



# TRAFFIC ANALYSIS HANDBOOK

June 2026

# Table of Contents

|                                                           |          |
|-----------------------------------------------------------|----------|
| <b>Chapter 1 Introduction</b>                             | <b>1</b> |
| 1.1 Purpose                                               | 1        |
| 1.2 Goals                                                 | 2        |
| 1.3 Intended Use                                          | 2        |
| 1.4 Handbook Organization                                 | 3        |
| 1.5 Distribution, Updates, and Contact                    | 4        |
| <b>Chapter 2 Traffic Analysis Methodology and Scoping</b> | <b>5</b> |
| 2.1 Methodology Elements                                  | 5        |
| 2.2 Project Description                                   | 6        |
| 2.2.1 Study Area Characteristics                          | 6        |
| 2.2.2 Prevailing Traffic Conditions                       | 6        |
| 2.3 Traffic Analysis Objectives                           | 7        |
| 2.4 Analysis Area Boundary Limits                         | 7        |
| 2.4.1 Spatial Boundary Limits                             | 8        |
| 2.4.2 Temporal Boundary Limits                            | 8        |
| 2.5 Data Requirements and Data Collection                 | 8        |
| 2.6 Performance Measures of Effectiveness                 | 9        |
| 2.7 Traffic Analysis Tool and Analysis Approach Selection | 10       |
| 2.8 Existing Conditions Analysis                          | 11       |
| 2.9 Project Traffic Demand Forecasting                    | 11       |
| 2.10 Project Alternatives (No-Build and Build)            | 12       |
| 2.11 Safety Analysis                                      | 12       |
| 2.12 Environmental Analysis                               | 12       |
| 2.13 Traffic Analysis Documentation                       | 12       |
| 2.14 Traffic Analysis Methodology Checklist               | 13       |
| 2.15 Estimation of the Level of Effort                    | 13       |

# Table of Contents

|                                                        |           |
|--------------------------------------------------------|-----------|
| <b>Chapter 3 Analysis Area Boundary Limits</b>         | <b>15</b> |
| 3.1 Spatial Boundary Limits                            | 15        |
| 3.2 Temporal Boundary Limits                           | 17        |
| <b>Chapter 4 Data Collection</b>                       | <b>19</b> |
| 4.1 Field Observations                                 | 20        |
| 4.2 Required Data                                      | 20        |
| 4.2.1 Roadway Characteristics                          | 20        |
| 4.2.2 Traffic Flow Characteristics                     | 21        |
| 4.2.3 Traffic Control and Operational Characteristics  | 21        |
| 4.2.4 Safety Data                                      | 22        |
| 4.2.5 Typical Input Data for Different Analysis Tools  | 22        |
| 4.3 Input Parameters Default Values                    | 24        |
| 4.4 Data Collection Plan                               | 24        |
| 4.4.1 Data Collection Considerations                   | 24        |
| 4.4.2 Data Collection Elements                         | 25        |
| 4.5 Existing Data Sources                              | 25        |
| 4.6 Data Collection Schedule                           | 26        |
| 4.7 Calibration and Validation Data                    | 27        |
| 4.8 Integrating “Big Data”                             | 28        |
| 4.8.1 Application of Big Data for Traffic Analysis     | 29        |
| 4.8.2 Challenges and Considerations for Using Big Data | 29        |
| 4.9 Quality Assurance                                  | 30        |
| <b>Chapter 5 Analysis Tools Selection</b>              | <b>31</b> |
| 5.1 Traffic Analysis Tools                             | 31        |
| 5.2 Which Tool is Appropriate                          | 33        |

# Table of Contents

|                                                            |           |
|------------------------------------------------------------|-----------|
| <b>Chapter 6 Performance and Measures of Effectiveness</b> | <b>37</b> |
| 6.1 Introduction                                           | 37        |
| 6.2 Purpose and Intended Use                               | 38        |
| 6.3 Operational Analysis Using Deterministic Tools         | 40        |
| 6.3.1 HCS Analysis                                         | 40        |
| 6.3.2 Synchro Analysis                                     | 44        |
| 6.3.3 Innovative Intersection and Interchange              | 46        |
| 6.4 Microsimulation Analysis                               | 51        |
| 6.4.1 Freeway Performance Measures                         | 52        |
| 6.4.2 Arterial Intersection Performance Measures           | 56        |
| 6.4.3 Network-wide Performance Measures                    | 57        |
| 6.4.4 Express Lanes Performance Measures                   | 58        |
| 6.4.5 Complex Weave Performance Measures                   | 60        |
| 6.5 Performance Measures Threshold                         | 63        |
| 6.5.1 Estimated Density and LOS                            | 64        |
| 6.5.2 Speed Thresholds                                     | 65        |
| <b>Chapter 7 Traffic Analysis Using Analytical Tools</b>   | <b>66</b> |
| 7.1 Generalized Service Volume Table                       | 66        |
| 7.2 HCM and HCS                                            | 67        |
| 7.3 SIDRA INTERSECTION                                     | 68        |
| 7.4 Synchro and SimTraffic                                 | 69        |
| 7.4.1 Inputs for Synchro/SimTraffic                        | 70        |
| 7.4.2 Calibration of Synchro/SimTraffic                    | 71        |
| <b>Chapter 8 Microsimulation Analysis</b>                  | <b>74</b> |
| 8.1 Base Model Development                                 | 75        |
| 8.1.1 Vissim Modeling Guidelines                           | 75        |
| 8.2 Model Verification/Error Checking                      | 78        |
| 8.2.1 Base Model Verification Checklist                    | 79        |

# Table of Contents

|                  |                                                 |           |
|------------------|-------------------------------------------------|-----------|
| 8.3              | Model Calibration and Verification              | 81        |
| 8.3.1            | Model Calibration Process                       | 82        |
| 8.3.2            | Calibration Objectives                          | 82        |
| 8.3.3            | Model Calibration Strategy                      | 82        |
| 8.3.4            | Number of Multiple Simulation Runs              | 83        |
| 8.3.5            | Calibration Targets                             | 84        |
| 8.3.6            | Vissim Model Calibration Process                | 88        |
| 8.3.7            | Notes Regarding VISSIM Calibration Process      | 90        |
| 8.4              | Correcting Effects of Unmet Demand in the Model | 91        |
| 8.5              | Future-Year Model Verification                  | 93        |
| 8.6              | Calibration and Validation Report               | 93        |
| 8.7              | Model Calibration Reviewer's Checklist          | 95        |
| 8.8              | Special Studies Using Microsimulation Models    | 95        |
| 8.9              | Animation                                       | 97        |
| 8.10             | Model Manual                                    | 97        |
| <b>Chapter 9</b> | <b>Express Lanes Analysis</b>                   | <b>99</b> |
| 9.1              | Introduction to Managed Lanes                   | 99        |
| 9.1.1            | What is an Express Lane?                        | 99        |
| 9.2              | Purpose and Intended Use                        | 100       |
| 9.3              | Project Scope                                   | 102       |
| 9.3.1            | Area of Influence (AOI) and Spatial Boundary    | 102       |
| 9.3.2            | Determination of Temporal Boundary              | 103       |
| 9.4              | Data Collection for Express Lanes               | 104       |
| 9.4.1            | Primary Data Types/Sources                      | 105       |
| 9.4.2            | Secondary Data Sources                          | 109       |
| 9.4.3            | Existing Express Lanes Within Study Area        | 110       |
| 9.5              | Travel Demand Forecasting for Express Lanes     | 110       |
| 9.6              | Traffic Assignment Methods                      | 111       |
| 9.6.1            | Static Traffic Assignment                       | 111       |

# Table of Contents

|      |                                                          |            |
|------|----------------------------------------------------------|------------|
|      | 9.6.2 Dynamic Traffic Assignment Using ODME              | 112        |
| 9.7  | Express Lane Traffic Modeling in Microsimulation         | 113        |
|      | 9.7.1 Static Express Lanes Traffic Assignment            | 113        |
|      | 9.7.2 Dynamic Express Lanes Assignment                   | 114        |
|      | 9.7.3 Summary                                            | 122        |
| 9.8  | Complex Weave Analysis                                   | 122        |
|      | 9.8.1 Method 1: Individual Elements Analysis (HCM Based) | 124        |
|      | 9.8.2 Method 2: V/C Ratio Using Vissim                   | 124        |
|      | 9.8.3 Critical Segment Segregation                       | 125        |
|      | 9.8.4 Speed Differential                                 | 126        |
|      | 9.8.5 Vehicles Diffused                                  | 126        |
|      | <b>Chapter 10 Traffic Analysis Documentation</b>         | <b>128</b> |
| 10.1 | Technical Memorandum                                     | 129        |
| 10.2 | Traffic Analysis Report                                  | 130        |
| 10.3 | Review of Traffic Analysis                               | 130        |
|      | <b>Appendix A Glossary of Terms</b>                      | <b>132</b> |
|      | <b>Appendix B Tool Selection Worksheet</b>               | <b>137</b> |

# List of Tables

|                   |                                                                 |    |
|-------------------|-----------------------------------------------------------------|----|
| <b>Table 2-1</b>  | Traffic Analysis Methodology Content Checklist                  | 14 |
| <b>Table 4-1</b>  | Typical Input Data for Different Analysis Types                 | 23 |
| <b>Table 4-2</b>  | Summary of Calibration Data with Sources and Usage              | 28 |
| <b>Table 5-1</b>  | Uses of Traffic Analysis Tools                                  | 32 |
| <b>Table 5-2</b>  | Traffic Analysis Software by System Element                     | 34 |
| <b>Table 6-1</b>  | Common Analysis Tools                                           | 39 |
| <b>Table 6-2</b>  | Typical Candidate Operational MOEs                              | 39 |
| <b>Table 6-3</b>  | Typical HCS Performance MOEs                                    | 41 |
| <b>Table 6-4</b>  | Synchro Typical MOEs                                            | 45 |
| <b>Table 6-5</b>  | Tabulation of Synchro Intersection Performance Measures Example | 46 |
| <b>Table 6-6</b>  | DLT Results Documentation Example                               | 48 |
| <b>Table 6-7</b>  | Partial DLT Results Documentation Example                       | 49 |
| <b>Table 6-8</b>  | ETT Summary Example                                             | 51 |
| <b>Table 6-9</b>  | Typical Microsimulation Performance MOEs                        | 52 |
| <b>Table 6-10</b> | Tabulation of Freeway Performance Measures Example              | 56 |
| <b>Table 6-11</b> | Tabulation of Arterial Performance Measures Example             | 57 |
| <b>Table 6-12</b> | Tabulation of Network-wide Performance Measures Example         | 58 |
| <b>Table 6-13</b> | Express Lanes Analysis Performance Measures                     | 58 |
| <b>Table 6-14</b> | Congestion Level Thresholds                                     | 65 |
| <b>Table 7-1</b>  | Guidance for Calibrating SimTraffic Model                       | 73 |

# List of Tables

|                  |                                                                                                       |     |
|------------------|-------------------------------------------------------------------------------------------------------|-----|
| <b>Table 8-1</b> | Guidance to Vissim Model Development                                                                  | 77  |
| <b>Table 8-2</b> | Vissim Model Verification (Error Checking) Process Checklist                                          | 80  |
| <b>Table 8-3</b> | Classical Model Calibration Targets                                                                   | 85  |
| <b>Table 8-4</b> | Traffic Volume Calibration with Demand and Simulated Volume Comparison with GEH Statistic Calculation | 86  |
| <b>Table 8-5</b> | Comparison of Simulated Travel Time and Observed Travel Times                                         | 87  |
| <b>Table 8-6</b> | Comparisons between the Simulated Speed and Observed Speed from RITIS                                 | 88  |
| <b>Table 8-7</b> | Vissim Model Calibration Parameters                                                                   | 89  |
| <b>Table 8-8</b> | Model Calibration Reviewer's Checklist                                                                | 96  |
| <b>Table 9-1</b> | Proposed Default LOS and Toll Settings for Interstate Facilities (Segment < 3 miles)                  | 117 |
| <b>Table 9-2</b> | Proposed Default LOS and Toll Settings for Interstate Facilities (Segment > 3 miles)                  | 117 |
| <b>Table 9-3</b> | Default Delta Density Settings for Interstate Facilities (Segment < 3 Miles)                          | 118 |
| <b>Table 9-4</b> | Default Delta Density Settings for Interstate Facilities (Segment > 3 Miles)                          | 119 |
| <b>Table 9-5</b> | Proposed Ranges for Decision Model Parameters                                                         | 121 |
| <b>Table 9-6</b> | Example of Probability Matrix                                                                         | 121 |
| <b>Table 9-7</b> | Express Lanes Traffic Modeling                                                                        | 123 |

# List of Figures

|                    |                                                                                        |     |
|--------------------|----------------------------------------------------------------------------------------|-----|
| <b>Figure 5-1</b>  | Traffic Analysis Tools                                                                 | 33  |
| <b>Figure 6-1</b>  | DLT Example                                                                            | 47  |
| <b>Figure 6-2</b>  | Partial DLT Example                                                                    | 49  |
| <b>Figure 6-3</b>  | Freeway Lane Schematics Example                                                        | 54  |
| <b>Figure 6-4</b>  | Density Heat Map Example                                                               | 55  |
| <b>Figure 6-5</b>  | Speed Profile for General Use Lanes and Express Lanes                                  | 59  |
| <b>Figure 6-6</b>  | Volume Profile for General Use Lanes and Express Lanes                                 | 59  |
| <b>Figure 6-7</b>  | Complex Weave Segment Speed by Lane Example                                            | 61  |
| <b>Figure 6-8</b>  | Complex Weave Segment Density by Lane Example                                          | 61  |
| <b>Figure 6-9</b>  | Complex Weave Analysis Documentation                                                   | 62  |
| <b>Figure 8-1</b>  | Speed Profile Showing Comparisons between the Simulated Speed and Field Measured Speed | 87  |
| <b>Figure 9-1</b>  | Managed Lane Strategies and Complexity                                                 | 100 |
| <b>Figure 9-2</b>  | Recommended Spatial Limits of Express Lanes in Microsimulation                         | 103 |
| <b>Figure 9-3</b>  | Flow Diagram for Vissim Managed Lanes Facilities Function                              | 114 |
| <b>Figure 9-4</b>  | Complex Weave Segment                                                                  | 122 |
| <b>Figure 9-5</b>  | Individual Elements Analysis within Complex Weave Segment                              | 124 |
| <b>Figure 9-6</b>  | Critical Segment within Complex Weave                                                  | 124 |
| <b>Figure 9-7</b>  | Critical Segment Segregation                                                           | 126 |
| <b>Figure 10-1</b> | Typical Traffic Analysis Report Outline                                                | 131 |

# Abbreviations

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

# Abbreviations

| <b>Keyword</b> | <b>Definition</b>                                                         |
|----------------|---------------------------------------------------------------------------|
| <b>GSVT</b>    | Generalized Service Volume Tables                                         |
| <b>HCM</b>     | Highway Capacity Manual                                                   |
| <b>HCS</b>     | Highway Capacity Software                                                 |
| <b>IAR</b>     | Interchange Access Request                                                |
| <b>IARUG</b>   | Interchange Access Request User's Guide                                   |
| <b>ICE</b>     | Intersection Control Evaluation                                           |
| <b>ICU</b>     | Intersection Capacity Utilization                                         |
| <b>ITS</b>     | Intelligent Transportation System                                         |
| <b>K</b>       | K Factor                                                                  |
| <b>LGCIP</b>   | Local Government Capital Improvement Plans                                |
| <b>LOS</b>     | Level of Service                                                          |
| <b>L RTP</b>   | Long-Range Transportation Plans                                           |
| <b>MLOU</b>    | Methodology Letter of Understanding                                       |
| <b>MOEs</b>    | Measures of Effectiveness                                                 |
| <b>MOT</b>     | Maintenance of Traffic                                                    |
| <b>MPO/TPO</b> | Metropolitan Planning Organization / Transportation Planning Organization |
| <b>MRM</b>     | Multiple Resolution Modeling                                              |
| <b>MUT</b>     | Median U-turn                                                             |
| <b>MUTCD</b>   | Manual on Uniform Traffic Control Devices                                 |
| <b>MUTS</b>    | Manual on Uniform Traffic Studies                                         |
| <b>MVDS</b>    | Microwave Vehicle Detection System                                        |
| <b>NCHRP</b>   | National Cooperative Highway Research Program                             |
| <b>O-D</b>     | Origin-Destination                                                        |
| <b>ODME</b>    | Origin-Destination Matrix Estimation                                      |
| <b>OEM</b>     | Office of Environmental Management                                        |

# Abbreviations

| <b>Keyword</b>   | <b>Definition</b>                                              |
|------------------|----------------------------------------------------------------|
| <b>PD&amp;E</b>  | Project Development and Environment                            |
| <b>PHF</b>       | Peak Hour Factor                                               |
| <b>QA/QC</b>     | Quality Assurance / Quality Control                            |
| <b>RBC</b>       | Ring Barrier Controller                                        |
| <b>RCI</b>       | Roadway Characteristics Inventory                              |
| <b>RCUT</b>      | Restricted Crossing U-turn                                     |
| <b>RITIS</b>     | Regional Integrated Transportation Information System          |
| <b>RSA</b>       | Reduced Speed Area                                             |
| <b>RTMC</b>      | Regional Transportation Management Center                      |
| <b>SAF</b>       | Safety Adjustment Factor                                       |
| <b>SHS</b>       | State Highway System                                           |
| <b>SIDRA</b>     | Signalized & Unsignalized Intersection Design and Research Aid |
| <b>SIRC</b>      | State Interchange Review Coordinator                           |
| <b>SLD</b>       | Straight-Line Diagram                                          |
| <b>T</b>         | Heavy Vehicles Percentage                                      |
| <b>TD</b>        | Traffic Density                                                |
| <b>TDM</b>       | Travel Demand Model                                            |
| <b>TEM</b>       | Traffic Engineering Manual                                     |
| <b>TMCs</b>      | Turning Movement Counts                                        |
| <b>TSM&amp;O</b> | Transportation System Management and Operation                 |
| <b>V/c</b>       | Volume to Capacity Ratio                                       |
| <b>VAP</b>       | Vehicle Actuated Programming                                   |
| <b>VISSIM</b>    | Verkehr In Staedten SIMulation                                 |
| <b>VMT</b>       | Vehicle-Miles Traveled                                         |
| <b>VTTS</b>      | Value of Travel Time Savings                                   |

# Chapter 1

# Introduction

Traffic analysis is the process of evaluating the effect of traffic demand and facility supply on the performance of a transportation infrastructure in relation to established goals and objectives of the facility. Demand represents the amount of traffic load that intends to use the facility, while supply refers to the infrastructure's capacity to accommodate that demand. These goals and objectives guide the transportation planning process and serve as benchmarks for assessing both implementation and ongoing operations. Goals typically address mobility, reliability, accessibility, safety, economy, and 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. As a result, selecting and applying the appropriate tool to address specific traffic issues presents a significant challenge for transportation professionals and decision-makers seeking reliable analysis outcomes for their projects. This complexity can impact both the cost and timeline of transportation initiatives. 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 the documentation and deliverables necessary to complete the traffic analysis process.

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 the 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 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](#).

This handbook focuses on methods, tools, and documentation for traffic analysis. It does not include safety analysis tools or methods. Analysts are advised to perform safety analyses for their specific

projects. For safety-related information and resources, please visit 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.

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 and Scoping**  
Provides guidelines to prepare methodology to conduct the traffic analysis and develop a scope for the traffic analysis.
- **Chapter 3: Analysis Boundary Limits**  
Provides guidance on establishing both the spatial and temporal limits of traffic analysis.
- **Chapter 4: Data Collection**  
Provides guidance on data requirements, resources, collection techniques and procedure.
- **Chapter 5: Analysis Tools Selection**  
Contains general guidelines on selecting proper traffic analysis tools.
- **Chapter 6: Performance and Measures of Effectiveness (MOE)**  
Contains guidance on which MOEs should be produced and appropriate documentation of MOEs for traffic analysis.
- **Chapter 7: Traffic Analysis using Analytical Tools**  
Contains additional guidelines on the use of deterministic tools that are used to perform traffic analysis.
- **Chapter 8: Microsimulation Analysis**  
Provides guidance on the use of traffic microsimulation tools, specifically Vissim. Key steps that are to be followed when performing microsimulation are also provided.
- **Chapter 9: Express Lanes Analysis**  
Contains guidance and key steps to be followed for analyzing express lanes facilities.
- **Chapter 10: Traffic Analysis Documentation**  
Contains guidelines for preparing traffic reports.
- **Appendices**  
Contains a glossary and Tool Selection Worksheet.

## 1.5 Distribution, Updates, and Contact

This document is available online at [Systems Implementation Office \(SIO\)](#) under [Document Repository](#).



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: [Andrea Hodge](#)

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 using it to obtain any latest process and technical requirements.

## Chapter 2

# Traffic Analysis Methodology and Scoping

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 or scoping development process as an opportunity to raise critical issues and concerns so that they can be resolved and incorporated in the analysis.

The methodology elements described below represent the general requirements for 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 objectives
- ▶ Analysis area boundary limit
- ▶ Data requirements and data collection plan
- ▶ Performance Measures of Effectiveness
- ▶ Traffic analysis tool(s) and analysis approach selection
- ▶ Existing Conditions Analysis
- ▶ Project traffic demand forecasting
- ▶ Project alternatives (No-Build and Build)
- ▶ Safety Analysis
- ▶ Environmental Analysis
- ▶ Traffic analysis report and technical documentation
- ▶ Estimation of the 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. Additional meetings such as analysis scoping meetings may be required to reach full agreement and to clearly define and document every aspect of the traffic analysis methodology.

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



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

## 2.2 Project Description

The project description is used to introduce the project. It includes general context and background information. A project location map should be included in the project description to offer a visual representation of the study area.

### 2.2.1 Study Area Characteristics

The study area characteristics are essential for understanding the context in which the traffic analysis will take place. These characteristics include geographic features, land use, demographics, and development patterns. The study area may encompass urban, suburban, or rural areas, each presenting distinct challenges and considerations for traffic analysis. Key elements such as major corridors, intersections, interchanges, and transit facilities should be identified, along with any planned developments or land use changes that could affect future traffic patterns. Additionally, it is important to assess the physical layout and connectivity of the road network, the availability of multimodal infrastructure, and any environmental constraints that may impact the study area.

### 2.2.2 Prevailing Traffic Conditions

A thorough description of the prevailing traffic conditions is critical for establishing a baseline for analysis. This includes traffic volumes, congestion levels, peak hour traffic patterns, and the level of service (LOS) on key roadways within the study area. It is essential to understand the existing demand for roadway capacity, traffic composition (e.g., percentages of passenger vehicles, trucks, and buses), and any seasonal or time-based variations in traffic flow. Crash data, particularly at high crash locations, can provide insight into safety concerns that may need to be addressed in the project.

## 2.3 Traffic Analysis Objectives

Traffic analysis objectives 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 Area Boundary Limits

The analysis area 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 area 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 analysis.

The analyst is responsible for determining 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 the new express lanes system and expansion of existing express lanes system is provided in **Chapter 9**.

### **2.4.1 Spatial Boundary Limits**

Spatial boundary limits are derived from the area of influence (AOI) or study area, which defines the geographic scope of the traffic analysis. The AOI depends on the type, location, and prevailing traffic operating characteristics of the project. Proper identification of the AOI enhances the accuracy of the traffic analysis tools in replicating real-world traffic conditions.

### **2.4.2 Temporal Boundary Limits**

Temporal boundary limits refer to the duration of the traffic analysis period. The analysis period should be selected to capture variations in traffic demand and ensure they are included in the analysis. Capacity analyses typically focus on weekday peak hours when demand to use the facility is high. However, depending on the project needs, other periods such as midday, weekend, or special event may also be included in the analysis.

## **2.5 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 being 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

the 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 the State Interchange Review Coordinator (SIRC). Historical traffic growth and the 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 4**.

## 2.6 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 into 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 performance and selecting MOEs for freeways and arterials (including intersections) and their documentation is provided in **Chapter 6**.

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 the 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 8**.

## **2.7 Traffic Analysis Tool(s) 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 an 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 be correlated with the project complexity, the level of traffic analysis, and the magnitude of the traffic problem being analyzed. Thus, the 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 limitations 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 5**. 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.**

## 2.8 Existing Conditions Analysis

The existing conditions analysis involves capacity and operational assessments to evaluate current traffic conditions. This analysis typically includes a summary of balanced turning movement counts for the study intersections or interchanges, along with an overview of operational and safety analyses under existing conditions. Depending on the project, the analysis may use the methodologies in the HCM or a more sophisticated tool such as microsimulation to analyze the interactions between different users across the entire network. Microsimulation analysis should also include base model development and calibration documentation.

## 2.9 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.

## 2.10 Project Alternatives (No-Build and Build)

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 of the project alternatives. No-build alternative includes existing conditions plus committed improvements with programmed funding in the study area. A description of how the alternatives will be evaluated and screened should be included.

## 2.11 Safety Analysis

Safety analysis includes analyzing crash history (usually five years) within the project limits to assess the existing safety performance and evaluating the potential safety implications of a project. Depending on project context, safety assessment of the project may use HSM methodologies and tools. The HSM is a collection of analytical procedures and methodologies for incorporating quantitative safety analysis and predicting safety performance of highways and streets to inform the highway transportation decision making process. Guidance for safety analysis can be found in the FDOT website: [Safety Analysis Methods & Resources](#).

## 2.12 Environmental Analysis

Environmental impact analyses such as land use, air quality, and noise depend on the outputs of traffic forecasting and analysis. The most common traffic data required for environmental analyses are AADT, peak hour volumes, peak hour truck volumes and traffic classification. Typical MOEs from the traffic analysis that are used for environmental analyses are vehicle miles of travel, vehicle hours of delay, vehicles hours of travel, travel speed, mobile source emissions, number of crashes, and travel time saving. The project manager should work with the District Environmental Manager and other environmental subject matter experts to determine the scale of traffic data needed for various environmental analyses.

## 2.13 Traffic Analysis 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**.

## 2.14 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 this checklist does not guarantee acceptance of the analysis methodology and/or results.

## 2.15 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 methodology which could help project stakeholders comprehend the realistic level of effort to carry out the analysis.

Efforts that involve modeling 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, the 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 the level of effort should also include time for reviews of the analysis methodology, preliminary data, analysis outputs and analysis reports.

**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 the objective, purpose and need. Include location map.                                                                                                                                                                                                            | <input type="checkbox"/> |         |
| Technical guidance and standards                         | Describe technical standards, procedures, and guidelines to be followed to conduct analysis. Include quality assurance/control commitment.                                                                                                                                                      | <input type="checkbox"/> |         |
| Analysis area boundary limit                             | Describe both spatial and temporal boundary limits. Include a legible and scaled area map showing all study intersections and interchanges.                                                                                                                                                     | <input type="checkbox"/> |         |
| 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.                                                                             | <input type="checkbox"/> |         |
| Performance measures of effectiveness                    | Describe performance measures of effectiveness (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. | <input type="checkbox"/> |         |
| Traffic analysis tool(s) and analysis approach selection | Describe the approach to be used to perform traffic analysis. List analysis tool(s) to be used along with their versions.                                                                                                                                                                       | <input type="checkbox"/> |         |
| Existing Conditions Analysis                             | Describe the analysis of existing conditions, identify any deficiencies in terms of safety and mobility, establish baselines for comparison.                                                                                                                                                    | <input type="checkbox"/> |         |
| Project traffic demand forecasting                       | Summarize methodology for projecting traffic forecast. List model base year, design year/planning horizon, opening and interim years.                                                                                                                                                           | <input type="checkbox"/> |         |
| Project alternatives (No-Build and Build)                | Describe no-build conditions and improvement (build) alternatives to the extent possible. Use graphics to illustrate build alternatives. Describe alternative screening criteria.                                                                                                               | <input type="checkbox"/> |         |
| Safety analysis                                          | Include analyzing crash history within the project limits to assess the existing safety performance and evaluating the potential safety implications of a project.                                                                                                                              | <input type="checkbox"/> |         |
| Environmental Analysis                                   | Prepare traffic data to support the evaluation of potential environmental impacts of the proposed alternatives.                                                                                                                                                                                 | <input type="checkbox"/> |         |
| Traffic analysis documentation                           | Describe required documentation requirements commensurate with the complexity of the analysis.                                                                                                                                                                                                  | <input type="checkbox"/> |         |

|                        |             |                        |             |
|------------------------|-------------|------------------------|-------------|
| Preparer's Name: _____ | Date: _____ | Reviewer's Name: _____ | Date: _____ |
|------------------------|-------------|------------------------|-------------|

## Chapter 3

# Analysis Area Boundary Limits

Defining the spatial and temporal scope is a crucial step in traffic analysis, as it delineates the extent and granularity of data collection and modeling efforts, directly impacting the relevance, reliability, and applicability of the analysis results. The spatial scope refers to the geographic area or network boundaries that are relevant to the study, such as intersections, corridors, or entire subareas, whereas the temporal scope encompasses the time periods over which traffic conditions are evaluated, such as peak hours, daily operations, or even seasonal variations. Establishing a clear and appropriate scope enables accurate representation of prevailing traffic conditions while minimizing unnecessary complexity and data requirements. This chapter offers guidance on setting both spatial and temporal boundary limits for traffic analyses that do not involve express lanes. For further information on boundary limit determination related to express lanes systems and their expansion projects, refer to **Chapter 9**.

### 3.1 Spatial Boundary Limits

The spatial boundary limit is determined by the area of influence (AOI) or study area, which defines the geographic scope used for 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 conduct a field inspection at the beginning of the project to determine the extent of the issue and uncover any hidden bottlenecks. The presence of a traffic bottleneck can affect the spatial boundary limit. A hidden bottleneck is a location with a physical restriction on traffic flow, but its impact is currently masked by congestion caused by an upstream bottleneck that limits the traffic entering the hidden bottleneck area. Improving or removing the more obvious upstream bottleneck may not resolve congestion and could even exacerbate it in the downstream area, as traffic flow increases and exposes the previously hidden bottleneck. A traffic study that overlooks hidden bottlenecks within the study area can lead to an incomplete and potentially misleading assessment of the transportation system's performance.

The analyst should clearly define the geographic area under consideration, as well as the required level of detail for representation within this region. The geographic scope should be large enough to:

- ▶ Encompass the full extent of queues and congestion.
- ▶ Include facilities that will influence, or be influenced by, proposed alternatives.

Resource limitations can affect the scope of a project; in these situations, increasing the time frame may help address these constraints.

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.
- ▶ Proposed major developments in the vicinity of the project.

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:

**Freeway Projects** – 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.

**Arterial Projects** – 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 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.

## 3.2 Temporal Boundary Limits

Temporal boundary limit is the length of the traffic analysis period. Temporal scope should be long enough to:

- ▶ Include the temporal onset and dissipation of congestion and queues in both the baseline and future years of analysis.
- ▶ Include time periods that will be impacted by the proposed alternatives.

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 FDOT traffic counts data collected from the Continuous Traffic Monitoring Sites (formerly Telemetered Traffic Monitoring Sites (TTMS)), or other data collected by local government agencies, 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.**

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.

If any of these conditions are 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 9**.

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 of having volume in one (1) direction at capacity while volume in the opposite direction is 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 8**.

## Chapter 4

# Data Collection

Data collection is often one of the most expensive and time-consuming components of an engineering and planning study. Careful planning for targeted data collection helps identify essential data needed for the analysis and ensures that reliable information is available to support the decision-making process.

**Fundamental principles of effective data collection include:**

- ▶ Utilizing data that are measurable in the field,
- ▶ Prioritizing the use of the most up-to-date data available,
- ▶ Ensuring the data reflects temporal varying characteristics,
- ▶ Incorporating contemporaneous information,
- ▶ Recognizing that both data quality and quantity substantially influence analytical outcomes, and
- ▶ Aligning the volume of collected data with the desired analytical accuracy and predictive requirements.

This chapter outlines the data requirements, data resources, and procedures for data collection. It also describes the processes for data collection and quality assurance. The topics covered in this chapter are presented in detail in the following sections.

- ▶ Field Observations
- ▶ Required Data
- ▶ Input Parameters Default Values
- ▶ Data Collection Plan
- ▶ Existing Data Sources
- ▶ Data Collection Schedule
- ▶ Calibration and Validation Data
- ▶ Quality Assurance

Additional guidance on data requirements for express lanes projects is provided in **Chapter 9**. Users are also advised to refer to FHWA's [Traffic Analysis Toolbox Volume II](#), Decision Support Methodology for Selecting Traffic Analysis Tools, for further information.

## 4.1 Field Observations

Field observation, also known as field inspection, in traffic analysis is the process of observing and documenting current traffic conditions and driver behaviors to gather empirical data. This can be done in person and by using tools such as video cameras or online street view applications. The resulting data is utilized to develop traffic models, identify safety concerns, and evaluate facility performance.

Field observations are essential for ensuring accurate traffic analysis outcomes. They allow analysts to gain a comprehensive understanding of general traffic operating characteristics and the surrounding environment within the study area. While tools such as aerial photographs, or online street view applications can supplement data review, they should not be considered substitutes for on-site field observations.

## 4.2 Required Data

The reliability of traffic analysis results depends on the accuracy and quality of the data. Therefore, it is essential to develop a comprehensive traffic data collection strategy prior to initiating data collection. The specific data requirements and underlying assumptions vary depending on the type and depth of analysis being conducted. For example, generalized planning analyses require less extensive and less-precise data than operational analyses, which are performed at a higher degree of detail and accuracy. To minimize project costs existing data should be used as much as possible.

Primary data categories for traffic analysis include roadway characteristics, traffic flow characteristics, traffic control and operational characteristics, and safety characteristics. The type of traffic analysis will determine which elements within these categories need to be collected and how detailed that information should be. Listed below are the essential data elements related to each category.

### 4.2.1 Roadway Characteristics

Roadway characteristics data, also known as road inventory data, include details about the physical features of a roadway as well as those of its associated intersections and interchanges. Key roadway characteristics data include:

#### Geometric Characteristics

- ▶ Number of lanes
- ▶ Lane width
- ▶ Shoulder type and width
- ▶ Presence and length of auxiliary lanes
- ▶ Presence of on-street parking
- ▶ Presence of transit lanes/transit stops
- ▶ Presence of bicycle lanes/bicycle Lane width
- ▶ Presence of railroad crossings
- ▶ Presence of sidewalks/sidewalk distance from travel lanes
- ▶ Presence of toll collecting systems
- ▶ Intersection types (signalized, stop controlled, roundabout, grade separated)
- ▶ Number of turn lanes
- ▶ Turn lane storage lengths
- ▶ Merge/diverge lengths
- ▶ Interchange spacing/density

- ▶ Functional Classification
- ▶ Context Classification
- ▶ Freeway, arterial, collector, local road
- ▶ Urban vs. rural classification

## 4.2.2 Traffic Flow Characteristics

Traffic flow characteristics data includes key variables used to study how people and goods travel within a road network.

**The core aspects of traffic flow are:**

- ▶ **Throughput:** Measures how many vehicles pass a certain point on a roadway during a specific time frame (e.g., vehicles per hour).
- ▶ **Speed:** Indicates how fast vehicles move in a particular direction (e.g., miles per hour).
- ▶ **Density:** Represents the number of vehicles present within a set length of road at a given moment (e.g., per mile or per lane mile).

**Common types of traffic flow data include:**

### Travel Demand

- ▶ Origin-Destination (O-D) by trip purpose and by time of day
- ▶ Annual Average Daily Traffic (AADT)
- ▶ Vehicle composition
- ▶ Turning movement counts
- ▶ Traffic Design Factors (K, D, and T)
- ▶ Peak Hour Factor (PHF)
- ▶ Vehicle Occupancy
- ▶ Transit ridership by route, by stop, and by time of day
- ▶ Bicycle and pedestrian counts

### Measures of Effectiveness

These are used to evaluate the operational quality of a road network.

- ▶ Average speed
- ▶ Travel time and delay
- ▶ Travel time reliability
- ▶ Queue length

## 4.2.3 Traffic Control and Operational Characteristics

A traffic control device is any sign, signal, marking, or other piece of equipment officially placed on or near a roadway to regulate, warn, or guide traffic. These devices are essential for promoting highway safety and efficiency by providing clear communication to all road users, including drivers, cyclists, and pedestrians. Common traffic control data includes:

- ▶ Posted speed limit
- ▶ Signs
- ▶ Signal density
- ▶ Traffic signal timing
- ▶ Locations of detectors and traffic signal head
- ▶ Ramp metering
- ▶ Lane restriction
- ▶ School zone

#### 4.2.4 Safety Data

Safety data is a collection of information used to understand the factors contributing to crashes and to identify opportunities for improvements. Key elements of safety data include:

- ▶ Number of crashes
- ▶ Location of crashes
- ▶ Types of crashes
- ▶ Severity of crashes (fatal, injury or property damage only)
- ▶ Contributing causes to crashes

Crash data is generally collected over a five-year period to discern consistent patterns while minimizing the impact of outlier events on the analysis.

#### 4.2.5 Typical Input Data for Different Analysis Tools

A clear understanding of different data types is essential for identifying information critical to traffic simulation and project evaluation. Structuring the data collection process based on the intended analytical methods ensures efficient use of resources and minimizes redundant data gathering, ultimately facilitating informed decision-making and providing justification for recommended improvements. Data needs for various traffic analysis tools are summarized in **Table 4-1**. 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 4-1** Typical Input Data for Different Analysis Types

| Input Data Category                                                   | Traffic Analysis Tools |          |       |                        |        |
|-----------------------------------------------------------------------|------------------------|----------|-------|------------------------|--------|
|                                                                       | GSVTs                  | HCM/ HCS | SIDRA | Synchro/<br>SimTraffic | Vissim |
| <b>Roadway Characteristics</b>                                        |                        |          |       |                        |        |
| Context Classification                                                | ●                      | ●        | ●     | ●                      |        |
| Cross Section Elements                                                | ●                      | ●        | ●     | ●                      | ●      |
| Geometry                                                              | ●                      | ●        | ●     | ●                      | ●      |
| Intersection Control Type                                             | ●                      | ●        | ●     | ●                      | ●      |
| Access Control                                                        | ●                      | ●        |       |                        | ●      |
| Access Density                                                        |                        | ●        |       |                        |        |
| Toll Facility                                                         |                        |          |       |                        | ●      |
| Bus & Transit Stops                                                   |                        | ●        |       | ●                      | ●      |
| Parking                                                               |                        |          | ●     | ●                      | ●      |
| Railroad Crossing                                                     |                        |          |       | ●                      | ●      |
| Aerial Images                                                         |                        | ●        |       | ●                      | ●      |
| <b>Traffic Flow Characteristics</b>                                   |                        |          |       |                        |        |
| Average Speed                                                         |                        | ●        | ●     | ●                      | ●      |
| Driver Behavior Characteristics (e.g., car following and lane change) |                        | ●        |       | ●                      | ●      |
| Demand (AADT, T%, TMC, O-D, spatial and temporal variation)           | ●                      | ●        | ●     | ●                      | ●      |
| Queue Length                                                          |                        | ●        | ●     | ●                      | ●      |
| Capacity/Saturation Flow                                              |                        | ●        |       | ●                      | ●      |
| Pedestrian Counts                                                     |                        | ●        | ●     | ●                      | ●      |
| Bicycle Counts                                                        |                        | ●        | ●     |                        | ●      |
| Bus & Transit Stops                                                   |                        | ●        |       | ●                      | ●      |
| Vehicle Composition                                                   |                        | ●        | ●     | ●                      | ●      |
| Vehicle Occupancy                                                     |                        |          |       |                        | ●      |
| Major Traffic Generators                                              |                        |          |       |                        | ●      |
| <b>Traffic Control and Operational Characteristics</b>                |                        |          |       |                        |        |
| Speed Limit/Free Flow Speed (FFS)                                     | ●                      | ●        | ●     | ●                      | ●      |
| Signs                                                                 |                        |          | ●     |                        | ●      |
| Signal Timing and Phasing Plans                                       |                        | ●        | ●     | ●                      | ●      |
| Detector Types and Locations                                          |                        | ●        |       | ●                      | ●      |
| Right/Left Turn Treatment                                             | ●                      | ●        | ●     | ●                      | ●      |
| Lane Restriction                                                      |                        |          |       |                        | ●      |
| Ramp Metering                                                         |                        |          |       |                        | ●      |
| School Zone                                                           |                        |          |       |                        | ●      |

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

## 4.3 Input Parameters Default Values

Most analytical tools come with default values that represent typical roadway features, vehicle operations, and common driver behaviors. While using field-measured input parameters is recommended, there are situations where defaults are appropriate. For example, planning-level analyses often rely on default values when data is unavailable or cannot be measured in the field, especially if future design and operation details are unknown. Defaults may also be acceptable if previous studies indicate these parameters have little impact on results.

Unlike planning-level analyses, design and operational analyses are conducted with greater detail and therefore require the use of accurate field-measured data. In certain cases, locally adapted default values may be utilized for specific input parameters in design and operational analyses when field data have not yet been collected or when it is impractical to obtain such data.

## 4.4 Data Collection Plan

After the traffic analysis methodology is determined, a data collection plan should be prepared and agreed upon with the reviewing agency. 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.

### 4.4.1 Data Collection Considerations

Before developing the data collection plan, the analyst should identify the specific data to be collected, determine appropriate timing and duration, select suitable locations for collection, and establish processes for effective data management. Additional considerations that the analyst should address 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?

#### 4.4.2 Data Collection Elements

At a minimum, the 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.

### 4.5 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: Objectives of the analysis.

- ▶ [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 \(FGDL\)](#) is a collection of geospatial data, and serves as a mechanism 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.
- ▶ [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.
- ▶ [Signal Four Analytics](#) which is a statewide interactive, web-based geospatial crash analytical tool.
- ▶ [The FDOT Performance Data Integration Space \(PDIS\)](#), which is the hub for information produced and curated by the Systems Forecasting and Trends Office (SFTO) to assist department stakeholders with data-driven transportation decisions.

- ▶ Traffic counts from local agency databases.
- ▶ State and local governments' signal timing databases.

Even when current data is considered adequate for meeting analysis objectives, conducting field observations remains essential to verify and confirm critical traffic and roadway information, such as geometric features, traffic controls, and driver behavior, which may impact operational characteristics at the study 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 mandatory in any traffic analysis to confirm existing characteristics.**

Measuring actual traffic demand during oversaturated conditions is challenging since automatic recorders do not account for demand caused by queueing. Under these conditions, the demand should be estimated, based on the FDOT's 200<sup>th</sup> Highest Hour Traffic Count Reports using data for unconstrained sites with similar roadway and geometric characteristics. The 200<sup>th</sup> Highest Hour Traffic Count reports for Continuous Traffic Monitoring Sites (or Telemetered Traffic Monitoring Sites (TTMS)) can be obtained from the [FTO](#). Another option is to count arriving vehicles upstream of the bottleneck to capture the true demand.

## 4.6 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 areas. 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.
- ▶ TMCs should include bicycle and pedestrian movements. Bicycle and pedestrian activity varies considerably depending on the location. In areas with minimal pedestrian or bicycle usage, peak period counts may be sufficient. However, in locations such as downtown districts, university campuses, or areas with high levels of pedestrian and/or bicycle traffic, an 8-hour count is recommended for greater accuracy.
- ▶ For projects involving transit, analysts should consult with the relevant local transit agency prior to initiating any data collection activities. Transit agencies are required to develop a 10-year Transit Development Plan (TDP), which generally contains significant amount of data that can be used for various transit analyses. The data collection effort may vary by route depending on the ridership.
- ▶ 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.
- ▶ Crash data should be collected for the most recent full five years plus partial current year. If five years of data are unavailable, a minimum of three years of data may be used; however, this must be accompanied by an appropriate explanation.

When using a microsimulation approach, the data collection schedule should incorporate additional field reviews during model calibration to assess traffic operations and compare them with model results. Alternatively, analysts can record the study area on video to gather vehicle behavior data needed for visually verifying simulation models.

## 4.7 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 compare field-measurements and simulation output and eventually streamline the calibration process.

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 (observed traffic conditions and driving behaviors, such as queues, aggressive driving, etc.)

**Table 4-2** provides a summary of the calibration data, including their respective sources and the model components they are utilized to calibrate. Comprehensive guidelines for the calibration and validation of microsimulation tools are provided in **Chapter 8**.

**Table 4-2** 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        |
| Queue, aggressive driving, lane changing/merging | Field observations                                      | Freeway, Ramps, Arterial |

## 4.8 Integrating “Big Data”

Traditional ways of collecting data, such as using physical sensors or conducting surveys, provide important information about existing conditions. However, these approaches can be expensive and time-consuming. As a result, they are often limited to high-priority projects or locations and can only cover short period of time, which means they gather only small samples and cannot capture a complete picture for traffic modeling and analysis.

Big Data refers to large, complex datasets that are generated at high velocity from various sources. In transportation, these include GPS traces, mobile phone data, connected vehicle data, traffic sensors, social media, and infrastructure monitoring systems. The integration of Big Data into traffic analysis enables more dynamic, granular, and predictive insights compared to traditional methods.

### 4.8.1 Application of Big Data for Traffic Analysis

#### Developing Origin-Destination (O-D) Trip Matrix

The O-D matrix is one of the most essential travel demand data for traffic modeling and simulation.

Traditionally, an initial O-D matrix (or seed O-D matrix) is estimated from a large-scale travel survey, usually conducted every several years due to prohibitively high cost. As a result, both the sampling rate and update frequency of survey data are limited, potentially resulting in biased O-D matrix pattern. Big Data allows for the creation of an O-D matrix at a much higher sampling rate for any given time-period for a fraction of the cost. Once expanded and validated against traffic counts, the O-D matrix can serve as input to a traffic simulation model for model calibration. Furthermore, instead of creating a single matrix for an entire time-period, hourly or sub-hourly matrices can be developed to reflect “peak spreading” and demand fluctuations.

### Modeling Travel Behavior

Big Data supports trajectory-based calibration through the analysis of individual vehicle movements. This helps fine-tune microscopic parameters, such as car-following and lane-changing behaviors, to better reflect observed conditions.

### Iterative and Automated Calibration

With Big Data, calibration can be done in an automated and iterative fashion. Advanced methods, such as machine learning, can be used to iteratively adjust model parameters until simulation outputs closely match observed Big Data targets. This reduces the manual effort and time traditionally required for trial-and-error calibration. It should be noted that the automated and iterative calibration is an emerging trend and is still being investigated/researched and not ready to be incorporated in the industry practice. Please refer to relevant NCHRP, TRB, and FHWA reports for more information. One such example could be the 2024 FHWA's [“Emerging Data Cleaning and Fusion for Traffic Model Calibration–Data Fusion for microsimulation Model Calibration”](#) report.

## 4.8.2 Challenges and Considerations for Using Big Data

Although Big Data offers many advantages for traffic simulation and analysis, it also presents certain challenges.

- ▶ **Data quality:** Big Data is collected from disparate sources with differing resolutions, formats, and degrees of reliability. It is essential to understand the data sources, sampling rates, and underlying methodologies used to combine and clean the data. This is particularly important for Big Data acquired from third party vendors.
- ▶ **Computational demand:** Processing and analyzing large quantities of Big Data, especially for large-scale networks, is computationally intensive and requires significant resources.
- ▶ **Privacy concerns:** Using location-based Big Data, such as GPS data, necessitates addressing privacy concerns to ensure data is properly anonymized and aggregated.



Before using Big Data, the traffic analyst should coordinate with the review agency to present pertinent information about the Big Data and obtain necessary approvals.

## 4.9 Quality Assurance

Data collection plans must emphasize 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 general rule for 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.

All collected data should be documented with relevant attributes, including source, collection time, condition, and any influencing factors. The analyst should implement clear data management strategies that are easily understood by data collectors.

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.

When using microsimulation methods, analysts need to ensure their data is highly accurate. Even minor mistakes in input data can cause those errors to multiply, resulting in significant inaccuracies in simulation results that cannot be calibrated. Such discrepancies severely impact the effectiveness of the simulation model. Therefore, it is essential for a quality assurance reviewer to confirm that all data used for model calibration and validation is both correct and collected or measured at the same time and place as the data used to develop the model.

## Chapter 5

# Analysis Tools Selection

Traffic analysis tools have different computational capabilities and underlying assumptions. This chapter offers guidance on selecting proper analysis tools to obtain cost-effective, yet reasonable analysis results at a desired level of confidence. Guidance on reporting MOEs from these tools is provided in Chapter 6. The following items are covered in this chapter:

- ▶ Traffic Analysis Tools
- ▶ Appropriate Tool for the Project

## 5.1 Traffic Analysis Tools

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

### Florida's Generalized Service Volume Tables (GSVT)

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 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 HCS 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 vehicle 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 the capability of building input files for detailed microsimulation analysis.

## 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.

**Table 5-1** provides a summary of the applications of these tools in different levels of analysis.

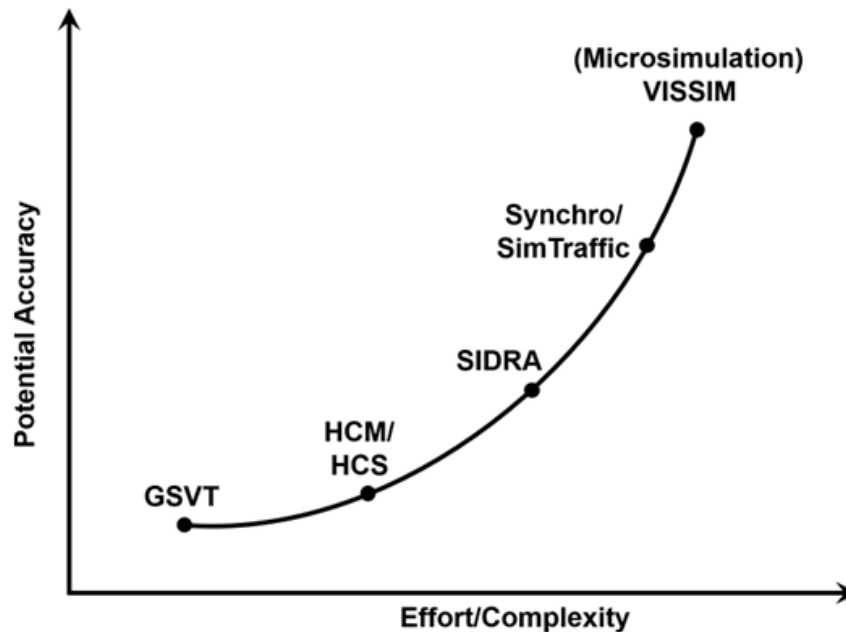
**Table 5-1** Uses of Traffic Analysis Tools

| Analysis Type                 | Level of Detail                                                                                                                                                | Level of Analysis                          | Analysis Tool       |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---------------------|
| <b>Sketch Planning</b>        | Analyzing system elements to obtain general order-of-magnitude estimates of performance based on capacity constraints and operational control                  | Generalized Planning                       | GSVT, HCS           |
| <b>Deterministic</b>          | 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 |
| <b>Microscopic Simulation</b> | Analyzing system performance based on detailed individual user interactions; geometry, and operational elements                                                | Preliminary Engineering; Design; Operation | Vissim, SimTraffic  |

## 5.2 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 5-1** demonstrates the relation between the levels of analysis, effort and degree of accuracy among different traffic analysis tools used by FDOT.

**Figure 5-1** 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 should 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.

**Table 5-2** 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 6** provides detailed guidance on the MOEs and their presentation from these tools.

**Table 5-2** Traffic Analysis Software by System Element

| Analysis Type                                  | Level of Detail                    | Level of Analysis                                                                   | Analysis Tool              |
|------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------|----------------------------|
| Limited Access                                 | Generalized Planning               | Determining the need for additional capacity                                        | GSVT                       |
|                                                | Preliminary Engineering and Design | Determining how the facility will operate                                           | HCS, Vissim                |
|                                                | Operational                        | Determining how well the facility operates                                          | HCS, 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, Vissim            |
|                                                |                                    | Analyzing weaving from ramp terminal to the nearest signalized intersection         | Vissim                     |
|                                                |                                    | Evaluating the operation of the entire interchange                                  | Vissim                     |
|                                                | Operational                        | Evaluating weaving operation                                                        | HCS, Vissim                |
| Urban Arterials                                | Generalized Planning               | Determining a need for additional capacity                                          | GSVT                       |
|                                                | Preliminary Engineering and Design | Determining how the facility will operate                                           | HCS, 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, Vissim |
| Rural two-lane Highways and Multilane highways | Generalized Planning               | Determining the need for additional capacity                                        | GSVT                       |
|                                                | Preliminary Engineering and Design | Determining how the facility will operate                                           | HCS                        |
|                                                | Operational                        | Determining how well the facility operates                                          | HCS                        |

| Analysis Type                             | Level of Detail                    | Level of Analysis                                       | Analysis Tool              |
|-------------------------------------------|------------------------------------|---------------------------------------------------------|----------------------------|
| <b>Intersections</b>                      | 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      | Vissim                     |
|                                           |                                    | Analyzing multimodal interactions                       | HCS, Vissim                |
|                                           | Operational                        | Evaluating the performance of signalized intersections  | HCS, Synchro, Vissim       |
| <b>Roundabouts</b>                        | 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                 |
| <b>Networks and Systems</b>               | Generalized Planning               | Forecasting system-wide future demand                   | GSVT, HCS                  |
|                                           | Preliminary Engineering and Design | Evaluating the performance of the entire network/system | Synchro/SimTraffic, Vissim |
|                                           | Operational                        | Evaluating the performance of the entire network/system | Synchro/SimTraffic, Vissim |
| <b>Multimodal Transportation District</b> | Planning                           | network/system                                          | GSVT, 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 there is no single microsimulation tool that can perfectly analyze all types of traffic problems. Each microsimulation tool that is available on the market has strengths and limitations. Microsimulation tools such as 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 should be considered when deciding to use 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 9**)

This list is not exhaustive, and it is the responsibility of the analyst to use good engineering 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 specific project circumstances, software limitations, and the 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** includes a Tool Selection Worksheet that can be used as part of the documentation to explain the use of alternative tools.

## Chapter 6

# Performance and Measures of Effectiveness

### 6.1 Introduction

Performance and Measures of Effectiveness (MOEs) are quantitative indicators that define the operational quality of transportation facilities. Operational MOEs represent numerical outputs derived from traffic analyses and serve as metrics for evaluating the performance of current and projected transportation networks. While existing conditions performance measures facilitate in adapting strategic visions for future system enhancements, future conditions performance measures link agency objectives to the anticipated outcomes of transportation improvements.

MOEs also enable comparison of system performance across various design configurations or improvement alternatives. Analysts must recognize and articulate any limitations inherent to the selected MOEs when evaluating system performance.

MOEs are tailored to individual projects and are determined and agreed upon during the development of the traffic analysis methodology. The selected MOEs form a part of the criteria for alternatives evaluation and should be incorporated into the evaluation matrix alongside other measures such as cost and environmental impact. Should there be modifications to the project's purpose and need during analysis—resulting in new or revised MOEs—such changes should be properly documented.

The study methodology should clearly identify all traffic operations MOEs that will be used to measure the performance of both the system and the alternatives under consideration. It is essential to specify whether the MOEs will be directly measured in the field or established through analytical methods. Additional project-specific MOEs relevant to alternative analysis may be sourced from applicable 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.

#### Level of Service (LOS)

Common MOEs used to evaluate facility performance include Highway Capacity Manual (HCM) LOS and volume-to-capacity (V/C) ratio. Operations resulting in LOS F or a V/C ratio exceeding 1.0 are deemed unacceptable. LOS serves as a recognizable qualitative indicator of traffic operations and is widely applied by various agencies to assess facility performance. However, relying solely on LOS

may not fully capture the overall performance of a facility. Additionally, LOS is not directly provided by several analytical programs, such as most microsimulation tools. Therefore, it is advisable to incorporate additional quantifiable measures within the analysis to achieve a comprehensive assessment of system or network performance. Analysts should consult with project stakeholders when determining appropriate MOEs for a given project. FDOT offers guidelines and tools intended to assist analysts in selecting suitable MOEs. The FDOT Systems Management [website](#) should be checked regularly for updates. Additional information about these supplementary quantifiable measures and their application is provided later in this chapter.

LOS targets for projects on the State Highway System (SHS) are determined according to the FDOT LOS policy ([FDOT Policy No. 000-525-006 – Level of Service Targets for the SHS](#)). Local governments may sometimes adopt LOS standards for state roads or local facilities that differ from those specified by FDOT. For projects on local government facilities, the agency's own LOS targets may be applied.

This chapter presents the following topics, which will be discussed in detail in the subsequent sections.

- **6.2 Purpose and Intended Use**  
|
- **6.3 Operational Analysis Using Deterministic Tools**  
|
- **6.4 Microsimulation Analysis**  
|
- **6.5 Performance Measures Threshold**

## 6.2 Purpose and Intended Use

The purpose of computing traffic operations MOEs is to quantify the impacts resulting from proposed modifications in a project and assess whether established goals have been met. Performance measures identified for analytical projects should be tailored to distinguish between alternatives. As these measures provide essential input for decision-making, early identification in the project timeline is important. Multiple MOEs are available to evaluate study alternatives and document findings. This chapter offers guidance on selecting relevant MOEs and appropriate documentation procedures for traffic analysis. It presents a basic set of MOEs useful for identifying congestion, capacity constraints, and operational issues using analytical tools and microsimulation analysis. The MOEs described in subsequent sections are part of the evaluation criteria for alternatives. If project objectives or purposes and needs change during the analysis and require additional MOEs, documentation for such changes should be included.

MOEs are project specific and should be selected and agreed upon in the traffic analysis methodology prepared in the beginning of the study. **Table 6-1** provides a list of commonly used analysis tools in Florida along with the recommended 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 (GSVTs) and Intersection Control Evaluation (ICE) are sometimes used in Planning and PD&E studies for initial screening of corridors and intersection alternatives. Information about the GSVTs is provided in the [FDOT Multimodal Quality/Level of Service Handbook](#) and is not covered in this chapter. The use of GSVTs in IAR and design projects is not advised.

**Table 6-1** Common Analysis Tools

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

*\*For deterministic analysis, HCS is recommended for one-lane roundabouts, while SIDRA is preferred for multilane roundabouts.*

MOEs can be measured in the field or calculated using analytical and microsimulation tools. Field measurements are ideal for calibration, while analytical methods are used for future scenario evaluation and comparison. Data collection should cover both calibration performance measures and demand estimates, and verification of geometric data, traffic control, and access management. The analyst should consult the [FDOT MUTS](#) and HCM for procedures for measuring performance measures in the field. Traffic operational MOEs can be calculated directly as basic measures, or they may be derived from these and additional inputs. **Table 6-2** contains a list of typical candidate operational MOEs, commonly reported for traffic analysis projects.

**Table 6-2** Typical Candidate Operational MOEs

| Operational MOEs                                         |
|----------------------------------------------------------|
| Travel time                                              |
| Speed                                                    |
| Delay                                                    |
| LOS                                                      |
| V/C ratio                                                |
| Throughput                                               |
| Density                                                  |
| Queue length                                             |
| Network-wide MOEs<br>(e.g. VMT, VHT, and network delays) |

## 6.3 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 the 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 for further consideration should be documented in the report.

HCS and Synchro are two commonly used deterministic analytical tools for operational analysis in Florida. Each corridor has distinct planning and operating considerations and characteristics. The selected MOEs should reflect the project's purpose and need and should be determined during the methodology phase.

### 6.3.1 HCS Analysis

HCS is a deterministic tool and is a reliable application of the HCM. The current HCS2025 program uses the methodologies outlined in HCM 7th 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 types and can be reported based on the project need. **Table 6-3** 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).

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

**Table 6-3** Typical HCS Performance MOEs

| Facility Type                                                                                 | MOEs                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Freeway Facilities</b>                                                                     | <ul style="list-style-type: none"> <li>» Individual segment <ul style="list-style-type: none"> <li>· Density (pc/mi/ln)</li> <li>· LOS</li> </ul> </li> <li>» Facility overall <ul style="list-style-type: none"> <li>· Density (pc/mi/ln)</li> </ul> </li> <li>» Speed (mph)</li> </ul> |
| <b>Basic Freeway Segments</b>                                                                 | <ul style="list-style-type: none"> <li>» Density (pc/mi/ln)</li> <li>» LOS</li> </ul>                                                                                                                                                                                                    |
| <b>Merge/Diverge Segments</b>                                                                 | <ul style="list-style-type: none"> <li>» Density (pc/mi/ln)</li> <li>» LOS</li> <li>» V/C for major merge/diverge segments</li> </ul>                                                                                                                                                    |
| <b>Weaving Segments</b>                                                                       | <ul style="list-style-type: none"> <li>» Density (pc/mi/ln)</li> <li>» LOS</li> </ul>                                                                                                                                                                                                    |
| <b>Ramp Roadways</b>                                                                          | <ul style="list-style-type: none"> <li>» V/C</li> </ul>                                                                                                                                                                                                                                  |
| <b>Signalized Intersections</b>                                                               | <ul style="list-style-type: none"> <li>» Intersection control delay *(sec/veh)</li> <li>» Movement delay (sec/veh)</li> <li>» Intersection LOS</li> <li>» Movement LOS</li> <li>» Back of queue ft/ln (95th percentile)</li> <li>» Back of queue veh/ln (95th percentile)</li> </ul>     |
| <b>Unsignalized Intersections<br/>(All Way Stop Controlled)<br/>(Two-Way Stop Controlled)</b> | <ul style="list-style-type: none"> <li>» Intersection delay** (sec/veh)</li> <li>» Intersection LOS**</li> <li>» Movement delay (sec/veh)</li> <li>» Movement LOS</li> <li>» 95th percentile queue length (veh)</li> </ul>                                                               |
| <b>Urban Streets</b>                                                                          | <ul style="list-style-type: none"> <li>» Travel speed (mph)</li> <li>» LOS</li> </ul>                                                                                                                                                                                                    |
| <b>Multi-lane Highways</b>                                                                    | <ul style="list-style-type: none"> <li>» Density (pc/mi/ln)</li> <li>» LOS</li> </ul>                                                                                                                                                                                                    |
| <b>Two-lane Highways</b>                                                                      | <ul style="list-style-type: none"> <li>» Follower density (followers/mi/ln)</li> <li>» LOS</li> </ul>                                                                                                                                                                                    |
| <b>Roundabouts</b>                                                                            | <ul style="list-style-type: none"> <li>» Control delay (sec/veh)</li> <li>» LOS</li> <li>» Approach delay (sec/veh)</li> <li>» Approach LOS</li> <li>» 95th percentile queue length (veh)</li> </ul>                                                                                     |

\* Intersection delay is the average control delay per vehicle for all approaches at a signalized intersection during the analysis period (e.g., peak hour).

\*\*AWSC LOS is calculated based on average control delay per vehicle for the intersection, weighted by volumes. TWSC Intersection LOS is determined by the worst minor-street movement (usually the one with the highest delay).

### 6.3.1.1 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 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).

### 6.3.1.2 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.

### 6.3.1.3 Travel Time Reliability

**Travel Time Reliability (TTR)** refers to a method for assessing how consistent travel times are on a roadway segment, essentially measuring the predictability of how long it will take to travel a certain distance, considering variations due to traffic conditions, incidents, and other factors. Recent editions of the HCM incorporate methods to calculate and analyze TTR metrics, allowing planners and engineers to evaluate the reliability of different roadway designs and operations strategies.

As a performance measure, TTR helps assess the quality of travel experience beyond just average travel time, considering the variability in travel times experienced by users on different days or at different times. Conceptually, TTR can be viewed as an extension that occurs in the time dimension, by transitioning from a “typical day” or “single study period” analysis to a reliability dimension, which is an extended-period analysis covering several days, weeks, months, or a full year. This new dimension gives rise to the following set of metrics:

- ▶ **Travel time:** The time required for a vehicle to travel the full length of the freeway facility from mainline entry point to mainline exit point without leaving the facility or stopping for reasons unrelated to traffic conditions.
- ▶ **Free-flow travel time:** The facility's length divided by its free-flow speed.
- ▶ **Travel time index (TTI):** The ratio of the actual travel time to the free-flow travel time. By definition, TTI is always greater than or equal to 1.0. The TTI's distribution is identical to that of travel time, except that its values are indexed to the free-flow travel time.

- ▶ **Percentile travel time index (TTI<sub>pp</sub>):** Represents the pp percentile TTI in the travel time distribution. For example, TTI<sub>85</sub> means that this observation is exceeded only 15% of the time in the travel time distribution. Common TTI percentiles are TTI<sub>50</sub> (the 50th percentile TTI, slightly lower than the median TTI due to the influence of rare, very long travel times in the distribution) and TTI<sub>95</sub> (the 95th percentile TTI, also known as Planning Time Index). When pp is omitted, the value often represents the mean TTI for the distribution, which is referred to as TTI<sub>mean</sub>.
- ▶ **Travel time distribution:** The distribution of average facility travel times by analysis period across the RRP. Each 15-min analysis period within each scenario contributes one data point to the travel time distribution. It is not the distribution of individual vehicle travel times (or TTIs).
- ▶ **Probability density function (PDF) and cumulative distribution function (CDF):** The PDF gives the number or percent of all observations within a specified travel time (or TTI) bin. The CDF gives the number or percent of all observations at or below a specified travel time bin.
- ▶ **Level of travel time reliability (LOTTR):** The ratio of 80th percentile TTI to 50th percentile TTI.

By incorporating travel time reliability analysis into traffic studies, transportation professionals can identify areas with significant travel time variability and prioritize projects to improve traffic flow and reliability.

HCS includes Freeways Reliability module and Streets Reliability module to evaluate the travel time reliability experienced by motorists on an urban or rural freeway facility and on an urban street facility, respectively.

### HCS Freeways Reliability Module

HCS implements the methodology prescribed in the HCM Chapters 11 and 25 for analyzing a freeway's travel time reliability over a multi-day or multi-month reliability reporting period (RRP). The methodology estimates the impacts of recurring congestion, caused by normal traffic demand variations, and non-recurring congestion, triggered by unpredictable factors such as incidents, severe weather conditions, work zones, and special events, on the travel time distribution over the course of the RRP. By incorporating these factors, the analysis generates statistical travel time distributions, enabling the calculation of key TTR metrics, including the percentile TTIs, LOTTR, and failure and on-time measures. This methodology can be applied to predict the reliability impacts of freeway investment options, such as adding general-purpose lanes and managed lanes.

As an extension, the methodology can be used to evaluate the benefits of Active Traffic and Demand Management (ATDM) strategies, such as ramp metering, variable speed limits, dynamic lane use, and part-time shoulder use, in improving travel time reliability and mitigating congestion.

### HCS Streets Reliability Module

HCS implements the methodology prescribed in the HCM Chapter 17 for analyzing travel time reliability on an urban street. This chapter's methodology relies on methodologies in other HCM chapters to compute the desired performance measures. Specifically, the methodology for aggregating segment performance measures to obtain an estimate of facility performance is

described in Chapter 16. The methodology for evaluating the individual segments is described in Chapter 18. The methodologies in Chapters 16 and 18 are applicable to an urban street facility that typically has a length of 1 mile or more in downtown areas and 2 miles or more in other areas.

The reliability methodology can be used to evaluate the following sources of unreliable travel time:

- ▶ Demand fluctuations,
- ▶ Weather,
- ▶ Traffic incidents,
- ▶ Work zones,
- ▶ Special events,
- ▶ Inadequate base capacity, and
- ▶ Traffic control devices on urban streets.

Demand fluctuations are represented in the methodology in terms of systematic and random demand variation by hour of day, day of week, and month of year. Fluctuations due to diversion are not addressed directly by the methodology but can be optionally provided by the analyst for work zones and special events through the demand specified in an alternative dataset.

## **HCM Computational Engine**

Because of the hundreds (or even thousands) of scenarios that are generated, implementation of this method is only practical through software. Software automates the scenario generation process, performs the computations associated with the HCM facility methodology for each scenario, and stores and processes the output performance measures generated for each scenario. In addition to utilizing the modules provided as part of HCS, source code listings for the HCM (e.g. [FREEVAL-HCM](#) and [STREETVAL](#)) are provided in the Technical Reference Library (HCM Page 776) in [HCM Volume 4](#). These engines were developed, maintained, and updated as HCM-based software to include freeway and urban street reliability analysis.

### **6.3.2 Synchro Analysis**

Synchro is a deterministic tool commonly applied to the analysis of signalized intersections, unsignalized intersections, and arterials. The primary MOEs generated by Synchro include intersection and individual movement control delay, V/C ratio, and 95th percentile queue length. Synchro does not offer freeway performance measures and is not intended for analyzing freeway facilities. It is frequently utilized to develop optimized signal timing plans, which can then be used as input for microsimulation software.

#### **6.3.2.1 Intersection Delay**

Synchro calculates control delay using two (2) different methods: The percentile delay methodology and the HCM methodology. Synchro's percentile methodology calculates delay for five distinct scenarios, 10th, 30th, 50th, 70th, and 90th percentile traffic volumes, which are then weighted to determine the final average delay.

Synchro also implements the intersection analysis methods from HCM 7th Edition, 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, HCM 6th Edition and HCM 7th 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 when the HCM methodology is not compatible. 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 6-4** provides a list of recommended Synchro Typical MOEs that apply to Synchro analyses.

**Table 6-4** Synchro Typical MOEs

| Intersection Type                 | MOEs                                                                                                                                                                                          |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Signalized Intersections</b>   | <ul style="list-style-type: none"> <li>» Intersection delay</li> <li>» Movement delay</li> <li>» Intersection LOS</li> <li>» Movement LOS</li> <li>» 95th percentile queue lengths</li> </ul> |
| <b>Unsignalized Intersections</b> | <ul style="list-style-type: none"> <li>» Minor movement delay</li> <li>» Minor movement LOS</li> <li>» 95th percentile queue lengths</li> </ul>                                               |
| <b>Arterials</b>                  | <ul style="list-style-type: none"> <li>» Travel time</li> <li>» Speed</li> <li>» Signal delay</li> <li>» LOS</li> </ul>                                                                       |

### 6.3.2.2 Queue Length

The 95<sup>th</sup> 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 212](#) 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<sup>th</sup> percentile queues from Synchro are valid for undersaturated conditions and should be reported with caution for saturated or oversaturated conditions. For saturated or 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. **Table 6-5** shows an example of tabular presentation of Synchro intersections performance measures.

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).

**Table 6-5** Tabulation of Synchro Intersection Performance Measures Example

| Intersection                      | Approach                         | Movement | Delay (Seconds) | LOS     | Available Storage (Feet) | 95 <sup>th</sup> % Queue (Feet) |
|-----------------------------------|----------------------------------|----------|-----------------|---------|--------------------------|---------------------------------|
|                                   |                                  |          | AM (PM)         | AM (PM) | # of Lanes/<br>Length    | AM (PM)                         |
| I-295 at<br>Atlantic<br>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)   |                          | -                               |
|                                   | Queue exceeds available storage. |          |                 |         |                          |                                 |

# indicates that the volume for the 95<sup>th</sup> percentile cycle exceeds capacity.

### 6.3.3 Innovative Intersection and Interchange

FDOT has developed an ICE policy as a performance-based procedure designed to quantitatively evaluate and rank various intersection control alternatives based on their operational and safety performance. The ICE procedure detailed in the [FDOT ICE Manual](#) offers a structured approach to selecting intersection control types during the initial screening or planning stage, ensuring a transparent and consistent evaluation of alternatives. This evaluation is based on metrics such as safety, operations, cost, and social, environmental, and economic impacts. Applicable to both new intersections and modifications to existing ones on the State Highway System (SHS), the ICE procedure is divided into multiple stages:

- ▶ **Screening/Preliminary Analysis (Stage 1):** Potential strategies are identified and screened quickly by defining the problem, reviewing data, and performing a preliminary analysis.
- ▶ **Detailed Analysis (Stage 2):** An in-depth assessment of shortlisted strategies is conducted, evaluating them against specific criteria, and a comparative analysis is provided.

- **Supplemental Analysis (Stage 3):** If needed, this stage addresses any remaining issues or refines the selected strategy.

Throughout the procedure, thorough documentation is essential, with practitioners using [FDOT ICE Forms](#) to record all findings, recommendations, and decisions. The goal of ICE is to better inform FDOT's decision-making by identifying and selecting control strategies that align with the project's purpose and need, fit the intersection location's context, provide safe facilities for all road users, and offer the overall best value. The ICE procedure is an effective tool for screening intersection alternatives during the planning stage. Practitioners are encouraged to stay updated with the latest manual revisions and undergo relevant training, with detailed guidelines and training material available through [FDOT's Traffic Engineering and Operations Office](#).

The ICE procedure promotes thoughtful consideration of the innovative intersection designs to the conventional intersection. 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 delays, 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: Median U-Turn (MUT); Restricted Crossing U-Turn (RCUT); Jughandle; Displaced Left-Turn (DLT), also known as Continuous Flow Intersection (CFI); Thru-Cut; Continuous Green T-Intersection (CGT); Quadrant Roadway (QR); Roundabout; Bowtie; Diverging Diamond Interchange (DDI). 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 distributed 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 6-4** to compare between the conventional intersection and the innovative intersections. In complex scenarios such as the DLT, when one (1) intersection is replaced by multiple distributed intersections, results should be reported for all the new intersections. It should be ensured that LOS, delay, and queue lengths

**Figure 6-1** DLT Example



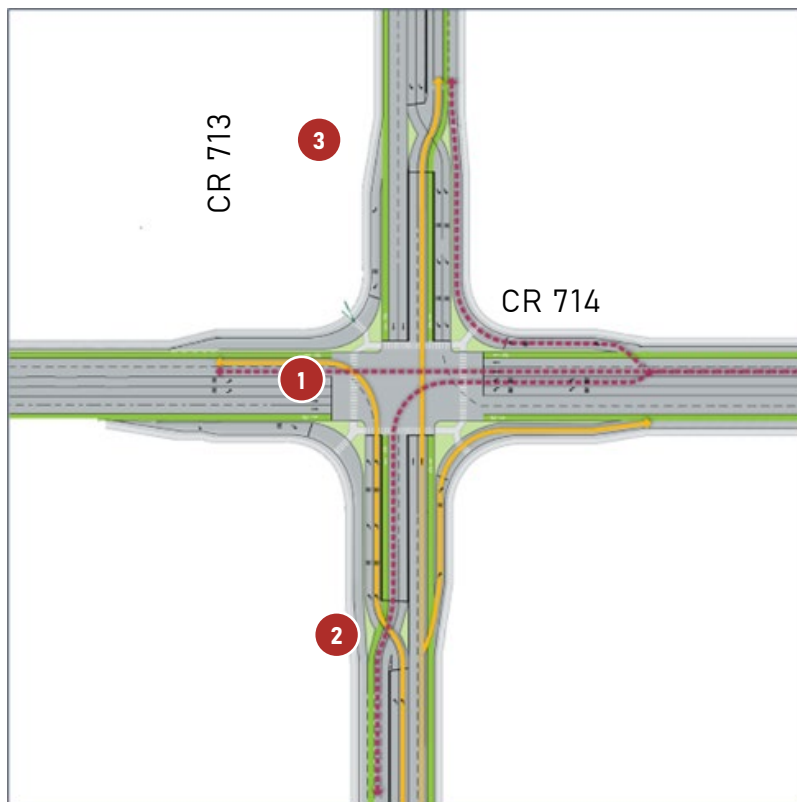
for all the new intersections are within the acceptable limits of the study. Also, when analysts seek to accumulate the delay at a signal from microsimulation analysis, they should investigate whether the delay and queues extend beyond the single approach links to the intersection. This is because all 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 6-1** and **Table 6-6** show an example of reporting results for the DLT concept that has multiple intersections.

**Table 6-6** DLT Results Documentation Example

| Intersection                   | Intersection Approach |          |                 |         | Overall Intersection |         |
|--------------------------------|-----------------------|----------|-----------------|---------|----------------------|---------|
|                                | Approach              | Movement | Delay (Seconds) | LOS     | Delay (Seconds)      | 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)   |                      |         |

**Figure 6-2** and **Table 6-7** show an example of reporting results for the Partial DLT concept that has multiple intersections for northbound and southbound directions.

**Figure 6-2** Partial DLT Example



**Table 6-7** Partial DLT Results Documentation Example

| Intersection                     | Movement | AM       |                 |     |                 |     | PM       |                 |     |                 |     |
|----------------------------------|----------|----------|-----------------|-----|-----------------|-----|----------|-----------------|-----|-----------------|-----|
|                                  |          | Movement |                 |     | Intersection    |     | Movement |                 |     | Intersection    |     |
|                                  |          | Volume   | Delay (seconds) | LOS | Delay (seconds) | LOS | Volume   | Delay (seconds) | LOS | Delay (seconds) | LOS |
| CR 713 at CR 714 Intersection #1 | EBL      | 102      | 42.3            | D   | 25.6            | C   | 105      | 39.2            | D   | 27.5            | C   |
|                                  | EBT      | 885      | 22.5            | C   |                 |     | 758      | 23.1            | C   |                 |     |
|                                  | EBR      | 342      | 0.3             | A   |                 |     | 167      | 0.1             | A   |                 |     |
|                                  | WBL      | 142      | 43.1            | D   |                 |     | 77       | 41.9            | D   |                 |     |
|                                  | WBT      | 568      | 17.5            | B   |                 |     | 688      | 25.3            | C   |                 |     |
|                                  | WBR      | 151      | 0.1             | A   |                 |     | 217      | 30.8            | C   |                 |     |
|                                  | NBL      | 193      | 35.1            | D   |                 |     | 342      | 32.6            | C   |                 |     |
|                                  | NBT      | 312      | 36.6            | D   |                 |     | 495      | 34.4            | C   |                 |     |
|                                  | NBR      | 76       | 49.1            | D   |                 |     | 141      | 55.4            | E   |                 |     |
|                                  | SBL      | 171      | 34.8            | C   |                 |     | 170      | 30.4            | C   |                 |     |
|                                  | SBT      | 475      | 39.3            | D   |                 |     | 333      | 32.2            | C   |                 |     |
|                                  | SBR      | 58       | 33.1            | C   |                 |     | 73       | 29.3            | C   |                 |     |
| NBL Crossover Intersection #2    | NBL      | 193      | 13.2            | B   | 5.3             | A   | 342      | 15.2            | B   | 5.4             | A   |
|                                  | NBT      | 388      | 0.1             | A   |                 |     | 636      | 0.1             | A   |                 |     |
|                                  | SBT      | 617      | 6               | A   |                 |     | 410      | 5.4             | A   |                 |     |
| SBL Crossover Intersection #3    | NBT      | 414      | 4.6             | A   | 4.1             | A   | 600      | 5.1             | A   | 4.8             | A   |
|                                  | SBL      | 171      | 14.4            | B   |                 |     | 170      | 14.4            | B   |                 |     |
|                                  | SBT      | 533      | 0.4             | A   |                 |     |          | 0.3             | A   |                 |     |

## Experienced Travel Time (ETT)

HCM 7th Edition offers an alternative procedure that uses ETT for LOS assessment capable of capturing specific signalized and arterial operations in a way that facilitates unbiased comparisons among types of distributed intersections. ETT includes intersection control delay and Extra Distance Travel Time (EDTT).

ETT allows the comparison of innovative intersections such as MUT, RCUT, DLT/CFI, DDI 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 6-1** below (HCM 7th Edition, Equation 23-1).

### Equation 6-1

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

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 (feet) 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.

These innovative intersections and interchanges are encouraged for their potential to improve safety, reduce congestion, and accommodate various road users more effectively than traditional designs. The ICE procedure systematically assesses these alternatives alongside conventional options, ensuring that innovative designs are not overlooked during the evaluation. By incorporating innovative intersections into the ICE procedure, FDOT aims to enhance the overall performance and adaptability of the SHS, providing more efficient and safer travel solutions that align with modern transportation needs. This approach allows FDOT to select intersection control strategies that not only meet the immediate project objectives but also contribute to long-term improvements in traffic management and road safety.

For the partial DLT example above, the ETT results are summarized in **Table 6-8**.

**Table 6-8** ETT Summary Example

| Intersection           | Movement | No Build |     | PDLT  |     |
|------------------------|----------|----------|-----|-------|-----|
|                        |          | Delay    | LOS | Delay | LOS |
| AM Peak Hour           |          |          |     |       |     |
| CR 713<br>at<br>CR 714 | NBT      | 79.1     | E   | 50.4  | D   |
|                        | NBL      | 76.5     | E   | 59.4  | E   |
|                        | SBT      | 75.5     | E   | 57.3  | E   |
|                        | SBL      | 69.0     | E   | 58.7  | E   |
| PM Peak Hour           |          |          |     |       |     |
| CR 713<br>at<br>CR 714 | NBT      | 64.8     | E   | 49.2  | D   |
|                        | NBL      | 57.9     | E   | 53.7  | D   |
|                        | SBT      | 71.9     | E   | 49.7  | D   |
|                        | SBL      | 71.9     | E   | 53.8  | D   |

## 6.4 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 6-9** provides a recommended list of microsimulation analysis MOEs and documentation. Most microsimulation models do not report LOS, especially for freeway segments. **Section 6.5** of this chapter outlines an approach to estimate LOS using density and speed results obtained from microsimulation analysis.

Additionally, TTR metrics, such as TTI and travel time distributions, can be derived from the detailed outputs of microsimulation models on a network-wide basis. This approach is particularly valuable when analyzing multimodal interactions or evaluating complex roadway configurations, such as those involving managed lanes, roundabouts, or high-density urban networks. Microsimulation provides the granularity needed to capture the dynamic behavior of different vehicle classes (e.g., passenger cars, buses, and trucks) and non-motorized modes (e.g., bicycles and pedestrians) under varying traffic conditions. Microsimulation allows for the modeling of stochastic factors such as fluctuating demand, driver behavior variability, and incident impacts, all of which contribute to a more comprehensive understanding of TTR across the network, especially in corridors or regions with significant congestion or multimodal demands.

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.

**Table 6-9** Typical Microsimulation Performance MOEs

| Intersection Type                                       | MOEs                                                                                                                                                                                                                                                                                                                        | Typical Presentation of the Measure                                                                                                                                                                                                 |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Freeway Segments (Merge/diverge, Basic or Weave)</b> | <ul style="list-style-type: none"> <li>» Density (veh/mi/ln)</li> <li>» Estimated Density (pc/mi/ln)</li> <li>» Estimated LOS</li> <li>» Speed (mph)</li> <li>» Travel Time (seconds)</li> <li>» Simulated Volume (reported along with Demand Volume)</li> </ul>                                                            | <ul style="list-style-type: none"> <li>» Graphical <ul style="list-style-type: none"> <li>• Lane Schematics</li> <li>• Density Heat Map</li> </ul> </li> <li>» Tabular (Optional if graphical documentation is provided)</li> </ul> |
| <b>Arterial Intersections</b>                           | <ul style="list-style-type: none"> <li>» Intersection Delay (sec/veh)</li> <li>» Movement Delay (sec/veh)</li> <li>» Intersection LOS (Estimated)</li> <li>» Movement LOS (Estimated)</li> <li>» Maximum Queue Length (feet)</li> <li>» Simulated Volume (reported along with Demand Volume)</li> </ul>                     | <ul style="list-style-type: none"> <li>» Tabular</li> </ul>                                                                                                                                                                         |
| <b>Arterials</b>                                        | <ul style="list-style-type: none"> <li>» Speed (mph)</li> <li>» Travel Time (seconds)</li> <li>» Simulated Volume (reported along with Demand Volume)</li> </ul>                                                                                                                                                            | <ul style="list-style-type: none"> <li>» Tabular</li> </ul>                                                                                                                                                                         |
| <b>Network-wide</b>                                     | <ul style="list-style-type: none"> <li>» Total Delay (hours)</li> <li>» Average Delay (seconds per vehicle)</li> <li>» Total Travel Time (hours)</li> <li>» Latent Delay (hours)</li> <li>» Latent Demand (veh)</li> <li>» Vehicles Arrived (veh)</li> <li>» Total Stops (number)</li> <li>» Average Speed (mph)</li> </ul> | <ul style="list-style-type: none"> <li>» Tabular</li> </ul>                                                                                                                                                                         |

## 6.4.1 Freeway Performance Measures

### 6.4.1.1 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 8**.

#### ► 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 data and results should be constructed to facilitate understanding. The presentation should be clear enough for both technical and non-technical audiences to comprehend.

- **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 6.5** and reported on lane schematics. **Figure 6-3** shows an example of lane schematics for freeway link-based performance measures.

- **Density Heat Map**

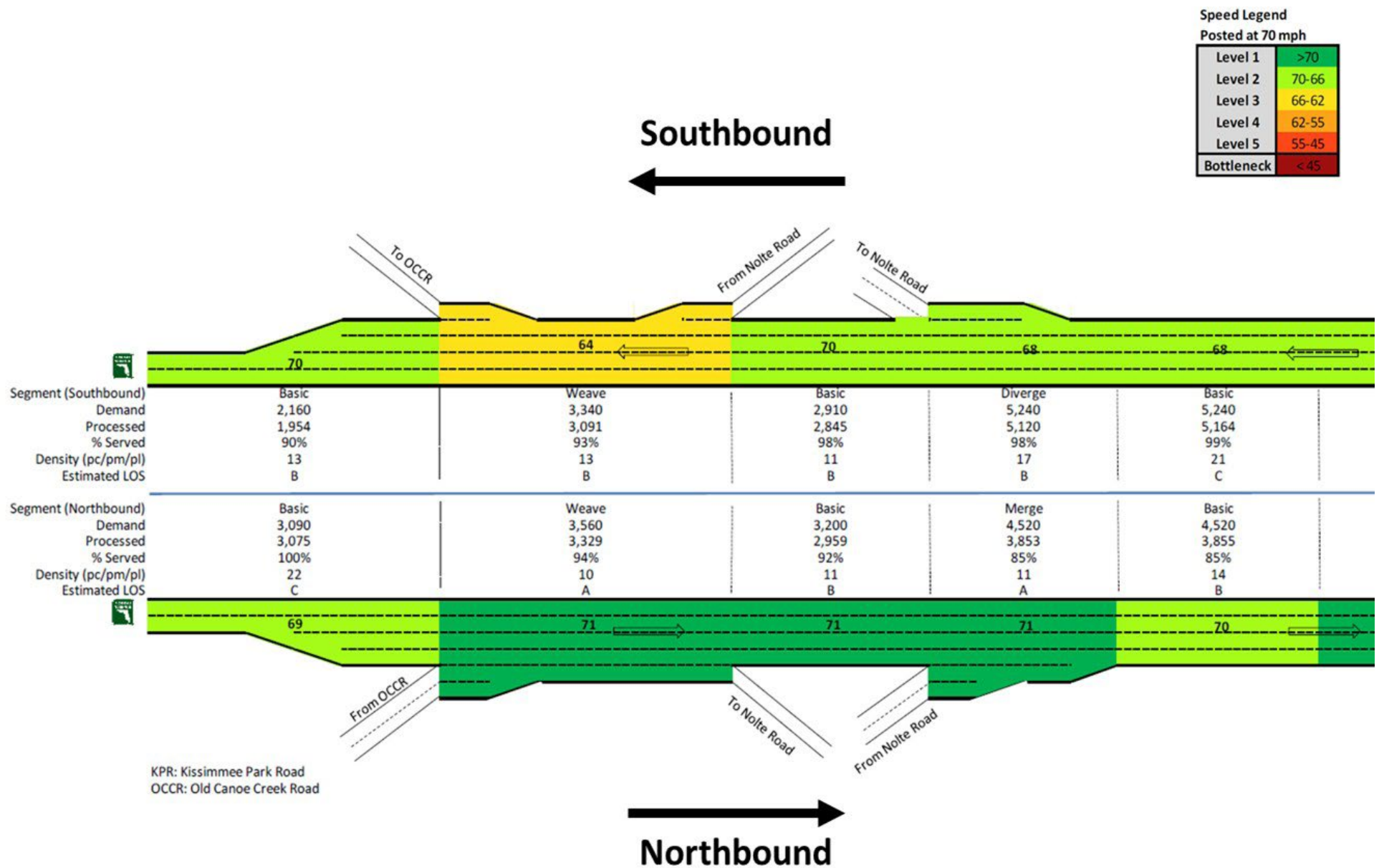
Density Heat Maps are graphical presentation of microsimulation results along the freeway with interchanges or ramps on one (1) axis and time period on the other axis. Individual density values are presented with colors. Generally, darker colors indicate heavy congestion occurrence. Density based heat 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 6-4** shows an example of a density heat map.

- ▶ **Tabular Presentation**

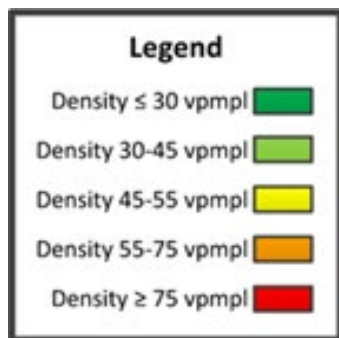
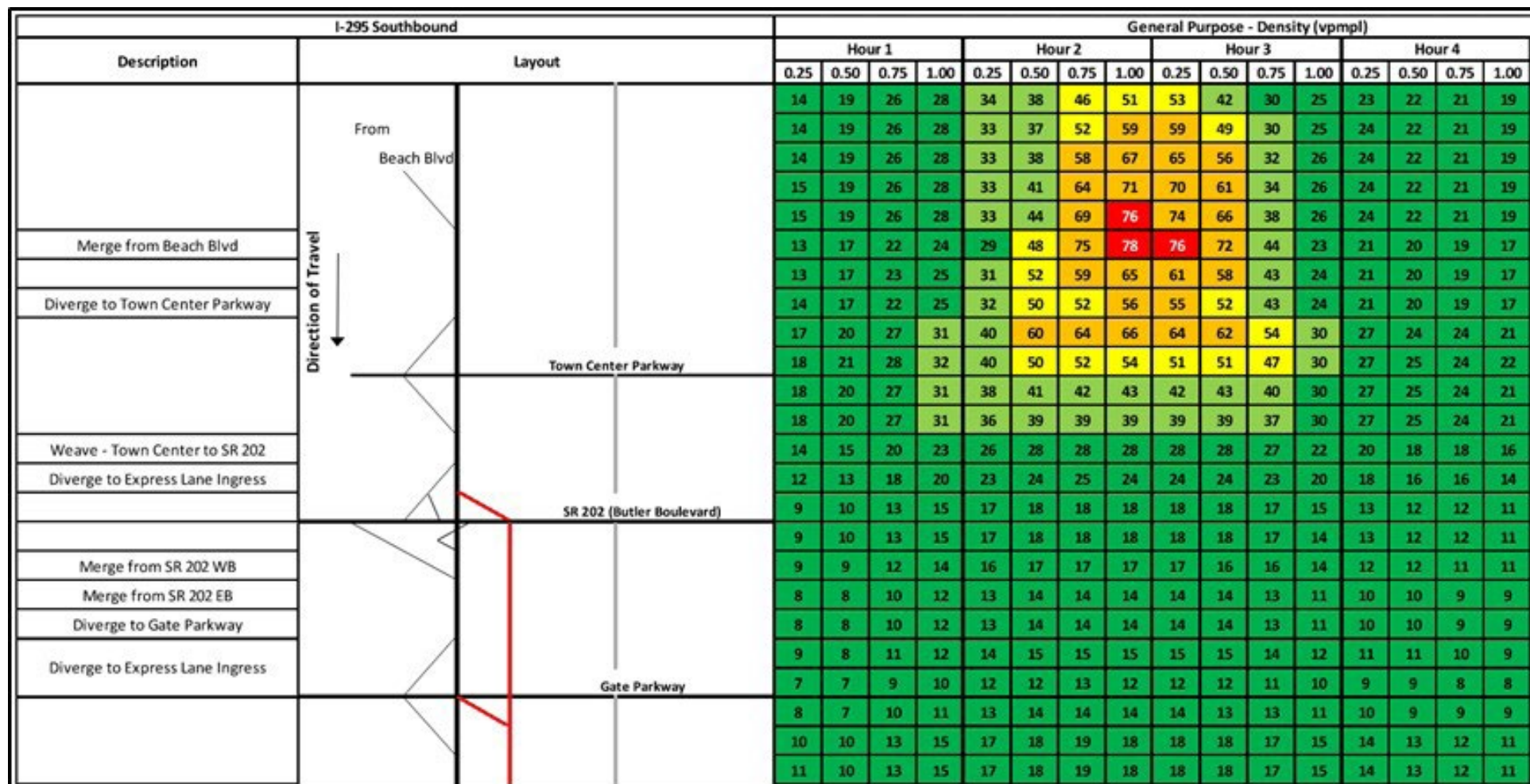
Tables should be used to present link-based results of the analysis if graphical presentation using link schematics and heat diagrams is not provided. All freeway link based MOEs including demand volumes, simulated volumes, speed, and density should be included in tabular format. Results can also be color coded for 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 6-10** shows an example of tabular presentation of link-based performance measures.

**Figure 6-3** Freeway Lane Schematics Example



**Figure 6-4** Density Heat Map Example



**Table 6-10** Tabulation of Freeway Performance Measures Example

| Segment                                                         | Lanes | Demand | Processed | % Served | Speed | Density (pc/mi/in) |
|-----------------------------------------------------------------|-------|--------|-----------|----------|-------|--------------------|
| 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 South 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 <35mph

### 6.4.2 Arterial Intersection 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.

#### 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. Delay from a microsimulation model is not the same as delay from HCM methodology. 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.

Queue lengths exceeding available storage and impacting upstream freeway or intersection operations should be documented. **Table 6-11** shows an example of tabular presentation of arterial intersections performance measures.

**Table 6-11** Tabulation of Arterial Performance Measures Example

| Phillips Highway & SR 9B NB Ramps | SR 9B Ramps |     |     | Phillips 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 |

### 6.4.3 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 the 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 6-12** shows an example of tabular presentation of network-wide performance measures.

#### Latent Demand

Latent demand refers to the number of vehicles that are unable to enter the network by the end of the simulation period, primarily due to limited network capacity. Latent demand may influence other network performance outcomes and produce results that do not accurately reflect actual conditions; as such, it should be included in analyses and in the comparison of alternatives. Adjustments for latent demand under current and future model scenarios are addressed in **Chapter 8**.

**Table 6-12** 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%         |

#### 6.4.4 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 6.4** 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 6-13**, 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 6-13** provides recommended list of MOEs and required documentation for express lanes analysis.

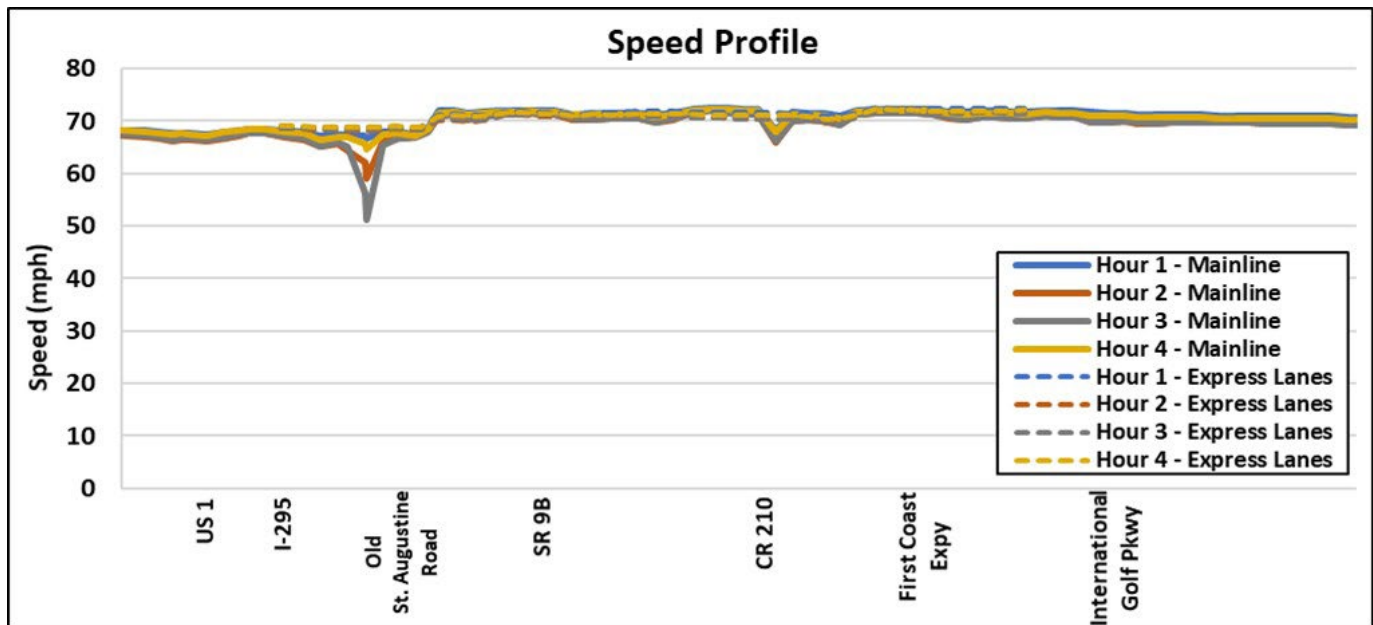
**Table 6-13** Express Lanes Analysis Performance Measures

| Category      | MOE                                                                            | Documentation                                                                                                                                                                                                                  |
|---------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Express Lanes | » Segment based MOEs                                                           | » Provide documentation listed in <b>Section 6.4</b> plus: <ul style="list-style-type: none"> <li>• General Use Lanes and Express Lanes Volume Profile</li> <li>• General Use Lanes and Express Lanes Speed Profile</li> </ul> |
|               | » Complex Weave <ul style="list-style-type: none"> <li>• Lane Based</li> </ul> | » Speed differential<br>» Vehicles diffused<br>» Graphical <ul style="list-style-type: none"> <li>• General Use Lanes Speed by lane</li> <li>• General Use Lanes Density by lane</li> </ul>                                    |

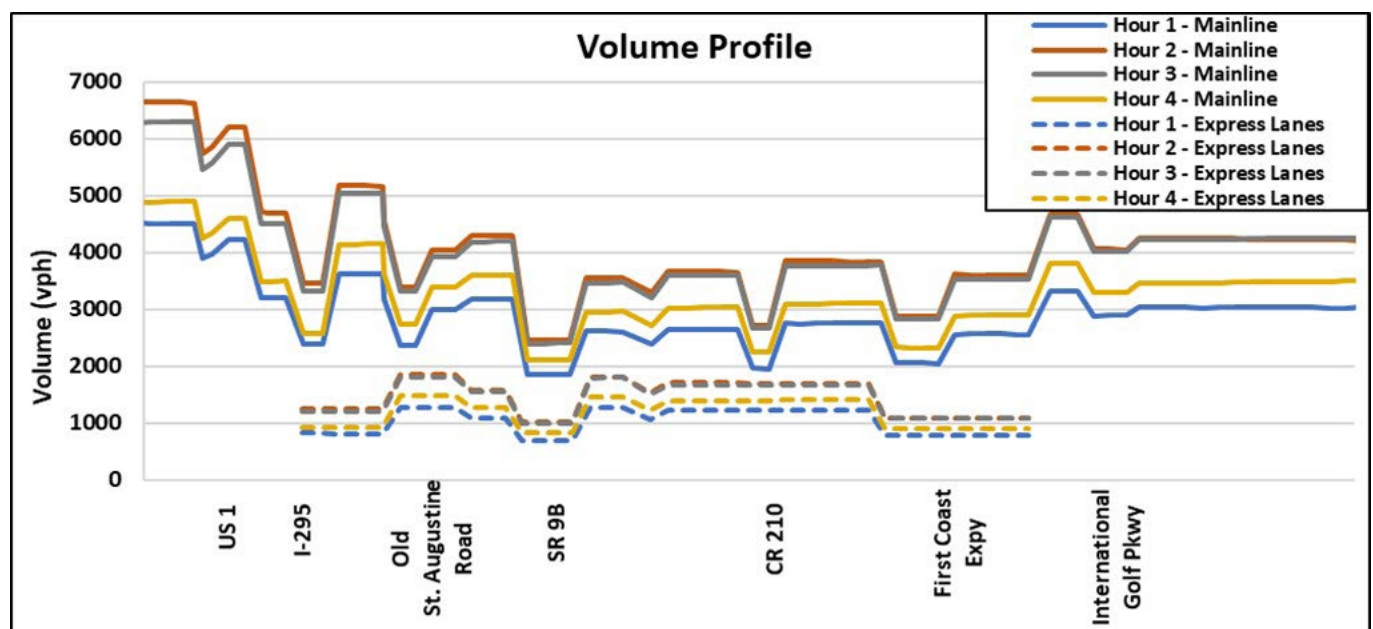
## Segment Based Performance Measures

Segment based performance measures should be documented as described in **Section 6.4** 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 6- 5** and **6-6** show an example of speed and volume profiles for general use lanes and express lanes.

**Figure 6-5** Speed Profile for General Use Lanes and Express Lanes



**Figure 6-6** Volume Profile for General Use Lanes and Express Lanes



### 6.4.5 Complex Weave Performance Measures

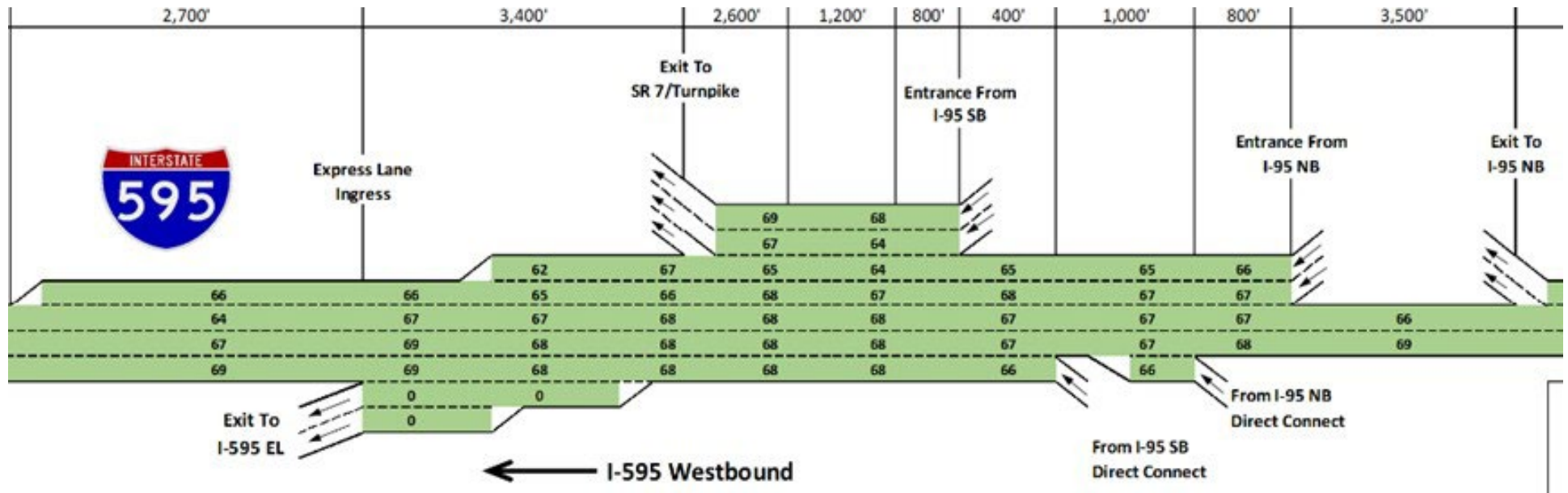
Complex weave analysis should be performed using methods described in **Chapter 9** of this handbook. MOEs reported specific to complex weave segments include simulated volume, speed for all weaving and non-weaving traffic movement pairs (speed differential) and diffused vehicles. Each segment simulated 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 6-7** and **6-8** show an example of speed and density by lane respectively for complex weave segments.

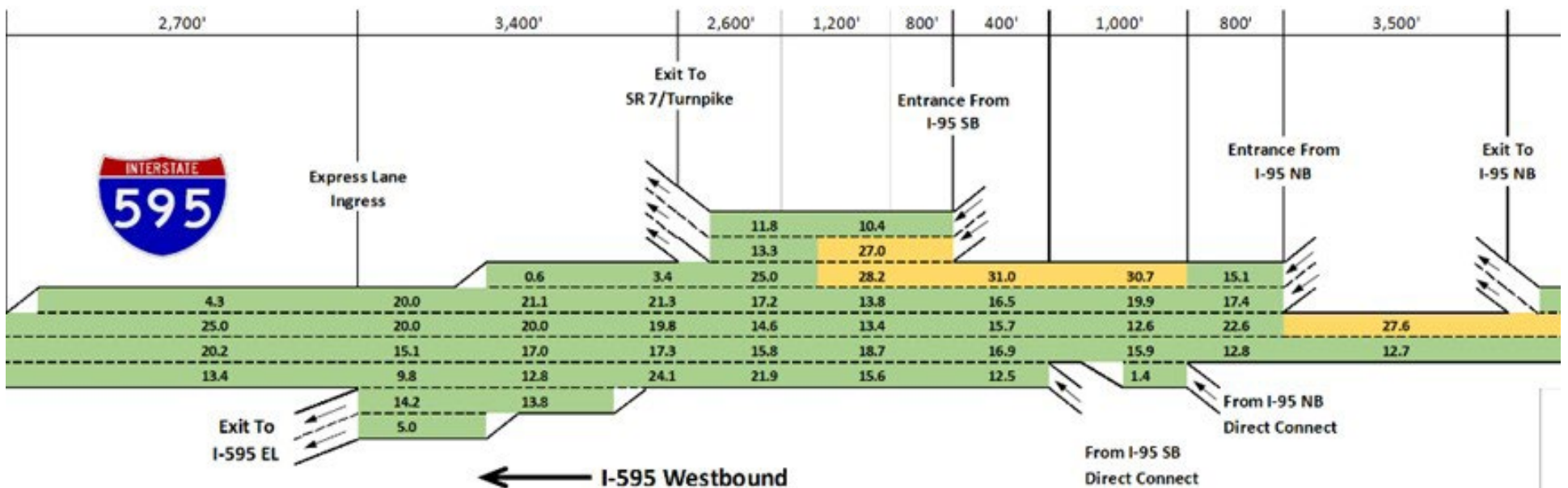
#### 6.4.5.1 Complex Weave Results Documentation

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 6-9** 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 6-9**.

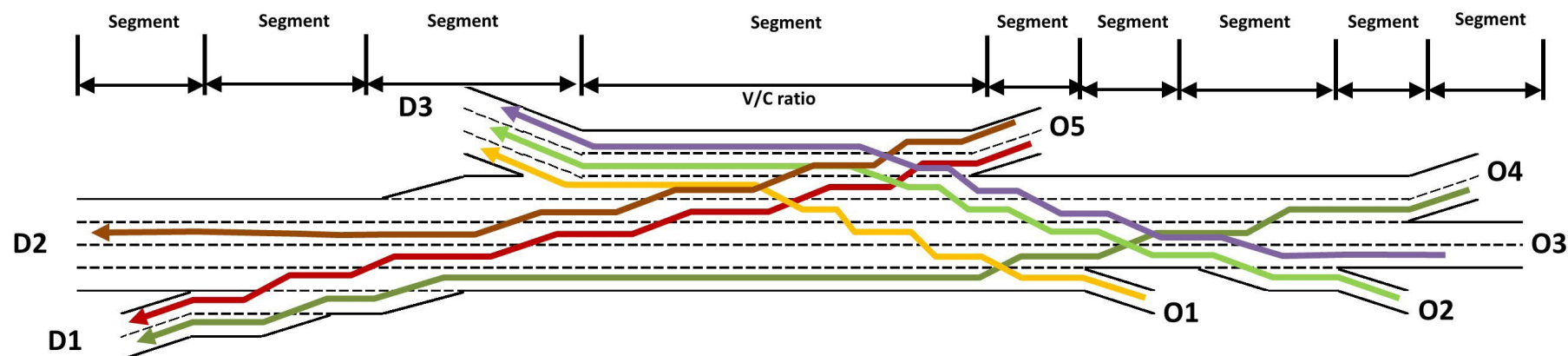
**Figure 6-7** Complex Weave Segment Speed by Lane Example



**Figure 6-8** Complex Weave Segment Density by Lane Example



**Figure 6-9** Complex Weave Analysis Documentation



| O-D   | Weaving and Nonweaving Speed (mph) | Build Speed Differential (mph) | Simulated Volume (vph) |
|-------|------------------------------------|--------------------------------|------------------------|
| 01-D1 | 64.5                               |                                | 1,000                  |
| 01-D2 | 67.6                               |                                | 1,000                  |
| 01-D3 | 66.9                               | 0.7                            | 1,000                  |
| 02-D1 | 60.0                               |                                | 500                    |
| 02-D2 | 60.0                               |                                | 500                    |
| 02-D3 | 60.0                               | 0                              | 500                    |
| 03-D1 | 66.0                               |                                | 1,000                  |
| 03-D2 | 66.8                               |                                | 1,000                  |
| 03-D3 | 60.0                               | 6.8                            | 1,000                  |
| 04-D1 | 64.5                               | 0.6                            | 500                    |
| 04-D2 | 65.2                               |                                | 1,000                  |
| 04-D3 | 60.0                               |                                | 500                    |
| 05-D1 | 62.0                               | 1.5                            | 500                    |
| 05-D2 | 62.5                               | 1.0                            | 1,000                  |
| 05-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

## 6.5 Performance Measures Threshold

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 represents the 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.

### 6.5.1 Estimated Density and LOS

Link based or travel time segment 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 6-2** and **6-3** below which can then be used to estimate LOS using HCM thresholds. The HCM 7th Edition density and LOS thresholds for basic freeway segments (HCM 7th Edition, Exhibit 12-15), merge and diverge segments (HCM 7th Edition, Exhibit 14-3) and weaving segment (HCM 7th Edition, Exhibit 13-6) can be used to determine if the freeway operates at acceptable LOS.

#### Equation 6-2

##### ► (a) Link Output

$$\text{Estimated Density}_{(pcpmpl)} = \frac{\text{Density}_{(vpmpl)}}{f_{(hv)}}$$

##### ► (b) Travel Time Segment Output

$$\text{Estimated Density}_{(pcpmpl)} = \frac{\text{Volume}_{(vph)}}{\text{Speed}_{(mph)} \times \text{Number of Lanes} \times f_{(hv)}}$$

Where,

$\text{Estimated Density}_{(pcpmpl)}$  = Link or segment density from microsimulation

$\text{Volume}_{(vph)}$  = number of vehicles per hour

$\text{Speed}_{(mph)}$  = vehicle speed miles per hour

$f_{(hv)}$  = Adjustment factor for presence of heavy vehicles in traffic stream using HCM 7th Edition

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

#### Equation 6-3

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

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.”

### 6.5.2 Speed Thresholds

For freeway facilities, speed serves as a key metric to indicate whether a facility is experiencing congestion. As demand approaches capacity, travel speeds on the freeway decrease. When speeds remain near the posted limit, the facility can be classified as undersaturated or operating under uncongested conditions. Conversely, significant reductions in speed from the posted limit indicate that the facility is oversaturated or congested.

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 6-14** shows corresponding levels of congestion for each posted speed limit.

**Table 6-14** Congestion Level Thresholds

| Congested Level      | Freeways           |             |             |             |             |
|----------------------|--------------------|-------------|-------------|-------------|-------------|
|                      | Posted Speed (mph) |             |             |             |             |
|                      | 50                 | 55          | 60          | 65          | 70          |
| Uncongested          | $\geq 47$          | $\geq 51$   | $\geq 56$   | $\geq 60$   | $\geq 63$   |
| Lightly Congested    | $< 47 - 44$        | $< 51 - 46$ | $< 56 - 51$ | $< 60 - 55$ | $< 63 - 57$ |
| Moderately Congested | $< 44 - 38$        | $< 46 - 39$ | $< 51 - 41$ | $< 55 - 44$ | $< 57 - 45$ |
| Heavily Congested    | $< 38$             | $< 39$      | $< 41$      | $< 44$      | $< 45$      |

The speed thresholds and associated colors may be utilized and reported for link-based MOEs, with lane schematics or tabular documentation as outlined in **Section 6.4.1**.

## Chapter 7

# 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.

### ● 7.1 Generalized Service Volume Table



### ● 7.2 HCM and HCS



### ● 7.3 SIDRA INTERSECTION



### ● 7.4 Synchro and SimTraffic

## 7.1 Generalized Service Volume Table

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 (GSVT) are the primary tools for conducting generalized planning analysis. The GSVTs, found at the end of the [FDOT Multimodal Quality/Level of Service Handbook](#), present maximum service volumes, or the highest numbers of vehicles for a given LOS. FDOT's GSVTs 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

The GSVTs should be used with the correct area type or FDOT context classification and facility type designations. It is important to select the appropriate values from the table. Adjustment factors must be applied, as appropriate. The GSVTs cannot be relied upon when approaching LOS E and LOS F thresholds, because of operational fluctuations at the thresholds. The GSVTs are not detailed enough for PD&E traffic analysis, final design or operational analysis work and should not be used for those purposes.

## 7.2 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-minute 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. 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 in urban areas if justified by traffic conditions.

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 obtains 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.

# **7.3 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 INTERSECTION offers SIDRA Standard, HCM 6, and HCM 2010 model options. 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 better driver familiarity. The Roundabout Capacity Model in HCM 7 is the same as the model in HCM 6. Therefore, the term "HCM 6 Roundabout Capacity Model" continues to be used.

## 7.4 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 the capability of performing traffic analysis and producing reports based on HCM 2000, HCM 2010, HCM 6th Edition, and HCM 7th Edition methodologies.

The Department's primary source for highway capacity and LOS analysis methodologies is the HCM. Analysis results from Synchro can be reported based on the Synchro methodology if the

HCM methodology is not supported. 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.**

Synchro does not have the 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 Vissim.

The analyst should be aware that Synchro does not accurately model oversaturated traffic conditions. Under such conditions, microsimulation tools such as 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 the 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 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.

### **7.4.1 Inputs for Synchro/SimTraffic**

Basic inputs for Synchro are identified in **Table 4-1** in **Chapter 4**. 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 the 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 7.2**.

## Signal Timing

Signal timing plans including offsets, cycle lengths, interconnection and phasing plans 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.

### 7.4.2 Calibration of Synchro/SimTraffic

The following guidelines are provided for the 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.
- ▶ 95<sup>th</sup> 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.

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 8**.

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 7-1**. 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 Vissim. Therefore, SimTraffic should mainly be used as an error-checking/validation tool for Synchro on arterial and intersection analysis and for gathering additional networkwide MOEs in simple arterial network.

**Table 7-1** Guidance for Calibrating SimTraffic Model

| Traffic Flow Issues in the Model                                | SimTraffic Calibration Parameters                      |                    |               |                |                                                                         |                               |            |                               |                              |
|-----------------------------------------------------------------|--------------------------------------------------------|--------------------|---------------|----------------|-------------------------------------------------------------------------|-------------------------------|------------|-------------------------------|------------------------------|
|                                                                 | Link-Based Parameters<br>(Synchro Simulation Settings) |                    |               |                | Global Parameters - Model<br>(SimTraffic Drivers and Internal Settings) |                               |            |                               |                              |
|                                                                 | Lane Alignment                                         | Mand. & Pos. Dist. | 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 are too slow when making a left or right turn          |                                                        |                    | 1             |                |                                                                         |                               |            |                               |                              |
| Queuing seems too short/long (assuming no upstream bottlenecks) | 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 8

# 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 the form of text reports and visual animations.

This chapter provides guidance on 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 Vissim models. This guidance is not applicable to multimodal alternative analysis studies.

Additional guidance is provided in **Chapter 9** for microsimulation analysis of express lanes. Guidance for SimTraffic simulation is provided along with Synchro guidance in **Chapter 7** 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.

- **8.1 Base Model Development**
- 
- **8.2 Model Verification/Error Checking**
- 
- **8.3 Model Calibration and Validation**
- 
- **8.4 Correcting Effects of Unmet Demand in the Models**
- 
- **8.5 Future Year Model Verification**
- 
- **8.6 Calibration and Validation Report**
- 
- **8.7 Model Calibration Reviewer's Checklist**
- 
- **8.8 Traffic Analysis using Microsimulation Models**
- 
- **8.9 Animation**
- 
- **8.10 Model Manual**

## 8.1 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 Vissim are provided in this section.

### 8.1.1 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. On-ramp DSD elements should be placed far enough upstream for adequate acceleration distance (such as the start of the on-ramp).
- 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 99 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. The link with the auxiliary lane should extend to the end of the on-ramp taper or start at the beginning of the auxiliary lane taper for off-ramps. 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 values ranging from 1,000 to 2,500 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 74 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 the 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 8-1** below to streamline coding and model review process. Additional default input values are provided in **Table 8-7**.

**Table 8-1** Guidance to Vissim Model Development

| Item                               | Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Simulation parameters</b>       | <ul style="list-style-type: none"> <li>» Set simulation period to be equal to the approved temporal limit of analysis plus a warm-up time.</li> <li>» The warmup time should be at least equal to twice the time it takes for a vehicle to fully traverse the network.</li> <li>» 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.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Desired speed</b>               | <ul style="list-style-type: none"> <li>» 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 <b>Section 8.1.1</b></li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Route decision and O-D data</b> | <ul style="list-style-type: none"> <li>» 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.</li> <li>» 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.</li> <li>» For closely spaced intersections, combine Routes tool should be used to combine static routes.</li> <li>» Vehicle routes should be coded in 15-minute or hourly demand increments.</li> <li>» Dynamic traffic assignment is preferred on large networks or when actual route behavior is of interest to solve the problem.</li> <li>» Routing decision must be reviewed to verify correct route paths have been defined accurately in the network.</li> </ul> |

| Item                                  | Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Traffic demand</b>                 | <ul style="list-style-type: none"> <li>» Input balanced demand (15-minute) volumes including traffic composition for all links entering the network.</li> <li>» Default vehicles in the North American Default.inpx should be used instead of Vissim standard default.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Traffic control and management</b> | <ul style="list-style-type: none"> <li>» 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.</li> <li>» 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.</li> <li>» 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.</li> <li>» Code signal heads, stop bars and detectors at proper locations.</li> <li>» In consultation with traffic operations and signal system engineers, exercise caution in changing the parameters.</li> </ul> |
| <b>Assumptions</b>                    | <ul style="list-style-type: none"> <li>» Document all assumptions made during network coding to streamline the review process.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

### 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 the 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.

## 8.2 Model Verification/Error Checking

Before proceeding to calibration, the base model must 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. 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.**

### 8.2.1 Base Model Verification Checklist

Checklist for verifying the accuracy of the base model coded using Vissim is provided as **Table 8-2**.

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 8-2** Vissim Model Verification (Error Checking) Process Checklist

| Project Name: _____                           |                                                                                                                                                                                                                                      |                          |
|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| State Road Number: _____ Co./Sec./Sub.: _____ |                                                                                                                                                                                                                                      |                          |
| Error Type                                    | Description                                                                                                                                                                                                                          | Check                    |
| <b>Software</b>                               | » Verify no runtime or syntax error occurs in the Protocol Window                                                                                                                                                                    | <input type="checkbox"/> |
|                                               | » Review the error file (.err) for any errors or runtime warnings that affect simulation results                                                                                                                                     | <input type="checkbox"/> |
|                                               | » Review RBC errors or warnings                                                                                                                                                                                                      | <input type="checkbox"/> |
| <b>Model run parameters</b>                   | » Review temporal boundary limit to confirm it matches the approved methodology                                                                                                                                                      | <input type="checkbox"/> |
|                                               | » Verify initialization period is at least equal to twice the time to travel the entire network                                                                                                                                      | <input type="checkbox"/> |
| <b>Network</b>                                | » Verify spatial boundary limit against approved methodology                                                                                                                                                                         | <input type="checkbox"/> |
|                                               | » Check basic network connectivity.                                                                                                                                                                                                  | <input type="checkbox"/> |
|                                               | » Verify the background image has been properly scaled                                                                                                                                                                               | <input type="checkbox"/> |
|                                               | » Verify link geometry matches lane schematics                                                                                                                                                                                       | <input type="checkbox"/> |
|                                               | » Check link types for appropriate behavior parameters                                                                                                                                                                               | <input type="checkbox"/> |
|                                               | » Check for prohibited turns, lane closures and lane restrictions at intersections and on links                                                                                                                                      | <input type="checkbox"/> |
|                                               | » Check and verify traffic characteristics on special use lanes against general use lanes                                                                                                                                            | <input type="checkbox"/> |
|                                               | » 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                                                              | <input type="checkbox"/> |
| <b>Demand and routing</b>                     | » Verify coded volume and vehicle mix/traffic composition                                                                                                                                                                            | <input type="checkbox"/> |
|                                               | » Check HOV vehicle type and occupancy distribution as appropriate                                                                                                                                                                   | <input type="checkbox"/> |
|                                               | » Check routing decision including lane change distances                                                                                                                                                                             | <input type="checkbox"/> |
|                                               | » Verify O-D matrices and their placement in the network                                                                                                                                                                             | <input type="checkbox"/> |
| <b>Control</b>                                | » 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 | <input type="checkbox"/> |
|                                               | » Check ramp meter control type and data                                                                                                                                                                                             | <input type="checkbox"/> |
|                                               | » Check conflict area settings                                                                                                                                                                                                       | <input type="checkbox"/> |
| <b>Traffic operations and management data</b> | » Verify bus operations—routes, dwell time                                                                                                                                                                                           | <input type="checkbox"/> |
|                                               | » Check parking operations                                                                                                                                                                                                           | <input type="checkbox"/> |
|                                               | » Verify transit operations behave as expected and do not deviate from expected operation lanes                                                                                                                                      | <input type="checkbox"/> |
|                                               | » Verify pedestrian operations and delays                                                                                                                                                                                            | <input type="checkbox"/> |
| <b>Driver and vehicle characteristics</b>     | » Check if driver behavior adjustments are necessary in saturated conditions                                                                                                                                                         | <input type="checkbox"/> |
|                                               | » Verify no lane changes occur in unrealistic locations and vehicles make necessary lane changes upstream in appropriate location                                                                                                    | <input type="checkbox"/> |
|                                               | » Verify average travel speed reasonably match field conditions                                                                                                                                                                      | <input type="checkbox"/> |
| <b>Animation</b>                              | » Review network animation with the model run at low demand levels— check for unrealistic operational characteristics such as congestion and erratic vehicle behaviors                                                               | <input type="checkbox"/> |
|                                               | » Review reasonableness of the model against data coding, route assignment and lane utilization                                                                                                                                      | <input type="checkbox"/> |
|                                               | » Compare model animation to field characteristics                                                                                                                                                                                   | <input type="checkbox"/> |
|                                               | » Verify all turn bays are fully utilized, and they are not blocked by through vehicles                                                                                                                                              | <input type="checkbox"/> |
|                                               | » Verify there are no vehicles turning at inappropriate time or locations                                                                                                                                                            | <input type="checkbox"/> |
|                                               | » Verify vehicles respond appropriately to all modeled traffic controls                                                                                                                                                              | <input type="checkbox"/> |

## 8.3 Model Calibration and Verification

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 matches 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). 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. Only under very rare conditions will the model be able to replicate the existing conditions using default values. As such, calibration of these parameters is essential to replicate reality to a high degree of confidence.



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

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

### 8.3.1 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.

### 8.3.2 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.

### 8.3.3 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.

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:

- **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.
- **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.
- **System performance calibration** – this involves fine tuning the model parameters to enhance the overall model performance with respect to speed, travel times and queues.

### 8.3.4 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:

**Equation 8-1**

$$n = \left( \frac{s * t_{a/2}}{\mu * \epsilon} \right)^2$$

Where,

$n$  = The required number of simulation runs.

$s$  = The standard deviation of the system performance measure based on previously conducted simulation runs.

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

$\mu$  = The mean of the system performance measure.

$\varepsilon$  = The tolerable error, specified as a fraction of  $\mu$ . A 10% error is desired.

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.

### 8.3.5 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 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 8-3** 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 8-3** Classical Model Calibration Targets

| Calibration Item                          | Calibration Target/Goal                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Capacity</b>                           | » Simulated capacity to be within 10% of the field measurements.                                                                                                                                                                                                                                                                                                    |
| <b>Traffic Volume</b>                     | » Simulated and measured link volumes for more than 85% of links to be: <ul style="list-style-type: none"> <li>• Within 100 vph for volumes less than 700 vph</li> <li>• Within 15% for volumes between 700 vph and 2700 vph</li> <li>• Within 400 vph, for volumes greater than 2700 vph.</li> </ul>                                                               |
|                                           | » Simulated and measured link volumes for more than 85% of links to have a GEH* statistic value of five (5) or lower. <ul style="list-style-type: none"> <li>• GEH &lt; 5.0: Acceptable</li> <li>• 5 ≤ GEH ≤ 10: Caution: possible model error or bad data</li> <li>• GEH &gt; 10: Unacceptable</li> </ul>                                                          |
|                                           | » 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.                                                                                                                                                                                                                                                                                          |
| <b>Travel Time<br/>(includes Transit)</b> | » The travel time is applicable for routes over 1.5 miles in length, unless the use of shorter segment is logical. Short travel time segments should be combined to make one longer travel time segment.                                                                                                                                                            |
|                                           | » Simulated travel time within one (1) minute for routes with observed travel times less than seven (7) minutes for 85% of routes identified in the data collection plan.                                                                                                                                                                                           |
|                                           | » Simulated travel time within 15% for routes with observed travel times greater than seven (7) minutes for 85% of routes identified in the data collection plan.                                                                                                                                                                                                   |
| <b>Speed</b>                              | » Modeled average link speeds to be within 20% of field-measured speeds for links with observed speeds less than 50 mph on at least 85% of all network links.<br>» Modeled average link speeds to be within the 10 mph of field-measured speeds for links with observed speeds greater than 50 mph on at least 85% of all network links.                            |
| <b>Intersection Delay</b>                 | » Simulated and field-measured link delay times to be within 15% for more than 85% of cases.                                                                                                                                                                                                                                                                        |
| <b>Queue Length</b>                       | » The queue difference is within 50% of the observed queues if the observed queue is less than 300 feet. (Wisconsin standards)<br>» The queue difference is within 150 feet for observed queues between 300 and 750 feet.<br>» Difference between simulated and observed queue lengths to be within 20% if the observed queue is greater than or equal to 750 feet. |
| <b>Visualization</b>                      | » 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 8-4** presents an example of traffic volume calibration with demand and simulated volume comparison with Geoffrey E. Havers (GEH) statistic calculation.

**Table 8-4** Traffic Volume Calibration with Demand and Simulated Volume Comparison with GEH Statistic Calculation

| Segment |                                   |                          |                              |                      |                      |            | Calibration Targets |                              |                              |                               |
|---------|-----------------------------------|--------------------------|------------------------------|----------------------|----------------------|------------|---------------------|------------------------------|------------------------------|-------------------------------|
| No.     | Location                          | Input Volume<br>(Hourly) | Simulated Volume<br>(Hourly) | Difference<br>Volume | Difference<br>Abs. % | GEH Volume | GEH (<5)            | Flow < 700 vph<br>(±100 vph) | 700 < Flow < 2,700<br>(±15%) | Flow > 2700 vph<br>(±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          | Yes                 | -                            | -                            | Yes                           |
| 104     | I-95 Northbound                   | 8,846                    | 8,843                        | -3                   | 0.0%                 | 0          | Yes                 | -                            | -                            | Yes                           |
| 105     | I-95 Northbound                   | 8,846                    | 8,848                        | 2                    | 0.0%                 | 0          | Yes                 | -                            | -                            | Yes                           |
| 106     | I-95 Northbound                   | 8,846                    | 8,850                        | 4                    | 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          | 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<br>Volume | Total Simulated<br>Volume | Volume<br>Difference | Percent<br>Difference |
|-----------------------|---------------------------|----------------------|-----------------------|
| 1,041,149             | 1,039,892                 | -1,257               | -0.1%                 |

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

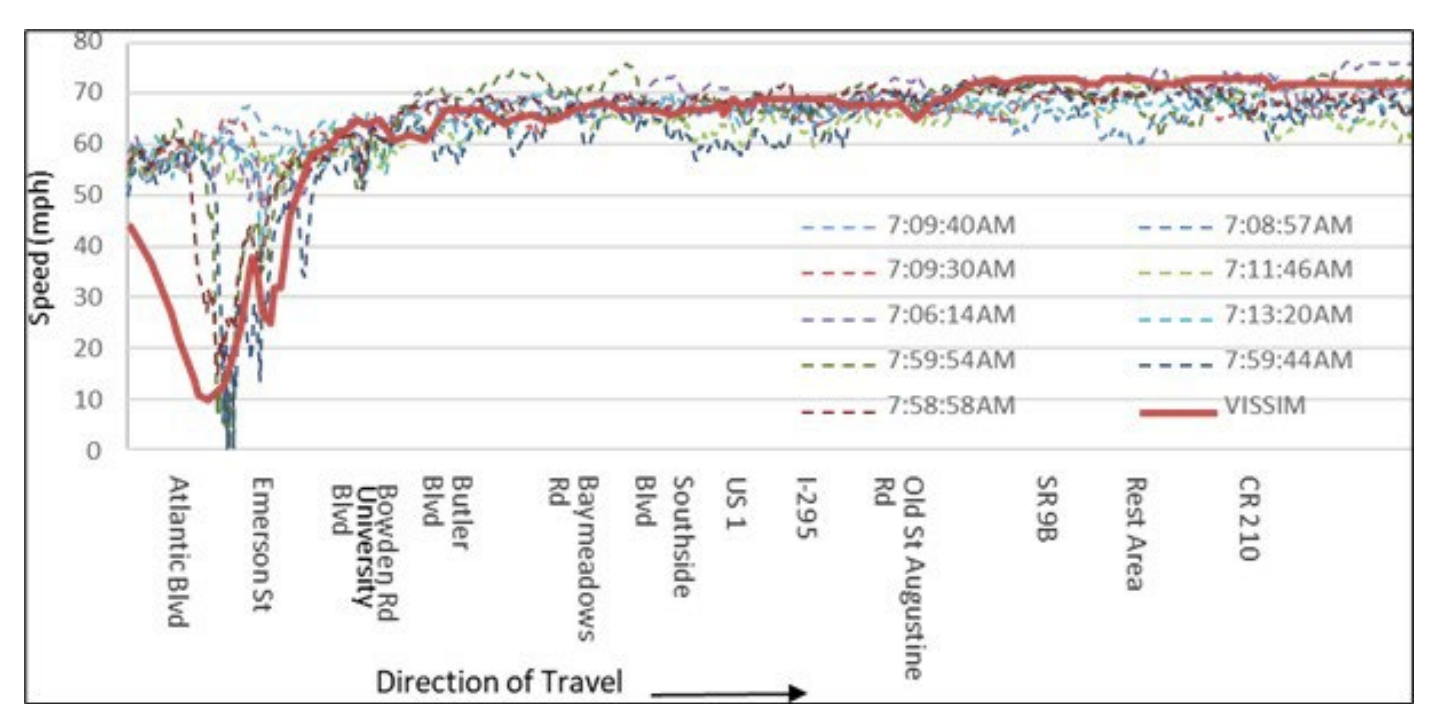
**Table 8-5** presents an example of comparisons for simulated travel time and observed travel times for different routes.

**Table 8-5** 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 8-1** 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 8-1** Speed Profile Showing Comparisons between the Simulated Speed and Field Measured Speed



**Table 8-6** presents an example of comparisons between the simulated speed and observed speed from Regional Integrated Transportation Information System (RITIS) in 15-minute intervals.

**Table 8-6** Comparisons between the Simulated Speed and Observed Speed from RITIS

| Zone | VISSIM ID | Location                        | Fifteen Minute Interval       |         |         |         | Peak Hour |
|------|-----------|---------------------------------|-------------------------------|---------|---------|---------|-----------|
|      |           |                                 | 7:30:00                       | 7:45:00 | 8:00:00 | 8:15:00 |           |
|      |           |                                 | AM - WB AVG Speeds - (VISSIM) |         |         |         |           |
| 4030 | 2000      | I-4 WB btw S.R. 434 & Lake Mary | 70.0                          | 70.0    | 70.4    | 70.2    | 70.1      |
| 4063 | 2020      | I-4 WB West of U.S. 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 S.R. 434 & Lake Mary | 67.3                          | 66.6    | 66.1    | 66.6    | 66.6      |
| 4063 | 2020      | I-4 WB West of U.S. 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 S.R. 434 & Lake Mary | -2.6                          | -3.4    | -4.3    | -3.7    | 3.5       |
| 4063 | 2020      | I-4 WB West of U.S. 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       |

### 8.3.6 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, reduced 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 8-7**. 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.

**Table 8-7** Vissim Model Calibration Parameters

| Calibration Parameter                     | Default Value                                                     | Suggested Range                                                                                       |                           |
|-------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|---------------------------|
|                                           |                                                                   | Basic Segment                                                                                         | Weaving/Merge/<br>Diverge |
| Freeway Car Following (Wiedemann 99)      |                                                                   |                                                                                                       |                           |
| CC0 Standstill distance                   | 4.92 ft                                                           | >4.00 ft                                                                                              | >4.92 ft                  |
| CC1 Gap time distribution                 | 0.9 s                                                             | 0.70 to 3.00 s                                                                                        | 0.9 to 3.0 s              |
| CC2 'Following' Distance oscillation      | 13.12 ft                                                          | 6.56 to 22.97 ft                                                                                      | 13.12 to 39.37 ft         |
| CC3 Threshold for entering 'following'    | -8                                                                | Use default                                                                                           |                           |
| CC4 Negative - speed difference           | -0.35                                                             | Use default                                                                                           |                           |
| CC5 Positive speed difference             | 0.35                                                              | Use default                                                                                           |                           |
| CC6 Speed Dependency of oscillation       | 11.44                                                             | Use default                                                                                           |                           |
| CC7 Oscillation acceleration              | 0.82 ft/s <sup>2</sup>                                            | Use default                                                                                           |                           |
| CC8 Standstill acceleration               | 11.48 ft/s <sup>2</sup>                                           | Use default                                                                                           |                           |
| CC9 Acceleration at 50 mph                | 4.92 ft/s <sup>2</sup>                                            | 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 <sup>i</sup>                                                                                 |                           |
| Multiplicative part of safety distance    | 3.00                                                              | 2.00 to 4.500 <sup>i</sup>                                                                            |                           |
| Lane Change                               |                                                                   |                                                                                                       |                           |
| Maximum deceleration                      | -13.12 ft/s <sup>2</sup> (Own)<br>-9.84 ft/s <sup>2</sup> (Trail) | -15 to -12 ft/s <sup>2</sup><br>-12 to -8 ft/s <sup>2</sup>                                           |                           |
| -1 ft/s <sup>2</sup> per distance         | 200 ft (Freeway)<br>100 ft (Arterial)                             | >100 ft<br>>50 ft                                                                                     |                           |
| Accepted deceleration                     | -3.28 ft/s <sup>2</sup> (Own)<br>-1.64 ft/s <sup>2</sup> (Trail)  | -2.5 to -4 ft/s <sup>2</sup><br>-1.5 to -2.5 ft/s <sup>2</sup>                                        |                           |
| Waiting time before diffusion             | 60 s                                                              | Should not be decreased from a default of 60 seconds but can be increased based on field observations |                           |
| Min. clearance (front/rear)               | 1.64 ft                                                           | 1.5 to 6 ft                                                                                           |                           |
| To slower lane if collision time is above | 11 s                                                              | Use default                                                                                           |                           |
| Safety distance reduction factor          | 0.6                                                               | 0.1 to 0.9                                                                                            |                           |
| Max. dec. for cooperative braking         | -9.84 ft/s <sup>2</sup>                                           | -32.2 to -3 ft/s <sup>2</sup>                                                                         |                           |
| Overtake Reduced speed areas              | Unchecked                                                         | Depends on field observations                                                                         |                           |
| Advanced Merging                          | Checked                                                           | Checked                                                                                               |                           |
| Vehicle routing decisions look ahead      | Checked                                                           |                                                                                                       |                           |
| Zipper merging <sup>ii</sup>              | Checked                                                           | Use default                                                                                           |                           |
| Minimum speed                             | 12.43 mph or depends on field observation                         |                                                                                                       |                           |
| Overtaking time distribution              | 2-4 s or depends on field observation                             |                                                                                                       |                           |
| Cooperative lane change                   | Unchecked                                                         | Checked especially for freeway merge/diverge areas                                                    |                           |

| Calibration Parameter                                   | Default Value                             | Suggested Range                                                                                                                                                                                  |                           |
|---------------------------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
|                                                         |                                           | Basic Segment                                                                                                                                                                                    | Weaving/Merge/<br>Diverge |
| Maximum speed difference                                | 6.71 mph or depends on field observations |                                                                                                                                                                                                  |                           |
| Maximum collision time                                  | 10.0 s or depends on field observations   |                                                                                                                                                                                                  |                           |
| 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 |                           |
| Signal Control                                          |                                           |                                                                                                                                                                                                  |                           |
| Reaction after end of green<br>Behavior at amber signal | Continuous check                          |                                                                                                                                                                                                  |                           |
| Reduced safety distance close to a stop<br>line Factor  | 0.60                                      | Higher value reduces the safety distance<br>between vehicles close to the signal stop bar                                                                                                        |                           |
| Start upstream of stop line (ft)                        | 328.08                                    | 328.08 or depends on field observations                                                                                                                                                          |                           |
| End downstream of stop line (ft)                        | 328.08                                    | 328.08 or depends on field observations                                                                                                                                                          |                           |

<sup>i</sup> The relationship should be based on the User Manual i.e., Multiplicative = Additive+1

<sup>ii</sup> zipper merging is used in VISSIM 2024 or later.

### 8.3.7 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.
- ▶ 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 suggests 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.

## 8.4 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. The 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 the 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 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 the 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 Vissim on 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 lengths that extend beyond network boundaries as discussed above.

## 8.5 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.

## 8.6 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.

Both calibrated and validated model results should be tabulated or graphed and compared with the field-measured data for each calibration period. 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 the 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:

### **1** *Introduction*

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

### **2** *Data Collection*

This section contains a summary of the existing data that is used to generate microsimulation

models. 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.

### **3 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, a summary of the comparison of animation and real world traffic conditions is presented.
- Specific assumptions made to the model development.

### **4 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.

### **5 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/MOE 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 8-4** to **Table 8-6**) and figure (**Figure 8-1**) provided in **Section 8.3.5**.

- Validation results of the calibration model using an independent data set (data that was not used for calibration).

## **6 Summary or Conclusions**

This section contains a summary of the calibration report.

## **8.7 Model Calibration Reviewer's Checklist**

**Table 8-8** 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.

## **8.8 Special Studies Using Microsimulation Models**

### **Maintenance of Traffic (MOT) Analysis**

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 purposes. 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.

### **Special Configuration**

For special roadway configurations, such as lane merge along arterials, managed lanes, flex/dynamic lanes, toll lanes, Center Turn Overpass (CTO), traffic simulation may be used as analysis tools are not available.

### **Lane Repurposing**

According to the Corridor Capacity Policy ([Topic No. 000-525-075](#)), the required analysis for lane repurposing projects must consider both congestion and safety impacts of the proposed improvements on the subject facility and the surrounding transportation network. If appropriate, microsimulation can be used for Type 1 corridor level analysis for instances where HCM level analysis will have limitations. If the project is in an area with oversaturated conditions microsimulation may be required for a Type 1 analysis. Coordination with the FDOT Systems Implementation Office (SIO) is required to determine the Area of Influence (AOI) and other analysis requirements. When network impacts are anticipated, a Type 2 network level analysis will be conducted. The operational effect of traffic diversion in the analysis AOI can be evaluated by using either a static assignment from the travel demand model's trip table imported into a microsimulation model or a Dynamic Traffic Assignment (DTA) tool within the microsimulation model. When a project involves removal of a travel lane for transit infrastructure to provide new transit service or connect to other modes, a Type 3 Transit Analysis is performed. Transit projects are required to conduct a network-level microscopic simulation or mesoscopic simulation analysis unless a Type 1 analysis was agreed upon in the approved methodology. Refer to the [FDOT Lane Repurposing Guidebook](#) as a resource to develop lane repurposing projects.

**Table 8-8** 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                    |
| <b>Model errors</b>                                             | » Simulation model contains no errors                                                                                               | <input type="checkbox"/> |
|                                                                 | » Simulation model was accurately verified                                                                                          | <input type="checkbox"/> |
| <b>MOEs</b>                                                     | » All calibration MOEs are listed                                                                                                   | <input type="checkbox"/> |
|                                                                 | » Calibration targets/goals have been outlined                                                                                      | <input type="checkbox"/> |
|                                                                 | » Calibration and validation data is sufficient to meet the targets                                                                 | <input type="checkbox"/> |
|                                                                 | » Bottlenecks and areas of congestion are clearly identified                                                                        | <input type="checkbox"/> |
| <b>Calibration process</b>                                      | » Calibration process is documented with all relevant calibration data, assumptions and include a history of base model development | <input type="checkbox"/> |
|                                                                 | » Calibration effort cover both AM and PM peak periods                                                                              | <input type="checkbox"/> |
|                                                                 | » Sufficient length of the simulation and warm up period is covered                                                                 | <input type="checkbox"/> |
|                                                                 | » Default calibration parameters were changed and documented for freeway                                                            | <input type="checkbox"/> |
|                                                                 | » Default calibration parameters were changed and documented for arterial                                                           | <input type="checkbox"/> |
|                                                                 | » Model animation matches expected driver behavior and conditions observed in the field                                             | <input type="checkbox"/> |
|                                                                 | » Model replicates real world bottleneck(s) and lane utilization                                                                    | <input type="checkbox"/> |
| <b>Calibration targets</b>                                      | » Calibration results are based on at least 10 simulation runs with different random seeds                                          | <input type="checkbox"/> |
|                                                                 | » Model output volumes satisfy volume calibration requirements                                                                      | <input type="checkbox"/> |
|                                                                 | » Model link capacities satisfy capacity calibration requirements                                                                   | <input type="checkbox"/> |
|                                                                 | » Model link speeds meet speed calibration requirements                                                                             | <input type="checkbox"/> |
|                                                                 | » Model link travel time meet calibration requirements                                                                              | <input type="checkbox"/> |
|                                                                 | » Model intersection delay results meet calibration requirements                                                                    | <input type="checkbox"/> |
|                                                                 | » Model queuing replicates real world conditions                                                                                    | <input type="checkbox"/> |
|                                                                 | » Two (2) calibration targets outside the volume and capacity are met                                                               | <input type="checkbox"/> |
| <b>Calibration documentation</b>                                | » Speed profile plots depicting field speed/ travel time and simulated speed are provided                                           | <input type="checkbox"/> |
|                                                                 | » Tables depicting field speed/ travel time and simulated speed are provided                                                        | <input type="checkbox"/> |
|                                                                 | » Table documenting total latent demand and latent demand as a percentage of overall demand volume                                  | <input type="checkbox"/> |
|                                                                 | » Tables depicting demand volume and simulated volume comparison with GEH calculation is provided for the entire simulation period  | <input type="checkbox"/> |
| Comments:<br><br><br>Reviewer's Name: _____<br>Date: _____      |                                                                                                                                     |                          |

## 8.9 Animation

One 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 audiences 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 each 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 may be presented in the form of screen shots of the animation system with supporting description of the animation.

## 8.10 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 below:

## **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 delays. 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 for each future year model analyzed. This section may be divided into subsections covering input data and output data for each analyzed alternative.

## Chapter 9

# Express Lanes Analysis

### 9.1 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 separation and access control, vehicle eligibility, and 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 maximizes throughput on these key facilities through managed lane vehicle eligibility standards, transit, access control, pricing, and other applicable techniques. Managed lanes should not be implemented on existing general use lanes for limited access facilities.

Figure 9-1 illustrates the different lane management strategies that fall into this broad definition of managed lanes. Traffic Management Technology, 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.

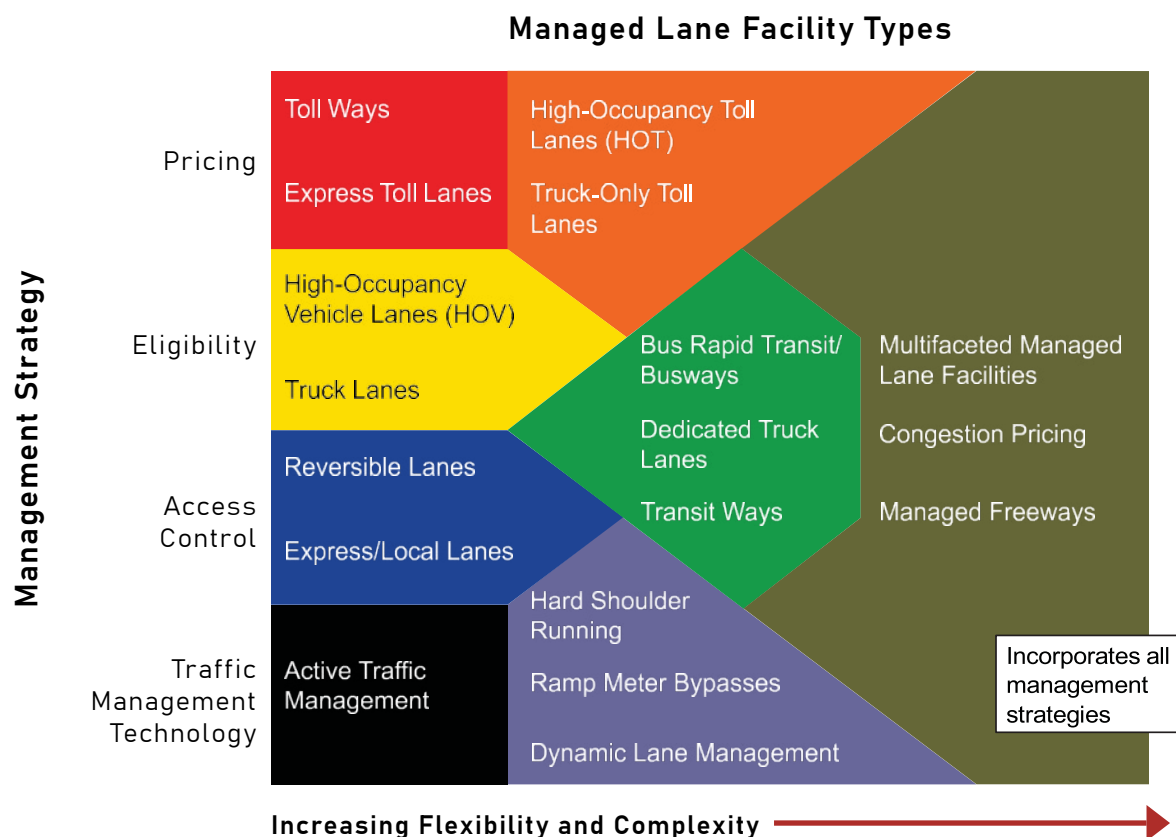


**If the managed lanes do not incorporate tolling, then this chapter is not applicable.**

#### 9.1.1 What is an Express Lane?

Express lanes are a type of managed lanes where congestion is managed with vehicle eligibility, separation and access control, and tolling. Express lanes are implemented on non-Turnpike

**Figure 9-1** Managed Lane Strategies and Complexity



**Source:** [NCHRP Research Report 835: Guidelines for Implementing Managed Lanes](#)

facilities to address existing and future congestion, enhance transit services, accommodate future regional growth and development, and improve system connectivity between key limited access facilities. Express lanes are separated from General Use Lanes (GUL) and provide optional travel lanes for two-axle vehicles (such as passenger cars) equipped with a transponder. In addition to vehicle eligibility, express lanes also use access control and tolling. Access is controlled using limited entrance and exit points that usually serve longer, regional trips. Tolling refers to static, Time of Day (TOD), or dynamic tolls during times with high demand such as peak travel periods. Tolling is utilized to maintain and promote free flow speed.



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

## 9.2 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 limited access highways.

The guidelines contained in this chapter are intended only for the implementation of express lanes on freeways or limited 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 8** of this handbook for the microsimulation model calibration and validation process. The following items are covered in this chapter:

● **9.3 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.

● **9.4 Data Collection**

Primary and secondary data sources and types of data.

● **9.5 Travel Demand Forecasting**

Methodologies and selection criteria for forecasting traffic for express lanes projects and an initial traffic assignment.

● **9.6 Traffic Assignment Methods**

Static and dynamic assignment methods for express lanes.

● **9.7 Express Lanes Modeling**

Criteria, guidelines and computational procedures for different methods of modeling express lanes using microsimulation, including final operational assessment.

● **9.8 Complex Weave**

Analysis methodology.

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

- ▶ [2023 FDOT Managed Lanes Guidebook](#)
- ▶ [2024 FDOT Project Traffic Forecasting Handbook](#)
- ▶ [Priced Managed Lane Guide](#), prepared by the FHWA
- ▶ [Managed Lanes: A Primer](#), prepared by FHWA

- ▶ [An Application of Microscopic Dynamic Lane Choice Assignment for Express Lanes](#), prepared by Florida Turnpike Enterprise (FTE)
- ▶ PTV Vissim User Manual
- ▶ PTV VISUM User Manual
- ▶ Vissim Managed Lanes Facilities Module User Guideline

## 9.3 Project Scope

Long-distance trips are one 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.

### 9.3.1 Area of Influence (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.**

#### 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.

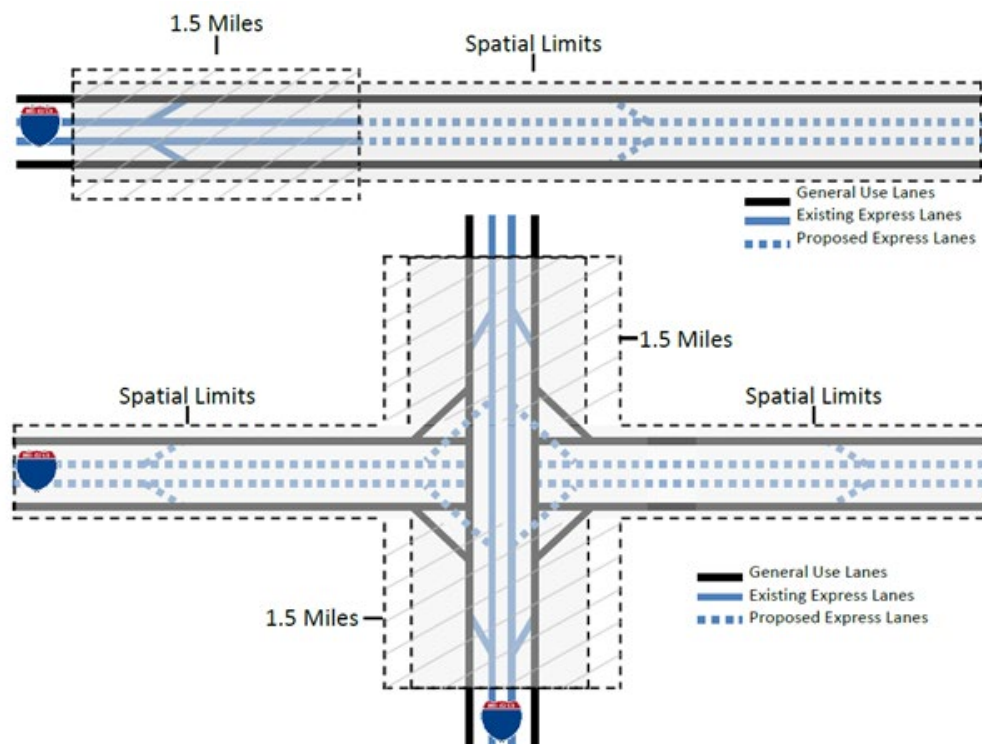
#### Expansion of Existing Express Lanes System

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 where the 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 9-2**.

**Figure 9-2** 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.

### 9.3.2 Determination of Temporal Boundary

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

#### 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.**

### **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.

## **9.4 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 in accordance with

the project requirements. The data collection plan should be developed per the 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.

### 9.4.1 Primary Data Types/Sources

#### 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 the 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.

## **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.), can be used to identify O-D patterns and develop trip matrices, along with travel time 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. The data can be extracted for different times of the year and by vehicle type. This method is suitable for applications in planning, PD&E and design projects.

### ► **Other Methods**

Trip tables from travel demand models 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.

## 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 bottleneck 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 Regional Integrated Transportation Information System (RITIS) is situational awareness, data archiving, and analytics platform 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 can be used to analyze express lanes in planning, PD&E and design projects.**

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.

### ► **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 an 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.

### **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 outlined above are necessary for analyzing express lanes in planning, PD&E, and design projects, and should be collected from primary sources. These data enable analysts to assess current conditions within the study area, serve as a foundation for calibrating microsimulation

models, and facilitate comparisons between existing and proposed operational outputs. The method used to gather this data may be selected by the analyst based on the project's objectives and the characteristics of the study area. Coordination with FDOT is required to obtain approval before conducting 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.**

### **9.4.2 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.**

#### **► Google Speed and Congestion Data**

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.

#### **► Stated Preference Survey Methods**

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.

### 9.4.3 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 AOL.

- ▶ **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.

## 9.5 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 9** 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:

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

The first three (3) project traffic forecasting methods are covered in detail in **Chapter 9** of the [FDOT 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.

## 9.6 Traffic Assignment Methods

An initial traffic assignment is performed to input the total corridor 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 corridor demand that is expected to enter the microsimulation model network prior to assigning traffic using the express lanes.

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

### 9.6.1 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 9.7** 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 on the following page.

### ► **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 9.5**. 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.

### ► **Static Routes Created from ODME**

The static routes obtained by assigning demand created from synthetic matrix estimation methods (ODME) can represent several periods. This method of obtaining route flows 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 generates route flows that feed into the ODME process. The ODME process uses route flows from a seed matrix and returns an adjusted trip matrix that fits a set of target counts. Visum provides two ODME methods – TFlowFuzzy (entropy based) and Least squares. The Least squares method is further extended to a Dynamic ODME variant that produces adjusted trip matrices and flows for several time periods at once. Network flows must be assigned using one of Visum's built-in dynamic assignment methods – ex: SBA to perform Dynamic ODME. The route flows generated in Visum can be exported to a Vissim model based on either network IDs or a coordinate based export that matches the geometry of the Visum network to a target Vissim network.. The seed matrix for the ODME can be generated as a unit matrix combined with a filter based on a skim matrix to eliminate invalid OD pairs. More recently, trip index matrices based on data from vendors such as INRIX, StreetLight, Replica, have also been used to create an initial seed matrix for the ODME process.

## **9.6.2 Dynamic Traffic Assignment Using ODME**

The dynamic traffic assignment can also be performed using O-D matrices within Vissim or Visum. The simulation-based assignment (SBA) in Visum is well suited for multi-period simulation of larger scale networks and can produce a good starting solution for detailed microsimulation downstream or as a screening tool to arrive at the preferred alternatives considered for more detailed analysis. 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.

## **9.7 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.

### **9.7.1 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.

#### **9.7.1.1 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.

#### **9.7.1.2 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 hourly volume of traffic 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.

### 9.7.1.3 Manual Methods Based on Previous Studies

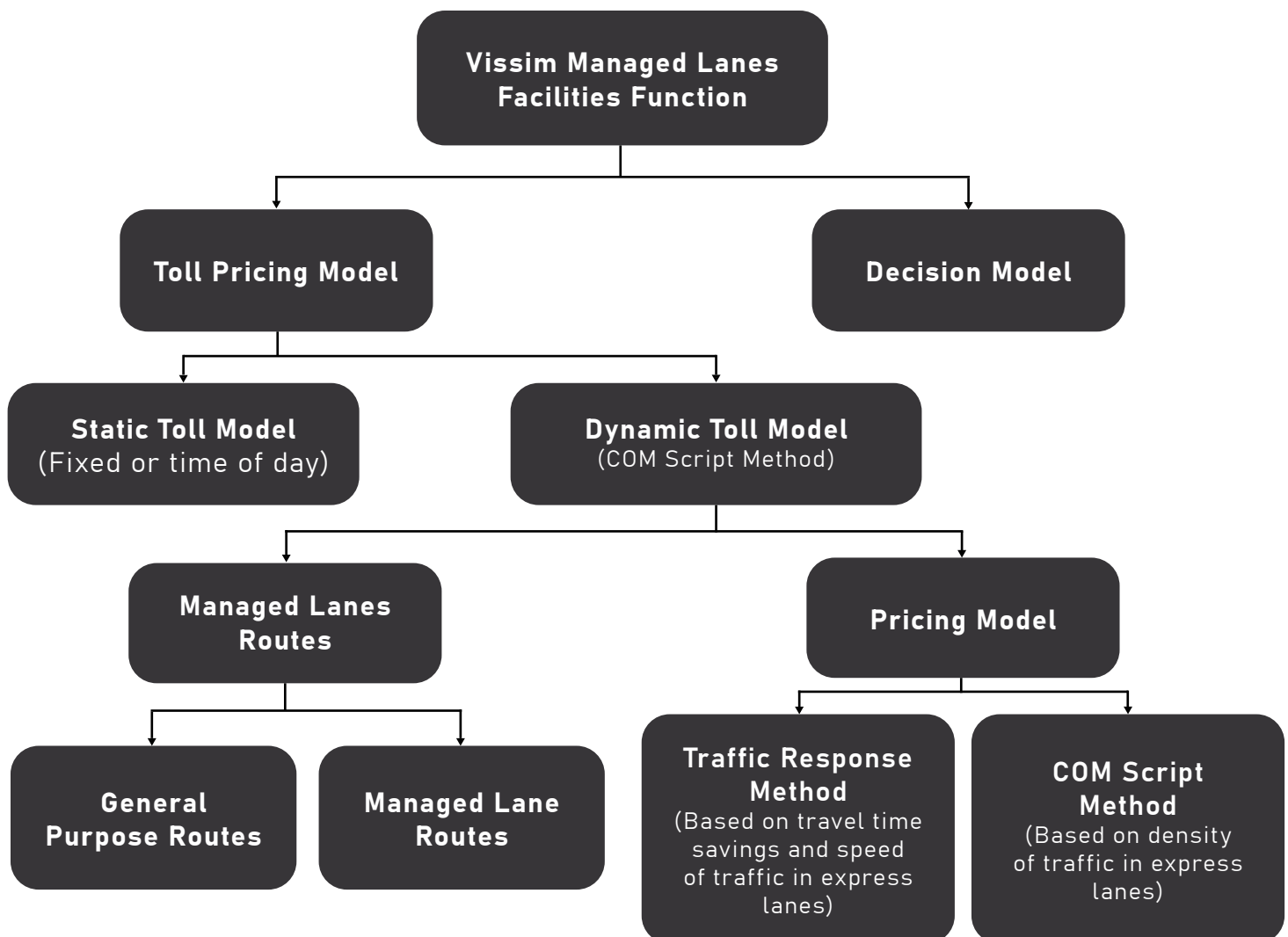
If a project with a small corridor or an interchange are extracted from a larger network for which traffic was already determined during the previous project's effort, the static volume assignment can be done utilizing the already approved express lanes volumes. This approach can be applied for planning,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

### 9.7.2 Dynamic Express Lanes 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 9-3** shows the flow diagram explaining the dynamic express lane assignment using the Vissim Managed Lanes Facilities function.

**Figure 9-3** 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.

### 9.7.2.1 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 9.3**.

### 9.7.2.2 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 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:

### ► The Traffic Responsive Method

The traffic responsive method should be used with caution, keeping in mind that it does not account for bespoke measures such as congestion thresholds in the express lanes by using density limits to ensure that the express lanes are operating at an acceptable level. Based on the model parameters 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.

### ► The COM Script Method

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 Traffic Density (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: FDOT District 6 Standard Operating Guidelines – 95 Express and [An Application of Microscopic Dynamic Lane Choice Assignment for Express Lanes](#)).

#### Step 1: Calculate $\Delta TD$

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

#### Step 1: Find $\Delta R$ based on $\Delta TD$ and $TD_t$

*Refer to Delta Settings Table  
(Table 9-3 or Table 9-4)*

#### Step 3: Calculate $R_t$

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

#### Step 4: Decide Final $R_t$

$R_t = \text{Max}$ , if  $R_t > \text{Max}$  (Table 9-1) or Table 9-2)  
 $R_t = \text{Min}$ , if  $R_t < \text{Min}$  (Table 9-1) or Table 9-2)  
 $R_t$ , otherwise

Where,

$R_t$  = Current Toll

$R_{t-1}$  = Previous Toll

$TD_t$  = Current TD

$TD_{t-1}$  = Previous TD

$\Delta TD$  = Change in TD

$\Delta R$  = Toll adjustment

$\text{Max}$  = Maximum Toll at an LOS

$\text{Min}$  = 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 9-1 and 9-2** show proposed default LOS and toll settings for interstate facilities for express lanes segments less than and greater than three (3) miles, respectively. **Tables 9-3 and 9-4** 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 the Enterprise. The most recent FDOT tolling policies should be investigated and discussed with FDOT in the beginning of the express lanes project.

**Table 9-1** 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 9-2** 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 9-3** Default Delta Density Settings for Interstate Facilities (Segment < 3 Miles)

[illegible]

**Table 9-4** Default Delta Density Settings for Interstate Facilities (Segment > 3 Miles)

[illegible]

### 9.7.2.3 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 9-1**:

#### Equation 9-1

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

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 9-2**:

#### Equation 9-2

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

Where,

a = alpha value and

$U_{Toll}$  = utility of managed lane

The decision model parameters in the above **Equations 9-1** and **9-2** 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 9-5** provides proposed ranges for decision model parameters for use in **Equations 9-1** and **9-2**.

**Table 9-5** 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 9-3    |
| Intercept/ Base utility     | -0.8 to 1.0     |

### Time Coefficient

The time coefficient can be obtained from **Equation 9-3**. 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 9-3

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

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 9-5**, the time coefficient using **Equation 9-3** 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 9-6** 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 9-6** Example of Probability Matrix

|                               |    | Toll  |       |       |       |       |       |       |       |       |       |        |
|-------------------------------|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
|                               |    | \$0.5 | \$1.0 | \$2.0 | \$3.0 | \$4.0 | \$5.0 | \$6.0 | \$7.0 | \$8.0 | \$9.0 | \$10.0 |
| Travel Time Savings (minutes) | 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%    |

### 9.7.3 Summary

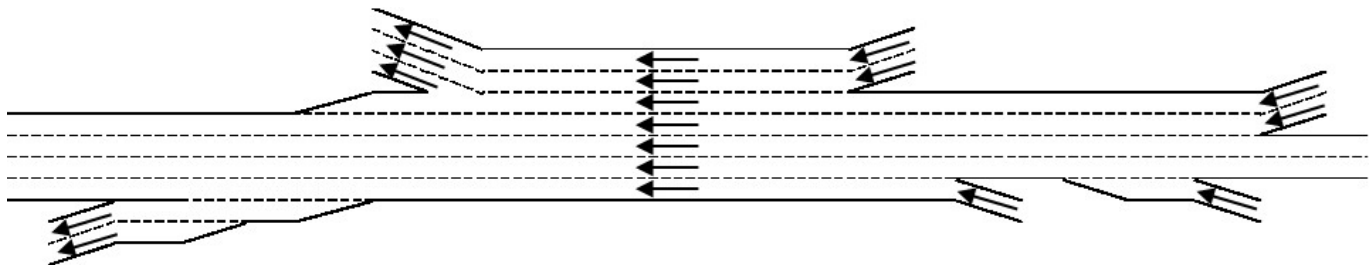
Static express lane assignment approach designates a predetermined traffic flow in express lanes, regardless of the congestion in general use lanes, and, therefore, there is no pricing model defined for this approach. The dynamic volume assignment method dynamically appoints traffic in express lanes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

**Table 9-7** summarizes express lane modeling with the pros, cons and applicability for each method.

## 9.8 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 9-4** shows an example of a complex weave segment.

**Figure 9-4** 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 diffused from the network. Each of these are described in subsequent sections. The MOEs for reporting complex weave analysis results are discussed in **Section 6.4** 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.

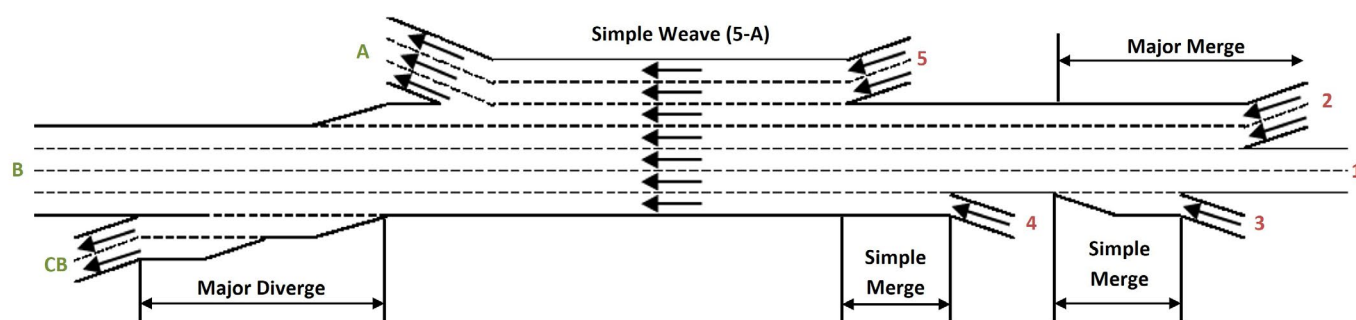
**Table 9-7** Express Lanes Traffic Modeling

| 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.                                                                                                                           | <ul style="list-style-type: none"> <li>» Peak period demand directly from TDM without needing to use another model</li> <li>» Easier to use for systemwide evaluation</li> </ul>                                                                                                                                                                                                  | <ul style="list-style-type: none"> <li>» Does not expressly consider queue accumulation and dissipation.</li> <li>» 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.</li> </ul> | Planning and PD&E projects. Not preferred for IARs    |
|                          | ELToD output                                                                                                                                      |                                                                                                                                                                        | <ul style="list-style-type: none"> <li>» Quick turnaround time for alternatives testing</li> <li>» Consistent results in controlled environment</li> <li>» Peak hour demand volume available</li> </ul>                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                        | 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 & design projects |
| Dynamic                  | TDM with or without built-in tolling algorithm, ELToD output                                                                                      | <ul style="list-style-type: none"> <li>» Pricing model can be static for the time of day or dynamic</li> <li>» Decision model parameters development needed</li> </ul> | <ul style="list-style-type: none"> <li>» Pricing model customized to match the statewide express lanes software tolling algorithm</li> <li>» Accounts for congestion build up and dissipation</li> <li>» Does not require manual assignment of express lanes traffic for all ingress/egress locations</li> <li>» Results may be more defensible than manual assignment</li> </ul> | <ul style="list-style-type: none"> <li>» Extensive time and effort</li> <li>» Requires customized scripting and other inputs using Vissim Managed Lanes Facilities functionality</li> <li>» Alternatives or ingress/egress testing can be cumbersome</li> </ul>                                        | PD&E and design projects. Preferred for IARs          |

### 9.8.1 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 9-5** provides a snapshot of segments identified for the individual elements analysis by segregating the complex weave segment.

**Figure 9-5** Individual Elements Analysis within Complex Weave Segment

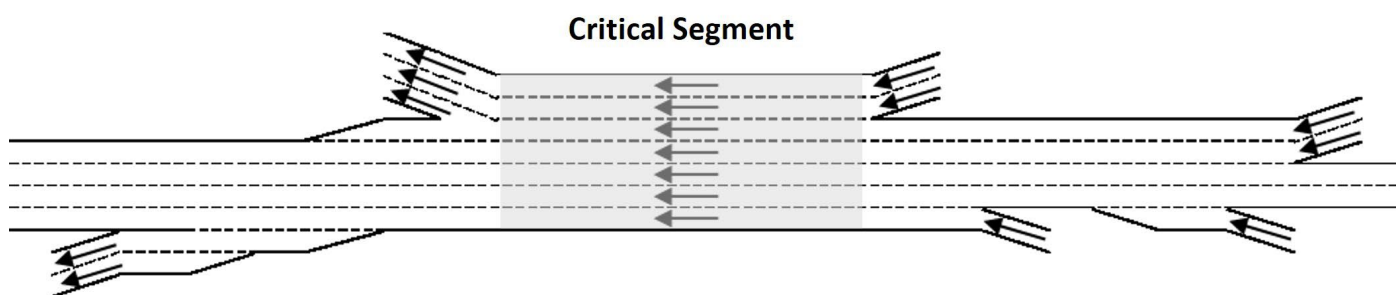


### 9.8.2 Method 2: V/C Ratio Using Vissim

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 9-6** shows an example of a critical segment within a complex weave segment.

**Figure 9-6** 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 9-4** for each complex weave segment within the project.

#### Equation 9-4

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

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, 7th 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.

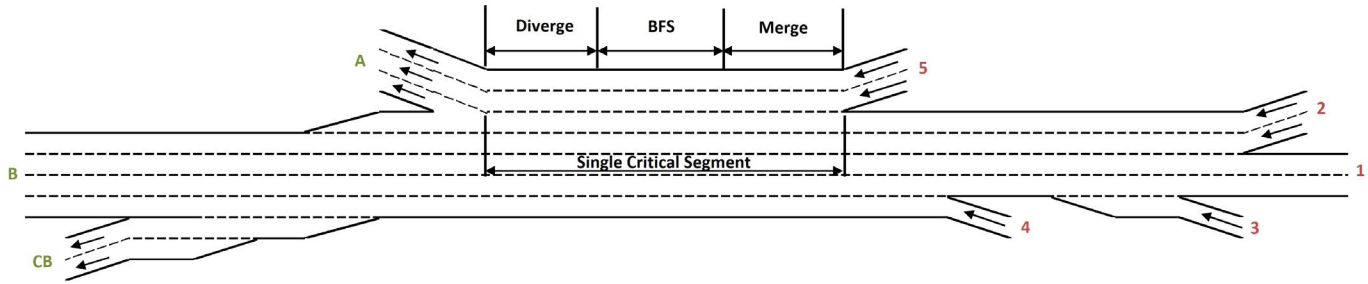
A critical weave segment with a V/C ratio greater than 1.0 should serve as a concern and an indication of potential issues for the complex weave segment operation. It is recommended to revisit these locations and investigate mitigation measures.

### 9.8.3 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 9-7**.

**Figure 9-7** Critical Segment Segregation



### 9.8.4 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.**

### 9.8.5 Vehicles Diffused

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 diffused from the network due to congestion or network coding issues are reported in the error (\*.err) file. It is recommended to use vehicles diffused 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 diffused within each

complex weave segment should be reported and compared between no-build (without express lanes) and build alternatives. The build alternative should not have more vehicles diffused than the no-build within the complex weave segment. In addition, the build alternative diffused 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 diffused vehicles should be less than ten (10) vph within the complex weave segment.**

## Chapter 10

# Traffic Analysis Documentation

Traffic analysis documentation consists of systematically describing the methodologies, results, findings, and recommendations from a traffic analysis study. The scope and detail of this documentation may vary, ranging from technical memorandums focusing on specific project aspects to comprehensive reports covering all phases of the analysis. This documentation serves to maintain clarity and consistency throughout the analytical process and facilitates efficient communication among project stakeholders, reviewers, and decision-makers. By thoroughly organizing and presenting each stage of the analysis, these reports foster transparency and provide a defensible basis for recommendations. The traffic reports should be prepared by transportation professionals who have knowledge and experience in the subject areas. This chapter provides guidelines for preparing traffic technical reports and details each of the following topics in subsequent sections.

- **10.1 Technical Memorandum**  
|
- **10.2 Traffic Analysis Report**  
|
- **10.3 Review of Traffic Analysis**

Traffic analysis documentation can be prepared in the form of a technical memorandum and/or a traffic analysis report. A technical memorandum focuses one or more components of the study. A traffic analysis report documents full spectrum of the study, including methodologies and assumptions, approach, data collection, and alternative analysis in detail. The final report format depends on factors such as the reviewing agency's guidelines and requirements, the size and complexity of the project, and final deliverables as specified in the scope of work. One way to structure the final report is to compile and combine all technical memorandums prepared during the study process if the technical memorandums are accepted and/or approved, and no changes are made afterwards. In many cases, the final traffic analysis report is a standalone document that includes all necessary elements.

## 10.1 Technical Memorandum

A Technical Memorandum (TM) is an interim report that addresses specific technical issues at each major phase of the traffic analysis process. It provides background information, analytical methodologies, key findings, and next steps relevant to that phase of the study. Each subsequent phase of the technical analysis builds upon the data and conclusions outlined in preceding memorandums. Technical Memorandums enable the reviewing agency to evaluate study outcomes prior to the completion of analysis and preparation of the final report. The quantity and scope of technical memorandums are based on the nature and complexity of the study and should be established during the scoping phase in consultation with the reviewing agency. The reviewing agency must review and concur with the content of the technical memorandums before the analyst advances to preparing the final report.

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

### ► **Methodology and Assumptions**

This memorandum outlines the methodologies and assumptions to be applied in evaluating the existing conditions, the future no-build conditions, and the proposed alternatives for any project traffic development and operational analyses. In general, the range of analysis methodologies and proposed tools from identifying traffic count locations through microsimulation, as well as safety and multimodal analyses should be included.

### ► **Existing Conditions**

This memorandum presents an inventory of geometric, traffic control, and operating characteristics of the transportation facility studied. It identifies deficiencies in terms of mobility, safety, accessibility, reliability, and system connectivity in the current conditions that will shape the development of future alternatives. This is an important document that establishes the connection between purpose and needs of a project and the proposed improvements. Its contents typically include field observations, data collection from various sources, and results of existing data analysis.

### ► **Model Calibration and Validation**

This memorandum provides documentation of the calibration and validation process and resulting changes made to the base model. The report should provide justification for any changes in 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 8**.

### ► **Project Traffic Forecasting**

This memorandum presents the traffic forecasting process and documentation procedures, assumptions and results. Its contents include TDM description, input data, alternatives and demand forecasts for each analyzed alternative. The memorandum 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 upon by all parties before the analyst proceed with analyzing the alternatives. Users are advised to follow the latest guidelines in the [FDOT Project Traffic Forecasting Handbook](#) when preparing the technical memorandum.

## ► Alternative Analysis

This memorandum presents the results of detailed analysis of all alternatives, including no-build, Transportation Systems Management and Operations (TSM&O), and selected number of alternatives. It is important to note the no-build or TSM&O might be a viable alternative, and in some cases, it is the preferred alternative. The future alternative analysis compares build alternatives with each other and the future no-build. The memorandum typically includes MOEs such as volume-to-capacity ratios, level-of-service, delays, queue lengths, crashes, multimodal analysis, and other operational performance measures. It also includes a set of appendices that provide supporting evidence to the results summarized in the main text.

## 10.2 Traffic Analysis Report

The Traffic Analysis Report describes the assumptions, methodologies, model development, traffic projections, results of the project's traffic analysis, conclusions and recommendations. It provides a comprehensive summary of data collection activities, input variables, analytical tools, current conditions, the development process for future traffic forecasts, as well as operational and safety evaluations for alternative project scenarios. The size of the report is determined by factors such as the geographic scope, the types of analyses performed, and the variety and complexity of improvement alternatives evaluated. 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.

The guidelines outlined in this chapter are intended for general traffic studies. Certain types of studies within the state may have additional requirements. For instance, a Project Traffic Analysis Report (PTAR) is necessary for a PD&E study, and should utilize the Technical Report Coversheet, [Form No. 650-050-38](#) as the coversheet of the report. The traffic analysis report should summarize the items presented in [Section 2.2.10.2](#) of the PD&E manual. The PTAR must be signed and sealed by a professional engineer in accordance with [Chapter 471](#), Florida Statutes (F.S.). Users are advised to consult with their project managers to determine the most appropriate type, format, and content of the traffic analysis report.

## 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 supporting technical documents including 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 provides early identification and resolution of potential issues, thereby minimizing the risk of delays.

**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**



## Appendix A

# Glossary

# Appendix A

## Glossary

| Keyword                              | Definition                                                                                                                                                     |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Access Control</b>                | A strategy in managed lanes where entry and exit points are regulated to improve traffic flow and safety.                                                      |
| <b>Analysis Area Boundary Limits</b> | The spatial and temporal boundaries established for a traffic analysis to accurately capture prevailing traffic operating characteristics.                     |
| <b>Analysis Tool</b>                 | A procedure, methodology, or computer model used to conduct traffic analyses, such as HCM, HCS, Synchro, Vissim, or SIDRA.                                     |
| <b>Arterial</b>                      | A major road or street that primarily serves through traffic and provides access to freeways and other arterials.                                              |
| <b>Base Model</b>                    | A simulation model representing existing or current conditions, serving as the foundation for modeling project alternatives.                                   |
| <b>Calibration</b>                   | The iterative process of adjusting model parameters so that simulation outputs closely match field-measured performance measures.                              |
| <b>Capacity</b>                      | The maximum number of vehicles that can reasonably be expected to pass a point or segment of a roadway during a given time period under prevailing conditions. |
| <b>Complex Weave Segment</b>         | A roadway segment with multiple, closely spaced merge and diverge areas, creating overlapping weaving movements.                                               |
| <b>Data Collection Plan</b>          | A documented plan outlining the data needs, sources, collection procedures, and quality assurance protocols for a traffic analysis.                            |
| <b>Density</b>                       | A measure of the number of vehicles occupying a given length of roadway, typically expressed as vehicles per mile per lane.                                    |
| <b>Deterministic Tool</b>            | A traffic analysis tool that does not incorporate randomness in its computations (e.g., HCM, HCS, Synchro, SIDRA).                                             |

# Glossary

## Keyword

## Definition

### **Dynamic Traffic Assignment**

A method in simulation models where vehicle routes are determined based on real-time network conditions, allowing for rerouting due to congestion.

### **Express Lanes**

Travel lanes physically separated from general use lanes, where tolls are set based on traffic conditions to manage congestion.

### **Field Observations**

On-site inspections conducted to understand traffic operating characteristics and verify data accuracy.

### **Free Flow Speed (FFS)**

The speed at which vehicles can travel under low-volume conditions, unaffected by other vehicles, roadway geometry, or traffic control.

### **Generalized Service Volume Tables**

Sketch-planning tools providing quick estimates of roadway capacity and level of service for planning analyses.

### **Highway Capacity Manual (HCM)**

A widely used reference containing methodologies for evaluating the capacity and quality of service of transportation facilities.

### **Highway Capacity Software (HCS)**

A computer program implementing HCM methodologies for analyzing capacity and level of service.

### **Level of Service (LOS)**

A qualitative measure describing operational conditions within a traffic stream, typically graded from A (best) to F (worst).

### **Managed Lanes**

Lanes within a highway facility that are proactively managed using strategies such as access control, vehicle eligibility, and pricing.

### **Microsimulation**

A modeling approach that simulates individual vehicle movements to analyze detailed traffic operations and interactions.

### **Microsimulation Tool**

A stochastic traffic analysis tool (e.g., Vissim, SimTraffic) that incorporates randomness to model real-world traffic conditions.

### **Model Calibration**

The process of adjusting simulation model parameters so that model outputs match observed field data.

# Glossary

## Keyword

## Definition

### Model Validation

Testing the performance of a calibrated model using an independent data set to confirm its accuracy.

### MOE (Measure of Effectiveness)

A quantitative metric used to assess the performance of a transportation system, such as speed, delay, density, or queue length.

### OD (Origin-Destination) Data

Information describing travel patterns between origins and destinations, critical for accurate traffic modeling.

### Peak Hour Factor (PHF)

A ratio used to convert peak 15-minute flow rates to hourly rates, reflecting the variability of traffic flow within the peak hour.

### Performance Measures

Quantitative indicators (MOEs) used to evaluate how well a transportation facility meets operational goals.

### Queue Length

The number of vehicles lined up at a bottleneck, intersection, or other point of congestion.

### SIDRA INTERSECTION

An analytical model used to analyze roundabout and intersection operations, capable of lane-by-lane analysis.

### SimTraffic

A microsimulation tool that models individual vehicle interactions and provides animation of traffic networks, using input from Synchro.

### Sketch Planning

A high-level analysis approach using generalized tools and default values to estimate traffic performance for planning purposes.

### Spatial Boundary Limit

The geographic extent of the area included in a traffic analysis.

### Static Traffic Assignment

A method where vehicle routes are predetermined and do not change in response to network conditions during simulation.

### Synchro

A macroscopic analysis tool for designing and modeling signalized and unsignalized intersections and arterials, optimizing signal timings.

### Temporal Boundary Limit

The time period over which a traffic analysis is conducted, selected to capture variations in traffic demand.

# Glossary

## Keyword

## Definition

### **Traffic Analysis**

The process of evaluating the effect of traffic demand and supply on the performance of a transportation facility.

### **Traffic Demand Forecasting**

The procedure for estimating future traffic volumes for use in traffic analysis.

### **Traffic Management Strategies**

Operational techniques (e.g., ramp metering, managed lanes) used to improve traffic flow and safety.

### **Validation**

The process of confirming that a calibrated model accurately represents real-world conditions using independent data.

### **Vissim**

A microsimulation tool used to analyze and model vehicular, transit, and pedestrian flows, with advanced animation and calibration features.



## Appendix B

# Tool Selection Worksheet

# Tool Selection Worksheet

Tool Name: \_\_\_\_\_ Version/Release: \_\_\_\_\_  
Vendor Name/Contact Information: \_\_\_\_\_

138

(Continued)

# Tool Selection Worksheet

| 1                                                                       | 2                         | 3                 | 4             | 5        |
|-------------------------------------------------------------------------|---------------------------|-------------------|---------------|----------|
| Criteria                                                                | Sub-Criteria<br>Relevance | Tool<br>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                                                        |                           |                   |               |          |
| Geometrics 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                                             |                           |                   |               |          |

(Continued)

# Tool Selection Worksheet

| 1                                                                       | 2                         | 3                 | 4             | 5        |
|-------------------------------------------------------------------------|---------------------------|-------------------|---------------|----------|
| Criteria                                                                | Sub-Criteria<br>Relevance | Tool<br>Relevance | Col 2 X Col 3 | Comments |
| 4 Management Strategy/Application (0 = not relevant, 5 = most relevant) |                           |                   |               |          |
| 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 System                                    |                           |                   |               |          |
| Pre-trip ATIS                                                           |                           |                   |               |          |
| Telephone-based traveler information                                    |                           |                   |               |          |
| Web-based traveler information                                          |                           |                   |               |          |
| Kiosks                                                                  |                           |                   |               |          |
| Handheld traveler information                                           |                           |                   |               |          |
| En-route ATIS                                                           |                           |                   |               |          |
| Highway Advisory Radio (HAR)                                            |                           |                   |               |          |
| Transit DMS                                                             |                           |                   |               |          |
| In-vehicle/handheld traveler information                                |                           |                   |               |          |
| Rail Grade Crossing Monitor                                             |                           |                   |               |          |
| Commercial Vehicle Operations                                           |                           |                   |               |          |
| Fleet administration                                                    |                           |                   |               |          |
| Electronic screening                                                    |                           |                   |               |          |
| Weight-in-motion                                                        |                           |                   |               |          |
| Electronic clearance                                                    |                           |                   |               |          |
| Safety information exchange                                             |                           |                   |               |          |
| On-board safety monitoring                                              |                           |                   |               |          |
| Electronic roadside safety inspection                                   |                           |                   |               |          |
| HazMat incident response/management                                     |                           |                   |               |          |

(Continued)

# Tool Selection Worksheet

| 1                                                                       | 2                         | 3                 | 4             | 5        |
|-------------------------------------------------------------------------|---------------------------|-------------------|---------------|----------|
| Criteria                                                                | Sub-Criteria<br>Relevance | Tool<br>Relevance | Col 2 X Col 3 | Comments |
| 4 Management Strategy/Application (0 = not relevant, 5 = most relevant) |                           |                   |               |          |
| 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 program                                                  |                           |                   |               |          |
| 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                                                      |                           |                   |               |          |

# Tool Selection Worksheet

142

(Continued)

# Tool Selection Worksheet

| 1                               | 2                                                          | 3                 | 4             | 5                                                                                           |
|---------------------------------|------------------------------------------------------------|-------------------|---------------|---------------------------------------------------------------------------------------------|
| Criteria                        | Sub-Criteria<br>Relevance                                  | Tool<br>Relevance | Col 2 X Col 3 | Comments                                                                                    |
| 5                               | Traveler Response (0 = not relevant, 5 = most relevant)    |                   |               |                                                                                             |
| 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:                                      |

# Tool Selection Worksheet

144

(Continued)

# Tool Selection Worksheet

| 1        | 2                                                             | 3                 | 4             | 5                                          |
|----------|---------------------------------------------------------------|-------------------|---------------|--------------------------------------------|
| Criteria | Sub-Criteria<br>Relevance                                     | Tool<br>Relevance | Col 2 X Col 3 | Comments                                   |
| 7        | Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant) |                   |               |                                            |
|          | Turn movements/fractions                                      |                   |               |                                            |
|          | Traffic composition                                           |                   |               |                                            |
|          | Occupancy                                                     |                   |               |                                            |
|          | Control devices                                               |                   |               |                                            |
|          | Spacing                                                       |                   |               |                                            |
|          | Computer run time                                             |                   |               | Average run time:                          |
|          | Post Processing Requirements                                  |                   |               |                                            |
|          | Metric options available                                      |                   |               |                                            |
|          | U.S. standards option available                               |                   |               |                                            |
|          | Documentation                                                 |                   |               |                                            |
|          | User's Manual                                                 |                   |               | Where to download:                         |
|          | Newsgroup available                                           |                   |               | Newsgroup address:                         |
|          | Chat rooms available                                          |                   |               | Chat room address:                         |
|          | Email 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 system                         |                   |               | Ideal OS:                                  |

(Continued)

# Tool Selection Worksheet

| 1        |                                                               | 2                         | 3                 | 4             | 5        |
|----------|---------------------------------------------------------------|---------------------------|-------------------|---------------|----------|
| Criteria |                                                               | Sub-Criteria<br>Relevance | Tool<br>Relevance | Col 2 X Col 3 | Comments |
| 7        | Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant) |                           |                   |               |          |
|          | Other model capabilities/conditions                           |                           |                   |               |          |
|          | Oversaturated conditions                                      |                           |                   |               |          |
|          | Weaving                                                       |                           |                   |               |          |
|          | Effects of incidents (objects, breakdowns, crashes)           |                           |                   |               |          |
|          | Weather effects (rain, ice, window, 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<br>(0 = not relevant, 5 = most relevant) |                                  | Criteria<br>Relevance | Weighted<br>Sub-totals | 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



# TRAFFIC ANALYSIS HANDBOOK

June 2026

Systems Implementation Office