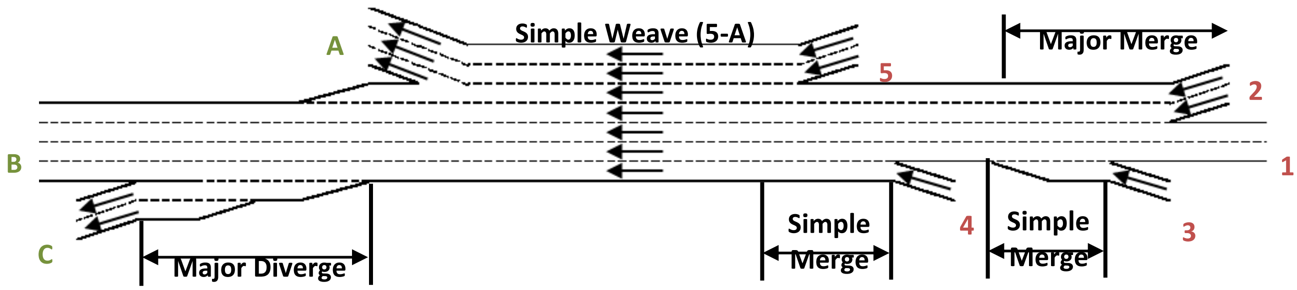
FDOT developed a methodology with FHWA to analyze complex weave segments. This methodology identified two (2) methods of analyzing complex weave segments. In addition, the methodology acknowledged a reduction in the capacity within complex weave segments and conducted a sensitivity analysis on the density and speed results, with several travel time segments using critical segment segregation. The methodology also provides recommendations on how to document results to capture the speed difference between weaving and nonweaving traffic and vehicles disappearing from the network. Each of these are described in subsequent sections. The MOEs for reporting complex weave analysis results are discussed in **Section 9.4** of this handbook.

Complex weave segments should be analyzed using the two (2) methods described below to confirm that there are no capacity and operational issues within the complex weave segment. The methodology discussed below should be used to analyze every complex weave segment within the project study area.

8.8.1 Method 1: Individual Elements Analysis (HCM Based)

It is recommended that multiple or complex weaving segments should be segregated into separate merge, diverge and simple weaving segments. Each segment should be appropriately analyzed by using the individual element analysis methodology in the HCM. Any segment operating at a density of 35 vehicles per mile per lane (vpmpl) or above should serve as a concern for potential issues in the complex weave segment operations. It is recommended to revisit these locations and investigate mitigation measures. In the case of a capacity constraint, these should be discussed with FDOT on a case-by-case basis. **Figure 8-5** provides snapshot of segments identified for the individual elements analysis by segregating the complex weave segment.

Figure 8-5 Individual Elements Analysis within Complex Weave Segment

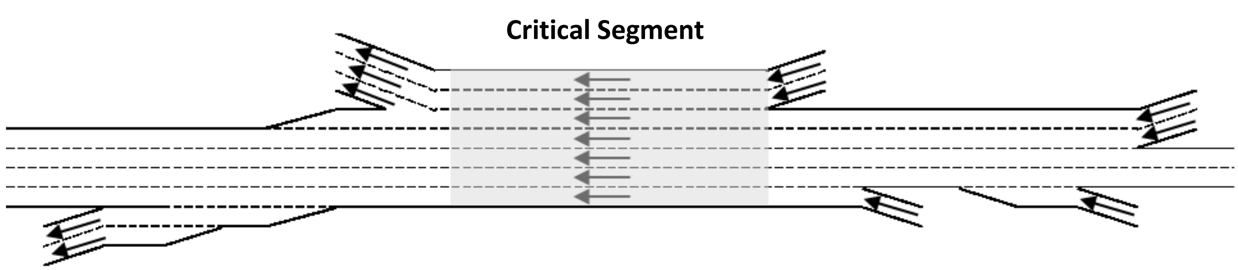


8.8.2 Method 2: V/C Ratio Using Vissim

The capacity of a complex weave segment is generally reduced compared to a similar basic freeway segment. This reduction in capacity depends on several parameters, such as the total volume, weaving volumes, weave length, number of lanes in weave segment, number and locations of origins or destinations, lane channelization and lane continuity in weave area. Changes to any of these parameters affect the capacity and operations of the complex weave segment.

A "critical segment" is defined as the segment within a complex weave segment, which is downstream of all entrances and upstream of all exits and where most lane changes occur. **Figure 8-6** shows an example of a critical segment within a complex weave segment.

Figure 8-6 Critical Segment within Complex Weave



The capacity of a critical weave segment can be determined by loading a combination of different demand and weaving volumes. The complex weave segment can be extracted from the larger microsimulation model network to perform this analysis. The reduction in the capacity should be used to determine the V/C ratio using **Equation 8-4** for each complex weave segment within the project.

Equation 8-4

$$V/_C = \frac{peak\ hour\ freeway\ demand\ volume\ in\ critical\ weaving\ segment}{per\ lane\ capacity \times number\ of\ lanes}$$

For projects with complex weave segments in which a capacity reduction cannot be determined using the above methodology, the critical segment capacity can be assumed as 1,600 to 1,800 vehicles per hour per lane (vphpl) to determine the V/C ratio (Reference Exhibit 12-30, Parameters for Basic Managed Lanes Segment Analysis, HCM, 6th Edition).

The capacity of a complex weave segment can be assumed to be 1,600 to 1,800 vphpl to calculate the V/C ratio.

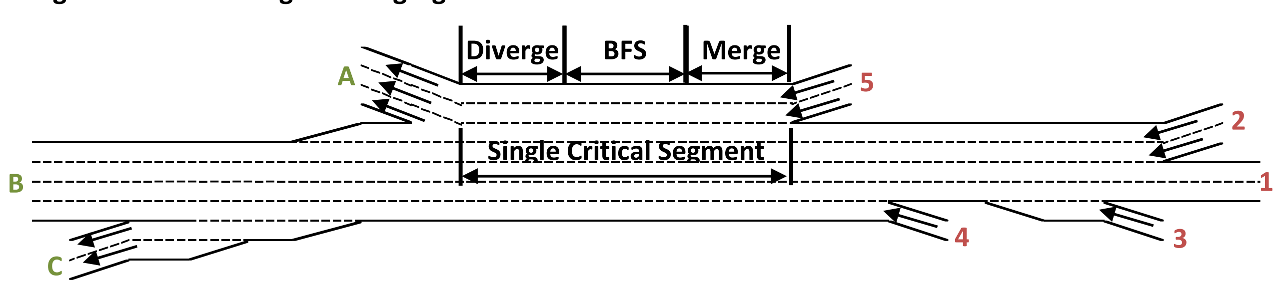
A critical weave segment with a V/C ratio greater than 1.0 should serve as a concern and an indication of potential issues for the complex weave segment operation. It is recommended to revisit these locations and investigate mitigation measures.

8.8.3 Critical Segment Segregation

Generally, a reduction in capacity of the general use lanes is observed within the critical segment. This reduction in capacity is due to cross weaving and lane changing maneuvers between traffic entering from multiple entrances and exiting to destinations located on both sides of the general use lanes. The critical segment in **Method 2** above should be evaluated further by placing additional travel time segments within the critical segment to assess the impact of the critical segment length on the results. The single travel time segment results do not accurately represent turbulence in the critical segment for longer lengths. The single critical segment can be divided into three (3) travel time segments representing merge, basic freeway and diverge segments.

It has been observed that within the critical segment — at densities greater than 45 vpmpl for the merge, basic freeway and diverge travel time segments — the merge segment has the highest density and lowest speed, while the diverge segment has the lowest density and highest speed. It is recommended to divide the critical segment into smaller travel time segments of merge area, basic freeway segment and diverge area in the microsimulation model to better understand the operations of the complex weave segment in express lanes projects. An example is shown in **Figure 8-7**.

Figure 8-7 Critical Segment Segregation



8.8.4 Speed Differential

The primary concern with any weave segment is the reduction in speed due to the weaving traffic movements. In a complex weave segment, there are multiple origins and destinations for the traffic movements, creating conflicts. The speeds for weaving and nonweaving vehicles from all origins and destinations within the complex weave segment should be extracted from the microsimulation model to assess the impacts of multiple crossing movements. The speed differential observed between weaving and nonweaving traffic should be minimal. A higher speed differential indicates slowdown, meaning the length of the complex weave segment is not adequate and there is congestion within the complex weave segment. It is recommended that the speed difference between weaving and nonweaving movements be within 10 mph. If higher speed difference than recommended is observed, then it should be investigated and documented. Additional design changes should be evaluated to ensure that the speed differential is below the threshold.

> It is recommended that the speed difference between weaving and nonweaving movements be within 10 mph.

8.8.5 Vehicles Disappearing

Express lanes access points are generally located to the left of the freeway and service interchange ramps to the right of the freeway. Traffic entering general use lanes from express lanes access points must weave across multiple lanes to access the downstream service interchange exit. Similarly, traffic entering from the service interchange and exiting general use lanes to enter the express lanes must weave across multiple lanes to enter the express lanes. In Vissim, vehicles that get "stuck" in the network for a specified duration are experiencing an error and are removed from the model. These vehicles disappearing from the network due to congestion or network coding issues are reported in the error (*.err) file. It is recommended to use vehicles disappearing as a measure to identify any disturbance or congestion within the complex weave segment and to determine if the length of the complex weave segment is adequate. The number of vehicles disappearing within each complex weave segment should be reported and compared between no-build (without express lanes) and build (with express lanes) alternatives. The build alternative should not have more vehicles disappearing than the no-build within the complex weave segment. In addition, the build alternative disappearing vehicles should be less than ten (10) vph within the complex weave segment. This is measured between upstream of the first entry to downstream of the last exit forming the complex weave segment.

> The build alternative disappearing vehicles should be less than ten (10) vph within the complex weave segment.

Chapter 9
Performance Measures of Effectiveness

9.1 Introduction

Performance MOEs are quantitative measures that define the performance of a transportation facility. Operational MOEs are numerical outputs from traffic analysis, which are metrics used to assess the operational performance of existing and future transportation networks. Existing conditions performance measures facilitate in adapting the vision to reshape transportation systems for the future. Future conditions performance measures provide a linkage between the agency's goal and ultimate outcome resulting from transportation improvements.

MOEs are also used to compare the system's performance under various design or improvement alternatives. The analyst should be aware of and able to identify any limitations of the MOEs to the measurement of performance of the system being evaluated.

MOEs are project specific and are selected and agreed upon in the traffic analysis methodology. The selected MOEs are part of the alternatives evaluation criteria and should be included in the evaluation matrix which contain other measures (related to cost and environmental impact) used in the alternative's evaluation. If the purpose and need is refined during analysis resulting in additional or different MOEs, documentation for such change should be provided.

The study methodology should identify all traffic operations MOEs that will be used to measure the performance of the system and alternatives being evaluated. It is important to describe the MOEs as field-measured or established analytically. Additional project related MOEs to be used in the alternative's analysis can be obtained from relevant local and regional agency guidelines.

The study methodology should identify all traffic operations MOEs that will be used to measure the performance of the system and alternatives being evaluated.

LOS

Common MOEs used to qualify the facility performance are HCM LOS and V/C ratio. Operations with LOS F or V/C ratio greater than 1.0 are unacceptable. LOS is a readily recognizable qualitative indicator of traffic operations and has been widely used by different agencies when evaluating the traffic operations performance of facilities. However, LOS alone does not necessarily give insight about the overall performance of the facility. Moreover, LOS is not directly reported by several analysis programs (such as most microsimulation programs). Thus, additional quantifiable measures should be included in the analysis to better assess the performance of the system or network being analyzed. It is recommended that the analyst seek input from project stakeholders when establishing MOEs for the project. Guidance is provided later in this chapter regarding these additional quantifiable measures and their use in projects.

LOS target for projects on the SHS are to be selected based on the FDOT LOS policy (FDOT Policy No. 000-525-006 – Level of Service Targets for the SHS). In some instances, local governments may have adopted LOS standards for state roads and/or local facilities that do not match LOS targets in FDOT's policy. Projects on local government facilities may use the agency's LOS target.

The following topics are covered in this chapter. Each of these topics are covered in detail in subsequent sections.

1. Purpose and Intended Use
2. Operational Analysis Using Deterministic Tools
3. Microsimulation Analysis
4. Express Lanes Performance Measures
5. Performance Measures Threshold for Microsimulation

9.2 Purpose and Intended Use

The purpose of computing traffic operations MOEs is to quantify the impacts resulting from the proposed modifications in a project and determine if identified goals are achieved. Performance measures identified for an analytical project should focus on what will differentiate the alternatives. Since these measures will directly inform decision makers, they are a critical element to focus on early in the project. There are several available MOEs that may be used to evaluate the study alternatives and document the results. The purpose of this chapter is to provide guidance on which MOEs should be produced and appropriate documentation of these MOEs for traffic analysis. This chapter provides a basic set of MOEs to identify congestion, capacity constraint and operational issues using analytical tools and microsimulation analysis. The selected MOEs listed in subsequent sections are part of the alternative's evaluation criteria. If the purpose and need is refined in the course of analysis and demand additional MOEs, documentation for such change should be provided.

The purpose of this chapter is to provide guidance on which MOEs should be produced and appropriate documentation of MOEs for traffic analysis.

MOEs are project specific and should be selected and agreed upon in the traffic analysis methodology prepared in the beginning of the study. **Table 9-1** provides a list of commonly used tools in Florida along with the facility types that they are used to analyze. MOEs from these tools are the focus of this chapter. It should be noted that HCS and microsimulation can analyze additional facility types than the ones listed below. The FDOT Generalized Service Volume Tables and Intersection Control Evaluation (ICE) are sometimes used in Planning and PD&E studies for initial screening of corridor and intersection alternatives. Information about the Generalized Service Volume Tables is provided in FDOT's Quality/Level of Service

Handbook and is not covered in this chapter. It is not recommended to use Generalized Service Volume Tables in IAR and design projects.

Table 9-1 Common Analysis Tools

Common Analysis Tools	Type of Analysis
Deterministic	
HCS	Freeway facilities, Basic freeway segments, Merge/Diverge segments, Weaving segments, Two-lanes and Multilane highways, Roundabouts*, Signalized and Unsignalized intersections, Urban Streets
Synchro	Signalized intersections, Unsignalized intersections, Arterials, Roundabouts*
SIDRA	Roundabouts*
Microsimulation	
Vissim/CORSIM	Freeways, Signalized and Unsignalized intersections, Arterials, Highways, Network-wide operations, Roundabouts*

*When performing deterministic analysis, preference for analyzing one-lane roundabouts is HCS and multilane roundabouts is SIDRA.

MOEs can be field-measured or computed by analytical and microsimulation tools. Field measurements are more appropriate for the calibration process; however, analytical measurements are used for future alternatives evaluation and comparison. Data should be collected for estimating both the calibration performance measures and demand data. Geometric data, traffic control data and access management data should be verified. The analyst should consult the FDOT MUTS and HCM for procedures for measuring performance measures in the field. Traffic operational MOEs can be directly computed/measured or derived from other measures. MOEs that are directly computed/measured are called basic measures while derived measures are computed from the basic measures and other inputs. **Table 9-2** provides a list of typical candidate MOEs reported for any traffic analysis project.

Table 9-2 Typical Candidate Operational MOEs

Operational MOEs
Travel time
Speed
Delay
LOS
V/C ratio
Throughput
Density
Queue length
Network-wide MOEs

9.3 Operational Analysis Using Deterministic Tools

In general, deterministic tools implement the procedures of the HCM. The HCM procedures are closed form (not iterative), macroscopic, deterministic and static analytical procedures that estimate capacity and performance measures to determine the LOS (e.g., density, speed and delay). Due to time and resources required for the traffic analysis efforts, especially microsimulation analysis and uncertainty of developing improvements concepts in the early stages of the project, it is beneficial to assess general feasibility of the concepts (Stage 1 analysis) by using sketch-planning tools such as Generalized Service Volume Tables or HCS for mainline and ICE for intersections. This approach would use general performance measures such as V/C ratios to screen the concepts. Screening of concepts would generate viable improvement alternatives which may be carried forward for more detailed traffic analyses (Stage 2 analysis). When V/C ratio is used, the analyst should make sure demand volume is used in the analysis. All improvement concepts that were rejected from further consideration should be documented and included in the alternatives' analysis report.

All improvement concepts that were rejected from further consideration should be documented and included in the alternatives' analysis report.

HCS and Synchro are the two (2) most used deterministic analytical tools for operational analysis in Florida. Every corridor is different with its own unique planning and operating challenges and characteristics. The selection of the MOEs should emphasize the project purpose and need and should be decided during the methodology phase.

9.3.1 HCS Analysis

HCS is a deterministic tool and is a reliable application of the HCM. The current HCS7 program uses the methodologies outlined in HCM 6th Edition. It calculates LOS based on density or delay depending on the facility type and uses a look up value table to convert numerical results into qualitative letter grades named as LOS A through LOS F. Typically, HCS analysis is done to determine if the individual element of the facility provides acceptable traffic operations for peak 15 minutes within the peak hour, for the existing conditions and future design.

HCS can be used to analyze interrupted and uninterrupted flow facilities including signalized and unsignalized intersections, freeway segments, merging and diverging junctions, weaving segments, collector-distributor facilities, multilane highways, two-lane highways and roundabouts. HCS analysis generates additional MOEs for each of these facility type and can be reported based on the project need. **Table 9-3** provides recommended list of typical MOEs from HCS analysis depending on the facility type being analyzed.

MOEs from HCS analysis are not required to be reported when microsimulation is performed and results from microsimulation are reported in the study report (such as IARs).

MOEs from HCS are not required to be reported when microsimulation analysis is performed.

Density from HCS is typically reported in passenger cars per mile per lane (pc/mi/ln) while density from the microsimulation model is reported in vehicles per mile per lane (veh/mi/ln). Density values from microsimulation need to be converted to pc/mi/ln in order to report equivalent LOS from the HCM. This is further explained in later sections of this chapter.

Table 9-3 Typical HCS Performance MOEs

Facility Type	MOE

Freeway facilities	• Individual segment
	  ○ Density (pc/mi/ln)
	  ○ LOS
	• Facility overall
	  ○ Density (pc/mi/ln)
	• Speed (mph)

Basic freeway segments	• Density (pc/mi/ln) • LOS
Merge/Diverge segments	• Density (pc/mi/ln) • LOS • V/C for major merge/diverge segments
Weaving segment analysis	• Density (pc/mi/ln) • LOS
Ramp Roadways	• V/C (Calculated)
Signalized intersection	• Intersection delay (sec/veh) • Movement delay (sec/veh) • Intersection LOS • Movement LOS • Back of queue ft/ln (95th percentile) • Back of queue veh/ln (95th percentile)
Unsignalized intersection (All Way Stop Controlled) (Two Way Stop Controlled)	• Intersection delay* • Intersection LOS* • Movement delay • Movement LOS • 95th percentile queue length (veh)
Urban Streets	• Travel Speed (mph) • LOS
Multi-lane highways	• Density (pc/mi/ln) • LOS
Two-lane highways	• Follower density (followers/mi/ln) • LOS
Roundabout	• Control delay (sec/veh) • LOS • Approach delay (sec/veh) • Approach LOS • 95th percentile queue length (veh)

*Intersection Delay and Intersection LOS for All Way Stop Controlled intersections only.

9.3.1.1 Freeway Facilities Analysis

HCS freeway facilities module evaluates the operations of an extended section of the freeway combining impacts of basic freeway, merge/diverge and weaving analysis. This analysis method aggregates the results of the HCS individual elements and provides speed, density, LOS and travel time MOEs for the entire facility being evaluated as well as for individual elements. HCS freeway facility analysis is a desired method of the analysis for larger network projects when microsimulation analysis is not performed. Results from the freeway facilities module should be used with caution, especially if average results are reported for the network. The performance of individual segments (basic segment, merge/diverge and weave) should be observed separately even if freeway facilities analysis is performed.

Freeway facility analysis may be performed for preliminary screening of alternatives, but it should not be used in lieu of microsimulation analysis. MOEs from freeway facility analysis are not required to be reported when microsimulation is performed and results from microsimulation are reported in the study report (such as IARs).

9.3.1.2 Intersection Analysis

HCS analysis examines the functionality of a signalized and unsignalized intersection in terms of specific MOEs, such as LOS, delay, or queue. An unsignalized intersection may either be All-Way Stop Controlled or Two-Way Stop Controlled. The preference is for roundabouts to be analyzed in HCS (single lane) or SIDRA (multilane) and signalized and unsignalized intersections to be analyzed in Synchro software for capacity analysis.

9.3.2 ICE Procedure

FDOT has developed ICE as performance-based procedure which quantitatively evaluates several intersection control alternatives and ranks these alternatives based on their operational and safety performance. The ICE procedure outlines methods of quantitative analysis to select intersection control types during initial screening or planning stage. ICE creates a transparent and consistent approach to consider intersection alternatives based on metrics such as safety, operations, cost and social, environmental and economic impacts. The ICE procedure is the same for new intersections or modifications to existing intersections.

The goal of ICE is to better inform the FDOT's decision-making to identify and select a control strategy meeting the project's purpose and need, fitting the intersection location's context classification, providing safe travel facilities for all road users and reflecting the overall best value. It is an effective tool to screen intersection alternatives during planning stage. Detailed information on this procedure and training material can be found at FDOT's Traffic Engineering and Operations Office.

9.3.3 Synchro Analysis

Synchro is a deterministic tool that is commonly used for analyzing signalized intersections, unsignalized intersections and arterials. Synchro uses delay as a basis for determining qualitative letter grades named as LOS A through LOS F. The most used MOEs from Synchro are intersection and individual movements control delay, V/C ratio and 95th percentile queue length. Synchro does not provide freeway performance measures and should not be used for analyzing freeway facilities. Synchro is often used to develop optimized signal timing plans which are then used as input to the microsimulation software.

9.3.3.1 Intersection Delay

Synchro calculates control delay using two (2) different methods: The Percentile Delay Methodology and the HCM methodology. Synchro percentile delay methodology includes an additional delay related to spillback from adjacent intersections and the total delay includes control delay plus the queue delay.

Synchro also implements the intersection analysis methods from HCM 6th Edition, HCM 2010 and HCM 2000. If the intersection is compatible with the selected HCM edition methodology, all necessary inputs and outputs are displayed mimicking the HCM computational methods. The calculated intersection delay is based on the method described in the selected HCM Edition. HCM methodologies in Synchro cannot analyze all intersection configurations including non-NEMA phasing plans and clustered intersections. Synchro uses HCM delay thresholds for reporting LOS for both delay calculation methods.

For unsignalized intersections, Synchro default window shows HCM 2000 methodology results and it also provides results from HCM 2010 and HCM 6th Edition. Results should be reported based on the latest HCM methodology. Synchro has limitations in analyzing unsignalized intersections, even if results are reported based on HCM thresholds.

The selection of either analysis method from Synchro for documenting intersection delay should be identified and agreed by all parties at the start of the project. Analysis results from Synchro can be reported based on the Synchro methodology or HCM methodology. The Department’s primary source for highway capacity and LOS analysis methodologies is the HCM. Synchro LOS are approximations based on several procedures included in the program. The analyst, client and approving authorities should agree and document the reporting methodology at the beginning of the study. If HCM based results are reported from Synchro, the latest available version of HCM should be selected. There are limitations to the HCM methodologies application in Synchro and these are not regularly updated in the Synchro program.

Table 9-4 provides a list of recommended MOEs that apply to Synchro analyses.

Table 9-4 Synchro Typical MOEs

Intersection Type	MOEs
Signalized intersection	• Intersection delay • Movement delay • Intersection LOS • Movement LOS • 95^{th} percentile queue lengths
Unsignalized intersection	• Minor movement delay • Minor movement LOS • 95^{th} percentile queue lengths
Arterials	• Travel time, speed, signal delay, LOS

9.3.3.2 Queue Length

The 95^{th} percentile queue length in feet, along with any special notes from Synchro, should be reported along with the available storage. The available storage for the turn movements, measured from the stop bar to the taper, should be clearly reported in tables for comparison with the queue length. Refer to FDM for further guidance on measuring storage length for turn lanes. At the off ramp terminal intersections, the queue length should be reported in tables along with the storage length for the left and right turn lanes. In addition to the available turn lane storage, the total ramp length, measured from stop bar to the gore point with the freeway, should be discussed in the document.

95^{th} percentile queues from Synchro are valid for undersaturated conditions and should be reported with caution for saturated/oversaturated conditions. For saturated/oversaturated conditions, it is preferred that queues are reported from a calibrated microsimulation model. Max queues should be reported based on simulation as discussed in later sections.

MOEs from Synchro analysis are not required to be reported when microsimulation is performed and results from microsimulation are reported in the study report (such as IARs).

> MOEs from Synchro analysis are not required to be reported when microsimulation analysis results are reported.

Table 9-5 shows an example of tabular presentation of Synchro intersections performance measures.

Table 9-5 Tabulation of Synchro Intersection Performance Measures Example

Intersection	Approach	Movement	Delay (Seconds)	LOS	Available Storage (Feet)	95th % Queue (Feet)
			AM (PM)	AM (PM)	# of Lanes/Length	AM (PM)
I-295 at Atlantic Boulevard	Eastbound	Left	52 (60.2)	D (E)	1/240'	93' (118')
		Through	25.9 (61.8)	C (E)	3/1000'	349' (#747')
		Right	0.4 (0.8)	A (A)	1/500'	0' (0')
	Westbound	Left	49.3 (75.8)	D (E)	1/330'	#165' (#283')
		Through	29.9 (21.7)	C (C)	3/1500'	#616' (373')
		Right	11.6 (7.4)	B (A)	1/165'	292' (180')
	Northbound	Left	54.9 (40.3)	D (D)	2/650'	#271' (700')
		Right	0.2 (0.1)	A (A)	1/650'	0' (0')
	Southbound	Left	51.1 (68.1)	D (E)	2/500'	#256' (#389')
		Right	0.1 (0.1)	A (A)	1/500'	0' (0')
	Overall intersection		***28.6 (38.9)***	***C (D)***		-

(shaded) Queue exceeds available storage

# indicates that the volume for the 95th percentile cycle exceeds capacity.

9.3.4 Innovative Intersections and Interchanges

Innovative intersections are created by rerouting one (1) or more movements from the conventional intersection to one (1) or more secondary junction(s). Innovative intersections and interchanges assist in reducing intersection delay, provide synchronized movements and increase efficiency and safety by modifying traffic movements and reducing conflict points at the underperforming conventional intersection. Innovative intersections often replace a single conventional intersection with two (2) or more intersections for more coordinated flow of traffic. The following are examples of innovative intersections and interchanges: Diverging Diamond Interchange (DDI); Restricted Crossing U-Turn (RCUT); Continuous Flow Intersection (CFI); Median U-Turn (MUT); Displaced Left Turn (DLT). More information about innovative intersections and interchanges can be found in FHWA Alternative Intersections/Interchanges: Informational Report.

To compare traffic analysis of innovative intersections to the conventional intersections, the reported MOEs must account for the multiple intersections, rather than the operation of a single intersection or movement. In addition, available queue storage should also be carefully evaluated to confirm there is no spillback to the upstream intersections.

When performing traffic operations analysis incorporating the innovative intersections, MOEs should be carefully selected from **Table 9-4** to compare between the conventional intersection and the innovative intersections. In complex scenarios such as the CFI, when one (1) intersection is replaced by multiple intersections, results should be reported for all the new intersections. It should be ensured that LOS, delay and queue lengths for all the new intersections is within the acceptable limits of the study. Also, when analysts seek to accumulate the delay at a signal from microsimulation analysis, they should investigate whether the delay and queues extend beyond the single approach links to the intersection. This is because all microsimulation models assign delay to the segment in which it occurs. For example, the delay associated with a single approach to a traffic signal may be parceled out over several upstream links if the queues extend beyond one (1) link upstream from the intersection. It is not recommended to calculate weighted average of delay for the movements and intersections between the different configurations as this may not provide an accurate representation of the operating conditions. **Figure 9-1** and **Table 9-6** show an example of reporting results for the CFI concept that has multiple intersections.

> It is not recommended to calculate weighted average of delay for the movements and intersections.

Figure 9-1 CFI Example

Table 9-6 CFI Results Documentation Example

Intersection	Intersection Approach				Overall Intersection	
	Approach	Movement	Delay (sec)	LOS	Delay (sec)	LOS
			AM (PM)	AM (PM)	AM (PM)	AM (PM)
Mahan Drive Intersection #1	Eastbound	Left	41.6 (44.7)	D (D)	10.6 (7.8)	B (A)
	Westbound	Through	13.3 (6.8)	B (A)		
	Southbound	Right	0.2 (0.1)	A (A)		
Mahan Drive Intersection #2	Eastbound	Through	24.3 (27.9)	C (C)	10.8 (14.7)	B (B)
	Northbound	Left	35.3 (21.3)	D (C)		
Mahan Drive Intersection #3	Westbound	Through	31.2 (26.3)	C (C)	18.8 (14.9)	B (B)
	Southbound	Left	26.5 (37.4)	C (D)		
Mahan Drive Intersection #4	Eastbound	Through	6.6 (13.9)	A (B)	7.9 (11.2)	A (B)
	Westbound	Left	49.2 (47.8)	D (D)		
	Northbound	Right	0.2 (0.3)	A (A)		
Capital Circle Intersection #1	Eastbound	Right	0.2 0.2)	A (A)	17.0 (14.2)	B (B)
	Northbound	Left	30.3 (31.8)	C (C)		
	Southbound	Through	30.4 (25.7)	C (C)		
Capital Circle Intersection# 2	Westbound	Left	19.9 (22.6)	B (C)	10.4 (10.2)	B (B)
	Northbound	Through	21.2 (21.4)	C (C)		
Capital Circle Intersection# 3	Eastbound	Left	10.7 (16.4)	B (B)	13.5 (17.1)	B (B)
	Southbound	Through	27.4 (32.7)	C (C)		
Capital Circle Intersection# 4	Westbound	Right	0.5 (0.5)	A (A)	9.8 (11.9)	A (B)
	Northbound	Through	22.3 (21.8)	C (C)		
	Southbound	Left	19.9 (31.3)	B (C)		

Experienced Travel Time (ETT)

HCM 6th Edition offers an alternative procedure that uses ETT for LOS assessment. ETT includes intersection control delay and Extra Distance Travel Time (EDTT).

ETT allows the comparison of innovative intersections such as DDI, RCUT, CFI, MUT, DLT with conventional intersections and can be selected as an MOE for all innovative intersection and interchange analyses. ETT is determined based on a combination of the control delay at signalized and unsignalized intersections and EDTT for O-D paths. ETT must be manually calculated for other intersection configurations or when using Synchro or any other traffic analysis tools. ETT in seconds per vehicle (sec/veh) can be computed using **Equation 9-1** below (HCM 6th Edition, Exhibit 23-13).

Equation 9-1

$$ETT = \sum d_i + \sum EDTT$$

Where,
d_i = Control delay at each junction i encountered on the path through the facility
$EDTT$ = Extra distance travel time;

For each O-D movement, the EDTT is calculated by dividing the extra distance traveled in the new O-D path by the FFS (converted to feet per second).

For innovative intersections and interchanges where rerouting occurs and additional travel distance is not significant, ETT is equal to control delay. This methodology can be employed to determine the LOS for each movement, approach and the overall intersection for comparing innovative intersections with conventional intersections.

9.3.5 SIDRA Analysis

SIDRA is an analytical model commonly used to analyze roundabout operations and is the preferred tool for analyzing roundabouts in Florida. SIDRA can incorporate various roundabout design components into the analysis, including splitter islands, slip/bypass lanes and overall geometry (such as the shape and number of lanes). SIDRA has the capability of performing lane-by-lane analysis for a single lane and multi-lane roundabouts. SIDRA can also be used to evaluate the effect of metering signals on roundabout performance. The commonly reported MOEs from SIDRA analysis are V/C ratio, delay, 95th percentile queues and LOS.

9.4 Microsimulation Analysis

Microsimulation models are stochastic tools and should be used for analyzing oversaturated traffic conditions where congestion extends beyond the peak hour of the analysis, complex geometric designs or where there is a need to evaluate traffic conditions involving managed lanes. The selection of MOEs for documenting microsimulation model results should be identified at the start of the project. The MOEs for microsimulation projects can be grouped under three (3) categories listed below and each of these categories are described in subsequent sections.

- Freeway performance measures
- Arterial intersections performance measures
- Network-wide performance measures

Table 9-7 provides a recommended list of microsimulation analysis MOEs and documentation. Most microsimulation models do not report LOS, especially for freeway segments. **Section 9.6** of this chapter outlines an approach to estimate LOS using density and speed results obtained from microsimulation analysis.

Table 9-7 Typical Microsimulation Performance MOEs

Category	MOE	Documentation
Freeway Segments (Merge/diverge, Basic or Weave)	• Density (veh/mi/ln) • Estimated Density (pc/mi/ln) • Estimated LOS • Speed (mph) • Travel Time (seconds) • Simulated Volume (reported along with Demand Volume)	• Graphical ○ Lane Schematics ○ Density Heat Map • Tabular (Optional if graphical documentation is provided)
Arterial intersections	• Intersection Delay (sec/veh) • Movement Delay (sec/veh) • Intersection LOS (Estimated) • Movement LOS (Estimated) • Maximum Queue Length (feet) • Simulated Volume (reported along with Demand Volume)	• Tabular
Arterials	• Speed (mph) • Travel Time (seconds) • Simulated Volume (reported along with Demand Volume)	• Tabular
Network-wide	• Total Delay (hours) • Average Delay (seconds per vehicle) • Total Travel Time (hours) • Latent Delay (hours) • Latent Demand (veh) • Vehicles Arrived (veh) • Total Stops (number) • Average Speed (mph)	• Tabular

Performance measures obtained from the microsimulation operations of freeway, merge/ diverge and weaving areas should be reported consistent with the methodology described in the HCM. The analyst should avoid averaging densities across all merge/diverge lanes.

9.4.1 Freeway Performance Measures

9.4.1.1 Segment Based Performance Measures

Segment based freeway performance measures should be provided for all freeway projects analyzed using microsimulation. Freeway performance measures include demand volumes, simulated volumes, speed or travel time and density reported for all freeway segments. Freeway MOEs should be presented per segment (merge/diverge, basic or weave) not necessarily by link. Links are to be broken only when there is a change in the number of lanes or at the end of a segment. Merge and diverge segments should be 1,500 feet each, per HCM. If there are two (2) or more links in a segment, a weighted average should be used to present results per segment. Freeway performance measures should be documented in graphical and tabular format as discussed below. Guidelines for documentation of calibration and validation are provided in **Chapter 7.**

i) Graphical Presentation

Graphical displays are excellent visual tools and are very effective in identifying the effects of each alternative on traffic operations within the analysis area. The lane schematics and link-node diagrams developed in the analysis stage of the project can easily be converted into a tool for displaying the results. Additionally, a time-series plot that compares MOEs from the simulation outputs can also be prepared, such as density heat map or speed/volume profile, to facilitate the understanding of the spatial-temporal behavior of the alternatives and eventually aid in making decisions.

Graphical presentation of the data and results should be carefully created to help in understanding of the results. The presentation should be simplified for the understanding of both technical and non-technical audiences.

Lane Schematics

Lane schematics are an excellent tool for displaying all freeway performance measures in a spatial scope. All freeway link based MOEs including demand volumes, simulated volumes, speed and density should be displayed on lane schematics. Speed and density values are reported for the peak hour. Lane schematics should be color coded to facilitate understanding of the spatial behavior of the alternatives. LOS can also be estimated using results from microsimulation analysis based on the recommended approach in **Section 9.5** and reported on lane schematics. **Figure 9-2** shows an example of lane schematics for freeway link-based performance measures.

Density Heat Map

Density Heat Maps are graphical presentation of microsimulation results along the freeway with interchanges or ramps on one (1) axis and time period on the other axis. Individual density values are presented with colors. Generally, darker colors indicate heavy congestion occurrence. Density based heat maps show variation and extent of congestion over the entire simulation time period in 15-minute intervals. This can facilitate understanding of the spatial and temporal behavior of the alternatives and eventually assist in the decision-making process. Density heat maps can be time consuming and their use should be determined on a project-by-project basis. **Figure 9-3** shows an example of a density heat map.

ii) Tabular Presentation

Tables should be used to present link-based results of the analysis if graphical presentation using link schematics and heat diagrams is not provided. All freeway link based MOEs including demand volumes, simulated volumes, speed and density should be included in tabular format. Results can also be color coded for the ease of reviewing. Freeway peak hour MOEs can be documented in the report tables and shoulder hours MOEs can be provided in the appendices.

Tabular presentation of freeway microsimulation results is optional if graphical documentation is provided.

Table 9-8 shows an example of tabular presentation of link-based performance measures.

Figure 9-2 Freeway Lane Schematics Example

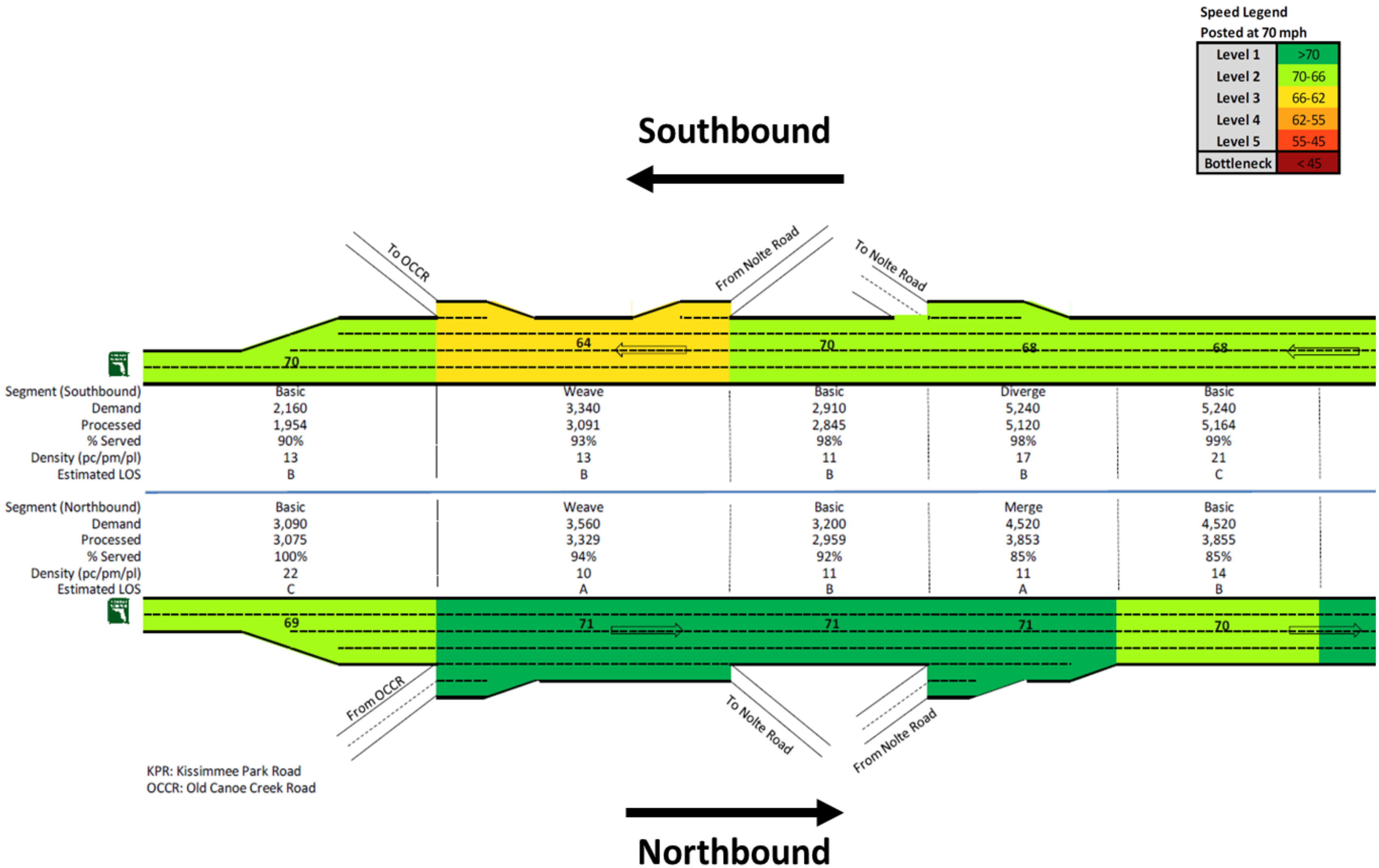


Figure 9-3 Density Heat Map Example

I-295 Southbound		General Purpose - Density (vpmpl)															
Description	Layout	Hour 1				Hour 2				Hour 3				Hour 4			
		0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00	0.25	0.50	0.75	1.00
		14	19	26	28	34	38	46	51	53	42	30	25	23	22	21	19
	From Beach Blvd	14	19	26	28	33	37	52	59	59	49	30	25	24	22	21	19
		14	19	26	28	33	38	58	67	65	56	32	26	24	22	21	19
		15	19	26	28	33	41	64	71	70	61	34	26	24	22	21	19
		15	19	26	28	33	44	69	76	74	66	38	26	24	22	21	19
Merge from Beach Blvd	Direction of Travel	13	17	22	24	29	48	75	78	76	72	44	23	21	20	19	17
		13	17	23	25	31	52	59	65	61	58	43	24	21	20	19	17
Diverge to Town Center Parkway		14	17	22	25	32	50	52	56	55	52	43	24	21	20	19	17
		17	20	27	31	40	60	64	66	64	62	54	30	27	24	24	21
	Town Center Parkway	18	21	28	32	40	50	52	54	51	51	47	30	27	25	24	22
		18	20	27	31	38	41	42	43	42	43	40	30	27	25	24	21
		18	20	27	31	36	39	39	39	39	39	37	30	27	25	24	21
Weave - Town Center to SR 202		14	15	20	23	26	28	28	28	28	28	27	22	20	18	18	16
Diverge to Express Lane Ingress		12	13	18	20	23	24	25	24	24	24	23	20	18	16	16	14
	SR 202 (Butler Boulevard)	9	10	13	15	17	18	18	18	18	18	17	15	13	12	12	11
		9	10	13	15	17	18	18	18	18	18	17	14	13	12	12	11
Merge from SR 202 WB		9	9	12	14	16	17	17	17	17	16	16	14	12	12	11	11
Merge from SR 202 EB		8	8	10	12	13	14	14	14	14	14	13	11	10	10	9	9
Diverge to Gate Parkway		8	8	10	12	13	14	14	14	14	14	13	11	10	10	9	9
Diverge to Express Lane Ingress		9	8	11	12	14	15	15	15	15	15	14	12	11	11	10	9
	Gate Parkway	7	7	9	10	12	12	13	12	12	12	11	10	9	9	8	8
		8	7	10	11	13	14	14	14	14	13	13	11	10	9	9	9
		10	10	13	15	17	18	19	18	18	18	17	15	14	13	12	11
		11	10	13	15	17	18	19	18	18	18	17	15	14	13	12	11

Legend

- Density ≤ 30 vpmpl
- Density 30-45 vpmpl
- Density 45-55 vpmpl
- Density 55-75 vpmpl
- Density ≥ 75 vpmpl

Table 9-8 Tabulation of Freeway Performance Measures Example

Segment	Lanes	Demand	Processed	% Served	Speed	Density (pc/mi/ln)
Florida's Turnpike Southbound (SB)						
Upstream of U.S. 192 North SB On-ramp_Basic	4	4,159	3,766	91%	39	54
U.S. 192 North SB On-ramp to U.S. 192 South SB Off-ramp_Merge	4	4,524	3,595	79%	28	95
U.S. 192 North SB On-ramp to U.S. 192 South SB Off-ramp_Basic	4	4,524	3,262	72%	14	113
U.S. 192 North SB On-ramp to U.S. 192 South SB Off-ramp_Diverge	4	4,524	3,030	67%	7	120
U.S. 192 Off-ramp to Kissimmee Park Road Off-ramp_Basic	2	3,915	2,365	60%	8	136
U.S. 192 Off-ramp to Kissimmee Park Road Off-ramp_Diverge	2	3,915	2,301	59%	11	118
Downstream of Kissimmee Park Road Off-ramp_Basic	2	2,488	1,464	59%	69	12
Florida's Turnpike Northbound (NB)						
Upstream of Kissimmee Park Road On-ramp_Basic	2	1,775	1,766	99%	70	14
Kissimmee Park Road On-ramp to U.S. 192 Off-ramp_Merge	2	4,541	3,427	75%	64	23
Kissimmee Park Road On-ramp to U.S. 192 Off-ramp_Basic	2	4,541	3,423	75%	67	28
Kissimmee Park Road On-ramp to U.S. 192 Off-ramp_Diverge	2	4,541	3,415	75%	69	21
U.S. 192 Off-ramp to U.S. 192 On-ramp_Basic	3	4,028	3,032	75%	71	13
Downstream of U.S. 192 On-ramp_Merge	4	5,394	4,376	81%	70	14
Downstream of U.S. 192 On-ramp_Basic	4	5,394	4,369	81%	70	17

Highlighted: unmet demand >5% and/or speed <35 mph

9.4.2 Arterial Intersections Performance Measures

Surface street intersections with excessive delay, long queues and storage length overflows affect traffic operations and can block exit or entry ramps. Arterial intersections demand volume, simulated volume, intersection and movement delay, maximum queue length and available storage from microsimulation analysis should be documented for all project area intersections and critical locations. It is recommended that peak hour MOEs for arterial intersections be provided within the body of a study report, while shoulder MOEs can be provided in the report appendix.

Peak hour MOEs for arterial intersections can be provided within the body of a study report, while shoulder MOEs can be provided in the report appendix.

Delay (sec/veh)

Microsimulation model delay is calculated as the difference between the simulated travel time and the theoretical travel time if the vehicle was operating at the anticipated speed. Intersection and movement delays should be tabulated for signalized intersections. Minor movement delays should be tabulated for unsignalized intersections.

Maximum queue length (feet)

Microsimulation model maximum queue length refers to the longest queue length that is simulated during the analysis period. Quantitative comparison of maximum queue length from microsimulation should be tabulated with available storage.

The 95th percentile queue length in feet, along with any special notes from Synchro, should be reported along with the available storage. The available storage for the turn movements, measured from the stop bar to the taper, should be clearly reported in tables for comparison with the queue length. Refer to FDM for further guidance on measuring storage length for turn lanes. At the off ramp terminal intersections, the queue length should be reported in tables along with the storage length for the left and right turn lanes. In addition to the available turn lane storage, the total ramp length, measured from stop bar to the gore point with the freeway, should be discussed in the document.

At the off ramp terminal intersections, the queue length should be reported in tables along with the storage length for the left and right turn lanes. In addition to the available turn lane storage, the total ramp length, measured from stop bar to the gore point with the freeway, should be discussed in the document.

Queue lengths exceeding available storage and impacting upstream freeway or intersection operations should be documented. **Table 9-9** shows an example of tabular presentation of arterial intersections performance measures.

Table 9-9 Tabulation of Arterial Performance Measures Example

Phillips Highway & SR 9B NB Ramps	SR 9B Ramps			Philips Highway		
	Westbound			Northbound		
	WBL	WBT	WBR	NBL	NBT	NBR
Demand Volume	560		220		1,640	755
Volume	561		218		1,643	753
Demand-Simulated Volume	1		-2		3	-2
Percentage (%)	0%		-1%		0%	0%
Movement Delay (sec/veh)	61		41		20	7
Approach Delay (sec/veh)	55.6			15.6		
Max Queue (ft)	429		161		414	123
Storage Length (ft)	600		600			700
Intersection Delay (sec/veh)						21.1

9.4.3 Network-wide Performance Measures

Network-wide performance measures are an important set of measures for understanding traffic operations of the entire project network. These provide information about performance of the network as a whole and can also help identify positive or negative impacts of proposed alternatives on the entire project area instead of just an individual element. Network performance is used to estimate the operational benefits of the evaluated alternatives which is used in the estimation of the Benefit/Cost ratio. Network-wide total delay, total travel time, latent delay, latent demand, vehicles arrived, total stops and average speed should be provided from microsimulation models to compare different project alternatives. These should be presented in tabular format depicting percentage difference between study alternatives evaluated for accurate comparison. **Table 9-10** shows an example of tabular presentation of network-wide performance measures.

Table 9-10 Tabulation of Network-wide Performance Measures Example

MOE (AM PEAK)	No-Build	Build	Difference
Average Speed (mph)	32	48	50%
Total Delay (hr)	26,112	7,948	-70%
Latent Delay (hr)	15,975	2,400	-85%
Latent Demand	6,764	133	-98%
Total Travel Time (hr)	57,203	40,669	-29%
Total Stops	2,232,326	458,585	-79%
Vehicles Arrived	322,094	335,565	4%

Latent demand

Latent demand is defined as the number of vehicles unable to enter the network at the end of the simulation time period. Latent demand occurs mainly due to insufficient capacity in the network. Latent demand can impact other network performance results, deliver misleading results and, therefore, should be accounted for in the results and comparison of alternatives. Correction due to latent demand for existing conditions and future conditions models is discussed in **Chapter 7.**

9.4.4 Express Lanes Performance Measures

Express Lanes are a type of managed lane where congestion is managed with vehicle eligibility, tolling, access and separation. Express Lanes are defined as a travel lane or lanes delineated or physically separated from a general use lane or general toll lane within a roadway corridor in which tolls are set based on traffic conditions. In other words, a managed lane for which tolling is an option, whether immediately or in the future, is an express lane. For express lanes projects, all freeway, arterial and network wide MOEs discussed in **Section 9.4** should be provided. Freeway performance measures such as density, speed, LOS, demand and simulated volumes should be provided for both general use lanes and express lanes. For express lanes projects, freeway performance measures should also include speed and volume profiles for freeway segments (which may be a link or travel time section). If the recommended alternative from the study contains a complex weave segment, then performance measures should be reported as discussed in sections below. In addition to the MOEs presented in **Table 9-11**, additional MOEs such as travel time comparisons between the general use lanes and express lanes, as well as basic weave diagrams may be required for weave segments.

Table 9-11 provides recommended list of MOEs and required documentation for express lanes analysis.

Table 9-11 Express Lanes Analysis Performance Measures

Category	MOE	Documentation
Express Lanes	• Segment based MOEs	• Provide documentation listed in **Section 9.4** plus: • General Use Lanes and Express Lanes Volume Profile • General Use Lanes and Express Lanes Speed Profile
	• Complex Weave ○ Lane Based	• Speed differential • Vehicles disappearing • Graphical ○ General Use Lanes Speed by lane ○ General Use Lanes Density by lane

Segment Based Performance Measures

Segment based performance measures should be documented as described in **Section 9.4** in graphical and tabular format for general use lanes and express lanes. In addition, speed and volume profiles should be provided for general use lanes and express lanes for the peak period of analysis depicting operations and throughput comparison for the entire corridor. **Figures 9-4** and **9-5** show an example of speed and volume profiles for general use lanes and express lanes.

Figure 9-4 Speed Profile for General Use Lanes and Express Lanes

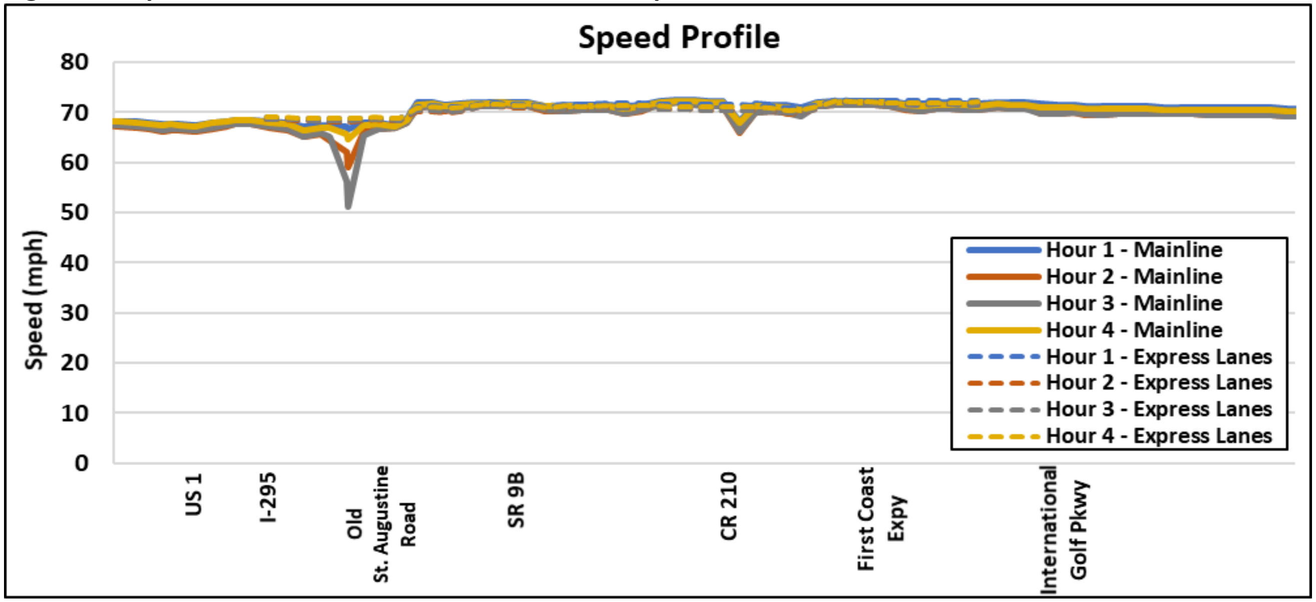
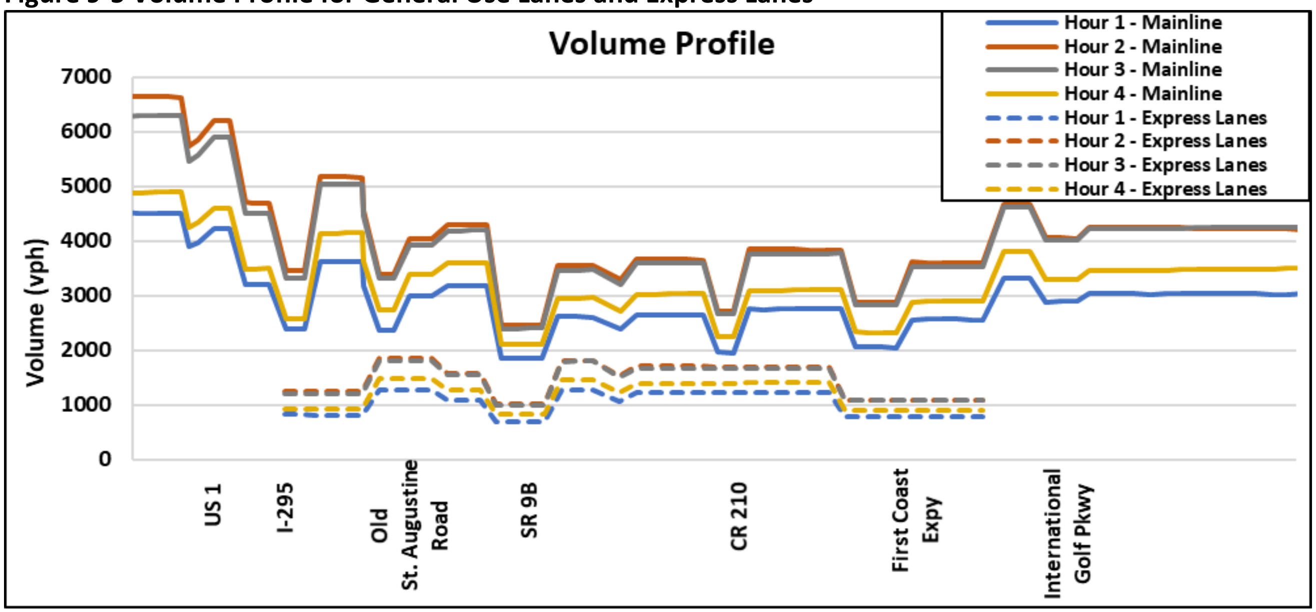


Figure 9-5 Volume Profile for General Use Lanes and Express Lanes



9.4.5 Complex Weave MOEs

Complex weave analysis should be performed using methods described in **Chapter 8** of this handbook. MOEs reported specific to complex weave segments include simulated volume, speed for all weaving and non-weaving traffic movement pairs (speed differential) and disappearing vehicles. Each segment simulated volume, speed, density within the complex weave segment and V/C ratio for the critical segment of the complex weave should be reported.

Lane based performance measures should be provided for complex weave segments in express lanes projects. The requirement for lane-based performance measures should be discussed with FDOT during the project. **Figures 9-6** and **9-7** show an example of speed and density by lane respectively for complex weave segment.

Figure 9-6 Complex Weave Segment Speed by Lane Example

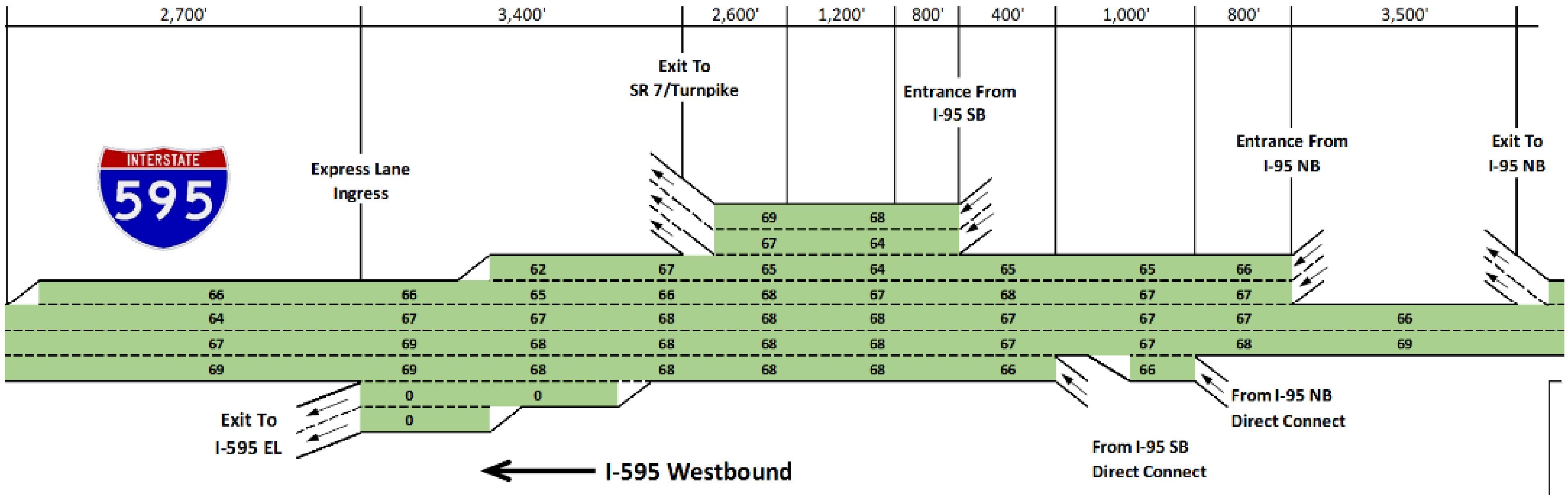
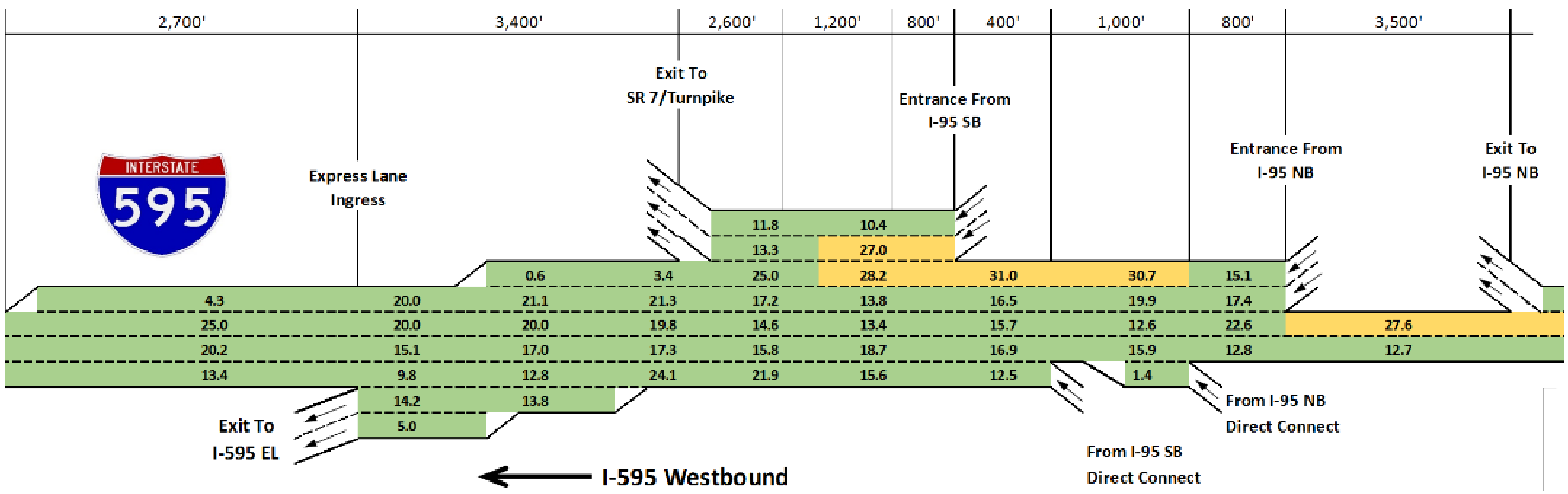


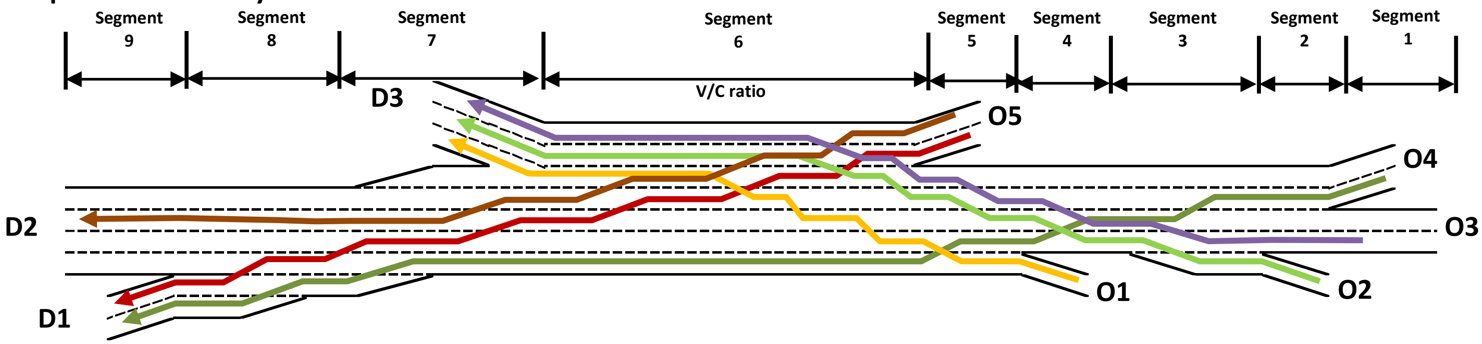
Figure 9-7 Complex Weave Segment Density by Lane Example



9.4.5.1 Complex Weave Results Documentation

The results for the complex weave segment should be documented in detail. The individual elements for LOS should be reported for **Method 1**. The documentation for **Method 2** should include the simulated volume and speed for each weaving and nonweaving movement and the speed differential between weaving and nonweaving volumes. Each segment demand volume, simulated volume, speed and density within the complex weave segment and V/C ratio for the critical weave segment should also be documented. The results should be provided for each hour within the peak period. The minimal difference in speeds between the weaving and nonweaving traffic movements indicates that the capacity and length provided for the complex weave segment is adequate. **Figure 9-8** shows an example of documentation for complex weave analysis results. An example of the speed differential between the same origin and different destinations is also shown in **Figure 9-8**.

Figure 9-8 Complex Weave Analysis Documentation



O-D	Weaving and Nonweaving Speed (mph)	Speed Differential (mph)	Simulated Volume (vph)
O1-D1	64.5		1,000
O1-D2	67.6		1,000
O1-D3	66.9	0.7	1,000
O2-D1	60.0		500
O2-D2	60.0		500
O2-D3	60.0	0	500
O3-D1	66.0		1,000
O3-D2	66.8		1,000
O3-D3	60.0	6.8	1,000
O4-D1	64.5	0.6	500
O4-D2	65.2		1,000
O4-D3	60.0		500
O5-D1	62.0	1.5	500
O5-D2	62.5	1.0	1,000
O5-D3	63.5		500

Description	Simulated (vph)	V/C Ratio*	Speed (mph)	Density (vpmpl)
Segment 1	3,000		65	23
Segment 2	5,000		63	19
Segment 3	6,500		62	20
Segment 4	6,500		62	26
Segment 5	8,500		60	28
Segment 6/ Critical Weave Segment	10,500	0.83	60	25
Segment 7	8,000		61	26
Segment 8	5,500		63	14
Segment 9	5,500		64	21

*Capacity 1,800 vphpl

9.5 Performance Measures Threshold for Microsimulation

Performance measures fall into two (2) broad categories: 1. Localized (i.e., segment level or intersection-level) performance, 2. System (i.e., route-level, corridor level or system level) performance. The localized measure should capture bottleneck dynamics, such as bottleneck throughput or duration, density and queuing. For system performance measure, the analyst may report travel time or speed profiles along one (1) or more key routes on the roadway network. Performance measures obtained from the microsimulation operations of freeway basic segments, merge/ diverge and weaving areas should be reported consistent with the methodology described in the HCM. The analyst should avoid averaging densities across all merge/diverge lanes.

The analytical tools, (HCS, Synchro) and microsimulation models report similar MOEs, e.g., density for uninterrupted flow facilities and delay for intersections. However, there is a fundamental difference in calculation of MOEs and results reported between analytical tools and microsimulation models methodology. Analytical tools are used to determine LOS on the performance of the facility during the peak 15-minute period within the analysis hour. HCS analysis converts trucks from the vehicles per hour input to passenger car equivalents. The density reported by HCS for uninterrupted flow facilities is in the passenger-car equivalent units. Microsimulation is the modeling of individual vehicle movements on a second or sub second basis for the purpose of assessing the traffic performance of highway and street systems. Microsimulation models simulate individual vehicle behavior within a predefined road network and evaluate the impact of changes in the traffic patterns due to traffic flow or roadway network changes. Density from microsimulation models represent actual number of vehicles simulated on the specified length for a specified time interval. These models report density in vehicles and trucks are also part of the traffic stream. Therefore, results from microsimulation models are not directly comparable to HCM LOS thresholds. Subsequent sections provide guidance on using density thresholds from HCM with microsimulation model results and speed thresholds to determine congested and uncongested conditions.

LOS computed from microsimulation analysis using the procedure outlined below in **Section 9.5.1** should be reported as an "estimated LOS".

9.5.1 Estimated Density and LOS

Link based density obtained from microsimulation model is in vehicles per mile. Microsimulation model density can be converted to passenger cars per mile per lane (pcpmpl) using the **Equations 9-2** and **9-3** below which can then be used to estimate LOS using HCM thresholds. The HCM 6th Edition density and LOS thresholds for basic freeway segments (HCM 6th Edition, Exhibit 12-15), merge and diverge segments (HCM 6th Edition, Exhibit 14-3) and weaving segment (HCM 6th Edition, Exhibit 13-6) can be used to determine if the freeway operates at acceptable LOS.

Equation 9-2

$$Estimated\ Density_{(pcpmpl)} = \frac{Density\ (vpmpl)}{Number\ of\ lanes} * f_{(hv)}$$

Where,
$Density\ (vpmpl) =$ Link Density from microsimulation
$f_{(hv)} =$ Adjustment factor for presence of heavy vehicles in traffic stream using HCM 6^{th} Edition

The adjustment factor for presence of heavy vehicles in the traffic stream $f_{(hv)}$ is calculated as following:

Equation 9-3

$$f_{(hv)} = \frac{1}{1 + P_T\ (E_T\ - 1)}$$

Where,
$f_{(hv)} =$ Heavy − vehicle adjustment factor (decimal)
$P_T =$ Proportion of Single Unit Trucks (SUTs)and Tractor Trailers (TTs) in traffic stream (decimal)
$E_T =$ Passenger car equivalent of one (1) heavy vehicle in traffic stream (PCEs)

The strategy to document density from microsimulation model and estimation of LOS should be identified and agreed upon during the initial study methodology phase. LOS computed from microsimulation analysis should be reported as an “Estimated LOS”.

9.5.2 Speed Thresholds

For freeway facilities, speed may be used as an indicator of whether a facility is uncongested or congested. Freeway travel speed declines as the facility approaches capacity. A facility may be identified as undersaturated or operating in uncongested conditions when speeds remain near the posted speed limit. A facility may be identified as oversaturated or congested when speeds are reduced considerably from the posted speed.

Link based speed obtained from microsimulation model may be used for determining level of congestion for freeway segment. FDOT in collaboration with FTE has developed thresholds for identifying levels of congestion based on posted speed limits. The thresholds were developed using the speed-flow relationships from the HCM. These thresholds can be applied to illustrate the level of congestion along freeway segments, merge/diverge areas, and weaving segments. **Table 9-12** shows corresponding levels of congestion for each posted speed limit.

Table 9-12 Congestion Level Thresholds

Congestion Level	Freeways				
	Posted Speed (mph)				
	50	55	60	65	70
Uncongested	>= 50	>= 53	>= 59	>= 61	>= 63
Lightly Congested	< 50 - 47	< 53 - 48	< 59 - 54	< 61 - 56	< 63 - 57
Moderately Congested	< 47 - 42	< 48 - 43	< 54 - 44	< 56 - 45	< 57 - 45
Heavily Congested	< 42	< 43	< 44	< 45	< 45

The above speed thresholds and corresponding colors can be applied and reported for link based MOEs with lane schematics or tabular documentation discussed in **Section 9.4.1**.

Chapter 10
Traffic Report

The traffic report and its supporting documentations, such as technical memorandums and data submitted in the appendices, should be prepared by transportation practitioners who have experience in the respective areas. The purpose of this chapter is to provide guidelines for preparing traffic technical reports. The following topics are covered in this chapter. Each of these topics are covered in detail in subsequent sections.

1. Traffic Analysis Report
2. Technical Memorandum
3. Review of Traffic Analysis

Traffic analysis documentation includes two (2) parts—Project Traffic Analysis Report and Technical Memorandums. The project traffic analysis report documents the analysis assumptions, analysis approach, data collection, analysis and analysis results in detail. Furthermore, the report is developed in detail to document or support assumptions, findings, recommendations and decisions that were made from the analysis. The final report includes the summaries of all interim technical memorandums that were prepared and submitted in the form of technical memorandums or interim reports to address one (1) or more stages of the analysis process. The technical memorandums can be attached in the traffic analysis report as appendices.

10.1 Traffic Analysis Report

The size of the report depends on the size and complexity of the project. Regardless of the complexity, the traffic analysis report should contain at least the items presented in **Figure 10-1**. The report should be divided into logical sections that can be easily followed and understood by the intended audience. All graphical and tabular displays presented in the report should be supported by text. The report is developed in a two-stage process. The first stage is the draft report to present the findings of the analysis and the second stage is the final report which incorporates any comments received from the review of the draft report.

Figure 10-1 Typical Traffic Analysis Report Outline

1. **Title Page**
2. **Executive Summary**
3. **Table of Contents**
   A. List of Figures
   B. List of Tables
4. **Introduction**
   A. Description of the proposed project
   B. Analysis objective and project scope
   C. Project location map
5. **Analysis Methodology**
   A. Analysis methodology and assumptions
   B. Analysis (temporal and spatial) boundary limits
   C. Analysis tool(s)
6. **Data Requirements**
   A. Data requirements and data sources
   B. Data collection methodology
   C. Summary of data collection and field observations
7. **Baseline Analysis (Existing Conditions Analysis)**
   Analytical Approach
   A. Operational analysis of the existing conditions
   B. Safety analysis based on crash data and HSM procedure as appropriate
   C. Multimodal evaluation
   Simulation Approach
   A. Base model development
   B. Model verification/error checking
   C. Model calibration
   D. Model validation
8. **Alternatives Analysis**
   A. No-build alternative
      i. Future year demand forecasts
      ii. No-build analysis (operational and safety)
   B. Preliminary alternatives
      i. Development of project concepts
      ii. Screening of concepts
   C. Build alternatives
      i. Alternatives considered
      ii. Traffic volume forecasts, trip pattern/circulation routes & assumptions
      iii. Design considerations
      iv. Model development (simulation approach only)
      v. Operational analysis
      vi. Safety analysis
   D. Alternative evaluation matrix and description of success/failure of alternatives
9. **Conclusions and Recommendations**
10. **References**
11. **Appendices**

10.2 Technical Memorandums

Technical memorandums (tech memos) are interim reports documenting technical issues relevant to the analysis process during the project development. The memos give the reviewing agency an opportunity to review study results before the analysis is completed and the final report prepared. The number and contents of the tech memos depend on the type and complexity of the analysis and they should be included in the analysis methodology and agreed upon with the reviewing entity. The reviewing entity must review and concur with the content of the technical memorandums before the analyst prepares the final report.

Generally, the following tech memos may be submitted prior to development of the final traffic analysis report:

- ***Existing Conditions Report*.** This report provides an overview of the condition of the existing transportation network under study. The purpose of this report is to set a context for understanding of the existing conditions in the network and assessing the problem that is to be solved by the traffic study. Its contents are derived from field observations, data collection from various sources and existing data analysis.
- ***Model Calibration Report***. This report provides documentation of the calibration and validation process and resulting changes made to the base model. The report should provide justification for any changes of the values of the default parameters and supportive statistics which compares field-measured and calibration MOEs. The format for this report is provided in **Chapter 7**.
- ***Project Traffic Forecasting Report***. This report presents the traffic forecasting process and documents procedures, assumptions and results. Its contents include TDM description, input data, alternatives and demand forecasts for each analyzed alternative. The report is important because future year demand forecasts are vital to the accuracy of the alternatives analysis. It is recommended that traffic forecasts results be agreed to by all parties before the analyst proceed with analyzing the alternatives.
- **Alternative Analysis Report**. This report summarizes the interim results of the alternatives analysis.

10.3 Review of Traffic Analysis

The review and approval of traffic analysis report is based on the methodology of the analysis and information contained in the submitted report and other interim technical documents which include model manuals. The submitted analysis documentation is subject to an independent review which can include recreating the analysis models. As such, the analyst must submit the model (or analysis) manuals for review prior to the submission of the draft project report. Concurrence on the analysis approach, assumptions and outputs must be reached prior to report preparation. This approach will help to identify issues and their resolutions very early in the process and consequently avoid delays.

Appendix A – Technical References

These documents were referenced in preparation of this handbook. The analyst may review these documents for detailed information to gain better understanding of the traffic analyses and the tools used to perform such analyses.

Barcelo (ed.), Fundamentals of Traffic Simulation, International Series in Operations Research & Management Science 145, Springer Science+Business Media, 2010

Chiu, Y., Bottom, J., Mahut, M., Paz, A., Balakrishna, R., Waller, T., and Hicks, J. *A Primer on Dynamic Traffic Assignment*. ADB30, Transportation Network Modeling Committee, Transportation Research Board, Washington, DC, 2011. Accessed Online: January 2010. (http://onlinepubs.trb.org/onlinepubs/circulars/ec153.pdf)

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Appendix B – Tool Selection Worksheet

Table 14. Tool selection worksheet.

Tool Name: ______________________ **Version/Release:** ______________
Vendor Name/Contact Information: ____________________________________

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
1 Geographic Scope (0 = not relevant, 5 = most relevant)				
Isolated Location				
Segment				
Corridor/Small Network				
Region				
Other: ________				
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		
2 Facility Type (0 = not relevant, 5 = most relevant)				
Isolated Intersection				
Roundabout				
Arterial				
Highway				
Urban				
Rural				
Freeway				
Mainline				
Shoulder				
HOV Lane				
Barrier-separated				
Buffer-separated				
Shoulder HOV				
HOT Lane				
HOV Bypass Lane				
Ramp				
Auxiliary Lane				
Reversible Lane				
Truck Lane				
Bus Lane				
Toll Plaza				
Light Rail Line				
Other: ________				
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		

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Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
3 Travel Mode (0 = not relevant, 5 = most relevant)				
SOV				
HOV				
HOV 2+				
HOV 3+				
As percentage of total vehicles				
Bus				
Local				
Express				
Train				
Truck				
Motorcycle				
Bicycle				
Pedestrian				
Other: ____________________				
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)				
Freeway Management				
Adding general purpose lanes				
Adding HOV lanes				
Geometric improvements				
Interchange geometric improvements				
Electronic toll collection (ETC)				
Fixed-time ramp metering				
Adaptive/actuated ramp metering				
Centrally controlled metering				
Add HOV bypass				
Freeway connector metering				
Reconstruction management				
Arterial Intersections				
Adding lanes				
Pre-timed signal				
Actuated signal				
Traffic adaptive control signal				
Centrally controlled signal				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
4 Management Strategy/Application (0 = not relevant, 5 = most relevant) (continued)				
Work Zone/Special Events				
Road closures due to events				
Traffic diversion due to events				
Work zone management				
Work zone safety monitoring				
Maintenance/construction vehicle AVL				
Maintenance/construction vehicle maintenance				
Advanced Public Transportation Systems				
Fleet maintenance				
Automatic scheduling for transit				
Automatic vehicle location (AVL)				
Transit security systems				
Electronic transit fare payment				
Advanced Traveler Information Systems				
Pre-trip ATIS				
Telephone-based traveler information				
Web-based traveler information				
Kiosks				
Handheld traveler information				
En-route ATIS				
Highway Advisory Radio (HAR)				
Dynamic Message Sign (DMS)				
Transit DMS				
In-vehicle/handheld traveler information				
Rail Grade Crossing Monitor				
Commercial Vehicle Operations				
Fleet administration				
Electronic screening				
Weigh-in-motion				
Electronic clearance				
Safety information exchange				
On-board safety monitoring				
Electronic roadside safety inspection				
HazMat incident response/management				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
4 Management Strategy/Application (0 = not relevant, 5 = most relevant) (continued)				
Advanced Vehicle Control & Safety System				
Ramp rollover warning				
Downhill speed warning				
Longitudinal collision avoidance				
Lateral collision avoidance				
Intersection collision avoidance				
Vision enhancement for crashes				
Safety readiness				
Automated highway system				
Traffic Surveillance				
CCTV/radar/microwave				
Loop detectors				
Probe vehicles				
Travel Demand Management (TDM)				
Dynamic ridesharing				
Congestion pricing				
Flex-time				
Park and ride facilities				
Preferential parking				
Trip reduction programs				
Traffic Calming				
Roundabout				
Raised intersection				
Speed humps				
Speed control				
Parking Management				
On-street				
Off-street/parking garages				
Bicycle Program				
Bike lane/path routing				
Bike racks/lockers				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
4 Management Strategy/Application (0 = not relevant, 5 = most relevant) (continued)				
Weather Management				
Data collection				
Information processing/distribution				
Automated treatment				
Winter maintenance				
Resource allocation management				
Other: ____________________				
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		
5 Traveler Response (0 = not relevant, 5 = most relevant)				
Route Diversion				
Pre-Trip Route Diversion				
En-Route Route Diversion				
All-or-nothing				
Capacity restraint				
Stochastic/probabilistic				
Incremental				
Equilibrium				
Dynamic				
Transit system-based				
Route-based				
Timetable-based				
Multipath				
Other: ____________________				
Departure Time Choice				
Mode Shift				
Logit				
Nested logit				
Other: ____________________				

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Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
5 Traveler Response (0 = not relevant, 5 = most relevant) (continued)				
Destination Choice				
Gravity model				
FRATAR model				
Trip chaining				
Parking cost-based				
Other: ______________________				
Induced/Foregone Demand				
Other: _________________________				
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				
6 Performance Measures (0 = not relevant, 5 = most relevant)				
LOS				*Circle all that apply:* Aggregated by link/node/vehicle type/facility type/regionwide/other: _____
Speed				link/node/vehicle type/facility type/regionwide/other: _____
Space-mean speed				link/node/vehicle type/facility type/regionwide/other: _____
Time-mean speed				link/node/vehicle type/facility type/regionwide/other: _____
Travel Time				link/node/vehicle type/facility type/regionwide/other: _____
Volume				link/node/vehicle type/facility type/regionwide/other: _____
Detector volume				link/node/vehicle type/facility type/regionwide/other: _____
Link average volume				link/node/vehicle type/facility type/regionwide/other: _____
Travel Distance				link/node/vehicle type/facility type/regionwide/other: _____
Ridership				link/node/vehicle type/facility type/regionwide/other: _____
Transit frequency				
Transit reliability				
Average Vehicle Occupancy (AVO)				link/node/vehicle type/facility type/regionwide/other: _____
V/C Ratio				link/node/vehicle type/facility type/regionwide/other: _____
Density				link/node/vehicle type/facility type/regionwide/other: _____
VMT/PMT				link/node/vehicle type/facility type/regionwide/other: _____
VHT/PHT				link/node/vehicle type/facility type/regionwide/other: _____
Delay				link/node/vehicle type/facility type/regionwide/other: _____
Stopped delay				link/node/vehicle type/facility type/regionwide/other: _____
Intersection delay				link/node/vehicle type/facility type/regionwide/other: _____
Total delay				link/node/vehicle type/facility type/regionwide/other: _____
Queue Length				link/node/vehicle type/facility type/regionwide/other: _____
Number of Stops				link/node/vehicle type/facility type/regionwide/other: _____

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
6 Performance Measures (0 = not relevant, 5 = most relevant) (continued)				
Crashes/ Accidents				link/node/vehicle type/facility type/regionwide/other: _____
Accidents by severity				link/node/vehicle type/facility type/regionwide/other: _____
Incident Duration				link/node/vehicle type/facility type/regionwide/other: _____
Travel Time Reliability				link/node/vehicle type/facility type/regionwide/other: _____
Emissions				link/node/vehicle type/facility type/regionwide/other: _____
Fuel Consumption				link/node/vehicle type/facility type/regionwide/other: _____
Noise				link/node/vehicle type/facility type/regionwide/other: _____
Vehicle Operating Costs				
Agency operating costs				
Mode Split				link/node/vehicle type/facility type/regionwide/other: _____
Monetized Benefits				link/node/vehicle type/facility type/regionwide/other: _____
Net Benefit				link/node/vehicle type/facility type/regionwide/other: _____
Implementation Cost				link/node/vehicle type/facility type/regionwide/other: _____
Benefit/Cost				link/node/vehicle type/facility type/regionwide/other: _____
Other: ____________________				link/node/vehicle type/facility type/regionwide/other: _____
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant)				
Tool capital cost				Price:
Level of effort/training				Training classes available:
Easy to use				
Windows-based				
Drag-and-drop capabilities				
Popular/well-trusted				Years in the U.S. market:
Hardware requirements				Recommended minimum hardware:
Data requirements				
Volume				
Geometry				
Road conditions				
Signal or meter phase/timing				
Node requirements				
Link requirements				
O-D tables				

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FDOT Maps and Publications website or Systems Management website under IAR

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant) (continued)				
Turn movements/fractions				
Traffic composition				
Occupancy				
Control devices				
Spacing				
Computer run time				Average run time:
Post-processing requirements				
Metric option available				
U.S. standards option available				
Documentation				
User's Manual				Where to download:
Newsgroup available				Newsgroup address:
Chat rooms available				Chat room address:
E-mail lists available				How to join list:
User support				Tech support contact:
Free/affordable annual cost of support				Price:
Toll-free support available				Toll-free number:
24-hour support available				24-hour support number:
Rapid response				Turnaround time:
Key parameters can be user-defined				
Default values are provided				
Integration with other software				Compatible software:
Geocoding to GIS available				
Data exchange				
Animation/presentation features				
Dynamic				
Passive				
Network size limitations				Size limitations (nodes, links, vehicles):
Compatible with most operating systems				Ideal OS:

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	**Sub-Criteria Relevance**	**Tool Relevance***	**Col 2 x Col 3**	**Comments**
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant) (continued)				
Other model capabilities/conditions				
Oversaturated conditions				
Weaving				
Effects of Incidents (objects, breakdowns, crashes)				
Weather effects (rain, ice, wind, snow)				
Queue spill back				
Effects of pedestrians				
Effects of bicycles/motorbikes				
Effects of parked vehicles				
Effects of commercial vehicles				
Acceleration/deceleration effects				
Models U.S. (right-hand side) roadways				
Other: ______________________				
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		

6	7	8	9
Criteria (0 = not relevant, 5 = most relevant)	**Criteria Weight**	**Weighted Subtotals**	**Col 7 x Col 8**
1 Geographic Scope			
2 Facility Type			
3 Travel Mode			
4 Management Strategy/Applications			
5 Traveler Response			
6 Performance Measures			
7 Tool/Cost Effectiveness			
		TOTAL SCORE	

* Use the following values for Tool Relevance: 0 = not featured, 5 = strongly featured by the tool.

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FLORIDA DEPARTMENT OF TRANSPORTATION

TRAFFIC ANALYSIS HANDBOOK

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Systems Implementation Office, Mail Station 19
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