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# Table of Contents

1. **INTRODUCTION** ........................................................................................................... 1
   1.1 BACKGROUND .............................................................................................................. 1
   1.2 PURPOSE OF THIS GUIDEBOOK ............................................................................. 1
   1.3 STAKEHOLDER INVOLVEMENT ............................................................................... 4
   1.4 APPLICATIONS OF THE GUIDEBOOK ..................................................................... 5

2. **COMMON ANALYTICAL SCENARIOS** ........................................................................... 7
   2.1 INTERSECTION ANALYSES ...................................................................................... 7
   2.2 HIGHWAY/FREeway/INTERCHANGE ANALYSES .................................................. 8
   2.3 MULTIMODAL AND MISCELLANEOUS ANALYSES ............................................... 9
   2.4 STUDY AREA CLASSIFICATIONS .......................................................................... 9
   2.5 UNDERSATURATED AND OVERSATURATED CONDITIONS ................................ 11

3. **COMMON ANALYTICAL TOOLS** ............................................................................. 13
   3.1 QUICKZONE ............................................................................................................ 13
   3.2 HIGHWAY CAPACITY SOFTWARE (HCS) ........................................................... 13
   3.3 SYNCHRO ............................................................................................................... 13
   3.4 SimTraffic ............................................................................................................... 14
   3.5 SIDRA INTERSECTION ............................................................................................ 14
   3.6 CORSIM .................................................................................................................. 15
   3.7 VISSIM .................................................................................................................... 15

4. **COMMON ANALYTICAL MEASURES OF EFFECTIVENESS (MOES)** ....................... 17
   4.1 COMMON MEASURES OF EFFECTIVENESS (MOEs) ........................................ 17

5. **MICROSIMULATION** .............................................................................................. 21
   5.1 MICROsIMULATION APPLICABILITY AND CALIBRATION ............................... 21
   5.2 SIMULATION SAMPLE SIZE ................................................................................ 22

6. **STANDARD REQUIREMENTS FOR ANALYSES** ..................................................... 25
   6.1 GEOMETRIC DATA .............................................................................................. 25
   6.2 TRAFFIC COUNT DATA ......................................................................................... 26
   6.3 SIGNAL OPERATIONS DATA ................................................................................ 33
   6.4 CALIBRATION DATA ............................................................................................. 33
   6.5 ROADWAY DESIGN IMPACTS .............................................................................. 35
# Table of Contents (cont.)

7 **STANDARD ASSUMPTIONS FOR TOOLS** ................................................................. 38

- 7.1 HCS 2010 ........................................................................................................... 38
- 7.2 SYNCHRO ......................................................................................................... 44
- 7.3 SIDRA INTERSECTION ....................................................................................... 48
- 7.4 CORSIM .............................................................................................................. 51
- 7.5 VISSIM ............................................................................................................... 55
- 7.6 SIMTRAFFIC ....................................................................................................... 59

8 **TRAFFIC OPERATIONS ANALYSIS TOOL SELECTION** ........................................ 62

- 8.1 SOFTWARE SELECTION TOOL ........................................................................ 62
- 8.2 SOFTWARE SELECTION TOOL INPUT FORM MACRO ..................................... 62
- 8.3 TOOL DETERMINATION MACRO, SET PRINT AREA, AND CLEAR TABLE MACROS .................................................................................................................... 63
- 8.4 SOFTWARE SELECTION TOOL MAINTENANCE ............................................. 68
- 8.5 ROUNDABOUT ANALYSIS METHODOLOGY .................................................. 68

9 **OUTPUT** .............................................................................................................. 70

- 9.1 OUTPUT FORMATS ........................................................................................... 70
- 9.2 HCS OUTPUT FORMATS .................................................................................. 71
- 9.3 SYNCHRO/SIMTRAFFIC OUTPUT FORMATS ............................................... 73
- 9.4 SIDRA INTERSECTION OUTPUT FORMATS .................................................... 76
- 9.5 CORSIM AND VISSIM OUTPUT FORMATS ..................................................... 76

**Technical Appendix**

A. Additional Resources Reviewed
B. Tool Selection Matrix
C. Traffic Simulation Calibration Factors
D. Traffic Simulation Output Level of Service Conversion
Table of Figures

60  Figure 1 – Example of Peak Hour Spreading .......................................................... 12
65  Figure 2 – Time/Cost Comparison for Deterministic and Microsimulation Tools ........ 21
69  Figure 3 – Screen Shot of Failing Sample Size Determination Tool .......................... 24
74  Figure 4 – Screen Shot of Passing Sample Size Determination Tool .......................... 24
79  Figure 5 – FHWA Vehicle Classification .................................................................. 31
6  Figure 6 – Effects of an Unbalanced Network on Microsimulation ............................... 32
12  Figure 7 – Bus Blockages to Include in Analysis ...................................................... 48
17  Figure 8 – SST Input Form .................................................................................... 64
22  Figure 9 – SST Selection Validation Check ................................................................ 65
27  Figure 10 – SST Location Type Validation Check ..................................................... 66
32  Figure 11 – SST Spreadsheet After Exporting Scenarios .......................................... 67
37  Figure 12 – Output from Executing the Tool Determination Macro ............................ 68
42  Figure 13 – HCS Depictive Figure - Freeways .......................................................... 72
47  Figure 14 – Synchro/SimTraffic/CORSIM/VISSIM LOS Depictive Figure - Intersections 74
52  Figure 15 – Synchro/SimTraffic/CORSIM/VISSIM Queue Depictive Figure - Intersections 75
57  Figure 16 – SIDRA Intersection Depictive Output Figure ......................................... 78
62  Figure 17 – SIDRA Intersection LOS Depictive Summary Figure ............................... 79
67  Figure 18 – CORSIM Lane Schematic Figure .......................................................... 82
72  Figure 19 – VISSIM Lane Schematic Figure ............................................................ 83

Table of Tables

80  Table 1 – Freeway Facility Level of Service in Terms of Density ............................... 18
85  Table 2a – Standard Geometric Parameters ............................................................. 27
89  Table 2b – Standard Geometric Parameters ............................................................. 28
94  Table 3 – Standard Traffic Data Collection Parameters ............................................. 29
99  Table 4 – Standard Calibration Data Parameters .................................................... 34
104 Table 5a – HCS 2010 Standard Parameters ............................................................. 39
109 Table 5b – HCS 2010 Standard Parameters ............................................................. 40
114 Table 6 – Synchro Standard Parameters ................................................................. 45
119 Table 7 – SIDRA Intersection Standard Parameters ............................................... 49
124 Table 8 – CORSIM Standard Parameters ............................................................... 52
129 Table 9 – VISSIM Standard Parameters ................................................................. 56
134 Table 10 – SimTraffic Standard Assumptions ........................................................ 60
139 Table 11 – HCS Tabular Output Format ................................................................ 60
144 Table 12 – Level of Service Table for Synchro/SimTraffic Output ............................ 73
149 Table 13 – Queue Table for Synchro/SimTraffic Output .......................................... 77
154 Table 14 – SIDRA Intersection Movement Summary Table ..................................... 80
159 Table 15 – CORSIM/VISSIM Output Results Table ............................................... 81
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Access management: The systematic control of the location, spacing, design, and operation of entrances, median openings/crossovers, traffic signals, and interchanges for the purpose of providing vehicular access to land development in a manner that preserves the safety and efficiency of the transportation system.

Area: An interconnected set of transportation facilities serving movements within a specified geographic space, as well as movements to and from adjoining areas.

Average travel speed: The length of highway segment divided by the average travel time of all vehicles traversing this segment, including all stopped delay times (expressed in mph). This speed is equivalent to space mean speed.

Back of queue: The maximum backward extent of queued vehicles during a typical cycle measured from the stop bar to the last queued vehicle (expressed in feet).

Calibration: Process where the modeler modifies the parameters that cause the model to best reproduce field-measured and observed local traffic conditions.

Control delay: Delay associated with vehicles slowing in advance of an intersection, the time spent on an intersection approach, the time spent as vehicles advance in a queue, and the time needed for vehicles to accelerate to their desired speed (expressed in seconds per vehicle).

Corridor: A set of parallel transportation facilities, such as a freeway and an arterial street.

Cycle: A complete sequence of signal indications.

Cycle length: The time required for one complete sequence of signal phases such that all of the movements at the intersection have been served at least once (expressed in seconds).

Delay: Additional travel time experienced by a driver, passenger, bicyclist, or pedestrian beyond that required to travel at the desired speed (expressed in seconds).

Density: The number of vehicles occupying a given length of lane at a particular instant (expressed in passenger cars or vehicles per mile per lane).

Deterministic traffic tools: Traffic analysis tools that assumes that there is no variability in the driver-vehicle characteristics (e.g., HCS 2010).

Facility: A length of roadway, bike path, or pedestrian walkway composed of a connected series of points and segments.

Flow rate: The equivalent hourly rate at which vehicles or other roadway users pass over a given point or section of a lane or roadway during a given time interval of less than one hour, usually 15 minutes.

Free-flow speed: The prevailing speed on highways at flow rates between 0 and 1,000 passenger cars per hour per lane (expressed in mph).

LOS: Level of service. Stratification of a performance measure(s) that represent quality of service, measured in an A-F scale with LOS A representing the best.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macroscopic analysis tools</strong></td>
<td>These tools are used to simulate traffic flow, taking into consideration aggregate traffic stream characteristics (speed, flow, and density) and their relationships (e.g., HCS 2010, SIDRA Intersection, and Synchro).</td>
</tr>
<tr>
<td><strong>Microsimulation</strong></td>
<td>Modeling of individual vehicle movements on a second or sub-second basis for the purpose of assessing the traffic performance of a transportation network.</td>
</tr>
<tr>
<td><strong>Microscopic analysis tools</strong></td>
<td>These tools are used to simulate the characteristics and interactions of individual vehicles. These tools include algorithms and rules describing how vehicles move and interact, including acceleration, deceleration, lane changing, and parking maneuvers (e.g., CORSIM, SimTraffic, and VISSIM).</td>
</tr>
<tr>
<td><strong>MOE</strong></td>
<td>Measure of effectiveness.</td>
</tr>
<tr>
<td><strong>Peak hour factor</strong></td>
<td>The hourly volume during the analysis hour divided by the peak 15-minute flow rate within the analysis hour; a measure of traffic demand fluctuation within the analysis hour.</td>
</tr>
<tr>
<td><strong>Phase</strong></td>
<td>The part of a signal cycle allocated to any combination of traffic movements receiving the right-of-way simultaneously during one or more intervals. A phase includes the green, yellow change, and red clearance intervals.</td>
</tr>
<tr>
<td><strong>Point</strong></td>
<td>A place along a facility where (a) conflicting traffic streams cross, merge, or diverge; (b) a single traffic stream is regulated by a traffic control device; or (c) there is significant change in the segment capacity (e.g., lane drop, lane addition, narrow bridge, significant upgrade, start or end of a ramp influence area).</td>
</tr>
<tr>
<td><strong>Project Manager</strong></td>
<td>Individual responsible for accomplishing the stated project objectives through planning, execution, and closing of a project.</td>
</tr>
<tr>
<td><strong>Queue length</strong></td>
<td>The distance between the upstream and downstream ends of the queue (expressed in feet).</td>
</tr>
<tr>
<td><strong>Segment</strong></td>
<td>1. For interrupted flow facilities, a link and its boundary points. 2. For uninterrupted flow facilities, the portion of a facility between two points.</td>
</tr>
<tr>
<td><strong>Space mean speed</strong></td>
<td>An average speed based on the average travel time of vehicles to traverse a length of roadway.</td>
</tr>
<tr>
<td><strong>Stochastic traffic tools</strong></td>
<td>Traffic simulation tools that assign driver-vehicle characteristics from statistical distributions using random numbers (e.g., CORSIM, SimTraffic, VISSIM).</td>
</tr>
<tr>
<td><strong>Stopped delay</strong></td>
<td>The amount of time that a vehicle is stopped when a vehicle is traveling less than 5 mph (expressed in seconds).</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td>All the transportation facilities and modes within a particular region.</td>
</tr>
<tr>
<td><strong>Validation</strong></td>
<td>Process where the modeler checks the overall model-predicted traffic performance for a network against field measurements of traffic performance (using data not used in the calibration process).</td>
</tr>
<tr>
<td><strong>Volume to capacity (v/c) ratio</strong></td>
<td>The ratio of the flow rate to the capacity for a system element.</td>
</tr>
<tr>
<td><strong>95th percentile queue length</strong></td>
<td>The queue length that has only a 5% probability of being exceeded during a given analysis period (expressed in feet).</td>
</tr>
</tbody>
</table>
1.1 Background

Traffic analysis tools help traffic engineers and transportation planners to analyze the transportation network for both existing conditions and future conditions. As they are tools, they are part of the decision making process that leads to transportation solutions. Traffic analysis tools alone are not the sole components in the decision making process, but they play an integral role in helping to understand and evaluate alternatives. As the complexity of potential improvement concepts increase, it is important for traffic engineers and transportation planners to choose the most appropriate traffic analysis tool for each condition.

VDOT has been using computer-based traffic analysis tools for over 30 years. These traffic analysis tools have become progressively more complex and diverse to more accurately document the impact of traffic on the transportation network. Over the past 15 years, microscopic analysis tools such as CORSIM, VISSIM, and SimTraffic have increasingly been used to analyze, simulate, and visualize existing and future transportation operations within complex networks. Additionally, macroscopic analysis tools such as Highway Capacity Software (HCS), Synchro, and SIDRA Intersection continue to be upgraded and are used to analyze a wide variety of transportation projects.

1.2 Purpose of this Guidebook

There are several types of traffic analysis tools designed to fit projects of different sizes, scopes, and objectives. Depending on the project type, there may be more than one suitable traffic analysis tool, or the project may require more than one traffic analysis tool to be used simultaneously. Based on these reasons, VDOT identified the need to develop this guidance document to help project managers select the most appropriate traffic analysis tool(s) during the project scoping phase, understand the standard assumptions related to each traffic analysis tool, and produce consistent output from these traffic analysis tools for transportation analyses.
The need for this guidebook was based on the premise that project managers will benefit from consistent guidance for scoping projects and reviewing results. This document is intended to supplement more general information provided at the federal level regarding the selection of traffic analysis tools.

This document is intended to be used by VDOT and consultant project managers on a wide variety of traffic analysis projects, and is intended to guide project managers on how best to evaluate various design, traffic operations, and planning analyses. Some of these traffic analysis projects may be part of the Scoping Phase of the VDOT Project Development Process and others will not. To most effectively use this guidebook, project managers should consult with technical specialists (traffic engineers, transportation planners, and/or traffic simulation modelers) as needed to assist them with the selection of the most appropriate traffic analysis tool(s).

Primary reasons for developing this guidebook:

1. To identify the acceptable range of conditions under which traffic analysis tool(s) should be used for typical traffic, geometric, and operational conditions to all VDOT divisions conducting analyses, and their consultants;
2. To provide a standard set of assumptions to be used for each traffic analysis tool; and
3. To provide standard output summary templates and requirements.

There is an unlimited array of traffic and geometric conditions that could be addressed in this guidebook. As it is impractical to include all possible combinations of traffic and geometric conditions, this guidebook will describe the selection of traffic analysis tools for common transportation analysis scenarios to help project managers select the most appropriate traffic analysis tool, whether it is a deterministic tool such as the Highway Capacity Software or a traffic simulation tool such as VISSIM or CORSIM. As conditions are encountered that vary from these common scenarios, revised supplemental guidelines may be developed on a case-by-case basis as the guidebook evolves over the next several years.

This guidebook provides guidance primarily for operational analyses for studies that focus on both short-term and long-term conditions. If the purpose of the study is to identify key design elements based on operations, then the study is an operational analysis. The following characteristics summarize study types that are covered in this guidebook:

- **Study Types**
  - Traffic Operations Analyses
    - Traffic signal timing
    - Freeway weaving and ramp analyses
    - Congestion mitigation studies
  - Access Management Studies
  - Traffic Impact Analysis (TIA) Studies
Design-Related Analyses
- Interchange justification/modification studies
- Roadway design analyses (turn-bay length, number of lanes, etc.)
- Maintenance of traffic analyses (work zone analysis)

Measures of Effectiveness (MOE), Outputs, and Results
- Operations/design levels of service
- Detailed queuing results
- Control delay
- Travel time
- Density
- Travel speed
- Number of stops

The following characteristics summarize study types that are not covered in the guidebook:

Study Types
- Long-Range Planning Studies
  - First- and second-tier NEPA studies
  - Studies requiring the use of long-range planning models to determine general traffic volume based improvements (e.g., “2,000 vehicles per hour (vph) requires 2 travel lanes”)

Measures of Effectiveness (MOE), Outputs, and Results
- General recommendations based solely on volumes
- Recommendations without definitive dimensions or those not supported by formal operational/queuing analyses
- Sketch planning

The Project Manager has the authority to review the recommendations in this guidebook and make the determination if any deviations are required, except as outlined in VDOT policy. If the project manager decides to use an alternate traffic analysis tool, then technical documentation justifying this decision must be included in the project file. Factors such as the required MOE(s); functionality of the traffic analysis tools; and available budget, schedule, and resources must be weighed to determine the most appropriate traffic analysis tool to use.

It is important that appropriate study documentation be submitted with the report to support the traffic analyses. The traffic analysis results shall be submitted in electronic format, so that the project manager, and/or their designee, can review the results with the appropriate traffic analysis tool. This documentation should include a summary of the following information:
Description of the study area
Data collection results – traffic counts, origin-destination information as appropriate, etc.
Simulation model documentation – link-node diagram, lane schematic diagram, etc. (if applicable)
Summary of field observations and geometric inventory
Measurement of back of queue to be used for estimating traffic demand
Description of methodology for model calibration (if applicable)
Model calibration results – travel time runs, volume throughput, etc. (if applicable)
Deviation from traffic analysis guidelines presented herein (if applicable)
MOE results (using templates provided in this guidebook)
Sensitivity testing results (if applicable)
Thorough summary of assumptions used in the analysis – how peak hour was determined, how traffic growth rate was determined, method used to balance peak hour traffic volumes, etc.
Quality control results

A more detailed description of the documentation requirements will be identified in a later chapter of this guidebook.

1.3 Stakeholder Involvement

A technical advisory committee (TAC) was created to provide guidance to the consultant team throughout the development of this manual. The TAC consisted of a variety of traffic engineers, transportation planners and researchers from VDOT and FHWA. This committee was responsible for discussing and vetting key issues throughout the process of developing this guidebook. These members included:

1.3.1 Public Sector
- Mena Lockwood – Central Office Traffic Engineering Division (VDOT Project Manager)
- Sanhita Lahiri – Central Office Traffic Engineering Division
- Mark Richards – Central Office Traffic Engineering Division
- Ritchie Robbins – Central Office Traffic Engineering Division
- Bill Guiher – Central Office Transportation and Mobility Planning Division
- Terry Short, Jr. – Staunton District Transportation Planning
- Mike McPherson – Southwest Region Operations
- Cheryl Reints – Eastern Region Operations
- Jung-Taek Lee – Northern Region Operations
- Noah Goodall – Virginia Center for Transportation Innovation and Research
- John Mazur – Federal Highway Administration – Virginia Division
1.3.2 Consultant Team

- Timothy White – Kimley-Horn and Associates (Consultant Project Manager)
- Ben Reim – Kimley-Horn and Associates
- Michael Wobken – Kimley-Horn and Associates
- Support from throughout Kimley-Horn and Associates for traffic analysis templates

1.4 Applications of the Guidebook

These guidelines establish consistency and uniformity of traffic analysis for VDOT. Not only will the process of traffic analysis tool selection be more consistent, but the summary of the output will also be much more consistent through the use of output templates provided.

By using the software selection tool that will accompany this guidebook and templates provided in this guidebook, project managers will be able to select the most appropriate tool(s) for analyzing and comparing transportation networks. The tool selection will be based on the goals, objectives, and location-specific conditions at each study location. In many cases, there may be multiple tools that could be chosen for a similar geometric condition (i.e., SIDRA Intersection or VISSIM for roundabouts). In addition, there may be multiple tools needed to fully analyze areas with dissimilar geometric conditions (i.e., using optimized signal timings from Synchro in a VISSIM model that is used to analyze both arterial and interstate facilities). On the other hand, it may be obvious that only one tool is needed (i.e., VISSIM for the analysis of transit conditions and/or non-traditional geometry).

There are various reasons for selecting one traffic analysis tool over another aside from the functionality of the tool. These reasons include the cost of the analysis, time to conduct the analysis, data requirements, data availability, and training requirements for different tools.

*This guidebook, however, does not specifically address other reasons for selecting one traffic analysis tool over another, such as the cost to conduct the analysis, time to conduct the analysis, and training requirements for different tools, to name a few. Pertaining to these issues, the project manager must weigh feedback from subject matter experts to make an informed decision.*

As a result of the Traffic Operations Analysis Tool Guidebook, an automated tool in Microsoft Excel was created to guide and assist traffic engineers and transportation planners with the selection of the most appropriate traffic analysis tool(s). This tool takes into account the congestion levels, the type of study to be conducted, and the required MOE to narrow down the selection to the most appropriate tool or combination of tools.

This guidebook consists of the following chapters:

- **Chapter 1 – Introduction**
  This chapter describes the history of the use of traffic analysis tools in Virginia. What is the purpose of this guidebook? How can the guidebook be applied?
Chapter 1 – Introduction

Chapter 2 – Common Analytical Scenarios
This chapter describes the various types of networks that traffic engineers and transportation planners analyze, including intersections, freeway segments, two-lane highways, and multi-modal facilities to name several.

Chapter 3 – Common Analytical Tools
This chapter describes the various traffic analysis tools that are available, such as both macroscopic and microscopic tools. This guidebook focuses on the following macroscopic and microscopic traffic analysis tools:

- Quickzone - macroscopic
- HCS - macroscopic
- Synchro - macroscopic
- SIDRA Intersection - macroscopic
- CORSIM - microscopic
- VISSIM - microscopic
- SimTraffic - microscopic

Chapter 4 – Common Analytical Measures of Effectiveness (MOEs)
This chapter describes many of the MOEs used to interpret the impacts of traffic on the roadway network. Some of these factors may include speed, delay, travel time, queue length, and throughput.

Chapter 5 – Microsimulation
This chapter describes the applicability and calibration for microsimulation analyses. This chapter also addresses the methodology for selecting the appropriate number of traffic simulation runs.

Chapter 6 – Standard Requirements for Analyses
This chapter describes the standard requirements for traffic analyses conducted in Virginia. As an example, what is the acceptable age of traffic count data? This chapter also addresses how traffic analysis tools should be used to determine the impact of design features, such as the length of turn lanes.

Chapter 7 – Standard Assumptions for Tools
This chapter describes the typical assumptions applicable to various inputs for each traffic analysis tool. These assumptions are described in detail for each of the 6 traffic analysis tools within this chapter, with the exception of Quickzone. Although Quickzone is considered an analysis tool, its application and inputs will not be discussed as part of this guidebook.

Chapter 8 – Traffic Operations Analysis Tool Selection
This chapter describes how the traffic analysis tool selection matrix was converted to a software program to make the selection of traffic analysis tools easy for users. This chapter also provides details on specific guidance for using this tool.

Chapter 9 – Output
This chapter describes the requirements and templates that were created to provide consistency with the output summary from the various traffic analysis tools.
Chapter 2 – Common Analytical Scenarios

There are many analytical scenarios that may be evaluated on any given project. In many cases, the use of multiple traffic analysis tools will be required to meet the project requirements. It is important to understand the differences between the various analytical scenarios, so the appropriate traffic analysis tool can be selected. The Traffic Operations Analysis Tool Guidebook considers the following three major types of Analytical Scenarios:

1. Intersection Analyses,
2. Highway / Freeway / Interchange Analyses, and
3. Multimodal / Miscellaneous Analyses.

The proceeding sections of this chapter will describe each of these scenarios in more detail. This chapter will also describe study area characteristics (e.g., points, segments, etc.) and the definition of oversaturated and undersaturated conditions.

2.1 Intersection Analyses

Within the intersection analyses analytical scenario, there are five main intersection types considered in this guidebook – signalized intersections, signalized intersection preemption and/or transit priority, unsignalized intersections (All-Way Stop and Two-Way Stop), roundabouts, and non-traditional intersections/interchanges. Descriptions of each category are described below in more detail:

- **Signalized Intersection Operations**: This type of analysis examines the functionality of an intersection controlled by a traffic signal in terms of specific MOEs, such as delay or queue.

- **Signalized Intersection Preemption and/or Transit Priority**: This type of analysis examines the impacts of a preemption or priority event at a signalized intersection, with or without transit operations with specific MOEs such as delay or queue.

- **Unsignalized Intersection Operations**: This type of analysis examines the functionality of an intersection not controlled by a traffic signal in terms of specific MOEs such as delay or queue. An unsignalized intersection may either be all-way stops or two-way stops.

- **Roundabout Operations**: This type of analysis examines the functionality of a roundabout in terms of specific MOEs including speed, delay, or queue.

- **Non-Traditional Intersection/Interchange Operations**: This type of analysis examines the functionality of non-traditional intersections/interchanges in terms of specific MOEs including speed, delay, or queue. Such examples include 5-legged intersections, diverging diamond interchanges (DDI), and Single Point Urban Interchanges (SPUI) to name a few. These analyses pertain to the intersection operations only for interchanges such as DDIs and SPUIs as opposed to the ramp and ramp-freeway junction operations.
2.2 Highway/Freeway/Interchange Analyses

A highway/freeway/interchange network consists of several elements that can be analyzed. These network elements are described in more detail below:

- **Freeway Segment Operations**: In this type of analysis, freeway segments not influenced by merging, diverging, or weaving maneuvers are analyzed in terms of flow, speed, and density. Lane changing within a basic freeway segment should be attributed to passing operations only.

- **Merge/Diverge Operations**: Merging and diverging freeway segments occur primarily near or at interchanges in the presence of an on- and off-ramp. A merging analysis is considered when two or more streams of traffic combine to form a single stream of traffic, while a diverging analysis is considered when a single stream of traffic divides into two or more streams of traffic. This type of analysis examines the functionality of a merge or diverge area in terms of specific MOEs including speed, flow, or density.

- **Weaving Segment Operations**: Weaving sections are formed when traffic streams traveling in the same direction are forced to change lanes and cross paths over a significant length of freeway. This type of analysis examines the functionality of the weaving segment in terms of specific MOEs including speed, flow, or density.

- **Freeway High-Occupancy Vehicle (HOV), High Occupancy Toll (HOT), or Ramp Metering Operations**: Freeway HOV lanes, HOT lanes, and ramp metering manage traffic demand by imposing travel restrictions. A freeway HOV lane is a freeway lane designated for a HOV, which typically is a vehicle with two or more occupants. HOT lanes require single-occupant vehicles to pay a toll that varies based on demand/capacity. The tolls change throughout the day according to real-time traffic conditions, managing the extent of congestion. A ramp metering system restricts access to freeways by regulating traffic entering the network based on operational conditions along the freeway network. This type of analysis examines the functionality of HOV, HOT, or ramp metering in terms of specific MOEs including speed, flow, or density.

- **Collector-Distributor Facility Operations**: A collector-distributor facility (or “C-D Road”) is parallel to a freeway facility, and is intended to “collect” and “distribute” traffic to one or more interchanges, while also removing weaving movements from the mainline freeway. This type of analysis examines the functionality of the C-D road in terms of specific MOEs including speed, flow, or density.

- **Multi-Lane Highway Operations**: This type of analysis examines the functionality of a highway with at least two lanes of traffic in each direction. Unlike a freeway, a multi-lane highway is not a limited access facility, and most typically will have interruptions in flow due to signalized at-grade intersections and/or unsignalized local roadways and site driveways. This type of analysis examines the functionality of the multi-lane highway in terms of specific MOEs including speed, flow, delay, or queue.
2.3 Multimodal and Miscellaneous Analyses

The multimodal and miscellaneous analyses category is intended to capture various common analyses that do not include characteristics of the previous two described categories, such as multimodal facilities, toll plazas, parking areas, public transit facilities, work zones, and pedestrian and bicycle facilities. Each of these various analyses is described in more detail below:

- **Multimodal Facilities**: This type of analysis evaluates the functionality of multimodal facilities such as transit centers, airport terminals, and bus stops.

- **Toll Plazas**: This type of analysis evaluates the functionality, capacity, serviceability, for a toll collection system. Other applicable operating systems can include security gate credential inspections.

- **Parking Areas**: This type of analysis evaluates the occupancy and flow within parking areas.

- **Public Transit Facilities**: This type of analysis determines the functionality of different types of planning-level public transit facilities, such as Bus Rapid Transit (BRT) and Light Rail Transit (LRT). This guidebook is not intended to provide guidance on large scale design and policy driven analyses. For such instances, the project manager should coordinate with the Department of Rail and Public Transit (DRPT).

- **Active Traffic Management (ATM)**: This type of ITS solution includes an integrated set of operating strategies and technologies for managing traffic demand, such as advanced lane control signal systems, variable speed limits, dynamic junction control, speed harmonization, and automated signs. This type of analysis examines network functionality for a variety of MOEs including speed, flow, density, travel time or queue.

- **Work zones**: This type of analysis evaluates the impacts of a work zone on freeway or arterial operations.

- **Pedestrian/Bicycle Simulation and Analysis**: This type of analysis evaluates the functionality of bicycle and/or pedestrian facilities. Such facilities include sidewalks, multiuse trails or paths, crosswalks at intersections, and bicycle lanes adjacent to mainline lanes of travel. The results provided in these analyses are in respect to the functionality of bicycle and pedestrian facilities themselves, and not their impact on signal operations. Under the various intersection analyses, pedestrians/bicyclists are an input to the analysis.

2.4 Study Area Classifications

This document utilizes the following study area classifications to define the geographic scope of the project, as defined in the *Highway Capacity Manual (HCM 2010)*:

- **Points**: A point is the smallest roadway system element. The *HCM 2010* defines a “Point” as follows:
“Points are places along a facility where (a) conflicting traffic streams cross, merge, or diverge; (b) a single traffic stream is regulated by a traffic control device; or (c) there is a significant change in the segment capacity (e.g., lane drop, lane addition, narrow bridge, significant upgrade, start or end of a ramp influence area).”

**Segments:** A segment consists of two points and is defined by the *HCM 2010* as follows:

“Segments are the length of roadway between two points. Traffic volumes and physical characteristics generally remain the same over the length of a segment, although small variations may occur (e.g., changes in traffic volumes on a segment resulting from a low-volume driveway). Segments may or may not be directional.”

**Facilities:** Facilities are made up of multiple points (2+) and segments. A facility is defined by the *HCM 2010* as follows:

“Facilities are lengths of roadways, bicycle paths, and pedestrian walkways composed of a connected series of points and segments. Facilities may or may not be directional and are defined by two endpoints.”

**Corridors:** Corridors are comprised of multiple facilities. The facilities must be parallel and can be an assortment of freeway, urban street, transit, or pedestrian/bicycle facilities. The *HCM 2010* defines a corridor as follows:

“Corridors are generally a set of parallel transportation facilities designed to move people between two locations.”

**Areas:** Areas consist of numerous facilities. Within an area, facilities do not need to be parallel to one another. The *HCM 2010* defines areas as follows:

“Areas consist of an interconnected set of transportation facilities serving movements within a specified geographic space, as well as movements to and from adjoining areas. The primary factor distinguishing areas from corridors is that the facilities within an area need not be parallel to each other. Area boundaries can be set by significant transportation facilities, political boundaries, or topographical features such as ridgelines or major bodies of water.”

**Systems:** A system is a larger version of an area. The *HCM 2010* defines a system as follows:

“Systems are composed of all the transportation facilities and modes within a particular region. A large metropolitan area typically has multiple corridors passing through it, which divide the system into a number of smaller areas. Each area contains a number of facilities, which, in turn, are composed of a series of points and segments. Systems can also be divided into modal subsystems (e.g., the roadway subsystem, the transit subsystem) as well as subsystems composed of specific roadway elements (e.g., the freeway subsystem, the urban street subsystem).”
2.5 Undersaturated and Oversaturated Conditions

It is important to recognize the difference between “undersaturated” and “oversaturated” conditions when choosing an analytical tool to use, since different equations and methodologies may be required depending on the selected tool. The HCM 2010 defines undersaturated flow and oversaturated flow as follows:

“Traffic flow during the analysis period is specified as ‘undersaturated’ when the following conditions are satisfied: (a) the arrival flow rate is lower than the capacity of a point or segment, (b) no residual queue remains from a prior breakdown of the facility, and (c) traffic flow is unaffected by downstream conditions.”

“Traffic flow during an analysis period is characterized as ‘oversaturated’ when any of the following conditions is satisfied: (a) the arrival flow rate exceeds the capacity of a point or segment, (b) a queue created from a prior breakdown of a facility has not yet dissipated, or (c) traffic flow is affected by downstream conditions.”

Speed is another element that can be used in conjunction with other parameters to determine whether a facility is undersaturated versus oversaturated, especially on uninterrupted flow facilities such as freeways and multilane highways. In undersaturated conditions, speeds are not impacted by volume of traffic; therefore, speeds are most influenced by the posted speed limit, the number of heavy vehicles, and/or the geometry of the roadway. For interrupted flow facilities, such as signalized intersections, queue lengths are a strong indicator of saturated traffic conditions. In oversaturated conditions, traffic speeds drop considerably depending on the severity of saturation. Typically, when vehicles travel at low speeds or are stopped completely, density cannot be calculated. The determination of when a study area is congested will be based on the following sources of information:

1. Current traffic count data
2. Current traffic analysis results
3. Results from previous studies conducted within the study area, within the last 5 years
4. Congestion mapping

One common phenomena resulting from oversaturated conditions is peak hour spreading or PHS. PHS is most prevalent in urban/suburban transportation networks where the peak hour traffic demand exceeds the available traffic capacity throughout the entire hour. This excess traffic then “spreads” to either side of the traditional peak hour, which creates a peak period of two or more hours as opposed to just one hour. Refer to Figure 1 as an illustrative example of one type of peak hour spreading.

There are various degrees of PHS that can occur depending on the extent of peak hour traffic demand and hourly peak period travel distributions; however, the occurrence of PHS needs to
be accounted for in operational analyses. This process involves the use of a microsimulation tool, such as SimTraffic, CORSIM, or VISSIM, and will require data to be entered in 15-minute intervals until all peak hour traffic demand is successfully spread across the adjacent 15-minute periods.

![Figure 1 – Example of Peak Hour Spreading](image)
A number of traffic analysis tools can be used to analyze the analytical scenarios presented in Chapter 2. Based on past experience and current practice in each VDOT district, seven tools were included for discussion in this guidebook. A brief description of the history and capabilities for each tool are provided in the following sections of this chapter.

3.1 Quickzone

Quickzone, which is a deterministic tool distributed by McTrans Center at the University of Florida, is used to evaluate the impacts of work zone mitigation strategies and can determine measures of effectiveness such as cost, delay, and queuing associated with a work zone.

3.2 Highway Capacity Software (HCS)

HCS 2010 is a deterministic tool distributed by McTrans. HCS uses the methodologies outlined in the HCM 2010. HCS can be used to analyze signalized intersections, unsignalized intersections (two-way and all-way), freeway segments, merging and diverging junctions, weaving segments, collector-distributor facilities, multilane highways, and two-lane highways.

3.3 Synchro

Synchro is a deterministic tool developed by Trafficware, and is primarily used for modeling traffic flow, traffic signal progression, and optimization of traffic signal timing. Additionally, Synchro may be used to analyze arterials, signalized intersections, and unsignalized intersections. Synchro cannot be used to analyze freeways, interchange systems, or ramps, and should only be used to analyze intersections, arterials, and corridors.

Synchro can utilize two different methodologies for analyzing intersections. The first methodology, Intersection Capacity Utilization (ICU), measures the capacity of an intersection, and was designed to handle planning level studies, such as traffic impact studies, future roadway design, and congestion management programs. While ICU does not predict delay, it can be used to predict how often an intersection could experience congestion. The ICU method is not an acceptable methodology to be used in Virginia.

The second methodology, HCM, is used to analyze intersection operations based on total control delay. In practice, the HCM methodology is the preferred methodology for all types of intersection operational analyses. The developer of Synchro, Trafficware, differentiates between the two methodologies as follows:

“The ICU has not been designed for operations and signal timing design. Delay based methods and simulation such as the Highway Capacity Manual (HCM), Synchro, and SimTraffic should be used for operations and signal timing design.”

-Trafficware
“The ICU has not been designed for operations and signal timing design. Delay based methods and simulation such as the Highway Capacity Manual (HCM), Synchro, and SimTraffic should be used for operations and signal timing design.”

The major difference between the two methodologies is the MOEs used. The ICU methodology is based on volume-to-capacity (v/c) ratios, while the HCM methodology is based on control delay. Based on the explanation provided by Trafficware on the two methodologies, all intersection analyses using Synchro will strictly reflect the HCM methodology, with the exception of Synchro analyses for traffic signal optimization. For these types of analyses, the progression optimization features in Synchro will be used.

3.4 SimTraffic

SimTraffic, a microsimulation tool, is the traffic analysis package included with Synchro. SimTraffic models any network that can be analyzed using Synchro. Prior to any analysis being performed in SimTraffic, the network must first be developed, as if a deterministic analysis was to be performed using Synchro. Once the network is developed, SimTraffic can be initiated either from within the Synchro interface or independently. Similar to CORSIM and VISSIM, SimTraffic has the ability to output several measures of effectiveness, which are specified by the user, such as delay per vehicle, total stops, travel distance, queue length, travel time, and average speed.

One of the strengths of SimTraffic is its functionality to simulate intersections, arterials, and corridors. Similar to Synchro, SimTraffic does not have the functionality to analyze freeway or interchange systems, including weaving segments, merge/diverge junctions, HOV lanes, collector-distributor facilities, or other similar facilities.

3.5 SIDRA Intersection

SIDRA Intersection is a deterministic tool developed by an Australian transportation operations company, Akcelik & Associates Pty Ltd. Although SIDRA Intersection can be used to analyze both individual signalized and unsignalized intersections, its primary application in the United States has been specifically for roundabout operations.

There are two main roundabout capacity models used in SIDRA Intersection at this time – the Standard Right-Side SIDRA Intersection model and the HCM 2010 model. Unlike Synchro, both models can be used in planning and operations level analyses and both use the same MOEs – delay, speed, and queue. Based on research conducted by the developers of SIDRA Intersection,
the HCM 2010 methodology does not account for the effects of vehicle arrivals based on adjacent traffic control devices, whereas the SIDRA Intersection model does, which is why SIDRA Intersection will be used for roundabout analyses where microsimulation is not warranted. More detailed differences between the two models are described in more detail in Chapter 7.

### 3.6 CORSIM

CORSIM (CORridor microscopic SIMulation) is a microsimulation and analytical tool that incorporates both urban traffic and freeway traffic simulation. Unlike HCS, which provides an analytical macroscopic snapshot, CORSIM uses microsimulation to explore the traffic operational behavior of various geometric conditions as traffic volumes and speeds fluctuate. The traffic simulation output includes several MOEs, and can be used to analyze many different traffic conditions and roadway configurations.

Through traffic simulation, CORSIM allows the user to evaluate existing and future traffic operations to assist in determining the effectiveness of geometric configurations. Additionally, CORSIM can provide cumulative performance results from several simulation iteration output files.

### 3.7 VISSIM

VISSIM is a microscopic traffic simulation model developed to analyze the full range of roadway and public transportation systems. The primary applications for VISSIM are arterial/corridor studies and freeway operational and planning studies; however, VISSIM can also be used for evacuation planning, LRT/BRT studies, transit center designs, railroad grade crossing analyses, toll plaza evaluations, and Intelligent Transportation Systems (ITS) assessments.

Similar to CORSIM, VISSIM provides the user with an ability to modify individual driver and vehicle characteristics, and can output a multitude of MOEs. VISSIM allows the user flexibility to develop a wide range of roadway networks with respect to vehicle movements and roadway geometry.
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4 Common Analytical Measures of Effectiveness (MOEs)

When conducting traffic analyses, there are many MOEs that can be used to document results. For this guidebook, several MOEs were evaluated and ultimately eight were chosen to be included in this guidebook. For consistency and simplicity reasons, all definitions presented in this chapter are referenced from the HCM 2010 with an understanding that each individual traffic analysis tool could have their own interpretation of the MOE definitions.

4.1 Common Measures of Effectiveness (MOEs)

The HCM defines a performance measure as a “quantitative or qualitative characterization of some aspect of the service provided to a specific road user group”. This guidebook considers the following eight performance measures:

- **Queue Length (measured in feet – ft):**
  The HCM 2010 defines queue length as “how far the traffic backs up as a result of traffic control or a vehicle stopped in the travel lane while waiting to make a turn”. The determination of queue length is complex and the methodology to compute this value is described in Section 6.5.2. Queue length is an MOE compatible with interrupted flow (i.e., arterial networks).

- **Delay (measured in seconds per vehicle – sec/veh):**
  Delay, as specified in the HCM 2010, is defined as “delay associated with vehicles slowing in advance of an intersection, the time spent stopped on an intersection approach, the time spent as vehicles move up in the queue, and the time needed for vehicles to accelerate to their desired speed”. Delay is an MOE compatible with interrupted flow (i.e., arterial networks).

- **Volume-to-Capacity (v/c) Ratio:**
  According to the HCM 2010, the v/c ratio is defined as “the ratio of the flow rate to capacity for a system element.” The HCM 2010 also states that “the volume-to-capacity (v/c) ratio is a special-case service measure. It cannot be directly measured in the field, nor is it a measure of traveler perceptions. Until capacity is reached (i.e., when flow breaks down on uninterrupted-flow facilities and when queues build on interrupted- or uninterrupted-flow facilities), the v/c ratio is not perceivable by travelers”. V/C ratio is an MOE compatible with interrupted flow (i.e., arterial networks), but may also be useful for comparison purposes as a surrogate measure on uninterrupted flow facilities, such as freeways.

- **Density (measured in passenger cars per lane per mile – pcplpm):**
  According to the HCM 2010, density is defined as “the number of vehicles occupying a given length of a lane or roadway at a particular instant”. Density is an MOE compatible with uninterrupted flow (i.e., freeway networks).
Speed (measured in miles per hour – mph):
According to the HCM 2010, “speed reflects how fast motorists can traverse a roadway section, including the effects of traffic-control devices, delays due to turning vehicles at intersections and driveways, and traffic demands on the roadway”. Speed is an MOE compatible with either interrupted (arterial networks) or uninterrupted (freeway networks) flows.

Average Travel Speed or ATS (measured in miles per hour – mph):
According to the HCM 2010, “average travel speed is defined as the highway segment length divided by the average travel time taken by vehicles to traverse it during a designated time interval.” ATS is an MOE compatible with uninterrupted (two-lane highways) flows.

Percent Time-Spent-Following or PTSF (measured in percentage – %)
According to the HCM 2010, percent time-spent-following “is the average percentage of time that vehicles must travel in platoons behind slower vehicles due to the inability to pass. Percent time-spent-following also represents the approximate percentage of vehicles traveling in platoons.” PTSF is an MOE compatible with uninterrupted (two-lane highways) flow. This guidebook recommends that this MOE only be used for undersaturated conditions.

Percent of Free-Flow Speed or PFFS (measured in percentage – %)
According to the HCM 2010, “percent of free-flow speed represents the ability of vehicles to travel at or near the posted speed limit.” PFFS is an MOE compatible with uninterrupted (two-lane highways) flow. This guidebook recommends that this MOE only be used for undersaturated conditions.

LOS is used to illustrate the relative difference for each aforementioned MOE, with the exception of v/c ratio. For example, to determine the performance or LOS of a freeway segment, density is used. Once density is determined through the traffic analysis, a LOS scale defined in the HCM 2010 is used to illustrate the density based on a letter grade (see Table 1). According to the HCM 2010, neither LOS nor any other single MOE tells the full story of roadway performance, which is why the HCM 2010 provides methods for estimating a variety of useful MOEs, some of which were previously mentioned.

### Table 1 – Freeway Facility Level of Service in Terms of Density

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Density (pc/mi/ln)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤ 11</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 11 - 18</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 18 - 26</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 26 - 35</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 35 - 45</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 45</td>
</tr>
</tbody>
</table>

*Source: HCM 2010, Volume 2, Page 10-9*
The analysis procedures and resulting MOEs (i.e., delay, density, speed, etc.) in the HCM 2010 are based on deterministic models, in the form of equations, which are based on traffic flow theory. Most of the equations from these models include empirical calibration factors derived from research. On the other hand, microsimulation is based on the flow of vehicles along a roadway segment in accordance with principles of physics, vehicle attributes, rules of the road, and driver behavior.

While both types of tools attempt to replicate travel conditions on the roadway, it is often challenging to find results that are comparable. For example, density reported from the HCM 2010 is expressed in terms of passenger cars per mile, while density reported from microsimulation tools is expressed in terms of actual vehicles per mile. Since different analysis tools contain different definitions for similarly named MOEs, inaccurate results and conclusions may be reported if the differences are not properly accounted for.
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When saturated conditions are prevalent within a transportation system, deterministic tools should not be used to analyze traffic operations due to limitations in the fundamental analysis equations used to develop the tools. Microsimulation tools can be very valuable for transportation analyses; however, similar to deterministic tools, there are limitations that need to be considered. For example, microsimulation tools are not designed to model two-way left-turn lanes.

5.1 Microsimulation Applicability and Calibration

With each model used to analyze traffic operations, there are tradeoffs. Deterministic models are relatively easy to use and are not very time or data intensive. In contrast, traffic simulation-based tools require more time and cost to develop a model and appropriately validate and calibrate. This difference is depicted illustratively in Figure 2.

Figure 2 – Time/Cost Comparison for Deterministic and Microsimulation Tools

The difference in time and cost for these tools is often interrelated and can be accounted for in the following factors: additional data collection requirements (e.g., calibration, origin-destination, etc.), effort to develop and calibrate the microsimulation model, additional time required for post-processing output, time to become proficient using the analysis tools, cost to purchase the analysis tools, to name several.

The capabilities of each tool are where the time and cost investments can be observed. Deterministic models perform “snapshot” analyses, which in most non-congested situations and traditional geometry is adequate. Microsimulation-based tools allow the user to evaluate both under- and oversaturated conditions while many different factors are allowed to fluctuate (speed, driver behavior, etc.) over time. The robustness of these tools can provide the user with...
much more information than a deterministic model could provide. Additionally, a traffic simulation tool can often provide 2-dimensional or 3-dimensional visualization of the results allowing the user to visually observe the analytical results – a very powerful benefit to discern between varying levels of oversaturated conditions.

The guiding principle for either deterministic or simulation models is that the model is only as accurate as the inputs that are used. This means that accurate and appropriate values for inputs should be used at all times supported by field documentation, when available. Chapter 6 provides guidance on common inputs available in each of the tools (deterministic and simulation-based) considered in this guidebook.

In addition to the use of accurate inputs, simulation-based models need to be calibrated. The calibration procedure is the most important component of network development to ensure that the model accurately represents existing and future traffic conditions. Making changes to global calibration factors such as car following or lane-changing characteristics prior to establishing that the link level conditions are as accurate as possible, will result in an unrealistic model. Therefore, more global changes to the model should be made as a last resort. For calibration purposes, refer to the suggested CORSIM and VISSIM calibration factors provided in Appendix C.

Although the calibration process is a critical component of traffic simulation, the intent of this guidebook is to focus on the selection and use of the most appropriate analytical tool(s) for various transportation analyses. Therefore, it is recommended that the user of this guidebook refer to the step-by-step calibration process described in the Traffic Operations Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Software (FHWA-HRT-04-040).

5.2 Simulation Sample Size

In addition to conducting proper network calibration, determining the appropriate number of simulation runs is also very important step in developing accurate traffic simulation results. The number of simulation runs shall be calculated based on the FHWA sample size determination methodology, as referenced in TE Memorandum XX (to be released). Using too few simulation runs will not fully account for simulation variance, while using too many runs will become overly time-intensive for analysis purposes. FHWA developed a statistical process to ensure that an appropriate number of simulation runs are performed at a 95th percentile confidence level. This methodology for determining the number of simulation runs was adopted in this guidebook. These computations shall be submitted as supporting documentation with the traffic simulation analysis.

The overall process represents a standard statistical “t-Test”, where the mean and standard deviation of specific MOEs are evaluated to determine whether they are within an allowable tolerance at a certain confidence level. FHWA recommends a 95th percentile confidence level with a 10% tolerance. The process starts by identifying a particular MOE and a location in the network to obtain the chosen MOE. The location should have some variance in results between the runs based on speed changes, conflicts (weaving segments), and signal control. Once the
location and MOEs are chosen, an initial number of 10 runs should be evaluated. From the results of the 10 runs, the mean and standard deviation should be computed. Once these values are obtained, Equation 1 should be used to determine the appropriate sample size:

\[ N = \left( \frac{Z}{S} \right)^2 \frac{S}{E^2} \]  

(1)

In this equation, “N” represents the necessary sample size, “Z” represents the number of standard deviations away from the mean corresponding to the required confidence level (assuming a normal distribution and confidence interval of 95\textsuperscript{th} percentile, which corresponds to a value of 1.96), “S” represents the sample standard deviation, and “E” represents the tolerable error in terms of the sample mean.

As an example of applying this methodology, assume that speed is chosen as the primary MOE for the project. After 10 initial runs, the sample mean is computed to be 32.5 mph and the sample standard deviation is 8.5 mph. The default confidence level and tolerance error assumed by FHWA are 95% and 10%, respectively. To calculate “E” in terms of the sample mean, multiply the mean (32.5 mph) by the tolerance error percent (10%). In this example, “E” would be 3.25 mph. Using Equation 1, the computed sample size is 26.27, or 27 runs. This result means that the initial 10 runs were not adequate and a new simulation must be performed for a minimum of 27 runs. The sample size methodology is an iterative process, such that a new round of calculations will need to be performed on the results of the 27 runs to see if 27 runs are adequate. Understanding that this iterative process could become very time consuming and costly, a maximum threshold of 30 runs was established.

To assist the users of this guidebook, a Sample Size Determination Tool was developed to accompany this guidebook. This Excel-based tool requires the user to enter the MOEs from the initial 10 runs. The 95\textsuperscript{th} percentile confidence interval and 10% tolerance remain default values in the tool and shall not be changed. An example of how the tool is used is shown in Figure 3 and Figure 4. For a more detailed explanation of the sample size determination calculations, see the Technical Appendix. In this example, values from a hypothetical MOE are reported for 10 runs (see Figure 3). After running the sample size determination methodology, it was determined that 13 runs do not fall within the 10% tolerance level. Working backwards, the tool estimates that 16 runs should be run and re-tested. After the second iteration with 16 runs, the MOE values from the 16 runs are determined to be within tolerance thresholds. The tool then reports that no more runs are required.
Chapter 5 – Microsimulation

Traffic Operations Analysis Tool Guidebook

Version 1.1

Figure 3 – Screen Shot of Failing Sample Size Determination Tool

Sample Size Determination Tool

<table>
<thead>
<tr>
<th>User Inputs</th>
<th>Sample Size (N) = Number of Model Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constants</td>
<td>Sample Mean ( \bar{X} = \frac{1}{N} \sum_{i=1}^{N} X_i )</td>
</tr>
<tr>
<td>Outputs</td>
<td>Sample Standard Deviation ( s = \sqrt{\frac{\sum (X_i - \bar{X})^2}{N-1}} )</td>
</tr>
</tbody>
</table>

- Sampling Error = \( Z \left( \frac{s}{\sqrt{N}} \right) \)
- Confidence Level = \( \bar{X} \pm Z \left( \frac{s}{\sqrt{N}} \right) \)
- \% of Sample Mean (E) = \% Tolerance * \( \bar{X} \)
- Sample Size Needed = \( \left( \frac{Z^2 \times s^2}{E^2} \right) \)

Model Iterations

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
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<td>45</td>
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</tr>
<tr>
<td>9</td>
<td>59</td>
</tr>
<tr>
<td>10</td>
<td>54</td>
</tr>
</tbody>
</table>

Sample Size Outputs

| N   | 10.0  |
| X_s | 46.1  |
| S_s | 8.1   |
| E   | 4.6   |
| Z   | 1.96  |

Z is the number of standard deviations away from the mean corresponding to the required confidence level in a normal distribution.

Figure 4 – Screen Shot of Passing Sample Size Determination Tool

Sample Size Determination Tool

<table>
<thead>
<tr>
<th>User Inputs</th>
<th>Sample Size (N) = Number of Model Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constants</td>
<td>Sample Mean ( \bar{X} = \frac{1}{N} \sum_{i=1}^{N} X_i )</td>
</tr>
<tr>
<td>Outputs</td>
<td>Sample Standard Deviation ( s = \sqrt{\frac{\sum (X_i - \bar{X})^2}{N-1}} )</td>
</tr>
</tbody>
</table>

- Sampling Error = \( Z \left( \frac{s}{\sqrt{N}} \right) \)
- Confidence Level = \( \bar{X} \pm Z \left( \frac{s}{\sqrt{N}} \right) \)
- \% of Sample Mean (E) = \% Tolerance * \( \bar{X} \)
- Sample Size Needed = \( \left( \frac{Z^2 \times s^2}{E^2} \right) \)

Model Iterations

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Speed</th>
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<tbody>
<tr>
<td>1</td>
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<td>11</td>
<td>43</td>
</tr>
<tr>
<td>12</td>
<td>46</td>
</tr>
</tbody>
</table>

Sample Size Outputs

| N   | 12.0  |
| X_s | 45.8  |
| S_s | 7.4   |
| E   | 4.6   |
| Z   | 1.96  |

Z is the number of standard deviations away from the mean corresponding to the required confidence level in a normal distribution.
When conducting either traffic or planning analyses, there are two types of assumptions that should be considered. The first group of assumptions pertains to the data and analysis methodologies required for traffic or planning analyses, which are discussed in Chapter 5, while the second group focuses on the assumptions for the individual traffic analysis tools, which are discussed in Chapter 6.

A project scoping meeting should be held prior to the start of the project between the VDOT project manager, other individuals involved in the project review process, and the transportation engineers and/or planners responsible for conducting the analysis. The agenda of the meeting should include a discussion of the study area (e.g., intersections and/or interchanges to be studied), required traffic analysis tools to be used for the network analysis derived from the traffic software selection tool, major traffic assumptions (e.g., growth rates, seasonal adjustment factors, peak hour factors, etc.), and the proposed study methodology.

The following analysis assumptions will be discussed in detail for each analysis type in this chapter:

- Geometric data
- Traffic count data
- Signal operations data
- Calibration data
- Roundabout analysis methodology
- Design impacts to analysis

A basic intersection analysis typically evaluates intersection operations with a minimum of two measures of effectiveness: delay (measured in seconds per vehicle) and queue length (measured in feet). Although individual intersection (signalized or unsignalized) analyses can be stand-alone analyses, arterial analyses consist of multiple intersection analyses combined using signal timing and progression. Therefore, all data for this category are pertinent to both individual intersection analyses and arterial analyses.

In some instances, multilane highways can be similar to freeway segments where opposing directions of travel are divided by a median, intersections are spaced greater than 2 miles apart, and travel speeds of 55 mph or greater are observed. In other instances, multilane highways operate more as an arterial with two-way-left-turn lanes and speeds of 45 mph or less.

### 6.1 Geometric Data

Geometric data includes any data required to develop the physical extents of a network including link lengths, travel lane widths, number of lanes, and lane designations. Overall, there are many different geometric inputs required to develop all of the analytical networks covered...
in this guidebook; however, not all geometric data are needed for each analysis. Table 2a and Table 2b indicate which geometric data is required for each analysis type.

Current aerial imagery should be used when initially developing all geometric networks; in addition, in-field verification should also be conducted to validate that the aerial imagery is accurate. For analytical tools that do not have taper length inputs, an “effective storage” length should be input into the storage bay length field, which is equal to half the taper length summed with the storage bay length.

6.2 Traffic Count Data

This section focuses on five essential peak hour traffic count data components:

1. Traffic count data requirements
2. Heavy vehicle classification
3. Appropriate age of traffic count data
4. Peak hour determination
5. Volume balancing

6.2.1 Traffic Count Data Requirements

Traffic count data includes all vehicular count data (automobiles, bicycles, and pedestrians) necessary to analyze existing or future condition operations. Other data pertinent to signal timing and calibration (speed and queue data) will be discussed in the following sections of this chapter. Table 3 indicates which traffic data is required for each type of traffic analysis.

Four consecutive hours of Turning Movement Counts (TMC) are suggested in each peak period, collected in 15-minute intervals. If peak hour spreading does not exist or the analysis is in a rural location, then 2 to 3 hours of TMC data could be acceptable. These counts need to include vehicular and heavy vehicle counts by movement, in addition to all pedestrian and bicycle crossings. In addition to TMC data, all bus blockages and parking maneuvers occurring within 250 feet (in either direction of travel) from the stop bar of an approach should be counted during the same time period.

For Toll Plaza Analyses, 4 hours of data for each payment choice (and lane) are required. In cases where severe peak hour spreading is occurring, more than four hours of data could be required, with the exception of Bicycle and Pedestrian Analyses. In all cases, any deviation from the standard 4 hours of data needs to be documented and agreed to by the project manager. Both raw and processed traffic count data shall be submitted with the analysis.

For vehicle classification data, 48 consecutive hours of data for each lane should be collected in 15-minute intervals. Detailed guidance on vehicle classifications will be provided later in this section. Although discussed in Section 6.4 of this chapter (Calibration Data), both vehicle classification and speed data should be counted concurrently with current traffic count technologies.
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<th>Location of Preemption Devices</th>
<th>Approach Grade</th>
<th>Lane Widths</th>
<th>Storage Bay Lengths</th>
<th>Taper Lengths</th>
<th>Intersection Approach Widths</th>
<th>Shoulder Widths</th>
<th>Lane Designations</th>
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Table 3 – Standard Traffic Data Collection Parameters

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<th>Vehicle Daily Link Traffic Counts</th>
<th>Heavy Vehicle Turning Movement Counts</th>
<th>Bicycle and Pedestrian Counts</th>
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For all traffic count data, average weekday traffic volumes should be collected only on Tuesdays, Wednesdays, and/or Thursdays, while average weekend traffic volumes should be collected only on Saturdays and Sundays. In cases where there are special events creating isolated peak travel periods, data should be collected on the same day(s) corresponding to the special event. All data should be collected concurrently on the same day(s) throughout the entire network to the extent possible.

For example, one intersection (or ramp) should not be counted in October 2012 and then another intersection (or ramp) counted in March 2013. In the event of any unplanned circumstances occurring during the data collection process, such as inclement weather or a vehicle crash, the event should be documented and evaluated by the project manager to determine if additional counts should be conducted. Any additional counts should be collected as close to the original count date as possible and during the same time period during the week (weekday or weekend).

In addition to the data identified in Table 3, origin-destination counts may be needed especially for more complex projects where calibration of a traffic simulation model is required. The scope and acceptable tolerances of the origin-destination counts should be approved by the project manager.

6.2.2 Appropriate Age of Traffic Count Data
Since traffic count data and aerial imagery are constantly changing, it is important that all network development and analyses be performed using the most up-to-date information. It is therefore essential that age limitation guidelines be established for all traffic count data and aerial imagery, regardless of analysis type. The appropriate age of traffic count data is 2 years from when the initial traffic data was collected or imagery was collected and when the analysis is being conducted. Furthermore, if travel conditions within the analysis study area have changed significantly within the aforementioned two-year timeframe, new traffic counts could be required by the project manager.

The appropriate age of aerial imagery that is used in coordination with traffic analysis is also 2 years; however, field validation is required to ensure that the aerial matches current conditions. The option to use older imagery should be made by the project manager based on validation.

6.2.3 Peak Hour Determination
For isolated, point analyses, the highest four consecutive 15-minute intervals of traffic count data should be considered the peak hour. For segment, corridor, system, and area analyses, a common uniform peak hour should be computed and applied throughout the entire network (e.g., each data entry should be from the same hour). For simulation analyses, the modeling period can be increased beyond one hour to account for this issue. For other types of analyses, one uniform peak hour should be used.
6.2.4 Heavy Vehicle Classification
For all analyses in this guidebook, heavy vehicle classifications should comply with existing guidelines established by FHWA. These guidelines, presented in Figure 5, contain 13 individual vehicle classifications. By definition, any vehicle with a classification of 4 or higher should be considered a “heavy vehicle” when traffic counts are collected.

Figure 5 – FHWA Vehicle Classification

6.2.5 Volume Balancing
When traffic volumes are collected and peak hour traffic volumes are computed, there are several factors that can cause imbalances in traffic volumes departing one intersection and arriving at the next. Factors impacting volume balancing can include:

1. The methodology in which peak hour volumes are selected (e.g., selecting peak hours for each intersection versus using a universal peak hour for all intersections)
2. The impact of private driveways, parking lots, or parking garages along arterials or multilane highways
3. Variations in traffic volumes between different days of the week, different weeks of the month, or different months of the year
4. The inherent variation in various traffic count equipment used
In most cases, there will be discontinuity in traffic volumes between intersections, even when traffic counts are conducted on the same day. Minor fluctuations (less than 25 vehicles or 10% of the total approach traffic volumes), can still yield accurate results in deterministic models (HCS, Synchro, and SIDRA Intersection); however, even minor fluctuations can have significant impacts on the volumes simulated in microsimulation-based models (CORSIM, VISSIM, and SimTraffic). Since some of the microsimulation tools depend on turning percentages, imbalances in traffic volumes will cause the percentages calculated by the software to differ, sometimes substantially.

If a substantial volume of traffic (greater than 10 percent) appears in the network or disappears from the network, or if a significant number of driveways exist between intersections, further investigation may be warranted before the network can be balanced. This investigation should be pursued to determine whether the imbalance is created due to a large trip generator between intersections. If there are no entrances or obvious reasons for the traffic volume variation and the difference in volumes are substantial, further investigation to determine the reason for the discrepancies is justified. Figure 6 depicts an example of an unbalanced network along with the associated impacts that would be experienced with a microsimulation model (depicted in the example as CORSIM).

**Figure 6 – Effects of an Unbalanced Network on Microsimulation**

There are many ways that traffic volumes can be balanced. A common practice is to proportionally change the individual downstream traffic volumes (by movement) based on a comparison of the original traffic volumes and upstream approaching traffic volumes. This methodology would then be repeated until the end of the network has been reached. Another method to balance the network is to add mid-block driveway(s) to account for the imbalances.
6.2.6 Other Data Considerations for Work Zones
In addition to the data collection requirements for work zones identified in Table 2a for work zone analyses, other work zone data should be obtained, such as lane closure information, lane closure lengths, time of day of closure, intensity of work zone, detour and alternative route availability, and condition of alternative routes (i.e., whether alternative routes are over or under capacity).

6.3 Signal Operations Data
For those analyses that involve either traffic signals or pedestrian signals, it is important to obtain critical signal timing data to accurately analyze existing conditions. All traffic and pedestrian signal timing data, in addition to being observed in the field, should be obtained from the appropriate VDOT Regional Traffic Operations office or city/town engineering office, and should include the following data for all timing plans:

- Splits
- Clearance intervals
- Cycle lengths
- Offsets
- Type of controller (NEMA, fixed time, etc.)
- Sequencing and phasing diagrams
- Time of day clocks
- Pedestrian crossing times ("WALK" and "DON'T WALK")
- Transit priorities
- Preemption timings
- Ramp metering data (i.e., processing splits, capacity criteria, etc.)

6.4 Calibration Data
Calibration data is required to develop an analytical network. There are a wide variety of calibration data available; however, they generally fall into four categories – peak hour traffic volume, speed, travel time, and/or queuing. Table 4 indicates which calibration data are required for each analysis; however, the various calibration data requirements may be modified at the discretion of the project manager. For example, the project manager may identify the need for a speed-delay run to supplement speed results. Lists of more detailed calibration factors specifically applicable to CORSIM and VISSIM are provided in Appendix C.

Regardless of whether the desired network is deterministic or stochastic, calibration data is required. For both types of networks, speed for uninterrupted flow facilities and queue length for interrupted flow facilities are critical elements that are highly desirable for calibration. Although roadways and ramps have posted speed limits and associated design speeds, the most
# Chapter 6 – Standard Requirements for Analyses

## Traffic Operations Analysis Tool Guidebook

**Version 1.1**

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<th>Peak Hour Traffic Volume</th>
<th>Pedestrian and Bicycle Travel Speeds</th>
<th>Mainline Speed Data</th>
<th>Ramp Speed Data</th>
<th>Toll Lane Processing Time by Payment Choice</th>
<th>Travel Times</th>
<th>Queuing Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signalized Intersection, Stop-Controlled Intersection, and Arterial Analyses</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Signalized Intersection Preemption and Transit Priority Analyses</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Roundabout Analyses</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Traditional Intersection/Interchange Analyses <em>(SPUI, CFI, Displaced Left-Turn Intersection)</em></td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Pedestrian and Bicycle Analyses <em>(On- and Off-Street)</em></td>
<td></td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeway and Interchange Analyses <em>(Merge, Diverge, Weave, and Collector-Distributor)</em></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Two-Lane Highway Analyses</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multilane Highway Analyses</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Workzone Traffic Analyses <em>(Freeway or Arterial)</em></td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toll Plaza Analyses</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Freeway HOV or Ramp Metering Analyses</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>
reliable data to calibrate freeway operations are speeds. Forty-eight consecutive hours of speed data for each direction of travel should be collected in 15-minute intervals. The most reliable data to calibrate arterial operations are delay, travel time, and queues. Travel time and delay runs should be conducted in the study corridor and queue lengths should be observed and measured. As previously discussed, this data should be collected at the same time as the vehicle classification counts.

Similar to the traffic count data, calibration data also has an age limit of 2 years from when the analysis is conducted. If the analysis is being performed on a future geometric network, then design speeds should be used in lieu of collected data. For toll plaza analyses, speed data is not required since travel speeds are dependent on the processing speeds of the individual toll lanes. At least 4 hours of vehicle processing data for all available payment options should be performed.

Travel time and queuing data are not required for deterministic networks, but are necessary to calibrate existing conditions in microsimulation networks. At least 10 travel time runs should be collected along any predetermined routes during each peak period being analyzed. For example, if AM and PM peak hour microsimulation analyses are to be performed, then there should be at least 10 travel time runs performed during the AM peak and at least another 10 travel time runs performed in the PM peak. If a travel time runs are conducted, then they shall be conducted in accordance with the procedures identified in the latest edition of the ITE Manual of Transportation Engineering Studies.

Queuing data includes queue lengths resulting from constricting roadway network elements such as intersections, lane drops, or construction zones. Queue lengths should be collected once every 5 minutes over the extent of time that queuing is known to occur.

Origin-destination (O-D) data can be used as another source of calibration data, although it is not a mandatory data requirement. Based on extensive time impacts and associated costs with collecting O-D data, it should only be required on a project if existing travel routes and turning movements will be changed under future conditions. The methodology used for collecting O-D data should be determined at the discretion of the project manager (e.g., survey, license plate survey, blue tooth, etc.) based on the budget and schedule constraints of the project. For fiscally-constrained projects, there are cheaper nontraditional methodologies to collect this data, such as probe data.

### 6.5 Roadway Design Impacts

The VDOT Road Design Manual references traffic analysis results for use in determining various geometric features of the highway. The key areas within the manual that reference the need for traffic analyses are described in the sections that follow. More specifically, the use of traffic analysis tools for determining left- and right-turn storage lengths and the use of traffic analysis tools to quantify the impacts of access management improvements are described in Appendix F of the VDOT Road Design Manual.
6.5.1 Determination of Roadway Design

The VDOT Road Design Manual (Section 2B–3 Determination of Roadway Design) recommends that the results of a capacity analysis be used to determine the number of through lanes on the mainline. Roadway capacities for connecting and crossing roadways should also be determined, taking into consideration plans for future improvements to these facilities.

Where at-grade intersections are proposed, along with other analyses, a capacity analysis should also be completed to determine whether or not the intersection will operate at a satisfactory level of service. If the analysis indicates an unsatisfactory service level, mitigating measures such as an interchange should be considered. When interchanges are proposed, or are being considered, a capacity analysis should be used to determine the interchange configuration required. For the roadway to meet future design year level of service requirements, a full interchange analysis should be performed.

Considering the case when intersecting streets do not materially impact the capacity results, HCS should be used to determine the number of lanes on the arterial. If the number of intersecting streets becomes an issue, then Synchro should be used to determine the number of lanes on the arterial, especially when the roadway is located within an urban environment. If Synchro is unable to model the roadway configuration, a microsimulation tool should be used (i.e., CORSIM or VISSIM).

6.5.2 Turn Lanes

According to the VDOT Road Design Manual - Appendix F (Figure 3-1 and Figure 3-4), the determination of the need for and the dimensions of left- and right-turn lanes should be based on traffic volumes and a traffic operations analysis. For oversaturated conditions, microsimulation should be used to determine the queue length (in feet). The results of the analysis should be summarized in the format(s) described in Chapter 9 or in similar graphical formats acceptable to the project manager.

To determine the length of queue turn lanes, results should be derived from Synchro, SimTraffic, CORSIM, and/or VISSIM depending on the complexity of the project and the preference of the project manager. Due to the complexity of computing queue length, it is preferred, but not required, that one of the three approved traffic simulation tools be used to estimate the queue length. The project manager will require that the back of queue (or maximum queue) to be reported; however, the entire impact of the queue must be determined by determining the impacts of spillback if it is applicable.

The impacts of queue spillback are accounted for differently in the various traffic simulation tools. For example, when queue spillback occurs in SimTraffic, vehicles not accounted for in the 95th percentile queue are identified by a queuing penalty. In this case, the additional number of vehicles identified in the queuing penalty should be multiplied by an average vehicle length of 25 feet. This product should then be added to the back of queue to derive the total estimated queue length. The overall queue length results from CORSIM and VISSIM should be derived by adding the maximum queues from the link including the turn lane to the associated queues on
upstream links, if applicable. The results of the analysis should be summarized in the format(s) described in Chapter 9 or in similar graphical format acceptable to the project manager.

According to the VDOT Road Design Manual - Appendix F (Figure 3-1), when dual left-turn lanes are required, a capacity analysis of the intersection should be performed to determine what traffic controls are necessary (i.e., signal phasing and timing modifications) for the dual left-turn lane to function properly. Depending on the traffic conditions at the intersection (assumed to be a signalized intersection), either Synchro/SimTraffic is the preferred method of analysis. The same procedure should be followed if dual right-turn lanes are required.

The results of the overall intersection analysis, in terms of delay per vehicle, should be summarized and compared to the delay thresholds established for that jurisdiction. In addition, the queue length for the turn lanes should be computed and compared to the proposed length of the turn lanes to determine if the storage and taper lengths are adequate. The results of the analysis should be summarized in the format(s) described in Chapter 9 or in similar graphical formats acceptable to the project manager.

6.5.3 Access Management Impacts

In addition, traffic analyses are required to determine the impacts of access management improvements according to the VDOT Road Design Manual - Appendix F. Pertaining to intersection analyses with respect to access management, the document states the following: “A Highway Capacity Manual (HCM) capacity or other appropriate analysis (Synchro/CORSIM) should be performed for intersection capacity and signalization requirements, and include a queuing analysis.”

6.5.3.1 Crossover Spacing

According to the VDOT Road Design Manual - Appendix F, new crossovers not meeting current VDOT crossover spacing standards will only be allowed if approved by the VDOT District Land Use Engineer. This analysis should be conducted using HCS or Synchro in undersaturated traffic conditions to determine if the crossover functions from an overall delay standpoint during the two weekday peak periods. During saturated traffic conditions, either VISSIM or CORSIM can be used to determine the delay and queuing impacts of the new crossover. The results of the analysis should be summarized in the format(s) described in Chapter 9 or in similar graphical formats acceptable to the project manager.

6.5.3.2 Traffic Signal Spacing

According to the VDOT Road Design Manual – Appendix F, efficient traffic progression is essential on arterials to maximize safety and capacity. To determine if a proposed traffic signal is negatively impacting traffic progression, a traffic analysis should be conducted using Synchro in conjunction with SimTraffic, since it has the capability of analyzing an optimized traffic signal network. Depending on the complexity of the roadway system to be analyzed, the project manager may require additional traffic signal analysis software to be used. The results of the analysis should be summarized in the format(s) described in Chapter 9 or in similar graphical formats acceptable to the project manager.
Chapter 7 – Standard Assumptions for Tools

Traffic Operations Analysis Tool Guidebook
Version 1.1

7 Standard Assumptions for Tools

Each traffic analysis tool evaluated in this guidebook has its own set of unique inputs. Although the inputs have varying levels of impact on the operational results, it is critical that clear guidance to be established for each input. This guidebook describes the most frequently used inputs for each analysis tool, regardless of the type of analysis.

The following sections of this chapter will detail the assumptions behind the inputs used for HCS, Synchro, SimTraffic, SIDRA Intersection, CORSIM, and VISSIM. The inputs used for Quickzone analyses should be agreed upon by the project manager. If a particular program input is not discussed in this chapter, then the default values should be used for all analyses. Any deviation from the following guidelines will require written documentation and justification prior to being reviewed by the project manager.

7.1 HCS 2010

The HCS 2010 software is comprised of many different modules to evaluate various geometric configurations. This guidebook covers the following HCS 2010 modules:

1. Freeways
2. Weaving
3. Ramps
4. Facilities
5. Multilane
6. Two-Lane
7. Streets
8. Unsignalized (TWSC and AWSC)
9. Signals

TWSC represents two-way stop-controlled intersections and AWSC represents all-way stop-controlled intersections.

Similar default values are utilized for the various HCS 2010 uninterrupted flow modules as shown in Table 5a and Table 5b. Parameters such as traffic volume, peak hour factor, and grade are applicable to multiple modules. The standard HCS parameters for freeways, inclusive of those mentioned above, are described within the following text and are also shown in Table 5a in Section 7.1.1. To reduce redundancy for describing these parameters in multiple sections, only the descriptions of the parameters differing from documentation in Section 7.1.1 are described in the subsequent sections of Section 7.1. For example, since all default values for weaving...
sections are the same as freeways except for the mainline free-flow speed, only mainline free-flow speed for weaving sections is further described in Section 7.1.2.

Table 5a – HCS 2010 Standard Parameters

<table>
<thead>
<tr>
<th>MODULE</th>
<th>HCS PARAMETER</th>
<th>TYPICAL VALUE, ACCEPTABLE RANGES, and/or SPECIAL NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merge/Diverge/Weave/Freeway/Facilities/Multilane/Two-Lane</td>
<td>Traffic Volume</td>
<td>Use a 60-minute peak hour traffic volume.</td>
</tr>
<tr>
<td>Merge/Diverge/Weave/Freeway/Facilities/Multilane/Two-Lane</td>
<td>Peak Hour Factor</td>
<td>Use existing count data for existing analyses. For future year analyses, the PHF should be calculated based on future land use. If that is not possible, then use 0.92 or existing whichever is higher.</td>
</tr>
<tr>
<td>Merge/Diverge/Weave/Freeway/Facilities/Multilane/Two-Lane</td>
<td>Grade</td>
<td>Use the existing grade, if available. If it is not available, use 0-2% for level, 2-4% for rolling, and 4%+ for mountainous.</td>
</tr>
<tr>
<td>Merge/Diverge</td>
<td></td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph. Analysis will not allow less than 55 mph or greater than 70 mph.</td>
</tr>
<tr>
<td>Weave Segment</td>
<td></td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph. Analysis will not allow less than 35 mph or greater than 80 mph.</td>
</tr>
<tr>
<td>Freeway Segment</td>
<td>Mainline Free-Flow Speed</td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph and apply the necessary adjustments. Analysis will not allow less than 55 mph or greater than 75 mph.</td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph. Analysis will not allow less than 55 mph or greater than 75 mph.</td>
</tr>
<tr>
<td>Multilane/Two-Lane</td>
<td></td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph and apply the necessary adjustments. Analysis will not allow less than 45 mph or greater than 60 mph.</td>
</tr>
<tr>
<td>Merge/Diverge/Weave/Freeway/Facilities/Multilane/Two-Lane</td>
<td>Truck, Bus, and RV Equivalent Factors</td>
<td>Should be based on HCM tables.</td>
</tr>
<tr>
<td>Merge/Diverge/Weave/Freeway/Facilities/Multilane/Two-Lane</td>
<td>Truck, Bus, and RV Percentages</td>
<td>Use existing count data. For future analyses, use existing values or 2%, whichever is greater.</td>
</tr>
<tr>
<td>Merge/Diverge</td>
<td>Number of Lanes</td>
<td>Analysis will not allow less than 2 lanes.</td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td>Analysis will not allow less than 2 lanes or greater than 5 mainline lanes.</td>
</tr>
<tr>
<td>Multilane</td>
<td></td>
<td>Analysis will not allow less than 2 lanes or greater than 3 mainline lanes.</td>
</tr>
<tr>
<td>Multilane/Two-Lane</td>
<td>Lane Widths</td>
<td>Use existing data. Acceptable range is between 10 and 12 feet.</td>
</tr>
</tbody>
</table>
### Table 5b – HCS 2010 Standard Parameters

<table>
<thead>
<tr>
<th>MODULE</th>
<th>HCS PARAMETER</th>
<th>TYPICAL VALUE, ACCEPTABLE RANGES, and/or SPECIAL NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-Lane</td>
<td>Shoulder Widths</td>
<td>Use existing data. Shoulder widths greater than 6 feet should be recorded as 6 feet.</td>
</tr>
<tr>
<td>Multi-Lane</td>
<td>Lateral Clearance</td>
<td>Use existing data. Lateral clearances greater than 6 feet should be recorded as 6 feet.</td>
</tr>
<tr>
<td>Two-Lane</td>
<td>Percent No Passing Zones</td>
<td>Use existing data.</td>
</tr>
<tr>
<td>Multi-Lane/Two-Lane</td>
<td>Access Point Density</td>
<td>Use existing data recorded in access points per mile in both directions. More than 40 access points per mile should be recorded as 40 access points per mile.</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Analysis Type</td>
<td>Use single period.</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Turn-Lane Storage Length</td>
<td>Use effective storage length (storage length + half taper length).</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Operating Parameters</td>
<td>Use default values.</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Traffic Signal Timing</td>
<td>Use existing data for existing analyses. If it is not available, measure it in field during the peak hour. For future analyses, use optimized signal timings.</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Minimum Green</td>
<td>Use existing data for existing analyses. For future analyses, typically use 5 seconds (based on VDOT preferences).</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Yellow</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 3 seconds (based on VDOT clearance interval standards).</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>All-Red</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 1 second (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Signalized Intersection</td>
<td>Base Saturation Flow Rate</td>
<td>Use 1,900 passenger cars per hour per lane (pcphpl).</td>
</tr>
<tr>
<td>Unsignalized Intersection</td>
<td>Critical Gap and Follow-Up Time</td>
<td>Use default values.</td>
</tr>
<tr>
<td>Unsignalized Intersection</td>
<td>Pedestrian Walking Speed</td>
<td>Use 4.0 feet per second.</td>
</tr>
<tr>
<td>Unsignalized Intersection</td>
<td>Base Saturation Flow Rate</td>
<td>Use 1,700 vehicles per lane (only valid if upstream signalized intersection exists).</td>
</tr>
<tr>
<td>Merge/Diverge/Facilities</td>
<td>Ramp Free-Flow Speed</td>
<td>Use existing data. If it is not available, use either the design speed or warning speed + 10 mph. Analysis will not allow less than 10 mph or greater than 70 mph.</td>
</tr>
<tr>
<td>Merge/Diverge/Facilities</td>
<td>Accel/Decel Lane Length</td>
<td>1,500 feet maximum. If it is longer, then use the maximum value of 1,500 feet.</td>
</tr>
<tr>
<td>Merge/Diverge/Weave/Freeway/Facilities/Multilane</td>
<td>Driver Population Adjustment Factors</td>
<td>Use default (1.00).</td>
</tr>
<tr>
<td>Facilities</td>
<td>Capacity Adjustment Factors</td>
<td>Use default (1.00).</td>
</tr>
<tr>
<td>Facilities</td>
<td>O-D Demand Adjustment Factors</td>
<td>Use default (1.00). Only modify default if conducting a sensitivity analysis at ramps.</td>
</tr>
<tr>
<td>Merge/Diverge</td>
<td>Capacity Checks</td>
<td>If any of the capacity checks are &quot;Yes&quot;, then a microsimulation tool should be used.</td>
</tr>
</tbody>
</table>
7.1.1 Freeways

Traffic Volume: Traffic volumes shall be entered as a 60-minute interval.

Peak Hour Factor: PHF should be determined based on existing traffic count data. For existing analyses, PHFs shall be computed from existing count data. For future year analyses, the PHF should be calculated based on future land use. If that is not possible, then use 0.92 or existing whichever is higher.

Grade: Grades should be based on existing data or existing design plans. If neither of these two sources are available, then the following ranges from the HCM 2010 should be used:
- Level Terrain (L): 0-2%
- Rolling Terrain (R): 2-4%
- Mountainous Terrain (M): 4-6%

Mainline Free-Flow Speed: Free-flow speed should be based on existing data. If existing data is not available, then a base free-flow speed equal to the posted speed limit +7 mph should be used, with the necessary HCM speed adjustments then being applied to determine a free-flow speed. HCS 2010 will not allow any measured free-flow speeds less than 55 mph or greater than 75 mph.

Heavy Vehicle Percentages: HVPS should be based on existing count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%. HCS 2010 will not allow a truck percentage greater than 25%.

Heavy Vehicle Equivalent Factors: These factors should be based on what is provided in Chapter 11 of the HCM 2010.

Driver Population Adjustment Factors: HCS 2010 default value of 1.0 should not be modified; however, adjustments ranging between 0.85 and 1.0 can be made as long as technical justification is provided about why the adjustment is necessary.

7.1.2 Weaving

Mainline Free-Flow Speed: Mainline free-flow speeds less than 35 mph or greater than 80 mph are not allowed in HCS 2010.

7.1.3 Ramps

Number of Lanes: HCS 2010 will not allow less than two mainline lanes.

Mainline Free-Flow Speed: Mainline free-flow speeds less than 55 mph or greater than 70 mph are not allowed in HCS 2010.

Ramp Free-Flow Speed: Free-flow speed should be based on existing data. If existing data is not available, then a free-flow speed equal to the design/warning speed limit +10 mph should be used. Ramp free-flow speeds less than 10 mph or greater than 70 mph are not allowed in HCS 2010.

Acceleration/Deceleration Lane Lengths: HCS 2010 will not accept any length greater than 1,500 feet. For situations where either an acceleration or deceleration lane is longer than 1,500 feet, then a default value of 1,500 feet should be used.
Chapter 7 – Standard Assumptions for Tools

Traffic Operations Analysis Tool Guidebook
Version 1.1

If any capacity checks fail, then the ramp analysis cannot be completed for that ramp junction, since oversaturated conditions are present. Therefore, another analysis tool should be used.

7.1.4 Facilities

- **Capacity Checks**: HCS 2010 performs various capacity checks for ramp analysis. Prior to reporting any results from the software, each capacity check should be verified to be satisfactory. If any capacity checks fail, then the ramp analysis cannot be completed for that ramp junction, since oversaturated conditions are present. Therefore, another analysis tool should be used.

- **Number of Lanes**: HCS 2010 will not allow less than two or greater than five mainline lanes.

- **Traffic Volume**: Traffic volumes should be entered in 15-minute intervals.

- **Ramp Free-Flow Speed**: Free-flow speed should be based on existing data. If existing data is not available, then a free-flow speed equal to the design/warning speed limit +10 mph should be used. HCS 2010 will not allow any ramp free-flow speeds less than 10 mph or greater than 70 mph.

- **Heavy Vehicle Equivalent Factors**: These factors should be based on HCM standards.

- **Acceleration/Deceleration Lane Lengths**: All acceleration and deceleration lanes should be less than 1,500 feet. For situations where either an acceleration or deceleration lane is longer than 1,500 feet, then a value of 1,500 feet should be used.

- **Capacity Adjustment Factor**: HCS 2010 default value of 1.0 should not be modified, unless specific technical justification can be provided as to why standard HCM capacity should be modified.

- **Origin/Destination Demand Adjustment Factors**: HCS 2010 default value of 1.0 should not be modified, and is typically only used for sensitivity analyses at ramps. If being used for a sensitivity analysis, technical justification should be provided to support any modification.

7.1.5 Multilane

- **Number of Lanes**: HCS 2010 will not allow less than two or greater than three mainline lanes.

- **Mainline Free-Flow Speed**: HCS 2010 will not allow any measured free-flow speeds less than 45 mph or greater than 60 mph.

7.1.6 Two Lane

- **Classification Type**: HCS 2010 requires the selection of one of three classifications, which is based on the function of the roadway. Class I and Class II address rural two-lane highways; whereas, Class III addresses two-lane highways in developed areas.
Shoulder Width: HCS 2010 will allow values between 0 to 99.9 feet in primary direction of analysis, but values greater than 6 feet do not reduce capacity.

Lane Width: HCS 2010 will allow values between 9 to 99.9 feet width, but values greater than 12 feet do not reduce capacity.

Access Point Density: HCS 2010 will allow values between 0 to 40 access points per mile (total in both directions).

Percent No Passing Zones: HCS 2010 will allow values between 0 to 100 percent no passing zones, but values less than 20% will not reduce capacity.

7.1.7 Signals

Analysis Type: HCS 2010 allows two different analyses – “Single Period” or “Multiple Period”. All signalized intersection analyses performed in HCS 2010 should be done in a “Single Period” setting. Technical justification is required for any consideration into multiple periods. Multiple Period analyses changes volumes to vehicles per period versus vehicles per hour and disables the ability to use PHFs.

Traffic Volume: Traffic volumes should be entered as a 60-minute interval.

Turn-Lane Storage Length: As described in Chapter 5, an “effective storage length” should be used in all analyses, which is equal to the storage length plus half of the taper length. Storage lengths can be obtained from either existing field measurements or existing design plans for existing analyses and proposed design plans for all future analyses.

Operating Parameters: All “Operating Parameters” need to be discussed with the project manager prior to any analysis being performed. Technical justification is required for the modification of any HCS 2010 default parameters.

Traffic Signal Timing: Existing traffic signal timing information should be obtained from the entity that controls the traffic signal. If no information is available, existing traffic signal timing information should be measured in the field during peak hour operations or at a time agreed upon with the project manager. Existing traffic signal timings should be used for existing analyses and optimized traffic signal timings should be used for future analyses.

Green Time: Use existing data for existing analyses. For future analyses, minimum green time can vary based on VDOT region/district preferences; however, the typical value should be 5 seconds. Any deviation from 5 seconds should be approved by the project manager prior to any analysis being performed. This minimum green time will be modified if a concurrent pedestrian phase exists.

Yellow Time: Use existing data for existing analyses. For future analyses, yellow times should be consistent with current VDOT clearance interval standards identified in TE-306.1 (Traffic Signals – Yellow Change Intervals and Red Clearance Intervals) with a minimum of 3 seconds.

All-Red Time: Use existing data for existing analyses. For future analyses, all-red times should be consistent with current VDOT clearance interval standards identified in TE-306.1 (Traffic Signals – Yellow Change Intervals and Red Clearance Intervals) with a minimum of 1 second.
To perform the arterial analysis, intersection analysis inputs are imported and a separation distance (in miles) is entered for this module to analyze the arterial.

### 7.1.8 TWSC and AWSC

- **Critical Gap and Follow-Up Time Parameters**: All “Critical Gap” and “Follow-Up Time Parameters” need to be discussed with the project manager prior to any analysis being performed. Technical justification is required for the modification of any HCS 2010 default parameters.
- **Pedestrian Walking Speed**: HCS 2010 default value of 4.0 feet per second should not be modified unless technical justification is provided.
- **Saturation Flow Rate per Lane**: This input is only valid if there is an upstream signalized intersection. HCS 2010 default value of 1,700 vehicles per lane should not be modified unless technical justification is provided as to why the adjustment is necessary.

### 7.1.9 Streets

Arterial analyses can only be performed once individual intersection analyses have been completed. To perform an arterial analysis, intersection analysis inputs are imported and a separation distance (in miles) is entered for this module to analyze the arterial.

### 7.2 Synchro

There are three different types of inputs detailed below for Synchro:

1. Geometric/Analytical Inputs
2. Signal Timing Inputs
3. Pedestrian, Parking, and Bus Inputs

The inputs considered for each category are described in more detail below and are summarized in Table 6.
### Table 6 – Synchro Standard Parameters

<table>
<thead>
<tr>
<th>SYNCHRO PARAMETER</th>
<th>TYPICAL VALUE, ACCEPTABLE RANGES, and/or SPECIAL NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Output</td>
<td>Synchro results for signal optimization. HCM methodology results for all other operational analyses.</td>
</tr>
<tr>
<td>Traffic Volume</td>
<td>60-minute interval.</td>
</tr>
<tr>
<td>Peak Hour Factors</td>
<td>Use existing count data for existing analyses. For future year analyses, the PHF should be calculated based on future land use. If that is not possible, then use 0.92 or existing whichever is higher.</td>
</tr>
<tr>
<td>Heavy Vehicle Percentages</td>
<td>Use existing count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.</td>
</tr>
<tr>
<td>Link Speed</td>
<td>Use existing data. If it is unavailable, use posted speed limits for existing analyses. For future analyses, use posted speeds + 7 mph.</td>
</tr>
<tr>
<td>Grade</td>
<td>Use the existing grade, if available. If it is not available, use 0-2% for level, 2-4% for rolling, and 4%+ for mountainous.</td>
</tr>
<tr>
<td>Link Distance</td>
<td>Links should be continuous through areas of consistent lane configuration and should be long enough to incorporate the 95th percentile queue depicted in SimTraffic.</td>
</tr>
<tr>
<td>Lane and Median Widths</td>
<td>Should be based on field measurements or design plans.</td>
</tr>
<tr>
<td>Storage Length (Turn Lanes)</td>
<td>Use effective storage length (existing storage length plus half taper length).</td>
</tr>
<tr>
<td>Right-Turn Lane Channelization</td>
<td>None, Yield, Free, Stop with existing or appropriate curb radii for all choices other than &quot;None&quot;.</td>
</tr>
<tr>
<td>Signal Timing (Cycle Length)</td>
<td>Use existing data for existing analyses. Typically 60-240 seconds (based on VDOT region/district preferences).</td>
</tr>
<tr>
<td>Signal Timing (Minimum Green)</td>
<td>Use existing data for existing analyses. For future analyses, typically use 5 seconds (based VDOT region/district preferences).</td>
</tr>
<tr>
<td>Signal Timing (Yellow)</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 3 seconds (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Signal Timing (All-Red)</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 1 second (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Signal Timing (Walk)</td>
<td>Use existing timings when applicable. For future analyses, calculate new time based on MUTCD requirements.</td>
</tr>
<tr>
<td>Signal Timing (Flashing Don’t Walk)</td>
<td>Use existing timings when applicable. For future analyses, calculate new time based on MUTCD requirements.</td>
</tr>
<tr>
<td>Signal Timing (Offsets)</td>
<td>Use existing timings when applicable. For future analyses, offsets should be developed from the Synchro time-space diagram.</td>
</tr>
<tr>
<td>Left-Turn Phasing</td>
<td>All future left-turn phasing alternatives should be discussed with and approved by the VDOT Project Manager prior to analysis.</td>
</tr>
<tr>
<td>Conflicting Pedestrians/Bicycles</td>
<td>Should always be considered and based on existing data from a one-hour interval.</td>
</tr>
<tr>
<td>Bus Blockages</td>
<td>Should only be considered when there is a minimum of 6 blockages per hour.</td>
</tr>
<tr>
<td>Parking Maneuvers</td>
<td>Should only be considered when there is a minimum of 50 maneuvers per hour in urban and CBD areas.</td>
</tr>
</tbody>
</table>
7.2.1 Geometric/Analytical Inputs

**Model:** Synchro allows the user to obtain results in both Synchro and HCM methodology formats. As detailed in Chapter 3, the HCM model shall be used for all operational analyses in Synchro, except for when the tool is used for signal optimization projects. Although HCM results can be obtained from the HCS software, the Synchro interface is much more efficient to use when compared to HCS 2010, especially since the tool will automatically optimize traffic signal timings, and is simulation-ready for use in SimTraffic.

**Traffic Volume:** Traffic and pedestrian volumes shall be entered as a 60-minute interval.

**Peak Hour Factors:** PHF should be determined by approach based on existing traffic count data. Project managers will be responsible for identifying any case-by-case scenarios where PHF shall be required for each movement. For existing analyses, PHFs shall be computed from existing count data. For future year analyses, the PHF should be calculated based on future land use. If that is not possible, then use 0.92 or existing whichever is higher.

**Heavy Vehicle Percentages:** HVP should be determined by movement based on existing traffic count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.

**Link Speed:** Link speeds should be obtained from existing field data. If existing speed data is not available, the link speed in the model should be the posted speed limit plus 7 mph. For future year analyses, the proposed posted speed plus 7 mph should be used.

**Grade:** Grades should be based on existing data or existing design plans. If neither of these two sources are available, then the following ranges from the *HCM 2010* should be used:

- Level Terrain (L): 0-2%
- Rolling Terrain (R): 2-4%
- Mountainous Terrain (M): 4-6%

**Link Distance:** Link lengths should represent existing link lengths. Links should be continuous through areas of consistent lane configuration. Links should be broken at each intersection or at a change in the number lanes (e.g., lane drop). Links must be long enough to contain the queue determined from field measurements, if available, or the 95th percentile queue from SimTraffic, if microsimulation is required.

**Lane and Median Widths:** All lane and median widths should be based on either existing field measurements or existing design plans for existing analyses and from proposed design plans for all future analyses.

**Turn-Lane Storage Length:** As described in Chapter 6, an “effective storage length” should be used in all analyses, which is equal to the storage length plus half of the taper length. Storage lengths can be obtained from either existing field measurements or existing design plans for existing analyses and proposed design plans for all future analyses.
Right-Turn Lane Channelization: Right-turn channelization shall be identified for all right-turn movements (Free, Yield, Stop, or None), with the appropriate curb radii provided for all selections other than “None”. Curb radii should be determined from either existing field measurements or existing design plans for existing analyses and proposed design plans for all future year analyses.

7.2.2 Signal Timing Inputs

Existing signal timing information should be obtained from the entity that controls the traffic signal. If not available, existing signal timing and offsets information should be measured in the field during the peak hour(s) of operation or as agreed upon with the project manager based on documentation. Existing signal timings should be used for existing analyses and optimized timings should be used for future analyses.

Cycle Length: Cycle lengths can vary based on VDOT region/district preferences; however, typical values should range between 60 and 240 seconds. Existing cycle lengths from the field should be used in existing analyses. Cycle lengths used in future analyses should be agreed upon with the project manager prior to any analysis being performed taking into account the system cycle lengths for intersections within a corridor.

Minimum Green Time: Use existing data for existing analyses. For future analyses, minimum green time can vary based on VDOT region/district preferences; however the typical value should be 5 seconds. Any deviation from 5 seconds should be approved by the project manager prior to any analysis being performed. This minimum green time will be modified if a concurrent pedestrian phase exists.

Lost Time Adjustment: Lost Time Adjustment is not the same as lost time. Lost time is equal to the extension of effective green time (2.5 seconds) subtracted from the sum of yellow time, all red time, and startup lost time (2.5 seconds). Evaluating this expression, lost time simply results in the sum of yellow time and all-red time. The Lost Time Adjustment is defaulted at -2 seconds in Synchro, and accounts for those vehicles that continue to enter the intersection during the yellow time. The default value of -2 seconds should not be modified unless the project manager approves the adjustment. Technical justification must accompany the request to adjust the factor.

Yellow Time: Use existing data for existing analyses. For future analyses, yellow times should be consistent with current VDOT clearance interval standards with a minimum of 3 seconds (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).

All-Red Time: Use existing data for existing analyses. For future analyses, all-red times should be consistent with current VDOT clearance interval standards with a minimum of 1 second (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).

Offsets: Use existing data for existing analyses. For future analyses, offsets should be optimized from the Synchro developed time-space diagrams.
7.2.3 Pedestrian, Parking, and Bus Inputs

- **Left-Turn Phasing**: Existing left-turn phasing should be used for existing analyses. For all future left-turn phasing alternatives, proposed left-turn phasing should be agreed to by the project manager prior to any operational analysis being performed.

- “WALK” Time: Existing “WALK” time data should be used for existing analyses. If existing timing is not available and for all future analyses, “WALK” time should be developed based on latest MUTCD standards.

- Flash “DON’T WALK” Time: Existing flash “DON’T WALK” time data should be used for existing analyses. If existing timing is not available and for all future analyses, “DON’T WALK” time should be developed based on MUTCD standards.

- Conflicting Pedestrians/Bicycles: This parameter should always be considered in the analyses and be based on existing data for a one-hour interval.

- Bus Blockages: This parameter should only be considered when there is a minimum of 6 blockages per hour (approximately 1 every 10 minutes). Bus blockages only include stops that occur within 250 feet (upstream or downstream) from the stop bar of an approach, as shown in Figure 7.

- Parking Maneuvers: This parameter should only be considered when there is a minimum of 50 maneuvers per hour and when the site is located within an urban or Central Business District (CBD).

Figure 7 – Bus Blockages to Include in Analysis

7.3 SIDRA Intersection

There are two models provided in SIDRA Intersection to analyze roundabouts, including SIDRA “Standard Right” (referred to as “SIDRA Model”) and HCM Roundabout (referred to as the “HCM Model”); however, only SIDRA Model is accepted for VDOT roundabout analyses. Prior to coding the model, the user should set the units to English units. The various inputs for this model are described below and are summarized in Table 7.

- **Model**: Based on standard practice for analyzing roundabouts in Virginia, the SIDRA Model has been widely accepted as the preferred methodology; therefore, the SIDRA Model shall be used for roundabout analyses. Justification and written
approval from the project manager is required for using the HCM Model. Prior to using the model, the user should change the units to English units.

- **Traffic Volume/Peak Flow Period**: All traffic and pedestrian volumes shall be entered as a single 60-minute interval with 15-minute peak flow periods.
- **Grade**: This parameter only affects fuel consumption results and can be left at 0% for operational analyses.
- **Basic Saturation Flow Rate**: 1,900 through car units per hour (tcu/hr) should be used.

### Table 7 – SIDRA Intersection Standard Parameters

<table>
<thead>
<tr>
<th>SIDRA Intersection Parameter</th>
<th>Typical Value, Acceptable Ranges, and/or Special Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Use SIDRA “Standard Right” Roundabout Model.</td>
</tr>
<tr>
<td>Traffic Volume/Peak Flow Period</td>
<td>Use 60-minute peak traffic volume with 15-minute peak flow periods.</td>
</tr>
<tr>
<td>Peak Hour Factors</td>
<td>Use existing count data. For future year analyses, the PHF should be calculated based on future land use. If that is not possible, then use 0.92 or existing whichever is higher.</td>
</tr>
<tr>
<td>Heavy Vehicle Percentages</td>
<td>Use existing count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.</td>
</tr>
<tr>
<td>Grade</td>
<td>This parameter only affects fuel consumption/estimate results and should be 0% for basic operational analyses.</td>
</tr>
<tr>
<td>Basic Saturation Flow Rate</td>
<td>Use 1,900 tcu/h.</td>
</tr>
<tr>
<td>Flow Scale</td>
<td>Use default (100%). This parameter should only be used in sensitivity analyses for particular movements.</td>
</tr>
<tr>
<td>Practical Degree of Saturation</td>
<td>Use default (0.85, based on FHWA).</td>
</tr>
<tr>
<td>Vehicle Occupancy</td>
<td>Use default (1.2 persons/vehicle).</td>
</tr>
<tr>
<td>Maximum Number of Circulating Lanes</td>
<td>Use existing number of lanes up to 2 lanes.</td>
</tr>
<tr>
<td>Extra Bunching</td>
<td>See SIDRA Intersection Help File for acceptable ranges and/or values as described in text.</td>
</tr>
<tr>
<td>Environmental Factor</td>
<td>Use default (1.2).</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>Use existing count data. If data is not available, SIDRA Intersection recommends using 400 ped/h for CBD areas and 50 ped/h for all other areas.</td>
</tr>
<tr>
<td>Approach Lane and Circulating Lane Widths</td>
<td>Use existing field measurements for existing analyses and proposed design plans for future analyses.</td>
</tr>
<tr>
<td>Island Diameter</td>
<td>Use existing field measurements for existing analyses and proposed design plans for future analyses.</td>
</tr>
<tr>
<td>Entry Radius and Entry Angles</td>
<td>Use existing field measurements for existing analyses and proposed design plans for future analyses.</td>
</tr>
</tbody>
</table>
Peak Hour Factors: PHF should be determined by approach based on existing traffic count data. Project managers will be responsible for identifying any case-by-case scenarios where PHF shall be required for each movement. For existing analyses, PHFs shall be computed from existing count data. For future year analyses, the PHF should be calculated based on future land use. If that is not possible, then use 0.92 or existing whichever is higher.

Heavy Vehicle Percentages: Heavy Vehicle Percentages (HVP) need to be determined by movement based on existing count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.

Flow Scale: This parameter can be used to depict “growth” in particular movements. This parameter should only be used or modified in cases where sensitivity analyses are being performed.

Practical Degree of Saturation: This parameter is a key threshold supported by FHWA as the point at which a roundabout reaches capacity (similar to a volume-to-capacity ratio). FHWA recommends that a value of 0.85 be used for all roundabout analyses.

Vehicle Occupancy: Default value of 1.2 persons per vehicle should not be modified unless approved by the project manager based on technical justification.

Maximum Number of Circulating Lanes: Roundabouts are limited to no more than 2 circulating lanes.

Extra Bunching: This parameter should be used to account for traffic platoons and impacts from upstream traffic signals. Based on the SIDRA Intersection “Help” Manual, the following values should be used.

<table>
<thead>
<tr>
<th>Distance to Upstream Signal (ft)</th>
<th>0 - 350</th>
<th>350 - 700</th>
<th>700 - 1,300</th>
<th>1,300 - 2,000</th>
<th>2,000 - 2,600</th>
<th>2,600+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Bunching %</td>
<td>25%</td>
<td>20%</td>
<td>15%</td>
<td>10%</td>
<td>5%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Environmental Factor: Default value of 1.2 should be used and not be modified unless approved by the project manager based on technical justification. For existing conditions analyses, VDOT standard practice is to use 1.2 for all districts other than Northern Virginia, in which 1.1 is used. For future conditions analyses, VDOT standard practice is to use 1.1 for all districts other than Northern Virginia, in which 1.05 is used.

Pedestrians: This parameter should always be considered and should be a 60-minute interval taken from existing count data. If count data is not available, SIDRA Intersection recommends using 400 pedestrians per hour for locations in the CBD and 50 pedestrians per hour for all other areas.

Approach Lane and Circulating Lane Widths: All lane widths should be representative of either existing field measurements or existing design plans for existing analyses and proposed design plans for all future analyses. The entry lane width should be a maximum of 15 feet.
Island Diameter: All center island diameters should be based on either existing field measurements or existing design plans for existing analyses and proposed design plans for all future analyses.

Entry Radii and Entry Angles: All entry radii and angles should be based on either existing field measurements or existing design plans for existing analyses and proposed design plans for all future analyses.

7.4 CORSIM

CORSIM has many inputs that need to be considered. These inputs include analytical, geometric, and driver/vehicular characteristic components. Although the majority of these inputs have default values that should remain constant (unless technical justification is available), there are some that can and should be modified. The following information, which is summarized in Table 8, either details these specific inputs, or further emphasizes the necessity for technical justification for modifying particular critical inputs.

Entry Traffic Volumes (Flows): Traffic volume intervals will vary by project; however, a minimum of four 15-minute intervals should be used. If an hourly volume is over capacity, additional 15-minute intervals may be necessary, either before and/or after the peak hour of interest, to account for peak hour spreading.

Heavy Vehicle Percentages: HVPs should be based on existing count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.

Grade: Grades should be based on existing data or existing design plans. If neither of these two sources are available, then the following ranges from the HCM 2010 should be used:
- Level Terrain (L): 0-2%
- Rolling Terrain (R): 2-4%
- Mountainous Terrain (M): 4-6%

Vehicle Entry Headway (Distribution Type): These distributions should be set to an Erlang Distribution with an “a” parameter equal to 1, which represents a negative exponential distribution, for networks with FRESIM dominance. A negative exponential distribution is commonly used for generating the inter-arrival time of vehicles to a system. Normal distribution should be set to a normal distribution for networks with NETSIM dominance.

Minimum Separation for Generation of Vehicles: This parameter adjusts capacity on all freeway links throughout the entire network. The CORSIM default value of 1.6 seconds should not be modified unless technical justification is provided as to why a network-wide adjustment is necessary. If individual freeway links have varying capacities, then Car Following Sensitivity Multipliers (CFSM) should be used.

Car Following Model: The CORSIM default model for freeways is the Pitt Model, which should not be modified unless technical justification is provided.

Freeway Free-Flow Speed: Freeway free-flow speed should be based on existing data. If existing data is not available, then a base free-flow speed equal to the posted speed limit +7 mph should be used. CORSIM will not allow any freeway free-flow speeds greater than 70 mph.
### CORSIM Standard Parameters

<table>
<thead>
<tr>
<th>CORSIM Parameter</th>
<th>Typical Value, Acceptable Ranges, and/or Special Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry Volumes (Flows)</td>
<td>One hour minimum and long enough to show traffic demand being within capacity on either end of the time period. Code in 15-minute intervals.</td>
</tr>
<tr>
<td>Heavy Vehicle Percentages</td>
<td>Use existing data for existing analyses. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.</td>
</tr>
<tr>
<td>Vehicle Entry Headway (Distribution Type)</td>
<td>Erlang with &quot;a&quot; = 1 for freeway dominated networks and normal for arterial dominated networks.</td>
</tr>
<tr>
<td>Minimum Separation for Generation of Vehicles</td>
<td>Use default (1.6 seconds). If individual links have varying capacities, use Car Following Sensitivity Multipliers (CFSM).</td>
</tr>
<tr>
<td>Car Following Model</td>
<td>Use default (Pitt Model).</td>
</tr>
<tr>
<td>Freeway Free Flow Speed</td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph up to a maximum of 70 mph. For future analyses, use existing values.</td>
</tr>
<tr>
<td>Ramp Free Flow Speed</td>
<td>Use existing data. If it is not available, use design or warning speed + 10 mph up to a maximum of 70 mph. For future analyses, use existing values.</td>
</tr>
<tr>
<td>Arterial Free Flow Speed</td>
<td>Use existing data. If it is not available, use posted speed limit + 7 mph up to a maximum of 65 mph. For future analyses, use existing values.</td>
</tr>
<tr>
<td>Link Length</td>
<td>No limitation on link length. Links should be continuous through areas with consistent lane configuration.</td>
</tr>
<tr>
<td>Curvature</td>
<td>Curvature should only be considered when &quot;short links&quot; (links &lt; 100 feet in length) are required without using curvature.</td>
</tr>
<tr>
<td>Origin-Destination (O-D)</td>
<td>Use existing data. If it is not available, use &quot;dummy&quot; O-D factors to calibrate weaving movements.</td>
</tr>
<tr>
<td>Conditional Turn Movements</td>
<td>Used to accurately model turn movement restrictions or arterial movements.</td>
</tr>
<tr>
<td>Vehicle Reaction Points (Distance)</td>
<td>Revise based on field observations to address simulation anomalies. For future analyses, use existing values.</td>
</tr>
<tr>
<td>Driver/Vehicle Parameters</td>
<td>These parameters should not be modified unless existing conditions require it for calibration purposes. Any changes should be documented with appropriate justification.</td>
</tr>
<tr>
<td>Lane Distribution of Entering Vehicles</td>
<td>Use existing data. If it is unavailable, assumed equal lane utilization. For future analyses, use existing values.</td>
</tr>
<tr>
<td>Traffic Signal Timing</td>
<td>Use existing data for existing analyses. If it is unavailable, measure it in field.</td>
</tr>
<tr>
<td>Traffic Signal Cycle Length</td>
<td>Use existing data for existing analyses. For future analyses, typically use 60-240 seconds (based on VDOT region/district preferences).</td>
</tr>
<tr>
<td>Traffic Signal Minimum Green</td>
<td>Use existing data for existing analyses. For future analyses, typically use 5 seconds (based on VDOT region/district preferences).</td>
</tr>
<tr>
<td>Traffic Signal Yellow Time</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 3 seconds (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Traffic Signal All-Red Time</td>
<td>Use existing data for existing analyses. For future analyses, a minimum of 1 second (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Traffic Signal Left-Turn Phasing</td>
<td>All future left-turn phasing alternatives should be discussed and approved by the VDOT Project Manager prior to analysis.</td>
</tr>
<tr>
<td>MOE Output Reporting</td>
<td>Summarized by link for arterials, by link and by lane for freeways, and by node for intersections.</td>
</tr>
<tr>
<td>Grade</td>
<td>Use the existing grade, if available. For future analyses, use the grade specified in the design, but if this information is not available, use 0-2% for level, 2-4% for rolling, and 4%+ for mountainous.</td>
</tr>
<tr>
<td>Seeding Time</td>
<td>Typically equal to either the existing peak hour travel time or twice the off-peak travel time between network study limits.</td>
</tr>
<tr>
<td>Number of Simulation Runs</td>
<td>Based on Formula (13) in Appendix B of the FHWA Traffic Operations Analysis Toolbox: Volume III. Initial assumption of 10 runs with a maximum of 30 runs.</td>
</tr>
</tbody>
</table>
**Ramp Free-Flow Speed:** Ramp free-flow speed should be based on existing data. If existing data is not available, then a free-flow speed equal to the design/warning speed limit +10 mph should be used. CORSIM will not allow any ramp free-flow speeds greater than 70 mph.

**Arterial Free-Flow Speed:** Arterial free-flow speed should be based on existing data. If existing data is not available, then a base free-flow speed equal to the posted speed limit +7 mph should be used. CORSIM will not allow any arterial free-flow speeds greater than 65 mph.

**Curvature:** This parameter should only be considered when “short links” (lengths less than 100 feet) are the only option to represent actual roadway curvature.

**Link Length:** Links should be continuous in areas of consistent lane configuration and be broken at each intersection. Typically, link lengths should range between 100 and 1,500 feet based on the length of influence areas defined for merge and diverge areas in the *HCM 2010*, but there is no limitation on link length.

**Origin-Destination:** This parameter should be used if O-D data is available. If actual O-D data is not available, then the O-D parameter should still be used to calibrate weaving movements on the freeway network to prevent inaccurate ramp-ramp movements.

**Conditional Turn Movements:** This parameter should be used to accurately model turning-movement restrictions (i.e., time-of-day left-turn prohibition). If turning movement restrictions are not present, this parameter should still be considered to calibrate arterial movements on the arterial network.

**Vehicle Reaction Points (Distance):** This parameter should be iteratively modified through simulation inspection to reflect existing travel conditions. In these cases, technical justification is not required; however, changes must be justified as a solution to an anomaly in the simulation. For future analyses, existing distances should be used unless modifications are required to help with calibrating the model.

**Driver/Vehicle Parameters:** These parameters should all remain consistent to the CORSIM default values. Technical justification is required before any modification can be considered.

**Lane Distribution of Entering Vehicles:** Both freeway and arterial lane distributions should be based on existing data. If existing data or other technical justification is not available, then equal distributions should be assumed. For future analyses, existing lane distributions should be maintained unless the network changes in way that will not permit the existing lane to distributions to be used.

**Traffic Signal Timing:** Existing traffic signal timing information should be obtained from the entity that controls the traffic signal. If not available, existing traffic signal timing information should be measured in the field during peak hour operations. Existing traffic signal timings should be used for existing analyses and optimized traffic signal timings should be used for future analyses.

**Cycle Length:** Cycle lengths can vary based on VDOT region/district preferences; however, typical values should range between 60 and 240 seconds. Use existing cycle lengths from the field in existing analyses taking into account the system cycle...
lengths for intersections within a corridor. Cycle lengths used in future analyses should be agreed upon with the project manager prior to any analysis being performed taking into account the system cycle lengths for intersections within a corridor.

- **Minimum Green Time**: Use existing data for existing analyses. For future analyses, minimum green time can vary based on VDOT region/district preferences; however, the typical value should be 5 seconds. Any deviation from 5 seconds should be approved by the project manager prior to any analysis being performed.

- **Simulation Run Time**: The simulation run time is the time it takes for the model to process the entire peak period.

- **Yellow Time**: Use existing data for existing analyses. For future analyses, yellow times should be consistent with current VDOT clearance interval standards identified in TE-306.1 (Traffic Signals – Yellow Change Intervals and Red Clearance Intervals) with a minimum of 3 seconds.

- **All-Red Time**: Use existing data for existing analyses. For future analyses, all-red times should be consistent with current VDOT clearance interval standards identified in TE-306.1 (Traffic Signals – Yellow Change Intervals and Red Clearance Intervals) with a minimum of 3 seconds.

- **Left-Turn Phasing**: Existing left-turn phasing should be maintained in all existing analyses. For all future left-turn phasing alternatives, proposed left-turn phasing shall be reviewed by the project manager prior to any analysis being performed.

- **MOE Output Reporting**: All arterial results should be reported by link, all freeway results should be reported by link and by lane, and all intersection results should be reported by node. Also provide spreadsheet in electronic format for review.

- **Lane-Change Parameters (Freeways Only)**: On heavily congested freeways, there are multiple lane-change parameters that may require adjustment to assist in the calibration process. These parameters include time to complete a lane-change maneuver (could be reduced from the default value of 20 seconds), percent of drivers desiring to yield right-of-way to lane-changing vehicles attempting to merge (could be increased from the default value of 20 percent), and mandatory lane-change gap acceptance parameter (could be reduced from the default value of 3 with 1 being the most aggressive and 6 being the least aggressive).

- **Warning Sign Location (Freeways Only)**: The distance from downstream end of link to exit warning sign parameters default value of 2,500 feet can be increased to give vehicles more time to prepare for exiting the freeway. This factor aids in the calibration of freeway operations, especially under congested conditions.

- **Lane-Change Parameters (Arterials Only)**: On heavily congested arterials, there are multiple lane-change parameters that may require adjustment to assist in the
calibration process. These parameters include duration of a lane-change maneuver (could be reduced from the default value of 3 seconds in a range of 1 to 8 seconds) and percentage of drivers who cooperate with a lane changer (could be increased from the default value of 50 percent).

**Seeding Time**: The seeding time should be long enough to distribute traffic throughout the entire network. Typically, seeding times should be approximately equal to either the actual peak hour travel time or twice the off-peak travel time, when traversing from one end of the network to the other.

**Number of Simulation Runs**: The minimum number of simulation runs shall be based on Formula (13) in Appendix B of the FHWA Traffic Operations Analysis Toolbox Volume II up to a maximum of 30 runs. An initial assumption of 10 simulation runs, with different random number seeds, will be performed prior to applying the aforementioned formula and methodology.

### 7.5 VISSIM

VISSIM is a complex microsimulation tool that allows for the flexibility to model a wide range of traffic environments. The majority of its parameters have default values that should remain constant (unless technical justification is provided). The following information describes the specific settings, which are also summarized in Table 9. These parameters have the greatest impact on model behavior and adherence to VDOT standards. Prior to running the model, the user should change the units to English units.

**Entry Traffic Volumes**: Traffic volume intervals will vary by project; however, a minimum of four 15-minute intervals (1 hour) should be used. Additional 15-minute intervals are necessary to illustrate a time period where traffic demand begins and ends within capacity, refer back to Figure 1 for an illustrative example.

**Heavy Vehicle Percentages (Vehicle Compositions)**: HVPs should be based on existing count data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.

**Arrival Distribution**: Arrival distribution cannot be changed in VISSIM. However, the software developer suggests that all inputs be set to “Exact Volume” instead of the default of “Stochastic Volume” to reduce the number of simulation runs required.

**Link Parameters**: Use individual lane widths as measured in the field.

**Grade**: Grades should be based on existing data or existing design plans. If neither of these two sources are available, then the following ranges from the *HCM 2010* should be used:

- Level Terrain (L): 0-2%
- Rolling Terrain (R): 2-4%
- Mountainous Terrain (M): 4-6%

**Link Length**: There is no limitation on link length in VISSIM. Links should be continuous through areas of constant lane configuration. As a general practice, links should be broken at each intersection.
Table 9 – VISSIM Standard Parameters

<table>
<thead>
<tr>
<th>VISSIM PARAMETER</th>
<th>TYPICAL VALUE, ACCEPTABLE RANGES, and/or SPECIAL NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry Volumes (Inputs)</td>
<td>One hour minimum and long enough to show traffic demand being within capacity on either end of the time period. Code data in 15-minute intervals.</td>
</tr>
<tr>
<td>Heavy Vehicle Percentages</td>
<td>Use existing data. For future analyses, existing HVP shall be used, but if that is not available, use a minimum of 2%.</td>
</tr>
<tr>
<td>Arrival Distribution</td>
<td>Arrival distribution cannot not be changed in VISSIM. Manufacturer suggests setting all inputs to &quot;Exact Volume&quot; instead of the default &quot;Stochastic Volume&quot;.</td>
</tr>
<tr>
<td>Link Length</td>
<td>No limitation on link length. Links should be continuous through areas with consistent lane configuration.</td>
</tr>
<tr>
<td>Link Speed (Desired Speed Distributions)</td>
<td>Posted speed limits should be used for existing analyses. For arterial networks, use linear distribution ranging +/- 5 mph from posted speed limit. For freeway networks, a detailed speed profile should be considered.</td>
</tr>
<tr>
<td>Turning Speed (Reduced Speed Areas)</td>
<td>For right turns, use 7.5 mph to 15.5 mph. For left turns, use 12.4 mph and 18.6 mph.</td>
</tr>
<tr>
<td>Origin-Destination (O-D)</td>
<td>Use existing data. Routing decisions can be combined or set up as O-D.</td>
</tr>
<tr>
<td>Car Following Model</td>
<td>For urban facilities and arterials, use Wiedemann 74. For freeways, use Wiedemann 99.</td>
</tr>
<tr>
<td>Vehicle Parameters</td>
<td>Individual vehicle parameter defaults should not be changed.</td>
</tr>
<tr>
<td>Vehicle Fleet</td>
<td>Use vehicle fleet in example file &quot;NorthAmericaDefault.inp&quot; provided with VISSIM installation.</td>
</tr>
<tr>
<td>Traffic Signal Timing</td>
<td>Use existing data for existing analyses. If it is not available, measure it in field during the peak hour.</td>
</tr>
<tr>
<td>Traffic Signal Cycle Length</td>
<td>Use existing data for existing analyses. For future analyses, typically use 60-240 seconds (based on VDOT region/district preferences).</td>
</tr>
<tr>
<td>Traffic Signal Left-Turn Phasing</td>
<td>All future left-turn phasing alternatives should be discussed with the project manager prior to analysis.</td>
</tr>
<tr>
<td>Traffic Signal Minimum Green Time</td>
<td>Use existing data for existing analyses. For future analyses, typically use 5 seconds (based on VDOT region/district preferences).</td>
</tr>
<tr>
<td>Traffic Signal Yellow Time</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 3 seconds (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Traffic Signal All-Red Time</td>
<td>Use existing data for existing analyses. For future analyses, use a minimum of 1 second (based on latest VDOT Yellow Change Intervals and Red Clearance Intervals Memo).</td>
</tr>
<tr>
<td>Traffic Signal Walk Time</td>
<td>Use existing timings, when applicable, for existing analyses. For future analyses, calculate new time based on MUTCD requirements.</td>
</tr>
<tr>
<td>Traffic Signal Flashing Don’t Walk Time</td>
<td>Use existing timings, when applicable, for existing analyses. For future analyses, calculate new time based on MUTCD requirements.</td>
</tr>
<tr>
<td>Grade</td>
<td>Use the actual grade, if available, for existing analyses. For future analyses, use 0-2% for level, 2-4% for rolling, and 4%+ for mountainous.</td>
</tr>
<tr>
<td>Performance Measure Intervals</td>
<td>Report in one-hour intervals, unless otherwise specified in project requirements.</td>
</tr>
<tr>
<td>Simulation Resolution</td>
<td>A value between 5 and 10 should be used on all models. Use the same resolution for existing and future conditions.</td>
</tr>
<tr>
<td>Number of Simulation Runs</td>
<td>Based on Formula (13) in Appendix B of the FHWA Traffic Operations Analysis Toolbox: Volume III. Initial assumption of 10 runs with a maximum of 30 runs.</td>
</tr>
</tbody>
</table>
Link Speed (Desired Speed Distributions): Posted speed limits should be used for all existing analyses. For arterial networks, a linear distribution ranging +/- 5 mph of the speed limit is sufficient. For freeway networks, a more detailed speed profile should be considered.

Turning Speed (Reduced Speed Areas): Reduced speed areas for turning vehicles should typically be set to Desired Speed Distributions ranging from 7.5 to 15.5 mph for right turns and 12.4 to 18.6 mph for left-turns as a starting point. These values can be adjusted (with technical justification documentation) as needed during the calibration process to match real-world conditions.

Vehicle Parameters: Individual vehicle defaults should not be changed, unless there is hard data indicating that a modification is required (i.e. LRT vehicle length, acceleration).

Origin-Destination: Origin-Destination (O-D) data, if available, should be coded as static routes. Dynamic Assignment features of VISSIM should only be used with prior approval from the project manager. Static routes can also be combined between closely spaced intersections as needed to control localized O-D behavior and to better replicate lane utilization.

Car Following Model: Driver behavior models, used during the calibration process, are coded on a link-by-link basis. Wiedemann 74 is intended to be used for arterials and Wiedemann 99 is used for freeway links. If individual parameters need to be changed, do not change or delete the default value, then create a new driving behavior profile, and modify the values as necessary. As a final step, document the justification for modifying the factors.

Vehicle Fleet: Use vehicle fleet in example file "NorthAmericaDefault.inp" provided with VISSIM installation. Vehicle models in this fleet are available on PTV website.

Traffic Signal Timing: The Ring-Barrier Controller (RBC) is the preferred traffic signal emulator. Existing traffic signal timing information should be obtained from the entity that controls the traffic signal. If not available, existing traffic signal timing information should be measured in the field during peak hour operations or agreed upon with the project manager. Existing traffic signal timings should be used for existing analyses and optimized traffic signal timings should be used for future analyses.

Cycle Length: Cycle lengths can vary based on VDOT region/district preferences; however, typical values should range between 60 and 240 seconds. Use existing cycle lengths from the field should in existing analyses. Cycle lengths used in future analyses should be agreed upon with the project manager prior to any analysis being performed taking into account the system cycle lengths for intersections within a corridor.

Left-Turn Phasing: Existing left-turn phasing should be maintained in all existing analyses. For all future left-turn phasing alternatives, proposed left-turn phasing shall be reviewed by the project manager prior to any analysis being performed.

Yellow Time: Use existing data for existing analyses. For future analyses, yellow times should be consistent with current VDOT clearance interval standards.
identified in TE-306.1 (Traffic Signals – Yellow Change Intervals and Red Clearance Intervals) with a minimum of 3 seconds.

- **All-Red Time:** Use existing data for existing analyses. For future analyses, all-red times should be consistent with current VDOT clearance interval standards identified in TE-306.1 (Traffic Signals – Yellow Change Intervals and Red Clearance Intervals) with a minimum of 1 second.

- **Minimum Green Time:** Use existing data for existing analyses. For future analyses, minimum green time can vary based on VDOT region/district preferences; however the typical value should be 5 seconds. Any deviation from 5 seconds should be approved by the project manager prior to any analysis being performed.

- **Performance Measure Intervals:** Report in one-hour intervals unless otherwise specified in project requirements.

- **“WALK” Time:** Existing “WALK” time data should be used for existing analyses. If existing timing is not available and for all future analyses, “WALK” time should be developed based on MUTCD standards.

- **Flash “DON’T WALK” Time:** Existing flash “DON’T WALK” time data should be used for existing analyses. If existing timing is not available and for all future analyses, “DON’T WALK” time should be developed based on MUTCD standards.

- **Number of Simulation Runs:** The minimum number of simulation runs shall be based on Formula (13) in Appendix B of the FHWA Traffic Operations Analysis Toolbox: Volume III up to a maximum of 30 runs. An initial assumption of 10 simulation runs, with different random number seeds, will be performed by setting the random number seed increment in the multi-run tool to one prior to applying the aforementioned formula and methodology (refer to Chapter 5).

- **Simulation Run Time:** The simulation run time is the time it takes for the model to process the entire peak period, including the seeding time.

- **Simulation Resolution:** The number of times the vehicle’s position will be calculated within one simulated second (range 1 to 10). The input of 1 will result in the vehicles moving once per simulation second while an input of 10 results in the vehicles’ position being calculated 10 times per simulation second thus making vehicles move more smoothly. The change of simulation speed is inversely proportional to the number of time steps. A value between 5 and 10 should be used on all models and this value shall not change between existing and future conditions analyses.

- **Evaluations:** VISSIM has numerous evaluation output file options available. The most common options are Link, Node, Queue Length, Travel Time, and Network Performance. The content of each of these output files should be customized for the individual needs of each project and submitted for approval by the VDOT Project Manager at the start of the project.

  - **Link:** primarily used for freeway links to collect average speed, volume, and density. Link Evaluation must be activated on a link-by-link basis. To ensure one set of results are reported for the entire link, the segment length should be set to a value larger than the link length. Link evaluation should be collected on a “by lane” basis in most cases.
+ **Node**: used to collect arterial intersection delays, queue lengths, and throughput volumes. Boundaries of each node should be placed at the stop line on all approaches and avoid boundaries between links and connectors to avoid errors in reporting.

+ **Queue Length**: Queue lengths should be obtained from the Node Evaluation in most cases. If additional queuing locations or time collection intervals are needed, queue counters can be placed at the stop line on each approach.

+ **Travel Time**: Travel time segments should be placed at the same start and end points as the field data collection runs.

+ **Network Performance**: Aggregates results from Node and Travel Time evaluation into overall summaries. Typical MOEs included are Average Delay, Total number of stops, and total delay time. Latent demand and latent delay can be used to determine the number of vehicles that could not enter the network due to congestion.

+ **Data Analyzer**: All individual evaluations listed above (with the exception of Link Evaluation) can be summarized and reported using the Data Analyzer post-processor, or another post-processor tool as approved by the VDOT Project Manager.

### 7.6 SimTraffic

Since SimTraffic is the microsimulation module of Synchro, a complete Synchro model is required prior to any SimTraffic analysis. Therefore, all of the inputs for Synchro are necessary for SimTraffic. In addition, the following simulation inputs, which are summarized in Table 10, should be addressed.

- **Mandatory and Positioning Distances**: These inputs should only be modified to address any existing simulation anomalies. In these cases, technical justification is not required; however, the changes must be justified as a solution to an anomaly in the simulation.

- **Headway Factors**: These inputs are automatically calculated through SimTraffic based on other inputs, and should not be modified. Technical justification is required for any modification to these factors.

- **Seeding Time**: The seeding time should be long enough to distribute traffic throughout the entire network. Typically, seeding times should be approximately equal to either the peak hour travel time OR twice the off-peak travel time, when traversing from one end of the network to the other.

- **Number of Intervals**: One seeding interval and four, 15-minute simulation analysis periods.

- **Number of Simulation Runs**: The minimum number of simulation runs shall be based on Formula (13) in Appendix B of the FHWA Traffic Operations Analysis Toolbox: Volume III up to a maximum of 30 runs. An initial assumption of 10 simulation runs, with different random number seeds, will be performed prior to applying the aforementioned formula and methodology.
### Table 10 – SimTraffic Standard Assumptions

<table>
<thead>
<tr>
<th>SIMTRAFFIC PARAMETER</th>
<th>TYPICAL VALUE, ACCEPTABLE RANGES, and/or SPECIAL NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Distances (MD)</td>
<td>These should only be modified if simulation anomalies exist.</td>
</tr>
<tr>
<td>Positioning Distances (PD)</td>
<td>These should only be modified if simulation anomalies exist.</td>
</tr>
<tr>
<td>Headway Factors</td>
<td>Automatically calculated by SimTraffic and should not be modified, unless it is required for calibration purposes as discussed in Chapter 5.</td>
</tr>
<tr>
<td>Seeding Time</td>
<td>Typically equal to either the actual peak hour travel time or twice the off-peak travel time between network study limits.</td>
</tr>
<tr>
<td>Simulation Settings</td>
<td></td>
</tr>
<tr>
<td>Number of Intervals</td>
<td>One seeding period and four 15-minute analysis periods.</td>
</tr>
<tr>
<td>Number of Simulation Runs</td>
<td>Based on Formula (13) in Appendix B of the FHWA Traffic Operations Analysis Toolbox: Volume III. Initial assumption of 10 runs with a maximum of 30 runs.</td>
</tr>
</tbody>
</table>

Note: All Synchro inputs are valid for SimTraffic (Synchro network must be completed prior to a SimTraffic analysis).
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Chapter 8 – Traffic Operations Analysis Tool Selection

Traffic Operations Analysis Tool Guidebook
Version 1.1

This chapter describes the methodology to be used for selecting the most appropriate traffic analysis tool. This selection process includes identifying the most appropriate tool(s) for any given analytical scenario presented in Chapter 2 in this guidebook. A Tool Selection Matrix (TSM), which is included in Appendix C, was developed to identify the various conditions under which specific traffic analysis tools were applicable. To assist users of this guidebook with selecting the most appropriate traffic analysis tool, an automated, Excel-based tool was developed to replicate the results derived from the TSM. This companion tool to the guidebook was created to assist users with identifying the most appropriate tool from the over 400 possible permutations.

8.1 Software Selection Tool

In conjunction with the development of tool selection methodologies, assumptions for the various analysis types, and assumptions on the inputs for each individual tool, a Software Selection Tool (SST) was developed. The SST is a self-guided decision matrix that allows a user to select from a range of traffic analysis criteria and MOEs to determine the appropriate traffic analysis tool(s). The SST was produced in Microsoft Excel and consists of 4 Visual Basic macros:

1. **Input Form**: Opens the “Input Form” and records the various analytical scenarios
2. **Tool Identification**: Identifies the applicable tools available for each analytical scenario
3. **Clear Form**: Clears the tool results when the user is finished or wishes to perform other analyses
4. **Set Print Area**: Sets the appropriate print area for the user to conveniently print the results of the tool evaluation

The following sections will describe the use of these macros in more detail.

8.2 Software Selection Tool Input Form Macro

Provided in the following sections is a description of the SST. If the user is looking for step-by-step instructions for using the SST, they are included with the SST itself. To use the software selection tool, a user must first identify one of three specific analysis categories (e.g., intersection, highway/freeway/interchange, or multimodal/miscellaneous). The SST Input Form makes this step very simple with the use of a pushbutton. Once the pushbutton (depicted as a light blue rectangle in the SST labeled “Open Form”) is clicked, a window appears prompting the user for input on all analysis scenarios under consideration. The SST Input Form provides 6 categories of analysis criteria to specify:
Analysis Type (variable depending on the Analysis Category selected)

Oversaturated or Undersaturated Conditions

Location Type
  a. Point
  b. Segment or Facility
  c. Corridor, Area, or System

Measures of Effectiveness (variable(s) depending on the Analysis Category and Type selected)

Microsimulation Preference
  a. This input accounts for those analyses where a microsimulation tool is preferred and deterministic tools should not be considered

Figure 8 is a screenshot of the SST Input Form. All input selections are in either Option Button (e.g., Analysis Category) or List Box (e.g., Analysis Type) formats. Once all input fields have been selected, the user can decide to export the information into the SST, where it will remain until the next macro is activated (Tool Determination Macro).

The user may export up to 65,000 scenarios before closing the form and running the Tool Determination Macro. The SST Input Form has two “validation checks” in place to ensure that all fields have been identified and that the appropriate “Location Type” has been selected (see Figure 8 and Figure 9, respectively). For the first selection check, if the user does not identify a particular field, a warning message will appear when the “Export to Spreadsheet” button is selected. The second check is in place for various Highway/Freeway/Interchange Type analyses where a “Point” analysis is not feasible (“Segment” is the most isolated choice feasible). If the user attempts to identify “Point” for any of these analyses, a warning message will appear indicating that it is not feasible and that a different Location Type must be selected as shown in Figure 10.

Once a scenario has been accurately identified in the form, the user must export the scenario to the SST worksheet using the “Export to Spreadsheet” button (see Section 8.3). Once all desired scenarios have been exported, the user should select “Cancel/Close” to exit the form. This button returns the user back to the SST with all of the exported analysis scenarios listed in the order they were generated from the form as shown in Figure 11. The “Tool Determination Macro” is used to generate the recommended software tools for each scenario.

8.3 Tool Determination Macro, Set Print Area, and Clear Table Macros

Having generated the list of analysis scenarios, the user can then initiate the Tool Determination Macro with another execution button, depicted as a light purple rectangle in the SST labeled “Calculate Software Options”). In the spreadsheet, a total of 7 different software packages are listed, including the following:
### Chapter 8 – Traffic Operations Analysis Tool Selection

#### Traffic Operations Analysis Tool Guidebook

**Version 1.1**

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**Figure 8 – SST Input Form**

<table>
<thead>
<tr>
<th>Software Selection Tool Input Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is the Analysis Category?</strong></td>
</tr>
<tr>
<td>☐ Intersection Type Analyses</td>
</tr>
<tr>
<td>☐ Highway / Freeway / Interchange Type Analyses</td>
</tr>
<tr>
<td>☐ Multimodal and Miscellaneous Type Analyses</td>
</tr>
<tr>
<td><strong>What is the Analysis Type?</strong></td>
</tr>
<tr>
<td>☐ Signalized Intersection Operations</td>
</tr>
<tr>
<td>☐ Signalized Intersection Preemption/Transit Priority</td>
</tr>
<tr>
<td>☒ Unsignalized Intersection Operations (AWS and TWS)</td>
</tr>
<tr>
<td>☐ Unsignalized Intersection Operations (Roundabout)</td>
</tr>
<tr>
<td>☐ Non-Traditional Intersection Operations (5-Legged, Single Point Urban Interchange, etc...)</td>
</tr>
</tbody>
</table>

**Does the study area experience Undersaturated or Oversaturated conditions?**

- ☐ Oversaturated
- ☒ Undersaturated

**Select the Location Type**

- ☐ Point
- ☐ Segment or Facility
- ☐ Corridor, Area, or System

**Select the MOE to use for the analysis**

- ☐ Delay
- ☒ Queue
- ☐ Speed
- ☐ V/C Ratio

**Is microsimulation being requested or required by a locality, the project manager, or by other VDOT documents such as L&D's IDIs, TED Memos, etc?**

- ☐ Yes
- ☐ No

---

[Export to Spreadsheet] [Cancel / Close] [Clear Form]
Figure 9 – SST Selection Validation Check

Software Selection Tool Input Form

What is the Analysis Category?
- Intersection Type Analyses
- Highway / Freeway / Interchange Type Analyses
- Multimodal and Miscellaneous Type Analyses

What is the Analysis Type?
- Signalized Intersection Operations
- Signalized Intersection Preemption/Transit Priority
- Unsignalized Intersection Operations (AWIS and TVIS)
- Unsignalized Intersection Operations (Roundabout)
- Non-Traditional Intersection Operations (5-Legged, Single Point Urban Interchange, etc.)

Does the study area experience undersaturated or oversaturated conditions?
- Oversaturated
- Undersaturated

Select the Location Type
- Point
- Segment or Facility
- Corridor, Area, or System

Select the MOE to use for the analysis
- Delay
- Queue
- Speed
- V/C Ratio

Is microsimulation being requested or required by a locality, the project manager, or by other VDOT documents such as L&D's IDs, TED Memos, etc.?
- Yes
- No

Export to Spreadsheet  Cancel / Close  Clear Form
Figure 10 – SST Location Type Validation Check

Software Selection Tool Input Form

**What is the Analysis Category?**
- Intersection Type Analyses
- Highway / Freeway / Interchange Type Analyses
- Multimodal and Miscellaneous Type Analyses

**What is the Analysis Type?**
- Freeway Segment Operations (Limited Access)
- Merge/Emerge Operations
- Weakening Segment Operations
- Freeway HOV/Ramp Metering Operations
- Collector-Distributor Facilities
- Multi-Lane Highway Operations
- Two-Lane Highway Operations

**Does the study area:**
- Oversaturated
- Undersaturated

**Select the Location:**
- Point
- Segment or Facility
- Corridor, Area, or System

**Select the HOC to use for the analysis:**
- Density
- Speed

**Is microsimulation being requested or required by a locality, the project manager, or by other VDOT documents such as LMD’s TRIS, TED Memos, etc?**
- Yes
- No

[Buttons: Export to Spreadsheet, Cancel/Close, Clear Form]
Specific software versions are not included in each software column heading, but are rather included in the disclaimers located at the top of the SST. This tool will need to be modified in the future as traffic analysis tool preferences change or as new traffic analysis tools and/or versions of existing traffic analysis tools become available for use in practice. For Version 1.4 of the SST (July 13, 2012), the following versions of each traffic analysis tool were assumed:

- HCS 2010
- Synchro 8.0 (HCM Module)
- SIDRA 5.1
- Quickzone 2.0
- SimTraffic 8.0
- CORSIM 6.3 (some special functionalities of CORSIM, Version 6.3, such as managed lanes and toll lanes are not addressed in this version of the guidebook)
- VISSIM 5.4

After selecting the “Calculate Software Options” button (depicted as a light purple rectangle in the SST labeled “Calculate Software Options”), a “✓” will identify the traffic analysis tool(s) that are appropriate to analyze the given analysis scenario(s), as depicted in Figure 12. Depending on the analysis scenario, multiple traffic analysis tools may be recommended.

The tool will provide applicable notes in the “Notes” column, located to the right of the VISSIM column as shown Figure 12. Only key notes are included in this column, and not every scenario may have a corresponding note(s). As an example, the note at the bottom of Figure 12 pertains to two-lane highways. For oversaturated conditions on two-lane highways, analysis tools are only available when speed is an MOE, so when another MOE is selected, a special note appears in the “Notes” column. For other notes that the user would like to document (i.e., cost
constraints, tool preference, etc.), a “Comments” column is provided. This column is the only area of the SST worksheet that is not protected, so the user can manually input text that helps to describe the differences between scenarios.

### Figure 12 – Output from Executing the Tool Determination Macro

<table>
<thead>
<tr>
<th>HCS</th>
<th>Synchro NCM Module</th>
<th>SIDRA</th>
<th>Quickzone</th>
<th>SimTraffic</th>
<th>CORSIM</th>
<th>VISSIM</th>
<th>NOTES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>To utilize the HCM Module of Synchro, select “File &gt; Create Report &gt; Select Reports &gt; HCM Signals” within Synchro. The subsequent output will generate HCM Module results.</td>
<td>&lt;User can insert comments here&gt;</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Use of SimTraffic requires a Synchro network to be developed. Signal timings for coordinated intersections should be optimized in Synchro before modeling in any microsimulation software.</td>
<td>&lt;User can insert comments here&gt;</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Coordinated signal timing plans can be developed using Synchro software and transferred into VISSIM or CORSIM (if desired), but all analysis shall be performed using CORSIM or VISSIM.</td>
<td>&lt;User can insert comments here&gt;</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No tools identified. Use speed as the preferred MOE using a microsimulation tool.</td>
<td>&lt;User can insert comments here&gt;</td>
</tr>
</tbody>
</table>

Once all comments have been inputted by the user, the user can print the result table using the “Set Print Area” macro (depicted as a light pink rectangle in the SST labeled “Set Print Area”). Running this macro will automatically set the printing extents to encompass the entire results table. Once all printing is completed and/or the user wishes to start over, the user should clear the table using the “Clear Table Macro”. The Clear Table Macro is depicted as a light orange rectangle in the SST labeled “Clear Table”. It is important to emphasize that all scenarios will be cleared once this macro runs.

### 8.4 Software Selection Tool Maintenance

VDOT will have the primary responsibility for maintaining the methodology and logic in the tool; however, future refinements (e.g., analysis type, analytical tools, input assumptions, and MOEs) should be based on input and feedback from a multidisciplinary technical advisory committee. When reevaluating the methodology and logic for the SST, the vision and goals of this guidebook should serve as the benchmark for any modification(s).

### 8.5 Roundabout Analysis Methodology

Supported by guidance provided in the current VDOT Road Design Manual, all roundabout analysis submissions shall be accompanied by a SIDRA Intersection analysis. The use of the SIDRA Intersection model is required for roundabout analyses conducted with SIDRA Intersection. However, there are conditions, such as those listed below, where VISSIM should be used to analyze the operations of roundabouts.
Two- or three-lane roundabouts
Hybrid roundabout configurations
Roundabouts in close proximity to traffic signals or other roundabouts
Roundabouts that are at or over capacity

Even when a VISSIM analysis is conducted, a SIDRA Intersection analysis shall be submitted assuming the tool can analyze the configuration that is being proposed. If VISSIM is used for a roundabout analysis, the calibration methodology should be documented and submitted with the results.
When multiple output formats are currently submitted to VDOT for review, VDOT staff must first familiarize themselves with the format of the output summary before actually reviewing the content of the information for accuracy and validity. This section describes approved, standardized formats to display results from the various types of traffic analysis tools described in previous chapters. The purpose of developing standardized output formats with this guidebook is twofold:

1. To provide consistent output formats to assist VDOT reviewers in:
   a. reducing the potential for requiring multiple submittals
   b. reducing review time required by VDOT staff
2. To relay key MOE information from traffic analysis tool outputs

It is important to note that the output formats presented in this chapter are standards, and should serve as the minimal for submittals, but can be expanded upon with approval from the VDOT project manager. The only case in which a modification will be considered by a project manager is one where a particular MOE will not conform to the standard presentation format. In these cases, it must be justified why the MOE will not conform to the associated output format(s). If and only then will consideration be made by the project manager to allow modifications to a particular output format for the associated analysis only. Revisions to the output formats will not constitute a permanent change in the approved output format for a particular tool, but could be considered as an additional output format if the project manager determines that it will be used in future analyses.

### 9.1 Output Formats

The two main types of output formats discussed in this guidebook are depictive and tabular. In a depictive output format, data and results are represented with colors, shapes, and/or symbols with numerical results. Tabular output formats display the results in tabular form with a varying number of rows and columns. Examples of each output style are described, with examples provided, in the following sections. Associated electronic outputs shall be included (actual model and results in .xls or .dbf formats) with the hard copy submittals.

Various examples of each output format were assessed as to how they would correlate with the tools described in this guidebook. Depictive results are required, but they should also always be supplemented with tabular formats, which allow for some redundancy with more than one output format. In addition, a minimum of two output formats:

- **Depictive**
- **Tabular**

Depictive results are required whenever possible, but they should also always be supplemented with tabular formats.
MOEs shall be summarized for each link or intersection in the network when more than one MOE is available. For example, since LOS is a description of density, another MOE, such as speed must be included, or to supplement intersection delay, queue length should be added. By using two different MOEs, transportation professionals will make more informed decisions regarding the adequacy of the network.

The following sections outline the output formats for each software tool (with exception of Quickzone). The output format for Quickzone should be agreed upon with the project manager on a case-by-case basis. Deviations from the intent of the recommended templates presented in this chapter will need to be discussed with and approved by the project manager. Modifications of the templates to meet the needs of specific projects will need to be approved by the project manager.

9.2 HCS Output Formats

Two output formats were selected for HCS 2010. Figure 13 illustrates a depictive output format for freeway operations, including ramps and weaving areas, which was created in Microsoft Excel. This template presents LOS and density in a depictive output style. Sections are appropriately color-coded according to the corresponding LOS and density. Other items illustrated on the figure include free-flow speed, traffic volume, distances between ramps, ramp lengths, ramp speeds, and acceleration/ deceleration lane lengths. A brief description of the ramps is also included on the figure. Additionally, an aerial that depicts the overall study area is included on the figure to serve as a geographical reference for the reviewer. The aerial is not a required on the output summary; however, an aerial should be included if one is available to help with the review process.

The second template is presented in a tabular format, which was also created in Microsoft Excel. Table 11 displays LOS and density for various ramp junctions/weave segments. In the table, results from multiple scenarios (both AM and PM) can be presented with this format.
Figure 13 – HCS Depictive Figure - Freeways

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Ramp / Merge Level of Service</th>
<th>FIGURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somewhere, Virginia</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Legend

<table>
<thead>
<tr>
<th>LOS / DENSITY (pc/ln/mi)</th>
<th>Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A / 0-14</td>
<td>B / 10-20</td>
</tr>
<tr>
<td>C / 20-25</td>
<td>D / 25-35</td>
</tr>
<tr>
<td>E / 35-43</td>
<td>F / 43+</td>
</tr>
</tbody>
</table>

* Numbers in this graphic are provided for illustrative purposes only.
Table 11 – HCS Tabular Output Format

<table>
<thead>
<tr>
<th>Direction</th>
<th>Movement</th>
<th>2012 Baseline LOS (Density- vplpm)</th>
<th></th>
<th>2012 Baseline LOS (Density- vplpm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AM</td>
<td>PM</td>
<td>AM</td>
<td>PM</td>
</tr>
<tr>
<td>Northbound I-95</td>
<td>Diverge: Off-ramp to Eastbound Main Street</td>
<td>C (22.7)</td>
<td>B (11.4)</td>
<td>D (33.4)</td>
<td>B (18.0)</td>
</tr>
<tr>
<td></td>
<td>Weave</td>
<td>C (20.5)</td>
<td>A (9.0)</td>
<td>E (36.2)</td>
<td>B (14.4)</td>
</tr>
<tr>
<td></td>
<td>Merge: I-95 Northbound On-ramp from Westbound Main Street</td>
<td>B (19.3)</td>
<td>A (9.9)</td>
<td>D (29.5)</td>
<td>B (15.8)</td>
</tr>
<tr>
<td>Southbound I-95</td>
<td>Diverge: Off-ramp to Main Street</td>
<td>A (6.7)</td>
<td>B (15.6)</td>
<td>A (8.5)</td>
<td>B (19.4)</td>
</tr>
<tr>
<td></td>
<td>Merge: On-ramp from Main Street</td>
<td>A (3.8)</td>
<td>B (11.6)</td>
<td>A (5.6)</td>
<td>B (17.4)</td>
</tr>
</tbody>
</table>

9.3 Synchro/SimTraffic Output Formats

Intersections in Synchro 8.0 can currently be analyzed using both HCM 2000 and HCM 2010 methodologies, with several restrictions using HCM 2010 (e.g., only NEMA phasing can be used, no more than four legs can be analyzed, etc.). Due to the difference in computation methodologies between the two HCM releases, the output values differ. It may be argued that the latest HCM 2010 methodology yields more realistic output; hence, the analyst may be inclined to use the outputs from the HCM 2010 to estimate intersection performance. However, at this time, the arterial analysis in Synchro 8.0 can only be performed using the HCM 2000 methodology. Trafficware is currently expanding the functionality of Synchro 8.0 to include the HCM 2010 methodology, but indicated that it will take time to finish the updates. Therefore, only the HCM 2000 methodology is currently useable for the analysis of a network that includes both arterials and intersections.

Until such time that the HCM 2010 methodologies are uniformly incorporated into Synchro 8.0, the users of this guidebook shall continue to use outputs from the HCM 2000 methodology. If outputs from HCM 2010 methodology become available before the next version of this guidebook is developed, then those results may only be used to supplement the HCM 2000 methodology output.

Three required output templates were created to summarize Synchro/SimTraffic results. The first two templates are depictive formats, which are presented in Figure 14 and Figure 15, were created in Microsoft Excel.
Figure 14 – Synchro/SimTraffic/CORSIM/VISSIM LOS Depictive Figure – Intersections

Legend
A – Movement Level of Service (Control Delay) [expressed in seconds per vehicle]
A – Overall Intersection Level of Service

Project Title
Somewhere, Virginia

Signalized Intersection Level of Service

FIGURE X
Figure 15 – Synchro/SimTraffic/CORSIM/VISSIM Queue Depictive Figure - Intersections

Legend
XX’ (XX’ – Length of Queue (Available Storage Length) [expressed in feet]

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Intersection Queue Lengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somewhere, Virginia</td>
<td></td>
</tr>
</tbody>
</table>
In both figures, multiple MOEs (in the example outputs, it is LOS and queue) are illustrated at four intersections. An aerial image helps to depict the general study area while a number labels each individual study intersection. Results are then reported off to the side of the labeled aerial image for each study intersection. The aerial is not a required piece of the output; however, an aerial should be included if one is available.

The third Synchro/SimTraffic template presents MOEs (LOS and delay) in a tabular format as shown for delay/LOS in Table 12 and queue length in Table 13. The tables, which were created in Microsoft Excel, can be used to summarize a multitude of scenarios and provide both overall results and results by individual intersection approach. In Table 12, the eastbound through and right-turn lane is shared; hence the respective cells are merged to provide one output for the lane group. The specific information shown in Table 12 and Table 13 may vary slightly depending on the requirements of the specific project as defined by the project manager.

### 9.4 SIDRA Intersection Output Formats

Three required output templates were created to summarize SIDRA Intersection results. Figure 16 shows a screen shot of a depictive output template, which was created in SIDRA Intersection, but it can show any MOE (in this case, delay). The second depictive template, Figure 17, shows LOS for each lane of a roundabout. Note that the LOS reported in this figure is the delay from the HCM as opposed to the degree of saturation from SIDRA Intersection. The final output template is in tabular format, as shown in Table 14. SIDRA Intersection automatically develops this tabular format once a roundabout analysis is processed.

### 9.5 CORSIM and VISSIM Output Formats

Since CORSIM and VISSIM have similar MOEs, five required output templates were created to summarize the results for these software programs depending on whether the results pertain to freeway operations or intersection operations. The first two templates pertain to intersections and are the same as the ones developed for Synchro and SimTraffic as shown in Figure 14 and Figure 15.

The third template is a depictive freeway schematic for CORSIM illustrated in Figure 18, which was created in Microsoft Excel. This template includes actual volumes, simulated volumes, link distances, speeds, and density between nodes. Additionally, results are reported for every lane of every segment, providing an in-depth evaluation of operations. With this template, various MOEs can be color coded to help the reviewer differentiate
# Table 12 – Level of Service Table for Synchro/SimTraffic Output

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Overall LOS</th>
<th>Level of Service per Movement by Approach (Delay in sec/veh)</th>
<th>Eastbound</th>
<th>Westbound</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AM Peak Hour</td>
<td>LT TH RT</td>
<td>LT TH RT</td>
<td>LT TH RT</td>
<td>LT TH RT</td>
</tr>
<tr>
<td>2012</td>
<td>D (40.9)</td>
<td>D (51.1) D (49.0) D (47.2) B (19.0) A (2.6) C (30.6) E (66.1) A (4.0) D (44.6) B (11.8) A (4.1)</td>
<td>D (49.1)</td>
<td>C (27.8) E (56.8) C (26.1)</td>
<td>D (47.7) E (58.9) D (39.5) D (36.2) B (11.4) B (14.5) C (31.7) A (4.4) D (52.9) C (33.1) B (17.1)</td>
<td>D (54.0) C (32.2) C (27.4) D (41.6)</td>
</tr>
<tr>
<td>2020</td>
<td>D (35.8)</td>
<td>D (40.1) D (48.0) E (59.8) D (53.6) C (28.5) C (21.0) A (1.3) E (62.3) C (31.9) C (25.7) D (38.8) B (12.1) A (4.5)</td>
<td>D (54.1)</td>
<td>B (18.3) C (33.6) B (15.9)</td>
<td>E (54.5) E (59.4) C (33.7) C (32.5) A (7.4) E (59.5) C (24.7) C (20.2) D (36.5) A (9.6) A (2.8)</td>
<td>E (57.0) C (26.0) C (27.0) B (13.5)</td>
</tr>
<tr>
<td>Build-Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>D (40.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Table 13 – Queue Table for Synchro/SimTraffic Output

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Movement</th>
<th>95th Percentile Queue Length (ft)</th>
<th>Storage Length Available (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Street/First Street</td>
<td>Westbound RT/LT</td>
<td>225</td>
<td>300</td>
</tr>
<tr>
<td>Main Street/First Street</td>
<td>Southbound TH</td>
<td>450</td>
<td>850</td>
</tr>
</tbody>
</table>
Figure 16 – SIDRA Intersection Depictive Output Figure

DETERMINATION (AVERAGE)
Average control delay per vehicle, or average pedestrian delay (seconds)
Sample Roundabout Roundabout

<table>
<thead>
<tr>
<th>Delay (Average)</th>
<th>South</th>
<th>East</th>
<th>North</th>
<th>West</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay (Average)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Colour code based on Level of Service

- LOS A
- LOS B
- LOS C
- LOS D
- LOS E
- LOS F

Level of Service Method: Delay (HCM 2000)
Figure 17 – SIDRA Intersection LOS Depictive Summary Figure
Table 14 – SIDRA Intersection Movement Summary Table

<table>
<thead>
<tr>
<th>MOVEMENT PERFORMANCE - VEHICLES</th>
<th>Site: New Site - 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Movement Performance - Vehicles</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mov ID</strong></td>
<td><strong>Turn</strong></td>
</tr>
<tr>
<td>South: Side Street</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>L</td>
</tr>
<tr>
<td>6</td>
<td>T</td>
</tr>
<tr>
<td>18</td>
<td>R</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>East: Main Street</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>L</td>
</tr>
<tr>
<td>6</td>
<td>T</td>
</tr>
<tr>
<td>16</td>
<td>R</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>North: Side Street</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>L</td>
</tr>
<tr>
<td>4</td>
<td>T</td>
</tr>
<tr>
<td>14</td>
<td>R</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>West: Main Street</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>L</td>
</tr>
<tr>
<td>2</td>
<td>T</td>
</tr>
<tr>
<td>12</td>
<td>R</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>All Vehicles</td>
<td></td>
</tr>
</tbody>
</table>

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalized Intersections.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.
between results. In this sample, density values were color coded. The fourth output template is also a freeway schematic, illustrated in Figure 19, which is similar to the other freeway template, but it is tailored to provide more flexibility for the summary of VISSIM output. The fifth output template, also created in Microsoft Excel, presents the results in tabular form as shown in Table 15. In addition, companion macros for this guidebook convert the traffic simulation results into results compatible with level of service. This table summarizes travel times on a specific link in the network, but it can be modified to summarize delay, queue lengths, traffic volumes, or a number of other MOEs from the microsimulation tools for multiple links in the analysis network.

The output table may be used to summarize results for any MOE. Depending on the complexity of the project, the project manager may require additional MOEs to be summarized. The results from the multiple runs must be averaged and then summarized in the tables and figures previously described. If the project manager wants to compare the results from the microsimulation tools to levels of service, the traffic simulation MOEs must be converted to equivalent deterministic model MOEs. An example of this conversion is provided in Appendix D for CORSIM. In this example, the density computed from CORSIM is converted to an adjusted density taking into account passenger car equivalency factors. The adjusted density is then assigned a corresponding level of service.

<table>
<thead>
<tr>
<th>Location</th>
<th>Speed Results for Link 1-2 (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM</td>
</tr>
<tr>
<td>Location 1</td>
<td>51.8</td>
</tr>
<tr>
<td>Location 2</td>
<td>50.3</td>
</tr>
<tr>
<td>Location 3</td>
<td>48.6</td>
</tr>
</tbody>
</table>
Chapter 9 – Output
Traffic Operations Analysis Tool Guidebook
Version 1.1

Figure 18 – CORSIM Lane Schematic Figure

NOTE: numbers in chart are provided for illustrative purposes only

LEGEND

Network Statistics
Selected Measures of Effectiveness
Results

Vehicle delay: Total Number of Stops
Other MOEs
Other MOEs
Other MOEs

INTERSTATE 95 NORTHBOUND

Actual Volumes Simulated Volumes

Distance (ft)
625 583 1,281 861 184 296 226 539 405 1,477 757 594 529 618 648 648

Speed (mph)
66.0 67.8 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0

Density (pc/ln/mi)
28.9 27.9 28.3 23.5 22.3 24.0 24.7 24.8 24.8 25.9 24.9 24.9 29.2 29.7 27.3 27.2 27.2

INTERSTATE 95 SOUTHBOUND

Actual Volumes Simulated Volumes

Distance (ft)
625 583 1,281 861 184 296 226 539 405 1,477 757 594 529 618 648 648

Speed (mph)
66.0 67.8 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0 66.0

Density (pc/ln/mi)
28.9 27.9 28.3 23.5 22.3 24.0 24.7 24.8 24.8 25.9 24.9 24.9 29.2 29.7 27.3 27.2 27.2

NOTE: numbers in chart are provided for illustrative purposes only
Figure 19 – VISSIM Lane Schematic Figure

**Legend**

- **Link Number:**
  - **Freeway Density:**
    - Green: 0-25
    - Yellow: 26-35
    - Red: 36-45
  - **Ramp Density:**
    - Green: 0-35
    - Yellow: 36-45
    - Red: 46-55
  - **Freeway, Varies, and Ramp Density:**
    - Green: 0-35
    - Yellow: 36-45
    - Red: 46-55
  - **Density per lane:**
    - Green: 0-10
    - Yellow: 11-18
    - Red: 19-28
  - **Density per ln:**
    - Green: 0-10
    - Yellow: 11-18
    - Red: 19-28

**Network Statistics**

- **Overall Segment:**
  - **Density:**
    - Green: 0-25
    - Yellow: 26-35
    - Red: 36-45
  - **Speed:**
    - Green: 0-5
    - Yellow: 6-10
    - Red: 11-15

**Distance (ft)**

- **Overall Segment:**
  - **Density:**
    - Green: 0-25
    - Yellow: 26-35
    - Red: 36-45
  - **Speed:**
    - Green: 0-5
    - Yellow: 6-10
    - Red: 11-15

**Scenario:**

- **7:15 - 8:15 AM**

**Actual Volumes:**

- **5,284**
  - **5,284**
  - **4,531**
  - **5,512**
  - **4,228**
  - **5,350**
  - **3,838**
  - **3,992**
  - **3,992**
  - **6,483**
  - **5,579**
  - **5,912**
  - **5,912**
  - **5,912**
  - **5,375**
  - **6,096**
  - **2,149**
  - **2,149**

**Figure XX**

- **I-64 and I-95 Overlap Report**
- **Northbound I-95 AM Peak Hour MOEs**
- **2022 No-Build Scenario**
- **7:15 - 8:15 AM**
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APPENDIX A

ADDITIONAL RESOURCES REVIEWED
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TRAFFIC ANALYSIS TOOLBOX VOLUME II: DECISION SUPPORT METHODOLOGY FOR SELECTING TRAFFIC ANALYSIS TOOLS
FHWA
JULY 2004

TRAFFIC ANALYSIS TOOLBOX VOLUME III: GUIDELINES FOR APPLYING TRAFFIC MICROSIMULATION MODELING SOFTWARE
FHWA
JULY 2004

TRAFFIC ANALYSIS TOOLBOX VOLUME IV: GUIDELINES FOR APPLYING CORSIM MICROSIMULATION MODELING SOFTWARE
FHWA
JANUARY 2007
Appendix A – Additional Resources

Traffic Operations Analysis Tool Guidebook
Version 1.1

TRAFFIC ANALYSIS TOOLBOX VOLUME VIII: WORK ZONE MODELING AND SIMULATION - A GUIDE FOR DECISION-MAKERS
FHWA
AUGUST 2008

PROTOCOL FOR VISSIM SIMULATION -
Oregon Department of Transportation
JUNE 2011

ADVANCED CORSIM TRAINING MANUAL -
Minnesota Department of Transportation
MAY 2004
http://www.dot.state.mn.us/trafficeng/modeling/resources/CORSIMmanua
al/final%20corsim%20manual%209-19-09.pdf

MICROSIMULATION CALIBRATION AND VALIDATION HANDBOOK -
Virginia Transportation Research Council
OCTOBER 2006
FHWA SAMPLE SIZE INFORMATION
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Determination of Sample Size

• Beside the urban myths of 10 / 20 / 30 runs?
• Here is a quick process
  – Choose your performance measures(s) (MOE)
  – Run the simulation a number of times initially (e.g.,10) to
determine the mean and the standard deviation
  – Choose a confidence level (this should be done in the
assumption document)
  – Choose a tolerance error (this should be done in the
assumption document)
  – Compute the required sample size
Sample Size Example

1. Assume MOE is Speed in mph
2. Run simulation (initially 10 times) with the following results:
   - Sample Mean (Xs) = 32.5 mph
   - Sample Standard Dev (Ss) = 8.5 mph
3. Assume 95% Confidence Level
4. Tolerance Error
   - Observed data: n = 30, Xs = 34.5 mph, Ss = 9.64 mph
   - Tolerable error is 10%
Sample Size Calculations

- **95% Confidence Interval** = \( X_s \pm Z(\frac{S_s}{\sqrt{N}}) \)

Where:
- \( Z(\frac{S_s}{\sqrt{N}}) \) = sampling error or tolerable error
- \( X_s \) = sample mean
- \( Z \) = Number of standard deviations away from the mean corresponding to the required confidence level in a normal distribution
- \( S_s \) = sample standard deviation
- \( N \) = sample size

32.5 ± 1.96(8.5/\sqrt{10}) → 32.5 ± 5.27 → 5.27 is 16.21% of the mean: too high. To bring it to 10% tolerable error or 3.25 mph away from the mean:

- **Sample Size Needed**

\[
N = \left( \frac{Z}{E} \right)^2 \left( \frac{\hat{p}(1-\hat{p})}{E^2} \right) = (1.96)^2 \left( \frac{8.5}{(3.25)^2} \right) = 27
\]

Therefore, 27 runs will be needed to be 95% confident that the sampling error or the tolerable error will not be greater than 10% of the mean speed.
Sample Size Calculations: Additional Iterations

When we run the simulation 17 more times to get to 27 runs, the mean and/or standard deviation may change. Once we have all 27 runs, repeat the computation of the confidence interval to make sure that the sampling error is 10% of the mean or lower.

- Example:
  - After 27 runs, mean is 31.5 mph and standard deviation is 10.5 mph.
  - New 95% confidence interval: $31.5 \pm 1.96(10.5/\sqrt{27}) \approx 31.5 \pm 3.96$.
  - The new sampling error is 12.57% of the mean which is still not good enough.
  - Repeating the computation of the sample size: $N = (Z)^2(Ss)^2/(E)^2 = (1.96)^2(10.5)^2/(3.15)^2 = 43$.
  - Therefore, 43 runs will be needed to be 95% confident that the sampling error or the tolerable error will not be greater than 10% of the mean speed.
  - Repeating the process of running the simulation 43 times, the new mean now is 30.5 with a standard deviation of 9.5 mph.
  - The new 95% confidence interval is: $30.5 \pm 1.96(9.5/\sqrt{43}) \approx 30.5 \pm 2.84$.
  - The new sampling error now is 9.31% of the mean which is lower that the maximum tolerable error of 10% so now we are 95% confident that the sampling error or the tolerable error is not greater than 10% of the mean speed.
APPENDIX B

TRAFFIC OPERATIONS ANALYSIS TOOL SELECTION MATRIX
### Traffic Operations Analysis Tool Selection Matrix

<table>
<thead>
<tr>
<th>Location Description</th>
<th>Point</th>
<th>Segment and Facility</th>
<th>Corridor, Area, and System</th>
<th>Point</th>
<th>Segment and Facility</th>
<th>Corridor, Area, and System</th>
<th>Special Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTERSECTION / HIGHWAY ANALYSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Use both SIDRA Intersection and Synchro for networks including roundabouts and signalized/unsignalized intersections.
- CORSIM and VISSIM should only be considered for oversaturated Segments, Facilities, Corridors, Areas, and Systems analyses due to modeling effort.
- Do not use HCS in oversaturated conditions or on Corridors, Areas, and Systems analyses. |
| Signalized Intersection Preemption/Transit Priority | VISSIM | VISSIM | VISSIM | VISSIM | VISSIM | VISSIM | - VISSIM is the preferred tool for this type of analysis. |
- For conditions where HCS cannot be used, Synchro is the preferred tool for this type of analysis supplemented by SimTraffic.
- Use both SIDRA Intersection and Synchro in networks including roundabouts and signalized/unsignalized intersections.
- CORSIM and VISSIM should not be used to model this intersection type unless the intersection is included in a larger model. |
| Unsignalized Intersection Operations (Roundabout) | SIDRA Intersection VISSIM | SIDRA Intersection VISSIM | SIDRA Intersection VISSIM | SIDRA Intersection VISSIM | SIDRA Intersection VISSIM | SIDRA Intersection VISSIM | - SIDRA intersection is the preferred tool for this type of analysis.
- When a simulation based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM.
- Use Synchro, SimTraffic, and HCS are the preferred tools for this type of analysis (HCS in undersaturated conditions only).
- Use SIDRA Intersection for this type of analysis if a roundabout is included.
- If roundabouts are included in a Synchro network, a separate analysis using SIDRA Intersection must be completed for the analysis of the roundabout(s).
- CORSIM and VISSIM should only be considered for oversaturated Segments, Facilities, Corridors, Areas, and Systems analyses due to modeling effort. |
| Two-Lane Highway Operations | Not Applicable | HCS VISSIM | VISSIM | Not Applicable | VISSIM | | - CORSIM, SimTraffic, and HCS are the preferred tools for this type of analysis (HCS in undersaturated conditions only).
- Use SIDRA Intersection for this type of analysis if a roundabout is included.
- When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM.
- CORSIM and VISSIM should not be used to analyze non-traditional intersections. |
| Multi-Lane Highway Operations | Not Applicable | CORSIM HCS SimTraffic Synchro VISSIM | CORSIM SimTraffic Synchro VISSIM | Not Applicable | CORSIM SimTraffic Synchro VISSIM | CORSIM SimTraffic Synchro VISSIM | - CORSIM, SimTraffic, and HCS are the preferred tools for this type of analysis (HCS in undersaturated conditions only).
- Use SIDRA Intersection for this type of analysis if a roundabout is included.
- When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM.
- CORSIM and VISSIM should only be considered for oversaturated Segments, Facilities, Corridors, Areas, and Systems analyses due to modeling effort. |
| Non-Traditional Intersection Operations (5-Legs, SPUI) | CORSIM VISSIM | CORSIM VISSIM | CORSIM VISSIM | CORSIM VISSIM | CORSIM VISSIM | CORSIM VISSIM | - CORSIM, SimTraffic, and HCS are the preferred tools for this type of analysis (HCS in undersaturated conditions only).
- Use SIDRA Intersection for this type of analysis if a roundabout is included.
- When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM.
- CORSIM and VISSIM should only be considered for oversaturated Segments, Facilities, Corridors, Areas, and Systems analyses due to modeling effort. |

| **GENERAL NOTES** |

The tools included in each box, in alphabetical order, are identified as acceptable tools for the subject analysis. If a tool is not listed, VDOT will not accept it for that type of operational analysis. Refer to "Special Notes" for tool preferences. Exact definitions for "Oversaturated Conditions" will differ between VDOT regions. Traffic analysis tools referred to in matrix: HCS 2010, Synchro/SimTraffic 8.0, SIDRA Intersection 5.1, VISSIM 5.4, and CORSIM 6.3.
## Traffic Operations Analysis Tool Selection Matrix

<table>
<thead>
<tr>
<th>Saturation Level (General Description)</th>
<th>Location Description</th>
<th>UNDERSATURATED CONDITIONS (No prolonged queuing approaching free-flow conditions)</th>
<th>OVERSATURATED CONDITIONS*</th>
<th>Special Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freeway Segment Operations (limited access)</td>
<td>Not Applicable</td>
<td>CORSIM  HCS VISSIM</td>
<td>CORSIM VISSIM  CORSIM VISSIM  CORSIM VISSIM</td>
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<tr>
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<td>Merge/Diverge Operations</td>
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<td>CORSIM VISSIM  CORSIM VISSIM  CORSIM VISSIM</td>
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<tr>
<td></td>
<td>Weaving Segment Operations</td>
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<td>CORSIM VISSIM  CORSIM VISSIM  CORSIM VISSIM</td>
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<tr>
<td></td>
<td>Freeway HOV/Ramp Metering Operations / Managed Lanes</td>
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<td>VISSIM  VISSIM  VISSIM  VISSIM</td>
<td></td>
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<tr>
<td></td>
<td>Collector-Distributor Facilities</td>
<td>CORSIM  HCS VISSIM</td>
<td>CORSIM VISSIM  CORSIM VISSIM  CORSIM VISSIM</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
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<td>HCS should not be used in oversaturated conditions or on Corridors, Areas, and Systems analyses, but is the preferred tool for undersaturated Segments and Facilities analyses</td>
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<td>When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM</td>
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<td>HCS should not be used in oversaturated conditions or on Corridors, Areas, and Systems analyses, but is the preferred tool for undersaturated Points, Segments and Facilities analyses</td>
</tr>
<tr>
<td></td>
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<td>When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM</td>
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<td></td>
<td>HCS should not be used in oversaturated conditions or on Corridors, Areas, and Systems analyses, but is the preferred tool for undersaturated Segments and Facilities analyses</td>
</tr>
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<td></td>
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<td>Point analyses are not applicable for this type of facility</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>VISSIM is the preferred tool for these analyses</td>
</tr>
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<td></td>
<td>Synchro, SIDRA Intersection, and HCS cannot be used for these types of analyses</td>
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<tr>
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<td></td>
<td>HCS should not be used in oversaturated conditions or on Corridors, Areas, and Systems analyses, but is the preferred tool for undersaturated Segments and Facilities analyses with more than one lane</td>
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<tr>
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<td>Point analyses are not applicable for this type of facility</td>
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<tr>
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<td></td>
<td></td>
<td>When a simulation-based tool is required, or chosen in lieu of HCS, there is no priority between CORSIM and VISSIM</td>
</tr>
</tbody>
</table>

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# Traffic Operations Analysis Tool Selection Matrix

## Traffic Operations Analysis Tool Guidebook

**Appendix B**

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### Traffic Operations Analysis Tool Selection Matrix

<table>
<thead>
<tr>
<th>Saturation Level (General Description)</th>
<th>UNDERSATURATED CONDITIONS (No prolonged queuing approaching free-flow conditions)</th>
<th>OVERSATURATED CONDITIONS* (Queuing exists beyond peak hour, HCM capacity checks fail)</th>
<th>Special Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location Description</strong></td>
<td><strong>Point</strong></td>
<td><strong>Segment and Facility</strong></td>
<td><strong>Corridor, Area, and System</strong></td>
</tr>
<tr>
<td>Pedestrian and Bicycle</td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
<tr>
<td>Simulation and Analysis</td>
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<td></td>
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</tr>
<tr>
<td>Multimodal Facilities (Transit Center,</td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
<tr>
<td>Airport Landside, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Transit Operations (BRT, LRT,</td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
<tr>
<td>etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Toll Plaza Operations</td>
<td>CORSIM</td>
<td>CORSIM</td>
<td>CORSIM</td>
</tr>
<tr>
<td></td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
<tr>
<td>Parking Operations</td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
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<td></td>
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</tr>
<tr>
<td>Workzone Traffic Operations/Queuing</td>
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<td>CORSIM</td>
<td>CORSIM</td>
</tr>
<tr>
<td>(Arterials)</td>
<td>Quickzone</td>
<td>Quickzone</td>
<td>Quickzone</td>
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<td></td>
<td>SimTraffic</td>
<td>SimTraffic</td>
<td>SimTraffic</td>
</tr>
<tr>
<td></td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
<tr>
<td>Workzone Traffic Operations/Queuing</td>
<td>CORSIM</td>
<td>CORSIM</td>
<td>CORSIM</td>
</tr>
<tr>
<td>(Freeways)</td>
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<td>Quickzone</td>
<td>Quickzone</td>
</tr>
<tr>
<td></td>
<td>VISSIM</td>
<td>VISSIM</td>
<td>VISSIM</td>
</tr>
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<td>FHWA REQUIREMENTS</td>
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<td>HCS</td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

---

### General Notes

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Page 3 of 3
APPENDIX C

TRAFFIC SIMULATION CALIBRATION FACTORS
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CORSIM Calibration Factors

Freeways – key calibration factors: speeds, travel time, queues
- Truck fleet
- Vertical grades
- Link free-flow speed
- Headway factor
- O-D matrix
- Vehicle entry headway distributions
  - Erlang – preferred for freeways
  - Normal – preferred for arterials
- Anticipatory lane change parameter – ramp merge speed (default – 43 mph)
- Warning sign location (merge) – location of warning sign upstream of merge (default – 1500 ft)
- Warning sign location (diverge/lane drop) – location of warning sign upstream of diverge (default – 2500 ft)
- Fresim vehicle parameters information
  - Current fleet percentages
  - Maximum non-emergency deceleration
  - Maximum emergency deceleration
- Fresim model parameters
  - Minimum separation for generation of vehicles – controls freeway capacity (default – 1.6 sec = 2250 vph)

Arterials – key calibration factors: speeds, travel time, queues
- Headway spacing
- Truck fleet
- Vertical grades
- Link free-flow speed
- Existing signal timing (if applicable)
- Vehicle entry headway distributions
  - Normal – preferred for arterials
- Netsim vehicle parameters information
  - Current fleet percentages
  - Maximum non-emergency deceleration
  - Maximum emergency deceleration
VISSIM Calibration Factors

Freeways – key calibration factors: output volumes, speeds, travel time, queues
- Truck fleet – vehicle compositions
- Vertical grades
- Free-flow speed – desired speed decisions
- O-D matrix – routing decisions
- Connector lane change and emergency stop distances
- Location of static route decision points
- Car following parameters
  - Wiedemann 99 model – freeway traffic
    - Standstill distance
    - Headway time
    - Necessary lane change parameters
    - Waiting time before diffusion
    - Safety distance reduction factor
  - Advanced merging
  - Cooperative lane change

Arterials – key calibration factors: output volumes, speeds, travel time, queues
- Truck fleet – vehicle compositions
- Free-flow speed – desired speed decisions
- Turning speeds – reduced speed areas
- Existing signal timing (if applicable)
- Connector lane change and emergency stop distances
- Location of static route decision points
- Dwell time distribution at STOP signs (if needed)
- Minimum headway – priority rules (if applicable)
- Conflict area parameters
  - Front gap
  - Rear gap
  - Safety Distance Factor
- Car following parameters
  - Wiedemann 74 model – arterial / urban traffic
    - Average standstill distance
    - Saturation flow rate (additive/multiplicative part of safety distance)
  - Necessary lane change parameters
  - Waiting time before diffusion
  - Safety distance reduction factor
  - Advanced merging
  - Cooperative lane change
- Unique parameters sets by link type (i.e., high speed arterial, bike path, etc.)
APPENDIX D

Traffic Simulation Output
Level of Service Conversion
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## CORSIM Point Processing Output - Freeways

<table>
<thead>
<tr>
<th>LINK</th>
<th>ID NO. (FT)</th>
<th>LENGTH (FT)</th>
<th>STATION</th>
<th>MEAN VOLUME (VPH)</th>
<th>MEAN SPEED (MPH)</th>
<th>MEAN HEADWAY (SEC)</th>
<th>OCCUPANCY RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(166, 167)</td>
<td>1</td>
<td>1179.00</td>
<td>6.0</td>
<td>1</td>
<td>COUPLED PAIR OF SHORT LOOPS</td>
<td>1454</td>
<td>28.476</td>
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<tr>
<td>(166, 167)</td>
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<td>6.0</td>
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<td>COUPLED PAIR OF SHORT LOOPS</td>
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<td>6.0</td>
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<td>COUPLED PAIR OF SHORT LOOPS</td>
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<td>497.00</td>
<td>6.0</td>
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<td>COUPLED PAIR OF SHORT LOOPS</td>
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<tr>
<td>(168, 169)</td>
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<td>6.0</td>
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<td>6.0</td>
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<td>(170, 171)</td>
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### CORSIM Level of Service Conversion – Freeways

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<th>Loop Position</th>
<th>Length (feet)</th>
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<th>VOL</th>
<th>Mean Speed (mph)</th>
<th>Mean Headway</th>
<th>Mean Occup</th>
<th>Non-Adjusted Density</th>
<th>Mean Speed (fps)</th>
<th>Mean Veh. Occ. (sec)</th>
<th>Avg. Veh. to Car Length (ft)</th>
<th>Avg. Veh. To Car Length Ratio</th>
<th>Equivalent pcphpl</th>
<th>Adj. Density (pc/mi/ln)</th>
<th>Lane LOS</th>
<th>Mainline LOS</th>
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<tbody>
<tr>
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<td>1</td>
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<td>6</td>
<td>1</td>
<td>1454</td>
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<td>45.3</td>
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<td>6</td>
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<td>2002</td>
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<td>1179</td>
<td>6</td>
<td>1</td>
<td>921</td>
<td>42.5</td>
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<td>8.2</td>
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<td>0.3</td>
<td>14.1</td>
<td>1.0</td>
<td>921.0</td>
<td>21.6</td>
<td>C</td>
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<tr>
<td>(168, 169)</td>
<td>1</td>
<td>497</td>
<td>6</td>
<td>2</td>
<td>535</td>
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<td>6.7</td>
<td>4.1</td>
<td>9.2</td>
<td>85.5</td>
<td>0.3</td>
<td>17.7</td>
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<td>10.5</td>
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</table>

**LOS Conversion (by lane):**

- **A** – length of detector expressed in feet (input to point processing)
- **B** – traffic volume expressed in vehicles per hour (direct output from point processing)
- **C** – mean speed expressed in miles per hour (direct output from point processing)
- **D** – mean headway expressed in seconds (direct output from point processing)
- **E** – mean occupancy rate (direct output from point processing)
- **F** (non-adjusted density expressed in vehicles per mile per lane) = \( \frac{3600}{C} \) / \( D \)
- **G** (mean speed expressed in feet per second) = \( (C \times 5280) / 3600 \)
- **H** (mean vehicle occupancy expressed in seconds) = \( [(E / 100) \times 3600] / B \)
- **I** (average vehicle to car length expressed in feet) = \( (G \times H) \) – \( A \)
- **J** (average vehicle to car length ratio) = \( (I / 15.5) \) [if \( I < 1.0 \), then \( 1.0 \)]
- **K** (equivalent passenger cars per hour per lane) = \( B \times J \)
- **L** (adjusted density expressed in passenger cars per mile per lane) = \( K / C \)

Lane LOS – equivalent HCM LOS for basic freeways for each lane

Mainline LOS – weighted HCM LOS for basic freeways by segment