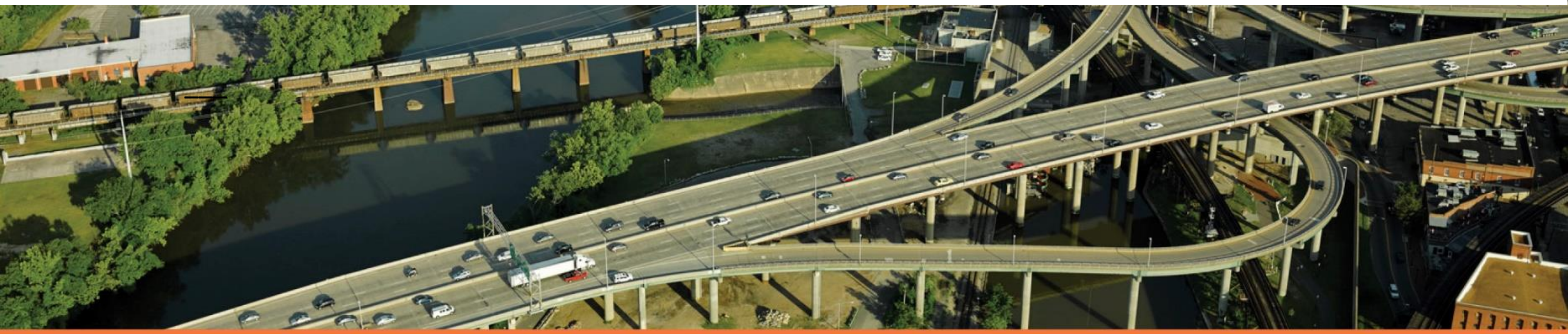
VDOT GOVERNANCE DOCUMENT



Traffic

Safety

TRAFFIC OPERATIONS AND SAFETY ANALYSIS MANUAL (TOSAM) – VERSION 2.0

Release Date: February 2020
Updated from TOSAM Version 1.0, released November 2015

VDOT
Virginia Department of Transportation
Traffic Engineering Division

Copyright

Definitions of "Shall", "Direction", "Should", "Guidance", and "May"

The following definitions apply to the use of these terms in this manual:

Shall: A mandatory condition. Any deviation from a shall condition requires approval from the District Traffic Engineer (DTE) or his/her designee supplemented by documentation of the decision in the project files.

Direction: A mandatory condition. Any deviation from a direction requires approval from the DTE or his/her designee supplemented by documentation of the decision in the project files.

Should: An advisory condition. A should condition is recommended but not mandatory. Any deviation from a should condition requires approval from the VDOT project manager supplemented by documentation of the decision in the project files.

Guidance: An advisory condition. A guidance condition is recommended but not mandatory. Any deviation from a guidance condition requires approval from the VDOT project manager supplemented by documentation of the decision in the project files.

May: A permissive condition. A may condition is optional.

Technical Advisory Committee

VDOT created a technical advisory committee (TAC) to collaborate in the development of this manual. The TAC consisted of traffic engineers, designers, transportation planners, and researchers from throughout the state from both the public and private sectors, including representatives from VDOT, the Virginia Transportation Research Council (VTRC), and Federal Highway Administration (FHWA). Development of this manual was based on current VDOT policies and guidelines; industry best practices; and research findings. The TAC was responsible for discussing and vetting issues throughout the manual development process. TAC members for the TOSAM, Version 2.0 are listed in the following section.

TOSAM, VERSION 2.0 TECHNICAL ADVISORY COMMITTEE

Public Sector

- Sanhita Lahiri – Central Office Traffic Engineering Division (VDOT Project Manager)
- Mena Lockwood – Central Office Traffic Engineering Division
- Mark Richards – Central Office Traffic Engineering Division
- Abraham Lerner – Northern Virginia Special Project Development
- Terrell Hughes – Central Office Transportation and Mobility Planning Division
- Matthew Bonacci – Central Office Traffic Engineering Division
- Huanyu "Allan" Yue – Central Office Traffic Engineering Division
- Terry Short, Jr. – Staunton District Transportation Planning
- Sharad Uprety – Central Office Transportation and Mobility Planning Division
- Justice Appiah – Virginia Transportation Research Council
- Stephen Read – Central Office Traffic Engineering Division
- Michael Fontaine – Virginia Transportation Research Council

Consultant Team

- Timothy White – Kimley-Horn (Consultant Project Manager)
- Daniel Markham – Kimley-Horn (Consultant Deputy Project Manager)
- Caitlin Kovel – Kimley-Horn
- Jiaxin Tong – Kimley-Horn
- Britton Hammit – Kimley-Horn
- Anthony Gallo – Kimley-Horn
- Sarah Sciarrino – Kimley-Horn
- Mark Herman – Kimley-Horn
- Support from throughout Kimley-Horn for the development of traffic analysis macros and templates

This page is intentionally left blank

Table of Contents

TECHNICAL APPENDIX

LIST OF FIGURES

LIST OF TABLES

This page is intentionally left blank

Glossary of Terms

Access management: The systematic control of the location, spacing, design, and operation of entrances, median openings, 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.

Active traffic management (ATM): A type of ITS solution that includes an integrated set of operating strategies and technologies for managing transportation demand, such as advanced lane control signal systems, variable speed limits, dynamic junction control, speed harmonization, and automated signs.

Adaptive signal control technology (ASCT): Technology that uses algorithms within traffic signal controllers to adjust signal timings every few minutes based on real-time traffic information to reduce congestion.

American Association of State Highway and Transportation Officials (AASHTO): An organization that advocates transportation-related policies and provides technical services to support states in their efforts to efficiently and safely move people and goods.

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

Automated Traffic Recorder (ATR): A traffic counter that collects volume, speed, and/or vehicle classification data over a period of time using an electronic device, such as count tubes, cameras, radar, or detectors.

Average travel speed (ATS): Speed (expressed in mph) on a segment computed by the length of a highway segment divided by the average travel time of all vehicles traversing this segment. This speed is equivalent to space mean speed.

Bus rapid transit (BRT): A permanent, integrated transportation system that uses buses or specialized vehicles on roadways or dedicated lanes to transport passengers more quickly and efficiently than traditional bus service.

Calibration parameter: Parameter used to fine-tune the base microsimulation model to reflect local, existing traffic operational behavior. For example, calibration parameters consist of queue lengths, travel time, saturation flow rate, start-up lost time, queue discharge headway, etc. Some of the information to perform calibration is collected from the field and others are user-adjustable values within the microsimulation models.

Central Business District (CBD): An urban area, typically characterized by narrow street rights-of-way, frequent parking maneuvers, vehicle blockages, taxi and bus activity, small-radius turns, limited use of exclusive turn lanes, high pedestrian activity, dense population, and midblock curb cuts.

Collector-distributor road (C-D road): A roadway parallel to the mainline facility designed to separate mainline travel lanes from merges, diverges, weaves, and access points. On arterials, C-D roads are also known as collector roads or frontage roads and primarily serve commercial or residential properties to reduce the number of access points on the arterial.

Conflict point: A location in which two or more road users approach each other in time and space to such an extent that there is risk of collision if their movements remain unchanged.

Congestion mapping: A graphical representation of traffic flow in over-capacity conditions based on collected speed data for a particular area.

Continuous-flow intersection (CFI): An alternative intersection configuration whereby left-turning cross vehicles at upstream intersections to allow left-turn signal phases to be served simultaneously with through movement signal phases. CFIs are also known as “Displaced Left-Turn” (DLT) or “Crossover Displaced Left-Turn” (XDL) intersections.

Continuous green-T intersection (CGT): An alternative intersection configuration that features a signalized three-approach intersection (T-intersection) where the mainline approach on the opposite side of the minor-street approach operates in a free-flow condition. Left-turning vehicles from the minor approach are provided an auxiliary lane in the median to merge onto the mainline. CGTs are also known as "Turbo-T" or "High-T" intersections.

Control delay: Delay associated with vehicles passing through an intersection, including 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 one or more parallel arterial streets.

Crash modification factor (CMF): Multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a site.

Critical links/movements/routes: A critical link, movement, or route represents a portion of a roadway network that is of decisive importance to the recommendations made as a result of a traffic operations analysis.

Cycle: A complete sequence of traffic signal indications.

Cycle length: The time required for one complete sequence of signal phases such that all of the movements at the intersection (that have not been omitted) have been served at least once (expressed in seconds).

Delay: Travel time experienced by a driver, passenger, bicyclist, or pedestrian beyond that required to travel at the desired speed (expressed in seconds per vehicle). See control delay or microsimulation delay for more information.

Density: The number of vehicles occupying a given length of lane at a particular instant (expressed in either passenger cars per mile per lane (pcpmpl) for deterministic traffic tools or vehicles per mile per lane (vpmpl) for stochastic traffic tools).

Deterministic traffic tools: Traffic analysis tools in which there is no variability in driver-vehicle characteristics (e.g., HCS7).

Diverging diamond interchange (DDI): An interchange configuration that is a diamond interchange where the directions of travel on the arterial cross over to the left side of the road at each ramp terminal. This configuration allows for left- and right-turn movements to operate as unsignalized intersections on the arterial. A two-phased traffic signal controls the intersections at the crossover points. A traffic signal phase can be provided for the ramp approaches when the opposing movement is not served, when applicable. A DDI is also known as a "double crossover diamond interchange" (DCDI).

Dynamic traffic assignment: A modeling approach that simulates vehicles making alternative route choices based on factors, such as congestion and travel time, within a network.

Effective auxiliary lane length: The length of the auxiliary lane plus two-thirds of the auxiliary lane taper length (expressed in feet).

Effective turn lane storage length: The full width turn lane storage length plus one half of the taper length (expressed in feet).

Empirical Bayes (EB) method: A statistical method used to improve the reliability of determining the number of crashes produced from a predictive model by combining the model prediction with observed crash data.

Engineering judgment: The evaluation of available information and the application of appropriate principles, provisions, and practices for the purpose of deciding upon the applicability and proper use of traffic operations and safety analysis tools and related methodologies.

Expected crashes: The estimate of long-term expected average crash frequency of a site, facility, or network under a given set of geometric conditions and traffic volumes (AADT) in a given period of years. In the Empirical Bayes (EB) method, this frequency is calculated from observed crash frequency at the site and predicted crash frequency at the site based on crash frequency estimates at similar sites.

Facility: A roadway, bike path, or pedestrian walkway composed of a connected series of points and segments and are defined by two endpoints.

Federal Highway Administration (FHWA): An agency within the U.S. Department of Transportation that supports state and local governments in the design, construction, and maintenance of the national highway system (Federal Aid Highway Program) and various federal- and tribal-owned lands (Federal Lands Highway Program).

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 (expressed in vehicles per hour).

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).

High-occupancy vehicle (HOV) lane: A restricted travel lane reserved for the exclusive use of vehicles with a driver and one or more passengers.

Highway Capacity Manual (HCM): A publication produced and maintained by TRB that contains concepts, guidelines, and computation procedures for calculating the capacity and quality of service of highway facilities.

Highway Safety Manual (HSM): A publication produced and maintained by AASHTO that contains a variety of methods for quantitatively estimating crash frequency and severity on various facility types.

Input parameter: Parameter that is collected and/or measured directly in the field and is used to build the base model. For example, input parameters consist of the number of lanes, lane widths, traffic volume, free-flow speed, etc. It is not customary to change input parameters; however, if there is a need for an adjustment, then the VDOT project manager should be consulted along with documented justification.

Intelligent Transportation Systems (ITS): Transportation infrastructure that is used collect, store, process and distribute information relating to the movement of people and goods.

Interchange Justification Report (IJR): An operational analysis prepared in accordance with both VDOT and FHWA guidelines for a proposed new interchange. The IJR process applies to all access additions and FHWA approval is required on all interstate projects greater than or equal to $1.0 million in construction costs.

Interchange Modification Report (IMR): An operational analysis prepared in accordance with both VDOT and FHWA guidelines for access modifications that are needed to improve operations and safety of an existing interchange. The IMR process applies to access modifications on the Interstate system, non-interstate National Highway System (NHS), and non-NHS.

Interrupted-flow facilities: Facilities that have fixed causes of periodic delay or interruption to the traffic stream, such as traffic signals and stop signs.

Level of service (LOS): Stratification of a performance measure(s) that represent quality of service, measured in an A-F scale with LOS A representing the best.

Light-rail transit (LRT): An electric railway system that operates single or multiple car trains along a fixed guideway. LRT guideways can be located in streets, on elevated platforms, or along exclusive rights-of-way.

Macroscopic analysis tools: Tools used to analyze traffic flow, considering aggregated traffic stream characteristics (speed, flow, and density) and their relationships (e.g., HCS7, SIDRA Intersection, and Synchro).

Managed lanes: Highway facilities or a set of lanes where operational strategies, such as ramp metering or variable speed limits, are proactively implemented and managed in response to changing conditions.

Maximum queue length: The longest queue length (see queue length) that is observed or simulated during a given analysis period (expressed in feet).

Measure of effectiveness (MOE): Factor that quantifies operational and safety objectives and provides a basis for evaluating the performance of the transportation network.

Mesoscopic analysis tools: Tools used to analyze traffic conditions using approximations of elements from both macroscopic and microscopic models.

Microsimulation: Modeling of individual vehicle movements on a second or sub-second basis to assess the traffic performance of a transportation node, segment, or network.

Microscopic analysis tools: Tools used to simulate the characteristics and interactions of individual vehicles. These tools include algorithms and rules describing how vehicles move and interact within the transportation network, including acceleration, deceleration, and lane changing (e.g., SimTraffic, VISSIM).

Microsimulation delay: The difference (expressed in seconds per vehicle) between the simulated travel time and the theoretical travel time if the vehicle was operating at the desired speed calculated by a microsimulation tool.

Model calibration: Modeling process where the modeler modifies calibration parameters that cause the model to best replicate field-measured and observed traffic volumes, speeds, travel times, and queues.

Multimodal facility: A place where at least two or more modes of transportation interface, such as bus and rail.

National Cooperative Highway Research Program (NCHRP): A program for coordinated and collaborative transportation research administered by the TRB and sponsored by FHWA, AASHTO and individual state departments of transportation.

Network link: A link connecting two nodes in a microsimulation model.

Node: An intersection of two or more roadway segments in a traffic model. A node may represent an actual intersection or point where roadway characteristics or geometry change.

Parameter: Any value assigned or input into an analysis tool by a user to configure the analysis tool to produce results.

Peak hour factor (PHF): The hourly volume during maximum volume hour of the day divided by the peak 15-minute flow rate within the peak hour. PHF is a measure of traffic demand fluctuation within the analysis hour.

Peak hour spreading (PHS): PHS occurs when the peak hour traffic demand exceeds the available traffic capacity throughout the entire peak hour. This excess traffic then “spreads” to either side of the computed peak hour, which creates a peak period of two or more hours as opposed to just one hour.

Percent of free-flow speed (PFFS): The average travel speed (see average travel speed) divided by the free-flow speed (see free-flow speed).

Percent time spent following (PTSF): The average percent of total travel time that vehicles must travel in platoons behind slower vehicles because of the inability to pass on a two-lane highway.

Phase: The part of a traffic signal cycle allocated to any combination of traffic movements receiving the right-of-way simultaneously during one or more intervals. A phase includes green, yellow change, and red clearance intervals.

Predicted crashes: The estimate of future average crash frequency that is forecasted to occur at a site using a predictive model.

Point: 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).

Potential for safety improvement (PSI): Factor that indicates a higher historical crash rate than the rate predicted by the *HSM* methodology, which is based on national averages. A positive PSI value indicates a location in need of safety improvement.

Public transit facilities: Roadway infrastructure that accommodates public transit modes such as buses, trolleys, and trains.

Quality control (QC): Measures taken within a project to produce work to acceptable standards that meet project requirements.

Queue length: The distance between the upstream and downstream ends of a traffic queue (expressed in feet).

Ramp metering: A traffic signal that regulates the flow of traffic entering a freeway from a ramp.

Roadway Network System (RNS): A web-accessible VDOT database that links data to roadway centerlines.

Roadway safety assessment (RSA): A formal examination of an existing roadway or project design in which a team of independent and multidisciplinary examiners report on the past safety performance and/or the crash potential performance of a project to recommend safety treatments to mitigate crashes in the future.

Safety performance function (SPF): A statistical model used to estimate the average crash frequency for a specific site type, with specified base conditions, based on traffic volume and roadway segment length.

Segment: For interrupted-flow facilities, a segment is defined as a link and its boundary points. For uninterrupted-flow facilities, a segment is defined as the portion of a facility between two points.

Single-point urban interchange (SPUI): Interchange configuration consisting of a diamond interchange that combines both ramp terminals into one intersection to allow left turns to operate simultaneously. A SPUI is also known as a "single-point interchange" (SPI), "single-point diamond interchange" (SPDI), or "single point urban diamond" (SPUD) interchange.

Space mean speed: Average speed based on the average travel time of vehicles to traverse a length of roadway (expressed in mph).

Speed: Rate of motion expressed as distance per unit of time (expressed in mph).

Stochastic traffic tools: Traffic microsimulation tools that assign driver-vehicle characteristics from statistical distributions using random numbers (e.g., SimTraffic, VISSIM).

Stopped delay: Amount of time that a vehicle is slowed to 5 mph or less (expressed in seconds).

Superstreet intersection: Intersection configuration where left-turning vehicles on the minor road must turn right onto the major road and make a U-turn at a designated location a short distance upstream. After completing the U-turn, the drivers may continue straight or make a right turn at the original intersection.

System: All transportation facilities and modes within a particular region.

Time mean speed: Average speed of vehicles observed passing a point on a highway (expressed in mph).

Toll plazas: An area on a facility where fares are collected in exchange for passage through a roadway network. Fares can be collected via toll booth or through electronic toll collection.

Traffic and safety project delivery process: All activities that occur within a traffic operations and safety analysis project between initiating a project scope and a completed project deliverable.

Traffic impact analysis (TIA): A traffic operations analysis that assesses the effect of a proposed land development project on a transportation system and recommends improvements to reduce the impacts.

Traffic operations analysis: An evaluation of how a roadway or a set of roadways functions under existing and/or projected traffic and geometric conditions.

Traffic safety analysis: An evaluation of safety components on a roadway or a set of roadways under existing and/or projected traffic and geometric conditions.

Transportation demand management (TDM): Strategies that increase system efficiency by focusing on traffic demand. TDM provides travelers with travel choices, such as work location, route, time and mode. TDM is also known as "traffic demand management."

Transportation Research Board (TRB): A major division of the National Research Council. The mission of the TRB is to promote innovation and progress in transportation through research.

Travel time: The average time spent by vehicles traversing a highway segment, including control delay (expressed in seconds).

Travel time routes: Routes taken to traverse a set of contiguous links and connectors that is part of a vehicle path, which may be wholly or partially within a full vehicle route. Travel time routes are defined based on project needs and goals.

Turning movement count (TMC): The process of collecting vehicle movement information data at an intersection. Data can be collected either manually or using technology such as video cameras.

Uninterrupted-flow facilities: Facilities that have no fixed causes of delay or interruption external to the traffic stream.

Model validation: Modeling process where the modeler checks the overall model-predicted traffic performance for a network against field measurements of traffic performance not using data from the calibration process.

VDOT project manager: Individual responsible for overseeing and directing the project from scoping through project delivery. The VDOT project manager is responsible for ensuring the direction and guidance presented in this manual are followed and should consult with subject matter experts, as needed, throughout the project process.

VDOT Sample Size Determination Tool: Tool used to determine the appropriate number of microsimulation runs for a given traffic analysis based on the FHWA sample size determination methodology.

VDOT Software Selection Tool (SST): 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) for a specific study.

Volume to capacity (v/c) ratio: The ratio of the flow rate to the theoretical maximum capacity for a system component.

Work zone: An area of a roadway network with highway construction, maintenance, or utility work activities.

95th percentile queue length: The queue length that has only a 5% probability of being exceeded during a given analysis period (expressed in feet).

List of Abbreviations

AADT – Annual Average Daily Traffic

AASHTO – American Association of State Highway and Transportation Officials

ATM – Active Traffic Management

ATR – Automated Traffic Recorder

ATS – Average Travel Speed

ASCT – Adaptive Signal Control Technology

AWSC – All-Way Stop Control

BRT – Bus-Rapid Transit

CBD – Central Business District

C-D – Collector-Distributor

CFI – Continuous-Flow Intersection

CFSM – Car Following Sensitivity Multiplier

CGT – Continuous Green-T

CMF – Crash Modification Factor

DCDI – Double Crossover Diamond Interchange

DDI – Diverging Diamond Interchange

DLT – Displaced Left-Turn

DRPT – Department of Rail and Public Transit

DTA – Dynamic Traffic Assignment

EB – Empirical Bayes

FFS – Free-Flow Speed

FHWA – Federal Highway Administration

GIS – Geographic Information System

HOT – High-Occupancy Toll

HOV – High-Occupancy Vehicle

HCM – Highway Capacity Manual

HCS – Highway Capacity Software

HSIP – Highway Safety Improvement Program

HSM – Highway Safety Manual

ICU – Intersection Capacity Utilization

IHSDM – Interactive Highway Safety Design Model

IJR – Interchange Justification Report

IMR – Interchange Modification Report

ITS – Intelligent Transportation System

LOS – Level of Service

LRT – Light-Rail Transit

MOE – Measure of Effectiveness

NCHRP – National Cooperative Highway Research Program

NHS – National Highway System

O-D – Origin-Destination

PFFS – Percent of Free-Flow Speed

PHF – Peak Hour Factor

PHS – Peak Hour Spreading

PSI – Potential for Safety Improvement

PTSF – Percent Time Spent Following

QC – Quality Control

RBC – Ring-Barrier Controller

RNS – Roadway Network System

RSA – Roadway Safety Assessment

SPF – Safety Performance Function

SPI – Single-Point Interchange

SPDI – Single-Point Diamond Interchange

SPF – Safety Performance Function

SPUD – Single-Point Urban Diamond

SPUI – Single-Point Urban Interchange

SSAM – Surrogate Safety Assessment Model

SST – Software Selection Tool

TAC – Technical Advisory Committee

TIA – Traffic Impact Analysis

TDM – Transportation Demand Management

TED – VDOT Traffic Engineering Division

TMC – Turning Movement Count

TMS – Traffic Monitoring System

TOSAM – Traffic Operations and Safety Analysis Manual

TRB – Transportation Research Board

TWSC – Two-Way Stop Control

VDOT – Virginia Department of Transportation

VISSIM – Verkerh In Städten – SIMulationmodel

VTRC – Virginia Transportation Research Council

V/C – Volume to Capacity

XDL – Crossover Displaced Left-Turn

1 Introduction

1.1 BACKGROUND

Traffic and safety analysis tools help transportation professionals analyze the operational and safety components of transportation networks under both existing and future conditions. As a result, these tools play an important role in the decision-making process that leads to transportation solutions. As the complexity of potential improvement concepts increases, it is important for transportation professionals to properly scope projects, including choosing the most appropriate traffic and safety analysis tool(s), execute projects, and effectively summarize the results in a report.

1.2 PURPOSE OF THIS MANUAL

There are several types of traffic and safety 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 or safety analysis tool, the project may require multiple tools be used simultaneously, or the selection of traffic and safety analysis tools may vary depending on preference. For these reasons, the Virginia Department of Transportation (VDOT) developed the Traffic Operations and Safety Analysis Manual (TOSAM) to provide direction to VDOT project managers in selecting the most appropriate traffic and safety analysis tool(s) during the project scoping phase; understanding the data requirements and standard assumptions related to each analysis tool; and producing reporting formats from these tools for traffic operations and safety analyses. This manual supersedes the VDOT TOSAM, Version 1.0.

The TOSAM establishes consistent and uniform direction and guidance for scoping, conducting, and reporting traffic and safety analyses in Virginia. Statewide uniformity across traffic and safety analyses is intended to improve the quality of deliverables for traffic and safety analyses and accelerate the review process for VDOT project managers. This document provides both direction, which is required, and guidance, which is recommended, for all applicable study types as defined in **Section 1.3**.

The direction and guidance provided in this manual shall be used by both VDOT personnel, localities, and consultants working on projects that will ***ultimately be submitted to VDOT for review***. This document will help standardize the evaluation of various design, traffic operations, planning, and safety analyses. To most effectively use this manual, VDOT project managers should consult with stakeholders—including subject matter experts (traffic engineers, transportation planners, safety specialists, and/or traffic microsimulation modelers), as needed—to obtain assistance in scoping the project, selecting the most appropriate traffic and safety analysis tool(s), and conducting and/or reviewing traffic and safety analyses.

The direction and guidance provided herein shall be used by both VDOT personnel, localities, and consultants working on projects that will ultimately be submitted to VDOT for review.

The primary products of this manual are:

- Direction and guidance on the acceptable range of conditions various traffic and safety analysis tool(s) may be used for evaluations either conducted by or for VDOT or ones that require VDOT review, comment, and/or approval
- Direction and guidance for data collection types and methods for traffic operations and safety analyses
- Standard assumptions to be used for each traffic and safety analysis tool
- Standard report summary examples and requirements for traffic and safety analysis measures of effectiveness (MOEs)
- Direction and guidance on the traffic and safety project process from scoping through reporting

1.3 INTENDED USES OF THIS MANUAL

There is an unlimited array of geometric and operational conditions that could be addressed in this manual. Since it is impractical to address all possible combinations of these conditions, this manual provides direction and guidance on the selection of traffic and safety analysis tools for the following four types of analysis scenarios, which are defined and discussed in more detail in **Chapter 2**.

This manual provides direction and guidance for operational and safety analyses for studies that focus on short-term and long-term conditions.

- Interrupted-flow operations analyses
- Uninterrupted-flow operations analyses
- Miscellaneous analyses
- Safety analyses

If a scenario is encountered that varies from these four types of analysis scenarios, VDOT personnel will provide direction and guidance on a case-by-case basis on which scenario to use based on VDOT policies and engineering judgment. This direction and guidance shall be documented for future reference. Supplemental direction and guidance may be developed and incorporated into future versions of this manual.

This manual provides direction and guidance for operational and safety analyses for studies that focus on short-term and long-term conditions. The following study types and MOEs are covered in this manual:

- Study types, including but not limited to:
  - Traffic operations analyses
    - Traffic signal timing
    - Freeway weaving and ramp analyses
    - Congestion mitigation studies
  - Access management studies (traffic operations only)
  - Traffic Impact Analyses (TIAs) not covered under VDOT TIA Regulations Administrative Guidelines (Chapter 527 of the 2006 Acts of Assembly)
  - Design-related analyses
    - Interchange justification/modification (IMR/IJR) studies
    - Roadway design analyses (turn-bay length, number of lanes, etc.)
    - Maintenance of traffic analyses (work zone analysis)
  - Safety analyses
    - Access management studies (safety analysis only)
    - Safety improvement alternatives evaluation
    - Design alternatives evaluation including design exceptions and waivers assessments
- Measures of Effectiveness (MOEs)
  - Traffic Operations
    - 95th percentile queue length (feet)
    - Control delay (seconds per vehicle)
    - Density (passenger cars per lane per mile or vehicles per lane per mile)
    - Maximum queue length (feet)
    - Microsimulation delay (seconds per vehicle)
    - Percent time spent following (percentage)
    - Percent of free-flow speed (percentage)
    - Predicted crashes or predicted average crash frequency (crashes or crashes per year)
    - Space mean speed (miles per hour)

    - Time mean speed (miles per hour)
    - Travel time (seconds)
    - Volume-to-capacity ratio
  - Reliability
    - 95th percentile travel time index
    - 80th percentile travel time index
    - 50th percentile travel time index
    - LOTTR (80th/50th)
  - Innovative Intersections
    - Experienced travel time (seconds)
  - Safety
    - Weighted total conflict points (number)
    - Predicted crashes or predicted average crash frequency (crashes or crashes per year)
    - Expected crashes or expected average crash frequency (crashes or crashes per year)

The following study types are **not** covered in this manual; however, this manual may be used as a guidance document for these study types when applying the traffic operations and safety analysis tools detailed in the manual.

- Planning data-based studies
  - Traffic forecasting studies and other studies requiring the use of travel demand models as the main means for analysis. These studies should reference the *VDOT Travel Demand Modeling Policies and Procedures Manual* or the *VDOT Traffic Forecasting Guidebook*
  - General traffic volume-based improvement studies (e.g., “2,000 vehicles per hour (vph) requires two travel lanes”)
  - First- and second-tier NEPA studies
- Active Traffic Management (ATM) and Dynamic Traffic Assignment (DTA) are not addressed in detail in this manual. Additional guidance on these topics may be found in the following FHWA Traffic Analysis Toolbox documents:
  - *Volume XIII: Integrated Corridor Management Analysis, Modeling, and Simulation Guide, February 2017*
  - *Volume XIV: Guidebook on the Utilization of Dynamic Traffic Assignment in Modeling, November 2012*
  - *Guide for Highway Capacity and Operations Analysis of Active Transportation and Demand Management Strategies, June 2013*
- Safety studies
  - Guardrail assessments
  - Highway Safety Improvement Program (HSIP) Studies
  - Roadway safety assessments
  - Signing and marking evaluations
  - Sight distance evaluations
  - Systematic safety evaluations
- Other studies
  - Signal justification studies
  - Speed studies

This manual does not address other considerations such as the cost of analysis, time to conduct an analysis, data availability, and training requirements for different tools. VDOT project managers should weigh these considerations in conjunction with the direction and guidance provided in this manual when selecting traffic and safety analysis tools.

1.4 MANUAL ORGANIZATION

This manual consists of the following chapters:

- **Chapter 1: Introduction**

  This chapter provides an overview of the TOSAM, including the background, purpose, and applications of this manual.

- **Chapter 2: Common Analysis Scenarios**

  This chapter defines study area characteristics and the types of traffic and safety analysis scenarios considered in this manual.

- **Chapter 3: Traffic and Safety Analysis Tools**

  This chapter provides a brief description of each traffic and safety analysis tool included in this manual:

  - AASHTO *HSM* Spreadsheets
  - FREEVAL
  - HCS
  - IHSDM
  - ISATe
  - SIDRA Intersection
  - SimTraffic
  - Synchro
  - VDOT Work Zone Tools
  - Vissim
  - VJuST

- **Chapter 4: Analysis Measures of Effectiveness**

  This chapter defines the MOEs used to interpret traffic and safety analysis results considered in this manual. Direction and guidance on applying level of service (LOS), determining acceptable thresholds for MOEs, and using sensitivity testing is also provided.

- **Chapter 5: Microsimulation**

  This chapter provides direction and guidance on the use of microsimulation tools for traffic operations and safety analyses. The direction and guidance cover scenarios where a microsimulation analysis may be needed, existing base model development methodology, acceptable calibration thresholds, and the selection of the appropriate number of microsimulation runs.

- **Chapter 6: Standard Data Requirements for Analyses**

  This chapter describes the standard requirements for different types of traffic and safety analyses. Standard requirements addressed in this chapter include geometric data, traffic count data, traffic signal operations data, calibration data, and safety data. Direction and guidance on acceptable sources of data are also provided.

- **Chapter 7: Standard Input Parameter Assumptions for Tools**

  This chapter provides direction and guidance on appropriate parameters for each traffic and safety analysis tool addressed in this manual. Direction and guidance are not provided for every parameter, but rather for parameters that require additional clarification or where modification of default values is recommended.

- **Chapter 8: Outputs and Reporting**

  This chapter describes output formats from the approved analysis tools, and guidance on reporting results from each of the traffic and safety analysis tools.

- **Chapter 9: Traffic Operations and Safety Analysis Project Scoping Considerations**
  This chapter provides a summary of the traffic and safety analysis scoping process, with discussion on the use of the manual from preparing for the scoping meeting to obtaining approval of the project scope.

This page is intentionally left blank

2 Common Analysis Scenarios

There are many analysis scenarios that may be evaluated on any given project. It is important to understand the differences between the scenarios so the appropriate analysis tool(s) may be selected. This chapter focuses on study area classifications and prevailing traffic and safety conditions to consider when defining an analysis scenario. Guidance on selecting analysis tools for specific traffic and safety scenarios is described in **Chapter 3.**

2.1 STUDY AREA CLASSIFICATIONS

The *Highway Capacity Manual 6th Edition (HCM)* and *Highway Safety Manual (HSM)* reference the following six roadway system components to define the scope of a project.

- **Point:** A point is the smallest roadway system component. The *HCM* defines a point as 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 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)."

  Intersections, whether they are unsignalized, signalized, or roundabouts, are considered points. An intersection is defined by the *HSM* as a "general area where two or more roadways or highways meet, including the roadway, and roadside facilities for pedestrian and bicycle movements within the area."
- **Segment:** A segment consists of two points. The *HCM* defines a segment as, "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."

  The *HSM* defines as segment as "A portion of a facility on which a crash analysis is performed. A segment is defined by two endpoints." Example segments include urban street segments, weaving segments, freeway diverge/merge segments, and basic freeway segments. Segments are defined as follows:
- **Facility:** Facilities are made up of more than two points and segments. The *HCM* defines a facility as, "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."
- **Corridor:** A corridor is comprised of multiple facilities. The *HCM* defines a corridor as "a set of parallel transportation facilities designed to move people between two locations." The facilities must be parallel and may be an assortment of freeway, urban street, transit, or pedestrian/bicycle facilities.
- **Area:** An area consists of numerous facilities. The *HCM* defines an area as a "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 may be set by significant transportation facilities, political boundaries, or topographical features such as ridgelines or major bodies of water."
- **System:** A system is a larger version of an area. The *HCM* defines a system as "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 several smaller areas. Each area contains multiple facilities, which, in turn, are composed of a series of points and segments. Systems may also be divided into modal subsystems (e.g., the roadway subsystem, the transit subsystem) as well as subsystems composed of specific roadway components (e.g., the freeway subsystem, the urban street subsystem)."

Specific combinations of the six roadway system components create different analysis scenarios, including:

- **Intersection:** A combination of three or more segments that share a single common point.
- **Interchange:** A combination of at least two individual segments that cross, but do not share a single common point. A series of segments and points link these two segments together.
- **Corridor:** A combination of at least two intersections and/or interchanges connected by segments in series.
- **Network:** A combination of at least two intersecting and/or parallel corridors connected by segments. All intersections and/or interchanges in a network should be linked such that a vehicle could navigate between all points within the network. A network can be classified as an area or a system.

2.2 PREVAILING TRAFFIC CONDITIONS

2.2.1 *Interrupted and Uninterrupted Traffic Flow*

Traffic flow can be divided into two primary types: interrupted and uninterrupted flow.

The *HCM* defines interrupted traffic flow as “traffic flow characterized by traffic signals, STOP signs, YIELD signs, or other fixed causes of periodic delay or interruption to the traffic stream.” In general, segments are considered to operate under interrupted flow conditions when the segment is located within two miles of a traffic signal.

Multiple types of interrupted traffic flow operations are considered in this manual, such as:

- **Conventional Signalized Intersection:** This type of analysis is used to evaluate the functionality of an intersection controlled by a traffic signal in terms of specific MOEs, such as delay and queue
- **Conventional Signalized Intersection Preemption and/or Transit Priority:** This type of analysis is used to evaluate the impacts of a preemption or priority event at a signalized intersection, with or without transit operations with specific MOEs, such as delay and queue.
- **Conventional Unsignalized Intersection:** This type of analysis is used to evaluate the functionality of an intersection not controlled by a traffic signal in terms of specific MOEs, such as delay and queue. All-way stop-controlled and two-way stop-controlled intersections are included in this scenario.
- **Roundabout:** This type of analysis is used to evaluate the functionality of a roundabout in terms of specific MOEs including speed, delay, and queue.
- **Arterial:** This type of analysis is used to evaluate the functionality of a roadway featuring interruptions in flow due to signalized and unsignalized intersections and is used to determine the functionality of the facility in terms of speed and queue.
- **Innovative Intersection/Interchange:** This type of analysis is used to evaluate the functionality of unconventional intersections in terms of specific MOEs including speed, delay, and queue. Examples of this scenario include, but are not limited to, 5-legged intersections, Diverging Diamond Interchanges (DDI), Single Point Urban Interchanges (SPUI), Restrict Crossing U-Turn (RCUT) Intersections, Continuous Green-T Intersections (CGT), and Continuous-Flow Intersections (CFI). These analyses only pertain to the intersection operations for interchanges such as DDIs and SPUIs as opposed to the ramp and ramp-freeway junction operations.
- **Parking Area:** This type of analysis is used to evaluate the impacts of on-street parking on arterial operations.
- **Public Transit Facility:** This type of analysis is used to evaluate the functionality of different types of public transit facilities, such as Bus Rapid Transit (BRT) and Light-Rail Transit (LRT). This manual is not intended to provide guidance on large scale design and policy-driven analyses. For such instances, the VDOT project manager shall coordinate with the Department of Rail and Public Transit (DRPT).

- **Adaptive Signal Control Technologies (ASCT):** This type of analysis is used to evaluate ASCT at single intersections or on an arterial facility. ASCTs contain algorithms that adjust traffic signal timings every few minutes based on real-time traffic information.
- **Pedestrian and Bicycle:** This type of analysis is used to evaluate the functionality of bicycle and/or pedestrian facilities, including sidewalks, multi-use trails or paths, crosswalks at intersections, and bicycle lanes adjacent to mainline lanes of travel. The results provided in these analyses are based on functionality of bicycle and pedestrian facilities themselves and not their impact on traffic signal operations. For intersection analyses, the number and location of pedestrians and bicyclists are parameters to the analysis.
- **Multimodal Facility:** This type of analysis is used to evaluate the functionality of roadway facilities that service a variety of transportation modes including automobiles, transit, bicycles, and pedestrians. These facilities include areas such as transit centers and airport terminals.

The *HCM* defines uninterrupted traffic flow as "Traffic flow that has no fixed cause of delay or interruption external to the traffic stream." Segments are considered to operate with uninterrupted flow when traffic is not influenced by traffic control devices and platoons are not formed at upstream traffic signals. In general, two-lane highway segments that are located two to three miles from traffic signals operate under uninterrupted-flow conditions.

Within the uninterrupted-flow operations analyses category, multiple analysis types are considered in this manual, such as:

- **Freeway Segment:** For this type of analysis, freeway segments not influenced by merging, diverging, or weaving maneuvers are analyzed in terms of speed and density. Lane changing impacts within a basic freeway segment should only be attributed to passing operations.
- **Freeway Merge/Diverge Segment:** Freeway merging and diverging segments occur primarily at or near 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 is used to evaluate the functionality of a merge or diverge area in terms of speed and density.
- **Freeway Weaving Segment:** Freeway weaving segments are formed when streams of traffic traveling in the same direction are forced to change lanes and cross paths over a significant length of freeway. This type of analysis is used to evaluate the functionality of the weaving segment in terms of speed and density.
- **Managed Lane or Ramp Metering:** Managed lanes and ramp metering control transportation demand by imposing travel restrictions. A managed lane provides operational flexibility by separating one or more lanes from the general-purpose lanes on a freeway. The managed lanes control demand through pricing and vehicle eligibility strategies. A ramp metering system restricts access to freeways by regulating traffic entering the network based on operational conditions on the freeway. This type of analysis is used to evaluate the functionality of managed lanes or the impacts of ramp metering on a freeway facility in terms of speed and density.
- **Collector-Distributor Facility:** A collector-distributor facility (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, merging, and diverging movements from the mainline freeway. This type of analysis is used to evaluate the functionality of the C-D road in terms of speed and density.
- **Multilane Highway:** This type of analysis is used to evaluate the functionality of a highway with at least two travel lanes in each direction, with traffic signals spaced greater than one mile apart, and with speeds greater than 45 mph. These types are facilities are not arterials nor are they freeways. Unlike freeways, multilane highway are not limited-access facilities; however, this type of analysis does not account for interruptions in flow due to signalized intersections. This type of analysis is used to evaluate the functionality of the multilane highway in terms of speed and density.
- **Two-Lane Highway:** This type of analysis is used to evaluate the functionality of a highway with one travel lane in each direction, although it may also include a truck climbing lane in one direction. This type

of analysis does not account for interruptions in flow due to signalized intersections. This type of analysis is used to evaluate the functionality of the multilane highway in terms of average travel speed (ATS), percent time spent following (PTSF), and percent of free-flow speed (PFFS).

2.2.2 *Undersaturated and Oversaturated Conditions*

It is important to recognize the difference between undersaturated and oversaturated traffic conditions when choosing the most appropriate traffic analysis tool. The *HCM* defines them as follows:

- **Undersaturated Flow:** "Traffic flow where (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."
- **Oversaturated Flow:** "Traffic flow where (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."

For uninterrupted-flow facilities, speed may be used as an indicator of whether a facility is undersaturated or oversaturated. As uninterrupted-flow facilities approach capacity, travel speeds decline; therefore, a facility may be identified as operating in undersaturated conditions when speeds remain at or near the posted speed limit. The determination of when a study area should be considered oversaturated should be based on current traffic count data and traffic analysis results, results from studies completed within the last 5 years in the study area, and congestion mapping.

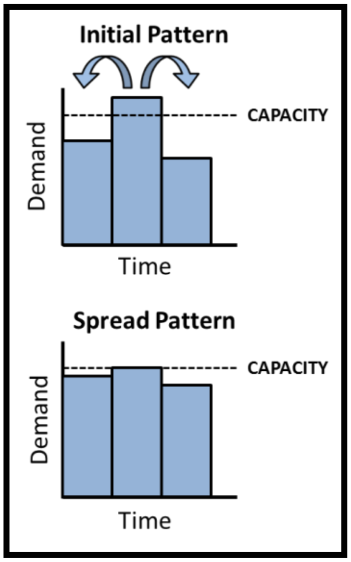
In many instances, a study area may be considered undersaturated under existing conditions but may be oversaturated under future conditions. Special consideration should be given to the saturation conditions in the future year(s) when selecting the most appropriate traffic analysis tool(s). If facilities within a study area are approaching capacity under the base year condition, then depending on the assumed traffic growth rate, oversaturated conditions should be assumed in the future year. Because of this issue, estimated future traffic volumes should be discussed at the scoping meeting.

Special consideration should be given to the saturation conditions in the future years of analyses when selecting the most appropriate traffic analysis tool(s).

One common phenomenon resulting from oversaturated conditions is peak hour spreading (PHS). PHS is most prevalent in urban and suburban transportation networks where peak hour traffic demand exceeds available traffic capacity throughout the entire peak hour. This excess traffic then "spreads" to either side of the computed peak hour, which creates a peak period of two or more hours as opposed to just one hour. Refer to **Figure 1** for an example of one type of PHS.

There are various degrees of PHS that may occur depending on the extent of peak hour traffic demand and hourly peak period travel distributions; however, the occurrence of PHS should be accounted for in operational analyses. The analysis of PHS requires the use of microsimulation tools, such as Vissim, and requires traffic data to be entered in 15-minute intervals until all peak hour traffic demand is successfully spread across the adjacent 15-minute periods. The analysis period should be long enough to allow the network to recover from PHS, which occurs when the demand no longer exceeds capacity.

Figure 1: Example of Peak Hour Spreading (PHS)



2.3 MISCELLANEOUS OPERATIONS ANALYSIS

Miscellaneous operations include common analyses that do not include characteristics of the two previously described categories. Multiple types of miscellaneous operations are considered in this manual, such as:

- **Toll Plaza Operations:** This type of analysis is used to evaluate the functionality, capacity, and serviceability of a toll collection system.
- **Gated Operations:** This type of analysis is used to evaluate the functionality, capacity, and serviceability of a gated facility. Gated operations may occur at secure locations such as military bases or draw bridges.
- **Work Zone Operations:** This type of analysis is used to evaluate the impacts of a work zone on freeway and arterial operations.
- **Active Traffic Management (ATM):** This type of ITS solution includes an integrated set of operating strategies and technologies for managing transportation demand, such as advanced lane control signal systems, variable speed limits, dynamic junction control, speed harmonization, and automated signs. This type of analysis is used to examine network functionality for a variety of MOEs including speed, density, travel time, or queue.
- **Dynamic Traffic Assignment (DTA):** DTA simulates vehicles making alternative route choices based on factors within a network, such as congestion and travel times. It may be appropriate use DTA when evaluating bottleneck removal, ATM and ITS strategies, managed lanes, tolled facilities, transportation demand management strategies, incident management response scenarios, special events, work zone impacts, and/or construction diversion.

Topics such as ATM and DTA are not addressed in detail in this manual. Additional guidance on these topics may be found in the FHWA Traffic Analysis Toolbox documents referenced in **Section 1.3**.

2.4 SAFETY ANALYSES

Safety analyses are used to evaluate the predicted safety operations of intersections, segments, and facilities. Analyses may use crash modification factors and/or crash prediction models, as detailed in the *HSM*, to determine predicted or expected crashes. Multiple types of safety analysis scenarios are considered in this manual, such as:

- **Rural Two-Lane Roads:** A rural two-lane road analysis will consist of the following components:
  - Intersections
  - Segments
  - Facilities
- **Rural Multilane Roads:** A rural multilane road (currently limited to four lanes) analysis will consist of the following components:
  - Intersections
  - Segments
  - Facilities
- **Urban and Suburban Arterials:** An urban and suburban arterials analysis will consist of the following components:
  - Intersections
  - Segments
  - Facilities
- **Freeway Facilities and Interchanges:** Freeway and interchange analysis will consist of the following components:
  - Freeway Segments
  - Ramp Segments
  - Ramp Terminals (i.e., intersections)
  - Freeway Facilities
- **Non-Traditional Safety Analyses** use crash modification factors or traffic modeling results to evaluate the safety benefits of roadway configurations that may not be included in the methodologies detailed in the *HSM*. This type of analysis may be required for arterials with higher volumes or more lanes than supported by the *HSM*. It may also be required for innovative intersection configurations.

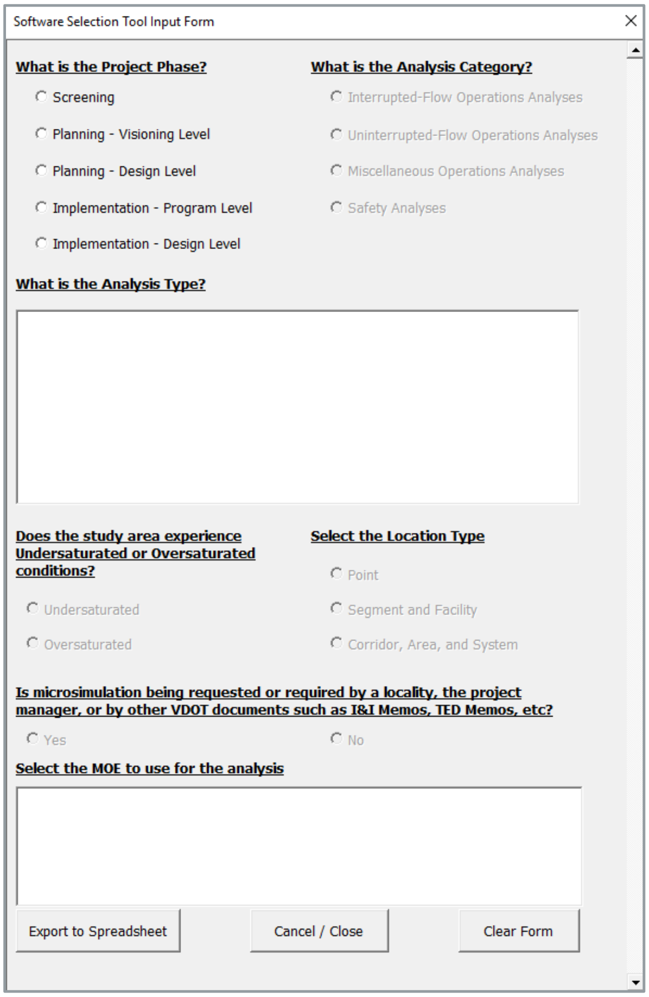
3 Traffic and Safety Analysis Tools

Several traffic and safety analysis tools may be used to determine results for the common analysis scenarios described in **Chapter 2**. Based on current traffic operations and safety analysis practices in the VDOT districts, twelve traffic operations and safety analysis tools were selected for inclusion in this manual. A brief description on the functionality of each tool is provided in the following sections of this chapter.

The VDOT Software Selection Tool (SST), as shown in **Figure 2**, was developed to assist users with selecting the appropriate traffic operations and safety analysis tools. Each traffic and safety analysis tool has limitations that should be considered when selecting a tool (i.e. the maximum number of travel lanes on an approach). This chapter does not detail all limitations of each tool; therefore, users should verify that analysis scenarios fall within the functionality of a tool prior to selecting the tool.

The user is responsible for any results derived from analysis tools. The user shall document that he/she has reviewed the results from analysis tools by understanding the capabilities and limitations for each tool. The results derived from tools used outside of their limitations may yield inconclusive or misleading results.

Figure 2: Software Selection Tool (SST) Input Form



Software Selection Tool Input Form

What is the Project Phase?

○ Screening
○ Planning - Visioning Level
○ Planning - Design Level
○ Implementation - Program Level
○ Implementation - Design Level

What is the Analysis Category?

○ Interrupted-Flow Operations Analyses
○ Uninterrupted-Flow Operations Analyses
○ Miscellaneous Operations Analyses
○ Safety Analyses

What is the Analysis Type?

Does the study area experience Undersaturated or Oversaturated conditions?

○ Undersaturated
○ Oversaturated

Select the Location Type

○ Point
○ Segment and Facility
○ Corridor, Area, and System

Is microsimulation being requested or required by a locality, the project manager, or by other VDOT documents such as I&I Memos, TED Memos, etc?

○ Yes ○ No

Select the MOE to use for the analysis

3.1 SUMMARY OF ANALYSIS TOOLS

Traffic and safety analysis tools are frequently updated as enhancements are made or when new analysis methodologies are developed, such as a when highway capacity equations or thresholds are changed. Prior to selecting traffic and safety analysis tools, verify which version(s) of analysis tools are accepted by VDOT.

Table 1 identifies the version(s) of each analysis tool described in this manual and serves as a reference for the version(s) that are applicable to the direction and guidance provided in this manual.

Analysis tool versions not listed in **Table 1** will be permitted for use on projects at the discretion of the VDOT project manager and with the approval of the District Traffic Engineer (DTE) or his/her designee. The same version and build of analysis tool(s) shall be used throughout the life of a project, even if new versions or builds are released, since different versions and builds of the same tool often yield different output results for identical parameters.

The same version and build of analysis tool(s) shall be used throughout the life of a project, even if new versions or builds are released.

Table 1: Traffic and Safety Analysis Tools in this Manual

Analysis Tool	Version(s)[1]
Traffic Analysis Tools[2]	
VDOT Work Zone Tools[3]	Varies by VDOT Operations District. Request the current version from VDOT District Operations in the region where the project is located.
VJuST	VJuST Version 1.02
HCS	HCS7
SIDRA Intersection	SIDRA Intersection 8
Synchro	Synchro 10
SimTraffic	SimTraffic 10
FREEVAL	FREEVAL+
Vissim	Vissim 11
Safety Analysis Tools	
AASHTO *HSM* Spreadsheets	*HSM* Rural 2-Lane Roads *HSM* Rural Multilane Roads *HSM* Urban Suburban Arterials
ISATe	ISATe – October 2011
IHSDM	IHSDM 2018 Release

[1] A listing of the most recent version(s) of analysis tools permitted for use is available on the OutsideVDOT Sharepoint site. Contact the VDOT Central Office Traffic Engineering Division to request access to the OutsideVDOT Sharepoint site and TOSAM supplemental materials.

[2] Aimsun and/or Visum may also be needed for projects requiring mesoscopic analysis.

[3] VDOT HUB-CAP may also be required to supplement the VDOT Work Zone Spreadsheets for construction projects that require road user fees to be determined.

3.2 VDOT WORK ZONE TOOLS

Three deterministic tools are available from VDOT to evaluate the impacts of work zone mitigation strategies:

- VDOT Work Zone Spreadsheets
- VDOT Freeway Basic Work Zone *HCM* Tool
- VDOT Highway User Benefit-Cost Analysis Program (HUB-CAP)

The tools are Microsoft® Excel-based spreadsheets, available upon request from VDOT. Each tool may be used to determine measures of effectiveness, such as queuing produced by work zones, based on methodologies outlined in the *HCM*. There are multiple versions of the work zone spreadsheets in use throughout Virginia; therefore, verify that the correct spreadsheet is used based on the project location.

HUB-CAP should be used to determine road user fees for construction projects, including projects that require incentives and/or disincentives to be established. HUB-CAP is distributed, on request, by VDOT and provides a standardized methodology for quantifying road user benefits-costs associated with various alternatives such as detours; temporary roadway and/or shoulder construction; off-peak hour day work; night work; and the most appropriate project delivery-based method.

3.3 VJUST

The VDOT Junction Screening Tool (VJuST) is a Microsoft® Excel-based tool that aids transportation engineers and planners in understanding which innovative intersection and interchange configurations might be appropriate to advance to further study, analysis, and design at a specific location. It also helps identify innovative intersection and interchange configurations that have the potential for reducing congestion and improving safety.

VJuST is most applicable at isolated intersections or interchanges because it does not account for the influence of adjacent intersections on traffic patterns; however, the results may be indicative of how an intersection or interchange within a corridor might operate. Results from the tool are not meant to replicate results obtained from more detailed traffic operations, safety, and design analyses.

VJuST is a modified version of the CAP-X Software developed by the Federal Highway Administration (FHWA). VDOT altered the CAP-X Software to include new intersection and interchange configurations, additional metrics, and an enhanced congestion metric that considers shared lanes and/or channelized right-turn lanes. VJuST Version 1.02 does not take into consideration costs such as construction or life cycle; it also does not consider right of way. Informed decisions shall be made by considering these factors as well.

3.4 HIGHWAY CAPACITY SOFTWARE

Highway Capacity Software (HCS) is a deterministic tool distributed by McTrans based on methodologies outlined in the *HCM*. HCS may be used to analyze urban street facilities, urban street segments, signalized intersections, unsignalized intersections (two-way and all-way), freeway facilities, basic freeway segments, merging and diverging segments, weaving segments, collector-distributor facilities, multilane highways, and two-lane highways.

As a deterministic tool, HCS shall not be used to analyze oversaturated conditions; however, the Freeway Facilities module of HCS may be used for the preliminary evaluation of alternatives on freeways. HCS7 (TRANSYT-7F) may be used to optimize traffic signal timings for an oversaturated network. These traffic signal timings should be further refined in the field and within microsimulation models.

3.5 SIDRA INTERSECTION

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

The Virginia Transportation Research Center (VTRC) conducted research on roundabout analysis tools and concluded that SIDRA Intersection is the only deterministic traffic analysis tool suitable for roundabout analyses at this time.

SIDRA Intersection uses two roundabout capacity models: the SIDRA Standard model and the US *HCM* model. Based on research conducted by the developers of SIDRA Intersection, the US *HCM* model does not account for the effects of vehicle arrivals based on adjacent traffic control devices; whereas, the SIDRA Standard model does account for these effects. As a result, SIDRA Intersection using the SIDRA Standard model shall be used for all roundabout analyses, even when microsimulation is warranted. More detailed differences between the two models are described in in **Chapter 7**. In oversaturated conditions, a Vissim analysis shall accompany a SIDRA Intersection roundabout analysis.

In oversaturated conditions, a Vissim analysis shall accompany a SIDRA Intersection roundabout analysis.

3.6 SYNCHRO

Synchro is a deterministic tool developed by Trafficware, primarily used for analyzing traffic flow, traffic signal progression, and traffic signal timing optimization. Additionally, Synchro may be used to analyze arterials, signalized intersections, and unsignalized intersections. Synchro shall not be used to analyze freeways, interchange systems, or ramps; therefore, it shall only be used to analyze intersections and arterials.

Synchro uses two different methodologies with different MOEs for analyzing intersections: *HCM* and Intersection Capacity Utilization (ICU). The *HCM* methodology is used to analyze intersection operations based on total control delay, whereas the ICU methodology was not designed for operations and signal timing design, and instead, measures the capacity of an intersection based on volume-to-capacity (v/c) ratios. The *HCM* methodology is the VDOT-preferred methodology for all types of intersection operational analyses. The ICU methodology is not accepted by VDOT.

The *HCM* methodology should not be used for traffic signal optimization. For these types of analyses, use the progression optimization features in Synchro.

Since Synchro is a deterministic tool, it shall not be used to analyze oversaturated conditions; however, Synchro may be used to optimize traffic signal timings on an oversaturated network. These traffic signal timings should be further refined in the field.

***HCM* methodology will be used on all intersection traffic analyses using Synchro, except for Synchro analyses for traffic signal optimization.**

3.7 SIMTRAFFIC

SimTraffic is the microsimulation companion tool of Synchro and is bundled with the Synchro suite of software tools. SimTraffic may be used to model any network that can be analyzed using Synchro. Prior to conducting analyses using SimTraffic, the network shall first be developed using Synchro. Once the network is developed in Synchro, SimTraffic can be initiated either from within the Synchro interface or independently. Like Vissim, SimTraffic can output several measures of effectiveness, such as microsimulation delay per vehicle, travel distance, maximum queue length, travel time, and average speed. SimTraffic requires calibration as a microsimulation tool.

One of the strengths of SimTraffic is that is includes the functionality to simulate intersections, arterials, and corridors. Like Synchro, SimTraffic does not have the functionality to analyze freeway or interchange systems.

3.8 FREEVAL

Freeway Evaluation (FREEVAL) is a deterministic software tool designed to conduct the operational analysis of undersaturated and oversaturated directional freeway facilities. FREEVAL uses methodology outlined in Chapters 10 and 11 of the *HCM*. It incorporates all freeway segment procedures outlined in Chapters 12, 13, and 14 for basic freeway segments, weaving segments, and merge and diverge segments, respectively.

FREEVAL can be used to analyze individual freeway segments or an entire directional facility. The user must define the different freeway segments and enter all required input data, including demand volumes, segment length, number of lanes, and the length of acceleration/deceleration lanes.

3.9 VISSIM

Vissim (Verkehr In Städten – SIMulationmodell) is a microscopic traffic microsimulation model developed by German-based PTV Group to analyze the full range of roadway and public transportation systems. The primary applications for Vissim are arterial studies and freeway operational studies; however, Vissim may also be used for evacuation planning, LRT/BRT studies, transit center designs, railroad grade crossing analyses, toll plaza evaluations, bicycle analyses, pedestrian analyses, ITS assessments, ATM, and DTA impacts. Vissim requires calibration as a microsimulation tool.

Vissim allows for flexibility to develop a wide range of roadway networks with respect to vehicle movements and roadway geometry. Vissim will move unmet demand from one time period to subsequent time periods within the overall analysis timeframe, which is helpful in congested networks experiencing PHS. Vissim is one of the recommended tools for analyzing oversaturated conditions.

3.10 SAFETY SPREADSHEET TOOLS

3.10.1 *AASHTO HSM Spreadsheets*

The AASHTO *HSM* Spreadsheets are Microsoft® Excel-based tools that were created to simplify the use of the *HSM Part C: Predictive Methods*. The AASHTO *HSM* Spreadsheets were originally created to test and verify Part C Predictive Method Worksheets for the arterials chapters. The AASHTO *HSM* Spreadsheets are based on national data and have not been calibrated to Virginia.

The AASHTO *HSM* Spreadsheets may be used to predict crashes on two-lane rural highways, multilane (presently four-lane) rural highways, and urban and suburban arterials. Five roadway types may be analyzed with the urban and suburban arterial spreadsheet: two-lane undivided sections, three-lane divided sections (with a two-way left-turn lane), four-lane undivided sections, four-lane divided sections, and five-lane divided sections (with a two-way left-turn lane).

In addition, five types of crashes are considered: multiple-vehicle non-driveway crashes, single-vehicle crashes, multiple-vehicle driveway-related crashes, vehicle-pedestrian crashes, and vehicle-bicycle crashes. The AASHTO *HSM* Spreadsheets consider the severity level of existing crash data and may be used to perform multi-year analyses. Output is summarized in tabular format like the worksheets provided in Part C of the *HSM*. To improve functionality, the AASHTO *HSM* Spreadsheets contain macros, which are compatible with Excel 2007 or later.

3.10.2 *ISATe*

Enhanced Interchange Safety Analysis Tool (ISATe) is a Microsoft® Excel-based tool developed by FHWA used to evaluate the safety effects of geometric design decisions on freeways. ISATe provides information about the safety effects of roadway geometric design features for freeway-to-arterial and freeway-to-freeway interchanges based on Part C of the *HSM* that quantifies the relationship between various design components, traffic flows, and expected average crash frequencies. ISATe may be used to evaluate the safety of freeways, interchanges, ramps, and C-D roads. ISATe is intended to help designers make informed judgments about the safety performance of design alternatives. ISATe implements *HSM* methods that use safety performance functions (SPFs), crash modification factors (CMFs), and local calibration factors to estimate average crash frequency by crash type or severity. The tool may be used when no existing crash data is available but may also incorporate existing crash data to obtain more reliable crash predictions.

3.11 IHSDM

Interactive Highway Safety Design Model (IHSDM) is a decision-support tool, developed, and distributed by FHWA, which may be used to evaluate the safety effects of geometric design on roadways. IHSDM estimates the expected safety results for different roadway designs and checks existing or proposed roadway designs against relevant design standards.

IHSDM maintains a direct relationship with the *HSM*. The Crash Prediction module implements Chapter 10, Chapter 11 and Chapter 12 of Part C of the *HSM* (Predictive Methods) to address rural two-lane roads, rural multilane highways, and urban and suburban arterials. The latest release of IHSDM also implements Chapters 18 and 19 of Part C of the *HSM* to address freeway segments and freeway ramps.

3.12 USE OF OTHER ANALYSIS TOOLS OR METHODS

There may be circumstances where it is necessary to use one or more analysis tools that are not addressed in this manual. Approval by the DTE or his/her designee, as well as written documentation, is required for the use of other analysis tools. This decision shall be based on the proposed analysis tool(s) providing functionality that is not available with the current suite of approved tools. Two common situations where the use of other analysis tools may be warranted are described below.

- **Newer Versions of Analysis Tools Addressed in this Manual:** New versions of common analysis tools are likely to be released before this manual is updated. VDOT would prefer to evaluate the newer versions prior to their use on projects and inclusion in this manual. However, there may be instances where a VDOT project manager may want to approve the use of a newer version of an analysis tool to take advantage of a new feature(s) that may benefit the project.
- **Analysis Tools with Increased Functionality:** The tools addressed in this manual may not fulfill all analysis needs on projects. In these situations, VDOT project managers should consult with subject matter experts to determine which tool(s) is(are) most appropriate for their project and then shall obtain approval from the DTE or his/her designee. If the project is a federal-aid project, FHWA approval is also required. If the tool has never been used on a project in Virginia, then the VDOT project manager shall contact the DTE and/or the Central Office TED - Systems Analysis Section for review and comment prior to using the analysis tool(s). Any tool that falls under this category may be evaluated for inclusion in future versions of this manual.

  Two tools that fall under this category are used for mesoscopic analysis: Aimsun and Visum. Mesoscopic modeling allows for the analysis of small-area networks, including the use of origins and destinations for vehicle routing. These tools can be used to report results similar to microscopic models, including travel time and delay; however, only microscopic analysis tools outlined in this manual shall be used for reporting traffic analysis measures of effectiveness. These tools are helpful to compare alternatives and conduct sensitivity analyses.

3.13 USE OF MULTIPLE ANALYSIS TOOLS

In many cases, only one analysis tool may be required to analyze the geometric and traffic conditions of a project; however, there may also be cases when multiple analysis tools are needed. It is important that the strengths, functionality, and limitations of each analysis tool are accounted for during the traffic and safety analysis scoping process to verify when multiple tools are required. When multiple tools are required, it is best to report the MOEs produced by the more appropriate tool and discard the results produced by the less appropriate tool. During the scoping process, the tool associated with each MOE should be determined. More information regarding when each analysis tool is applicable may be found by using the SST.

While it is desirable to ensure that the results from both tools are similar, it may not be practical for them to be identical. Inconsistencies between the results from traffic and safety analysis tools cannot always be eliminated. Each tool has different methodologies for approximating real-world conditions; therefore, two tools may not present the same results. Results from both tools should be evaluated and presented. Both analysis tools should produce the same general conclusions if a thorough analysis has been conducted with both tools.

Examples of common situations where multiple tools may be selected are described below in more detail.

- **Synchro and HCS:** This combination may occur when a project encompasses an arterial, an interchange, and multiple freeway segments when microsimulation is not required.
  - Synchro may be used to analyze the signalized intersections along the arterial as well as the operations on the arterial facility.
  - HCS may be used to analyze interchange merging, diverging, and weaving segments, if applicable, for undersaturated freeway conditions.
  - The VDOT project manager should verify that arterial operations do not influence freeway and ramp operations to confirm that microsimulation is not required. Users should verify that queues at ramp terminals do not spill back onto the freeway and that the queues from arterial intersections do not spill back to adjacent interchanges. Additionally, users should have enough information to determine whether arterial operations will influence freeway and ramp operations for future conditions.
- **Synchro and Vissim:** This combination may occur when a project encompasses an arterial, an interchange, and multiple freeway segments when microsimulation is required due to factors other than those mentioned in this manual even though the network consists of undersaturated conditions.
  - Synchro may be used to analyze the signalized intersections along the arterial as well as the operations on the arterial facility. Alternatively, Synchro may simply be used to develop optimized traffic signal timings for input into Vissim.
  - Vissim may be used to analyze the intersections, arterials, especially for oversaturated conditions, and/or interchange ramps, and freeway operations in one model.
  - Networks should overlap when splitting them between multiple tools to model the interaction between arterials and freeways. In this case, the Vissim model should include arterial intersections adjacent to the interchange to account for the interaction between the arterial facility and the freeway facility. The practice of modeling arterial intersections adjacent to interchanges assists in the calibration process of the freeway. In many cases, arterial intersections impact how traffic flows enter the freeway by creating platoons and metering traffic. It is best practice to model the arterial intersections directly adjacent to the interchange ramp terminals.
- **Synchro or HCS and SIDRA Intersection:** This combination may occur when a project involves the analysis of an arterial that includes a roundabout and one or more signalized or unsignalized intersections when microsimulation is not required.
  - Synchro or HCS may be used to analyze the signalized or unsignalized intersections along an arterial as well as the operations of the arterial facility for undersaturated conditions.

  - SIDRA Intersection shall be used to analyze the roundabout because SIDRA Intersection is required for all roundabout analyses.
- **SIDRA Intersection and Vissim:** This combination may occur when a project involves the analysis of an intersection as a roundabout when microsimulation is required due to the study area being oversaturated, when a freeway ramp terminal includes a roundabout, when an arterial contains intersections that may interact with a roundabout, or when a Vissim model is required for other purposes (e.g., public presentation, verification of operational behavior on the roundabout).
  - SIDRA Intersection shall be used to analyze the roundabout because SIDRA Intersection is required for all roundabout analyses.
  - Vissim should be used to analyze the roundabout and the remainder of the study area to produce microsimulation results and animation; however, the Vissim results shall be accompanied by SIDRA Intersection analysis results.
- **AASHTO *HSM* Spreadsheets and ISATe:** This combination may occur when a project involves performing a safety analysis for a project that includes an arterial, an interchange, and freeway segments.
  - AASHTO *HSM* Spreadsheets should be used to analyze arterial segment and intersection safety conditions.
  - ISATe should be used to analyze interchange ramps, terminals, and freeway safety conditions.
- **Vissim and IHSDM or ISATe:** This combination may occur when a project involves performing traffic operations and safety analyses for a proposed interchange concept.
  - Vissim may be used to analyze traffic operational conditions of existing conditions and the proposed interchange concept.
  - IHSDM or ISATe may be used to analyze the safety operations of both existing conditions and the proposed interchange concept

4 Analysis Measures of Effectiveness (MOEs)

When conducting traffic and safety analyses, there are many measures of effectiveness (MOEs) that may be used to document results. This chapter presents the traffic operations and safety MOEs that are accepted for use on projects conducted by or for VDOT.

MOEs should be selected during the project scoping process based on the project purpose and goals. Refer to **Chapter 9** for guidance on selecting MOEs. The use of any MOE not listed in this chapter shall be approved by the DTE or his/her designee.

4.1 TRAFFIC OPERATIONS MOES

For consistency, all definitions presented for traffic operations MOEs are referenced from the *HCM* with an understanding that each individual traffic analysis tool may have their own interpretation of the MOE definitions. 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." **Table 2** denotes which MOEs are acceptable to report for each traffic analysis tool, as listed in the VDOT Software Selection Tool. The traffic operations MOEs approved by VDOT are described below:

- **95th Percentile Queue Length (measured in feet – ft)**

  The *HCM* defines queue length as "the distance between the upstream and downstream ends of the queue." The 95th percentile queue length is the queue length that has only a 5 percent probability of being exceeded during a given analysis period. The computation of queue length is a complex process depending on the degree of congestion. 95th percentile queue length is an MOE that is applicable to both interrupted- and uninterrupted-flow conditions (e.g., arterial and freeway networks).

- **Control Delay (measured in seconds per vehicle – sec/veh)**

  The *HCM* defines control delay as "delay brought about by the presence of a traffic control device, including 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." Control delay is an MOE that is only applicable to interrupted-flow conditions.

- **Density (measured in passenger cars per lane per mile or vehicles per lane per mile– pcplpm or vplpm)**

  The *HCM* defines density as "the number of vehicles occupying a given length of a lane or roadway at a particular instant." HCS7 expresses density results in passenger cars per lane per mile (pcplpm) in all uninterrupted-flow modules and in vehicles per lane per mile (vplpm) in only the Freeways module. Microsimulation tools express density in vplpm. Density is an MOE compatible with only uninterrupted-flow

- **Maximum Queue Length (measured in feet – ft)**

  The maximum queue length refers to the longest queue length that is observed or simulated during a given analysis period. The computation of queue length is a complex process depending on the amount of congestion. Maximum queue length is an MOE that is applicable to interrupted- and uninterrupted-flow conditions (e.g., arterial and freeway networks).

- **Microsimulation Delay (measured in seconds per vehicle – sec/veh)**

  Microsimulation delay is equal to the difference between the simulated travel time and the theoretical travel time if the vehicle was operating at the desired speed calculated by a microsimulation tool. Microsimulation delay is an MOE that is applicable to interrupted- and uninterrupted-flow conditions;

however, for the purposes of identifying traffic analysis tools in this manual, microsimulation delay is assumed to be only applicable to interrupted-flow conditions.

- **Percent Time Spent Following or PTSF (measured in percentage – %)**

  The *HCM* defines percent time-spent-following as "the average percentage of total travel time that vehicles must travel in platoons behind slower vehicles because of the inability to pass on a two-lane highway." PTSF also represents the approximate percentage of vehicles traveling in platoons. PTSF is an MOE compatible with only uninterrupted-flow, specifically for Class I and Class II two-lane highways. This MOE shall only be used for analyses performed in HCS7for undersaturated conditions.

- **Percent of Free-Flow Speed or PFFS (measured in percentage – %)**

  The *HCM* defines percent of free-flow speed as "the average travel speed divided by the free-flow speed," where free-flow speed is defined as "the average speed of vehicles on a given segment, measured under low-volume conditions, when drivers are free to drive at their desired speed and are not constrained by the presence of other vehicles or downstream traffic control devices." PFFS represents the ability of vehicles to travel at or near the posted speed limit." PFFS is an MOE compatible with only uninterrupted-flow conditions, specifically for Class III two-lane highways. This MOE shall only be used for analyses performed in HCS7 for undersaturated conditions.

- **Space Mean Speed (measured in miles per hour – mph)**

  The *HCM* defines space mean speed as "an average speed based on the average travel time of vehicles to traverse a length of roadway." For analyses of Class I two-lane highways in HCS7, space mean speed is referred to as average travel speed (ATS). Space mean speed is an MOE compatible with both interrupted- or uninterrupted-flow conditions.

- **Time Mean Speed (measured in miles per hour – mph)**

  The *HCM* defines time mean speed as "the average speed of vehicles observed passing a point on a highway." Time mean speed is an MOE compatible with both interrupted- or uninterrupted-flow conditions.

- **Travel Time (measured in seconds – sec)**

  The *HCM* defines travel time as "the average time spent by vehicles traversing a highway segment, including control delay." For freeway facilities, the *HCM* defines travel time as "the time required for a vehicle to travel the full length of the freeway facility from mainline entry point to mainline exit point without leaving the facility or stopping for reasons unrelated to traffic conditions." Travel time is an MOE compatible with both interrupted- or uninterrupted-flow conditions.

- **Volume-to-Capacity (v/c) Ratio**

  The *HCM* defines volume-to-capacity ratio as "the ratio of the flow rate to capacity for a system element." The *HCM* also states that "the volume-to-capacity (v/c) ratio is a special-case service measure. This ratio cannot be directly measured in the field, nor is it a measure of driver perception. Until capacity is reached (i.e., when flow breaks down on uninterrupted-flow facilities or when queues build on interrupted- or uninterrupted-flow facilities), the v/c ratio is not perceivable by travelers." V/C ratio is an MOE that is applicable to both interrupted- and uninterrupted-flow conditions, assuming that capacity has been defined for the facility in accordance with *HCM* methodology.

Table 2: Traffic Operations Analyses MOEs

Traffic Operations MOE	VJuST	HCS7	SIDRA Intersection	Synchro	FREEVAL	SimTraffic	Vissim
95th Percentile Queue Length, ft		✓	✓	✓		✓	
Control Delay, sec/veh		✓	✓	✓			
Density, pcplpm		✓					
Density, vplpm		✓					✓
Experienced Travel Time (ETT), sec/veh		✓					
Maximum Queue Length, ft						✓	✓
Microsimulation Delay, sec/veh						✓	✓
Percent of Free-Flow Speed		✓					
Percent Time Spent Following		✓					
Reliability							
95th Percentile Travel Time Index					✓		
80th Percentile Travel Time Index					✓		
50th Percentile Travel Time Index					✓		
LOTTR (80th/50th)					✓		
Space Mean Speed, mph		✓	✓	✓		✓	✓
Time Mean Speed, mph							✓
Travel Time, sec		✓				✓	✓
Volume to Capacity (v/c) Ratio	✓	✓	✓	✓			

This page is intentionally left blank

4.1.1 *Reliability Performance Measures*

Reliability is defined in the *HCM* as "the distribution of travel times for trips traversing an entire freeway facility over an extended period of time, typically one year, during any portion of the day." The reliability performance measures approved by VDOT are described below:

- **95th Percentile Travel Time Index (TTI95)**

  The *HCM* defines the 95th Percentile TTI as "the added time travelers must budget to ensure an on-time arrival with "failure" limited to one trip per month." The 95th Percentile TTI is commonly referred to as the Planning Time Index (PTI).
- **80th Percentile Travel Time Index (TTI80)**

  The *HCM* defines the 80th Percentile Travel Time Index as being more useful for strategy comparison and prioritization purposes since it is more sensitive to operational changes than the 95th Percentile Travel Time Index.
- **50th Percentile Travel Time Index (TTI50)**

  The *HCM* defines the 50th Percentile Travel Time Index as the median of the travel time index distribution.
- **LOTTR (Level of Travel Time Reliability)**

  LOTTR is defined as the 80th percentile TTI divided by the 50th percentile TTI.

4.1.2 *Innovative Intersections MOEs*

Innovative intersections and interchanges modify vehicle movements to reduce delay, increase efficiency and increase safety and, in doing so, the design may require vehicles to travel a longer distance or include multiple intersections in the overall design. As a result, to compare traffic analysis of innovative intersections to conventional intersections, the reported MOEs must account for the overall operation, rather than the operation of a single intersection or movement.

When conducting traffic operations analyses that include the consideration of innovative intersections and interchanges, it is important to report MOEs that can be compared to traditional innovative intersections and interchanges as well as to other innovative intersections and interchanges. The following MOEs are recommended for traffic analysis projects that include the analysis of innovative intersections:

- **V/C Ratio**
- **95th Percentile Queue Length**
- **Travel Time**
- **Experienced Travel Time (ETT) (measured in seconds per vehicle – sec/veh)**

  ETT allows for the comparison of different intersection types, especially those where movements are rerouted and shall be selected as an MOE for all innovative intersection and interchange analyses. The *HCM* defines experienced travel time for a given origin-destination movement as "the sum of extra distance travel time (the free-flow travel time1 required to traverse an interchange or alternative intersection minus the hypothetical shortest-path free-flow travel time making right-angle turns) and the control delay experienced at each junction encountered with an interchange or alternative intersection is traversed." For innovative intersections and interchanges where rerouting occurs and additional travel distance is not significant, ETT is equal to control delay. Refer to **Appendix G** for guidance on calculating ETT.

Experienced Travel Time (ETT) allows for the comparison of different intersection types, especially those where movements are rerouted and shall be selected as an MOE for all innovative intersection and interchange analyses.

4.2 SAFETY MOES

Table 3 illustrates which MOEs are acceptable to report for each safety analysis tool, as listed in the SST.

Table 3: Safety Analyses MOEs

Safety MOE	VJuST	AASHTO *HSM* Spreadsheets	IHSDM[1]	ISATe[2]
Weighted Total Conflict Points	✓			
Predicted Average Crash Frequency		✓	✓	✓
Expected Average Crash Frequency		✓	✓	✓

[1] IHSDM output reports always provide an expected crash frequency. If the EB Method was used, the results should be reported as an expected crash frequency. If the EB Method was not used, the results should be reported as a predicted crash frequency.

[2] ISATe output reports provide an estimated crash frequency. If the EB Method was used, the results should be reported as an expected crash frequency. If the EB Method was not used, the results should be reported as a predicted crash frequency.

The safety MOEs approved by VDOT are described below. For consistency, definitions presented for the safety MOEs are referenced from the *HSM*, if they are available.

- **Weighted Total Conflict Points**

  Three types of conflict points (crossing, merging, and diverging) are weighted in VJuST based on the calculated average crash cost associated with each conflict point type. The methodology for determining the weighting system is outlined in the VJuST Safety Information worksheet.

- **Predicted Crashes or Predicted Average Crash Frequency (measured in crashes or crashes per year)**

  The *HSM* defines predicted average crash frequency as "the estimate of long-term average crash frequency which is forecast to occur at a site using a predictive model found in Part C of the *HSM*. The predictive models in the *HSM* involve the use of regression models, known as Safety Performance Functions, in combination with Crash Modification Factors and calibration factors to adjust the model to site-specific and local conditions." The predicted average crash frequency is based on crash frequencies of similar sites.

- **Expected Crashes or Expected Average Crash Frequency (measured in crashes or crashes per year)**

  The *HSM* defines expected average crash frequency as "the estimate of long-term expected average crash frequency of a site, facility, or network under a given set of geometric conditions and traffic volumes (AADT) in a given period of years. In the Empirical Bayes (EB) methodology, this frequency is calculated from observed crash frequency at the site and predicted crash frequency at the site based on crash frequency estimates at similar sites." This MOE shall only be used if the EB Method is used. Direction and guidance on when to use the EB Method is provided in **Chapter 7**.

4.3 APPLYING LEVEL OF SERVICE

The deterministic analysis procedures outlined in the *HCM* result in MOEs that are based on traffic flow theory. Level of Service (LOS) may be used to describe and illustrate the relative differences between traffic operations MOEs. The *HCM* provides a LOS scale for several analysis types with a letter grade corresponding to a specified range of values for one or more MOEs. For example, density values for freeway segments may be supported by the corresponding letter grades shown in **Table 4**.

Table 4: Freeway Facility Level of Service in Terms of Density

Level of Service	Density (pc/mi/ln)	
	Urban	Rural
A	≤ 11	≤ 6
B	> 11 - 18	> 6 – 14
C	> 18 - 26	> 14 – 22
D	> 26 - 35	> 22 - 29
E	> 35 - 45	> 29 – 39
F	> 45*	> 39*

*or any component segment v/c ratio > 1.0
Source: *HCM* 6th Edition, Volume 2

In contrast to deterministic tools, microsimulation models (stochastic tools) are 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. Since microsimulation tools contain different definitions for similarly-named MOEs (e.g., microsimulation tools denote density in vehicles per mile, whereas the *HCM* methods express density results in passenger cars per mile), inaccurate results and conclusions may be reported if the differences are not considered. For this reason, LOS shall not be used to support results from microsimulation models.

4.4 SENSITIVITY TESTING

The VDOT project manager may choose to perform sensitivity analyses to evaluate how the operational or safety performance of a design alternative is impacted by uncertainties in the parameters. Sensitivity tests that may be practical for traffic operations and safety analysis projects include, but are not limited to, tests for traffic demand and design components. For example, to account for the inherent uncertainty of traffic demand forecasts, traffic demand may be varied by ± 10 percent or some other percentage that indicates the expected forecast error, to determine its impact on operational results. Various design components may be similarly altered (e.g., increasing or decreasing lane or shoulder widths by one foot, increasing or decreasing cycle length by ten seconds) to determine their impacts on safety and operational results.

This page is intentionally left blank

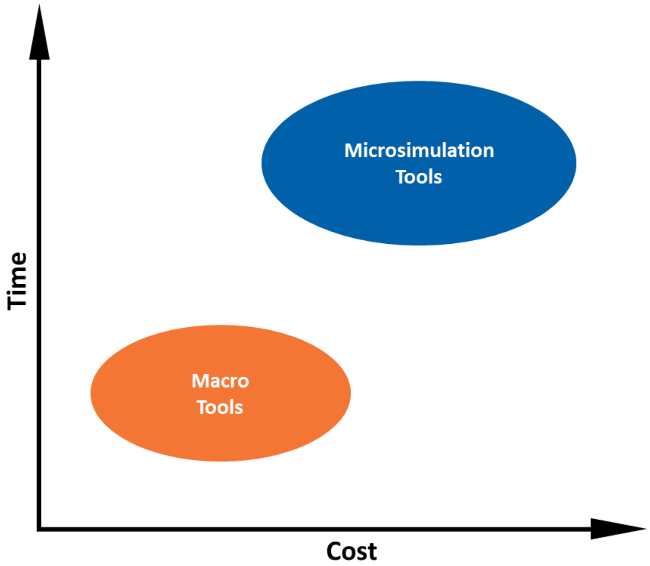
5 Microsimulation

When oversaturated conditions are prevalent within a transportation system, deterministic tools shall not be used to analyze traffic operations due to limitations in the fundamental equations used to develop the tools. Microsimulation (stochastic) tools are used for conducting traffic operational analyses in oversaturated conditions, where complex geometric conditions exist, or where there is a need to evaluate traffic conditions involving specific car following and lane changing behavior; however, like deterministic tools, microsimulation tools have limitations that need to be considered.

5.1 MICROSIMULATION APPLICABILITY

With each traffic analysis tool, there are tradeoffs that must be made during the analysis process. Deterministic tools are relatively easy to use and are not very time or data intensive. In contrast, microsimulation tools require more time, data, and cost to develop, validate, and calibrate. This difference is depicted in **Figure 3**.

Figure 3: Time and Cost Comparison for Macro and Microsimulation Tools



The difference in time and cost to use these two types of tools can be explained with the following factors (applicability is based on the type of tool used):

- Additional data collection requirements for microsimulation tools for input and/or calibration purposes
  - Geometric data (grade)
  - Demand data (15-minute traffic flow)
  - Origin-destination data
  - Travel times
  - Speeds
  - Queue lengths
- Additional time to develop and calibrate microsimulation tools
- Additional time required to post-process output from microsimulation tools
- Significantly more time to learn how to use and properly apply microsimulation tools
- Larger computer storage requirements for microsimulation tools than for deterministic tools

The basic functionality of each type of tool is where the time and cost impacts can best be observed. Deterministic tools perform “snapshot” analyses, which, in most undersaturated conditions with non-complex geometry, is adequate. On the other hand, microsimulation tools allow the user to evaluate both undersaturated and oversaturated conditions while other factors fluctuate (speed, lane-changing behavior, driver behavior, etc.) over time. Additionally, microsimulation tools can provide 2-dimensional and/or 3-dimensional visualizations of the results allowing the user to visually observe the analysis results, which is helpful when discerning between varying levels of oversaturated conditions or for public presentations of alternatives.

The guiding principle when using either deterministic or microsimulation tools is that the model is only as accurate as the parameters that are used. This means that the most accurate and appropriate values for parameters should always be used and should be supported by field data and documentation, when available.

5.2 EXISTING BASE MODEL DEVELOPMENT

The goal of developing an existing base model is to determine whether the model accurately represents the conditions that are observed in the field and matches the collected data. It is good practice to develop an existing base model that is systematically reviewed for errors prior to starting the model calibration process. The calibration process is often a time-consuming process, but one that cannot be overlooked.

Prior to the model development, the temporal and spatial limits of the model should be determined by the project team during the scoping process, as detailed in **Chapter 9**. The user should first enter the geometric configuration – depending on the tool used, these will either be links and nodes or connections (e.g., roadway segments, intersections, ramps, etc.). Once the geometry has been reviewed, the user should input the traffic control (traffic signals, stop signs, stop bars, etc.), traffic volumes, and microsimulation run control data.

Thorough quality control reviews should occur during the existing base model development process. Reviews should verify that the network is properly coded and determine if the model is calibrated to existing traffic and geometric conditions. Fully-calibrated base models should be used to develop future microsimulation models.

5.3 CALIBRATION THRESHOLDS

In addition to the use of accurate parameters, microsimulation tools need to be calibrated. A calibration parameter is a piece of information or variable that is used to fine-tune the base microsimulation model to reflect local, existing traffic operational behavior. These parameters may be collected from the field or be in the form of user-adjustable values within the microsimulation models. A calibrated model should satisfactorily replicate existing conditions and not have coding errors. Global changes to the model should only be made as appropriate to represent network-wide conditions. Making changes to global calibration parameters, such as car-following or lane-changing characteristics, prior to establishing that the link level conditions are as accurate as possible will result in a model that does not reflect existing conditions. During the calibration process, first use the calibration parameters documented in **Appendix E** for SimTraffic or the step-by-step process described in the *VDOT VISSIM User Guide*. If other factors need to be modified to meet the calibration thresholds, then these other factors should be approved by the VDOT project manager prior to the completion of the calibration process.

Level of service shall not be used to support results from microsimulation models.

Calibration measures and minimum microsimulation model calibration thresholds, as shown in **Table 5**, were identified to provide direction on verification that microsimulation models accurately represent existing conditions. VDOT project managers may develop calibration thresholds more stringent than the minimum calibration thresholds based on field conditions and the specific project purpose and need. It is best practice to develop these thresholds to achieve desired calibration accuracy while also considering incremental time and cost required for additional fine-tuning.

Multiple calibration measures shall be selected during the project scoping process. Simulated traffic volume shall be used as a measure for all projects. Other selected measure(s) may vary based on the purpose and goals of the project and the type of analysis. Microsimulation models shall meet these thresholds in **Table 5** for the selected measures. Technical justification shall be provided to and approved by the DTE or his/her designee whenever a specific calibration threshold cannot be met.

Table 5: Microsimulation Model Calibration Thresholds

Simulated Measure	Calibration Threshold
Simulated Traffic Volume (vehicles per hour) 85% of the network links and/or turning movement, and a select number of critical links and/or turning movements, as determined by the DTE or his/her designee, shall meet the calibration thresholds.	Within ± 20% for <100 vph Within ± 15% for ≥100 vph to <1,000 vph Within ± 10% for ≥1,000 vph to <5,000 vph Within ± 500 vph for ≥5,000 vph The traffic volumes identified above are actual traffic volumes from traffic counts as opposed to simulated traffic volumes.
Simulated Travel Time (seconds) 85% of the travel time routes and segments, or a select number of critical routes and segments, as determined by the DTE or his/her designee, shall meet the calibration thresholds. Travel time routes should be determined in cooperation with the VDOT project manager based on project needs and goals.	Within ± 30% for average observed travel times on arterials Within ± 20% for average observed travel times on freeways The travel time should be calibrated for segments and routes separately or as deemed appropriate by the VDOT project manager.
Simulated Queue Length (feet) A select number of critical locations and/or movements, as determined by the DTE or his/her designee, shall meet the calibration thresholds.	Visually acceptable maximum queue lengths are represented at critical locations

Notes:

1. The calibration thresholds shall be used as minimum thresholds for calibration. The VDOT project manager may decide to use stricter thresholds based on the project needs. If the minimum thresholds cannot be achieved, written justification shall be provided for review and approval by the DTE or his/her designee.
2. Field measurements should be made when there are no unusual traffic conditions, such as special events, crashes, incidents, etc. and preferably at the same time as the counts are conducted.
3. Critical links, turning movements, routes and/or segments in the network, if needed, shall be determined in coordination with the VDOT project manager during scoping.

At a minimum, calibration thresholds shall be met for the peak hour(s). Depending on the project, multiple hours of the peak period may need to be calibrated for certain measures. For example, when congestion sustains over multiple hours, travel time could be calibration for the entire peak period and not just the peak hour. The calibration period should be identified for each measure during project scoping.

Simulated average speed and bottlenecks can be considered as a project-specific validation measure in cases where significant speed differentials exist in the network (e.g. congested ramp movement with adjacent free-flow through conditions), or where congestions on a freeway facility (e.g., large speed reductions from free-flow speed) sustain both temporally (e.g., over multiple hours) and spatially (e.g., over multiple locations or extended from one location). These measures should be evaluated graphically to display the spatial and temporal extents of speed reductions that replicate field conditions as described in **Section 5.3.2**. The project manager should discuss locations where speed validation may be necessary during project scoping.

5.3.1 *Simulated Traffic Volume Guidance*

The selection of links or turning movements may vary by type of analysis:

- **Intersection Analysis:** 85 percent of intersection turning movements
- **Arterial Analysis (no freeways):** 85 percent of intersection turning movements
- **Freeway Analysis (no arterials):** 85 percent of freeway segments
- **Network Analysis (both freeways and arterials):** 85 percent of intersection turning movements and 85 percent of freeway segments AND a select number of critical links and/or turning movements, as determined by the DTE or his/her designee, may be selected and required to meet the calibration thresholds.

Links included in the 85 percent should be unique and not include duplicative links, such as a segment that has been broken into more than one link. Links exiting the study network should also be excluded from the 85 percent link selection. If determined to be a critical link by the DTE, such links can be included as noted below.

A critical link or turning movement represents a portion of a roadway network that is of decisive importance to the recommendations made because of a traffic operations analysis. To replicate existing conditions accurately, some networks need to be extended beyond the model spatial limit. In these cases, the decision to calibrate to critical links and/or turning movements in addition to 85 percent of network links and/or turning movements may be appropriate. The decision to calibrate to critical links and/or turning movements as well as the determination of critical links and/or turning movements shall be based on engineering judgment and agreed upon by the DTE or his/her designee. The following criteria shall be considered when selecting critical links or turning movements:

- **Traffic Volume:** Areas in the network that carry the highest traffic volumes, such as freeway and arterial mainlines, and will be a primary focus of the traffic operations analyses.
- **Location:** Areas that experience the most congestion within a network or areas within a roadway network that have impacts on the operations of the rest of the network, such as bottlenecks, and will be a primary focus of the traffic operations analyses. These areas may meter traffic throughout the rest of the network and have impacts on upstream and downstream facilities.
- **Impacts on MOEs:** Areas in the network that have the largest impact on MOEs such as density, delay, and queue length and will be a primary focus of the traffic operations analyses. Emphasis should be placed on areas that experience the largest differences in speeds between uncongested and congested periods, highest densities, and highest delays and longest queues.
- **Project Purpose and Goals:** Areas in the network that are most important to the project, for example, the links or turning movements that are being evaluated for an improvement such as ramp widening, lengthening of a merge area, or lengthening of a turn lane.

5.3.2 *Simulated Average Speed and Bottlenecks Guidance*

Speed and bottleneck validation should be visualized in a space-mean speed “heat map” as a supplemental tool for calibration when data is available and speed is identified as a project-specific validation measure. Speed data from probe data sources, such as INRIX, are readily available for most freeway segments and limited-access facilities in short intervals of time for all periods of the day; historical data for multiple months can also be retrieved. Speed heat maps for arterials should be generated, if necessary, based on INRIX XD data from VDOT iPeMS.

Speed heat map figures should have distance and reference points along the corridor on one axis and simulation time on the other axis in 15-minute increments. Speed should be collected from models at segments or spots that align with probe data segmentation and/or spot speed data collected specifically for the project. Figure colors should be varied at 5 to 10 mph increments (e.g., < 10 mph is dark red, > 60 mph is light green) and can be adjusted to match the free-flow speed of the roadway (e.g. 45 mph arterial may display > 45 mph as light green). The quantitative difference of simulated speed and probe vehicle speed for the speed heat map should be tabulated or graphically depicted (e.g., in the heat map) and reported in project documentation to assist with review.

5.3.3 *Simulated Travel Time Guidance*

Start and end points for travel time routes should be selected to cover the area(s) that are most important to the purpose and goals of the project. Travel time should be calibrated for segments with the same start and end points as collected in the field, and not only for an aggregate of multiple field-collected travel time segments. Routes that span a long distance, such as through multiple freeway interchanges, should be split and calibrated as multiple segments (such as interchange-to-interchange), in addition to calibrating to the overall travel time route. This approach is not always applicable for arterials, where intersection-to-intersection travel time can vary significantly depending on if the vehicle is stopped by a red light during field data collection. Short travel time segments (e.g., less than 30 seconds), where percent difference can result in the need to meet a small absolute difference, may be combined with other segments.

Modelers should ensure an adequate sample size of travel time data is available for comparison with average model outputs. Field conditions may limit the number of travel time runs that can be completed during the peak period. It is recommended that the project team discuss this topic during project scoping. Refer to **Chapter 6** for specific guidance on travel time data collection.

5.3.4 *Simulated Queue Length Guidance*

Queue length should be calibrated for a select number of critical locations and/or turning movements before considering minor, low-volume movements. The intent of queue length calibration is to ensure the model represents field-observed queuing and the resulting impact to traffic operations. Critical locations should be selected as those most relevant to the purpose and goals of the project during project scoping and data collection planning. The following criteria should be used when selecting critical locations:

- Queues exceed available storage of turn lanes at intersections
- Queues impact operations of upstream signalized intersections
- Queues are not cleared in one cycle at signalized intersections
- Queues exceed available storage of freeway off-ramps and impact upstream freeway operations
- Queues exceed available storage of on-ramps to a freeway and impact upstream arterial operations due to queue spillback from the freeway

Justification of how the model reasonably represents observed queueing should be provided in project documentation. A graphical comparison of simulated maximum queue length compared to observed queue length should be provided at the request of the DTE or his/her designee. Quantitative comparison of simulated maximum queue length (absolute and percent difference) along with available storage should be tabulated and reported in project documentation. Average queue lengths from the model may be reported as a supplemental data for comparison with observed queuing condition in justifying the adequacy of queue calibration.

Refer to **Chapter 6** for specific guidance on queue data collection.

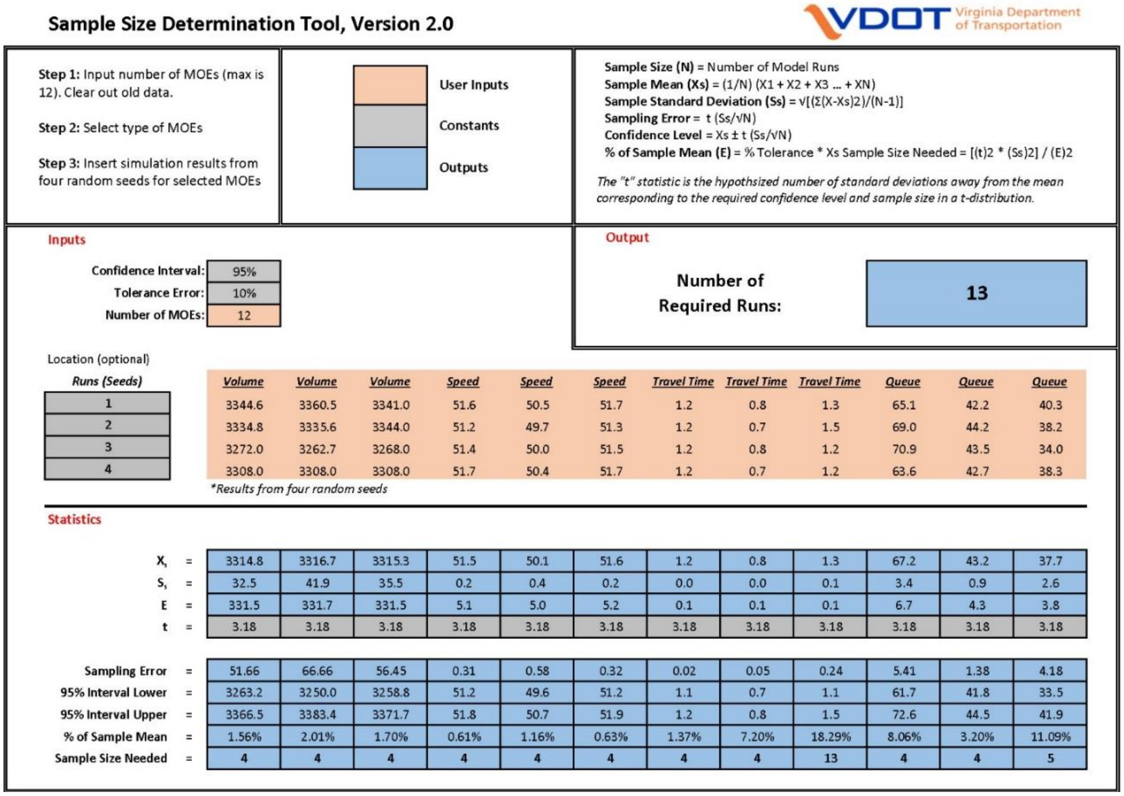
5.4 MICROSIMULATION SAMPLE SIZE

In addition to conducting proper network model calibration, determining and applying the appropriate number of microsimulation runs is a very important step in developing accurate microsimulation results. Using too few microsimulation runs will not fully account for microsimulation 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 microsimulation runs are performed at a 95th percentile confidence level.

To assist the users of this manual, the VDOT Sample Size Determination Tool, as shown in **Figure 4,** was developed to determine the appropriate number of microsimulation runs. The number of microsimulation runs shall be calculated using the VDOT Sample Size Determination Tool, which is based on the FHWA sample size determination methodology, as referenced in **Appendix A**. Computations from the VDOT Sample Size Determination Tool shall be submitted as supporting documentation with the microsimulation analysis results.

MOE results shall be input into the VDOT Sample Size Determination Tool for a minimum of the initial 10 runs. The MOE(s) used to determine the minimum number of microsimulation runs needed, as well as the location(s) from where the MOE(s) are gathered, should be agreed upon with the VDOT project manager. If multiple MOEs are used to determine the minimum number of microsimulation runs, the highest number of microsimulation runs shall be performed. The 95th percentile confidence interval and 10 percent error tolerance values should not be changed. For step-by-step instructions on how to use the VDOT Sample Size Determination Tool and more detailed explanation of the sample size determination calculations, see the *Excel-Based Macro User Guide* in **Appendix F**.

Figure 4: Sample Size Determination Tool



Sample Size Determination Tool, Version 2.0

VDOT Virginia Department of Transportation

Step 1: Input number of MOEs (max is 12). Clear out old data.

Step 2: Select type of MOEs

Step 3: Insert simulation results from four random seeds for selected MOEs

🟧 User Inputs
⬜ Constants
🟦 Outputs

Sample Size (N) = Number of Model Runs
Sample Mean (Xs) = (1/N) (X1 + X2 + X3 ... + XN)
Sample Standard Deviation (Ss) = √[(Σ(X-Xs)2)/(N-1)]
Sampling Error = t (Ss/√N)
Confidence Level = Xs ± t (Ss/√N)
% of Sample Mean (E) = % Tolerance * Xs Sample Size Needed = [(t)2 * (Ss)2] / (E)2

The "t" statistic is the hypothsized number of standard deviations away from the mean corresponding to the required confidence level and sample size in a t-distribution.

Inputs

Confidence Interval: 95%
Tolerance Error: 10%
Number of MOEs: 12

Output

Number of Required Runs: 13

Location (optional)

Runs (Seeds)	*Volume*	*Volume*	*Volume*	*Speed*	*Speed*	*Speed*	*Travel Time*	*Travel Time*	*Travel Time*	*Queue*	*Queue*	*Queue*
1	3344.6	3360.5	3341.0	51.6	50.5	51.7	1.2	0.8	1.3	65.1	42.2	40.3
2	3334.8	3335.6	3344.0	51.2	49.7	51.3	1.2	0.7	1.5	69.0	44.2	38.2
3	3272.0	3262.7	3268.0	51.4	50.0	51.5	1.2	0.8	1.2	70.9	43.5	34.0
4	3308.0	3308.0	3308.0	51.7	50.4	51.7	1.2	0.7	1.2	63.6	42.7	38.3

**Results from four random seeds*

Statistics

X_s	=	3314.8	3316.7	3315.3	51.5	50.1	51.6	1.2	0.8	1.3	67.2	43.2	37.7
S_s	=	32.5	41.9	35.5	0.2	0.4	0.2	0.0	0.0	0.1	3.4	0.9	2.6
E	=	331.5	331.7	331.5	5.1	5.0	5.2	0.1	0.1	0.1	6.7	4.3	3.8
t	=	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18

Sampling Error	=	51.66	66.66	56.45	0.31	0.58	0.32	0.02	0.05	0.24	5.41	1.38	4.18
95% Interval Lower	=	3263.2	3250.0	3258.8	51.2	49.6	51.2	1.1	0.7	1.1	61.7	41.8	33.5
95% Interval Upper	=	3366.5	3383.4	3371.7	51.8	50.7	51.9	1.2	0.8	1.5	72.6	44.5	41.9
% of Sample Mean	=	1.56%	2.01%	1.70%	0.61%	1.16%	0.63%	1.37%	7.20%	18.29%	8.06%	3.20%	11.09%
Sample Size Needed	=	4	4	4	4	4	4	4	4	13	4	4	5

5.5 UNMET DEMAND

Unmet demand is typically referred to as the number of vehicles that are destined to travel through a network at a specific time but cannot do so due to capacity constraints. Unmet demand typically occurs during oversaturated conditions and is a cause of peak hour spreading. Under these conditions, turning movement counts for a particular time do not always reflect demand. The number of vehicles in queues at intersections or on roadway segments at the end of the analysis period may be used to determine unmet demand.

Models should replicate existing traffic conditions; therefore, for instances when unmet demand occurs during existing conditions, factors such as traffic volume and maximum queues should be replicated. Unmet demand can have a dramatic impact on results and should be accounted for and quantified.

In many instances, future no-build condition microsimulation runs may have capacity constraints that prohibit forecasted demand from being modeled. Confirm with the VDOT project manager that planned background improvements (e.g. programmed widening, funded interchange improvements) are incorporated into the no-build condition microsimulation model before performing any runs. Adding any additional improvements to this no-build model to represent build conditions, such as additional roadway capacity, may reduce the amount of unmet demand. However, simulating different volumes between the build conditions and the no-build conditions may lead to misleading results, such as similar travel speeds. The amount of unmet demand should be quantified for each model to better explain analysis results by comparing the forecasted traffic volumes to the simulated model throughput.

In some instances, it may be appropriate to refine forecasted traffic volumes to account for peak spreading. Traffic volumes may need to be adjusted to spread traffic volumes from over-capacity time periods to adjacent time periods; therefore, it is critical to select a traffic analysis tool that can account for multiple time analyses. Refer to the *VDOT Traffic Forecasting Guidebook* for additional guidance.

In instances where unmet demand occurs, users should verify that all demand is allowed entry into the network for each microsimulation run to properly measure the impacts of unmet demand. The following steps should be followed to reduce the number of vehicles being denied entry into a microsimulation model:

- Users should view error logs to determine the locations where vehicles have been denied entry.
- Users should verify that vehicles are not being denied entry due to coding errors such as traffic signal timings or incorrect lane alignments.
- Users should verify that the spatial limits of the network are extended to accommodate the maximum queue lengths simulated within the network.
- Users should verify that the temporal limits of the model are extended to accommodate the surge of traffic demand simulated within the network prior to the analysis period.
- When extension of spatial and temporal limits fails to account for all unmet demand, the model results should be adjusted to account for unreported congestion in the analysis outputs. Alternatively, other calibration techniques may be applied to create the conditions. Documentation should be provided to indicate that boundary and temporal limit expansion did not account for the unmet demand.

This page is intentionally left blank

6 Standard Data Requirements for Analyses

Collecting the most appropriate data is vital to conducting traffic operations and safety analyses. Transportation professionals should make informed decisions on what data to collect, when to collect it, where to collect it, how long to collect it, and how to manage it once it has been collected. This chapter focuses on answering these questions regarding the collection of data and the management of the information, which is dependent on the type of analysis being conducted.

The following traffic operations and safety analysis data types are addressed in this chapter:

- Geometric
- Traffic count
- Signal operations
- Calibration
- Safety

In addition, this chapter includes a list of acceptable traffic count and crash data sources with known issues and limitations of each source. Data sources should be identified and selected during the project scoping process based on the project purpose and goals. It is the responsibility of the project manager to verify the potential issues and limitations that may affect the results of the analysis. The use of any data sources not listed in this chapter shall be approved by the DTE or his/her designee.

As mentioned in **Chapter 9**, a traffic and safety analysis scoping meeting shall be held prior to the start of the project between the VDOT project manager, stakeholders involved in the project review process, and subject matter experts responsible for conducting and/or reviewing the analysis. The assumptions needed to conduct the analysis shall be discussed and approved at this scoping meeting. Tables with the various types of analysis assumptions provided in this chapter should be considered at the scoping meeting to help with the traffic operations and safety analysis assumptions discussion.

6.1 GEOMETRIC DATA

Geometric data includes any data required to develop the physical extents and characteristics of a network, such as link lengths, travel lane widths, number of lanes, turn lane lengths, and lane designations. Overall, there are many different geometric input parameters required to develop all types of networks covered in this manual; however, not all geometric data are needed for each analysis. **Table 6** provides a summary of typical geometric data required for each analysis type. Additional geometric data may be required based on the selected analysis tool. Current aerial imagery should be used when developing all networks for traffic operations analyses. The accuracy of aerial imagery should be field verified.

This page is intentionally left blank

Table 6: Standard Geometric Input Parameters

Analysis Categories/ Standard Geometric Assumptions	Number of Lanes	Location of Preemption Devices	Approach Grade	Lane Widths	Storage Bay Lengths	Taper Lengths	Intersection Approach Widths	Shoulder Widths	Lane Designations	Presence of Pedestrians or Bike Lanes	Length of Passing Lane(s), if present	Length of No Passing Zone(s)
Signalized Intersection, Unsignalized Intersection, and Arterial Analyses	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Roundabout Analyses	✓		✓	✓	✓		✓		✓	✓		
Innovative Intersection/Interchange Analyses	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Pedestrian and Bicycle Analyses (On- and Off-Street)	✓			✓			✓	✓		✓		
Freeway/Interchange Analyses (Merge, Diverge, Weave, and Collector- Distributor)	✓		✓	✓				✓	✓			
Two-Lane Highway Analyses			✓	✓				✓		✓	✓	✓
Multilane Highway Analyses	✓		✓	✓	✓	✓		✓	✓	✓		
Work Zone Traffic Analyses (Freeway or Arterial)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Toll Plaza and Gated Analyses	✓			✓					✓			
Managed Lane or Ramp Metering Analyses	✓			✓					✓			
Safety Analyses	✓		✓	✓				✓	✓	✓		

Table 6: Standard Geometric Parameters (continued)

Analysis Categories / Standard Geometric Assumptions	Roundabout Approach Widths	Ped/Bike Crossing Distances	Roadside Shoulder Slope	Interchange Configuration	Ramp Length and Radii	Acceleration/ Deceleration Lane Lengths	Distances to Adjacent Interchanges	Distance to Upstream Warning Signs	Driveway Spacing	Median Data	Distance to Constricting Infrastructure	Payment Choices	Time of Day Restrictions
Signalized Intersection, Unsignalized Intersection, and Arterial Analyses		✓							✓	✓	✓		✓
Roundabout Analyses	✓	✓					✓			✓	✓		
Innovative Intersection/Interchange Analyses		✓		✓	✓	✓	✓	✓	✓	✓	✓		
Pedestrian and Bicycle Analyses (On- and Off-Street)		✓	✓							✓	✓		
Freeway and Interchange Analyses (Merge, Diverge, Weave, and Collector- Distributor)				✓	✓	✓	✓	✓			✓		
Two-Lane Highway Analyses											✓		
Multilane Highway Analyses									✓	✓	✓		
Work Zone Traffic Analyses (Freeway or Arterial)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Toll Plaza and Gated Analyses					✓	✓		✓			✓	✓	
Managed Lane or Ramp Metering Analyses								✓			✓		✓
Safety Analyses		✓	✓	✓	✓	✓	✓		✓	✓	✓		

6.2 TRAFFIC COUNT DATA

Traffic count data includes all volume data necessary to analyze existing or future conditions, including passenger cars, heavy vehicles, bicycles, and pedestrians. Other data pertinent to signal timing and model calibration, such as speed and queue length, is addressed later in this chapter. This section of the manual focuses on the following topics concerning traffic count data:

- Traffic count data collection best practices
- Traffic count data requirements
- Heavy vehicle classifications
- Appropriate age of traffic count data
- Peak hour/period determination
- Traffic volume balancing
- Data considerations for work zone

6.2.1 *Traffic Count Data Collection Best Practices*

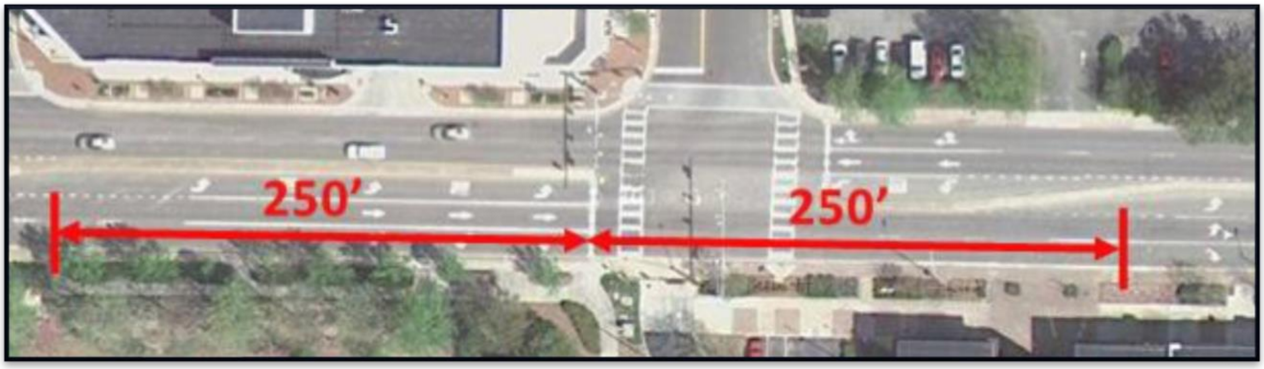
Table 7 documents the traffic data required for each type of traffic analysis. In addition to the data identified in the table, origin-destination (O-D) counts may be needed for projects requiring microsimulation. The scope and acceptable error tolerances of the O-D counts should be approved by the VDOT project manager.

The following best practices should be followed when collecting traffic count data for traffic operations analyses.

6.2.1.1 Physical and Temporal Limits

- Conduct automated traffic recorder (ATR) counts over a period of seven days to determine the peak period prior to performing turning movement counts (TMCs).
- Collect traffic data, including TMCs, ATR counts, and microsimulation calibration data (if needed), during approximately the same time periods, if possible. Collect data in 15-minute or shorter intervals. Large data collection efforts may span a week or two; however, it is preferable to coordinate efforts between data collection parties to minimize the number of data collection days.
- Do not collect data on holidays or the days before or after the holiday. If possible, also avoid collecting data the week of the holiday if the holiday is in the middle of the week.
- Minimize traffic data collection between Thanksgiving Day and New Year's Day, especially in areas with a high concentration of retail establishments, unless the study is specifically focused on operational impacts during that period.
- Do not collect traffic data when school is out of session in areas influenced heavily by school traffic from K-12, colleges and/or universities.
- Count the unmet demand for intersections operating in oversaturated conditions when conducting TMCs by observing and documenting the length of the queue for all movements at the end of each traffic count interval. Use this distance to estimate the number of queued vehicles.
- Count bus blockages and parking maneuvers occurring within 250 feet (in each direction of travel) of the stop bar on each approach, as shown in **Figure 5**, during the same time period as the TMCs.

Figure 5: Location of Bus Blockages to Include in Analysis



- Collect a minimum of 48 consecutive hours of data in 15-minute intervals for each lane for vehicle classification counts. Collect both vehicle classification and speed data concurrently with traffic count data. The VDOT project manager should determine the acceptable sample size and methodology used for collecting speed data (e.g., GPS, Bluetooth/WiFi, tube counts, and/or radar gun) based on the required level of accuracy, project schedule, and project budget.
- Collect weekday traffic volumes on Tuesdays, Wednesdays, and/or Thursdays. Collect weekend traffic volumes on Saturdays and/or Sundays. In cases where there are special events creating unique peak travel periods, collect data on the same day(s) that corresponds to the special event.
- Conduct traffic counts for four consecutive hours in each peak period, collected in 15-minute intervals to ensure that the peak hour is captured during the traffic counting period for intersection TMCs, especially in heavily congested areas.
- In cases where PHS occurs, except for bicycle and pedestrian analyses, more than four hours of data may be required by the VDOT project manager. If PHS does not exist or the analysis is in a rural location, then two to three hours of TMC data may be acceptable, if approved by the VDOT project manager. Collect heavy vehicles by movement for each TMC. When pedestrians and bicycles are present at the intersection, the TMC shall account for them as well.
- Traffic count data is required for all toll plaza analyses. Collect four hours of traffic count data for each payment choice and lane.
- Document unplanned events that occur during the data collection process, such as inclement weather or a vehicle crash. The VDOT project manager will determine if additional traffic counts should be conducted. Recollect traffic data if anomalies caused by human error or equipment malfunction are present. Collect additional traffic counts as close to the original count dates as possible and during the same period during the week.

Table 7: Standard Traffic Data Collection Requirements

Analysis Categories / Standard Traffic Assumptions	Peak Hour Turning Movement Counts	Automated Traffic Recorder Counts	Annual Average Daily Traffic (AADT)	Parking Maneuvers	Transit Service Data	Vehicle Classification Data	Speed Data	Toll Plaza and Gate Lane Data
Conventional Signalized Intersection, Conventional Unsignalized Intersection, and Arterial Analyses	✓	✓		✓	✓	✓	✓	
Conventional Signalized Intersection Preemption and Transit Priority Analyses	✓	✓		✓	✓	✓	✓	
Roundabout Analyses	✓			✓	✓	✓	✓	
Innovative Intersection/Interchange Analyses	✓	✓		✓	✓	✓	✓	
Pedestrian and Bicycle Analyses (On- and Off-Street)	✓	✓		✓			✓	
Freeway and Interchange Analyses (Merge, Diverge, Weave, and Collector-Distributor)		✓				✓	✓	
Two-Lane Highway Analyses		✓				✓	✓	
Multilane Highway Analyses		✓		✓	✓	✓	✓	
Work Zone Traffic Analyses (Freeway or Arterial)	✓	✓		✓	✓	✓	✓	✓
Toll Plaza and Gated Analyses						✓	✓	✓
Managed Lane or Ramp Metering Analyses		✓				✓	✓	
Safety Analyses			✓				✓	

This page is intentionally left blank

6.2.1.2 Documentation and Review

- Document the source; collection day of the week, date, and time; and condition of the data.
- Review and check traffic count data for reasonableness. Check data for:
  - Variation in traffic counts collected during the same time periods over several days.
  - Variation in traffic counts between adjacent intersections in a network.
  - Possible influence of weather, construction, or incidents.
  - Difference between the maximum traffic count and estimated theoretical capacity of the roadway.
  - Consistency in the operating speeds at the time of data collection.
  - Variation in traffic counts, caused by stationary traffic on the tube for extended periods of time due to congestion or an incident (if traffic count tubes are used). Use non-intrusive data collection devices at locations where congested conditions are expected. Video data collection should be used where extended periods of low-speed vehicular activity are expected due to the limitations of other non-intrusive data collection devices.
  - Consistency and reasonableness in the time periods and counts on each approach (if TMCs are conducted). This may be done by comparing the TMCs to ATR count data collected during the same time period. Orientation of TMCs (e.g. north/south/east/west) should also be checked to ensure that the orientation of roadways during data collection is aligned with the assumed orientation of roadways for the project.
- Develop a data collection summary to document data needs, data collection methods, data storage, and quality control procedures. Include the summary in the existing conditions analysis in the final traffic analysis report.
- Summarize data collection results graphically. Include lane schematics, intersection geometry, traffic volumes, and traffic control.

6.2.2 *Appropriate Age of Data*

Since traffic count data and aerial imagery are constantly changing, it is important that the network development and analyses be performed using the latest available information.

The appropriate age of traffic count data is two years from when the initial traffic data was collected and when the analysis is being conducted, provided that the roadway has not experienced any major geometric and/or traffic control changes since the data was collected.

Traffic count data that is older than two years may be considered given the following circumstances:

- Minimal change in average daily traffic volume
- Traffic growth limited to a small portion of the project study area
- Traffic growth associated with confined trip generator (i.e., new development) with documented peak hour volumes and travel patterns through project study area

These circumstances do not absolve the project manager from collecting new traffic count data. The project manager shall document justification for the use of previously collected traffic data. The project manager may request spot data collection (e.g., turning movement counts at critical intersections, new ATR counts) to validate that traffic volumes have not changed significantly since the date of previously collected traffic data.

The appropriate age of aerial imagery used in coordination with traffic operations and safety analyses is also two years; however, field validation is required to ensure that the aerial imagery matches current conditions.

6.2.3 *Peak Hour Determination*

For isolated intersection analyses, define the peak hour as the four consecutive 15-minute intervals of turning movement traffic count data that represent the highest hour. For segment, facility, corridor, system, and area analyses, compute and apply a common uniform peak hour throughout the entire network. The method for determining the common uniform peak hour should be approved by the VDOT project manager. For special cases, such as analyses near schools or industrial sites, an additional peak hour may be selected for the analysis based on a critical movement for a specific intersection approach instead of volumes for the entire intersection. This peak period may not fall during the typical morning and evening peak periods.

As described in **Chapter 5**, the modeling period for microsimulation analyses may be increased beyond one hour, with volumes coded in 15-minute intervals, to account for different peak periods at intersections throughout a network.

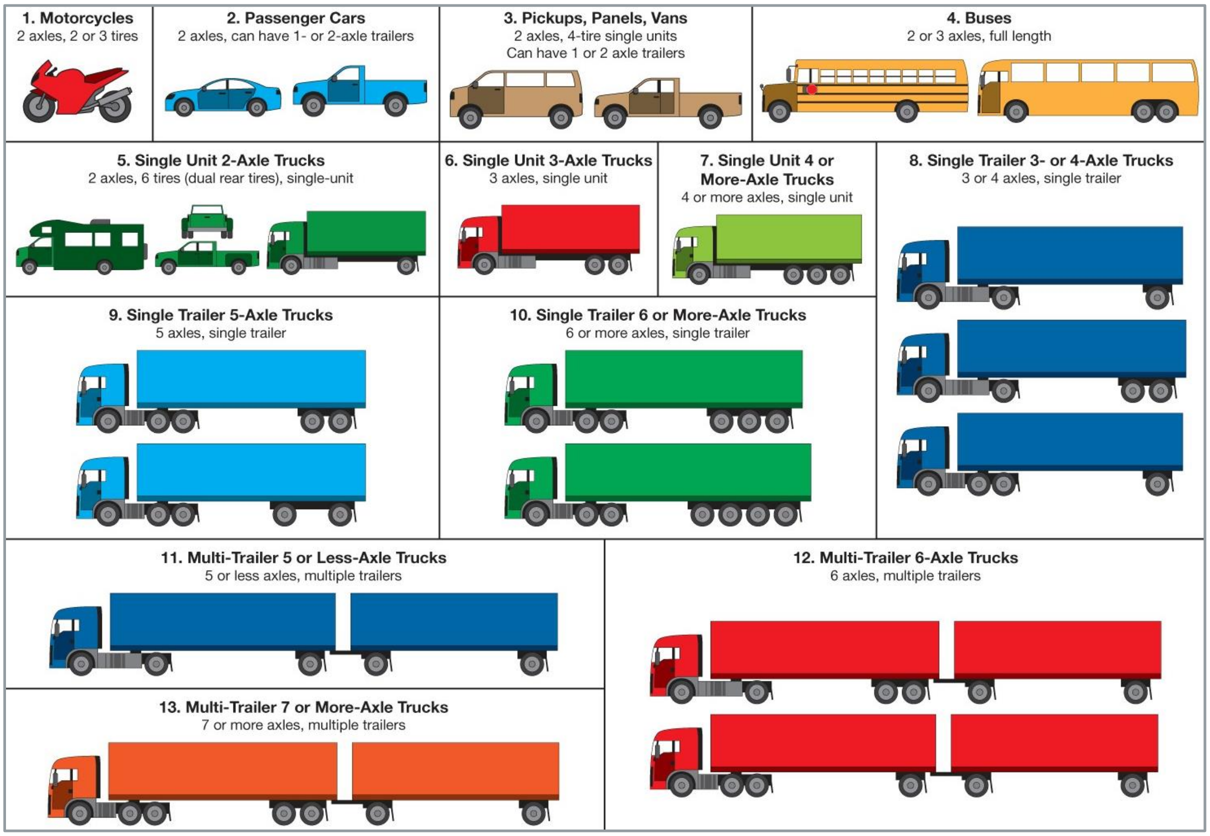
6.2.4 *Seasonal Adjustment Factors*

In areas with seasonal fluctuations in traffic, it may be appropriate to apply seasonal factors. Seasonal factors may be applied to ATR counts and vehicle classification counts. Monthly seasonal factors may be obtained from the VDOT website; however, the VDOT project manager shall approve proposed methodologies for obtaining and applying seasonal factors.

6.2.5 *Heavy Vehicle Classification*

For traffic data collection, heavy vehicle classifications should comply with existing guidelines established by FHWA. These guidelines, presented in **Figure 6**, contain thirteen vehicle classifications. Any vehicle with a classification of 4 (Buses) or higher should be considered a heavy vehicle when traffic counts are collected.

Figure 6: FHWA Vehicle Classification



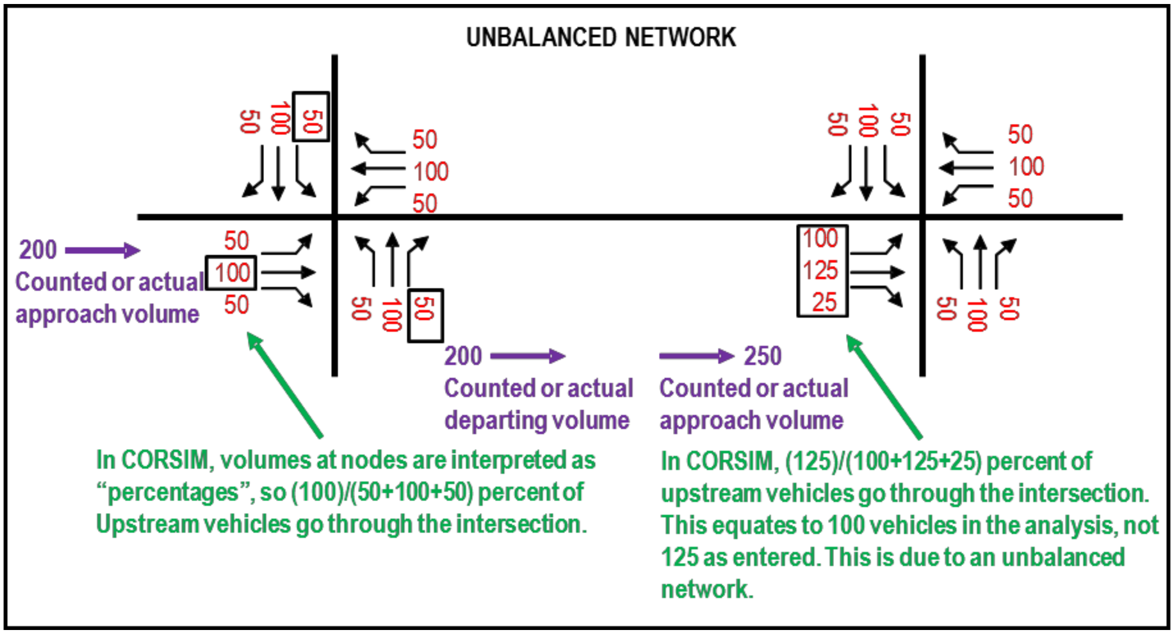
6.2.6 *Traffic Volume Balancing*

When peak period turning movement counts are collected and peak hour traffic volumes are computed, there are several factors that may cause imbalances in traffic volumes departing one intersection and arriving at the next, such as:

- Peak hour selection (e.g., selecting a uniform peak hour between two adjacent intersections that may not be the same as the actual peak hours for both intersections)
- Traffic impact of private driveways, parking lots, or parking garages along the facility that are not counted
- Variations in traffic volumes between different days of the week, different weeks of the month, or different months of the year
- Variations in school calendars (e.g., if a local school was in session when counts were conducted at one intersection in the network and the school was out of session when counts were conducted at another intersection in the network)
- Variations caused by different traffic counting methods (e.g., turning movement counts conducted by video at one location in the network compared to turning movement counts conducted by a human at another location in the network)

All traffic model networks shall be reviewed for volume balancing between intersections. Unless there are documented network elements that contribute to imbalance between intersections (e.g., parking garage, unsignalized parcel driveway), the network should be balanced to within 10 percent of the approach and departure volumes between intersections. Deterministic tools with minor fluctuations in volumes (less than 25 vehicles or 10 percent of the total approach traffic volumes) can still yield accurate results; however, minor fluctuations in volumes can have significant impacts on results from microsimulation tools. Since most microsimulation tools depend on turning percentages, imbalances in traffic volumes will cause the percentages calculated by the software to differ, which impacts the results from these tools. **Figure 7** depicts an example of an unbalanced network along with the associated impacts that would be experienced with a microsimulation model. For these reasons, balanced traffic volumes shall be used in microsimulation tools.

Figure 7: Effects of an Unbalanced Network on Microsimulation



In CORSIM, volumes at nodes are interpreted as "percentages", so (100)/(50+100+50) percent of Upstream vehicles go through the intersection.

In CORSIM, (125)/(100+125+25) percent of upstream vehicles go through the intersection. This equates to 100 vehicles in the analysis, not 125 as entered. This is due to an unbalanced network.

If a volume difference greater than 10 percent occurs between intersections or count locations in the network, or if a significant number of driveways exist between intersections, then further investigation may be warranted before the network can be balanced. It is important to determine if the imbalance is created by a large trip generator between intersections. If the differences cannot be attributed to the intermediate driveways, then some of the other previously-mentioned factors (e.g., human error, orientation of turning movement counts, etc.) may be impacting the traffic counts.

There are several methods to balance traffic volumes through a network. The recommended practice is to follow guidance outlined in Section 5.4.1 of the *Transportation Research Board (TRB) National Cooperative Highway Research Program (NCHRP) Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design.* Schematic diagrams for both the unbalanced volumes and the balanced volumes, a description of the volume balancing process, and any assumptions made regarding traffic volume balancing shall be included in the traffic and safety analysis report for review.

6.2.7 *Other Data Considerations for Work Zones*

In addition to the data collection requirements for work zones identified in **Table 6** and **Table 7** 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 (e.g., one lane closed on some days and two lanes closed on some days)
- Detour and alternative route availability
- Condition of alternative routes (i.e., whether alternative routes are over or under capacity)
- Percentage of traffic volume expected to detour
- Reduction in speed limit

6.3 FUTURE TRAFFIC DATA

The VDOT project manager shall approve proposed methodologies used to develop traffic growth rates and corresponding future year traffic volumes prior to conducting traffic analyses. Refer to the *VDOT Traffic Forecasting Guidebook* and VDOT *Travel Demand Modeling Policies and Procedures* for guidance.

The methodology used to develop design ADT, design hourly volume, directional distribution factor, and the truck percentages for roadway design projects shall be approved by the VDOT project manager.

6.4 TRAFFIC SIGNALS OPERATIONS DATA

For those analyses that involve either traffic or pedestrian signals, it is important to obtain signal timing data to accurately analyze existing conditions. All traffic and pedestrian signal timing data, in addition to being observed in the field, shall be obtained from the appropriate VDOT Traffic Operations office or city/town engineering office, and should include, at a minimum, the following timing plan data:

- Green times (minimum green/minimum initial and maximum green)
- All-red time/red clearance and yellow time/yellow clearance
- Cycle lengths
- Offsets
- Type of controller (NEMA, fixed time, etc.)
    - If an existing traffic signal operates with ASCT, the methodology for determining existing signal parameters shall be approved by the DTE or his/her designee.
- Sequencing and phasing diagrams
- Actuation type
- Vehicle extension and gap time
- Recall mode

- Time of day clocks
- Pedestrian crossing times ("WALK" and "DON'T WALK")
- Transit priorities
- Preemption timings
- Ramp metering data (processing splits, capacity criteria, etc.)

Existing data obtained from the appropriate VDOT Traffic Operations office or city/town engineering office shall be provided in the appendix of traffic and safety analysis reports.

6.5 CALIBRATION DATA

Calibration data is required to properly develop a traffic operations microsimulation model that reflects local driving conditions and characteristics. Without calibration, the analyst has no assurance that the model will correctly predict traffic performance for the project. There is a wide variety of calibration data needs; however, data generally falls into four categories: traffic volume, speed, travel time, and queuing. **Table 8** indicates which calibration data are required for each analysis category. The VDOT project manager may request additional data based on the traffic analysis needs.

For example, the VDOT project manager may identify the need for a travel time run to supplement speed results. Refer to **Chapter 5** for calibration thresholds. Calibration data for operational analyses shall be no more than two years old, provided that the roadway has not experienced any major geometric and/or traffic control changes since the data was collected. If older calibration data is used, the VDOT project manager may request that additional sample data be collected and field observations be made for verification.

Field observations should be made during the collection of calibration data to note any unique operating conditions that may aid in the calibration process. These observations may include operating conditions that contribute to higher than expected queue lengths or travel times. Unusual operating conditions, such as slow right-turning speeds or the impacts of a combined through-left lane that operates like a de facto left-turn lane due to a high volume of left turning vehicles, need to be documented.

O-D data may be used as another source of calibration data, although it is not a mandatory data requirement. Due to the extensive amount of time to collect and process the data and the associated costs with collecting the data, it should only be collected if the analysis of important traffic movements in the existing conditions would benefit from an understanding of the origins and destinations or if existing travel routes and turning movements will be changed under future conditions. The methodology used for collecting O-D data (e.g., license plate surveys, Bluetooth/WiFi technology, vehicle probe data) should be determined by the VDOT project manager based on the required level of accuracy, the project schedule, and the project budget.

This page is intentionally left blank

Table 8: Standard Traffic Operations Calibration Data Requirements

Analysis Categories / Standard Calibration Assumptions	Peak Hour/Period Traffic Demand	Pedestrian & Bicycle Travel Speeds	Mainline Speed Data	Ramp Speed Data	Toll Lane & Gate Processing Time by Payment Choice	Travel Times	Queuing Data	Existing Crash Data
Signalized Intersection, Unsignalized Intersection, and Arterial Analyses	✓		✓			✓	✓	
Signalized Intersection Preemption and Transit Priority Analyses	✓		✓			✓	✓	
Roundabout Analyses	✓		✓				✓	
Innovative Intersection/Interchange Analyses	✓		✓	✓		✓	✓	
Pedestrian and Bicycle Analyses *(On- and Off-Street)*		✓						
Freeway and Interchange Analyses (Merge, Diverge, Weave, and Collector-Distributor)	✓		✓	✓		✓	✓	
Two-Lane Highway Analyses	✓		✓			✓		
Multilane Highway Analyses	✓		✓			✓	✓	
Work Zone Traffic Analyses (Freeway or Arterial)	✓		✓	✓	✓	✓	✓	
Toll Plaza and Gated Analyses	✓		✓		✓	✓	✓	
Managed Lane or Ramp Metering Analyses	✓					✓	✓	
Safety Analyses								✓

This page is intentionally left blank

6.5.1 Speed Data

Where spot-speed calibration is considered, a minimum of 48 consecutive hours of speed data should be collected for each direction of travel in 15-minute intervals. Spot-speed data may be collected to obtain a reliable source for corridor operating speeds; however, travel time data can also be used to establish average segment speeds.

For toll plaza analyses, speed data is not required since travel speeds are dependent on the processing speeds of the individual toll lanes; however, speed data should be collected for uninterrupted-flow tolling facilities, such as express lane toll plazas. At least four hours of vehicle processing data for all available payment options should be performed.

6.5.2 Travel Time Data

The number of travel time runs completed for calibration purposes during peak periods will depend on the length of the network and the level of congestion; however, it is recommended that at least 10 travel time runs be collected within the analysis area for each direction of travel during each peak period. For example, if AM and PM peak hour microsimulation analyses will be performed, then at least 40 travel time runs should be conducted for the same route over the two peak periods. Field travel time runs should be conducted over a minimum of two days. A recommended approach is conducting initial runs on the first day, evaluating the variability, and calculating the additional runs needed for the second day to produce a statistically significant sample size.

At a minimum, field-collected data must be obtained; however, probe data or other crowd-sourced data can be used to supplement field-collected data. When available, probe vehicle data sources should be used to provide a large sample size of data over multiple days. A longer duration may be considered as long as the chosen time span reflects like conditions.

The field data and probe data should align with the period of travel time calibration (e.g., peak period or peak hour). For example, if travel time is being calibrated for a peak hour, only travel time data for runs completed during that peak hour should be averaged and compared to model outputs. Travel time runs should be conducted in accordance with the procedures identified in the latest edition of the ITE *Manual of Transportation Engineering Studies*. Additional information pertaining to the collection of travel time data can be found under the FHWA Traffic Analysis Tools Program, *Traffic Analysis Toolbox Volume VI: Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness*.

6.5.3 Queue Data

To collect queue data for calibration purposes, queue lengths should be collected at intervals of approximately 60 seconds, aggregated into five-minute intervals, during the data collection period. The interval of data collection at signalized intersections should not be a multiple of the signal cycle length. This should be done by observing and documenting the length of queue for all movements. In oversaturated conditions, the entire extent of the queue should be observed and documented, even if the queue extends past an adjacent intersection. Maximum queue lengths should be observed in the field at critical locations for the extent of the calibration period (e.g., peak hour or peak period). Local knowledge of queuing impacts and bottleneck locations and other available sources such as aerial photography and Google Maps typical traffic conditions may be used to supplement field observations.

The following additional guidance is offered pertaining to queue data collection for calibration purposes:

- During project scoping, the project team should identify critical movements at the study intersection(s) to collect queue data. The intent of queue data collection is to ensure the model replicates field conditions (queue spillback from a turn lane or blocking a turn lane, queue spillback impacting operations at adjacent intersections).

- Queue data collection should be recorded in units of feet, not the number of vehicles. Landmarks or other fixed points of reference can be recorded during queue data collection and transcribed to units of feet during post-processing.
- For movements with extended queues, it is recommended that two people be available to record queue lengths – one person to record queues near the intersection and one person to move with and record the back of the total queue (i.e., the individual only moves away from the intersection as the queue grows through the peak period). This is intended for movements that experience multiple cycle failures at an intersection.
- Queue data collection along limited access facilities can be performed using landmarks as a reference on an aerial, or when feasible, using automated video data collection. Freeway queue data may be collected as often as arterial queues; however, it may not be practical to collect data in the field due to access limitations. The project team should discuss what amount of queue data should be collected during project scoping. Safety Data

6.5.4 *Historical Crash Data*

Historical crash data shall be collected for safety analyses that use the Empirical Bayes (EB) Method (see **Chapter 7** for direction and guidance on when to use the EB Method). At least two years of crash data (five years, preferred) should be collected from VDOT or the appropriate locality for all roadways in the study area and should include crash location, type, number of vehicles and severity, at a minimum. Historical crash data shall not be used if the roadway has experienced any major geometric and/or traffic control changes within the past two years.

6.5.5 *Field-Collected Data*

The amount of geometric and/or traffic control data required for safety analyses may differ depending on the safety analysis tool selected. The data requirements for the tool(s) that will be used on the project should be verified prior to collecting field data.

6.5.6 *Roadway Alignment Data*

Roadway alignment data should be used to define tangents, curves, and grades for safety analyses on interstate systems.

VDOT maintains a geospatial database of horizontal and vertical alignment data on the mainline interstate and primary routes, however, some discrepancies exist between grade and vertical curve information included in the database, particularly on flatter terrain. For this reason, the VDOT project manager should request point file elevation (Z axis) data from Central Office Traffic Engineering Division (TED). The data can be used to determine grades on 24-foot increments, providing a better representation of grades along a segment.

Survey data and proposed alignment data, if available, may also be used for existing and future conditions, respectively.

6.5.7 *Crash Modification Factors (CMFs)*

Predictive crash methods outlined in the *HSM Part C* do not apply to every condition (e.g., replacing a signalized intersection with a roundabout); crash modification factors (CMFs) may be used to estimate safety performance for those conditions instead. A CMF is a multiplicative factor that is applied to an existing crash total or *HSM* crash prediction to compute the expected number of crashes for a site after implementing a given countermeasure. CMFs often target only specific crash types or crash severities. The VDOT Highway Safety Improvement Program (HSIP) maintains a Virginia State Preferred CMF List. CMFs for improvements not listed in the preferred list should be retrieved from the *HSM Part D: Introduction and Applications Guidance* or the FHWA CMF Clearinghouse, which is an online application.

The *HSM Part D* provides a standard error to indicate the precision of a CMF. CMFs with a standard error less than 0.1 are the most reliable and are unlikely to change substantially with new research. The CMF Clearinghouse similarly rates CMFs but relies on a star rating (one through five) system instead of an adjusted standard error. The star rating is based on the cumulative performance of the CMF in five categories: study design, sample size, standard error, potential biases, and data source. Star ratings above three should be used if they are available. Often there are multiple CMFs for an improvement. To select the most applicable CMF, review the references provided for the highway and traffic conditions and crash types assessed to develop the published CMF. The VDOT project manager shall approve both the use of CMFs for a given project and the selection of individual CMFs from the Virginia State Preferred CMF List, the *HSM Part D*, or the CMF Clearinghouse based on the adjusted standard error or star rating, respectively.

6.5.8 *Safety Calibration Factors*

Crash predictions determined from predictive models are based on national averages and should be calibrated for Virginia conditions whenever possible. Predictive models shall only be used to compare predicted or expected crashes between analysis alternatives. VDOT project managers shall confirm that calibration factors have not yet been released before proceeding with publishing no-build and build and/or alternative design crash output values.

6.5.9 *Crash and Severity Distributions*

VDOT has not yet produced site sub-type tables of proportions applicable to Virginia. Once developed, the tables of proportions may be used to convert crash predictions for all injury crashes to the individual injury types. Until the Virginia-specific tables of proportions are available, crash predictions for all injury crashes may be converted to individual types, if necessary, using national averages from the *HSM* or project-level assumptions. The tables of proportions will be published on the VDOT TED website once they have been developed. VDOT project managers shall confirm that the tables of proportions have not yet been released before proceeding to use predictive models to compare project alternatives.

6.6 ACCEPTABLE SOURCES OF DATA

There are a variety of data types to support traffic and safety analyses, including field collected and passive data (probe big data), geometry, and safety data. Each component is unique to individual projects, and the data accuracy and applicability varies among sources and collection methodologies.

Table 9 summarizes the availability of common, acceptable data sources in Virginia. A description of each source, including known issues and limitations, is provided in this section. It is the responsibility of the project manager to verify the potential issues and limitations when using data for a traffic analysis project that may affect the results of the analysis. Availability may vary among sources.

Table 9: Data Source Availability

Data Source		Availability			
		VDOT Staff Only*	Available with VDOT Permission	Publicly Available for Purchase from Vendors	Publicly Available (Free)
Traffic Data Maintained by VDOT	VDOT Traffic Count Data				✓
	Virginia Traffic 511				✓
	Count	✓			
	iPeMS (contains INRIX**, VA Traffic, crash, and traffic count data)		✓		
Probe and Mobile Device Traffic Data	RITIS (contains INRIX** data)		✓		
	StreetLight Data		✓	✓	
	Other O-D Probe Data Products (AirSage, HERE, Verizon, etc.)			✓	
	Bluetooth- and WiFi-Based Data Collection and Software (BlueToad, Acyclica, etc.)			✓	
	Waze	✓			
	Google Maps Typical Traffic/Travel Times				✓
	Google Travel Times API (Traction)			✓	
Bicycle and Pedestrian Data	Bicycle and Pedestrian Counter Data		✓		✓
	Capital Bikeshare				✓
	Strava			✓	
Safety Data	FR300-P Reports	✓			
	Roadway Network System (RNS)	✓			✓***

*Data availability is limited to VDOT staff. The project manager may request data through VDOT project manager, if needed.

**INRIX data is publicly available for purchase at https://analytics.inrix.com/roadway_analytics

***Limited data available

6.6.1 *Traffic Data Maintained by VDOT*

6.6.1.1 VDOT Traffic Management System (TMS) Data

The VDOT Traffic Data website includes count data for each interstate and primary highway segment and provides the AADT, classification data and average vehicle miles traveled within each jurisdiction (e.g., County, independent Cities or Towns), and by functional classification. Data is collected from two primary sources:

- **Permanent continuous count stations:** Continuous count stations include in-road loop and piezo sensors and side fire radar sensors (aka Wavetronix in Virginia).
- **Short-term counts:** Federal guidance requires ramps to be counted every 6 years for 8 hours on two consecutive days. This includes both tube and portable Wavetronix count data.

TMS data can be a useful point of reference for historical traffic data on screening, visioning, and programming projects. Typical applications may include estimating historical growth patterns, evaluating previous intersection traffic volumes, or estimating approximate demand for roadway facilities. TMS data should only be used as a source for traffic analyses if the project manager can confirm the data quality code and provide the exact location of where the data was collected.

6.6.1.2 Virginia Traffic 511

Virginia Traffic 511 reports real-time road conditions and traffic information, such as travel time, average speed, and incidents. Event data is compiled from a variety of sources, including VDOT safety service patrols, VDOT construction crews, traffic cameras, the Virginia State Police, and the public. Data is accessible via the Virginia Traffic 511 website or mobile app. The main data source for travel time and speed is INRIX.

Since Virginia Traffic 511 provides real-time information, it should only be used as a source for planning for data collection needs during scoping. Virginia Traffic 511 should not be used as a data source for traffic analysis.

6.6.2 *Count*

Count is a cloud storage program that contains additional traffic data supplied by VDOT staff. Count allows VDOT staff to upload and download documents and associated metadata, search with results arranged in a list or on a map, collaborate between multiple peers via comments, and visualize user-selected data.

Count data should only be used as a source for traffic analyses if the project manager can confirm the availability of relevant data, and exact date, source of the data, and quality of data collection.

6.6.3 *iPeMS*

The Iteris Performance Management System (iPeMS) combines historical and real-time traffic volume and speed data to monitor and measure system performance for arterials and freeways. IPeMS includes crash and incident data, weather data, and all data collected from VDOT-maintained TMS and TOC detectors as well as INRIX XD data. The INRIX data can be queried for speed and travel time information for roadway segments.

INRIX XD data can be used as a basis for calibration of microsimulation models; however, it should not be used as a replacement for field-collected speed and travel time information until such time that VTRC (or other agencies deemed appropriate by VDOT) can validate the sole use of the data for model calibration. Unless approved by the VDOT project manager, the project manager shall collect speed and travel time information as prescribed in **Section 6.5.**

6.6.4 *Probe and Mobile Device Data*

6.6.4.1 RITIS

The Regional Integrated Transportation Information System (RITIS) compiles speed data from third-party probe data vendors, and incident information (including work zones and special events) from partner agencies. It contains a suite of tools for real-time traffic information and management, and a historic archive of traffic data which can be queried and visualized. RITIS also hosts the National Performance Management Research Data Set (NPMRDS) Analytics Platform to facilitate federal system performance measure requirements. The NPMRDS contains speed data for all vehicles, including trucks.

RITIS can be used to query INRIX speed and travel time data for roadway segments. This data can be used as a basis for calibration of microsimulation models; however, it should not be used as a replacement for field-collected speed and travel time information until such time that VTRC (or other agencies deemed appropriate by VDOT) can validate the sole use of the data for model calibration. Unless approved by the VDOT project manager, the project manager shall collect speed and travel time information as prescribed in **Section 6.5**.

6.6.4.2 Origin-Destination Probe Data Platforms

Probe data platforms, such as StreetLight Data, can also be used to obtain O-D data. StreetLight uses location-based services from mobile devices and GPS-navigation data from personal vehicles and commercial trucks to assess the mobility of a network. The StreetLight online platform allows users to create customizable analyses to estimate origin-destination patterns for a variety of potential applications, including developing trip distributions for traffic impact studies, obtaining O-D routes for corridor studies, and capturing weaving patterns. Other web-based probe data platforms for O-D information, such as those provided by vendors including AirSage, HERE, and Verizon, can be used at the discretion of the VDOT project manager in the absence of available StreetLight data.

StreetLight also currently provides beta-level tools for AADT estimation and multimodal (bicycle and pedestrian) O-D estimation; however, until such time that VTRC (or other agencies deemed appropriate by VDOT) can validate the accuracy of StreetLight AADTs, use of StreetLight to estimate AADTs shall be at the discretion of the VDOT project manager and should not be used as a replacement for field-collected or VDOT-collected AADT data.

6.6.4.3 Bluetooth and WiFi Field Data Collection

Bluetooth- and WiFi-based sensors identify and match the “signatures” from devices that have Bluetooth or WiFi enabled, respectively. This can be used to measure travel times, average running speeds, and O-D patterns of travelers. Examples of vendors in this space include BlueToad and Acyclica.

These data sources can be used to understand corridor travel times and speeds as well as study area O-D patterns. If the project manager can capture a statistically significant amount of data, this form of data collection can be used for calibration of microsimulation models.

6.6.4.4 Other Crowdsourced Data Products

Other products utilizing crowdsourced data from active or passive mobile device users include the following. Until such time that VTRC (or other agencies deemed appropriate by VDOT) can validate the accuracy and broad penetration of these data sources (e.g., Google, Waze) to use for documenting travel times, speeds, and O-D patterns, crowdsourced data products should not be used for traffic analysis projects; rather, they can be used as qualitative tools for demonstrating these attributes of a study area on screening, visioning, and programming projects.

- **Waze:** Waze crowdsourced real-time travel information and driver-reported roadway incident data using location-based services from smartphones and other devices. Incident data is shared for free with cities and departments of transportation through the Connected Citizens Program (CCP). Virginia is a member of the Waze CCP; the data is only available to VDOT employees.

- **Google:** Google crowdsourced real-time travel time data can be accessed via the Google Application Programming Interface (API), although Google specifically currently prohibits archiving of this data for API users without a negotiated business arrangement. Separately, Google Maps provides "typical" traffic on roadway segments via a color-coded map. While this color-coded map does not provide specific values to align speeds with colors, this tool can be used to get an order-of-magnitude understanding of queue formation at different times of the day or days of the week.

  A range of typical travel times for a given route can also be estimated using Google Maps' directions, including travel times at different times of the day and different days of the week. Google does not specify whether holidays are eliminated, nor does it provide information on the length of time in their historic archive on which this estimate is based.

6.6.5 *Bicycle and Pedestrian Data*

Several sources currently exist for providing bicycle and pedestrian data beyond field counts, although their coverage areas remain limited:

6.6.5.1 *Bicycle and Pedestrian Automatic Counter Data*

Bicycle and pedestrian counts collected from permanent or portable automatic counters can be viewed and downloaded from a public online data portal. Such counters are maintained by local jurisdictions. For example, Arlington County maintains a system of permanent automatic counters to monitor bicycle and pedestrian volumes 24 hours a day at selected locations. VDOT also maintains a small inventory of counters.

6.6.5.2 *Capital Bikeshare*

The Metropolitan DC bikeshare program has a large coverage of service in Northern Virginia. Bike usage data can be publicly viewed and downloaded from Capital Bikeshare website. This includes O-D information segmented into times of day and days of the week.

6.6.5.3 *Strava*

Strava is a fitness application that crowdsources cycling and running data using GPS. The data must be licensed from Strava, and the cost varies based on the size of the study area, the time span of data required, and the level of granularity and features of the dataset.

6.6.5.4 *StreetLight Data*

StreetLight Data now offers O-D data separately for bicycle and pedestrian modes. Data is available for a few months prior to 2019 but will be made available for all months moving forward. At this time, limited information is available on the accuracy and reliability of this data source.

The data sources listed for bicycle and pedestrian data can be used for historical data on screening, visioning, and programming projects. Given that bicycle and pedestrian impacts are typically of primary concern in urbanized areas where activity of these users can be influenced by localized and regional changes in the available network, these data sources should not be used for operations and design projects unless otherwise approved by the VDOT project manager.

6.6.6 *Safety Data*

6.6.6.1 FR300-P Reports

Police crash reports provided in a database indexed on a unique document number should be retrieved from VDOT. Crash data is available through VARoads and the VDOT ArcGIS Online portal.

6.6.6.2 Roadway Network System (RNS)

The VDOT geospatial RNS includes a variety of data such as roadway inventory components, speed zone locations, crash data, and railroad crossing locations. The VDOT project manager may request roadway and related crash information from the RNS through District Traffic Engineering staff to Central Office TED. Snapshots of crash data from RNS are made publicly available through ArcGIS Online.

7 Standard Input Parameter Assumptions for Tools

Each traffic and safety analysis tool incorporated in this manual has a standard set of input parameters. To promote consistency and uniformity in the use of these tools, it is critical that clear direction and guidance be provided on the correct application of these input parameters. Most, if not all, of the input parameters should be based on existing or future traffic or geometric conditions. Some of these input parameters require assumptions to be made to properly apply the tool, while others do not. This chapter provides direction and guidance to the VDOT project manager for two important reasons:

- To identify input parameters that require direction or guidance on typical values, acceptable ranges, and/or special notes
- To identify input parameters with default values that should be modified to account for available data

All input parameters not mentioned in this chapter should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager. The direction and guidance provided for each tool should be applied regardless of the type of analysis. Any deviation from the direction and guidance presented in this chapter or default values within the program requires written documentation and justification prior to VDOT project manager review.

The sections in this chapter document standard input parameter assumptions for the following traffic and safety analysis tools:

7.1 VDOT WORK ZONE TOOLS

Prior to performing a work zone analysis, a VDOT work zone tool should be selected based on the project location and requested from the appropriate VDOT Operations Region. The VDOT project manager shall confirm that the most up-to-date version is used. If a work zone tool is not available and a work zone analysis is required, the tools and methodology of the analysis should be determined by the VDOT project manager.

7.1.1 *VDOT Work Zone Spreadsheets*

Since the VDOT Work Zone Spreadsheets are periodically updated, VDOT project managers shall confirm that the most up-to-date version is used. Input parameters in the VDOT Work Zone Spreadsheets should be based on existing field measurements, observations, and/or planning documents, and discussed and agreed upon with the VDOT project manager.

7.1.2 *VDOT Freeway Basic Work Zone HCM Tool*

The latest version of the Basic Work Zone *HCM* Tool or a district-maintained version of the tool should be selected based on which one is calibrated for local conditions. If a calibrated version does not exist, the user should coordinate with the district to obtain existing data and compare the results to existing conditions for use in calibrating the model. The VDOT PM, or their designee, should review and approve the calibration results of the model prior to its use.

Input parameters in the VDOT Freeway Basic Work Zone *HCM* Tool should be based on existing field measurements, observations, and/or planning documents, and discussed and agreed upon with the VDOT project manager. Input parameters in the VDOT Freeway Basic Work Zone *HCM* Tool are described in the VDOT Freeway Basic Work Zone *HCM* Tool Manual.

7.2 VJUST

Input parameters in VJuST should be based on existing field measurements, observations, and/or planning documents. VJuST does not have any input parameters that require specific direction or guidance, nor are there any default values.

The following VJuST input parameters do not require specific direction or guidance, but they should be adjusted to reflect field measurements and observations when data is available:

- Traffic volume demand
- Configuration consideration
- Base number of through lanes and configuration

7.3 HCS

HCS is a deterministic tool distributed by McTrans that uses the methodologies of the *HCM*. HCS7 includes several modules to evaluate different roadway geometric configurations within a transportation network. This manual covers the following HCS7 modules:

- Streets
- Stop
  - All-way stop control (AWSC)
  - Two-way stop control (TWSC)
- Freeways
  - Basic
  - Weaving
  - Merge and diverge segments
  - Facilities
- Highways
  - Two-lane
  - Multi-lane

Input parameters in HCS should be based on existing field measurements, observations, and/or design plans. Traffic and pedestrian volume input parameters should be based on existing traffic counts for existing analyses and projected volumes for future analyses. Traffic volume projections shall be approved by the VDOT project manager. In addition, existing traffic signal timing information shall be obtained from the entity that maintains the timings for the traffic signal. Refer to **Appendix G** for guidance on modeling innovative intersections.

Input parameters in HCS may be classified into the following three categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are listed but are not described in this manual
3. Input parameters with default values that should not be modified without VDOT project manager approval—these input parameters are not listed in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. Input parameters that fall into the second category do not require specific direction or guidance, but they should be adjusted to reflect field measurements, observations, and/or design plan data, when data is available. These input parameters are listed, but are not described in detail, at the end of the section for each module.

All other input parameters not addressed in this chapter fall into the third category and should not be modified from the default value unless a modification is supported by data and is approved by the VDOT project manager.

Table 10 summarizes all HCS7 standard input parameters. Some parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then the direction or guidance given should be applied to both existing and future analyses.

Table 10: HCS Standard Input Parameters

HCS Input Parameter	Module	Typical Value and/or Acceptable Ranges	
		Existing Conditions	Future Conditions
Acceleration Length	Freeways	Effective auxiliary lane length from existing field measurements	▪ Effective auxiliary lane length from existing field measurements for No-Build scenarios OR ▪ Effective auxiliary lane length from design plans
Adjacent Ramp*	Freeways	Obtain from existing field measurements	Obtain from existing field measurements or design plans
Cycle Length	Streets	Obtain from existing timing plans or field measurements	▪ Set equal to existing conditions if typical conditions are not expected to change OR ▪ Set between 60 to 240 seconds and obtain approval from the VDOT project manager
Deceleration Length	Freeways	Effective auxiliary lane length from existing field measurements	▪ Effective auxiliary lane length from existing field measurements for No-Build scenarios OR ▪ Effective auxiliary lane length from design plans
Demand	All	▪ 15-minute volume on each segment for undersaturated conditions OR ▪ Number of vehicles desiring to enter each segment during each 15-minute period for oversaturated conditions	
Highway Class	Two-Lane	Select according to driver expectations, length of trip (long or short), purpose of trip (commuting or sight-seeing), and development of the surrounding area	
Mainline Free-Flow Speed*	All	Obtain from existing speed data	▪ Obtain from existing speed data if future geometry is similar to the existing geometry OR ▪ 7 mph above the posted speed limit if future geometry is different than the existing geometry OR ▪ Maximum allowable FFS in HCS7 if 7 mph above the posted speed limit exceeds the allowable FFS in HCS7

HCS Input Parameter	Module	Typical Value and/or Acceptable Ranges	
		Existing Conditions	Future Conditions
Minimum Green	Streets	Obtain from existing timing plans or field measurements	▪ Obtain from existing timing plans or field measurements OR ▪ Other, as approved by the VDOT project manager
Number of Periods	Streets	One period	
Number of Transit Stops*	Streets	Obtain from existing count data	▪ Obtain from existing count data if future transit service is projected to be similar to existing service OR ▪ Obtain from future transit service plans
Offset	Streets	Obtain from existing timing plans or field measurements	Obtain from time-space diagram**
Optimization	Streets	Discuss the use of the optimization functionality and methodology with the VDOT project manager**	
Parking Maneuvers per Hour	Streets	Calculate number of maneuvers that occur within 250 feet (upstream) of the stop bar on an approach from existing parking count data	▪ Calculate number of maneuvers that occur within 250 feet (upstream) of the stop bar on an approach from existing parking count data OR ▪ Calculate based on projected future parking conditions
Passing Lane Analysis*	Two-Lane	▪ Set equal to the entire length of the passing lane and the length of the downstream effect of the passing lane, for level or rolling terrain ▪ Set equal to the entire length of the climbing lane analysis segment, for specific grades	▪ Set equal to the entire length of the passing lane and the length of the downstream effect of the passing lane, for level or rolling terrain ▪ Set equal to the entire length of the climbing lane analysis segment, for specific grades
Peak Hour Factor	All	Calculate using existing traffic count data	▪ Calculate using future land use data, if known OR ▪ Higher of 0.92 or existing PHF (Urban) OR ▪ Higher of 0.88 or existing PHF (Rural)

HCS Input Parameter	Module	Typical Value and/or Acceptable Ranges	
		Existing Conditions	Future Conditions
Pedestrian Clearance Interval	Streets	Obtain from existing timing plans or field measurements	Calculate according to the latest guidance in the *MUTCD* and VDOT regional pedestrian policy
Pedestrian Walking Speed	TWSC	3.5 ft/sec based on the current guidance in the *MUTCD*	
Percent Heavy Vehicles	TWSC AWSC Streets	Obtain from existing traffic count data	▪ Obtain from existing traffic count data if future vehicle mix is projected to be similar to existing vehicle mix OR ▪ Calculate based on projected future vehicle mix
Percent Trucks	All	Obtain from existing count data	▪ Obtain from existing count data if future vehicle mix is projected to be similar to existing vehicle mix OR ▪ Calculate based on projected future vehicle mix
Phasing	Streets	Obtain from existing timing plans or field measurements	Obtain from existing timing plans unless otherwise directed by the VDOT project manager
Progression Speed	TWSC	▪ Obtain from existing speed data OR ▪ Posted speed limit	
Ramp Free-Flow Speed*	Freeways	Obtain from existing speed data	▪ Obtain from existing speed data if future geometry is similar to the existing geometry OR ▪ Design speed or 10 mph above the posted warning speed if future geometry is different than the existing geometry OR ▪ Maximum allowable FFS in HCS7 if 10 mph above the posted warning speed exceeds the allowable FFS in HCS7
Red Clearance	Streets	Obtain from existing timing plans or field measurements	Calculate according to guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1)

HCS Input Parameter	Module	Typical Value and/or Acceptable Ranges	
		Existing Conditions	Future Conditions
Segment Length	Freeways	Calculate based on the influence area of each feature along the freeway segment, as defined by the *HCM*	
Segment Type	Freeways	▪ Select "Basic Segment", "Weaving", "On-Ramp", or "Off-Ramp" based on the definitions presented in the Freeways module ▪ Select "Ramp Overlap" when the distance between the successive on- and off-ramps is less than 3,000 feet	
Short Length	Freeways	Obtain from existing field measurements	Obtain from existing field measurements or design plans
Storage Length	Streets	Effective storage length from existing field measurements	▪ Effective storage length from existing field measurements for No-Build scenarios ▪ 95th percentile queue length as a minimum for Build scenarios
Terrain	Freeways Multilane Two-Lane	▪ Obtain from existing data OR ▪ Select "Level", "Rolling", or "Specific Grade" based on *HCM* guidance	▪ Obtain from existing data or design plans OR ▪ Select "Level", "Rolling", or "Specific Grade" based on *HCM* guidance
Walk Interval	Streets	Obtain from existing timing plans or field measurements	Calculate based on latest guidance in the *MUTCD* and VDOT regional pedestrian policy
Yellow Change	Streets	Obtain from existing timing plans or field measurements	Calculate based on guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1)

* Refer to bulleted guidance for special notes

Many of the HCS7 modules contain the same input parameters. To reduce redundancy in application, HCS7 input parameters applicable to more than one module, and which require specific direction or guidance, are listed below:

- **Demand:** For undersaturated conditions, set the demand equal to the 15-minute volume on each segment. For oversaturated conditions, set the demand equal to the number of vehicles desiring to enter each segment during each 15-minute analysis period. Enter the demand for each 15-minute analysis period on each segment, then balance the demand between each adjacent segment for all 15-minute periods.
- **Peak Hour Factor (PHF):** For existing analyses, calculate the PHF using existing traffic count data. For future analyses, base the PHF on future land use, if possible; otherwise, use the higher of 0.92 and the existing PHF for analyses in urban areas or the higher of 0.88 and the existing PHF for analyses in rural areas.

- **Mainline Free-Flow Speed (FFS):** For all analyses conducted in HCS7, select "Measured FFS". For existing analyses, use the FFS of the facility from existing speed data. For future analyses, use the existing FFS of the facility when the future geometry is the same as the existing geometry; otherwise, use an FFS of 7 mph above the posted speed limit. If an FFS of 7 mph above the posted speed limit exceeds the maximum accepted FFS in HCS7, then use the maximum accepted FFS.
- **Percent Trucks:** For existing analyses, calculate the existing percentage of trucks from existing traffic count data. For future analyses, use the existing percentages when future vehicle mix is expected to be similar to existing vehicle mix; otherwise, use percentages representative of the projected future vehicle mix. When analyzing a specific grade, enter the proportion of single-unit trucks (SUT) and tractor-trailers (TT). Otherwise, for level and rolling terrain, enter the total truck percentage.
- **Terrain:** Obtain grade data from existing data or design plans, if available. Select Level, Rolling, or Specific Grade based on the steepest grade and the length of the grade, according to guidance provided in **Table 11**. Level or Rolling should be selected based on the following guidance from the *HCM*:
    - *Level Terrain:* Terrain that permits heavy vehicles to operate at the same speed as passenger cars. Typically, level terrain contains grades of no more than 2 percent.
    - *Rolling Terrain:* Terrain that causes heavy vehicles to reduce their speeds substantially below the speeds of passenger cars but does not cause heavy vehicles to operate at crawl speed for significant distances or at frequent intervals. The *HCM* defines crawl speed as the maximum speed that trucks can maintain on an extended upgrade of a given percent.
    - *Specific Grade:* When Specific Grade is selected, enter the appropriate grade(s) and the corresponding length(s) of grade.

Table 11: Freeway Terrain Guidance

Steepest Grade (G)	≤2%	2%≤G<3%			≥3%
Length of Grade (L, miles)	All Lengths	L≤ 0.25	0.25<L≤0.50	L>0.50	All lengths
Selection	Level or Rolling			Select Grade	

- **Managed Lane:** If applicable, check the Managed Lane box and input managed lane data.
- **Speed and Capacity Adjustment Factors:** Select the appropriate speed and capacity adjustment factors according to guidance provided in **Table 12** and **Table 13**, respectively. The mixed flow model can be used if truck percentages are high or grades are significant.
- **Work Zone:** If applicable, check the Work Zone box. Input parameters for work zones which require specific direction or guidance include the following:
- **Area Type:** Select Urban Area or Rural Area based on the following guidance from *HCM*:
    - *Urban Area:* An area typified by high densities of development or concentrations of population, drawing people from several areas within a region.
    - *Rural Area:* An area with widely scattered development and a low density of housing and employment.
- **Percent Drop in Capacity:** Use an average default value of 13.4.

Table 12: *HCM* Speed Adjustment Factors

Weather Type	Weather Event Definition	Speed Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	>0.10-0.25 in./h	0.96	0.95	0.94	0.93	0.93
Heavy rain	>0.25 in./h	0.94	0.93	0.93	0.92	0.91
Light snow	>0.00-0.05 in./h	0.94	0.92	0.89	0.87	0.84
Light-medium snow	>0.05-0.10 in./h	0.92	0.90	0.88	0.86	0.83
Medium-heavy snow	>0.10-0.50 in./h	0.90	0.88	0.86	0.84	0.82
Heavy snow	>0.50 in./h	0.88	0.86	0.85	0.83	0.81
Severe cold	<-4°F	0.95	0.95	0.94	0.93	0.92
Low visibility	0.50-0.99 mi	0.96	0.95	0.94	0.94	0.93
Very low visibility	0.25-0.49 mi	0.95	0.94	0.93	0.92	0.91
Minimal visibility	<0.25 mi	0.95	0.94	0.93	0.92	0.91
Non-severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: *HCM*, Volume 2, Exhibit 11-20

Table 13: *HCM* Capacity Adjustment Factors

Weather Type	Weather Event Definition	Capacity Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	>0.10-0.25 in./h	0.94	0.93	0.92	0.91	0.90
Heavy rain	>0.25 in./h	0.89	0.88	0.86	0.84	0.82
Light snow	>0.00-0.05 in./h	0.97	0.96	0.96	0.95	0.95
Light-medium snow	>0.05-0.10 in./h	0.95	0.94	0.92	0.90	0.88
Medium-heavy snow	>0.10-0.50 in./h	0.93	0.91	0.90	0.88	0.87
Heavy snow	>0.50 in./h	0.80	0.78	0.76	0.74	0.72
Severe cold	<-4°F	0.93	0.92	0.92	0.91	0.90
Low visibility	0.50-0.99 mi	0.90	0.90	0.90	0.90	0.90
Very low visibility	0.25-0.49 mi	0.88	0.88	0.88	0.88	0.88
Minimal visibility	<0.25 mi	0.90	0.90	0.90	0.90	0.90
Non-severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: *HCM*, Volume 2, Exhibit 11-20

7.3.1 Freeways

The HCS7 Freeway module applies the analysis methodology presented in Chapter 11 (Basic Freeway Segments) of the *HCM*, and includes functionality for the following segments, as defined by the *HCM*:

- **Basic freeway segments:** All segments that are not merge, diverge, or weaving segments
- **Weaving freeway segments:** Segments in which two or more traffic streams traveling in the same general direction cross paths along a significant length of freeway without the aid of traffic control devices (except for guide signs)
- **Merge and diverge freeway segments:** Segments in which two or more traffic streams combine to form a single traffic stream (merge) or a single traffic stream divides to form two or more separated streams (diverge)
- **Freeway facility:** An extended length of freeway composted of continuously connected basic freeway, weaving, merge, and diverge segments

7.3.1.1 Basic Freeway Segments

The HCS7 Basic Freeway Segment analysis applies to segments with constant geometric and traffic conditions. The segment should be located outside the influence areas of merging, diverging, and weaving maneuvers. When creating a new Freeways file, select "Basic." Using this module, freeway analyses should be performed separately for each direction of travel.

Input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3.**

The mixed flow model can be used if truck percentages are high or grades are significant. The mixed flow model uses additional supporting equations to estimate Speed Adjustment Factors, Capacity Adjustment Factors, breakpoint, density at capacity, speed at capacity, and exponent calibration parameter. Passenger car volumes, SUT volumes, and TT volumes are all used directly in the estimation of mixed-flow speed and density. This model can only be used for basic freeway segments.

The following basic freeway segment input parameters do not require specific direction or guidance, but should be adjusted to reflect field measurements, observations, or design plan data, when data is available:

- Number of lanes
- Lane width
- Adjustment Factors
    - Driver population
    - Weather type
    - Incident type
- Work Zone data, if applicable
    - Lane closure type
    - Daylight or night
    - Barrier type
    - Speed limit
    - Lateral distance

7.3.1.2 Weaving Freeway Segments

The HCS7 Weaving Segment analysis applies the analysis methodology presented in Chapter 12 (Freeway Weaving Segments) of the *HCM*. This analysis applies to freeway segments where two or more traffic streams traveling in the same direction cross paths. When creating a new Freeways file, select Weaving. The following weaving freeway segment input parameters require specific direction or guidance**:**

- **Cross Weaving Managed Lane:** If applicable, check the Cross Weaving Managed Lane box and input cross weaving data.
- **Short Length:** Obtain the short length from existing measurements or design plans for weaving segments. The short length is defined as the distance where lane changing is not prohibited or discouraged by solid white pavement markings. This length is shorter than the gore-to-gore distance.

Additional input parameters which require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following weaving freeway segment input parameters do not require specific direction or guidance, but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Number of lanes
- Weaving configuration
- Weaving segment length
- Number of maneuver lanes
- Interchange density
- Minimum lane changes
- On-ramp and off-ramp number of lanes
- Demand

7.3.1.3 Merge and Diverge Freeway Segments

The HCS7 Merge and Diverge Segment analysis apply the analysis methodology presented in Chapter 13 (Freeway Merge and Diverge Segments) of the *HCM*. This analysis applies to freeway merge and diverge segments at ramp-freeway junctions. For the purposes of analysis, junctions that are designed for high speed merging or diverging with uncontrolled ramp terminals are classified as ramp-freeway junctions. When creating a new Freeways file, select Merge or Diverge.

The following merge and diverge freeway segment input parameters require specific direction or guidance include:

- **Adjacent Ramps:** Fields for adjacent ramps are enabled when the number of freeway lanes is 3. Identify any adjacent upstream and/or downstream ramp(s) within 8,000 feet of the analysis ramp and enter the associated ramp data. Run the analysis twice if there are both upstream and downstream adjacent ramps. Report the analysis results that produce the larger value for the proportion of freeway vehicles remaining in lanes 1 and 2 (the two outside lanes) immediately upstream of the on-ramp influence area or immediately upstream of the deceleration lane.
- **Ramp Free-Flow Speed (FFS):** For existing analyses, use the FFS on the ramp from existing speed data. For future analyses, use the existing FFS on the ramp when the future ramp geometry is the same as the existing geometry; otherwise, an FFS equal to the design speed or 10 mph above the posted warning speed should be used, if possible. If an FFS of 10 mph above the posted warning speed exceeds the maximum accepted FFS in HCS7, the maximum accepted FFS should be used.
- **Acceleration Length:** Use effective auxiliary lane lengths from existing measurements for existing conditions. Auxiliary lane lengths should be based on effective auxiliary lane length from existing field measurements for No-Build conditions or effective auxiliary lane length should be determined from design plans.
- **Deceleration Length:** Use effective auxiliary lane lengths from existing measurements for existing conditions. Auxiliary lane lengths should be based on effective auxiliary lane length from existing field measurements for No-Build conditions or effective auxiliary lane length should be determined from design plans. Additional input parameters which require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following merge and diverge freeway segment input parameters do not require specific direction or guidance, but they should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Number of lanes
- Ramp lanes
- Ramp side
- Freeway demand
- Merge or diverge demand

7.3.1.4 Freeway Facilities

The HCS7 Freeway Facility Analysis applies the methodology presented in Chapter 10 (Freeway Facilities) of the *HCM*. This analysis applies to extended freeway sections that are continuous and contain basic freeway, weaving, merge, and diverge segments. When creating a new Freeways file, select Facility.

This scenario allows multiple 15-minute time periods to be analyzed. Although the module was created to analyze oversaturated conditions using demand volumes, it was not included as an accepted traffic analysis tool to analyze oversaturated conditions on freeways, since it is a deterministic model. However, this module may be used for the preliminary evaluation of alternatives in oversaturated conditions. Microsimulation is required once the preliminary evaluation has been completed. When using this module, select the segments and time periods included in the analysis such that the first and last segments in the facility do not operate at LOS F and the first and last time periods of the analysis do not include any segments that operate at LOS F.

Reference to input parameters from other file types within the Freeways Module (Basic, Weaving, Merge and Diverge Segments) may be necessary when defining segment types. The following freeway facilities input parameters require specific direction or guidance:

- **Mainline Free-Flow Speed (FFS):** For existing analyses, base the FFS of the freeway segment on existing speed data. For future analyses, use the existing FFS of the freeway segment when the future freeway geometry is the same as the existing geometry; otherwise, use an FFS of 7 mph above the posted speed limit. If an FFS of 7 mph above the posted speed limit exceeds the maximum accepted FFS in HCS7, use the maximum accepted FFS.
- **Ramp Free-Flow Speed (FFS):** For existing analyses, base the FFS on the ramp on existing speed data. For future analyses, use the existing FFS on the ramp when the future ramp geometry is the same as the existing geometry; otherwise, use an FFS equal to the design speed or 10 mph above the posted warning speed. If an FFS of 10 mph above the posted warning speed exceeds the maximum accepted FFS in HCS7, use the maximum accepted FFS.
- **Segment Type and Segment Length:** Divide the freeway facility into segments for analysis purposes. Segment lengths should be based on the influence areas of each feature along the freeway segment, as defined by the *HCM*. Apply the following guidance when determining the segment length:
    - *Weaving Segment:* The length of a weaving segment should be the gore-to-gore distance of the weave plus 500 feet upstream of the entry gore and 500 feet downstream of the entry gore.
    - *Merge Segment:* The length of a merge segment should be 1,500 feet, starting at the gore of the merge point, if there is no adjacent off-ramp located less than 3,000 feet downstream of the on-ramp gore. If there is an off-ramp located less than 3,000 feet downstream of the on-ramp gore, the length of the on-ramp segment should be reduced to the distance between the on- and off-ramp gores minus 1,500 feet.
    - *Diverge Segment:* The length of a diverge segment should be 1,500 feet, ending at the gore of the diverge point, if there is no adjacent on-ramp located less than 3,000 feet upstream of the off-ramp gore. If there is an on-ramp located less than 3,000 feet upstream of the off-ramp gore, the length of the off-ramp segment should be reduced to the distance between the on- and off- ramp gores minus 1,500 feet.
    - *Ramp Overlap Segment:* Only use a ramp overlap segment when the distance between successive on- and off- ramps is less than 3,000 feet. The length of the ramp overlap segment should be equal to the distance between the on- and off-ramp gores minus the length of the on-ramp segment and the length of the off-ramp segment.
    - *Basic Segment:* The length of a basic segment should include the distance not within the influence area of any weaving segments or ramps.

Additional input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following freeway facilities input parameters do not require specific direction or guidance, but they should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Jam density
- Queue discharge capacity drop
- Demand factor
- Minimum lane changes
- Freeway lanes
- Ramp lanes
- Number of weaving lanes
- Ramp to ramp proportion
- Weaving configuration

7.3.2 *Multilane Highways*

The HCS7 Multilane Highways module applies the analysis methodology presented in Chapter 14 (Multilane Highways) of the *HCM*. This analysis applies to multilane highways segments operating under uninterrupted-flow conditions. In general, segments are considered to operate with uninterrupted flow when the segment is located two or more miles away from a traffic signal.

Input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following Multilane Highways module input parameter does not require specific direction or guidance, but it should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Number of lanes
- Median type
- Lane width
- Right and left side clearance
- Access point density

7.3.3 *Two-Lane Highways*

The HCS7 Two-Lane Highways module applies the analysis methodology presented in Chapter 15 (Two-Lane Highways) of the *HCM*. This analysis applies to highways segments with one traffic lane in each direction operating under uninterrupted-flow conditions. Segments are considered to operate with uninterrupted flow when traffic is not influenced by traffic control devices and platoons are not formed at upstream traffic signals. In general, two-lane highway segments that are located two to three miles from traffic signals operate under uninterrupted-flow conditions. Using this module, two-lane highway analysis should be performed separately for each direction.

The following two-lane highways module input parameters require specific direction or guidance:

- **Highway Class**: Base the selection of Class I Highway, Class II Highway, or Class III Highway class on driver expectations, length of trip (long or short), purpose of trip (commuting or sight-seeing), and surrounding development. The *HCM* provides the following guidance on the three classes of two-lane highways:
    - *Class I Highway*: Two-lane highways that mostly serve long-distance trips or provide connections between facilities that serve long-distance trips. Motorists on Class I highways expect to travel at relatively high speeds.
    - *Class II Highway*: Two-lane highways that largely serve sight-seeing or recreational routes. Two-lane highways that pass through rugged terrain are also classified as Class II highways. Drivers on Class II highways are typically traveling short distances and do not expect to travel at high speeds.
    - *Class III Highway*: Two-lane highways in moderately developed areas with higher traffic volumes and more frequent access points.

- **Passing Lane Analysis:** Analyze the effect of a passing lane or climbing lane on the operation of a two-lane highway segment. For level or rolling terrain, select Passing Lane and for specific grades, select Climbing Lane. For passing lane analyses, the analysis segment should include the entire passing lane and the length of the downstream effect of the passing lane. After selecting Passing Lane, enter the length of the two-lane highway upstream of the passing lane and the length of the passing lane, including tapers. The climbing lane analysis assumes the climbing lane extends the entire length of the analysis segment and requires no additional input parameters. HCS7 reports performance measures with and without considering passing or climbing lanes in the two-lane module.

Additional input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following two-lane highways module input parameters do not require specific direction or guidance but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Access-point density
- Lane width
- Observed total demand
- Percent no-passing zones
- Segment length
- Shoulder width

7.3.4 *TWSC (Two-Way Stop Control)*

The HCS7 TWSC module applies the analysis methodology presented in Chapter 19 (Two-Way Stop-Controlled Intersections) of the *HCM*. This analysis applies to intersections where the major street approaches are uncontrolled and the minor street approaches are controlled by stop signs.

The following TWSC module input parameters require specific direction or guidance:

- **Pedestrian Walking Speed:** Set the pedestrian walking speed to 3.5 ft/sec based on the current guidance in the *MUTCD*.
- **Proportion of Time Blocked:** Proportion of time blocked is only a required input parameter for major street approaches where upstream traffic signals are present.
- **RCUT Alternative Intersection:** Check the RCUT Alternative Intersection box, if applicable, and select the intersection type. Code the RCUT specific inputs in the sections Conventional Intersection, RCUT Main Intersection, and U-Turn Crossovers.

Additional input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following TWSC module input parameters do not require specific direction or guidance, but they should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Upstream signal
- Flared minor street approach and storage
- Left-turn storage
- Major street direction
- Major street median type
- Number of lanes and usage
- Percent grade
- Percent using shared lane
- RCUT, if applicable
    - Main intersection storage length
    - U-turn crossover distance from main intersection
    - U-turn crossover storage length
- Right turn channelized
- Pedestrian volumes and adjustments

7.3.5 AWSC (All-Way Stop Control)

The HCS7 AWSC module applies the analysis methodology presented in Chapter 20 (All-Way Stop-Controlled Intersections) of the *HCM*. This analysis applies to intersections where all approaches are controlled by stop signs.

Input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

The following AWSC module input parameters do not require specific direction or guidance but should be adjusted to reflect field measurements, observations, or design plan data, when data is available:

- Number of lanes and usage
- Percent through vehicles using shared lane

7.3.6 Streets

The HCS7 Streets module applies the analysis methodology presented in Chapter 17 (Urban Street Segments) and Chapter 18 (Signalized Intersections) of the *HCM*. This analysis applies to isolated three- and four-leg signalized intersections as well as urban or suburban street segments that include coordinated intersections.

Input parameters that require specific direction or guidance, applicable to more than one HCS7 module, are listed in **Section 7.3**.

HCS7 Streets module input parameters that require specific direction or guidance fall into the following categories:

- Geometric/analysis input parameters
- Signal timing input parameters
- Multimodal input parameters

7.3.6.1 Geometric and Analysis Input Parameters

The following geometric and analysis input parameters require specific direction or guidance:

- **Number of Periods:** All analyses should be done in one period. For multiple period analyses, convert volumes to vehicles per period rather than vehicles per hour and disable the use of PHF, which is not consistent with the methodologies in other HCS7 modules. If there are specific reasons for using multiple periods, their use should be approved by the VDOT project manager.
- **Storage Length:** For existing and future no-build analyses, use the effective storage length, which is equal to the existing storage length plus half of the existing taper length. Obtain existing storage and taper lengths from existing field measurements or design plans. For future build analyses, determine the 95th percentile queue length and use that length as the minimum storage length.

7.3.6.2 Signal Timing Input Parameters

The following signal timing input parameters require specific direction or guidance:

- **Cycle Length:** For existing analyses, obtain cycle lengths from existing signal timing plans or field measurements. For future analyses, cycle lengths shall be approved by the VDOT project manager. Unless conditions change significantly in the future, the cycle length should be consistent with existing conditions. Typical cycle length values range from 60 to 240 seconds.
- **Minimum Green:** For existing analyses, obtain minimum green times from existing signal timing plans or field measurements. For future analyses, use the existing minimum green time or other minimum green time approved by the VDOT project manager. Minimum green times should not be less than five seconds.

- **Offset:** For existing analyses, obtain offsets from existing timing plans or field measurements. For future analyses, offsets should be optimized using HCS7 Streets time-space diagrams and approved by the VDOT project manager.
- **Optimization:** HCS7 Streets module has the functionality to optimize signal timing. The use of the optimization functionality, as well as the input parameters, should be discussed with and approved by the VDOT project manager.
- **Phasing:** For existing analyses, obtain phasing from existing timing plans or field measurements. For future analyses, use the existing phasing unless otherwise directed by the VDOT project manager. Modify the following phasing input parameters to match existing or future signal timing plans:
    - Force Mode
    - Lag Phase
    - Phase Split
    - Phase 2 and Phase 4 Directions
    - Recall Mode
    - Reference Phase and Reference Point
    - Side Street Split Phasing
- **Red Clearance:** For existing analyses, obtain all-red time from existing timing plans or field measurements. For future analyses, compute all-red time based on the guidance in the *Yellow Change Intervals and Red Clearance Intervals TED Memorandum (TE-306.1)*.
- **Yellow Change:** For existing analyses, obtain yellow time from existing timing plans or field measurements. For future analyses, compute yellow time based on the guidance in the *Yellow Change Intervals and Red Clearance Intervals TED Memorandum (TE-306.1)*.

7.3.6.3 Multimodal Input Parameters

For analyses including pedestrians, bicycles, or transit, adjust default input parameter values based on field measurements, observations, or design plans. The following transit, parking, and pedestrian input parameters require specific direction or guidance:

- **Number of Transit Stops:** The number of transit stops should only be considered if the stops impede traffic flow. Transit stops are only counted if the stop occurs within 250 feet (upstream or downstream) of the stop bar on an approach. For existing analyses, obtain the number of transit stops from existing traffic count data. For future analyses, use the existing number of transit stops when future transit behavior is expected to be similar to existing conditions; otherwise, use a number of transit stops representative of the projected future transit behavior. When modifying the number of transit stops for future analyses, provide supporting documentation.
- **Pedestrian Clearance Interval:** For existing analyses, obtain the pedestrian clearance interval from existing timing plans or field measurements. For future analyses, base the pedestrian clearance interval on the latest guidance in the *Manual on Uniform Traffic Control Devices (MUTCD)* and VDOT regional pedestrian policy.
- **Parking Maneuvers Per Hour:** Parking maneuvers are only counted if the maneuver occurs within 250 feet (upstream) of the stop bar on an approach. For existing analyses, obtain the number of parking maneuvers from existing parking count data. For future analyses, use the existing number of parking maneuvers when future parking conditions are expected to be similar to existing conditions; otherwise, use a number of parking maneuvers representative of the projected future parking conditions.
- **Walk Interval:** For existing analyses, obtain the walk interval from existing timing plans or field measurements. For future analyses, compute the walk interval based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy.

In addition to the input parameters listed above, adjust the following Streets module default values to reflect field measurements, observations, design plan data, or signal timing plans, when available:

- Alternative intersection type
- Arrival type
- Forward direction
- Grade
- Heaviest lane volume
- Interchange type
- Length of restrictive median
- Lanes/shared lanes/receiving lanes
- Area type
- Lane width
- Percent of right-hand curb
- Percent turn in shared lane
- Right-hand access points
- Right-turn on red (RTOR)
- Segment length
- Speed limit

7.4 SIDRA INTERSECTION

SIDRA Intersection is a deterministic tool developed by an Australian transportation operations company, Akcelik & Associates Pty Ltd that may be used to analyze signalized, unsignalized, and roundabout operations. However, VDOT only accepts the use of SIDRA Intersection to analyze roundabouts, and, as a result, this section only includes a discussion of the standard input parameter assumptions that apply to roundabout analyses. As a starting point, the units should be set to English for all analyses. Input parameters to SIDRA Intersection should be based on existing field measurements, observations, and design plans. Vehicle and pedestrian volume input parameters should be from existing counts for existing analyses and projected volumes for future analyses. Volume projections shall be approved by the VDOT project manager. When creating a new file, the Current Setup in the Settings tab of the ribbon should be set as US *HCM* (Customary).

Input parameters in SIDRA Intersection may be classified into the following three categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are listed but not described in this manual
3. Input parameters with default values that should not be modified without VDOT project manager approval—these input parameters are not listed in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are described in **Sections 7.4.1** and **7.4.2** and are summarized in **Table 14**. Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then the direction or guidance given should be applied to both existing and future analyses.

The input parameters listed below fall into the second category and do not require specific direction or guidance but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Approach distance
- Circulating transition line
- Dominant lane
- Downstream distance
- Lane configuration
- Lane control
- Lane disciplines
- Leg geometry
- Lane length
- Lane type
- Lane utilization ratio
- Lane width
- Movement exists
- Pedestrian
- Pedestrian approach travel distance
- Raindrop design
- Slip/bypass lane control
- Turn designation

All other input parameters not addressed in this chapter fall into the third category and should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager. Comparisons of roundabout operations to other intersection control should only consider delay results; however, if LOS is required for design purposes, follow the guidance below pertaining to the LOS method.

Table 14: SIDRA Intersection 8 Standard Input Parameters

SIDRA Intersection Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Geometric and Analysis Input Parameters		
Approach Cruise Speed/Exit Cruise Speed	▪ Obtain from existing speed data OR ▪ Posted speed limit	
Capacity Model	Select "SIDRA Standard" in the "Options" tab of the "Roundabouts" parameter dialog	
Circulating Width	Obtain from existing field measurements	▪ Obtain from existing field measurements or design plans OR ▪ 16 to 20 feet for single-lane roundabouts and 28 to 32 feet for two-lane roundabouts if full design has not yet been completed
Current Setup	Select "US *HCM* (Customary)" in the "Settings" tab of the Ribbon	
Entry Angle	Obtain from existing field measurements	▪ Obtain based on existing field measurements or design plans OR ▪ 20° to 40° if full design has not yet been completed
Entry Radius	Obtain from existing field measurements	▪ Based on existing field measurements or design plans OR ▪ Where full design has not yet been completed, use 50 to 100 feet for single-lane roundabouts and 65 to 120 feet for two-lane roundabouts
Environment Factor	▪ 1.1 in the Northern Virginia District OR ▪ 1.2 in all other districts	▪ 1.05 in the Northern Virginia District OR ▪ 1.1 in all other districts
Extra Bunching	Refer to the recommended values in the *Quick Guide to SIDRA Intersection*	
Inscribed Diameter	Obtain from existing field measurements	▪ Obtain from existing field measurements or design plans OR ▪ 90 to 180 feet for single-lane roundabouts and 150 to 300 feet for two-lane roundabouts where full design has not yet been completed
Island Diameter	Island Diameter = Inscribed Diameter – 2 x Circulating Width	
Movement Classes	Determine based on the existing vehicle-type composition.	▪ Determine based on future land use OR ▪ Determine based on the existing vehicle-type composition

<table>
<tr><th rowspan="2">SIDRA Intersection Input Parameter</th><th colspan="2">Typical Value and/or Acceptable Ranges</th></tr>
<tr><th>Existing Conditions</th><th>Future Conditions</th></tr>
<tr><td>Number of Circulating Lanes*</td><td>Obtain from existing field measurements</td><td>Obtain from existing field measurements or design plans</td></tr>
<tr><td>Peak Flow Factor*</td><td>Obtain from existing traffic count data</td><td>▪ Calculated based on future land use data, if known OR
▪ Higher of 0.92 or existing PHF (Urban) OR
▪ Higher of 0.88 or existing PHF (Rural)</td></tr>
<tr><td>Roundabout Level of Service (LOS) Method</td><td colspan="2">Select “Same as Signalized Intersection” OR “Same as Sign Control” in the “Options” tab of the “Roundabouts” parameter dialog as noted below.
▪ Select “Same as Sign Control” in the “Options” tab of the “Roundabouts” parameter dialog when comparing the roundabout to an unsignalized intersection or performing a standalone roundabout analysis OR
▪ Select “Same as Signalized Intersection” in the “Options” tab of the “Roundabouts” parameter dialog when comparing the roundabout to a signalized intersection</td></tr>
<tr><td>Sensitivity Analysis</td><td colspan="2">Discuss the use of the sensitivity analysis functionality with the VDOT project manager**</td></tr>
<tr><td>Vehicle Percentages</td><td>Obtain from existing traffic count data</td><td>▪ Obtain from existing traffic count data if future vehicle mix is projected to be similar to existing vehicle mix OR
▪ Calculated based on projected future vehicle mix</td></tr>
<tr><td colspan="3">Pedestrian Parameters</td></tr>
<tr><td>Pedestrian Movement Definition</td><td colspan="2">Select “Staged Crossing” on all approaches with a pedestrian movement</td></tr>
<tr><td>Pedestrian Walking Speed</td><td colspan="2">3.5 ft/sec, based on the current guidance in the <i>MUTCD</i>.</td></tr>
</table>

* Refer to bulleted guidance for special notes

7.4.1 *Geometric and Analysis Input Parameters*

The following geometric and analysis input parameters require specific direction or guidance:

- **Approach Cruise Speed/Exit Cruise Speed:** For existing analyses, the approach and exit cruise speeds should be from existing speed data, if available; otherwise, the posted speed limits should be used. For future analyses, the existing speed data should be used; otherwise, the posted speed limits should be used. Individual approach and exit cruise speeds should be entered for each movement class.
- **Capacity Model:** "SIDRA Standard" should be selected for all analyses in the "Options" tab of the "Roundabouts" input parameter dialog.
- **Circulating Width:** The roundabout circulating width should be obtained from existing field measurements or design plans. For future analyses where full design has not yet been completed, the circulating width should fall within the following ranges, based on guidance from the *NCHRP Report 672: Roundabouts: An Informational Guide (Second Edition):*
    - Single-lane roundabout: 16 to 20 feet
    - Two-lane roundabout: 28 to 32 feet
- **Current Setup:** US HCM (Customary) should be selected in the Settings tab of the Ribbon before a roundabout is created.
- **Entry Angle:** The entry angle should be obtained from existing field measurements or design plans. For future analyses where full design has not yet been completed, the entry radius should be between 20 degrees and 40 degrees, based on guidance from the *NCHRP Report 672: Roundabouts: An Informational Guide* (Second Edition).
- **Entry/Circulating Flow Adjustment:** The default setting is none. If this parameter is set to one of the other options, it may affect the capacity.
- **Entry Radius:** The entry radius should be obtained from existing field measurements or design plans. For future analyses where full design has not yet been completed, the entry radius should be within the following ranges, based on guidance from the *NCHRP Report 672: Roundabouts: An Informational Guide (Second Edition)*:
    - Single-lane roundabout: 50 to 100 feet
    - Two-lane roundabout: 65 to 120 feet
- **Environment Factor:** For existing analyses, a factor of 1.1 should be used in the Northern Virginia District and a factor of 1.2 should be used in all other districts. For future analyses, a factor of 1.05 should be used in the Northern Virginia District and a factor of 1.1 should be used in all other districts.
- **Extra Bunching:** This input parameter is used to account for traffic platoons and impacts from upstream traffic signals. The Extra Bunching input parameter for an approach should only be modified from the default value of 0.0 percent when there is an upstream traffic signal on an approach that is less than 2,600 feet from the roundabout. The distance to the upstream signal should be measured from the downstream side of the traffic signal to the stop bar of the roundabout approach.

  When there is an upstream traffic signal on an approach, select "Input" and specify Extra Bunching as a percentage value. The values listed in **Table 15**, recommended in the Quick Guide to SIDRA Intersection 8, should be used.

Table 15: SIDRA Intersection Extra Bunching Percentage

Distance to Upstream Signal (ft)	<350	350 - 700	700 - 1,300	1,300 - 2,000	2,000 - 2,600	>2,600
Extra Bunching (%)	25	20	15	10	5	0

- **Inscribed Diameter:** Select Input and obtain the inscribed diameter from existing field measurements or design plans. For future analyses where full design has not yet been completed, the inscribed diameter should be within the following ranges, based on guidance from the *NCHRP Report 672: Roundabouts: An Informational Guide, Second Edition*:
  - Single-lane roundabout: 90 to 180 feet
  - Two-lane roundabout: 150 to 300 feet
- **Island Diameter:** The island diameter is dependent on the inscribed diameter and circulating width of the roundabout. Calculate the inscribed diameter using the following equation:

  Island Diameter = Inscribed Diameter – 2x Circulating Width
- **Movement Classes:** Analyses in SIDRA Intersection always include Light Vehicles and Heavy Vehicle Classes. Only select one of the four additional standard movement classes in SIDRA Intersection (Buses, Bicycles, Large Trucks, and Light Rail/Trams) when there is supporting traffic count data. For existing analyses, base the selection of movement classes on the existing vehicle-type composition. For future analyses, base the selection of movement classes on future land use, if possible; otherwise, use the existing analysis movement classes. In cases where lane use is restricted based on movement classes (i.e., bus lanes or bike lanes), specify movement classes.
- **Number of Circulating Lanes:** Obtain the number of circulating lanes from existing field measurements or design plans. SIDRA Intersection allows for entry of up to six circulating lanes; however, enter no more than two circulating lanes for roundabouts analyzed in Virginia.
- **Peak Flow Factor:** Set the Peak Flow Factor equal to the overall intersection vehicle and pedestrian PHFs, expressed as percentages. Use a "Peak Flow Period" of 15 minutes for all analyses. For existing analysis, calculate the PHF of the overall roundabout using existing traffic and pedestrian count data. For future analyses, base the PHF of the overall intersection on future land use, if possible; otherwise, use the higher of 0.92 and the existing PHF for analyses in urban areas or the higher of 0.88 and use the existing PHF for analyses in rural areas. Enter the overall intersection vehicular and pedestrian peak flow factors for all individual movements. If individual approaches or movements are known to peak at different times, analyze multiple 15-minute analysis periods separately.
- **Roundabout Level of Service (LOS) Method:** Select Same as Signalized Intersections as the roundabout LOS method in the Options tab of the Roundabouts input parameter dialog when comparing a roundabout to a signalized intersection. When comparing a roundabout to an unsignalized intersection or performing a standalone roundabout analysis, select Same as Sign Control as the roundabout LOS method. Comparisons of roundabout operations to other intersection control should only consider delay results; however, if LOS is required for design purposes, report LOS results for both LOS methods.
- **Sensitivity Analysis:** SIDRA Intersection has the functionality to perform sensitivity analysis. The use of this functionality should be discussed with and approved by the VDOT project manager.
- **Vehicle Percentages:** Enter vehicle percentages by movement for all movement classes included in the analysis. For existing analyses, calculate the heavy vehicle (and, when applicable, bus, bicycle, large trucks, and light rail/trams) percentages using existing count data. For future analyses, use the existing percentages when future vehicle mix is expected to be similar to existing vehicle mix; otherwise, use percentages representative of the projected future vehicle mix. When modifying the vehicle percentages for future analyses, provide supporting documentation.

7.4.2 *Pedestrian Input Parameters*

The following pedestrian input parameters require specific direction or guidance:

- **Pedestrian Movement Definition:** Consider pedestrian movements for all analyses. The presence of pedestrian crossings should be based on existing conditions or design plans. On all approaches with a pedestrian movement, select "Staged Crossing" as the "Main Crossing" type. Enter data separately for both stages of the crossing.
- **Pedestrian Walking Speed:** Set the pedestrian walking speed to 3.5 ft/sec based on the current guidance in the *MUTCD*.

7.5 SYNCHRO

Synchro is a deterministic tool developed by Trafficware that may be used to analyze arterials, signalized intersections, and unsignalized intersections. Input parameters to Synchro should be from existing field measurements, observations, and design plans. Obtain base traffic, conflicting pedestrian, and conflicting bicycle volume input parameters from existing counts for existing analyses and projected volumes for future analyses. In addition, obtain signal timing information from the entity that maintains the timings for the traffic signal. Refer to **Appendix G** for guidance on modeling innovative intersections.

Input parameters in Synchro may be classified into the following three categories:

1. Input parameters that require specific direction or guidance for proper application – these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application – these input parameters are listed but not described in this manual
3. Input parameters with default values that should not be modified without VDOT project manager approval – these input parameters are not listed in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are provided in **Sections 7.5.1** through **7.5.3** and are summarized in **Table 16**.

The input parameters listed below fall into the second category and do not require specific direction or guidance but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Area type CBD
- Crosswalk width
- Enter blocked intersection
- Grade
- Lane alignment
- Lanes and sharing
- Lane utilization/right-turn/left-turn factors
- Lane width
- Median width
- Right turn on red
- Storage lanes
- Turning speed
- TWLTL median

Table 16: Synchro 10 Standard Input Parameters

Synchro Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Geometric/Analysis Input Parameters		
Analysis Method	▪ Select *HCM* methodology OR ▪ Select *HCM* 2000 methodology for analyses where *HCM* methodology does not apply	
Heavy Vehicles	Calculate using existing traffic count data	▪ Calculate using existing traffic count data if future vehicle mix is projected to be similar to existing vehicle mix OR ▪ Calculate based on projected future vehicle mix
Link Distance*	Obtain from existing field measurements	Obtain from existing field measurements or design plans
Link Speed	▪ Obtain from existing speed data OR ▪ Posted speed limit (arterial only)	
Peak Hour Factor*	Calculate using existing traffic count data	▪ Calculate based on future land use, if known OR ▪ Higher of 0.92 or existing PHF (Urban) OR ▪ Higher of 0.88 or existing PHF (Rural)
Right-Turn Channelized	Select the type of control on the channelized movement (Free, Yield, Stop, or Signal) and enter the curb radius, obtained from existing field measurements	Select the type of control on the channelized movement (Free, Yield, Stop, or Signal) and enter the curb radius, obtained from existing field measurements or design plans
Storage Length	Effective storage length from existing field measurements	▪ Effective storage length from existing field measurements for No-Build scenarios OR ▪ Maximum back-of-queue length as a minimum for Build scenarios
Taper Length	Set the taper length equal to zero feet	
Signal Timing Input Parameters		
All-Red Time	Obtain from existing timing plans or field measurements	Refer to guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1)

Synchro Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Control Type	Obtain from existing timing plans or field measurements	Obtain from existing timing plans unless otherwise directed by the VDOT project manager
Cycle Length	Obtain from existing timing plans or field measurements	Ranges from 60 to 240 seconds and be approved by the VDOT project manager
Minimum Initial	Obtain from existing timing plans or field measurements	▪ Obtain from existing timing plans or field measurements OR ▪ Should be approved by the VDOT project manager
Minimum Split	Obtain from existing timing plans or field measurements	▪ Obtain from existing timing plans or field measurements OR ▪ Should be approved by the VDOT project manager
Offset	Obtain from existing timing plans or field measurements	▪ Obtain from time-space diagrams ▪ Should be approved by the VDOT project manager
Optimize**	Methodology should be approved by the VDOT project manager	
Total Split	Obtain from existing timing plans or field measurements	▪ Obtain from existing timing plans or field measurements OR ▪ Should be approved by the VDOT project manager
Turn Type	Obtain from existing timing plans or field measurements	Calculate based on TED Guidance for Determination and Documentation of Left-Turn Phasing Mode
Yellow Time	Obtain from existing timing plans or field measurements	Calculate based on guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1)
Pedestrian, Parking, and Bus Input Parameters		
Adjacent Parking Lane	Obtain from existing parking count data, only considering maneuvers that occur within 250 feet (upstream) of the stop bar on an approach	▪ Obtain from existing parking count data, only considering maneuvers that occur within 250 feet (upstream) of the stop bar on an approach, if future parking conditions are expected to be similar to existing conditions OR ▪ Calculate based on projected future parking conditions

Synchro Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Bus Blockages*	Calculate from existing traffic count data, only considering movements that occur within 250 feet (upstream or downstream) of the stop bar on an approach	▪ Calculate from existing traffic count data, only considering movements that occur within 250 feet (upstream or downstream) of the stop bar on an approach, if future bus service is projected to be similar to existing service OR ▪ Calculate based on future bus service
Flash Don't Walk	Obtain from existing timing plans or field measurements	Calculate based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy
Walk Time	Obtain from existing timing plans or field measurements	Calculate based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy

* Refer to bulleted guidance for special notes
** Requires approval from VDOT Project Manager

All other input parameters not addressed in this chapter fall into the third category and should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager.

Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then the direction or guidance given should be applied to both existing and future analyses.

The input parameters listed below fall into the second category and do not require specific direction or guidance but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Area type CBD
- Crosswalk width
- Enter blocked intersection
- Grade
- Lane alignment
- Lanes and sharing
- Lane utilization/right-turn/left-turn factors
- Lane width
- Median width
- Right turn on red
- Storage lanes
- Turning speed
- TWLTL median

All other input parameters not addressed in this chapter fall into the third category and should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager.

7.5.1 Geometric and Analysis Input Parameters

The following geometric and analysis input parameters require specific direction or guidance:

- **Analysis Method:** Select the appropriate analysis method in the "Create Report" dialog box after the model has been built. Use *HCM* methodology for all operational analyses for which it is applicable. For analyses where *HCM* methodology does not apply (e.g., intersections with non-NEMA phasing, intersections with five or more legs, clustered intersections), use *HCM* 2000 methodology.

- **Heavy Vehicles:** For existing analyses, calculate the heavy vehicle percentage for each movement from existing traffic count data. For future analyses, use the existing percentages when future vehicle mix is expected to be similar to existing vehicle mix; otherwise, use percentages representative of the projected future vehicle mix. When modifying the heavy vehicle percentage for future analyses, provide supporting documentation.
- **Link Distance:** Base link lengths on field measurements or design plans. If microsimulation is required, links at network entry points should be longer than the maximum queue observed in the field for existing analyses and the maximum queue reported by SimTraffic for future analyses.
- **Link Speed:** For existing analyses, base the link speeds on existing speed data if available; otherwise, use the posted speed limits (for arterials only). For future analyses, use the existing speed data; otherwise, use the posted speed limits (for arterials only).
- **Peak Hour Factor (PHF):** For existing analyses, calculate the PHF of the overall intersection using existing traffic count data. For future analyses, base the PHF of the overall intersection on future land use, if possible; otherwise, use the higher of 0.92 and the existing PHF for analyses in urban areas or the higher of 0.88 and use the existing PHF for analyses in rural areas. Enter the overall intersection PHF for all individual movements. If individual approaches or movements are known to peak at different times, analyze multiple 15-minute periods separately.
- **Right-Turn Channelized:** For all channelized right-turn movements, select the type of control on the channelized movement (Free, Yield, Stop, or Signal) and enter the curb radius. Obtain the curb radii from existing field measurements or design plans.
- **Storage Length:** For existing and future no-build analyses, use the "effective storage length", which is equal to the existing storage length plus half of the existing taper length. Obtain existing storage and taper lengths from existing field measurements. For future build analyses, the storage length should be greater than or equal to the back-of-queue length.
- **Taper Length:** For all analyses, set the taper length equal to zero. For existing and future no-build analyses, the length of the taper is considered in the "effective storage length" to remain consistent with other traffic analysis tools. For future build analyses, the storage length will accommodate the maximum queue on the link, so it is not necessary to enter a taper length.

7.5.2 Signal Timing Input Parameters

The following signal timing input parameters require specific direction or guidance:

- **All-Red Time:** For existing analyses, obtain all-red time from existing timing plans or field measurements. For future analyses, compute all-red time based on the guidance in the *Yellow Change Intervals and Red Clearance Intervals TED Memorandum (TE-306.1)*.
- **Control Type:** For existing analyses, base the control type (Pretimed, Semi-Actuated-Uncoordinated, Actuated-Uncoordinated, Actuated-Coordinated, and/or Unsignalized) on the existing type of controller. For future analyses, use the existing control type unless otherwise directed by the VDOT project manager. After selecting the control type, modify the following input parameters to match existing or future signal timing plans:
    - Referenced to and Reference Phase (coordinated control only)
    - Lagging Phase
    - Vehicle Extension (actuated control only)
    - Minimum Gap (actuated control only)
    - Time Before Reduce (actuated control only)
    - Time to Reduce (actuated control only)
    - Recall Mode (actuated control only)
    - Detector sizes, positions, and settings (actuated control only)

- **Cycle Length:** For existing analyses, obtain cycle lengths from existing timing plans or field measurements. For future analyses, cycle lengths shall be approved by the VDOT project manager. Unless conditions change significantly in the future, the cycle length should be consistent with existing conditions. Typical cycle length values range from 60 to 240 seconds.
- **Minimum Initial:** For existing analyses, obtain minimum initial green times from existing timing plans or field measurements. For future analyses, the existing minimum initial green time or other minimum initial green time approved by the VDOT project manager should be used. Minimum initial green times should not be less than five seconds.
- **Minimum Split:** For existing analyses, obtain minimum split times from existing timing plans or field measurements. For future analyses, use the existing minimum split time or other minimum split time approved by the VDOT project manager.
- **Offset:** For existing analyses, obtain offsets from existing timing plans or field measurements. For future analyses, optimize offsets using time-space diagrams from Synchro.
- **Optimize:** Synchro has the functionality to optimize cycle length, splits, and lead/lag operations. The use of the optimization functionality for existing and future analyses should be discussed with and approved by the VDOT project manager.
- **Total Split:** For existing analyses, obtain total split times from existing timing plans or field measurements. For future analyses, the existing total split time or other total split time approved by the VDOT project manager should be used.
- **Turn Type:** For existing analyses, obtain left-turn type and right-turn type from existing timing plans or field observations. For future analyses, left-turn type should be based on the following guidance from the VDOT *Guidance for Determination and Documentation of Left-Turn Mode* and should be approved by the VDOT project manager:
    - If there are two or more left-turn lanes on the approach, protect the left-turn phase.
    - If there are four or more through lanes on the opposing approach, protect the left-turn phase.
    - If the posted speed limit on the opposing approach is greater than 45 mph, protect the left-turn phase.
    - If there are two or three through lanes on the opposing approach and the product of the left-turn volume and the opposing right-turn/through volume is greater than 100,000 during the peak hour, the left-turn phase should be protected plus permissive or protected only. Otherwise, the left-turn phase may be permissive.
    - If there is one through lane on the opposing approach and the product of the left-turn volume and the opposing right-turn/through volume is greater than 50,000 during the peak hour, the left-turn phase should be protected plus permissive or protected only. Otherwise, the left-turn phase may be permissive.
- **Yellow Time:** For existing analyses, obtain yellow time from existing timing plans or field measurements. For future analyses, compute yellow time based on the guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1).

7.5.3 *Pedestrian, Parking, and Bus Input Parameters*

The following pedestrian, parking, and bus input parameters require specific direction or guidance:

- **Adjacent Parking Lane:** Parking maneuvers are only counted if the maneuver occurs within 250 feet (upstream) of the stop bar on an approach. For existing analyses, obtain the number of parking maneuvers from existing parking count data. For future analyses, use the existing number of parking maneuvers when future parking conditions are expected to be like existing conditions; otherwise, use several parking maneuvers representative of the projected future parking conditions.

- **Bus Blockages:** The number of bus blockages should only be considered if the bus blockages impede traffic flow. Bus blockages are only counted if the stop occurs within 250 feet (upstream or downstream) from the stop bar of an approach. For existing analyses, obtain the number of bus blockages from existing count data. For future analyses, use the existing number of bus blockages when future bus behavior is expected to be like existing conditions; otherwise, use several bus blockages representative of the projected future bus behavior. When modifying the number of bus blockages for future analyses, provide supporting documentation.
- **Flash Don't Walk:** For existing analyses, obtain the flash don't walk time from existing timing plans or field measurements. For future analyses, compute the flash don't walk time based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy.
- **Walk Time:** For existing analyses, obtain the walk time from existing timing plans or field measurements. For future analyses, compute the walk time on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy.

7.6 SIMTRAFFIC

SimTraffic is the microsimulation companion tool of Synchro and is pre-loaded with the Synchro suite of software tools. A complete Synchro model which follows the direction and guidance provided in **Section 7.5** is required before any SimTraffic analysis can be conducted.

Input parameters in SimTraffic may be classified into the following two categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters with default values that should not be modified without VDOT project manager approval – these input parameters are not described in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are summarized in **Table 17**. Apply the direction or guidance provided to both existing and future analyses.

All other input parameters not addressed in this chapter fall into the second category and should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager.

Table 17: SimTraffic 10 Standard Input Parameters

SimTraffic Input Parameter	Typical Value and/or Acceptable Ranges
Anti-PHF Adjust	▪ Select "Yes" for the three, 15-minute recording intervals where PHF Adjust is set to "No" ▪ Select "No" for the seeding interval and the recording interval where PHF Adjust is set to "Yes"
Number of Intervals	One seeding interval and four, 15-minute recording intervals
Number of Runs	Calculate using the Sample Size Determination Tool. Refer to the direction and guidance on the microsimulation sample size provided in Section 5.4
PHF Adjust	▪ Select "Yes" for one of the four, 15-minute recording intervals ▪ Select "No" for all other intervals
Seeding Interval Duration	Set the duration long enough to distribute traffic throughout the entire network

Note: The Synchro network should be developed using the direction and guidance in Section 7.5, prior performing SimTraffic analysis.

The following analysis input parameters require specific direction or guidance:

- **Anti-PHF Adjust:** For all analyses, set the Anti-PHF Adjust to Yes for the three, 15-minute recording intervals where PHF Adjust is set to No. Set the Anti-PHF Adjust to No for the seeding interval and the recording interval where PHF Adjust is set to Yes.
- **Number of Intervals:** For all analyses, use one seeding interval and four, 15-minute recording intervals.
- **Number of Runs:** Determine the minimum number of microsimulation runs based on the microsimulation sample size direction and guidance provided in **Section 5.4** of this manual and the Sample Size Determination Tool.
- **PHF Adjust:** For all analyses, set the PHF Adjust to Yes for one of the four, 15-minute recording intervals and to No for all other intervals.

- **Seeding Interval Duration:** The duration of the seeding interval should be long enough to distribute traffic throughout the entire network. In general, the minimum seeding interval duration is equal to the peak hour travel time through the network or two times the off-peak travel time.

The input parameters listed below fall into the second category and do not require specific direction or guidance, but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Bus stations
- Grade
- HOV lanes
- Pavement
- Radius
- Number of lanes
- Lane add/drop
- Lane alignment
- Lane channelization
- Lane distribution of entering vehicles
- Lane width
- Parking location
- Parking maneuvers
- Pedestrian traffic
- Superelevation
- Truck lane restrictions
- Turn movements
- Type(s) of auxiliary lanes

All other input parameters not addressed in this chapter fall into the third category and should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager.

7.7 FREEVAL

FREEVAL is a deterministic software tool designed to conduct operational analyses for undersaturated and oversaturated directional freeway facilities. Input parameters to FREEVAL should be based on existing field measurements, observations, and design plans.

Input parameters in FREEVAL may be classified into the following three categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are listed but not described in this manual
3. Input parameters with default values that should not be modified without VDOT project manager approval—these input parameters are not listed in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are summarized in **Table 18**. Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then the direction or guidance given should be applied to both existing and future analyses.

The following FREEVAL input parameters do not require specific direction or guidance, but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Number of *HCM* segments
- Study period start and end time
- Jam density
- Capacity drop due to breakdown (%)
- GP vehicle occupancy
- Area type
- Number of mainline lanes
- Number of ramp lanes
- General purpose segment type

Table 18: FREEVAL Standard Input Parameters

FREEVAL Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Geometric/Analysis Input Parameters		
Acceleration Length	Effective auxiliary lane length from existing measurements	▪ Effective auxiliary lane length from existing measurements for No-Build conditions, OR ▪ Effective auxiliary lane length from design plans for Build conditions
Deceleration Length	Effective auxiliary lane length from existing measurements	▪ Effective auxiliary lane length from existing measurements for No-Build conditions, OR ▪ Effective auxiliary lane length from design plans for Build conditions
Mainline Demand	▪ For undersaturated conditions, set the demand equal to 15-minute volume on each segment ▪ For oversaturated conditions, set the demand equal to the number of vehicles desiring to enter the freeway segment during each 15-minute analysis period.	
Mainline Free-Flow Speed	Obtain from existing speed data	▪ Obtain from existing speed data if future geometry is similar to the existing geometry OR ▪ 7 mph above the posted speed limit if future geometry is different than the existing geometry OR ▪ Maximum allowable FFS in FREEVAL if 7 mph above the posted speed limit exceeds the allowable FFS in FREEVAL
Ramp Free-Flow Speed	Obtain from existing speed data	▪ Obtain from existing speed data if future geometry is similar to the existing geometry OR ▪ Design speed or 10 mph above the posted warning speed if future geometry is different than the existing geometry OR ▪ Maximum allowable FFS in FREEVAL if 10 mph above the posted warning speed exceeds the allowable FFS in FREEVAL
Percent Trucks and Buses/Percent Recreational Vehicles*	Calculate from existing traffic count data	▪ Calculate from existing traffic count data OR ▪ Calculate based on projected future vehicle mix

FREEVAL Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Speed and Capacity Adjustment Factors	Select the appropriate factor according to guidance provided in **Table 12** and **Table 13**, respectively.	
Terrain*	▪ Obtain from existing data OR ▪ Select "Level", "Rolling", or "Specific Grade" based on *HCM* guidance.	▪ Obtain from existing data or design plans OR ▪ Select "Level", "Rolling", or "Specific Grade" based on *HCM* guidance.

* Refer to bulleted guidance for special notes

The following FREEVAL input parameters require specific direction or guidance:

- **Mainline Demand:** For undersaturated conditions, set the demand equal to 15-minute volume on each segment. For oversaturated conditions, set the demand equal to the number of vehicles desiring to enter each freeway segment during each 15-minute analysis period. Enter the demand for each 15-minute analysis period on each segment, then balance the demand between each adjacent segment for all 15-minute periods.
- **Acceleration Length:** Use effective auxiliary lane lengths from existing measurements for existing conditions. Auxiliary lane lengths should be based on effective auxiliary lane length from existing field measurements for No-Build conditions or effective auxiliary lane length should be determined from design plans.
- **Deceleration Length:** Use effective auxiliary lane lengths from existing measurements for existing conditions. Auxiliary lane lengths should be based on effective auxiliary lane length from existing field measurements for No-Build conditions or effective auxiliary lane length should be determined from design plans.
- **Mainline Free-Flow Speed (FFS):** For all analyses conducted in FREEVAL, use the FFS of the facility from existing speed data. For future analyses, use the existing FFS of the facility when the future geometry is the same as the existing geometry; otherwise, use an FFS of 7 mph above the posted speed limit. If an FFS of 7 mph above the posted speed limit exceeds the maximum accepted FFS in FREEVAL, then use the maximum accepted FFS.
- **Ramp Free-Flow Speed (FFS):** For existing analyses, use the FFS on the ramp from existing speed data. For future analyses, use the existing FFS on the ramp when the future ramp geometry is the same as the existing geometry; otherwise, a use an FFS equal to the design speed or 10 mph above the posted warning speed should be used, if possible. If an FFS of 10 mph above the posted warning speed exceeds the maximum accepted FFS in FREEVAL, the maximum accepted FFS should be used.
- **Speed and Capacity Adjustment Factors:** Select the appropriate speed and capacity adjustment factors according to guidance provided in **Table 12** and **Table 13**, respectively.
- **Percent Trucks and Buses/Percent Recreational Vehicles:** For existing analyses, calculate the existing percentage of trucks and buses and percentage of recreational vehicles from existing traffic count data. For future analyses, use the existing percentages when future vehicle mix is expected to be similar to existing vehicle mix; otherwise, use percentages representative of the projected future vehicle mix. When modifying the percentage of trucks and buses or the percentage of recreational vehicles for future analyses, provide supporting documentation. If the ratio of trucks and buses to recreational vehicles is 5:1 or greater, the percentage of all heavy vehicles (trucks, buses, and recreational vehicles) may be

entered as the percentage of trucks and buses and the recreational vehicles percentage may be set to 0 percent.

- **Terrain:** Obtain grade data from existing data or design plans, if available. Select Level, Rolling, or Specific Grade based on the steepest grade and the length of the grade, according to guidance provided in **Table 11**.

7.8 VISSIM

Vissim is a complex microsimulation tool that allows for the flexibility to model a wide range of traffic environments. Base input parameters to Vissim on existing field measurements, observations, and design plans. Traffic, conflicting pedestrian, and conflicting bicycle volume input parameters should be derived from existing counts for existing analyses and forecasted volumes for future analyses. Volume projections shall be approved by the VDOT project manager. In addition, obtain traffic signal timing information from the entity that maintains the timings for the traffic signal. Prior to running a Vissim model, the user should change the units to English units.

Input parameters in Vissim may be classified into the following four categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual.
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are listed but not described in this manual.
3. Input parameters used in model calibration that should be adjusted according to guidance provided in the *VDOT VISSIM User Guide*.
4. Input parameters with default values that should not be modified without VDOT project manager approval—these input parameters are not listed in this manual.

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are provided in **Sections 7.8.1** through **7.8.3** and are summarized in **Table 19**. Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then apply the direction or guidance given to both existing and future analyses.

In addition to the direction and guidance provided in this manual, VDOT has developed the *VDOT VISSIM User Guide* to assist Vissim users with model development, calibration, and post-processing using VISSIM. The practices outlined in the guide are intended to supplement the direction and guidance provided in this document.

Table 19: Vissim Standard Input Parameters

Vissim Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Geometric and Analysis Parameters		
Arrival Distribution	Select to "Exact Volume" instead of the default "Stochastic Volume"	
Auxiliary Lane Length	Use existing field measurements	Based on existing field measurements or design plans
Car Following Model	▪ Use the Wiedemann 74 car following model (arterial links) OR ▪ Use the Wiedemann 99 car following model (freeway links)	
Entry Traffic Volumes	Enter as 15-minute volumes for a period long enough to account for PHS and for a minimum of four 15-minute intervals	
	Use existing traffic count data	Based on projected traffic count data
Evaluations	Refer to the *VDOT VISSIM User Guide* for more detail on the different evaluation methods and guidance on coding each evaluation method (Node Evaluation, Data Collection Points, Queue Counter, Travel Time, Link Evaluation, and Network Performance)	
Heavy Vehicle Percentages (Vehicle Compositions)	Use existing count data	▪ Based on existing count data if future vehicle mix is projected to be similar to existing vehicle mix OR ▪ Based on projected future vehicle mix (minimum of 2%)
Link Length	▪ Arterial links should be broken at each intersection ▪ Freeway links should be broken according to *HCM* "Influence Area" definitions (i.e., weaving, merging, diverging)	
	For turn lanes, use effective storage length from existing field measurements	▪ For turn lanes, use effective storage length from existing field measurements for No-Build scenarios ▪ For turn lanes, use maximum queue length as a minimum for Build scenarios
Link Speed (Desired Speed Distributions)	Use existing speed data	▪ Based on existing speed data if the future geometry is similar to the existing geometry OR ▪ Use a linear distribution ranging +/- 5 mph from the posted speed limit (arterials) OR ▪ Use a linear distribution ranging from 3 mph below the posted speed limit to 10 mph above the posted speed limit (freeways)

Vissim Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Number of Microsimulation Runs	Based on the microsimulation sample size direction and guidance provided in Section 5.4 and the Sample Size Determination Tool	
Origin-Destination (O-D)	▪ Based on existing O-D data OR ▪ Routing decisions may be combined or set up as O-D	
Performance Measure Intervals	Report in one-hour intervals unless otherwise specified in project requirements	
Simulation Resolution	▪ Use minimum value of 10 ▪ This value shall not change between existing and future analyses	
Simulation Run Time	▪ A minimum of a one-hour peak period should be analyzed ▪ Determined by the peak period duration, which may extend beyond an hour ▪ Each evaluation time period should be 900 seconds (15 minutes) ▪ Future analyses should include the same simulation run time as existing analyses	
Turning Speed (Reduced Speed Areas)	▪ For right turns, use 7.5 mph to 15.5 mph ▪ For left turns, use 12.4 mph to 18.6 mph	
Vehicle Fleet	Use default vehicle fleet for North America provided by PTV in the Training Directory	
Signal Timing Input Parameters		
All-Red Time	Based on existing timing plans or field measurements	Based on guidance in the *Yellow Change Intervals and Red Clearance Intervals TED Memorandum (TE-306.1)*
Controller	Ring-Barrier Controller (RBC) is the preferred traffic signal emulator	
	Use existing timing plans or field observations	Based on existing timing plans unless otherwise directed by the VDOT project manager
Cycle Length	Use existing timing plans or field measurements	▪ Should range from 60 to 240 seconds and be approved by the VDOT project manager ▪ Given approval by the project manager, optimize cycle length to accommodate future conditions
Left-Turn Phasing	Use existing timing plans or field observations	Based on TED Guidance for Determination and Documentation of Left-Turn Phasing Mode
Max Green Mode	Use existing timing plans or field measurements	▪ Based on existing timing plans or field measurements OR ▪ Should be approved by the VDOT project manager

Vissim Input Parameter	Typical Value and/or Acceptable Ranges	
	Existing Conditions	Future Conditions
Max Recall	Use existing timing plans	▪ Based on existing timing plans OR ▪ Should be approved by the VDOT project manager
Minimum Green Time	Use existing timing plans or field measurements	▪ Based on existing timing plans or field measurements OR ▪ Should be approved by the VDOT project manager
Min Recall	Use existing timing plans	▪ Based on existing timing plans OR ▪ Should be approved by the VDOT project manager
Offset Reference	Use existing timing plans or field measurements	▪ Use HCS7 (TRANSYT-7F) or Synchro time-space diagrams ▪ Should be approved by the VDOT project manager
Yellow Time	Use existing timing plans or field measurements	Based on guidance in the *Yellow Change Intervals and Red Clearance Intervals TED Memorandum (TE-306.1)*
Pedestrian Input Parameters		
Flash Don't Walk Time	Use existing timing plans or field measurements	Based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy
Walk Time	Use existing timing plans or field measurements	Based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy

The input parameters listed below fall into the second category and do not require specific direction or guidance but should be adjusted to reflect field measurements, observations, or design plan data when data is available:

- Grade
- Number of lanes
- Lane configurations
- Lane restrictions
- Parking maneuvers
- Pavement
- Pedestrian traffic
- Transit information
- Turn movements
- Type(s) of auxiliary lanes

All other parameters not addressed in this chapter fall into the third and fourth categories. Adjustment of calibration parameters should be guided by the *VDOT VISSIM User Guide*; however, all other parameters should not be modified from the default value unless a modification is supported by data and approved by the VDOT project manager.

7.8.1 *Geometric and Analysis Input Parameters*

The following geometric and analysis input parameters require specific guidance:

- **Arrival Distribution:** Arrival distribution cannot be changed in Vissim. Set all input parameters to "Exact Volume" instead of the default of "Stochastic Volume" to reduce the number of microsimulation runs required.
- **Auxiliary Lanes:** Obtain effective auxiliary lane lengths from existing measurements or design plans.
- **Car Following Model:** For arterial links, use the Wiedemann 74 car following model. For freeway links, use the Wiedemann 99 car following model. If individual input parameters need to be changed, create a new driving behavior profile so the values may be modified as necessary. Provide justification for the modification of any factors.
- **Entry Traffic Volumes:** Traffic volume intervals will vary by project; however, code entry traffic volumes for a minimum of four, 15-minute intervals. Traffic volumes are entered in vehicles per hour even if the time period is not one hour. 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 PHS. For existing analyses, use existing 15-minute traffic volumes. For future analyses, use projected 15-minute traffic volumes.
- **Evaluations:** Vissim has numerous evaluation output file options available. The most common options are node evaluation, data collection points, queue counters, travel times, link evaluation, delay evaluation and network evaluation. Customize the content of each of these output files for the individual needs of each project and submit it for approval by the VDOT project manager at the start of the project. Refer to the *VDOT* VISSIM User Guide for more detail on the different evaluation methods and guidance on coding each evaluation method.
  - *Node Evaluation:* Should be used to evaluate intersections. Intersection microsimulation delay and maximum queues may be derived from node evaluation results.
  - *Data Collection Points:* May be used to collect MOEs at specific locations on a network, such as volumes and speeds. Data collection points collect time mean speed.
  - *Queue Counter:* Queue lengths at intersections should be obtained from the node evaluation; however, place queue counters at the stop line on each approach if additional queuing locations are necessary.
  - *Travel Time:* Travel time segments may be used report travel times through specific parts of a network. Travel time segments should be placed at the same start and end points as the field data collection runs.
  - *Link Evaluation:* May be used to report freeway link results, such as average space mean speed, volume, and density. Link Evaluation may be activated on a link-by-link basis for the full link or "by lane". 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.
  - *Network Performance:* Should only be used when system-wide MOEs, such as total microsimulation delays are reported.
- **Heavy Vehicle Percentages (Vehicle Compositions):** For existing analyses, calculate existing heavy vehicle percentages from existing traffic count data. For future analyses, use existing heavy vehicle percentages when future vehicle mix is expected to be similar to the existing vehicle mix; otherwise, use percentages representative of the projected future vehicle mix. When modifying the heavy vehicle percentages for future analyses, provide supporting documentation.
- **Link Length:** As a general practice, arterial links should be broken at each intersection. Along freeways, links should be broken according to the *HCM* definitions for Influence Areas (i.e., weaving, merging, diverging).

  - *Turn Lanes:* For existing and future no-build analyses, use the effective storage length, which is equal to the existing storage length plus half of the existing taper length. Obtain existing storage and taper lengths from existing field measurements or design plans. For future build analyses, determine the maximum queue length and use that length as the minimum storage length.
- **Link Speed (Desired Speed Distributions):** Use existing speed data for existing analyses. For future analyses, use existing speed data if the future geometry is similar to the existing geometry. Otherwise, for future analyses on arterial networks, use a linear distribution ranging +/- 5 mph of the posted speed limit and for future analyses on freeway networks, use a linear distribution ranging from 3 mph below the posted speed limit to 10 mph above the posted speed limit.
- **Number of Microsimulation Runs:** The minimum number of microsimulation runs shall be based on the VDOT Sample Size Determination Tool up to a maximum of 30 runs. An initial assumption of four microsimulation runs, with different random number seeds, will be performed prior to applying the methodology outlined in the VDOT Sample Size Determination Tool.
- **Simulation Resolution:** The number of times the position of a vehicle will be calculated within one simulated second (ranging from 1 to 10). The input parameter of one will result in the vehicles moving once per simulation second while an input parameter of 10 will result in the position of the vehicle being calculated 10 times per simulation second, thus making vehicles move more smoothly throughout the network. The change of simulation speed is inversely proportional to the number of time steps. A minimum value of 10 should be used on all models and this value shall not change between existing and future analyses.
- **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.
  - The seeding period refers to a period of simulation time prior to the analysis period(s) used to populate the model with enough vehicles to better represent field conditions. MOEs used for calibration and reporting should not be reported for seeding period. Typically, initialization time 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.
  - The simulation run time should be determined by the peak period duration, which may extend beyond an hour. Each time period should be 900 seconds (15 minutes). Analyze a minimum of a one-hour peak period in Vissim; in other words, analyze a minimum of four 15-minute time periods unless the peak period warrants additional time periods. Future analyses should include the same simulation run time as existing analyses.
- **Turning Speed (Reduced Speed Areas):** Reduced speed areas for turning vehicles should typically be set to “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 may be adjusted (with technical justification documentation) as needed during the calibration process to match real-world conditions.
- **Vehicle Fleet:** Use the default vehicle fleet for North America provided by PTV in the Training Directory. The directory is accessible by navigating to “Help/Examples/Open Training Directory/Vehicle Fleet & Settings Default/USA.”

7.8.2 *Signal Timing Input Parameters*

The following signal timing input parameters require specific guidance:

- **All-Red Time:** For existing analyses, obtain all-red time from existing timing plans or field measurements. For future analyses, compute all-red time based on the guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1).
- **Controller:** The Ring-Barrier Controller (RBC) is the preferred traffic signal emulator. Obtain existing traffic signal timing information from the entity that controls the traffic signal. If not available, measure

existing traffic signal timing information in the field during peak hour operations. Use existing traffic signal timings for existing analyses and use optimized traffic signal timings for future analyses.

  - *Timing Optimization:* Vissim does not have the functionality to optimize cycle length, splits, and lead/lag operations. Other tools such as HCS7 or Synchro should be used to optimize traffic signal timings. The use of the optimization functionality for existing and future analyses should be discussed with and approved by the VDOT project manager.

- **Cycle Length:** For existing analyses, obtain cycle lengths from existing timing plans or field measurements. For future analyses, cycle lengths shall be approved by the VDOT project manager. Typical cycle length values range from 60 to 240 seconds. Given approval by the project manager, optimize cycle lengths to accommodate future conditions.
- **Left-Turn Phasing:** For existing analyses, obtain left-turn type and right turn type from existing timing plans or field observations. For future analyses, base left-turn type on the following guidance from the latest VDOT *Guidance for Determination and Documentation of Left-Turn Mode* and should be approved by the VDOT project manager:
  - If there are two or more left-turn lanes on the approach, protect the left-turn phase.
  - If there are four or more through lanes on the opposing approach, protect the left-turn phase.
  - If the posted speed limit on the opposing approach is greater than 45 mph, protect the left-turn phase.
  - If there are two or three through lanes on the opposing approach and the product of the left-turn volume and the opposing right-turn/through volume is greater than 100,000 during the peak hour, the left-turn phase should be protected + permissive or protected only. Otherwise, the left-turn phase may be permissive.
  - If there is one through lane on the opposing approach and the product of the left-turn volume and the opposing right-turn/through volume is greater than 50,000 during the peak hour, the left-turn phase should be protected + permissive or protected only. Otherwise, the left-turn phase may be permissive.
- **Max Green Mode:** For existing analyses, obtain the max green mode to replicate existing timing plans or field measurements. For future analyses, use the existing max green mode or another max green mode approved by the VDOT project manager.
- **Max Recall:** For existing analyses, obtain max recall selected/not selected from existing timing plans. For future analyses, use the existing max recall or another max recall approved by the VDOT project manager.
- **Minimum Green Time:** For existing analyses, obtain minimum green times from existing timing plans or field measurements. For future analyses, use the existing minimum green time or another minimum green time approved by the VDOT project manager. Minimum green times should not be less than five seconds.
- **Min Recall:** For existing analyses, obtain min recall selected/not selected from existing timing plans. For future analyses, use the existing min recall or another min recall approved by the VDOT project manager.
- **Offset Reference:** For existing analyses, obtain offset references from existing timing plans or field measurements. For future analyses, optimize offsets using Synchro or HCS7 time-space diagrams.
- **Yellow Time:** For existing analyses, obtain yellow time from existing timing plans or field measurements. For future analyses, compute yellow time based on the guidance in the *Yellow Change Intervals and Red Clearance Intervals* TED Memorandum (TE-306.1).

7.8.3 *Pedestrian Input Parameters*

The following pedestrian input parameters require specific guidance:

- **Flash Don't Walk Time:** For existing analyses, obtain the flash don't walk time from existing timing plans or field measurements. For future analyses, compute the flash don't walk time based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy.
- **Walk Time:** For existing analyses, obtain the walk time from existing timing plans or field measurements. For future analyses, compute the walk time based on the latest guidance in the *MUTCD* and VDOT regional pedestrian policy.

7.9 AASHTO ARTERIAL SPREADSHEETS

The AASHTO *HSM* Spreadsheets were created by AASHTO and NCHRP to simplify the use of the *HSM Part C: Predictive Methods Spreadsheets*. Three separate spreadsheets have been created that may be used to predict crashes on rural two-lane roads, rural multilane highways, and urban and suburban arterials. The spreadsheet for urban and suburban arterials may be used to analyze five roadway types: two-lane undivided sections, three-lane sections (with a two-way left-turn lane), four-lane undivided sections, four-lane divided sections, and five-lane sections (with a two-way left-turn lane).

Input parameters in the AASHTO *HSM* Spreadsheets may be classified into the following two categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are not described in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are summarized in **Table 20**.

Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then apply the direction or guidance given to both existing and future analyses.

All other input parameters not addressed in this chapter fall into the second category and do not require specific direction or guidance, but should be adjusted to reflect field measurements, observations, and/or design plan data when data is available.

Table 20: AASHTO *HSM* Spreadsheets Standard Input Parameters

Input Parameter	Spreadsheet	Typical Value and/or Acceptable Ranges
$AADT_{major}$/$AADT_{minor}$	All	Use the larger value of two road legs for $AADT_{major}$ and $AADT_{minor}$
Driveway Density	Rural Two-Lane Roads	Calculate over the length of the entire study area facility
Major/Minor Driveways	Urban and Suburban Arterials	▪ Determine according to: ▪ Site characteristics OR ▪ Number of parking spaces (major = 50+) ▪ Assume two driveways for sites with continuous access along the property frontage
Number of Bus Stops/ Alcohol Sales Establishments	Urban and Suburban Arterials	Calculate only if located within 1,000 feet of the center of the intersection.
Observed Crashes	All	▪ Enter site-specific of project-specific crash data if an alternative contains only minor changes from the existing conditions ▪ Classify each crash if entering crash data per site: ▪ Intersection-related or segment-related ▪ Single-vehicle or multiple-vehicle (urban and suburban arterials) ▪ Driveway-related or non-driveway-related (urban and suburban arterials)
Roadside Hazard Rating	Rural Two-Lane Roads	Calculate average roadside hazard rating for a segment, provided that the difference between the maximum and minimum ratings throughout the segment should be less than two
Segment Length*	All	▪ Distance between the center of two intersections OR ▪ The break point between two homogenous segments

* Refer to bulleted guidance for special notes

7.9.1 *Geometric and Analysis Input Parameters*

The following geometric and analysis input parameters require specific guidance:

- **$AADT_{major}$/$AADT_{minor}$:** If the AADTs on the two major-road legs or on the two minor-road legs of an intersection differ, use the larger of the two values for $AADT_{major}$ or $AADT_{minor}$.
- **Driveway Density:** Use the driveway density over the length of the entire facility, rather than the segment-specific driveway density. The segment-specific driveway density may result in an inflated number of predicted crashes for segments shorter than 0.5 miles.
- **Major/Minor Driveways:** A major driveway is generally considered one that serves sites with 50 or more parking spaces while a minor driveway is generally considered one that serves sites with fewer than

50 parking spaces. The VDOT project manager may also classify driveways as major or minor based on the character of the establishment served by the driveway (e.g., the entrance to a high-turnover, fast-food restaurant with fewer than 50 parking spaces may be considered a major driveway). Sites with no restrictions on access along the entire property frontage should be considered to have two driveways.

- **Number of Bus Stops/Alcohol Sales Establishments:** This input parameter should only be considered if a bus stop or alcohol sales establishment is located within 1,000 feet of the center of the intersection in any direction.
- **Roadside Hazard Rating:** Roadside Hazard Rating is a seven-point categorical scale from 1 (best) to 7 (worst) to characterize crash potential for roadside designs on two-lane highways. An average roadside hazard rating for a segment should be used, provided that the difference between the maximum and minimum ratings throughout the segment is not greater than two.
- **Segment Length:** A roadway segment is a section of continuous road that is not interrupted by an intersection and consists of homogenous geometric features. A new segment should be created if any input parameter changes along a roadway. The *HSM* may be consulted for more specific guidance on how to properly segment a roadway for use with the AASHTO *HSM* spreadsheets. The length of a segment should be measured to or from the center of an intersection or the break point between two homogenous segments. For the rural two-lane road and rural multilane highway modules, the segment length should not be shorter than 0.10 miles.

7.9.2 Crash Data Input Parameters

The Empirical Bayes (EB) Method may be used to improve the reliability of the number of crashes produced from a predictive model by combining the model prediction with observed crash data. In cases where the EB Method will not be used to compare alternatives for future analyses, the user shall run the existing scenario using the EB Method only to gain an understanding of the reasonableness of the predictive model and not for comparison purposes. The AASHTO *HSM* Spreadsheets can implement the EB Method if the user inputs observed crashes on a site-specific or project-specific level. Guidance on when to use the EB Method is detailed in the *HSM Part C*.

The following crash data input parameter requires specific guidance:

- **Observed Crashes:** For future analyses, observed crashes should be entered on a site-specific or project-specific level if alternatives that are being compared only contain minor changes from the existing conditions. A minor change should be considered any change that does not affect the safety performance functions (SPFs) used in the analysis of the existing conditions (e.g., change in site type, area type, number of through lanes, traffic control type, alignment for a substantial portion of the project length). Observed crashes should not be entered for future analyses where any alternative contains a major change from the existing conditions. If observed crash data is used, at least two years, and preferably five years of crash data should be used if no major geometric or traffic control change has occurred during the period. If site-specific crash data is available, each crash shall be classified as an intersection-related or segment-related crash based on the guidance provided in the *HSM Part C* Appendix A.2. For analyses of urban and suburban arterials, each crash shall be further classified as a single-vehicle or multiple-vehicle crash and as a driveway-related or non-driveway-related crash.

7.10 IHSDM

IHSDM is a tool developed and distributed by FHWA to predict crashes at intersections and segments along rural two-lane roads, rural multilane highways, urban and suburban arterials, freeways, and ramps. IHSDM implements the arterial and freeway chapters of Part C of the *HSM* (Predictive Methods). Input parameters to IHSDM may be entered, viewed, and edited through the following editors:

1. Highway Editor
2. Intersection Editor
3. Ramp Terminal Editor
4. Site Set Editor

The Highway, Intersection, and Ramp Terminal Editors require location-based data (by either stations or mile points), while the Site Set Editor requires site-based data. Support facilities must be created prior to analyzing a specific facility using the location-based method (e.g. if the analysis includes an intersection, at least two highways must be established before the intersection can be created). The site-based method allows the user to create and analyze facilities independent of its supporting facilities.

Input parameters in IHSDM may be classified into the following two categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are not described in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are provided in **Sections 7.10.1** and **7.10.2** and are summarized in **Table 21**.

Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then apply the direction or guidance given to both existing and future analyses.

All other input parameters not addressed in this chapter fall into the second category and do not require specific direction or guidance, but should be adjusted to reflect field measurements, observations, and/or design plan data when data is available.

Table 21: IHSDM Standard Input Parameters

IHSDM Input Parameter	Model	Typical Value and/or Acceptable Ranges
AADT_{max}	- Rural Two-Lane Roads - Rural Multilane Highway - Urban and Suburban Arterials	Set equal to the larger value of two road legs

Crash Data	All	- Classify each crash severity:
		  - Fatal or nonfatal injury (K/A/B/C)
		  - Fatal or serious injury (K/A/B)
		  - Property damage only (O)
		- Classify each crash type:
		  - Unknown
		  - Single-vehicle
		  - Multiple-vehicle
		  - Driveway-related
		  - Vehicle-pedestrian
		  - Vehicle-bicycle

Driveway Density	Rural Two-Lane Roads	Length of the entire study area facility

Major/Minor Driveways	Urban and Suburban Arterials	- Determine according to:
		  - Site characteristics OR
		  - Number of parking spaces (major = 50+)
		- Assume two driveways for sites with continuous access along the property frontage

Number of Bus Stops/ Alcohol Sales Establishments/ Schools	Urban and Suburban Arterials	Calculate only if located within 1,000 feet of the center of the intersection.
Roadside Hazard Rating	Rural Two-Lane Roads	Calculate average roadside hazard rating for a segment, provided that the difference between the maximum and minimum ratings throughout the segment should be less than two
Segment Length*	- Rural Two-Lane Roads - Rural Multilane Highway - Urban and Suburban Arterials	- Distance between the center of two intersections OR - The break point between two homogenous segments

IHSDM Input Parameter	Model	Typical Value and/or Acceptable Ranges
Segment Length	Freeways and Ramps	Begin a new segment when there is a significant change in at least one of the following input parameters: number of through lanes; lane width; shoulder width; median width; ramp presence; clear zone width; merging/diverging ramp; C-D road presence
Ramp Entrance/Exit in Segment	Freeways and Ramps	Only consider when a segment contains ramp speed-change lane, lane add, or lane drop
EB Analysis	All	Select "None," "Whole-Project," or "Site-Specific"

* Refer to bulleted guidance for special notes

7.10.1 *Geometric and Analysis Input Parameters*

The following geometric and analysis input parameters require specific guidance:

- **AADT$_{max}$:** If the AADTs on the two major-road legs or on the two minor-road legs of an intersection differ, use the larger of the two values for AADT$_{max}$.
- **Driveway Density:** Use the driveway density over the length of the entire facility, rather than the segment-specific driveway density. The segment-specific driveway density may result in an inflated number of predicted crashes for segments shorter than 0.5 miles.
- **Major/Minor Driveways:** A major driveway is generally considered one that serves sites with 50 or more parking spaces while a minor driveway is generally considered one that serves sites with fewer than 50 parking spaces. The VDOT project manager may also classify driveways as major or minor based on the character of the establishment served by the driveway (e.g., the entrance to a high-turnover, fast-food restaurant with fewer than 50 parking spaces may be considered a major driveway). Sites with no restrictions on access along the entire property frontage should be considered to have two driveways.
- **Number of Bus Stops/Alcohol Sales Establishments/Schools:** This input parameter should only be considered if a bus stop, alcohol sales establishment, or school is located within 1,000 feet of the center of the intersection in any direction.
- **Roadside Hazard Rating:** Roadside Hazard Rating is a seven-point categorical scale from 1 (best) to 7 (worst) to characterize crash potential for roadside designs on two-lane highways. An average roadside hazard rating for a segment should be used, provided that the difference between the maximum and minimum ratings throughout the segment is not greater than two.
- **Segment Length:** A roadway segment is a section of continuous road that is not interrupted by an intersection and consists of homogenous geometric features. A new segment should be created if any input parameter changes along a roadway. The *HSM* may be consulted for more specific guidance on how to properly segment a roadway for use with IHSDM. The length of a segment should be measured to or from the center of an intersection or the break point between two homogenous segments. For the rural two-lane road and rural multilane highway modules, the segment length should not be shorter than 0.10 miles. A new segment should begin when there is a significant change in at least one of the following freeway input parameters.
    - Number of through lanes
    - Lane width
    - Shoulder width
    - Median width

  - Ramp presence
  - Clear zone width
  - Merging ramp or C-D road presence
  - Diverging ramp or C-D road presence
- **Ramp Entrance/Exit in Segment:** These input parameters should only be considered when a ramp speed-change lane, lane add, or lane drop is present in the segment. A speed-change lane or lane add/drop begins or ends at the gore point, which is the point at which the pair of solid white pavement edge markings that separate the ramp from the freeway main lanes are two feet apart.

7.10.2 *Crash Data Input Parameters*

The following crash data input parameters require specific guidance:

- **Empirical-Bayes Analysis:** The Empirical Bayes (EB) Method may be used to improve the reliability of the number of crashes produced from a predictive model by combining the model prediction with observed crash data.
  - *None:* In cases where the EB Method will not be used to compare alternatives for future analyses, run the 'no-build' scenario using the EB Method only to gain an understanding of the reasonableness of the predictive model and not for comparison purposes. IHSDM can implement the EB Method by considering observed crash data on a site-specific or project-specific level.
  - *Whole Project:* The project-specific EB Method is not recommended for use with this manual.
  - *Site-Specific Crash Data:* For future analyses, enter site-specific crash data if alternatives that are being compared only contain minor changes from the existing conditions. A minor change should be considered any change that does not affect the SPFs used in the analysis of the existing conditions (e.g., change in site type, area type, number of through lanes, traffic control type, alignment for a substantial portion of the project length). For future analyses where any alternative contains a major traffic control, alignment, or cross-section change from the existing conditions, do not include site-specific crash data. When site-specific analysis is selected, input the following additional inputs parameters:
- **Year of crash occurrence:** At least 2 years, and preferably 5 years, of crash data should be used.
- **Severity level:** Classify each crash as a fatal or nonfatal injury (K/A/B/C), fatal or serious injury (K/A/B) crash, or as a property damage only (O) crash.
- **Type:** Classify each crash as a single-vehicle, multiple-vehicle, driveway-related, vehicle-pedestrian, or vehicle-bicycle crash.
- **Evaluation Year:** The evaluation year is the period for which the safety performance is to be predicted. The minimum period for which safety performance can be predicted is one year.

7.11 ISATE

ISATe is a Microsoft® Excel-based tool that has been developed by FHWA. ISATe may be used to evaluate the safety performance of freeways, interchanges, ramps, and C-D roads by using SPFs, CMFs, and a local calibration factor, if available from VDOT, to estimate average crash frequency by crash type or by severity.

ISATe does not have default values. Input parameters may be classified into the following two categories:

1. Input parameters that require specific direction or guidance for proper application—these input parameters are described in this manual
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application—these input parameters are not described in this manual

Input parameters that fall into the first category require specific direction or guidance for proper application. These input parameters are provided in **Sections 7.11.1** and **7.11.2** and are summarized in **Table 22**. Some input parameters require different direction or guidance for existing and future analyses. If different direction or guidance is not provided, then the direction or guidance given should be applied to both existing and future analyses.

Table 22: ISATe Standard Input Parameters

ISATe Input Parameter	Typical Value and/or Acceptable Ranges
Crash Data Description	▪ Set as "Data for each individual segment" if each alternative contains only minor changes from the existing conditions ▪ Set as "No crash data" if any alternative contains a major change
Crash Period*	▪ Use at least two years of crash data (five years preferred) ▪ The first year of crash data and the last year of crash data.
Curve Radius	Exclude segments containing horizontal curves with radii less than 1,000 feet on freeway segments or less than 100 feet on ramp segments
Freeway Segment Crashes by Year	▪ Use at least two years of crash data (five years preferred) ▪ Classify each crash: ▪ fatal/injury or property damage only ▪ ramp related or non-ramp related ▪ single-vehicle or multiple vehicle
Ramp Entrance/Exit in Segment	Only consider when a segment contains ramp speed-change lane, lane add, or lane drop
Segment Length	Begin a new segment when there is a significant change in at least one of the following input parameters: number of through lanes; lane width; shoulder width; median width; ramp presence; clear zone width; merging/diverging ramp; C-D road presence
Study Period	The first year of analysis through the last year of analysis

* Refer to bulleted guidance for special notes

7.11.1 *Geometric and Analysis Input Parameters*

The following are geometric and analysis input parameters that require specific guidance:

- **Curve Radius:** ISATe is not designed to analyze curve radii less than 1,000 feet on freeway segments or less than 100 feet on ramp segments. For curves less than 1,000 or 100 feet on the respective facilities, the project team should review and determine if the curve radius can be increased to 1,000 or 100 feet for the analysis. If the radius cannot be increased, then exclude the segment containing the horizontal curve from the analysis.
- **Ramp Entrance/Exit in Segment:** These input parameters should only be considered when a ramp speed-change lane, lane add, or lane drop is present in the segment. A speed-change lane or lane add/drop begins or ends at the gore point, which is considered to be the point at which the pair of solid white pavement edge markings that separate the ramp from the freeway main lanes are two feet apart.
- **Segment Length:** A roadway segment is a section of continuous road that consists of homogenous geometric features. A new segment should begin when there is a significant change in at least one of the following input parameters. The ISATe User Manual may be consulted for more specific guidance on the segmentation of the network for analysis purposes.
  - Number of through lanes
  - Lane width
  - Shoulder width
  - Median width
  - Ramp presence
  - Clear zone width
  - Merging ramp or C-D road presence
  - Diverging ramp or C-D road presence

7.11.2 *Crash Data Input Parameters*

The Empirical Bayes (EB) Method may be used to improve the reliability of the number of crashes produced from a predictive model by combining the model prediction with observed crash data. In cases where the EB Method is not to be used to compare alternatives for future analyses, run the no-build scenario using only the EB Method to gain an understanding of the reasonableness of the predictive model and not for comparison purposes. ISATe can implement the EB Method by considering observed crash data on a site-specific or project-specific level. The project-specific EB Method is not recommended for use with this manual. Guidance on when to use the EB Method is detailed in the *HSM Part C*.

The following crash data input parameters require specific guidance:

- **Freeway Segment Crashes by Year:** Classify each crash as a fatal and injury crash or as a property-damage-only crash, and as a ramp-related crash or a non-ramp-related crash. For a segment with a ramp speed-change lane, consider a crash as ramp-related if it is located between the gore point and the taper point of the ramp speed-change lane. No crashes should be designated as ramp-related for a ramp entrance that adds a lane to the freeway cross-section or a ramp exit that removes a lane from the freeway cross-section. For a segment with a Type B weaving section (as defined in the ISATe user guide), a crash should be considered as ramp-related if it is located between the two gore points and the distance between the two gore points is less than 4,500 feet. If the distance between the two gore points exceeds 4,500 feet, the segment is no longer considered a Type B weave and no crashes should be designated as ramp-related. Any crash classified as a non-ramp-related crash shall also be classified as a multiple-vehicle crash or a single-vehicle crash.
- **Ramp Segment Crashes by Year:** Classify each crash as a fatal and injury crash or as a property damage only crash, and as a multiple-vehicle crash or as a single-vehicle crash.
- **Ramp Terminal Crashes by Year:** Classify each crash as a fatal and injury crash or as a property damage only crash.
- **Crash Data Description:** For future analyses where alternatives contain minor changes from the existing conditions, set this input parameter as "Data for Each Individual Segment." A minor change

should be considered any change that does not affect the base condition of the SPFs used in the analysis of the existing conditions (e.g., change in site type, area type, number of through lanes, traffic control type, alignment for a substantial portion of the project length). For future analyses where any alternative contains a major change from the existing conditions, this set this input parameter as "No Crash Data".

- **Study Period:** The study period is defined as the first year of analysis through the last year of analysis.
- **Crash Period:** The crash period is defined as the first year of crash data and the last year of crash data. Guidance on the number of years for crash data is provided in **Chapter 6**.

8 Outputs and Reporting

Both depictive and tabular reports are required for all analyses.

To provide a clear, accurate and effective depiction of traffic operations and safety performance, results should be conveyed in formats that are easy to digest and understand by both technical and non-technical audiences. This chapter describes outputs from the tools described in **Chapter 3** and provides recommended reporting formats to present the MOEs addressed in this manual. The VDOT project manager may request additional reporting requirements not discussed in this manual, such as congestion mapping or MOE statistics, such as standard deviation. The purpose of developing standardized output and reporting formats is twofold:

1. To provide consistent reporting formats to VDOT reviewers, reducing the review time required by VDOT staff and potential for requiring multiple submittals
2. To relay key MOE information from traffic and safety analysis tool outputs

Analysis tool outputs and reporting formats can be categorized as depictive or tabular. A depictive output format represents data and results with colors, shapes, and/or symbols along with numerical results. A tabular output format represents data and results in rows and columns.

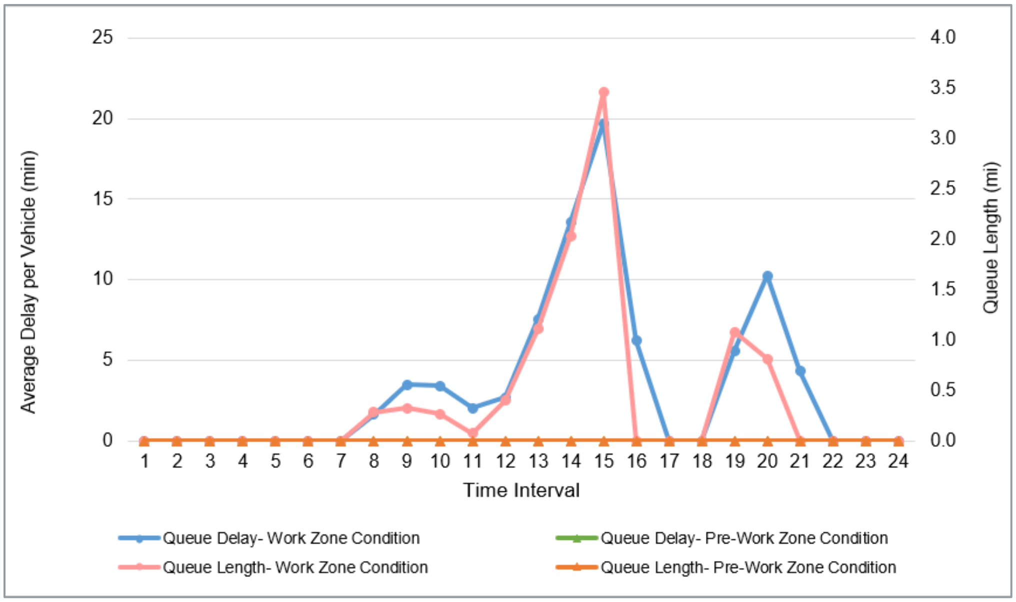
8.1 ANALYSIS TOOL OUTPUTS

The following sections of this chapter outline the outputs from each software tool. Software outputs shall be included with all submittals. Refer to **Table 2** in **Chapter 4** for information about which MOEs are outputted from each traffic operations and safety analysis tools.

8.1.1 *Work Zone Tools*

Outputs from the VDOT work zone tools are available as tabular and depictive summaries. All or a portion of each report can be exported from Microsoft Excel or copied to the system clipboard for insertion into reporting formats discussed in **Section 8.2. Figure 8** shows a sample depictive summary.

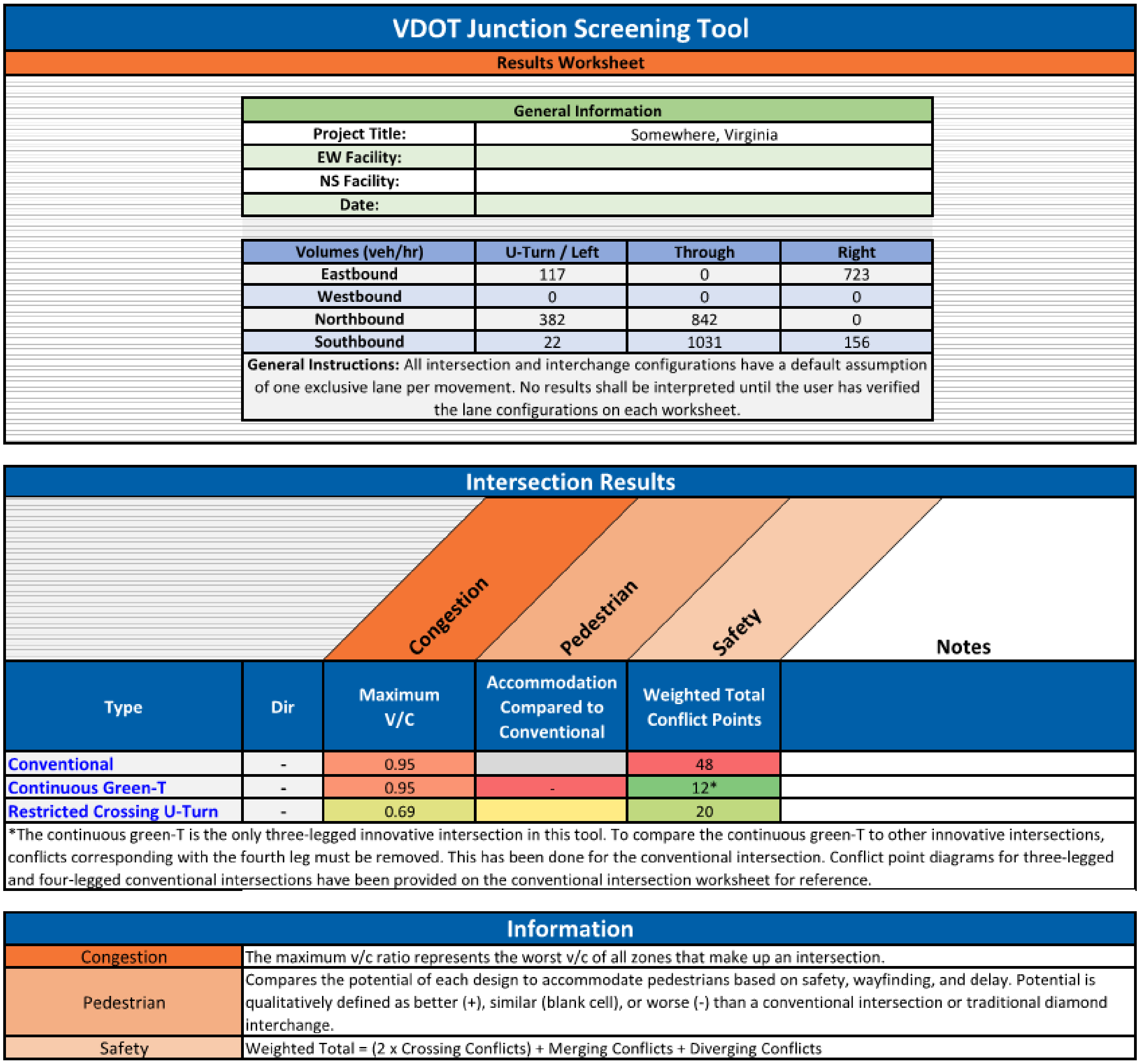
Figure 8: VDOT Freeway Basic Work Zone Tool Depictive Output



8.1.2 *VJuST*

VJuST generates summary reports that compare the effectiveness of intersection and interchange alternative configurations. A tabular summary, shown in **Figure 9**, presents a comparison of congestion, pedestrian, and safety MOEs. Depictive summaries, shown in **Figure 10**, are available for intersection and interchange alternatives.

Figure 9: VJuST Tabular Output



VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Somewhere, Virginia
EW Facility:	
NS Facility:	
Date:	

Volumes (veh/hr)	**U-Turn / Left**	**Through**	**Right**
Eastbound	117	0	723
Westbound	0	0	0
Northbound	382	842	0
Southbound	22	1031	156

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

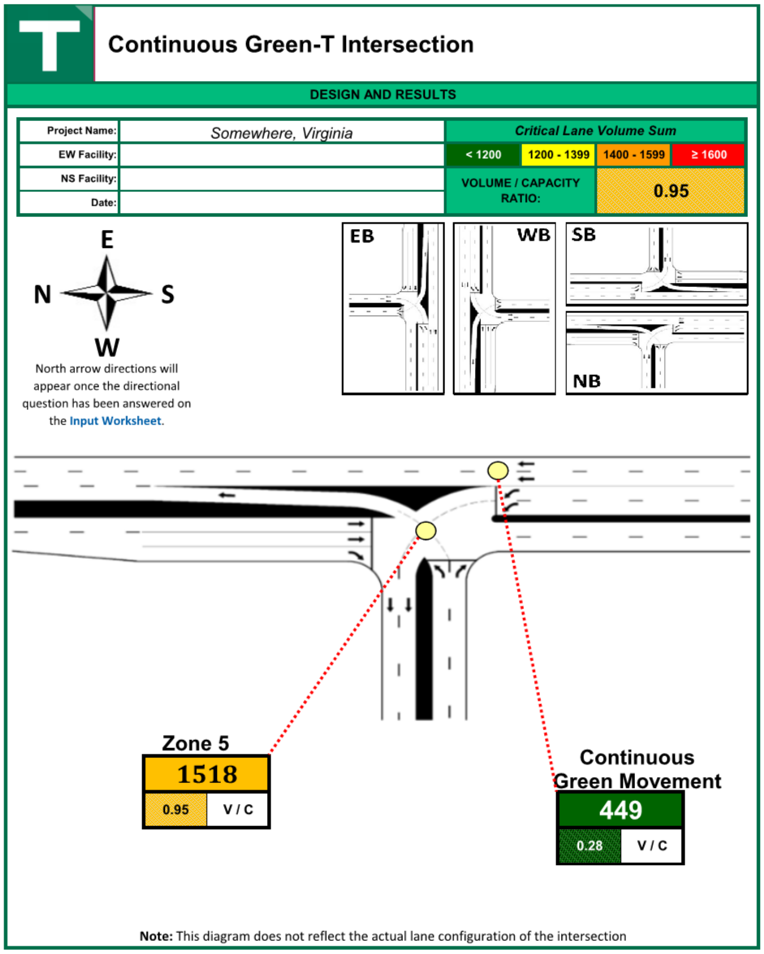
		Congestion	Pedestrian	Safety	Notes
Type	**Dir**	**Maximum V/C**	**Accommodation Compared to Conventional**	**Weighted Total Conflict Points**	
Conventional	-	0.95		48	
Continuous Green-T	-	0.95	-	12*	
Restricted Crossing U-Turn	-	0.69		20	

*The continuous green-T is the only three-legged innovative intersection in this tool. To compare the continuous green-T to other innovative intersections, conflicts corresponding with the fourth leg must be removed. This has been done for the conventional intersection. Conflict point diagrams for three-legged and four-legged conventional intersections have been provided on the conventional intersection worksheet for reference.

Information

Congestion	The maximum v/c ratio represents the worst v/c of all zones that make up an intersection.
Pedestrian	Compares the potential of each design to accommodate pedestrians based on safety, wayfinding, and delay. Potential is qualitatively defined as better (+), similar (blank cell), or worse (-) than a conventional intersection or traditional diamond interchange.
Safety	Weighted Total = (2 x Crossing Conflicts) + Merging Conflicts + Diverging Conflicts

Figure 10: VJuST Depictive Format



Continuous Green-T Intersection

DESIGN AND RESULTS

Project Name:	*Somewhere, Virginia*
EW Facility:	
NS Facility:	
Date:	

Critical Lane Volume Sum

< 1200	1200 - 1399	1400 - 1599	≥ 1600

VOLUME / CAPACITY RATIO: 0.95

North arrow directions will appear once the directional question has been answered on the Input Worksheet.

Zone 5
1518
0.95 V / C

Continuous Green Movement
449
0.28 V / C

Note: This diagram does not reflect the actual lane configuration of the intersection

8.1.3 *HCS*

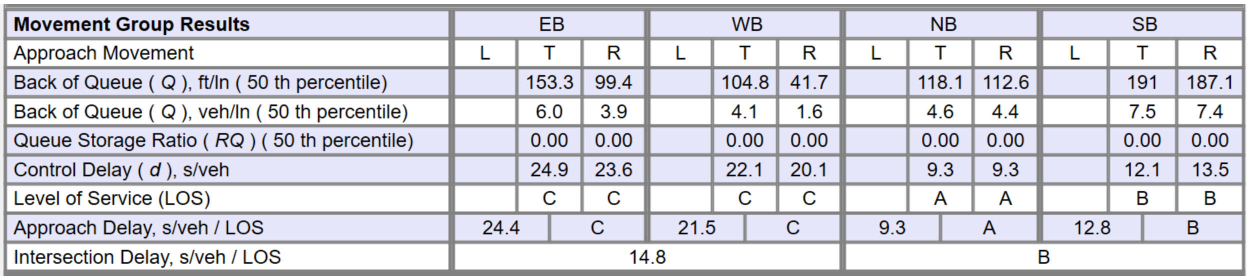
HCS shall only be used to report results for analyses operating in undersaturated conditions. HCS generates summary reports for each module, which include input data and analysis results. Outputs are available as formatted, tabular summaries, text reports, and depictive summaries. All or a portion of each report can be copied to the system clipboard for insertion into reporting formats discussed in **Section 8.2**.

Figure 11 shows a sample tabular summary**.** The following HCS output reports should be printed or saved to a PDF and submitted to VDOT within a report appendix:

- **Freeways:** HCS Freeways Report (Basic, Merge, Diverge, and/or Weaving)
- **Two-Lane Highways:** HCS Two-Lane Highways Text Report
- **Multi-lane Highway:** HCS Multilane Highway Report
- **Streets:** HCS Streets Full Report
- **TWSC:** HCS Two-Way Stop Control Report
- **AWSC:** HCS All-Way Stop Control Report

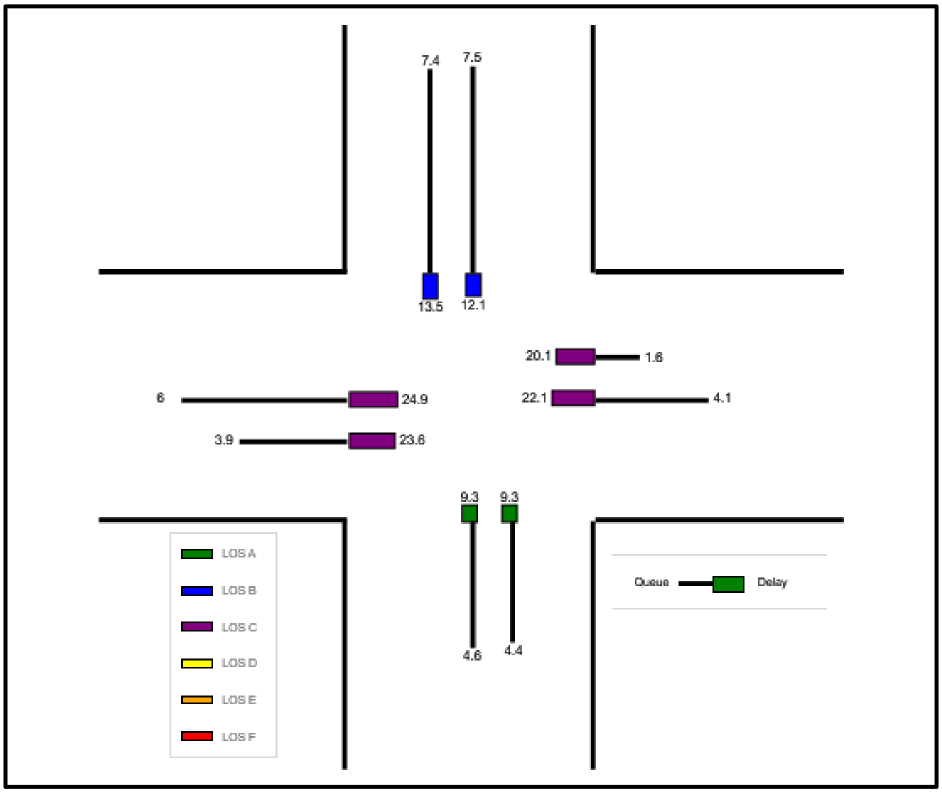
Depictive outputs may be included in the analysis report alongside the narrative. A depictive LOS summary, as shown in **Figure 12**, is included in the HCS Streets Full Report.

Figure 11: HCS Tabular Output



Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Back of Queue (*Q*), ft/ln (50 th percentile)		153.3	99.4		104.8	41.7		118.1	112.6		191	187.1
Back of Queue (*Q*), veh/ln (50 th percentile)		6.0	3.9		4.1	1.6		4.6	4.4		7.5	7.4
Queue Storage Ratio (*RQ*) (50 th percentile)		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Control Delay (*d*), s/veh		24.9	23.6		22.1	20.1		9.3	9.3		12.1	13.5
Level of Service (LOS)		C	C		C	C		A	A		B	B
Approach Delay, s/veh / LOS	24.4	C		21.5	C		9.3	A		12.8	B	
Intersection Delay, s/veh / LOS	14.8						B					

Figure 12: HCS Signalized Intersection Graphical Summary



8.1.4 *SIDRA Intersection*

SIDRA Intersection produces several output summaries, which may be included in the analysis report. Select the desired output reports and displays from the Output Options in the Settings Tab before processing the site. The following tabular reports should be exported and submitted to VDOT:

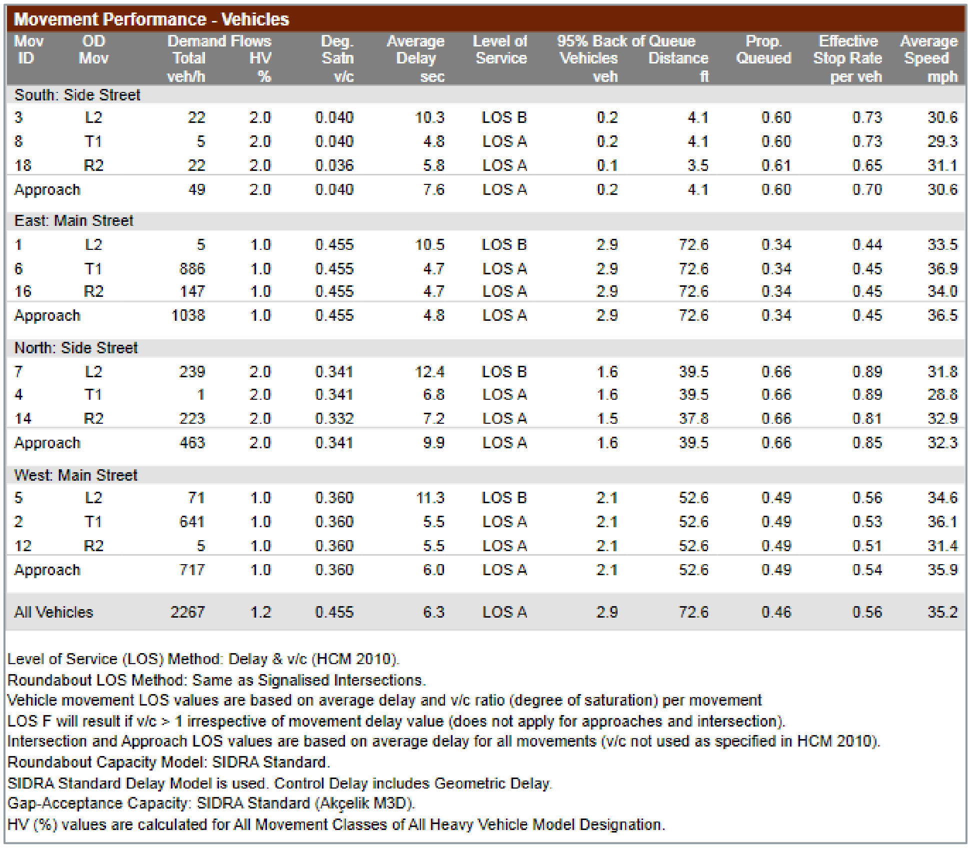
- Detailed Output
- Intersection Summary
- Movement Summary

The Movement Summary, shown in **Figure 13**, is a tabular output that summarizes v/c ratio, average control delay, LOS, 95th percentile queue length, and average speed for each movement. The following depictive outputs may be exported for reporting. Movement displays show arrows representing each movement that are color-coded based on the specified MOE.

- Control Delay Movement Display
- Level of Service Movement Display
- Degree of Saturation Movement Display
- 95th Percentile Vehicle Queue Movement Display

The Control Delay Movement Summary, shown in **Figure 14**, is a depictive output that summarizes average control delay by movement. Arrows representing each movement are color-coded based on the LOS of the movement.

Figure 13: SIDRA Intersection Movement Summary Tabular Output

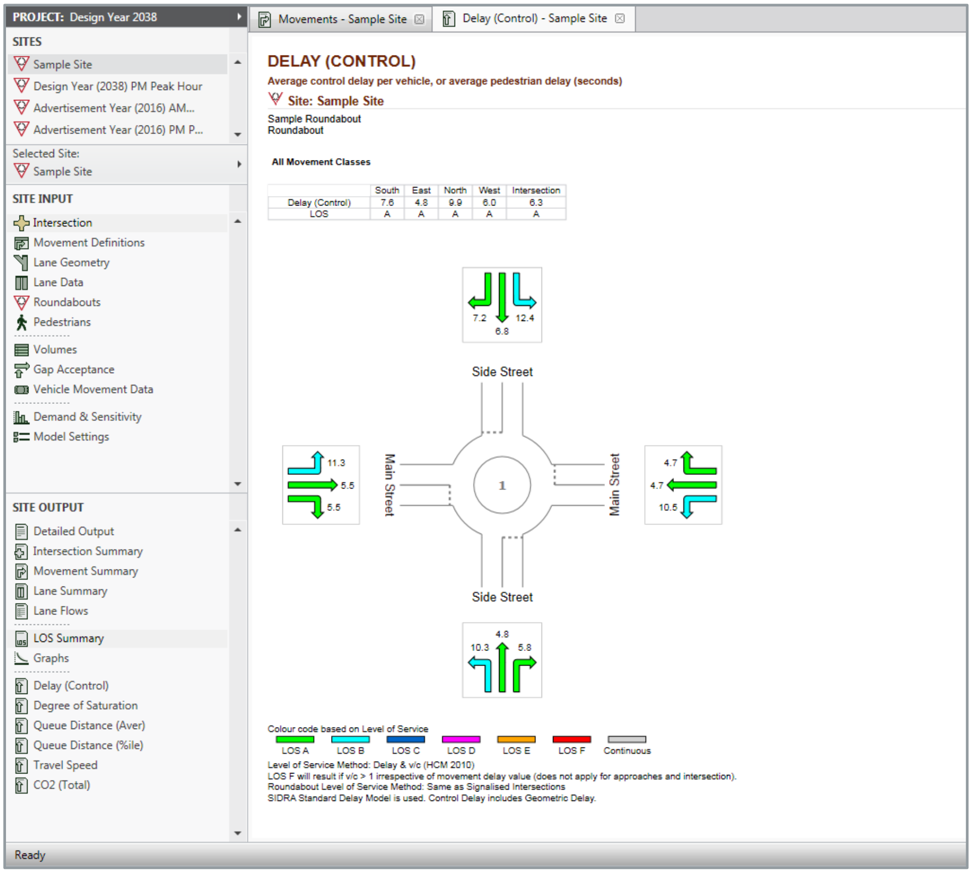


Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Side Street											
3	L2	22	2.0	0.040	10.3	LOS B	0.2	4.1	0.60	0.73	30.6
8	T1	5	2.0	0.040	4.8	LOS A	0.2	4.1	0.60	0.73	29.3
18	R2	22	2.0	0.036	5.8	LOS A	0.1	3.5	0.61	0.65	31.1
Approach		49	2.0	0.040	7.6	LOS A	0.2	4.1	0.60	0.70	30.6
East: Main Street											
1	L2	5	1.0	0.455	10.5	LOS B	2.9	72.6	0.34	0.44	33.5
6	T1	886	1.0	0.455	4.7	LOS A	2.9	72.6	0.34	0.45	36.9
16	R2	147	1.0	0.455	4.7	LOS A	2.9	72.6	0.34	0.45	34.0
Approach		1038	1.0	0.455	4.8	LOS A	2.9	72.6	0.34	0.45	36.5
North: Side Street											
7	L2	239	2.0	0.341	12.4	LOS B	1.6	39.5	0.66	0.89	31.8
4	T1	1	2.0	0.341	6.8	LOS A	1.6	39.5	0.66	0.89	28.8
14	R2	223	2.0	0.332	7.2	LOS A	1.5	37.8	0.66	0.81	32.9
Approach		463	2.0	0.341	9.9	LOS A	1.6	39.5	0.66	0.85	32.3
West: Main Street											
5	L2	71	1.0	0.360	11.3	LOS B	2.1	52.6	0.49	0.56	34.6
2	T1	641	1.0	0.360	5.5	LOS A	2.1	52.6	0.49	0.53	36.1
12	R2	5	1.0	0.360	5.5	LOS A	2.1	52.6	0.49	0.51	31.4
Approach		717	1.0	0.360	6.0	LOS A	2.1	52.6	0.49	0.54	35.9
All Vehicles		2267	1.2	0.455	6.3	LOS A	2.9	72.6	0.46	0.56	35.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Figure 14: SIDRA Intersection Control Delay Depictive Output



DELAY (CONTROL)

Average control delay per vehicle, or average pedestrian delay (seconds)

Site: Sample Site

Sample Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Control)	7.6	4.8	9.9	6.0	6.3
LOS	A	A	A	A	A

Colour code based on Level of Service

🟩	▬	▬	▬	▬	🟥	▭
LOS A	LOS B	LOS C	LOS D	LOS E	LOS F	Continuous

Level of Service Method: Delay & v/c (HCM 2010)
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Roundabout Level of Service Method: Same as Signalised Intersections
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

8.1.5 *Synchro*

Synchro shall only be used to report results in undersaturated conditions. Select the desired output report from the Reports dialog. The following tabular output reports should be exported and submitted to VDOT:

- *HCM*[1] Signalized
- *HCM*[1] AWSC
- *HCM*[1] TWSC

Select the *HCM* 6th Edition methodology for reporting Synchro analyses, unless the analysis includes intersections with non-NEMA phasing, intersections with five or more legs, or clustered intersections. *HCM* 2000 methodology should be used for reporting all Synchro analyses that fall under these limitations. If one or more intersections in a network require the use of *HCM* 2000 methodology, the VDOT project manager may decide to use the *HCM* 2000 methodology for reporting the entire network.

Once a report is selected, select which data to include in the options dialog. At a minimum, select the defaults option, which includes lane inputs and outputs, volume inputs and outputs, simulation settings, detector

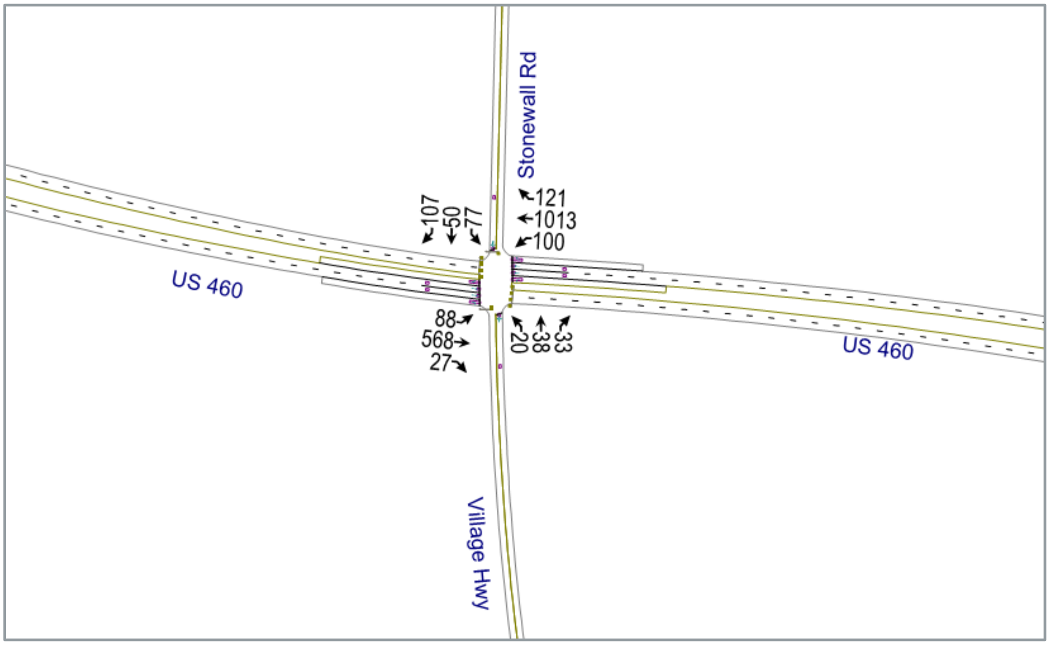
---

[1] The *HCM* methodology version will vary depending on intersection conditions. *HCM 2000* methodology should be used for reporting all Synchro analyses that fall under the limitations listed in this section.

settings, level of service, timing inputs, v/c ratios, delay, and actuated inputs. Configure header and footer options to include the project name and analysis period.

Depictive views of each intersection may be exported from Synchro. Select Print Window from the File dialog to capture intersection configurations to be used in analysis reports. **Figure 15** shows an exported window that displays movement volumes at each intersection.

Figure 15: Synchro Intersection Turning Movement Volumes Depictive Output



8.1.6 *SimTraffic*

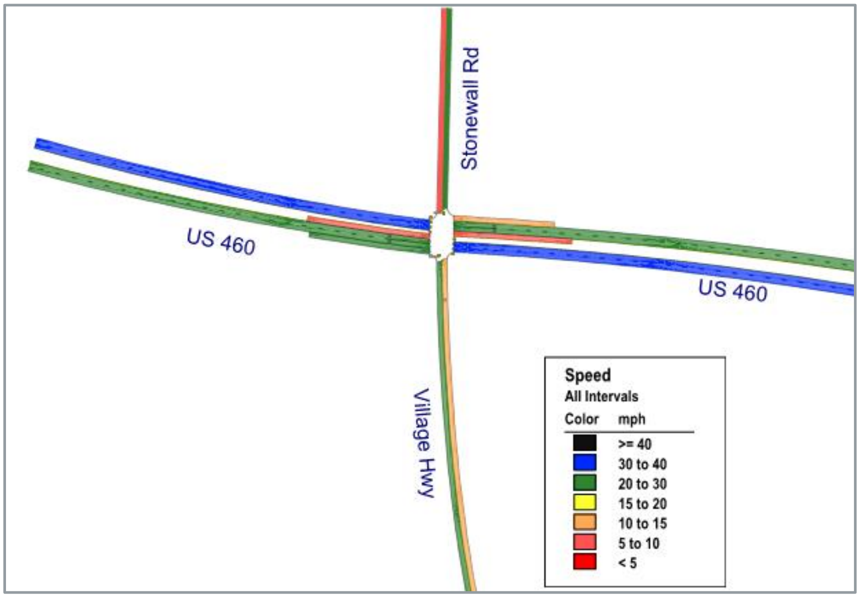
SimTraffic generates summary reports after recording simulation intervals. Select the Create Reports button from the Reports tab. The following tabular output reports should be exported and submitted to VDOT:

- Simulation Summary Report
- Queuing Information
- Actuated Timings
- Performance Report

Select Multiple Runs in the Reports dialog prior to exporting the report to generate a report that averages the results of multiple runs. Configure header and footer options to include the project name and analysis period. Select which data to include in the Performance Report options dialog. At a minimum, select the defaults option.

Depictive views of each intersection may be exported from SimTraffic. Static graphics are available for several MOEs including delay per vehicle, stopped delay per vehicle, stops per vehicle, average speed, and queues. Select Static Graphics from the Options ribbon, and the select the desired MOE from the list. Select Print Window from the File dialog to capture depictive summaries to be used in analysis reports. **Figure 16** shows an exported window that displays speed along each intersection leg.

Figure 16: SimTraffic Average Speed Depictive Output



8.1.7 *FREEVAL*

FREEVAL continuously computes segment and period outputs and performance measures as inputs are entered. Tabular outputs may be viewed and exported by selecting the Single Seed/Scenario I/O, Analysis Period Summary or Segment & Facility Summary tab. All or a portion of each report can be copied to the system clipboard for insertion into reporting formats discussed in **Section 8.2**.

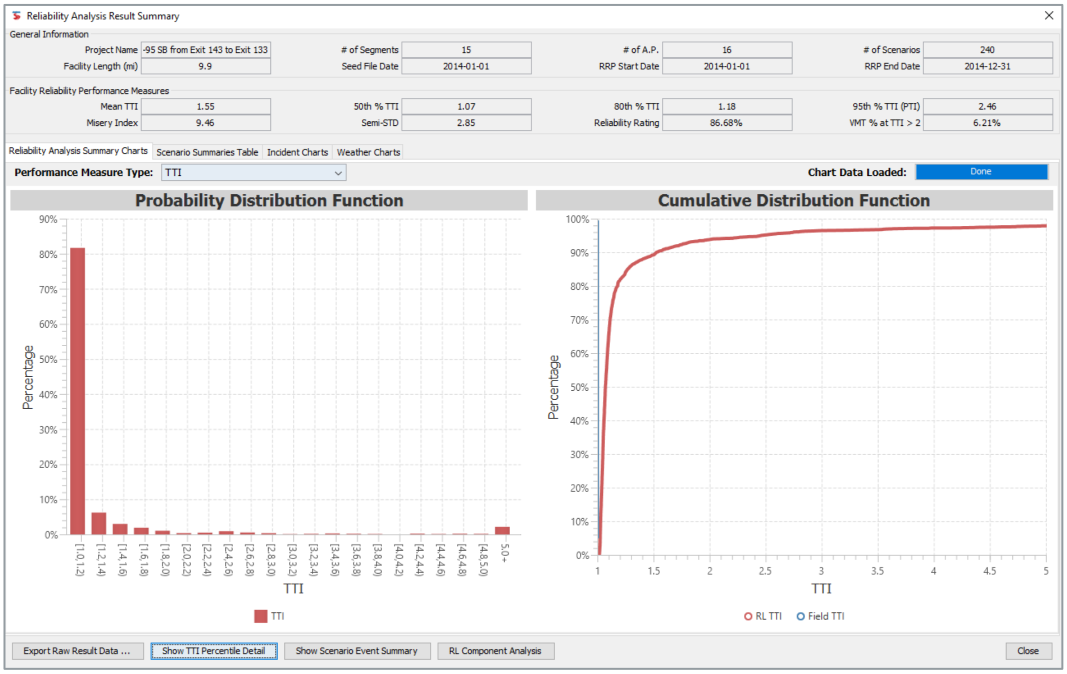
FREEVAL tabular outputs may be viewed or exported as contour plots. Select the Result Contours tab and specify which MOE to display: speed, density, v/c ratio, or queue.

Results from reliability analyses may be viewed in the Reliability Analysis Result Summary tab. **Figure 17** shows an example Reliability Analysis Summary Chart. These depictive reports can be displayed TTI, speed, and travel time.

The following tabular reliability analysis summaries can also be displayed:

- Scenario Summaries Table, as shown in **Figure 18**
- Incident Charts
- Weather Charts

Figure 17: FREEVAL Reliability Analysis Depictive Output



Reliability Analysis Result Summary

General Information

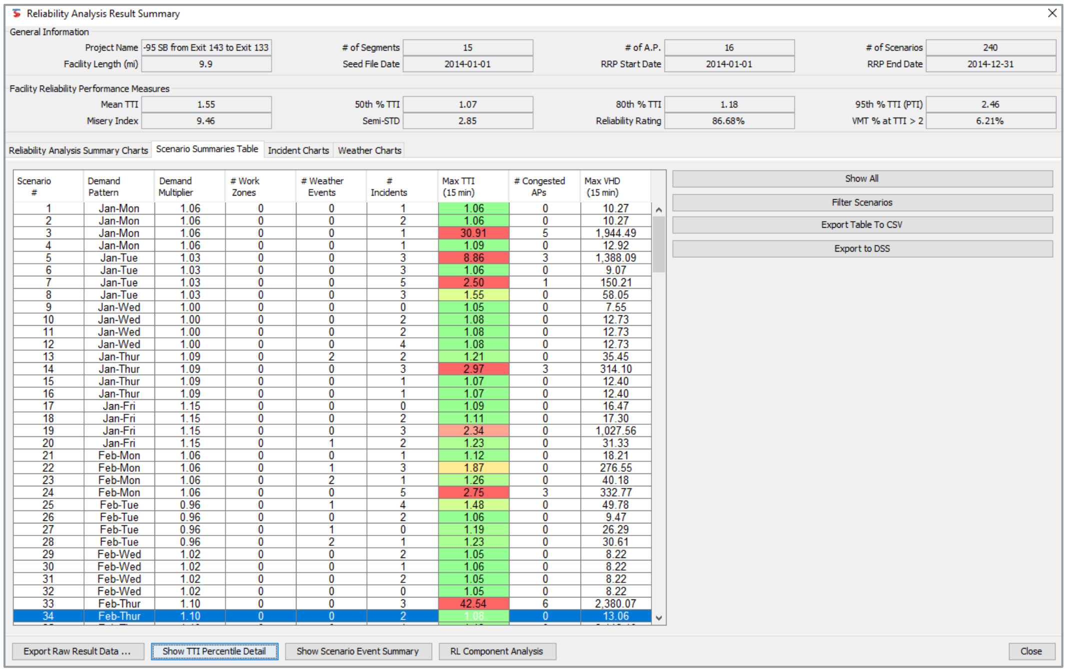
Project Name: I-95 SB from Exit 143 to Exit 133
Facility Length (mi): 9.9
# of Segments: 15
Seed File Date: 2014-01-01
# of A.P.: 16
RRP Start Date: 2014-01-01
# of Scenarios: 240
RRP End Date: 2014-12-31

Facility Reliability Performance Measures

Mean TTI: 1.55
Misery Index: 9.46
50th % TTI: 1.07
Semi-STD: 2.85
80th % TTI: 1.18
Reliability Rating: 86.68%
95th % TTI (PTI): 2.46
VMT % at TTI > 2: 6.21%

Performance Measure Type: TTI
Chart Data Loaded: Done

Figure 18: FREEVAL Reliability Analysis Tabular Output



Reliability Analysis Result Summary

General Information

Project Name: I-95 SB from Exit 143 to Exit 133
Facility Length (mi): 9.9
# of Segments: 15
Seed File Date: 2014-01-01
# of A.P.: 16
RRP Start Date: 2014-01-01
# of Scenarios: 240
RRP End Date: 2014-12-31

Facility Reliability Performance Measures

Mean TTI: 1.55
Misery Index: 9.46
50th % TTI: 1.07
Semi-STD: 2.85
80th % TTI: 1.18
Reliability Rating: 86.68%
95th % TTI (PTI): 2.46
VMT % at TTI > 2: 6.21%

Scenario #	Demand Pattern	Demand Multiplier	# Work Zones	# Weather Events	# Incidents	Max TTI (15 min)	# Congested APs	Max VHD (15 min)
1	Jan-Mon	1.06	0	0	1	1.06	0	10.27
2	Jan-Mon	1.06	0	0	2	1.06	0	10.27
3	Jan-Mon	1.06	0	0	1	30.91	5	1,944.49
4	Jan-Mon	1.06	0	0	1	1.09	0	12.92
5	Jan-Tue	1.03	0	0	3	8.86	3	1,388.09
6	Jan-Tue	1.03	0	0	3	1.06	0	9.07
7	Jan-Tue	1.03	0	0	5	2.50	1	150.21
8	Jan-Tue	1.03	0	0	3	1.55	0	58.05
9	Jan-Wed	1.00	0	0	0	1.05	0	7.55
10	Jan-Wed	1.00	0	0	2	1.08	0	12.73
11	Jan-Wed	1.00	0	0	2	1.08	0	12.73
12	Jan-Wed	1.00	0	0	4	1.08	0	12.73
13	Jan-Thur	1.09	0	2	2	1.21	0	35.45
14	Jan-Thur	1.09	0	0	3	2.97	3	314.10
15	Jan-Thur	1.09	0	0	1	1.07	0	12.40
16	Jan-Thur	1.09	0	0	1	1.07	0	12.40
17	Jan-Fri	1.15	0	0	0	1.09	0	16.47
18	Jan-Fri	1.15	0	0	2	1.11	0	17.30
19	Jan-Fri	1.15	0	0	3	2.34	0	1,027.56
20	Jan-Fri	1.15	0	1	2	1.23	0	31.33
21	Feb-Mon	1.06	0	0	1	1.12	0	18.21
22	Feb-Mon	1.06	0	1	3	1.87	0	276.55
23	Feb-Mon	1.06	0	2	1	1.26	0	40.18
24	Feb-Mon	1.06	0	0	5	2.75	3	332.77
25	Feb-Tue	0.96	0	1	4	1.48	0	49.78
26	Feb-Tue	0.96	0	0	2	1.06	0	9.47
27	Feb-Tue	0.96	0	1	0	1.19	0	26.29
28	Feb-Tue	0.96	0	2	1	1.23	0	30.61
29	Feb-Wed	1.02	0	0	2	1.05	0	8.22
30	Feb-Wed	1.02	0	0	1	1.06	0	8.22
31	Feb-Wed	1.02	0	0	2	1.05	0	8.22
32	Feb-Wed	1.02	0	0	0	1.05	0	8.22
33	Feb-Thur	1.10	0	0	3	42.54	6	2,380.07
34	Feb-Thur	1.10	0	0	2	1.08	0	13.06

8.1.8 *Vissim*

Vissim outputs may be processed to report results graphically. **Figure 19** shows a depictive freeway schematic that was created using a Microsoft® Excel-based macro. This template includes actual volumes, simulated volumes, link distances, speeds, and densities. Results are reported both by segment and by lane. With this template, select MOEs can be color coded to help the reviewer interpret the results. Instructions for the Microsoft® Excel-based macro used to create this template are provided in **Appendix F**. Additionally, the individual conducting the analysis should electronically submit output files for each individual microsimulation run to the reviewing agency(ies).

Refer to the *VDOT* VISSIM User Guide for additional ways to visualize and report Vissim model outputs.

8.1.9 *AASHTO HSM Spreadsheets Output Formats*

The AASHTO *HSM* Spreadsheets generates a report titled "Project Safety Performance Summary" that includes input data and analysis results. Outputs are available within the formatted, tabular summary. A depictive chart of the anticipated average crashes per year is provided. All or a portion of each report can be copied to the system clipboard for insertion into reporting formats discussed in **Section 8.2**.

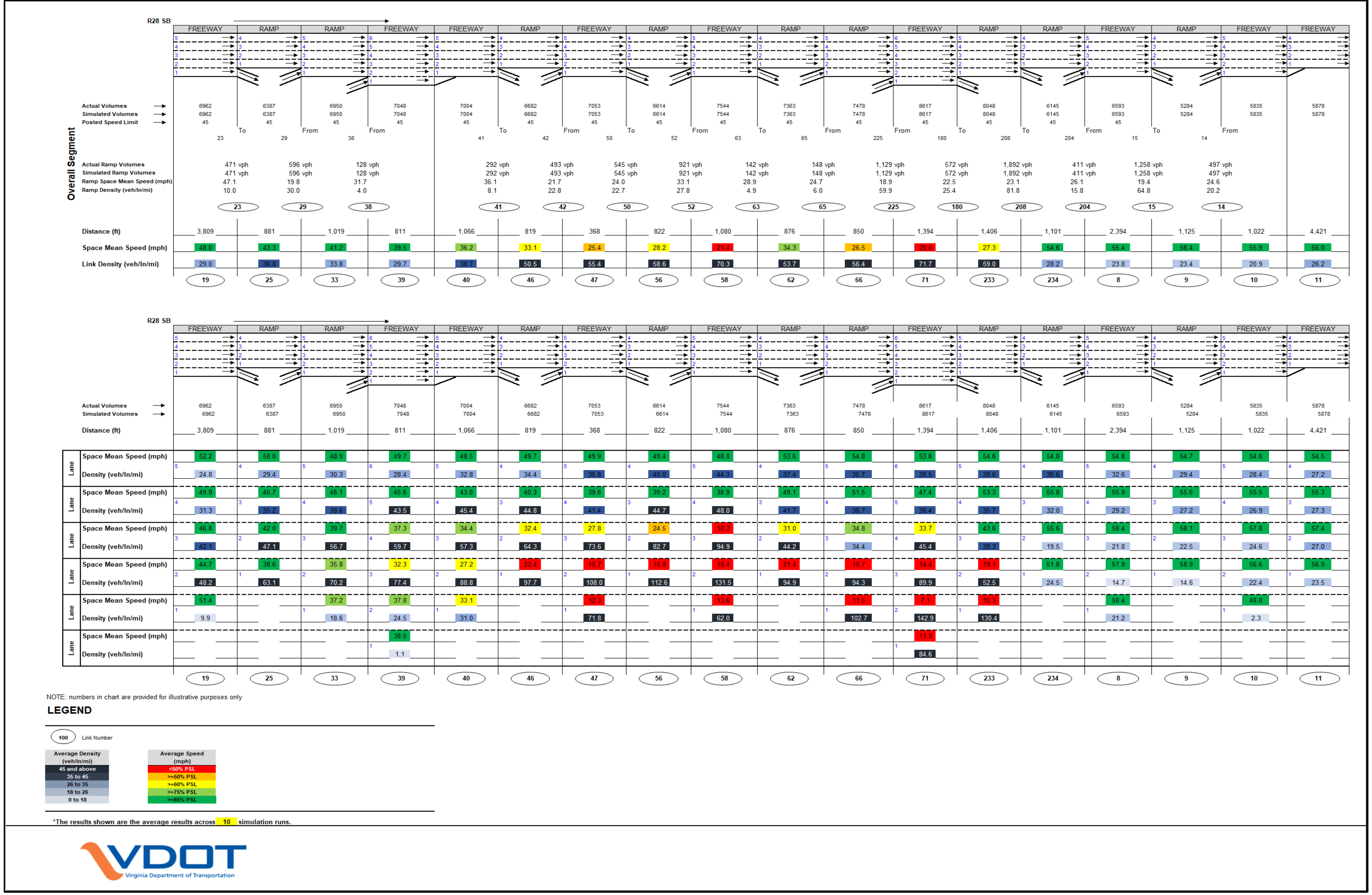
8.1.10 *IHSDM Output Formats*

IHSDM outputs evaluation reports for each module. The Crash Prediction Evaluation Report should be submitted to VDOT in its entirety. The report includes tabular output summaries that summarize the highway and intersection data used for the evaluation and expected crash frequencies and rates. The following tables are included in the Crash Prediction Evaluation Report:

- Report Overview
- Evaluation Highway Summary Table
- Evaluation Intersection Summary Table
- Predicated Highway Crash Rates and Frequencies Summary Table
- Predicted Crash Frequencies and Rates by Highway Segment/Intersection Table
- Predicted Crash Frequencies by Horizontal Design Table
- Predicted Crash Frequencies by Year Table
- Predicted Crash Type Distribution Table

A depictive crash prediction summary showing a histogram of expected crash rates is shown in **Figure 20**. A sample tabular output summary is shown in **Figure 21**.

Figure 19: Vissim Freeway Lane Schematic Depictive Format



Overall Segment

	FREEWAY	RAMP	RAMP	FREEWAY	FREEWAY	RAMP	FREEWAY	RAMP	FREEWAY	RAMP	RAMP	FREEWAY	RAMP	RAMP	FREEWAY	RAMP	FREEWAY	FREEWAY
Actual Volumes →	6962	6387	6950	7048	7004	6682	7053	6614	7544	7363	7478	8617	8048	6145	6593	5284	5835	5878
Simulated Volumes →	6962	6387	6950	7048	7004	6682	7053	6614	7544	7363	7478	8617	8048	6145	6593	5284	5835	5878
Posted Speed Limit →	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45			
Distance (ft)	3,809	881	1,019	811	1,066	819	368	822	1,080	876	850	1,394	1,406	1,101	2,394	1,125	1,022	4,421
Space Mean Speed (mph)	48.0	43.3	41.2	39.5	36.2	33.1	25.4	28.2	21.4	34.3	26.5	20.0	27.3	54.6	55.4	56.4	55.9	56.0
Link Density (veh/ln/mi)	29.0	36.8	33.8	29.7	38.7	50.5	55.4	58.6	70.3	53.7	56.4	71.7	59.0	28.2	23.8	23.4	20.9	26.2
	19	25	33	39	40	46	47	56	58	62	66	71	233	234	8	9	10	11

	To	From	From	To	From	To	From	To	From	From	To	To	From	To	From
	23	29	38	41	42	50	52	63	65	225	180	208	204	15	14
Actual Ramp Volumes	471 vph	596 vph	128 vph	292 vph	493 vph	545 vph	921 vph	142 vph	148 vph	1,129 vph	572 vph	1,892 vph	411 vph	1,258 vph	497 vph
Simulated Ramp Volumes	471 vph	596 vph	128 vph	292 vph	493 vph	545 vph	921 vph	142 vph	148 vph	1,129 vph	572 vph	1,892 vph	411 vph	1,258 vph	497 vph
Ramp Space Mean Speed (mph)	47.1	19.8	31.7	36.1	21.7	24.0	33.1	28.9	24.7	18.9	22.5	23.1	26.1	19.4	24.6
Ramp Density (veh/ln/mi)	10.0	30.0	4.0	8.1	22.8	22.7	27.8	4.9	6.0	59.9	25.4	81.8	15.8	64.8	20.2
	23	29	38	41	42	50	52	63	65	225	180	208	204	15	14

	FREEWAY	RAMP	RAMP	FREEWAY	FREEWAY	RAMP	FREEWAY	RAMP	FREEWAY	RAMP	RAMP	FREEWAY	RAMP	RAMP	FREEWAY	RAMP	FREEWAY	FREEWAY
Actual Volumes →	6962	6387	6950	7048	7004	6682	7053	6614	7544	7363	7478	8617	8048	6145	6593	5284	5835	5878
Simulated Volumes →	6962	6387	6950	7048	7004	6682	7053	6614	7544	7363	7478	8617	8048	6145	6593	5284	5835	5878
Distance (ft)	3,809	881	1,019	811	1,066	819	368	822	1,080	876	850	1,394	1,406	1,101	2,394	1,125	1,022	4,421
Lane: Space Mean Speed (mph)	52.2	50.0	48.9	49.7	48.5	49.7	49.9	49.4	48.8	53.6	54.8	53.8	54.6	54.8	54.8	54.7	54.6	54.5
Lane: Density (veh/ln/mi)	5 24.8	4 29.4	5 30.3	6 28.4	5 32.8	4 34.4	5 35.8	4 40.0	5 44.3	4 37.4	5 35.7	6 38.5	5 38.6	4 36.6	5 32.6	4 29.4	5 28.4	4 27.2
Lane: Space Mean Speed (mph)	49.9	46.7	46.1	45.6	43.8	40.3	39.6	39.2	38.9	49.1	51.5	47.4	53.3	55.8	55.9	55.6	55.5	55.3
Lane: Density (veh/ln/mi)	4 31.3	3 35.2	4 39.6	5 43.5	4 45.4	3 44.8	4 41.4	3 44.7	4 48.0	3 41.7	4 38.7	5 38.4	4 35.7	3 32.0	4 29.2	3 27.2	4 26.9	3 27.3
Lane: Space Mean Speed (mph)	46.8	42.0	39.7	37.3	34.4	32.4	27.8	24.5	18.3	31.0	34.8	33.7	43.6	55.6	58.4	58.1	57.8	57.4
Lane: Density (veh/ln/mi)	3 42.1	2 47.1	3 56.7	4 59.7	3 57.3	2 64.3	3 73.6	2 82.7	3 94.9	2 44.2	3 34.4	4 45.4	3 39.3	2 19.5	3 21.8	2 22.5	3 24.6	2 27.0
Lane: Space Mean Speed (mph)	44.7	38.6	35.8	32.3	27.2	22.4	15.7	15.8	10.4	21.4	15.7	14.4	19.1	51.8	57.9	58.9	56.6	56.9
Lane: Density (veh/ln/mi)	2 48.2	1 63.1	2 70.2	3 77.4	2 88.8	1 97.7	2 108.0	1 112.6	2 131.5	1 94.9	2 94.3	3 89.9	2 52.5	1 24.5	2 14.7	1 14.6	2 22.4	1 23.5
Lane: Space Mean Speed (mph)	51.4		37.2	37.8	33.1		12.3		13.6		11.5	7.1	10.3		50.4		48.0	
Lane: Density (veh/ln/mi)	1 9.9		1 18.6	2 24.5	1 31.0		1 71.8		1 62.0		1 102.7	2 142.9	1 130.4		1 21.2		1 2.3	
Lane: Space Mean Speed (mph)				38.5								11.9						
Lane: Density (veh/ln/mi)				1 1.1								1 84.6						
	19	25	33	39	40	46	47	56	58	62	66	71	233	234	8	9	10	11

NOTE: numbers in chart are provided for illustrative purposes only

LEGEND

(100) Link Number

Average Density (veh/ln/mi)
45 and above
35 to 45
26 to 35
18 to 26
0 to 18

Average Speed (mph)
🟥 <50% PSL
🟧 >=50% PSL
🟨 >=60% PSL
🟩 >=75% PSL
🟩 >=85% PSL

*The results shown are the average results across 10 simulation runs.

Figure 20: IHSDM Crash Predication Summary Depictive Output

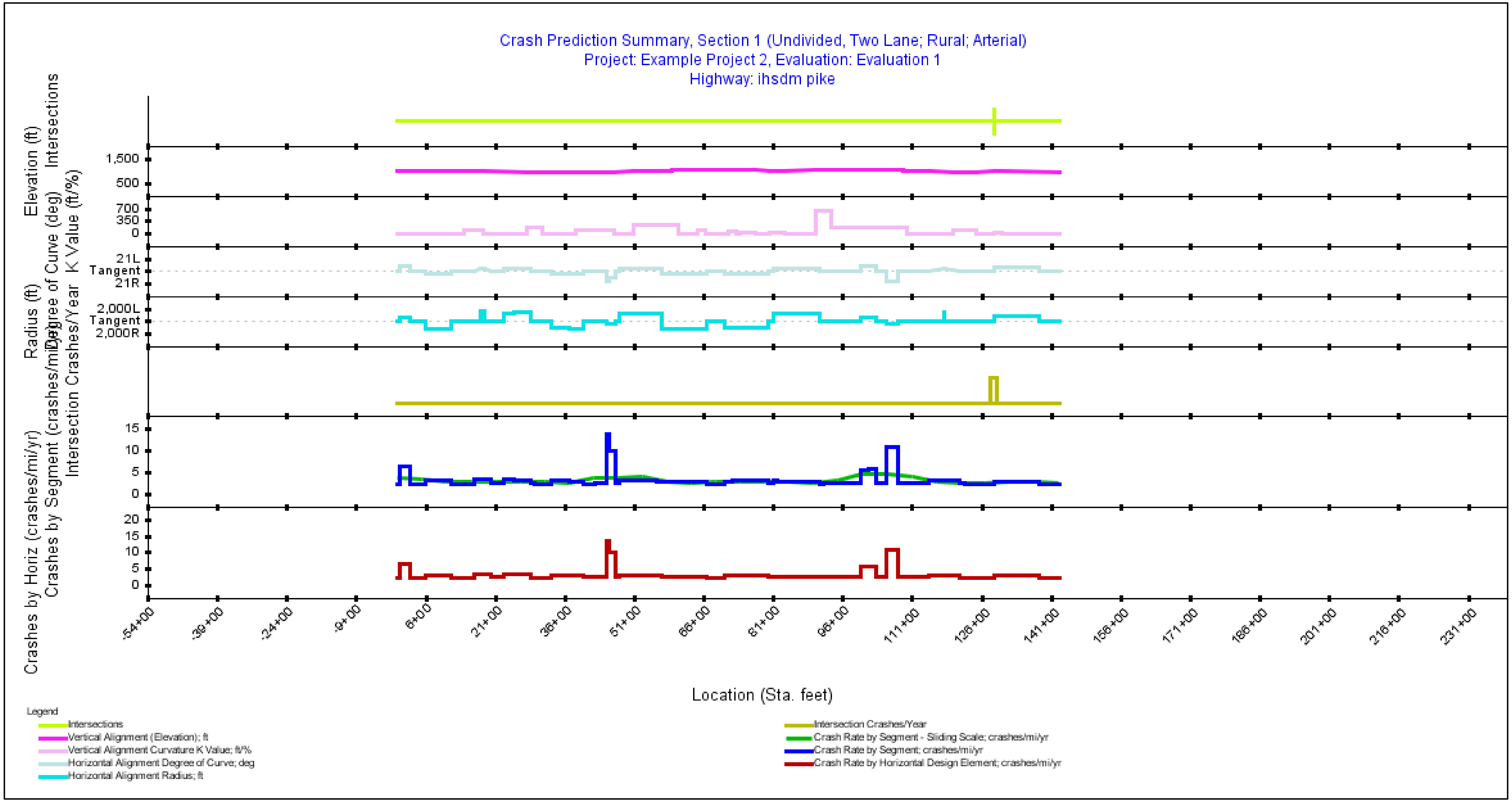
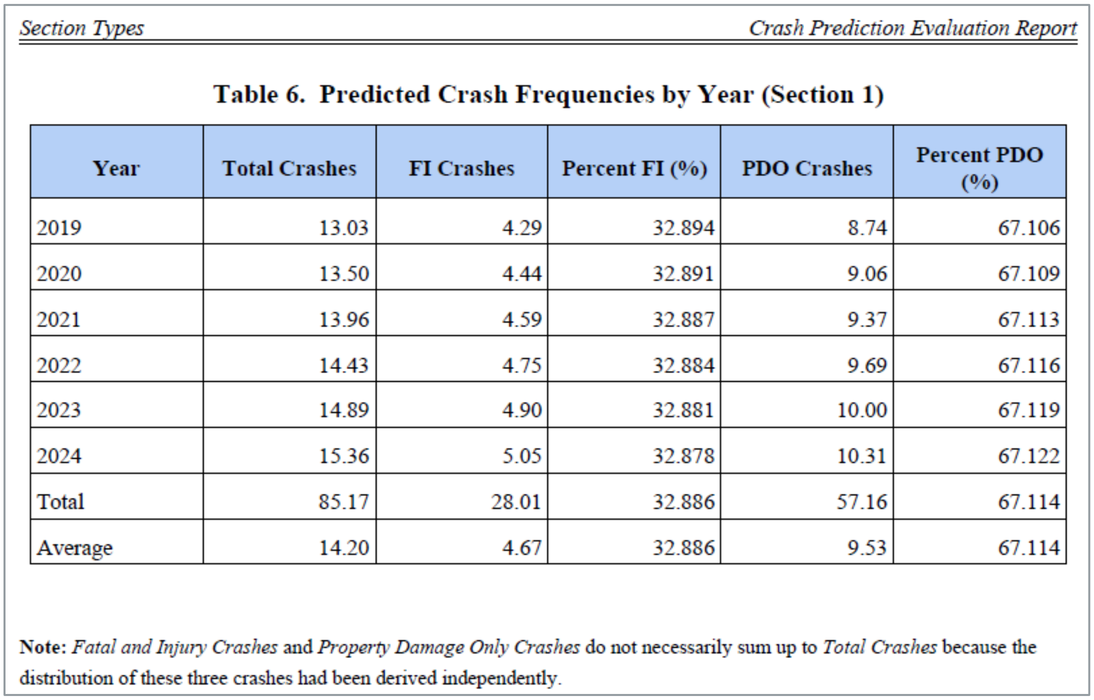


Figure 21: IHSDM Predicted Crash Frequencies by Year Tabular Output



Section Types *Crash Prediction Evaluation Report*

Table 6. Predicted Crash Frequencies by Year (Section 1)

Year	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
2019	13.03	4.29	32.894	8.74	67.106
2020	13.50	4.44	32.891	9.06	67.109
2021	13.96	4.59	32.887	9.37	67.113
2022	14.43	4.75	32.884	9.69	67.116
2023	14.89	4.90	32.881	10.00	67.119
2024	15.36	5.05	32.878	10.31	67.122
Total	85.17	28.01	32.886	57.16	67.114
Average	14.20	4.67	32.886	9.53	67.114

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

8.1.11 *ISATe Output Formats*

ISATe generates summary reports that include input data and analysis results. Outputs are available as formatted, tabular summaries. All or a portion of each report can be copied to the system clipboard for insertion into reporting formats discussed in **Section 8.2**.

The following ISATe output summaries should be printed or saved to a PDF and submitted to VDOT within a report appendix:

- Output Summary
- Output Freeway Segments
- Output Ramp Segments
- Output Ramp Terminals

8.2 REPORTING

Both depictive and tabular reports are required for all analyses. Tabular reports may be created in Microsoft® Excel to display MOEs outputted from analysis tools, as described in **Section 8.1**. Depictive reports may be created using Microsoft® PowerPoint or graphic design tools.

8.2.1 *Reporting Traffic Operations Analysis MOEs*

The following sections outline recommended formats for commonly reported traffic operations MOEs. A full list of acceptable analysis MOEs, and guidance on accepting MOEs, is provided in **Chapter 4**.

8.2.1.1 Delay

Recommended depictive and tabular formats for reporting delay are provided in **Table 23** and **Figure 22**, respectively.

Figure 22 displays delay at four intersections. An aerial image is included to depict the general study area while a number is used as a label for each study intersection. The aerial image is not a required component, but is recommended to orient the reviewer, thus expediting the review process.

When displaying results from Vissim, **Table 23** and **Figure 22** shall not display LOS and should contain a note indicating that the results displayed are the average results across "X" number of microsimulation runs. When reporting delay results from HCS or Synchro, control delay shall be reported. When reporting delay results from SimTraffic or Vissim, microsimulation delay shall be reported.

Table 23: Example Delay Tabular Format

Scenario	Overall Delay (LOS)	AM Peak Hour Delay per Lane Group by Approach (sec/veh) (Level of Service)											
		Eastbound			Westbound			Northbound			Southbound		
		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
2012 Existing	40.9 (D)	51.1 (D)	49.0 (D)		47.2 (D)	19.0 (B)	2.6 (A)	30.6 (C)	66.1 (E)	4.0 (A)	44.6 (D)	11.8 (B)	4.1 (A)
		49.1 (D)			27.8 (C)			56.8 (E)			26.1 (C)		
2020 No Build	35.8 (D)	47.7 (D)	58.9 (E)		39.5 (D)	36.2 (D)	11.4 (B)	14.5 (B)	31.7 (C)	4.4 (A)	52.9 (D)	33.1 (C)	17.1 (B)
		54.0 (D)			32.2 (C)			27.4 (C)			41.6 (D)		
2020 Build-Out	40.1 (D)	48.0 (D)	60.5 (E)		54.8 (D)	32.4 (C)	6.3 (A)	14.4 (B)	40.9 (D)	14.0 (B)	54.8 (D)	30.6 (C)	10.4 (B)
		55.0 (D)			37.8 (D)			36.0 (D)			41.4 (D)		
		57.4 (E)			25.9 (C)			34.1 (C)			16.7 (B)		

8.2.1.2 Queue Length

Recommended depictive and tabular formats for reporting queue length are provided in **Table 24** and **Figure 23**, respectively.

Table 24: Example Queue Length Tabular Format

Intersection	Movement	Queue Length (ft)	Storage Length Available (ft)
Main Street/First Street	Westbound RT/LT	225	300
Main Street/First Street	Southbound TH	450	850

When reporting results from SimTraffic or Vissim, **Table 24** and **Figure 23** should contain a note indicating that the results displayed are the average results across "X" microsimulation runs. When reporting queue results from HCS or Synchro, 95th percentile queue length shall be reported. When reporting queue results from SimTraffic, or Vissim, maximum queue length shall be reported.

Figure 23 displays the queue length at four intersections. An aerial image is included to depict the general study area while a number is used as a label for each study intersection. The aerial image is not a required component but is recommended to orient the reviewer, which can expedite the review process.

This page is intentionally left blank

Figure 22: Example Delay Depictive Format

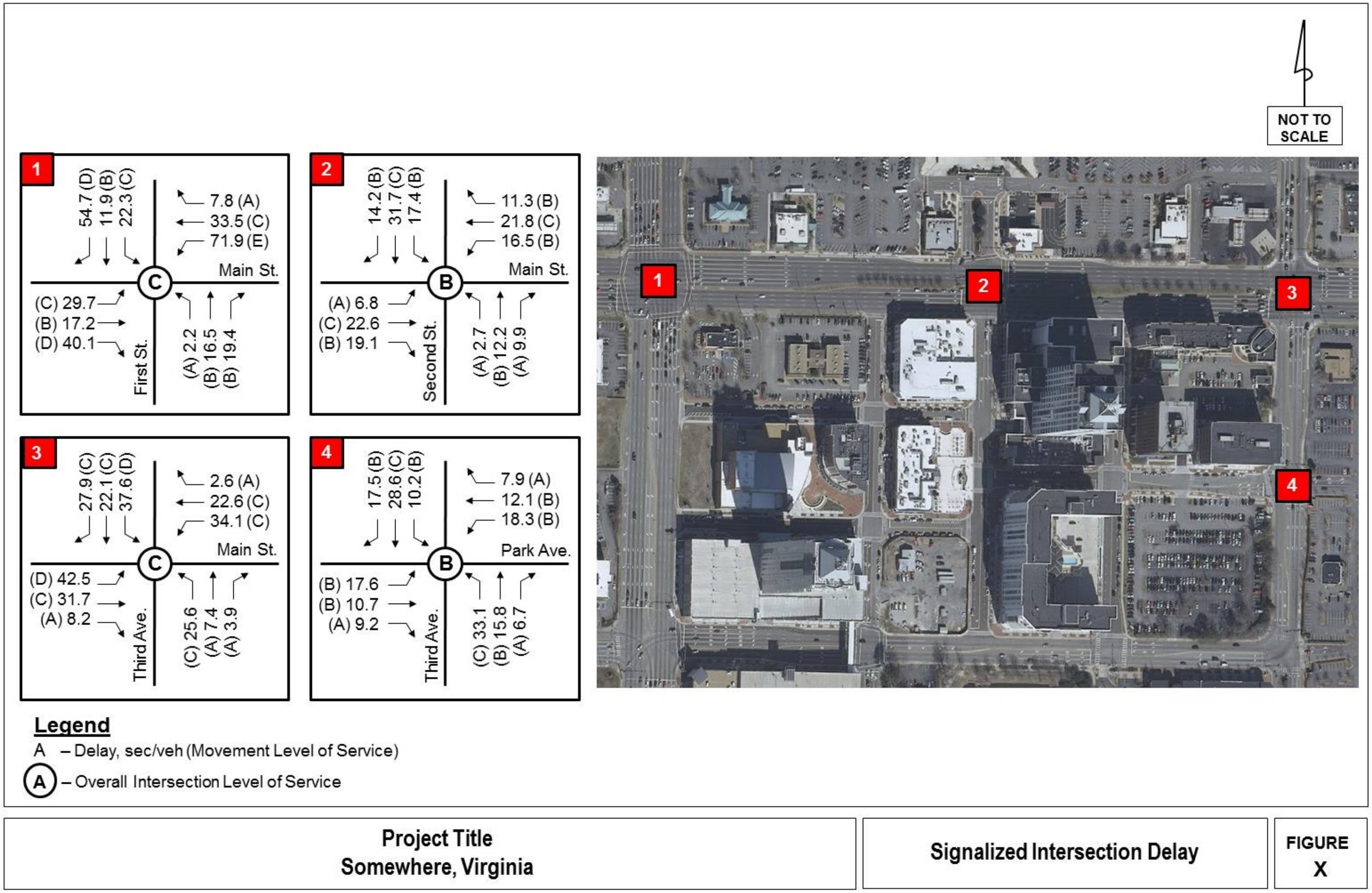
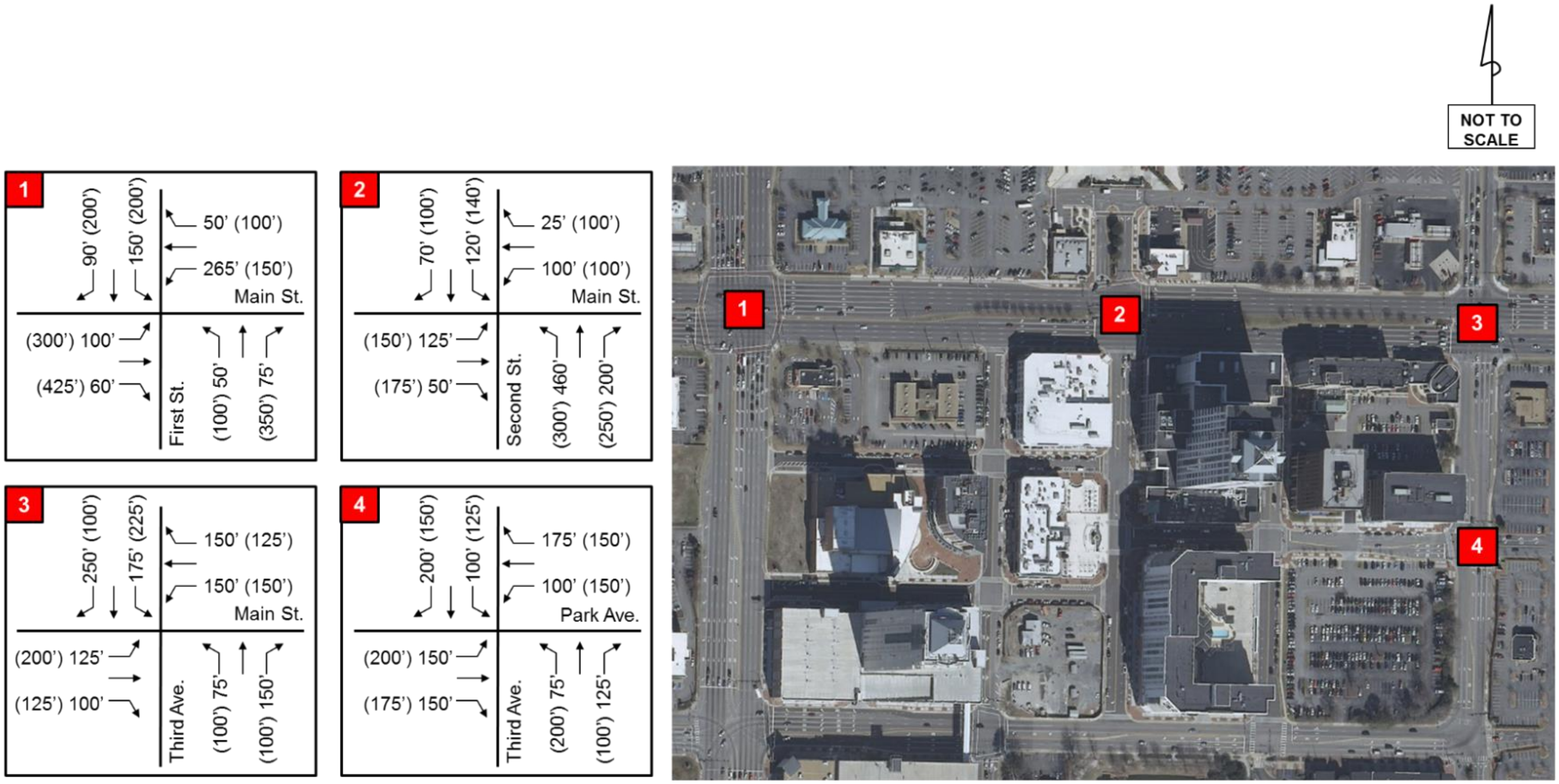


Figure 23: Example Queue Lengths Depictive Format



Legend

XX' (XX') – Queue Length** (Available Storage Length) [expressed in feet]

Project Title **Somewhere, Virginia**	**Intersection Queue Lengths****	**FIGURE** **X**

8.2.1.3 Density

Recommended tabular and depictive formats for reporting density are provided in **Table 25** and **Figure** 24, respectively.

When reporting results from Vissim, **Table 25** shall not display LOS and should contain a note indicating that the results displayed are the average results across "X" microsimulation runs. Density results from Vissim should be reported in vplpm.

Figure 24 display freeway operations, including ramps and weaving areas. The figure presents density and speed, with the density results supplemented by LOS. Sections are 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, and acceleration/deceleration lane lengths. Brief descriptions of the ramps are also included on the figure. An aerial that depicts the overall study area is also included on the figure for reference. The aerial imagery is not a required component on the output summary, but is recommended to orient the reviewer, thus expediting the review process.

Table 25: Example Density Tabular Format

Direction	Movement	2012 Baseline Density - pcplpm (LOS)		2020 Baseline Density - pcplpm (LOS)	
		AM	PM	AM	PM
Northbound I-95	Diverge: Off-ramp to Eastbound Main Street	22.7 (C)	11.4 (B)	33.4 (D)	18.0 (B)
	Weave	20.5 (C)	9.0 (A)	36.2 (E)	14.4 (B)
	Merge: I-95 Northbound On-ramp from Westbound Main Street	19.3 (B)	9.9 (A)	29.5 (D)	15.8 (B)
Southbound I-95	Diverge: Off-ramp to Main Street	6.7 (A)	15.6 (B)	8.5 (A)	19.4 (B)
	Merge: On-ramp from Main Street	3.8 (A)	11.6 (B)	5.6 (A)	17.4 (B)

8.2.1.4 Travel Time

Recommended depictive and tabular formats for reporting travel time are provided in **Table 26** and **Figure 25,** respectively.

Table 26: Example Travel Time Comparison Tabular Format

Direction	AM Peak Hour				PM Peak Hour			
	Existing (sec)	No Build (sec)	Build (sec)	Percent Reduction	Existing (sec)	No Build (sec)	Build (sec)	Percent Reduction
Eastbound	641	697	655	6%	971	914	801	12%
Westbound	714	962	674	30%	1,126	1382	925	33%

This page is intentionally left blank

Figure 24: Example Density Depictive Format

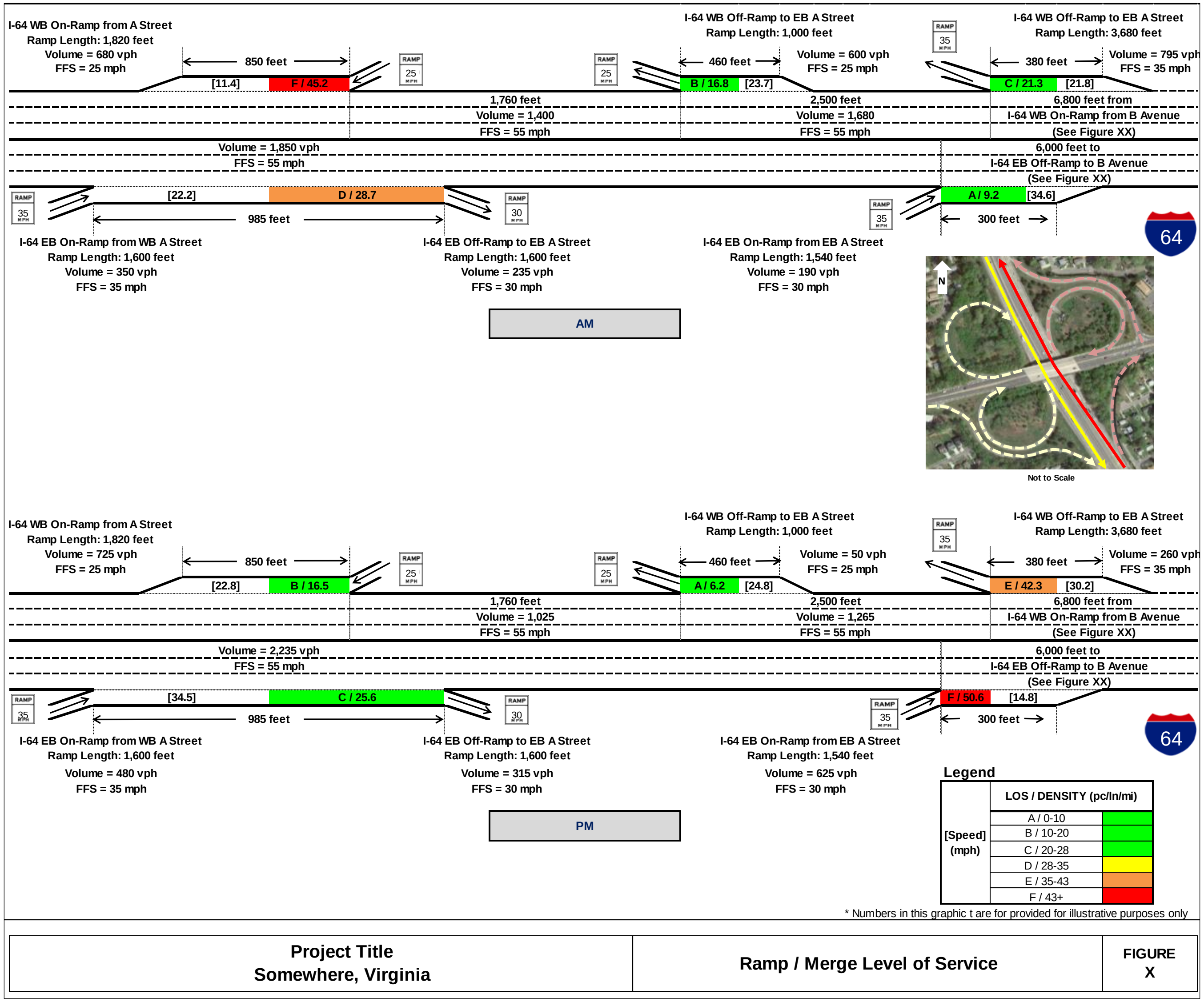
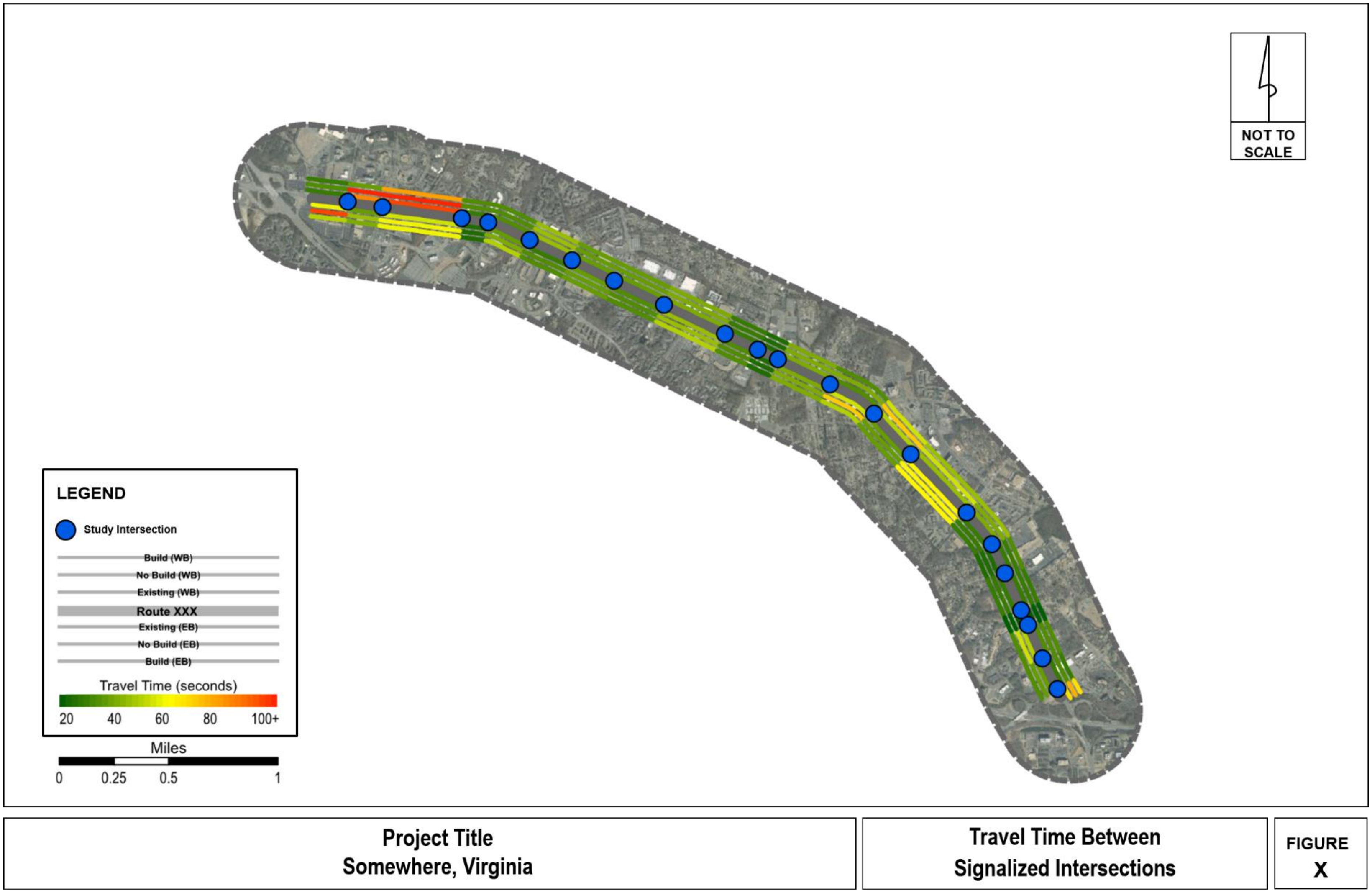


Figure 25: Example Travel Time Depictive Format



8.2.1.5 Speed

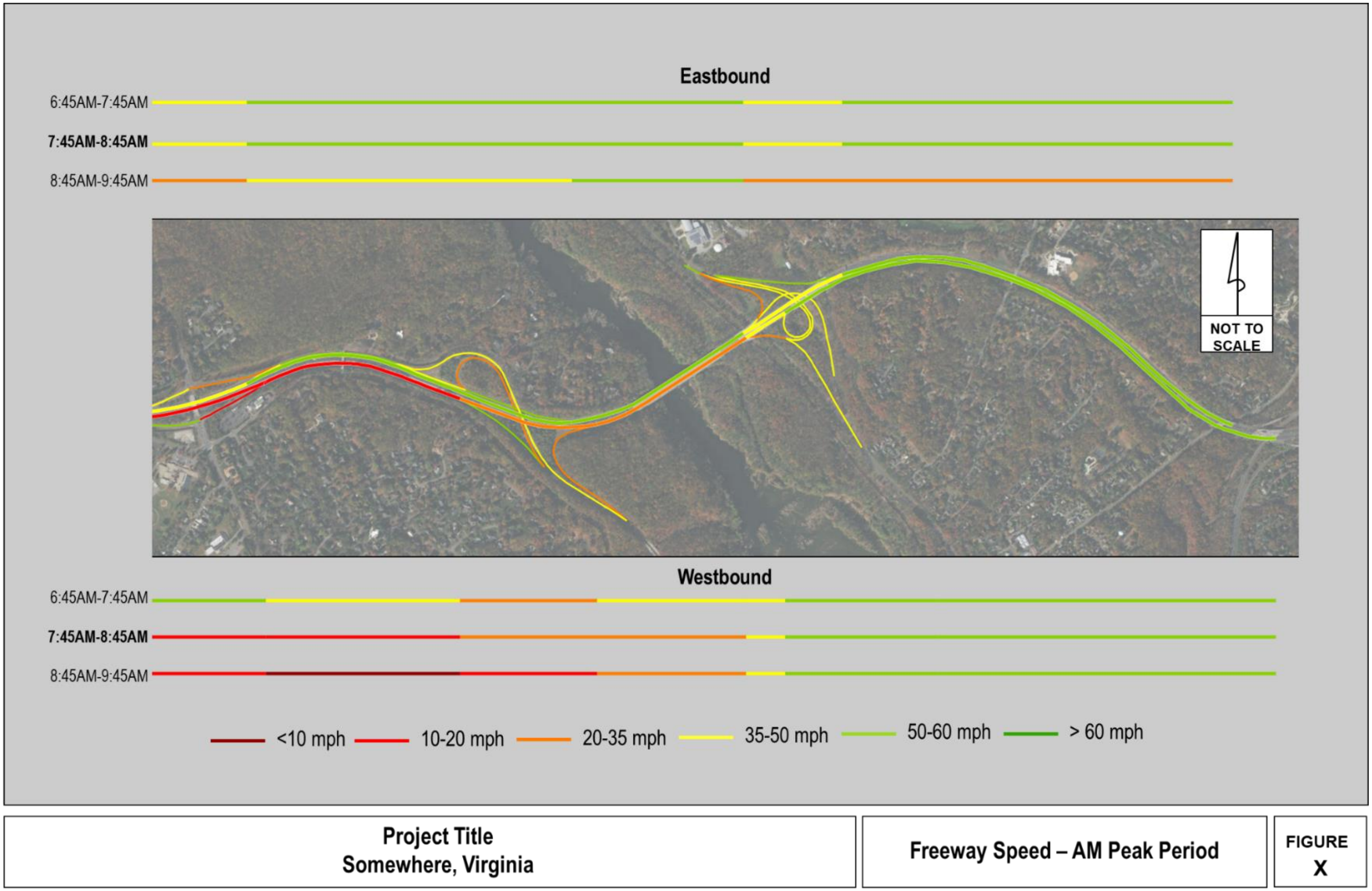
Recommended depictive and tabular formats for reporting speed are provided in **Table 27** and **Figure 26**, respectively.

Table 27: Example Speed Tabular Report

Roadway	Time													
	7:00 AM		7:30 AM		8:00 AM		8:30 AM		9:00 AM		9:30 AM		10:00 AM	
Route 1	10	10	9	9	8	8	7	8	7	8	12	20	30	32
Route 2	10	10	9	9	9	8	8	8	7	9	9	15	22	22
Route 3	8	7	7	6	6	6	6	6	6	7	6	8	10	10
Route 4	13	13	12	12	12	11	11	11	11	11	11	12	10	10
Route 5	19	19	19	19	19	19	19	19	19	19	19	19	18	18

This page is intentionally left blank

Figure 26: Example Speed Depictive Format



This page is intentionally left blank

8.2.2 *Reporting Safety MOEs*

The following sections outline recommended formats for commonly reported safety MOEs. Refer to **Table 3** in **Chapter 4** for information about which MOEs are acceptable to report for each safety analysis tool.

8.2.2.1 Crash Frequency

Recommended tabular formats for reporting crash frequency are provided in **Table 28**, **Table 29**, **Table 30**, and **Table 31**. **Table 28** shows results for an existing conditions analysis that incorporated the EB Method in tabular format. **Table 29** shows presents results for a future year analysis in tabular format. The table may be modified to display predicted crash frequency if the EB method was not used or expected crash frequency if the EB method was used.

Table 30 provides the breakdown of crash types for a given site in tabular format. The table may be modified to display results for multiple alternatives.

Table 31 may be used to present all applicable CMFs applied to a given alternative. This table may also be used to present applicable countermeasures if the CMF Clearinghouse is used for any analysis type not covered by the safety tools described in this manual. The standard error or the star rating from the CMF Clearinghouse should be reported for any CMF if it is available.

Figure 27 reports predicted crash frequency and severity by roadway segment in a depictive format. This template may be modified to compare crashes across several alternatives, provided that each alternative has the same segmentation. An aerial image that depicts the overall study area is also included on the figure for reference. The aerial image is not a required component on the output summary, but is recommended to orient reviewers, thus expediting the review process.

Table 28: Example Expected Crash Frequency Tabular Format

Segment/ Intersection	Historical Crash Data			Predicted Crash Frequency (crashes/year)			Expected Crash Frequency (crashes/year)		
	KABC	PDO	Total	KABC	PDO	Total	KABC	PDO	Total
Segment 1	0.3	3.0	3.3	2.0	6.1	8.1	0.8	3.5	4.3
Segment 2	1.8	4.2	6.0	4.1	8.3	12.4	2.4	5.9	8.3
Segment 3	3.6	7.5	11.1	4.0	8.9	12.9	3.7	7.7	11.4
Intersection 1	0.5	4.4	4.9	1.2	7.5	8.7	0.8	6.3	7.1
Intersection 2	0.7	2.4	3.1	1.4	10.1	11.5	0.9	4.9	5.8
Total	**6.9**	**21.5**	**28.4**	**12.7**	**40.9**	**53.6**	**8.6**	**28.3**	**36.9**

Table 29: Example Predicted Crash Frequency Tabular Format

Alternative	Segments	Predicted Crash Frequency (crashes/year)			Percent Reduction in Crashes vs No Build (%)		
		KABC	PDO	Total	KABC	PDO	Total
No Build	1-20	40.0	102.1	142.1	--	--	--
	21-27	16.1	39.7	55.8	--	--	--
	Total	56.1	141.8	197.9	--	--	--
Alternative 1	1-20	34.9	88.8	123.7	12.8	13.0	13.0
	21-27	14.3	33.5	47.8	11.2	15.6	14.3
	Total	49.2	122.3	171.5	12.3	13.8	13.3
Alternative 2	1-20	34.4	90.2	124.6	14.0	11.7	12.3
	21-27	14.4	34.1	48.5	10.6	14.1	13.1
	Total	48.8	124.3	173.1	13.0	12.3	12.5

Table 30: Example Crash Type Tabular Format

Crash Type	FI		PDO		Total	
	Crashes	Crashes (%)	Crashes	Crashes (%)	Crashes	Crashes (%)
Crashes with Animal	0.12	0.0	0.87	0.2	0.98	0.3
Crashes with Fixed Object	21.34	5.6	28.20	7.4	49.55	13.0
Crashes with Other Object	1.51	0.4	5.48	1.4	6.98	1.8
Crashes with Parked Vehicle	0.44	0.1	0.63	0.2	1.07	0.3
Other Single Vehicle Crashes	6.15	1.6	4.22	1.1	10.36	2.7
Total Single Vehicle Crashes	29.56	7.7	39.39	10.3	68.95	18.0
Right-Angle Crashes	2.11	0.6	4.42	1.2	6.53	1.7
Head-On Crashes	0.55	0.1	0.49	0.1	1.04	0.3
Rear-End Crashes	51.14	13.4	169.25	44.3	220.39	57.6
Sideswipe Crashes	12.27	3.2	65.25	17.1	77.52	20.3
Other Multiple Vehicle Crashes	2.11	0.6	5.89	1.5	8.00	2.1
Total Multiple Vehicle Crashes	68.19	17.8	245.29	64.1	313.48	82.0
Total Crashes	**97.75**	**25.6**	**284.68**	**74.4**	**382.43**	**100.00**

Table 31: Example CMF Tabular Format

Description/Countermeasure	CMF	Source	Standard Error/Star Rating*
Lane Width	1.00	*HSM Part D*	--
Shoulder Width and Type	1.29	*HSM Part D*	--
Horizontal Curves	1.00	*HSM Part D*	--
Superelevation	1.00	*HSM Part D*	--
Grades	1.10	*HSM Part D*	--
Driveway Density	1.00	*HSM Part D*	--
Centerline Rumble Strips	0.94	*HSM Part D*	--
Passing Lanes	1.00	*HSM Part D*	--
Two-Way Left-Turn Lane	1.00	*HSM Part D*	--
Roadside Design	1.14	*HSM Part D*	--
Lighting	0.92	*HSM Part D*	--
Automated Speed Enforcement	1.00	*HSM Part D*	--
Total CMF	**1.52**	**--**	**--**

*The standard error from the *HSM Part D* or the star rating from the CMF Clearinghouse for a given CMF should be provided if it is known.

This page is intentionally left blank

Figure 27: Example Crash Frequency Depictive Format

Project Title Somewhere, Virginia	Predicted Crash Frequency	FIGURE X

This page is intentionally left blank

9 Traffic Operations and Safety Analysis Project Scoping Considerations

This Chapter outlines the level of effort and steps that should be considered when scoping traffic operations or safety analysis projects that:

1. VDOT is responsible for approving or
2. Fall under the purview of VDOT jurisdiction, such as VDOT-administered projects or locally administered projects.

The project scoping meeting is defined as the meeting between the project team, consultants, subject matter experts, stakeholders, and other representatives.

The guidance provided is generalized so it can be applied to a broad range of projects. While the overall considerations for scoping will stay the same, the scale at which those are applied could vary based on relevance to individual projects. The VDOT project manager, in coordination with subject matter experts, is responsible for applying engineering judgment and situational awareness to interpret and apply the guidance, regardless of whether this manual governs the analysis.

Figure 28 outlines key traffic and safety analysis considerations that should be agreed upon and documented at each stage of the project scoping process[2]. The decision points are organized chronologically, in reference to the project scoping meeting:

- Before the Project Scoping Meeting
- At the Project Scoping Meeting
- After the Project Scoping Meeting

The project scoping process is not linear, but rather iterative. For example, an aggressive schedule should not be agreed to before selecting an analysis tool. If the scoping team determines that a microsimulation model is warranted, a well-calibrated microsimulation analysis may be infeasible due to schedule limitations, funding constraints, and/or scope restrictions, causing changes to the study area, MOEs, and/or overall analysis approach.

Figure 28: Traffic Operations and Safety Analysis Scoping Considerations

Before the Project Scoping Meeting	At the Project Scoping Meeting	After the Project Scoping Meeting
•Roles and Responsibilities •Project Purpose and Need •Preliminary Data Review •Preliminary Alternative Identification •Initial MOE Selection •Analysis Tool Consideration	•Final MOE Selection •Analysis Tool Selection •Calibration and Validation Requirements for Microsimulation •Data Source Selection •Alternatives Analysis Requirements •Quality Review Requirements •Report Structure	•Follow-Up Actions

---

[2] Figure 28 is based on Project Phase, referenced in Table 32

9.1 BEFORE THE PROJECT SCOPING MEETING

The project manager should record the considerations in this section on the *TOSAM Project Scoping Meeting Preparation Form* before the project scoping meeting.

It is critically important to identify key assumptions and ensure the appropriate agencies and individuals are invited to the project scoping meeting. Thinking through the project, framing the purpose and need, gathering preliminary data, and analyzing the data will position the project team to conduct a focused and effective project scoping meeting. To avoid changes in the project purpose and/or scope of work that may occur during the life of a project, the following topics should be considered prior to the project scoping meeting and discussed at the meeting:

- Previous studies and/or projects completed in or near the study area
- Ongoing projects or funded/programmed projects in or near the study area
- Known risks and/or concerns in the study area
- Future development(s) causing changes to future traffic volume and/or patterns
- Known or potential budget and/or schedule constraints
- Types of alternatives to be considered
- Stakeholders and their concerns (including public where relevant)
- Approving agency(ies) and their preferences
- Available resources
- Availability and quality of existing data

The project manager should record the considerations in this section on the *TOSAM Project Scoping Meeting Preparation Form* (found in **Appendix B**) before the project scoping meeting. The Project Categorization Matrix **(Table 32)** can be referenced to define the characteristics of a project and distinguish appropriate traffic operations and safety analysis tool(s) before the scoping meeting. Supplementary tools, such as travel demand models, are not listed.

Table 32: Project Categorization Matrix

Project Phase		Objective	Horizon Year	Cost Estimating Level[1]	Typical Number of Inputs and Outputs[2]	Typical Traffic Tools[4]			Typical Safety Tools			Approval
						Intersection/ Interchange[6]	Corridor[7]	Network[8]	Intersection/ Interchange	Corridor	Network	
Screening		To determine suitability of project alternatives. The results from this stage, which will consist of multiple alternatives, will be evaluated later in the project development process. The tools and methodologies used in this stage will apply to various project types.	Applies to all Timeframes	Planning Level	Input: Many Output: Several	HCS SIDRA Synchro VJuST	HCS FREEVAL Synchro VJuST	HCS Synchro	VJuST *HSM* Spreadsheets IHSDM	*HSM* Spreadsheets IHSDM ISATe	IHSDM	VDOT Project Manager or Designee
Project Planning[5]	Visioning Level	To refine project alternatives. The results from this stage are evaluated and assessed to determine viable improvements based on anticipated traffic growth. Microsimulation is not used in this stage. Example Project Types: Small Area Plan, Network Analysis	10 to 20 Years	Planning Level	Input: Several Output: Few	HCS SIDRA Synchro VJuST	HCS FREEVAL Synchro VJuST	HCS Synchro	*HSM* Spreadsheets IHSDM	*HSM* Spreadsheets IHSDM ISATe	IHSDM	VDOT Project Manager or Designee
	Program Level	To select a preferred alternative that is intended to be shared with stakeholders for investment decisions. Consists of project location and design concepts with associated cost estimation for future operations and design purposes. Microsimulation may be used in this stage. Example Project Types: Corridor Studies (APP, STARS), Intersection Evaluations, Interchange Alternatives Analysis, Interchange Justification/Modification Reports	10 to 20 Years	Project Level	Input: Few Output: One or Two	HCS SIDRA SimTraffic Synchro Vissim	HCS FREEVAL SimTraffic Synchro Vissim	HCS SimTraffic Synchro Vissim	*HSM* Spreadsheets IHSDM	*HSM* Spreadsheets IHSDM ISATe	IHSDM	VDOT Project Manager, District Traffic Engineer, or Designee
Project Implementation	Operations Level	To determine roadway, signal, and safety impacts to project area. Microsimulation may be used in this stage. Example Project Types: Traffic Impact Analysis, Traffic Signal Justification Reports, Traffic Signal Optimization, Work Zone Hours of Operation	Less than 10 Years	Project Level	Input: Few Output: One or Two	HCS SIDRA SimTraffic Synchro Vissim	FREEVAL HCS SimTraffic Synchro Vissim Workzone Tool	HCS SimTraffic Synchro Vissim	*HSM* Spreadsheets IHSDM	*HSM* Spreadsheets IHSDM ISATe	IHSDM	VDOT Project Manager, District Traffic Engineer, or Designee
	Design Level	To model traffic impacts to inform design decisions. Traffic simulation may be used in this stage. *Example Project Types: Intersection Design, Maintenance of Traffic, Roadway Safety Assessment*	Less than 5 Years[3]	Project Level	Input: Few Output: One or Two							

Notes:

[1] Different cost estimating tools are used throughout the project development process: VDOT TMPD Cost Estimating Worksheets; Project-level cost estimates; VDOT Project Cost Estimating System

[2] Refers to the number of alternatives for a given project.

[3] Traffic analysis for roadway design projects may require advertisement date plus 22 years. Refer to the VDOT Road Design Manual for guidance.

[4] The tools included in each box, listed 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. It is recommended that characteristics such as roadway saturation and anticipated changes in travel patterns due to proposed project improvements be considered when selecting a traffic software. In case a geometry type or other unique feature(s) of an alternative requires use of a software not listed in this matrix, then it should be discussed with the VDOT PM ahead of software selection and approval obtained from the District Traffic Engineer.

[5] The project planning phase informs funding decisions and could be used to support funding such as SMART SCALE, HSIP, CMAQ, etc.

[6] SIDRA is the preferred software for undersaturated roundabout analyses. Vissim is the preferred software for oversaturated roundabout analyses.

[7] FREEVAL is the preferred software for freeway reliability analyses. Synchro, SimTraffic, and SIDRA should not be used for freeway reliability analyses.

[8] Software listed for network analyses may be used in conjunction with other software.

This page is intentionally left blank

9.1.1 *Roles and Responsibilities*

There are many roles that support the successful execution of a project. Below are identified roles and specific responsibilities that should be considered before the scoping meeting.

9.1.1.1 Role of the Project Manager

The project manager is the individual leading a project within VDOT, a locality or agency, or agency partner, such as a consultant. The role of the project manager is to:

- Oversee and direct the project team
- Ensure the direction and guidance presented in this manual are followed
- Prepare for the project scoping meeting
- Identify key stakeholders
- Reach agreement regarding scoping decisions and, as necessary, obtain relevant approvals and/or waivers from the DTE or other approving authority

Projects typically involve two project managers: one administering the project and one delivering the project. The project manager at the administering agency initiates the project and will:

- Direct the project team delivering the project to complete the analysis in accordance with this manual.
- Manage deviations from this manual as follows:
  - Approvals for deviations from a "should condition" are authorized by the VDOT Project Manager
  - Approvals for deviations from a "shall" condition require written approval from the DTE or his/her designee
  - Document all deviations in the technical report
- Provide early notification from deviations to the DTE and provide prompt feedback to stakeholders such that sufficient time is available for consideration, and the project can be kept on schedule.
- If a project is initiated within a locality, and located within a VDOT jurisdiction, a project manager from both the locality and VDOT will be appointed.

Typically, the administering project manager is within VDOT, a locality, or other agency, whereas the delivering project manager may be a consultant. Refer to the following VDOT policy documents for more information regarding the role of the project manager.

- Department Policy Memoranda (DPM) "VDOT Project Management" – DPM Number: 1-21
- Project Management Office (PMO) Procedures "Initiate Project Scope" – PMO-1.4
- Project Management Office (PMO) Procedures "Final Project Scope" – PMO-4.2

9.1.1.2 Role of the District Traffic Engineer or Designee

The DTE or designee should be actively involved in the project scoping process to identify any potential issues before major scheduling and/or cost concerns arise, and review and approve projects in the planning and implementation phases, as outlined in the Project Categorization Matrix **(Table 32)**. The DTE is not required to attend the scoping meeting; however, the project manager should notify and invite the DTE in advance of the scoping meeting if a deviation is requested or if one is identified following the meeting. Regardless of the timing of the deviation request, the DTE shall be required to approve the deviation.

9.1.1.3 Role of Stakeholders

Stakeholders may provide review support and input throughout a project to influence decisions but are not considered to be final decision makers. Stakeholders should include individuals with relevant experience or familiarity with a project and its complexity. The project manager should consider individuals from partnering departments within an agency, subject matter experts, community members, and/or elected officials when identifying potential stakeholders.

9.1.2 Project Purpose and Need

The project team should develop a clear purpose and need statement that drives the assumptions and information are needed and can help identify existing project constraints. As the project progresses, the purpose and need should be revisited if or when new information is uncovered.

It is at the discretion of the project manager to determine whether a traffic analysis, safety analysis, or both are required based on the project purpose and need.

9.1.2.1 Project Phase

Identifying the project phase helps to select an appropriate horizon year, cost estimating level, and one or more analysis tool(s) for transportation studies executed at the state, regional, and local levels. The purpose and need of each project should be assessed concurrently to ensure that the defined project purpose will fulfill a specified need. The various projects phases include:

- **Screening Phase:** Determine the suitability of project alternatives and evaluate multiple alternatives in a cost-effective manner that can be evaluated in detail during later phases. It is expected that screening will not be a standalone stage in the project development process and may be followed by one or more additional phases. The tools and methodologies used in this stage will apply to various project types.
- **Planning Phase:** Refine and select project alternatives and allow stakeholders to provide input. This phase is divided into two stages:
  - ***Visioning Level:*** Refine and assess project alternatives to determine viable improvements based on future conditions. Traffic simulation is not typically used in this stage. Projects in the visioning stage may include statewide or regional planning studies such as small area plans and network analyses.
  - ***Program Level:*** Determine a preferred alternative to be shared with stakeholders for investment decisions. Project location, design concepts, and other elements from the operations and design stages may be incorporated to better inform project decisions. Traffic simulation may be required at this stage. Program-level projects are typically detailed planning studies conducted to guide future development efforts and inform future investment decisions, but may also include intersection evaluations, interchange alternatives analyses, and interchange justification or modification reports.
- **Project Implementation Phase:** Further refine the project alternatives from the planning stage and finalize details for preliminary engineering design and operations.
  - ***Operation Level:*** Determine roadway, traffic signal, and safety impacts to a project area. Traffic simulation may be used. Operation projects may include traffic signal justification reports, traffic signal phasing or lane configuration modification evaluations, traffic signal optimizations, or work zone hours of operation evaluations.

  - *Design Level:* Determine design elements, such as turn lane storage, ramp terminal spacing, and number of lanes. Traffic simulation may be used. Design projects may include intersection design, roadway design (arterial or freeway), or interchange design.

9.1.3 *Study Limits*

Both physical and temporal study limits should be defined. These limits are typically defined prior to the scoping meeting, and refined, if needed, during and/or after the meeting.

Considerations to help refine physical study limits are listed below. Those indicated with an asterisk (*) are less applicable to the screening phase.

- Are the physical and temporal limits sufficient in size to address queue formation and dissipation?* Do queues spill back from one intersection to another?* In case of interstates, consider spillbacks from ramps.*
- Does the project impact existing travel patterns and future traffic growth?*
- System performance of what area would be influenced by the expected alternatives?*
- Will adjacent facilities be affected?
- What would be the network area that future volume demand would require for vehicles to get into the system?*
- Does the study require National Environmental Policy Act (NEPA) compliance (e.g., interchange justification report)? If so, refer to NEPA guidelines to ensure the study area includes all necessary roadways, intersections, and interchanges.

Temporal limits are defined by the purpose and need of the project. It is common practice to define it by the duration of the peak periods. For projects where traffic forecasting will be performed, consideration for temporal limits should include the horizon year. Identifying what the temporal limits may be prior to the scoping meeting helps support decision making related to data collection; however, limits are typically refined after the meeting once data is collected. A variety of data sources may be used to determine the peak period(s) of a study area. The project team should consider varying time periods that will influence system performance for the expected alternatives.

- Nonstandard peak periods may be considered for analysis at the following locations:
  - Businesses with atypical shift change
  - Schools
  - Retail centers with weekend peaks
  - Tourist and/or vacation destinations
- Facilities that host special events outside of typical weekday commuter peak periods

9.1.4 *Preliminary Data Review*

Preliminary traffic data will need to be gathered prior to the project scoping meeting to determine project characteristics that will frame decisions.

Just as the project size, phase, and purpose dictate the selected MOEs and analysis tool(s), the selected tool and the alternatives analysis requirements dictates which data is needed for analysis. Standard data requirements for analyses are provided in various tables in **Chapter 6.** These should be consulted during the Preliminary Data Review and should be taken to the scoping meeting to help with the traffic operations and safety analysis assumptions discussion. The project manager should prepare a preliminary data collection plan as a starting point for discussion at the project scoping meeting.

9.1.4.1 Traffic Analysis

The project team should review readily available traffic data listed in **Chapter 6** prior to the scoping meeting to understand existing and future traffic conditions. Historical traffic counts, k-factors, d-factors, and truck percentages are available on the VDOT website, and can be used to gain a preliminary understanding of the level of saturation within a project area.

9.1.4.2 Safety Analysis

If conducting a safety analysis, the project team should review readily available safety data and occurrence of fatal (K) and incapacitating injury (A) crashes via the VDOT Crash Analysis Tool as well as prior to the scoping meeting to identify locations with high potential for safety improvement (PSI). The VDOT PSI map should be consulted. PSI indicates a higher historical crash rate than the rate predicted by the Highway Safety Manual (*HSM*) methodology, which is based on national averages for sites with similar geometry and volumes. Listings and maps of roadway segments and intersections with the highest ranked PSI values in each VDOT District are published by the Traffic Engineering Division (TED) each year. The entire study area should be considered for a safety analysis. All PSI locations in the project limits should be included in the safety analysis.

9.1.5 Preliminary Alternative Identification

Establishing expectations leading up to the project scoping meeting allows the project team to define the expected outcomes and consider reasonable alternatives based on the project phase. For example, an individual intersection analysis (safety or operations) should consider localized alternatives to address existing conditions commensurate with the opportunity to implement improvements. Questions to consider include:

- Will access restrictions be permitted to improve safety or operations?
- Is grade separation feasible at this location or included in an existing comprehensive plan?
- Is it feasible to implement additional capacity improvements without significantly impacting the surrounding area, thereby precluding the project?

The project manager should consider what a reasonable alternative could be to satisfy the purpose and need of the project at a scope consistent with the project phase and project location.

9.1.6 Initial MOE Selection

When conducting traffic analyses, there are several MOEs that can be used to document results. The analysis MOE(s) and acceptable thresholds for each MOE vary by project phase and should be selected based on the size, phase, and purpose of the project. After compiling and reviewing readily-available data, including spot observations of existing conditions to understand current operations and/or safety challenges, the project team should have an idea of which MOE(s) will be recorded for the traffic and/or safety analysis project.

Chapter 4 presents the traffic operations MOEs that are accepted for reporting on projects conducted by or for VDOT. The use of any MOE not listed in this manual shall be approved by the DTE or their designee at the scoping meeting.

9.1.7 *Analysis Tool Consideration*

An array of traffic analysis tool(s) could be associated with each project phase. The **VDOT Software Selection Tool**, which is one of the companion macro tools to this manual, shall be used to help the study team identify appropriate traffic and/or safety analysis tool(s). The project team should bring the VDOT Software Selection Tool report to the project scoping meeting. In addition, the project team should consider the following questions before the project scoping meeting:

- Can the saturation level be determined based on traffic volumes alone?
- Do typical traffic conditions (reference probe data sources) indicate oversaturation? If so, microsimulation will be required.
- Are there any project needs, such as need for visualization, that could drive the use of a more robust tool (e.g., are there expected alternatives that could need microsimulation)?
- Is there a need for origin-destination data given travel patterns within the study area? If so, certain traffic analysis tools cannot be used given the limitations of data input.
- What is the expected future demand? A currently undersaturated network could be oversaturated with future demand and thereby be unfit for deterministic analysis.
- Consider the end goal of the project. What is trying to be conveyed?

9.2 AT THE PROJECT SCOPING MEETING

Clearly defining the scope of the project is critical to the success of any project, which is why it is important to hold a project scoping meeting for traffic operations and safety analysis projects prior to establishing the scope of work, budget, and schedule. All parties should come to the meeting prepared to discuss the wide variety of topics considered. The completed *TOSAM Project Scoping Meeting Preparation Form* (found in **Appendix B**) should be used as a guide for discussion.

9.2.1 *Final MOE Selection*

MOE selection is important in defining data collection needs and establishing a framework to satisfy the project purpose and need. The project team should consider how many MOEs are necessary to demonstrate that the purpose and need of a project has been met. The number of MOEs should be commensurate with the project phase: a screening project may only require one MOE, while a design project may require two or three. The VDOT project manager should exercise engineering judgment as well as take into consideration the audience to whom MOEs need to be communicated when making the final determination on the number of MOEs required and which ones are selected.

9.2.2 *Analysis Tool Selection*

Analysis tools may only be selected once MOEs are selected. VDOT subject matter experts should be present at the project scoping meeting to recommend the appropriate tool(s), along with the specific versions, based on the analysis category, location type, saturation conditions, and microsimulation requirements, if applicable. The project team should bring the VDOT Software Selection Tool results to the scoping meeting.

9.2.3 *Calibration and Validation Requirements for Microsimulation*

The calibration procedure is the most important step in a network that requires microsimulation, whereby the modeler adjusts model parameters to accurately represent existing traffic conditions. Validation is an evaluation of the calibration effort, whereby the calibrated model is applied, and results are compared against observed traffic data. Subject matter experts, including modelers, should be present at the project scoping meeting to discuss whether an adequate sample size of data is available for comparison with average model outputs. Field conditions may limit the amount of data that can be collected during the peak periods for certain metrics (e.g., travel time, queue data).

If microsimulation tools are proposed, calibration measures discussed in **Chapter 5** will be considered and selected at the project scoping meeting, along with calibration period for each measure. Applicable calibration thresholds and methodology identified should be agreed upon by the reviewer. Critical links, turning movements, routes and/or segments in the network, if needed, will also be determined in coordination with the project manager during the project scoping meeting. The project manager also should discuss locations where speed validation may be necessary (e.g., a congested ramp movement with adjacent free-flow through conditions).

Questions to identify calibration factors include:

- What calibration measures should be met?
- Should critical links be used? If yes, which links should be identified as critical links?

- Are less strict calibration thresholds needed? Adherence to calibration thresholds is the expected standard for most traffic analyses. Where specific situations warrant consideration of adjusted calibration thresholds, the DTE shall approve deviations for thresholds established in **Chapter 5**.

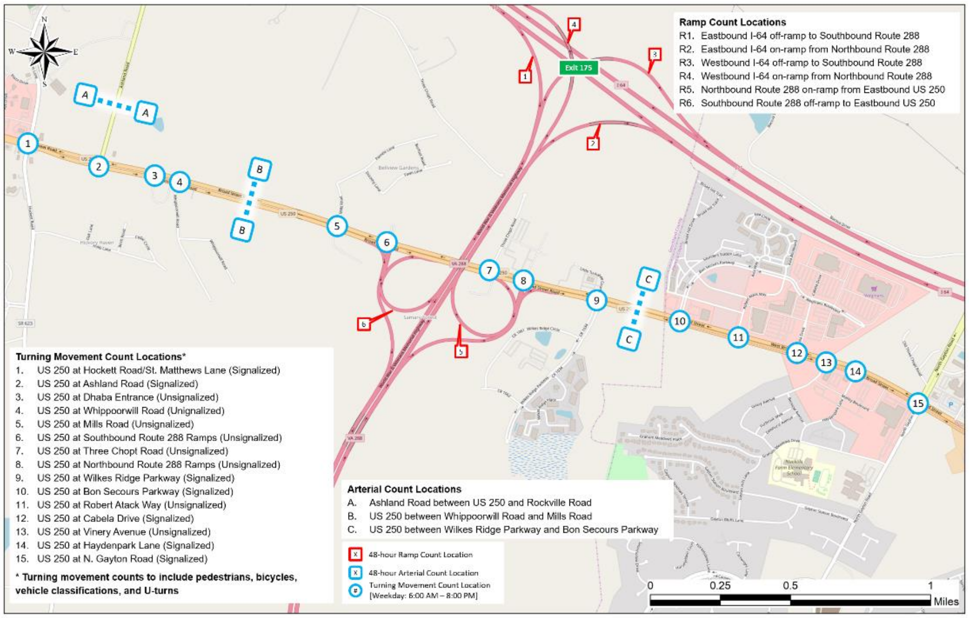
If network operating conditions outside the study area boundaries have the potential to impact traffic operations at study area intersections or along study area link segments, consider coding terminal conditions at the network boundaries. Terminal conditions do not represent nodes or segments for which MOEs are reported; rather, these are network elements to account for downstream congestion or traffic patterns that influence the study area. Refer to the *VDOT VISSIM User Guide* for additional considerations for model development and field data collection.

9.2.4 *Data Source Selection*

The data requirements discussion should be centered around determining the sources and collection methods for roadway geometry, traffic volumes, traffic signal data, and traffic microsimulation model calibration data, as outlined in **Chapter 6**. The methodology for selecting peak hour(s), determining and applying seasonal adjustment factors, and balancing traffic volumes, if applicable, should be discussed. In addition, a data collection plan that aligns with the analysis tool needs should be discussed. An example data collection plan is shown in **Figure 29**.

During the project scoping meeting, it is important that all parties agree to the type and location of data collection. It is difficult to collect additional data without impacting analysis if determined to be needed later in the project. This is an especially important decision as it relates to calibration. All parties, including VDOT, regardless of the project management arrangement, and subject matter experts familiar with the analysis tools, need to reach a consensus on data collection during the project scoping meeting. Related to calibration, all parties should agree to the location, duration, and sample size of data collection for calibration, including queue data and travel time data.

Figure 29: Example Data Collection Plan



9.2.5 *Alternatives Analysis Requirements*

Considering multiple alternatives may require a different analysis approach than a conventional traffic operations or safety analysis. Since the type of alternatives can dictate the MOEs, data requirements, and analysis tool to be considered, a discussion regarding types of alternatives to be considered is important to set expectations for the analysis. Additional data requirements may be necessary to support the discussion. As such, the subject matter experts should verify the appropriate MOEs, analysis tools, and data collection at the project scoping meeting so a decision can be made at the completion of the project that differentiates the alternatives. The project team should discuss the impact of different geometric scenarios as part of the project that may violate access management or design guidelines. Additional alternatives not discussed during this stage may still be considered once the project is underway.

Questions to help drive decisions based on the analysis may include:

- Which alternative results in the greatest reduction in travel time? This decision is not applicable to the screening project phase unless the travel time output from HCS is used.
- Which alternative results in the lowest experienced travel time for displaced movements, if any?
- Which alternative results in the least variation in travel speeds?
- Which alternative results in the least (or greatest) amount of traffic diversion to other facilities?
- Could certain alternatives require a design waiver or exception that may not be feasible, thereby rendering that alternative unviable? It is not expected that the project team will analyze design elements to identify specific waivers and/or exceptions, rather it is important to discuss the potential challenges associated with an alternative relative to VDOT standards (e.g., access management).

9.2.6 *Quality Review Requirements*

Quality control is a critical part of all traffic operations and safety analyses. The purpose is to verify that parameters and assumptions match the study requirements, that analyses are performed appropriately, models properly calibrated, and results are reasonable. Independent reviewers with experience in traffic operations and safety analyses, commensurate with the scope of the project, will complete the quality control reviews. These reviews will be performed throughout the project with time for these reviews included in the project budget and schedule.

The Traffic and Safety Operations Analysis Reviewers Prompt List, which is provided in **Appendix C**, should be used during the quality control review.

9.2.7 *Recommended Report Structure*

Traffic operations and safety analysis reports document the project purpose, analysis results, and conclusions. These reports are submitted in electronic format and contain the complete report, documentation of any deviation(s) from direction and guidance in this manual, and the analysis files from all tools used so the VDOT project manager and/or their designee can review the results using the appropriate traffic operations or safety analysis tool. Report formats and level of detail will vary depending on the type and complexity of the project, and the intended audience. Project-specific reporting guidelines, including any requirements for hard copies, should be determined on a case-by-case basis and agreed upon by the VDOT project manager at the project scoping meeting.

It is important that appropriate documentation is submitted with the report to support the traffic operations and safety analyses. Recommended output formats for each tool to be used are addressed in **Chapter 8**.

The following list of basic report sections should be considered (additional sections not listed below may also be considered depending on the nature of the project):

- Title Page
- Executive Summary
- Table of Contents
- Introduction
  - Purpose and Need
  - Project Background
  - Project Location Map
  - Analysis Objective(s)
- Analysis Methodology
  - Assumptions and Deviations, if any
  - Identification of Analysis Years/Scenarios
  - Analysis Tools and Outputs
  - Measures of Effectiveness
  - List of Stakeholders
- Existing Conditions Analysis
  - Data Collection
  - Field Review
  - Analysis Tool Calibration and Validation
  - Analysis Approach and Results
  - Crash Analysis
- Future Alternatives Analysis
  - Traffic Forecasting
  - No-Build Operational and/or Safety Analysis Results
  - Development of Alternatives
  - Build Alternatives Operational and/or Safety Analysis Results
  - Predictive Crash Analysis (if applicable)
  - Summary of Results
  - Public Involvement or Stakeholder Engagement (if applicable)
- Conclusions and Recommendations
- References
- Appendices

9.3 AFTER THE PROJECT SCOPING MEETING

Following the project scoping meeting, the primary action for the project manager is to revise and update the scoping document based on the outcome of the scoping meeting. Examples of additional coordination that may be required to complete follow up actions include:

- Conduct a site visit during the anticipated analysis period to verify the limits of congestion are captured within the defined project study area
- If microsimulation is required, use the VDOT Sample Size Determination Tool to determine the required number of microsimulation runs and if that aligns with expectations discussed during the scoping meeting
- Determine the availability of traffic data (consistent with the data collection plan discussed at the scoping meeting) and whether their availability or lack thereof impacts the data collection plan
- Confirm the availability of past studies or ongoing projects/studies pertaining the project study area and if they impact the opportunity to develop alternatives

It is the responsibility of the VDOT project manager or their designee to facilitate any resolutions in the project scope as they are ultimately the review agency that must approve the project, assuming the project is executed in compliance with the agreed upon scope elements. Once all project scoping items outlined in **Section 9.2** have been resolved, whether during or following the project scoping meeting, the project managers will sign the *TOSAM Project Scoping Meeting Preparation Form* (found in **Appendix B**). If there are scope items that deviate from the TOSAM or specifically require DTE authorization, as identified in the Project Categorization Matrix **(Table 32)**, the DTE should sign the form before project activities initiate.

9.4 PROJECT SCOPING EXAMPLE

The following sections present an example of how to apply the scoping guidance provided herein to a project.

9.4.1 *Background*

The Town of Somewhere, Virginia, recognizes the need to replace the existing Line Drive/Route Z Bypass signalized intersection. The intersection causes significant congestion during both the A.M. and P.M. peak periods as well as during special events at a nearby college. A pattern of rear-end collisions has been noticed due to the queuing that develops along the arterial. The existing intersection is the only traffic signal on an approximately 50-mile stretch to the next town.

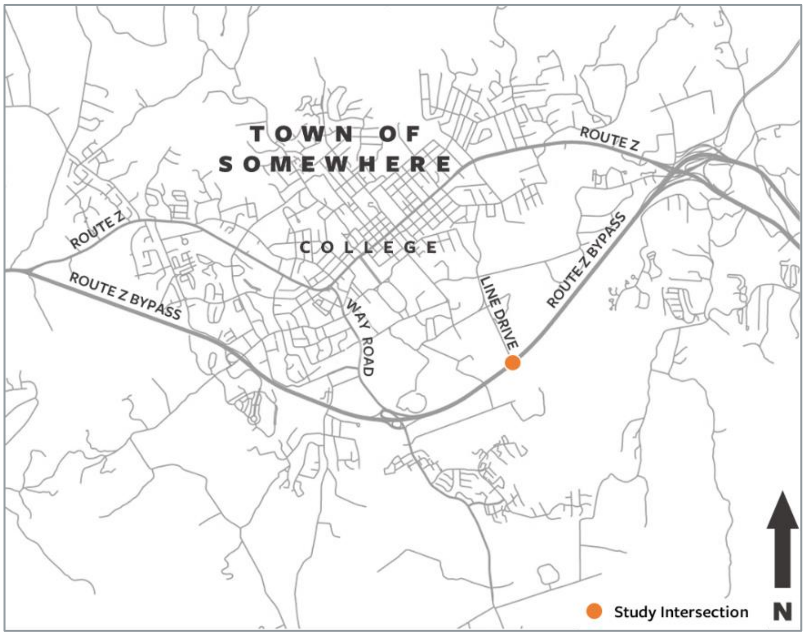
For this example, consider the following factors:

- Route Z Bypass is a roadway maintained by VDOT.
- Funding for design and construction of the anticipated improvements must be obligated within two years.
- The local comprehensive plan calls for a grade-separated interchange.
- A previous study was conducted by the MPO in cooperation with VDOT and the college. The study provided existing turning movement counts (TMCs) and estimated TMCs for 2040 by growing volumes from the 2030 regional travel demand model.
- Since Route Z Bypass is a Corridor of Statewide Significance and a National Highway System (NHS) route surrounded by interchanges on both sides, VDOT is requiring the development of an interchange justification report (IJR) to identify a preferred alternative.

9.4.2 *Roadway Descriptions*

A project location would be developed like that shown in **Figure 30**. Route Z Bypass is a limited-access, four-lane divided highway. Each direction of travel has a dedicated turn lane. Line Drive is a two- to four-lane urban collector with shoulders. The Line Drive/Route Z Bypass intersection has two left-turn lanes and one right-turn lane.

Figure 30: Project Scoping Location Map Example



9.4.3 *Before the Project Scoping Meeting*

The following activities would need to be completed prior to the project scoping meeting:

Roles and Responsibilities: **Identify and define the roles and responsibilities of the project manager, reviewing agency(ies), and project stakeholders.**

The responsibilities of the project manager include overseeing and directing the project team; ensuring the direction and guidance presented in the TOSAM are followed; and preparing for the project scoping meeting. Since the project is initiated within the Town of Somewhere, and located on a roadway maintained by VDOT, the Town of Somewhere and VDOT are considered the review agencies.

Since VDOT is requiring an IJR in accordance with the regulations outlined in the latest version of *IIM-LD-200*, the project manager needs to invite the following key reviewers to the scoping meeting:

- Representatives from the Town of Somewhere and the college.
- The District Planner and Engineer (or their designees) to discuss their specific requirements for the analysis and reporting.
- Technical experts responsible for scoping and reviewing the traffic analysis. Individuals chosen for this assignment may be different depending on whether Vissim, SimTraffic, and/or SIDRA is selected. For Vissim analysis, this individual will discuss specific requirements for model calibration and reporting. For SIDRA analysis, this individual will discuss specific requirements for the operational analysis.
- Safety analysis technical expert responsible for scoping and reviewing the safety analysis. For this type of project, the decision of whether to use predictive methods will be at the discretion of the DTE. The individual chosen for this assignment may be different depending on whether a predictive crash analysis is required. For this example, assume that a predictive crash analysis is not required, so the DTE or their designee should participate in the scoping meeting.

Project Purpose and Need: **Develop a purpose and need statement by reviewing established plans and ongoing projects including local comprehensive plans to understand future proposed improvements around the study area. Reference Section 9.1.2 to determine the project phase and review the Project Categorization Matrix (Table 32) prior to the project scoping meeting to determine typical project characteristics.**

To define the purpose and need statement, factors to consider include:

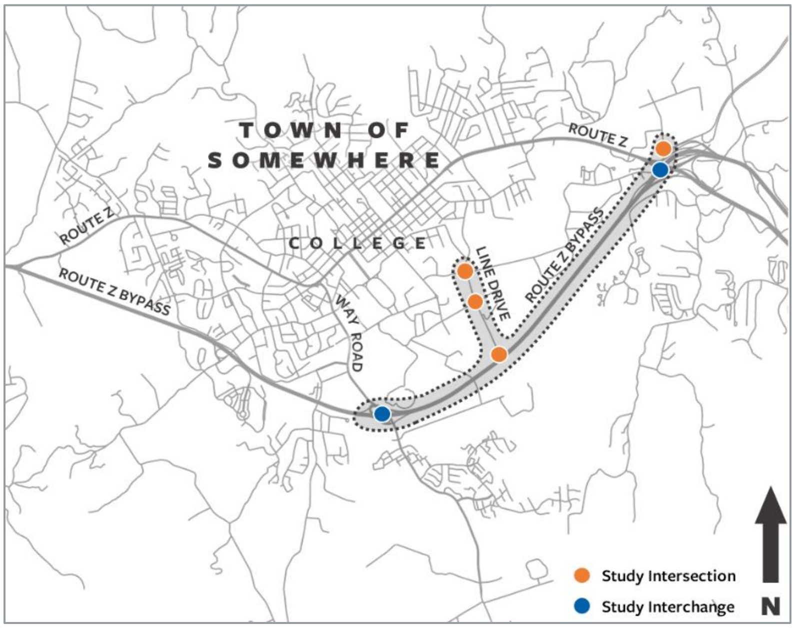
- The purpose of the project is to improve safety and operational conditions along Route Z Bypass during weekday A.M. and P.M. peak hours and during special events at the college. The goal is to identify improvements that accommodate future traffic along Line Drive and may be programmed for design and construction within two years.
- The project is in the development program-stage since the IJR is intended to recommend an alternative configuration.
- The project will consider adjacent land use and potential development that could impact the operational conditions along Route Z Bypass.

Study Limits: **Determine the physical study limits based on the latest *VDOT IIM-LD-200 (Development of Justification for Additional or Revised Access Points)*, which states that the limits must meet two criteria:**

1. **At a minimum, in urbanized areas, the analysis must extend through at least the first adjacent existing or proposed intersection on either side of the interchange.**
2. **At a minimum, in urbanized areas, the analysis must extend through at least the first adjacent existing or proposed major intersection on either side of the interchange.**

The proposed study limits are presented in **Figure 31**. The limits include the northeast and southwest interchanges, two signalized intersections along Route Z Bypass, and two signalized intersections along Line Drive. The intersection north of the Route Z Bypass/Route Z interchange is captured to present a complete picture of the existing and anticipated traffic operations.

Figure 31: Study Limits Map



It is at the discretion of the review project manager as to whether interchanges greater than 2 miles from the study location or intersections more than one-half mile from the study location should be considered as part of the analysis. Study locations that fall under the purview of the Federal Highway Administration (FHWA) (i.e., interchange justification/modification report including an NHS roadway) are governed by FHWA requirements.

This study considers urbanized areas; however, were the study area to be considered a rural area, the study limits would consider access points (e.g., signalized intersection, unsignalized interchange, interchange access point) within 2 miles along the primary route. It is at the discretion of the review project manager whether these locations are included in the analysis based on the proximity and type of access control.

Preliminary Data Review: **Review previous studies prior to the project scoping meeting to help screen alternatives and identify viable solutions.**

Previously conducted traffic count data is available throughout the study area. Identify the typical AM and PM weekday peak periods for analysis.

Review current saturation data from VDOT iPeMS and future traffic projections on this route from the Statewide Planning System (SPS) will be reviewed, where available, to determine if microsimulation is necessary. Alternatively, consult with District Planning staff to obtain future traffic projections and/or evaluate historical traffic data.

Review known or anticipated development in the vicinity. Consider land development plans and activity in adjacent communities that may serve the labor and/or student population at the college.

Traffic Forecasting: **Determine what the opening/interim and design years will be and select a forecasting methodology. Consult with District Planning to develop an appropriate forecasting methodology. Where possible, use regional travel demand models to consider regional planned development and traffic growth**.

After determining that a travel demand model is available, consult the *VDOT Traffic Forecasting Guidebook* to determine the appropriate forecasting technique for the analysis. Since the college is anticipating high growth in the surrounding area that will change regional travel patterns, select a travel demand model as the forecasting methodology.

According to the Project Categorization Matrix **(Table 32)**, the suggested horizon years for a project in the development program-level stage is 10 to 20 years. Projects in this stage typically have few inputs and one or two outputs from analysis tools. Select the design year according to the *VDOT IIM-LD-200*: advertisement date plus 22 years.

Preliminary Alternative Identification: **Develop preliminary project alternatives based on the project purpose and need. Establish appropriate evaluation criteria that will be used to screen alternatives.**

Based on a review of iPeMS and SPS, the projected traffic volumes on the Route Z Bypass are anticipated to exceed the capacity of an intersection improvement. Since TMCs are available from previous studies, screen intersection and interchange alternatives using VJuST.

Since right-of-way (ROW) is a limitation for future interchange configurations along the Route Z Bypass, do not consider alternatives with significant ROW impact (e.g., full cloverleaf interchange).

Consider the following four build alternatives based on the VJuST analysis:

- Diverging diamond
- Roundabout diamond
- Partial cloverleaf
- Standard diamond

Initial MOE Selection: **Determine which MOEs satisfy the purpose and need and will be recorded for the traffic operations and/or safety analysis project. MOEs will be discussed at the project scoping meeting.**

Select control delay and queue length as the MOE to compare intersection operations when screening alternatives. For the roadway network operations, select average delay, maximum 95th percentile queues, and travel time.

For the safety analysis, compare the projected number of crashes for each alternative.

Analysis Tool Consideration: **Determine the appropriate tool using the VDOT Software Selection Tool. Refer to the Project Categorization Matrix (Table 32) for a list of approved analysis tools for projects in the Project Development Stage.**

A review of preliminary data revealed the study is in an oversaturated area. Narrow the tools from the Project Categorization Matrix **(Table 32)** to microsimulation tools that include SimTraffic and Vissim and a macroscopic analysis tool for the roundabout analysis such as SIDRA.

9.4.4 At the Project Scoping Meeting

At the project scoping meeting, discuss refinements to preliminary considerations, in addition to the following factors.

Analysis Tool Selection and Calibration Requirements: **Discuss the preliminary analysis tool considerations, standard input parameters, including any anticipated changes to default values, and calibration parameters, if microsimulation tools are proposed.**

Since a roundabout is being considered as an alternative, SIDRA and Vissim are the preferred software tools. Consider traffic volume, travel time, and queue length calibration parameters and the parameters for collecting this data (i.e., duration, location(s), sample size). If traffic projections are low, consider performing a sensitivity analysis to test if the preferred alternative can handle additional traffic.

Data Source Selection: **Discuss how standard input parameters for the selected analysis tools will be collected. Refer to Chapter 7 for guidance on which input parameters are required.**

- ***Geometry:*** Existing geometric data will be field collected. Aerial imagery will be provided by VDOT and field verified by the study team.
- ***Traffic counts:*** A 24-hour traffic count will be field collected along the Route Z Bypass and the on- and off-ramps at the adjacent interchanges. Turning movement counts will be field collected at all intersections within the study area.
- ***Signal operations:*** Traffic signal operations data will be provided by the VDOT Regional Traffic Operations office.
- ***Calibration:*** Queues will be field observed and recorded at agreed upon locations and movement(s) within the study area. Travel time data will be field collected to achieve the agreed upon number of data points (runs) along the Route Z Bypass.
- ***Safety:*** Crash information will be provided by VDOT and the College.

Alternatives Analysis Requirements: **Discuss potential alternatives and the proposed alternatives evaluation methodology.**

The alternatives will be evaluated based on safety, traffic operations, environmental compliance, design compliance, and research of comparable designs currently in operation in Virginia and in adjacent states. Safety screening will include a crash data evaluation, but no predictive crash analysis will be required other than the comparison of crash modification factors where applicable. The results of the traffic operations analysis will be used to compare travel times, delays, and queues for the no-build versus build conditions.

Quality Review Requirements and Reporting Structure: **Discuss reporting requirements and review responsibilities.**

The IJR will adhere to all applicable VDOT criteria, including the regulations outlined in the latest version of *IIM-LD-200*. Before the scoping meeting, the VDOT Project Manager identifies the following key reviewers:

- State Location & Design Engineer (final VDOT IMR approval)
- District Location & Design Engineer (first level VDOT IMR approval)
- District Planner (approval of traffic forecasting growth rates)
- Vissim technical expert from either the offices of the DTE or State Traffic Engineer (approval of traffic simulation modeling and calibration requirements using Vissim)
- SIDRA technical expert from either the offices of the DTE or State Traffic Engineer (approval of traffic analysis requirements using SIDRA)
- Safety technical expert from the office of the DTE (approval of the nonpredictive traffic safety analysis)
- With these individuals in attendance, discuss the report review requirements and analysis assumptions and requirements.

9.4.5 *After the Project Scoping Meeting*

The study team will collect additional data to support decisions made at the project scoping meeting. Existing 24-hour directional volumes and peak-hour turning movement volumes will be collected at all key intersections within the study area. In addition, queue and speed data will be collected to support the Vissim calibration effort.

The delivery project manager will develop a scope based on the agreed upon parameters discussed during the project scoping meeting. If the project is already underway, the project managers should formalize an agreement to the parameters discussed at the scoping meeting.

APPENDIX A

Additional Resources Reviewed

This page is intentionally left blank

References

CMF Clearinghouse. U.S. Department of Transportation Federal Highway Administration, 2009. Web. <http://www.cmfclearinghouse.org/index.cfm>

Decision Support Methodology for Selecting Traffic Analysis Tools. Traffic Analysis Toolbox. Vol. II.: U.S. Department of Transportation Federal Highway Administration, 2004. Web. <http://ops.fhwa.dot.gov/trafficanalysistools/tat_vol2/vol2_Methodology.pdf>

Evaluation of Software Tools for Modeling and Simulating Roundabouts. Virginia Center for Transportation Innovation and Research. Print.

Guidelines for Applying Traffic Microsimulation Modeling Software. Traffic Analysis Toolbox. Vol. III.: U.S. Department of Transportation Federal Highway Administration, 2019. Web. < https://ops.fhwa.dot.gov/publications/fhwahop18036/fhwahop18036.pdf>

Highway Capacity Manual. 6th Edition. Transportation Research Board of the National Academies, 2016. Print.

Highway Safety Manual. 1st Edition. American Association of State Highway and Transportation Officials, 2010. Print.

Instructional and Informational Memorandum – Development of Justification for Additional or Revised Access Points; Creation of Interchange Justification/Modification Reports (IIM-LD-200.7). Virginia Department of Transportation Location and Design Division, 2013. Web. <http://www.virginiadot.org/business/resources/LocDes/IIM/IIM200.pdf

Microsimulation Simulation Model Calibration and Validation Handbook. Virginia Transportation Research Council, 2006. Web. <http://www.virginiadot.org/vtrc/main/online_reports/pdf/07-cr6.pdf>

National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design. Transportation Research Board of the National Academies, 2014. Web. <http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_765.pdf>

Protocol for VISSIM Simulation. Oregon Department of Transportation, 2019. Web. <https://www.oregon.gov/ODOT/Planning/Documents/APMv2_Add15A.pdf>
Synchro vs. SimTraffic Queue Results. Trafficware, 2013. Print.

Traffic Analysis Handbook. Florida Department of Transportation Systems Planning Office, 2014. Web. <https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/planning/systems/programs/traffanalysis/traffic-analysis-handbook_march-2014.pdf?sfvrsn=1edf5030_2>

Traffic Analysis Toolbox Volume VI: Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness. U.S. Department of Transportation Federal Highway Administration, 2007. Web. <http://ops.fhwa.dot.gov/publications/fhwahop08054/sect4.htm>

Traffic Data. Virginia Department of Transportation. Web. <http://www.virginiadot.org/info/ct-TrafficCounts.asp>

Traffic Engineering, Operations, and Safety Manual. Wisconsin Department of Transportation, 2005. Web. < https://wisconsindot.gov/dtsdManuals/traffic-ops/manuals-and-standards/teops/teops.pdf>

Updated Administrative Guidelines for the Traffic Impact Analysis Regulations. Virginia Department of Transportation, Transportation and Mobility Planning Division, 2014. Web.
<http://www.virginiadot.org/projects/resources/chapter527/Administrative_Guidelines_2014.pdf>

Work Zone Modeling and Simulation – A Guide for Decision-Makers. Traffic Analysis Toolbox. Vol. VIII: U.S. Department of Transportation Federal Highway Administration, 2008. Web.
<http://ops.fhwa.dot.gov/wz/traffic_analysis/tatv8_wz/tatv8workzone.pdf>

Working White Paper on the Implementation of the 2010 Highway Capacity Manual within Synchro Version 8. Trafficware, 2013. Web.
<http://www.trafficware.com/uploads/2/2/2/5/22256874/working_white_paper_on_the_implementation_of_the_2010_highway_capacity_manual_within_synchro_8_version_8.pdf>

This page is intentionally left blank.

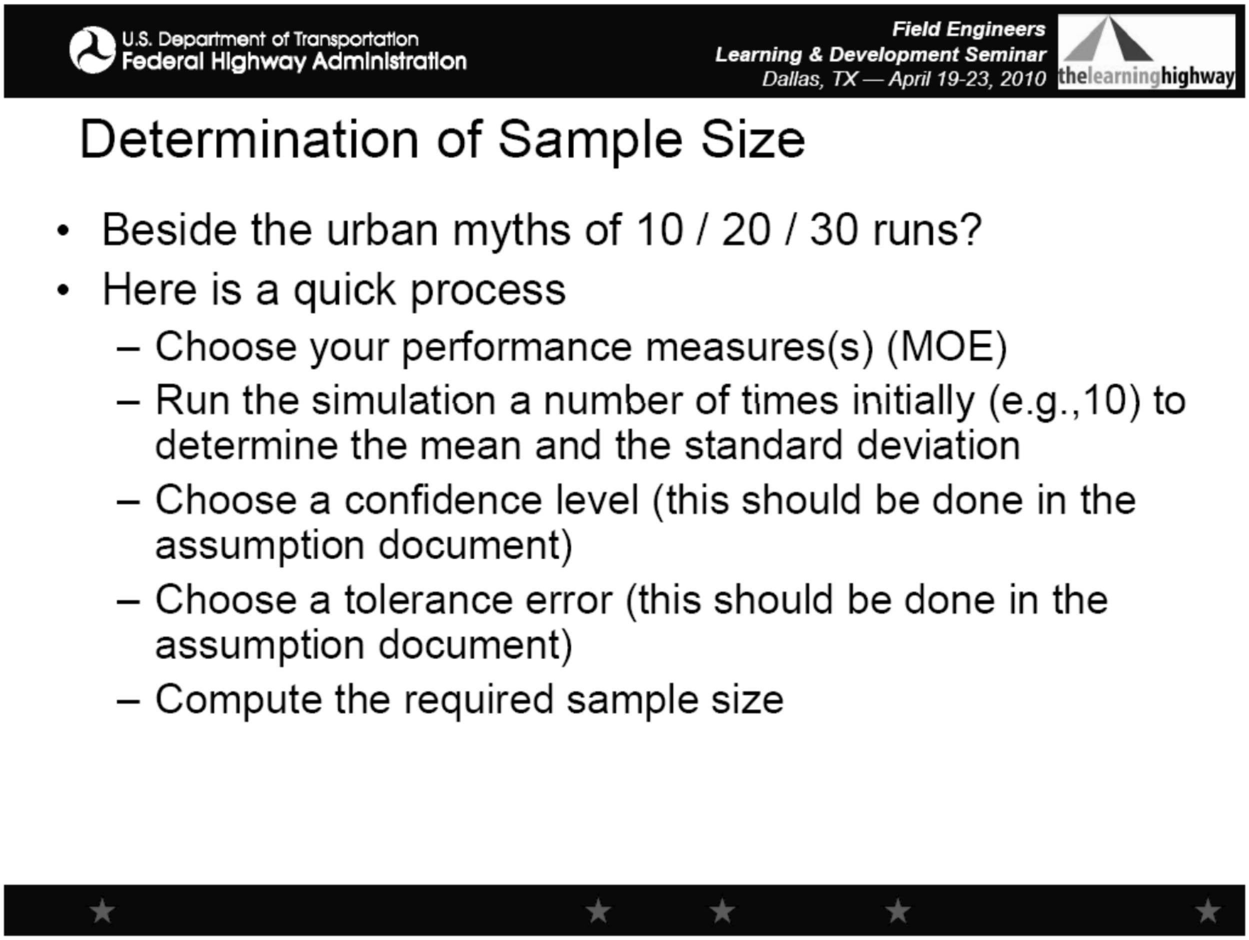
List of White Papers

The following white papers were prepared by the project team in support of developing updates to TOSAM Version 2.0. Electronic copies of these white papers are available through the VDOT website.

- *FREEVAL+*
- *HCS7, Version 7.6*
- *Innovative Intersections and Interchanges*
- *SIDRA Intersection 8*
- *Synchro 10*
- *Traffic Data Sources*
- *VISSIM 11 Evaluation Final Report*

This page is intentionally left blank.

FHWA Sample Size Information

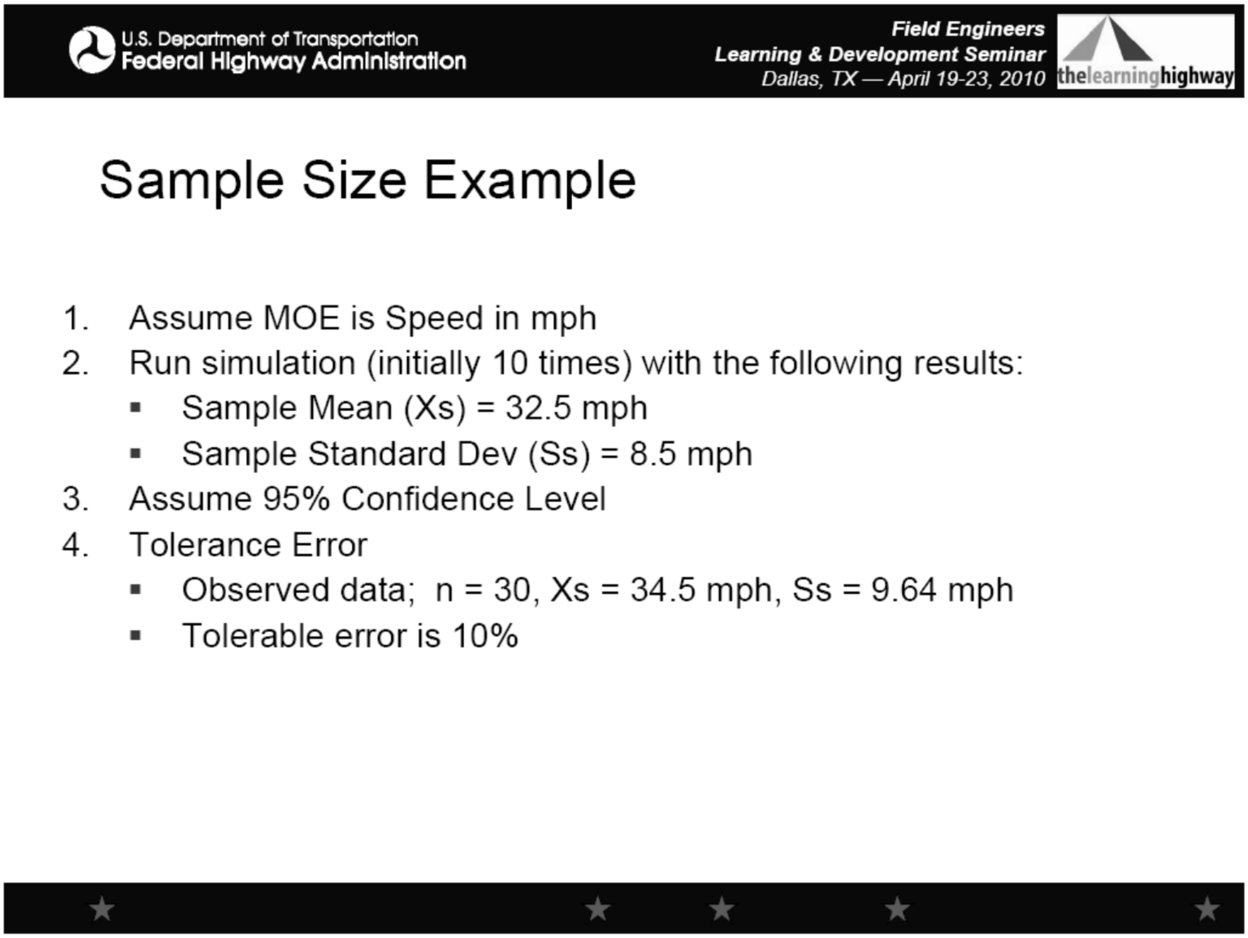


U.S. Department of Transportation
Federal Highway Administration

Field Engineers
Learning & Development Seminar
Dallas, TX — April 19-23, 2010

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



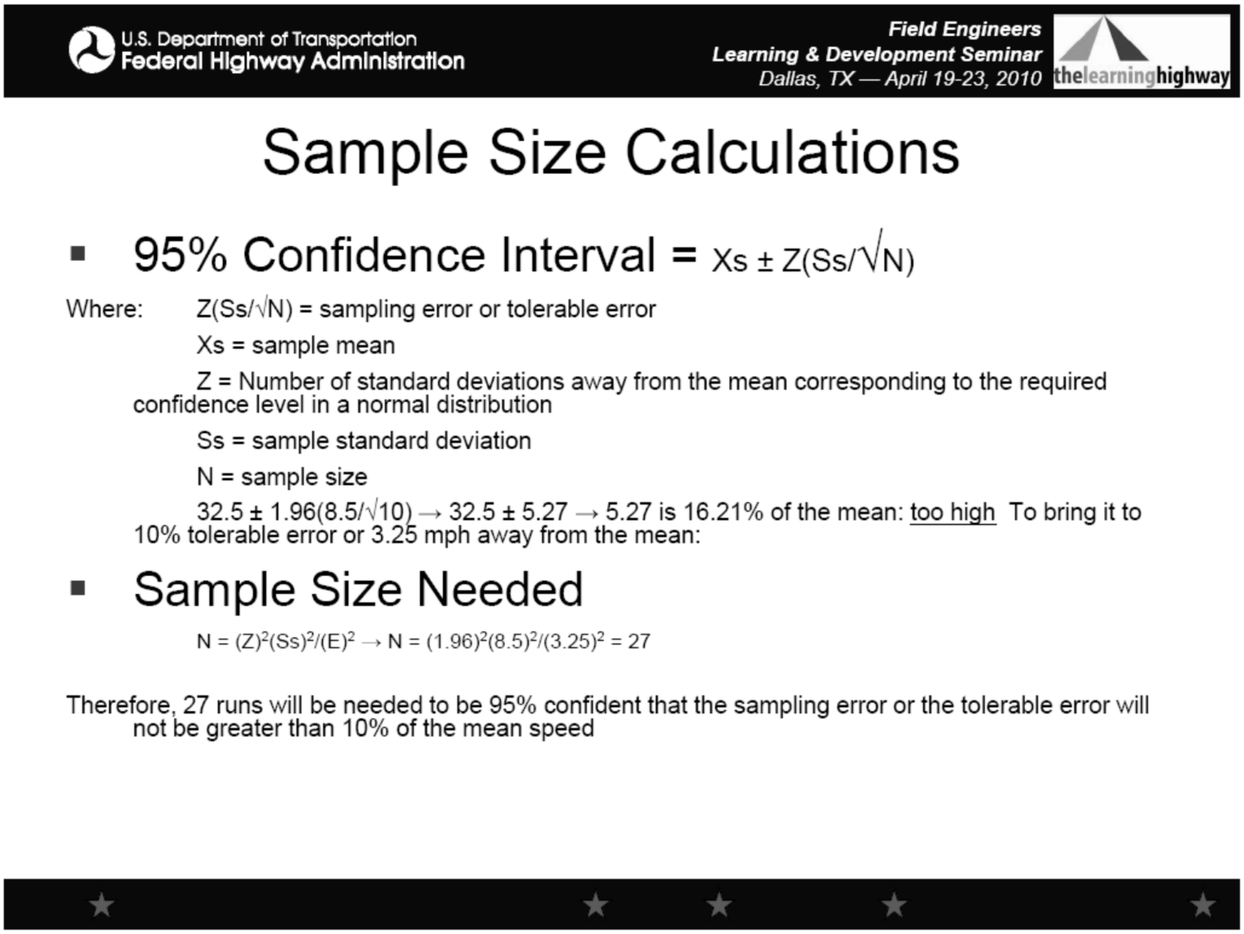
U.S. Department of Transportation
Federal Highway Administration

Field Engineers
Learning & Development Seminar
Dallas, TX — April 19-23, 2010

thelearninghighway

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%



U.S. Department of Transportation
Federal Highway Administration

Field Engineers
Learning & Development Seminar
Dallas, TX — April 19-23, 2010

thelearninghighway

Sample Size Calculations

- 95% Confidence Interval = $Xs \pm Z(Ss/\sqrt{N})$

Where: $Z(Ss/\sqrt{N})$ = sampling error or tolerable error

Xs = sample mean

Z = Number of standard deviations away from the mean corresponding to the required confidence level in a normal distribution

Ss = sample standard deviation

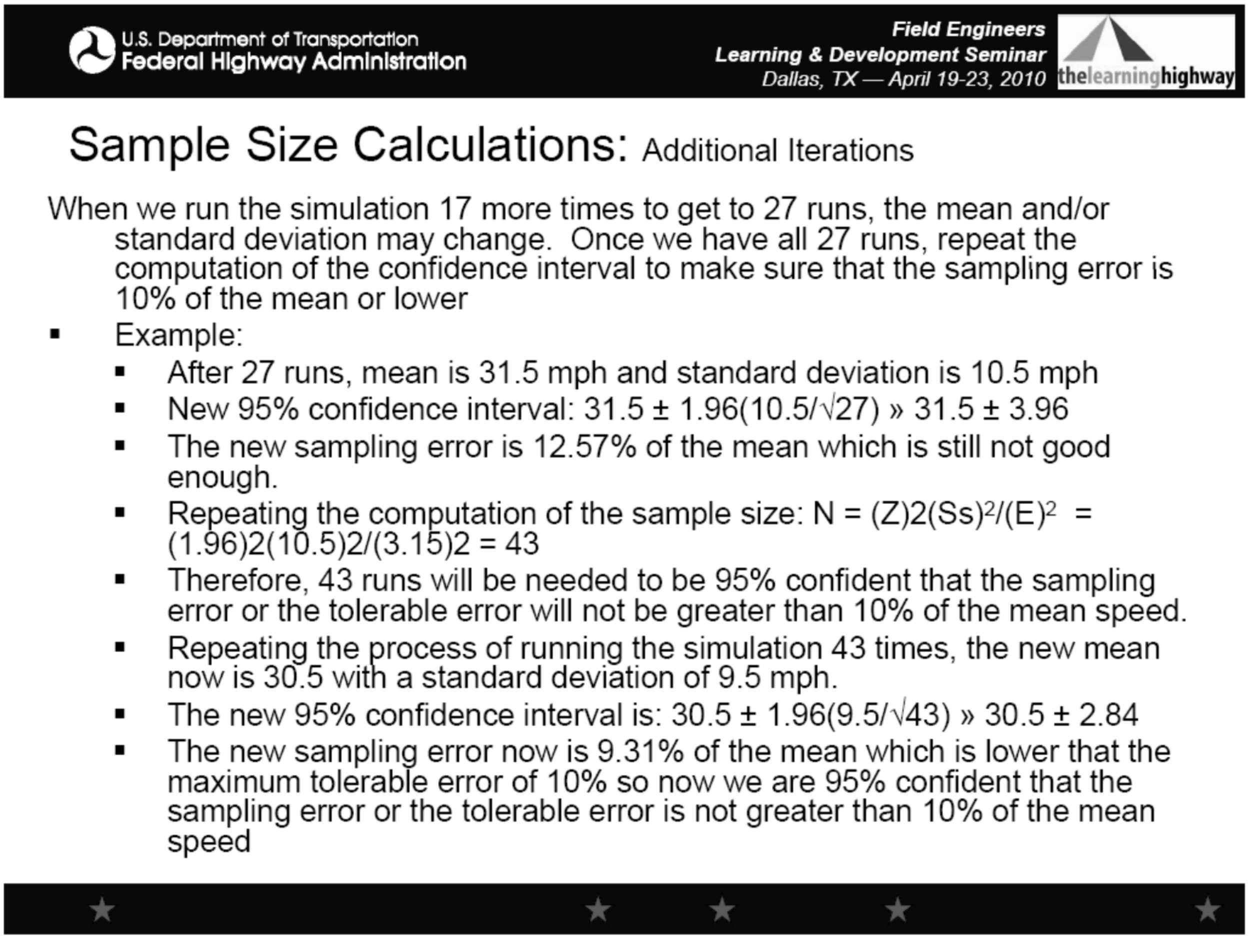
N = sample size

$32.5 \pm 1.96(8.5/\sqrt{10}) \rightarrow 32.5 \pm 5.27 \rightarrow 5.27$ 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

$N = (Z)^2(Ss)^2/(E)^2 \rightarrow N = (1.96)^2(8.5)^2/(3.25)^2 = 27$

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



U.S. Department of Transportation
Federal Highway Administration

Field Engineers
Learning & Development Seminar
Dallas, TX — April 19-23, 2010

thelearninghighway

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 ± 1.96(10.5/√27) » 31.5 ± 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 ± 1.96(9.5/√43) » 30.5 ± 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

This page is intentionally left blank.

APPENDIX B

TOSAM Project Scoping Meeting Preparation Form

This page is intentionally left blank

TOSAM Project Scoping Meeting Preparation Form

Traffic and Safety Analysis Considerations

In preparation for the project scoping meeting, enter the relevant information associated with traffic and safety analysis considerations, as outlined in TOSAM Section 9.1 - Before the Project Scoping Meeting. Submit the form to VDOT and the locality, if applicable, no less than five business days prior to the meeting. If a form is not received by this deadline, the project scoping meeting may be postponed.

Part I: Traffic Operations and Safety Analysis Assumptions

CONTACT INFORMATION Refer to TOSAM Section 9.1.1 – Roles and Responsibilities for guidance			
Project Manager (Administering Agency)	Name, Organization		
	Phone		
	Email		
Project Manager (Delivering Agency)	Name, Organization		
	Phone		
	Email		
Project Stakeholders	Name, Role		
	Name, Role		
	Name, Role		
	Name, Role		
	Name, Role		
	Name, Role		
PROJECT INFORMATION Refer to TOSAM Section 9.1.2 – Project Purpose and Need and Section 9.1.3 – Study Limits for guidance			
Project Name		Locality/County	
Project Description / Purpose and Need			
Study Limits	Project Location and Study Area Intersections	*Attach project map*	
	Temporal Limits, if known	Existing Year: Build-out Year: Design Year: Peak Period(s) for Study:	
External Factors that could affect the project (Programmed, proffered and planned road improvements, and other nearby developments; assumed background conditions for future analyses)			
Consistency with VTRANS			

PRELIMINARY DATA REVIEW Refer to TOSAM Section 9.1.4 – Preliminary Data Review for guidance		
Background Traffic Studies Considered (if applicable)		
Existing Traffic Operations Data	Historical Traffic Counts ☐ K-Factors ☐ D-Factors ☐ Truck Percentages ☐ Site Observations ☐ INRIX Speeds ☐	
Future Traffic Operations Data	Forecasts from Previous Studies ☐ Planning Forecasts ☐	
Safety Analysis Data	Crash Reports ☐ PSAP ☐ PSI ☐	
Data Collection Plan (Indicate the location and type of data to be collected, and any applicable sources)	*Attach project map indicating:* ☐ Maximum Queue Location(s) ☐ TMC Location(s) ☐ Travel Time Segment(s) ☐ Other -	
PRELIMINARY ALTERNATIVE IDENTIFICATION Refer to TOSAM Section 9.1.5 – Preliminary Alternative Identification for guidance		
Potential Alternatives that could be Considered (at-grade vs grade-separated options, roundabouts vs RCUTs vs MUTs)		
INITIAL MOE SELECTION Refer to TOSAM Section 9.1.6 – Initial MOE Selection for guidance		
Traffic Operations MOEs	95th Percentile Queue Length ☐ Control Delay ☐ Density ☐ ETT ☐ Maximum Queue Length ☐ Microsimulation Delay ☐ Percent of Free-Flow Speed ☐ Percent Time Spent Following ☐ Space Mean Speed ☐ Reliability: 95th% TTI ☐ 80th% TTI ☐ 50th% TTI ☐ LOTTR ☐ Time Mean Speed ☐ Travel Time ☐ V/C Ratio ☐	
Safety MOEs	Weighted Total Conflict Points ☐ Predicted Average Crash Frequency ☐ Expected Average Crash Frequency ☐	
ANALYSIS TOOL CONSIDERATION Reference outputs from the VDOT Software Selection Tool. Refer to TOSAM Section 9.1.7 – Analysis Tool Consideration for guidance		
Traffic Operations Software Tools (Select all tools under consideration)	FREEVAL ☐ HCS ☐ SIDRA ☐ SimTraffic ☐ Synchro ☐ VDOT Work Zone Tools ☐ VJuST ☐ VISSIM ☐ Other ☐ -	
Safety Analysis Software Tools	IHSDM ☐ ISATe ☐ VDOT Extended HSM Spreadsheets ☐ Other ☐ -	
Microsimulation (if applicable)	Calibration measures to be met (Refer to TOSAM - Chapter 5)	Simulated Traffic Volume ☐ Simulated Travel Time ☐ Simulated Queue Length ☐
	Critical link(s) for calibration	*Attach project map*

TRAFFIC FORECASTING Refer to the VDOT Traffic Forecasting Guidebook	
Traffic Forecasting Methodology (Indicate which travel demand model will be used, if applicable. Refer to the VDOT Traffic Forecasting Guidebook for guidance)	
NOTES ON ASSUMPTIONS	

Part II: Traffic Impact Analysis Base Assumptions (if applicable)

TRAFFIC IMPACT ANALYSIS ASSUMPTIONS			
Submission Type	Comp Plan ☐ Rezoning ☐ Site Plan ☐ Subdivision Plat ☐		
Consistency with Comprehensive Plan (Land use, transportation plan)			
Proposed Use(s)	Residential ☐ Commercial ☐ Mixed Use ☐ Other ☐		
	Residential Uses Number of Units: ITE LU Code(s): **Commercial Uses** ITE LU Code(s): Square Ft or Other Variable:	**Other Uses** ITE LU Code(s): Independent Variables:	
Total Peak Hour Trip Projection	Less than 100 ☐ 100-499 ☐ 500-999 ☐ 1,000 or more ☐	Annual Vehicle Trip Growth Rate (if different rate used by link/area, provide map or description summarizing growth rates)	
Peak Period for Study (Check all that apply)	AM ☐ PM ☐ SAT ☐	Peak Period of the Generator	
Trip Distribution (Attach sketch and indicate source)	Road Name: Road Name: Road Name: Road Name:		
Trip Adjustment Factors	Internal Allowance: Reduction:	Pass-by allowance: Reduction:	
Plan Submission	Master Development Plan ☐ Generalized Development Plan ☐ Preliminary/Sketch Plan ☐ Other Plan Type ☐ -		

APPROVAL

Project Manager (Administering Agency)

Signed: ____ Date: ________________

Print Name: ____

Project Manager (Delivering Agency)

Signed: ____ Date: ________________

Print Name: ____

VDOT District Traffic Engineer (if required)

Signed: ____ Date: ________________

Print Name: ____

APPENDIX C

Traffic Operations Analysis Reviewers Prompt List

This page is intentionally left blank.

Version 2.0, Rev 11/19

Traffic Operations and Safety Analysis Manual, Version 2.0
Traffic Operations Analysis Reviewers Prompt List

Project Information

Project Name ____________________

Project Description ____________________

UPC Number ____________________ State Project Number ____________________

Project Location ____________________

City/County ____________________ VDOT District ____________________

VDOT Project Manager ____________________

Locality/Agency Project Manager ____________________

Agency Partner Project Manager ____________________

Project Type/Analysis Category ____________________

Software Tool(s) Version and Build ____________________

Study Limits ____________________

Traffic Operations Analysis Review

The following items should be considered during data collection. Every item will not apply to all projects.

Inputs and Assumptions

__________ Geometric inputs based on existing field measurements and/or design plans

__________ Existing traffic volume inputs based on existing traffic count data

__________ Future traffic volume inputs based on projected traffic volumes approved by the PM

__________ Traffic signal timing inputs obtained from the entity that maintains the traffic signal timings

__________ All TOSAM standard input assumptions identified in Chapter 7 for each traffic and safety analysis tool

__________ Written documentation of justification and PM approval of any deviation from TOSAM standard input parameters.

Model Calibration (for microsimulation)

__________ Calibration process, including assumptions and calibration parameters, clearly documented

__________ Model runs, without errors, with balanced traffic volumes

__________ Model animation accurately represents the observed field conditions

__________ Model meets minimum calibration targets identified in Table 5 of TOSAM

__________ Model meets any additional calibration targets required by the PM

__________ Technical justification for any calibration targets not met

__________ Appropriate number of microsimulation runs completed (as determined by the VDOT Sample Size Determination Tool)

Results

__________ MOEs summarized for each link or intersection in the network

__________ MOEs summarized in tabular output format(s)

__________ MOEs summarized in depictive output format(s)

__________ Analysis report submitted in the format determined by the PM

__________ Documentation of any deviation from standards in the TOSAM submitted with the analysis report

__________ Analysis files submitted in electronic format

Comments

____

APPENDIX D

Data Collection Prompt List

This page is intentionally left blank.

Traffic Operations and Safety Analysis Manual, Version 2.0
Data Collection Prompt List

Project Information

Project Name ______________________________

Project Description ______________________________

UPC Number ______________ State Project Number ______________

Project Location ______________________________

City/County ______________ VDOT District ______________

VDOT Project Manager ______________________________

Locality/Agency Project Manager ______________________________

Agency Partner Project Manager ______________________________

Project Type/Analysis Category ______________________________

Software Tool(s) Version and Build ______________________________

Study Limits ______________________________

Traffic Operations Analysis Review

The following items should be considered during data collection. Every item will not apply to all projects.

Geometric Data

__________ Geometric input parameters identified in Table 6 of TOSAM for the project analysis category

Traffic Count Data

__________ Traffic data collection parameters identified in Table 7 of TOSAM for the project analysis category

__________ Traffic count data collected during the same time periods

__________ Turning movement counts (TMCs) conducted for at least 4 consecutive hours in each peak period

__________ Vehicle classification counts conducted for a minimum of 48 consecutive hours

__________ All traffic count data collected at 15-minute or shorter intervals

__________ Heavy vehicle classification counts that comply with FHWA guidelines

__________ Pedestrian and/or bicycle counts (when present at an intersection)

__________ Weekday traffic counts collected only on Tuesdays, Wednesdays, and/or Thursdays

__________ Weekend traffic counts collected on Saturdays and/or Sundays (as needed based on project goals)

__________ Traffic count data not collected on holidays or days influenced by holiday traffic

__________ Traffic count data collected when school is in session in areas influenced by school traffic

__________ Traffic count data collected when major employment centers are operating on a normal schedule

__________ Traffic count data reviewed and checked for reasonableness

__________ Traffic count data that is no more than two years old and the roadway has not experienced any major geometric and/or traffic control changes since data was collected (see Chapter 6 for guidance on appropriate age of data)

__________ Common uniform peak hour computed and applied to the entire network (method of determining common uniform peak hour to be approved by VDOT project manager)

__________ Balanced traffic count data (recommended for all analysis tools, required if using microsimulation)

__________ Work zone data including lane closure information, lane closure lengths, time of day closure, intensity of work zone, detour and alternative route availability, condition of alternative routes, and percentage of traffic volume expected to detour (for work zone analysis)

Traffic Operations and Safety Analysis Manual, Version 2.0
Data Collection Prompt List

Signal Operations Data

____________ Traffic and pedestrian signal timing data obtained from the appropriate VDOT Regional Traffic Operations office or city/town engineering office

____________ Green times (minimum and maximum)

____________ Clearance intervals

____________ Cycle lengths

____________ Offsets and associated reference point within the signal cycle

____________ Type of controller (NEMA, fixed time, etc.)

____________ Sequencing and traffic signal phasing diagrams

____________ Actuation type

____________ Vehicle extension and gap time

____________ Recall mode

____________ Time of day plans

____________ Pedestrian crossing times ("WALK" and "DON'T WALK") and signal controller mode for accommodating pedestrian crossing times that exceed corresponding vehicular signal phase green time (coordinated operations only)

____________ Transit priorities

____________ Preemption timings and signal controller mode for returning to normal operations after a preemption event

____________ Ramp metering data (processing splits, capacity criteria, etc.)

Calibration Data

____________ Refer to Table 8 in TOSAM for a listing of calibration parameters for each project analysis category

____________ When using speed data for valibration, collect a minimum of 48 consecutive hours of speed data in each direction of travel in 15-minute intervals.

____________ When using travel time data for calibration, collect data according to guidelines in Chapter 6

____________ When using queues for calibration, collect queue lengths according to guidelines in Chapter 6 at locations agreed upon and verified by the VDOT project manager during project scoping

____

For toll plaza analyses, collect vehicle processing data for all available payment options according to guidelines in Chapter 6

____________ Identify other additional calibration data requirements of the VDOT project manager

____________ Calibration data that is no more than two years old and the roadway has not experienced any major geometric and/or traffic control changes since the data was collected (see Chapter 6 for guidance on appropriate age of data)

Safety Data

____________ Historical crash data for at least 2 years (5 is preferable) that includes crash location, type, and severity (at a minimum)

____________ All geometric and/or traffic control data required for the specific safety analysis tool

____________ All roadway alignment data required for the specific safety analysis tool

____________ VDOT project manager approval of the use of CMFs on a project and the selection of individual CMFs

____________ SPF site sub-type calibration factors to adjust national averages to Virginia conditions (if available)

____________ Table of proportions to adjust national averages of crash and severity distributions to Virginia conditions (if available)

APPENDIX E

SimTraffic Calibration Parameters

This page is intentionally left blank.

This appendix is intended to provide a list of SimTraffic input parameters that can be modified to meet the thresholds outlined in **Table 5**, the calibration thresholds that shall be used as minimum thresholds for calibration. The VDOT project manager may decide to use stricter thresholds based on the project needs. If the minimum thresholds cannot be achieved, written justification shall be provided for review and approval by the RTE or his/her designee. Out of the calibration parameters identified in this appendix some have values that are directly measured in the field while some cannot be directly measured; and there may be instances where these field-measured values may be modified to achieve calibration thresholds. It must be noted that before beginning the model calibration process, users should verify that all field-measured values, for both input and calibration parameters, have been correctly coded including balanced volumes.

A memorandum detailing which parameters were adjusted to calibrate a network shall be provided with traffic operations analysis results.

SIMTRAFFIC CALIBRATION PARAMETERS

***Intersections* –** simulated traffic volume and simulated queue length should be used for calibration.

***Arterials* –** simulated traffic volume, simulated travel time, and simulated queue length should be used for calibration.

Simulation Settings (Synchro)

- Headway Factor
- Turning Speed (mph)
- Mandatory Distance (ft)
- Positioning Distance (ft)
- Mandatory Distance 2 (ft)
- Positioning Distance 2 (ft)

SimTraffic Parameters (SimTraffic)

- Vehicles
  - Vehicle Occurrence (%)
- Drivers
  - Speed Factor (%)
  - Headway @ 0 mph (s)
  - Headway @ 20 mph (s)
  - Headway @ 50 mph (s)
  - Gap Acceptance Factor
  - Positioning Advantage (veh)
  - Optional Advantage (veh)
  - Mandatory Dist Adj (%)
  - Positioning Dist Adj (%)
  - Average Lane Change Time (s)

SIMTRAFFIC BEST PRACTICES

The following are recommended best practices when calibrating a Synchro model for microsimulation using SimTraffic. These are not the only parameters suggested for adjustment when using SimTraffic; rather, these represent the parameters, adjustable within the Synchro model, with a greater potential impact on the results of a microsimulation analysis in SimTraffic. A complete list of parameters that can be adjusted are listed in the subsequent section.

Turn Lanes

Where turn lanes are present between two closely spaced intersections (e.g. diamond interchange), consider coding a storage length for the turn lane equal to the link distance despite the lane being continuous between intersections. Doing so will prevent vehicles turning left at the first intersection from entering the left-turn lane at the second intersection. **Figure E1** illustrates this recommended model coding practice.

Figure E1: Recommended Geometric Configuration for Continuous Turn Lanes between Intersections

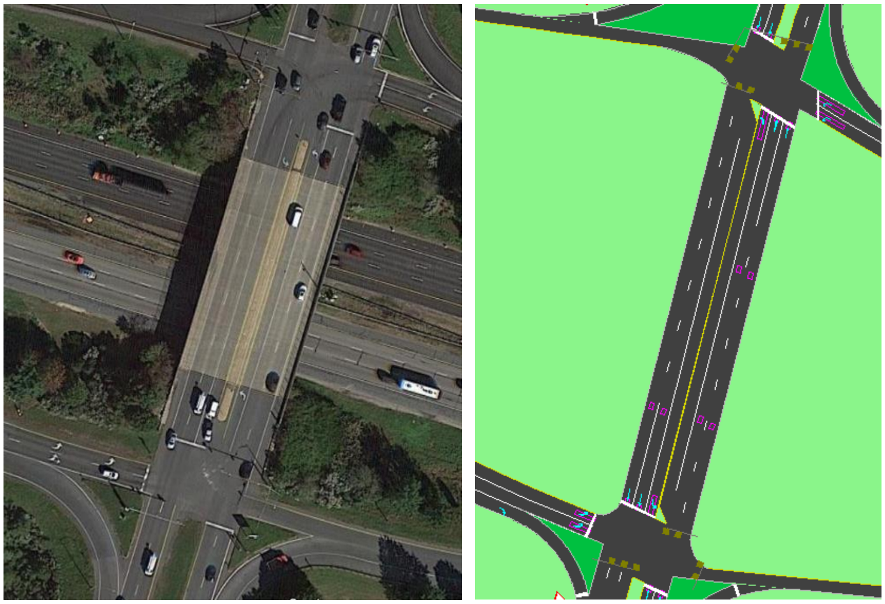


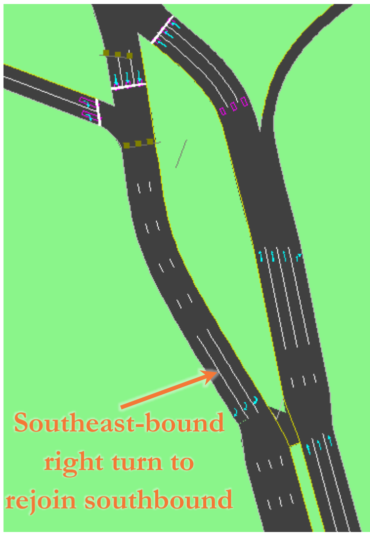
Image source: Google

Turning Speed (mph)

The default turning speed in SimTraffic (adjusted in Synchro) is 15 mph for left turns and 9 mph for right turns. Regardless of the speed of the roadway coded in Synchro, microsimulation within SimTraffic will limit vehicle travel speeds to these parameters. Turning speed can be adjusted based on the geometry and operations at a particular intersection or node. Examples of locations where turning speed should be considered for adjustment include:

- Channelized right turns with larger corner radii than a conventional perpendicular right turn
- Left turns at large intersections where vehicles are not inhibited from traveling at higher speeds (e.g. obtuse left turns at skewed

Figure E2: Example of Turning Speed Adjustment for DDI



intersections, wide intersections with set-back side street approaches)

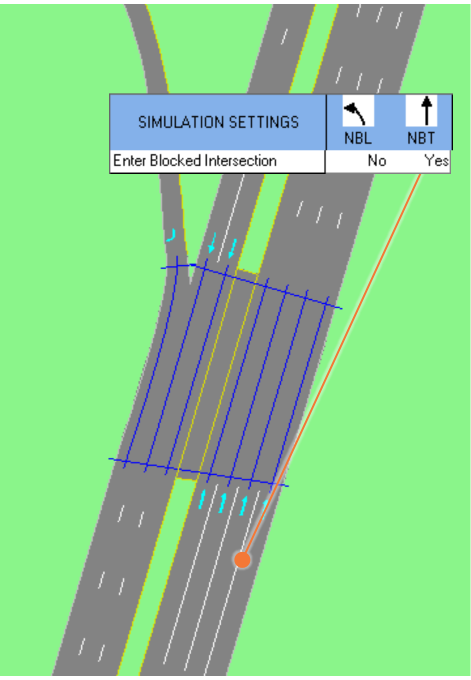
- Left turns at narrow intersections with narrow receiving lanes (e.g. urban intersections with a narrow receiving lane)
- Permissive left turns where drivers are observed making more aggressive (i.e. faster) turning maneuvers
- Entry ramp at an uncontrolled node (e.g. freeway off-ramp)
- Intersection of two directional links at a bidirectional link (e.g. diverging diamond interchange (DDI) – refer to **Figure E2**)

Consider data collection (field measured in a vehicle or using a radar device) or design speeds of the facility to confirm appropriate turning speed adjustments.

Enter Blocked Intersection

The default setting for SimTraffic (through Synchro) is that no vehicle should occupy (or enter) an intersection (node) if there is insufficient queuing space in the downstream link. This is typically a reasonable default setting to leave unchanged; however, there are circumstances where adjusting this parameter could have an impact on the microsimulation. Highly congested networks where vehicle blockages are routine may warrant the selection of "1 veh" or "2 veh" under the "Enter Blocked Intersection" setting. Another circumstance, illustrated in **Figure E3**, is at nodes where one direction of travel does not include intersecting links. In this example, were vehicles to queue through this node from a downstream intersection, queue spillback would be exacerbated by the fact that vehicles would not occupy the entirety of the node (upwards of 4 passenger car lengths). Setting the "Enter Blocked Intersection" parameter to "Yes" would reduce the impact of queue spillback to an upstream intersection. The "Enter Blocked Intersection" parameter may also be checked "Yes" to improve throughput for permissive left-turn movements.

Figure E3: Example of Location where "Enter Blocked Intersection – Yes" is Recommended

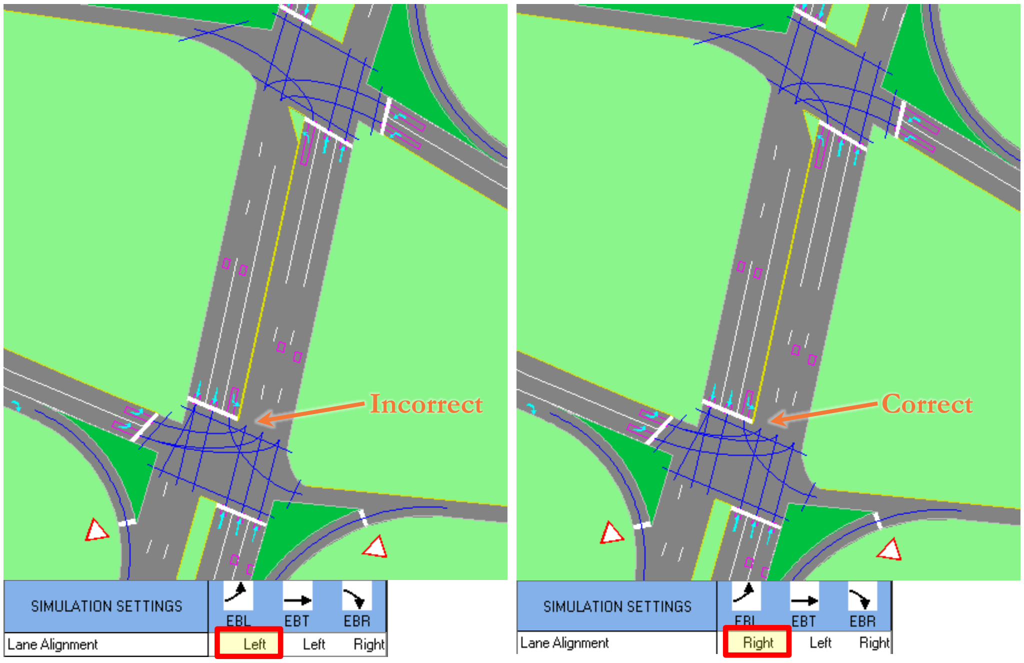


SIMULATION SETTINGS	NBL	NBT
Enter Blocked Intersection	No	Yes

Lane Alignment

Where turn lanes develop from upstream through lanes between two closely spaced intersections, it is recommended that lane alignments for side street turning movements be adjusted (or confirmed) not to direct vehicles exclusively into the turn lane. Otherwise, lane utilization of the side street turn lane into the downstream turn lane will be low, directly impacting simulated queue and simulated delay results. Adjust the lane alignment to be "right" in the case of a downstream left-turn lane (illustrated in **Figure E4**)and "left" in the case of a downstream right-turn lane.

Figure E4: Illustration of Incorrect (left image) and Correct (right image) Lane Alignment Settings for Downstream Lane Drop



SIMULATION SETTINGS	EBL	EBT	EBR
Lane Alignment	Left	Left	Right

SIMULATION SETTINGS	EBL	EBT	EBR
Lane Alignment	Right	Left	Right

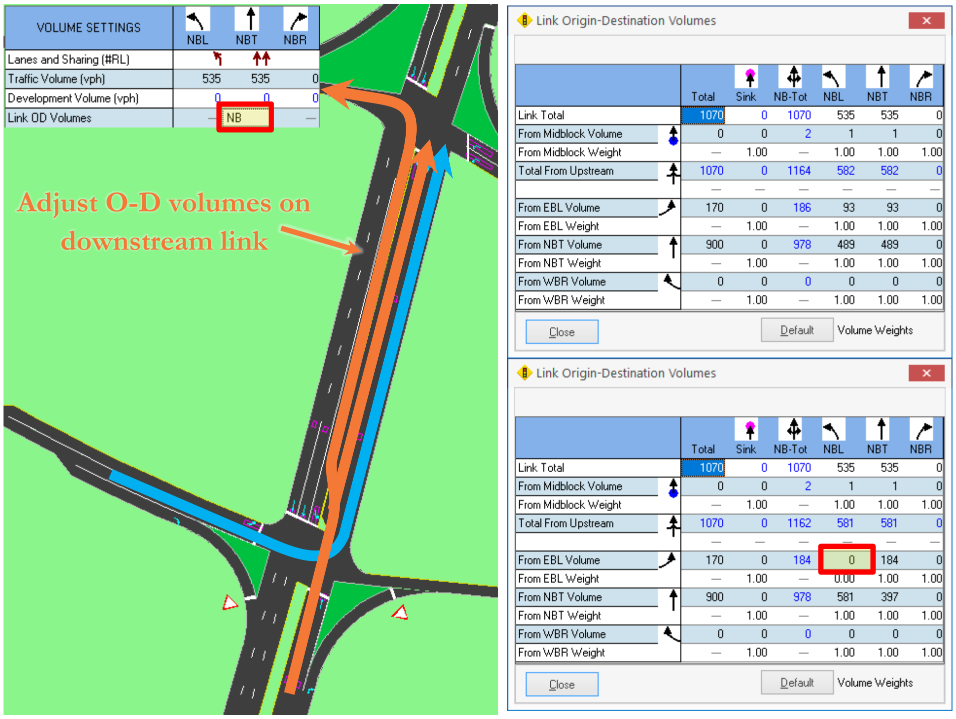
Link Origin-Destination (O-D) Volumes

Synchro contains default parameters for routing vehicles through a network. In certain geometric conditions, it is recommended that link O-D Volumes be adjusted to control the routing of specific movements between two nodes. These conditions include:

- Short links (less than 300 feet)
- Clustered intersections
- Between intersections of a freeway interchange
- In the median of a wide arterial
- Between nodes of an offset T-intersection

If link O-D volumes are not adjusted, circuitous routes may be simulated in SimTraffic that could cause queue spillback. **Figure E5** illustrates the adjustment of link O-D volumes in Synchro from the default settings to preclude eastbound left turns from completing a subsequent northbound left turn.

Figure E5: Example Link O-D Volume Adjustment at Diamond Interchange



VOLUME SETTINGS	NBL	NBT	NBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	535	535	0
Development Volume (vph)	0	0	0
Link OD Volumes	—	NB	—

Adjust O-D volumes on downstream link

Link Origin-Destination Volumes

	Total	Sink	NB-Tot	NBL	NBT	NBR
Link Total	1070	0	1070	535	535	0
From Midblock Volume	0	0	2	1	1	0
From Midblock Weight	—	1.00	—	1.00	1.00	1.00
Total From Upstream	1070	0	1164	582	582	0
	—	—	—	—	—	—
From EBL Volume	170	0	186	93	93	0
From EBL Weight	—	1.00	—	1.00	1.00	1.00
From NBT Volume	900	0	978	489	489	0
From NBT Weight	—	1.00	—	1.00	1.00	1.00
From WBR Volume	0	0	0	0	0	0
From WBR Weight	—	1.00	—	1.00	1.00	1.00

Default O-D volumes are assigned proportionally by turning volumes

Link Origin-Destination Volumes

	Total	Sink	NB-Tot	NBL	NBT	NBR
Link Total	1070	0	1070	535	535	0
From Midblock Volume	0	0	2	1	1	0
From Midblock Weight	—	1.00	—	1.00	1.00	1.00
Total From Upstream	1070	0	1162	581	581	0
	—	—	—	—	—	—
From EBL Volume	170	0	184	0	184	0
From EBL Weight	—	1.00	—	0.00	1.00	1.00
From NBT Volume	900	0	978	581	397	0
From NBT Weight	—	1.00	—	1.00	1.00	1.00
From WBR Volume	0	0	0	0	0	0
From WBR Weight	—	1.00	—	1.00	1.00	1.00

Manually override the "From EBL Volume" to zero – this will automatically adjust the O-D volumes for other contributing movements (i.e. NBT volume)

Crosswalk Width

The default value for this field is 16 feet. Adjusting this parameter changes where the stop bars are located. The stop bar placement affects gap acceptance and the use of yellow time to clear the intersection, in particular for permissive left turns.

Median Width

This value is calculated automatically in Synchro and is based on the number of left-turn lanes modeled. For example, modeling two left-turn lanes results in a median width of 24 feet. Consider adjusting this value to match field conditions if additional width is available. Vehicles may utilize the space in the median to complete two-stage left turns at unsignalized intersections.

APPENDIX F

Excel-Based Macro User Guide

This page is intentionally left blank.

Virginia Department of Transportation

Traffic Operations and Safety Analysis Manual

EXCEL-BASED MACRO USER GUIDE

Version 2.0

VDOT Traffic Engineering Division

January 2020

Notice and Disclaimer

This document is disseminated by the Virginia Department of Transportation (VDOT) for informational purposes only. No changes or revisions may be made to the information presented in this document without the express consent of VDOT.

The recommendations in this guide are based on VDOT's experiences, best practices and engineering preferences. VDOT assumes no liability for the use of the information contained in this document nor endorses any products or manufacturers referenced in this document. Trademarks or manufacturers' names are used solely for reference purposes.

Copyright

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

Glossary of Terms

***.ATT:** Vissim, Version 6.0 and newer output file containing microsimulation results.

Control Delay: Delay associated with vehicles passing through an intersection, including 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).

Data Collection File: Text file that contains Vissim data collection points.

Delay: Travel time experienced by a driver, passenger, bicyclist, or pedestrian beyond that required to travel at the desired speed (expressed in seconds per vehicle). See control delay or microsimulation delay for more information.

Density: The number of vehicles occupying a given length of lane at a particular instant (expressed in either passenger cars per mile per lane (pcpmpl) for deterministic traffic tools or vehicles per mile per lane (vpmpl) for stochastic traffic tools).

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

***.INP:** Vissim, Version 5.4 model file extension.

***.INPX:** Vissim, Version 6.0 model file extension.

***.KNA:** Vissim 5.4 and older output file containing arterial results.

Level of service (LOS): Stratification of a performance measure(s) that represent quality of service, measured in an A-F scale with LOS A representing the best.

Measure of Effectiveness (MOE): Factor that quantifies operational and safety objectives and provides a basis for evaluating the performance of the transportation network.

***.MES:** Vissim output file containing freeway results.

Microscopic analysis tools: Tools used to simulate the characteristics and interactions of individual vehicles. These tools include algorithms and rules describing how vehicles move and interact within the transportation network, including acceleration, deceleration, and lane changing (e.g., SimTraffic and Vissim).

Microsimulation: Modeling of individual vehicle movements on a second or sub-second basis to assess the traffic performance of a transportation node, segment, or network.

Microsimulation delay: The difference (expressed in seconds per vehicle) between the simulated travel time and the theoretical travel time if the vehicle was operating at the desired speed calculated by a microsimulation tool.

Model calibration: Modeling process where the modeler modifies calibration parameters that cause the model to best replicate field-measured and observed traffic volumes, speeds, travel times, and queues.

Model validation: Modeling process where the modeler checks the overall model-predicted traffic performance for a network against field measurements of traffic performance not using data from the calibration process.

***.STR:** Vissim, Version 5.40 output file containing microsimulation results.

***.TNO:** TSIS, Version 6.3 file extension compatible with TRAFED.

TOSAM: Acronym for the *VDOT Traffic Operations and Safety Analysis Manual.*

TRAF Editor (TRAFED): A graphical input editor used to define traffic networks and other input for microsimulation.

TRAFVU: TRAF Visualization Utility: A graphics processor used to display traffic networks and animate vehicles and traffic signals on that network.

Tshell: The graphical user interface (GUI) for TSIS.

VDOT project manager: Individual responsible for overseeing and directing the project from scoping through project delivery. The VDOT project manager is responsible for ensuring the direction and guidance presented in this manual are followed and should consult with technical specialists, as needed, throughout the project process.

VDOT Sample Size Determination Tool (Version 2.0): This tool helps the project manager determine the number of traffic microsimulation runs to be conducted for each project (VDOT_Sample_Size_Determination_Tool_v2.0.xlsx).

VDOT Software Selection Tool (Version 2.1): This tool provides direction to the project manager to determine the most appropriate traffic operations and/or safety analysis tool(s) to be used for each project (VDOT_Software_Selection_Tool_v2.1.xlsm).

VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2): This tool helps the project manager during the VISSIM calibration and output processing, specifically for freeway operations (VISSIM_Calibration_and_Freeway_Output_v2.0.xlsm).

VISSIM Intersection Data Processing Tool (Version 2.0): This tool helps the project manager to summarize intersection-related output from VISSIM (VISSIM_Intersection_v2.0.xlsm).

1 INTRODUCTION

1.1 BACKGROUND

This user guide is intended to assist users of the *Traffic Operations and Safety Analysis Manual, Version 2.0* (*TOSAM*) in using the Microsoft® Excel-based macros that were developed in support of the manual. VDOT identified the need to develop the *TOSAM* to provide direction to project managers to select the most appropriate traffic and analysis tool(s) during the project scoping phase, understand the data requirements and standard assumptions related to each analysis tool, and produce consistent output results from those tools for transportation analyses. As part of the process to produce consistent output results from traffic analysis tools, multiple Excel-based macros were developed in conjunction with the *TOSAM* to assist users in reporting output results in a graphical format. This user guide and the associated Excel-based macros are intended to be used by VDOT and consultant project managers.

This user guide is intended to assist users of the *Traffic Operations and Safety Analysis Manual, Version 2.0,* in using the macros supporting the manual.

The current version of the *TOSAM* requires users to report output results in a graphical format. The following macros were developed to assist users in applying the methodologies outlined in the *TOSAM:*

- VDOT Software Selection Tool (Version 2.1)
- VDOT Sample Size Determination Tool (Version 2.0)
- VISSIM Intersection Data Processing Tool (Version 2.0)
- VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2)

The calibration and output processing macros are intended to:

1. Combine output results from multiple microsimulation runs into a single set of results; and
2. Extract output data from microsimulation runs into tabular and graphical formats compatible with the *TOSAM*.

The Excel-based macros **WILL NOT**:

1. Report MOEs other than density, microsimulation delay and space mean speed;
2. Report Level of Service (LOS);
3. Produce arterial outputs in a graphical format;
4. Identify user errors in the coding of microsimulation models;
5. Work with versions of Microsoft® Excel earlier than 2007; and
6. Ensure that the minimum requirement of reporting two MOEs is met (Note: the freeway results that are reported on the output schematic will meet this requirement).

Limitations specific to each Excel-based tool are explained in its respective section.

This user guide is not intended to serve as a specific software user guide; however, it does provide guidance on how to properly code VISSIM models to produce outputs compatible with the Excel-based macros. For a brief description of the history and capabilities of VISSIM, refer to Chapter 3 of the *TOSAM*.

1.2 EXCEL-BASED MACRO MAINTENANCE AND UPDATES

VDOT will have the primary responsibility for maintaining the functionality of the Excel-based macros. Future refinements and improved functionality are expected as analytical tools change and the *TOSAM* evolves.

2 VDOT SOFTWARE SELECTION TOOL (VERSION 2.1)

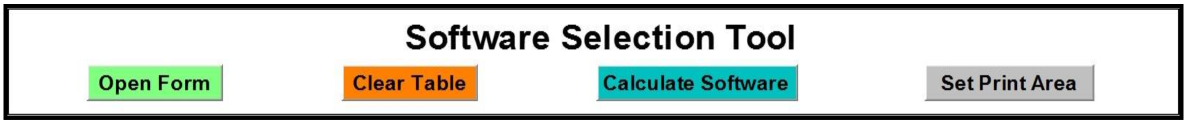
This chapter describes how to use the VDOT Software Selection Tool (Version 2.1). Instructions for using the tool may also be found in the "User Guide" tab of the Excel spreadsheet.

Microsoft® Excel may produce a security warning message that some of the active content in the tool has been disabled. Select "Enable Content" to enable macros within the spreadsheet. If the macro does not work after it has been enabled, verify that security settings have enabled all macros and that the version of Microsoft® Excel is compatible with the macro.

This tool consists of the following four buttons as shown in **Figure 1**:

1. Open Form
2. Calculate Software
3. Set Print Area
4. Clear Table

Figure 1: Macro Buttons

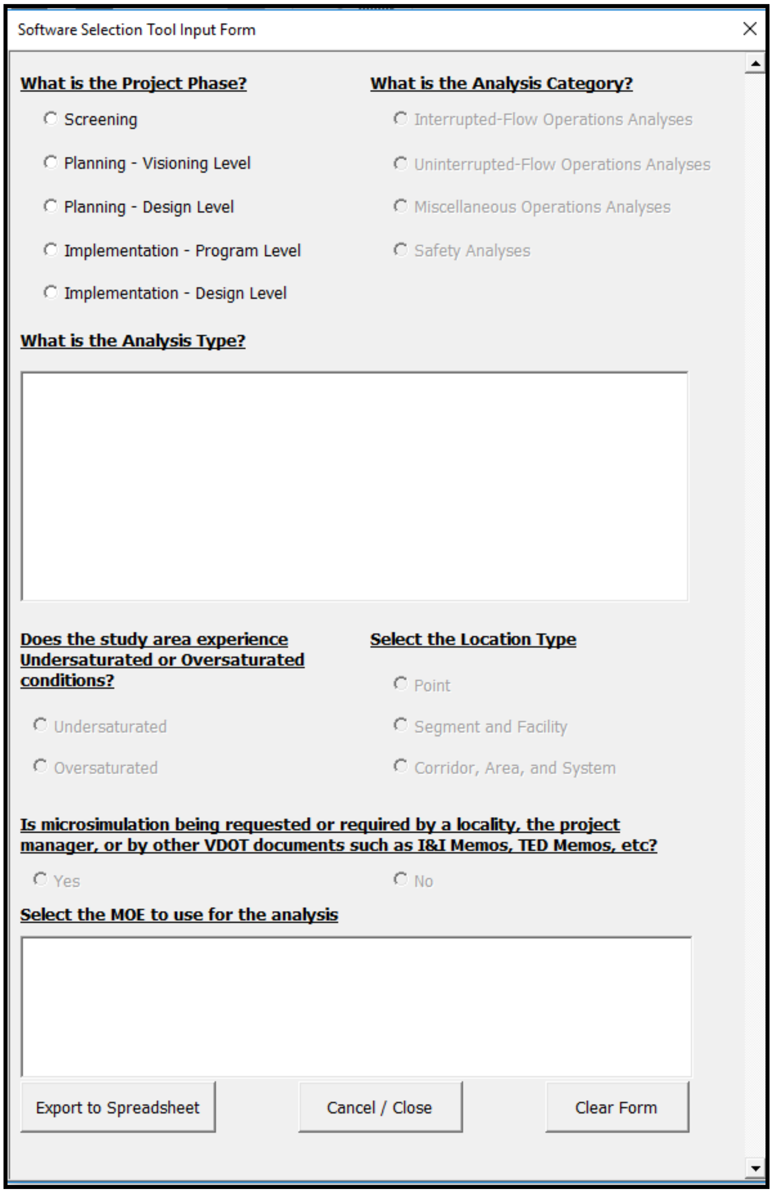


2.1 OPEN FORM

Once the "Open Form" button is clicked, the "Software Selection Tool Input Form" will open in a popup window (**Figure 2**). The input form allows the user to specify the following seven criteria:

- Project Phase
- Analysis Category
- Analysis Type
- Oversaturated or Undersaturated Conditions
- Location Type
- Microsimulation Preference
- Measure of Effectiveness (MOE)

Figure 2: Software Selection Tool Input Form



Software Selection Tool Input Form

What is the Project Phase?

○ Screening
○ Planning - Visioning Level
○ Planning - Design Level
○ Implementation - Program Level
○ Implementation - Design Level

What is the Analysis Category?

○ Interrupted-Flow Operations Analyses
○ Uninterrupted-Flow Operations Analyses
○ Miscellaneous Operations Analyses
○ Safety Analyses

What is the Analysis Type?

Does the study area experience Undersaturated or Oversaturated conditions?

○ Undersaturated
○ Oversaturated

Select the Location Type

○ Point
○ Segment and Facility
○ Corridor, Area, and System

Is microsimulation being requested or required by a locality, the project manager, or by other VDOT documents such as I&I Memos, TED Memos, etc?

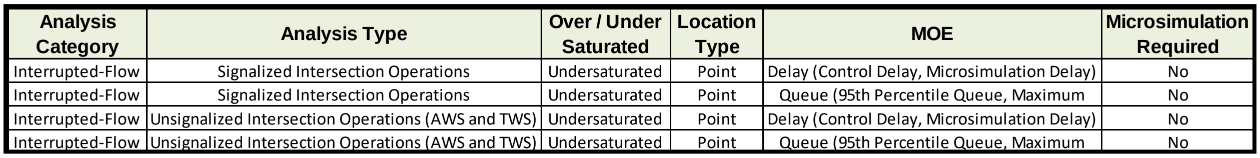
○ Yes
○ No

Select the MOE to use for the analysis

Project Phases are defined in Chapter 9 of the *TOSAM*. Direction on determining analysis category, analysis type, saturation conditions, and location type can be found in Chapter 2 of the *TOSAM*. Direction and guidance on MOEs can be found in Chapter 4 of the *TOSAM*. Direction and guidance on determining microsimulation requirements can be found in Chapter 5 of the *TOSAM*.

Once the inputs have been specified, click "Export to Spreadsheet" to transfer the selected inputs to the Excel spreadsheet as shown in **Figure 3**. The user may continue to export scenarios to represent all the project needs. For example, if the user would like to report both delay and queue length for an intersection analysis, the user should fill out the form twice, once with delay selected and once with queue length selected. The user may export as many scenarios as they choose before closing the form and running the "Calculate Software" macro (Section 2.2).

Figure 3: Output from Software Selection Tool Input Form

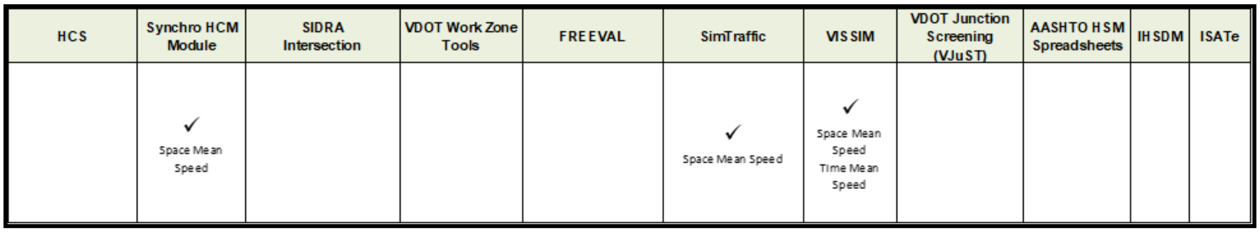


Analysis Category	Analysis Type	Over / Under Saturated	Location Type	MOE	Microsimulation Required
Interrupted-Flow	Signalized Intersection Operations	Undersaturated	Point	Delay (Control Delay, Microsimulation Delay)	No
Interrupted-Flow	Signalized Intersection Operations	Undersaturated	Point	Queue (95th Percentile Queue, Maximum	No
Interrupted-Flow	Unsignalized Intersection Operations (AWS and TWS)	Undersaturated	Point	Delay (Control Delay, Microsimulation Delay)	No
Interrupted-Flow	Unsignalized Intersection Operations (AWS and TWS)	Undersaturated	Point	Queue (95th Percentile Queue, Maximum	No

2.2 CALCULATE SOFTWARE, SET PRINT AREA, CLEAR TABLE

Once the inputs from the "Software Selection Tool Input Form" have been exported to the Excel spreadsheet, click "Calculate Software". A "✓" will indicate which traffic operations or safety analysis tool(s) is applicable for each input scenario (**Figure 4**). If an MOE with multiple definitions is specified (delay, queue, or speed), then the definition that applies to a certain tool will be listed underneath the "✓". Additionally, the tool provides notes that may be helpful in determining which of the indicated tools (if multiple tools are identified) should be selected. A column is also included for the user to document any additional comments on the project such as budget or time constraints.

Figure 4: Calculated Software Example



HCS	Synchro HCM Module	SIDRA Intersection	VDOT Work Zone Tools	FREEVAL	SimTraffic	VISSIM	VDOT Junction Screening (VJuST)	AASHTO HSM Spreadsheets	IHSDM	ISATe
	✓ Space Mean Speed				✓ Space Mean Speed	✓ Space Mean Speed Time Mean Speed				

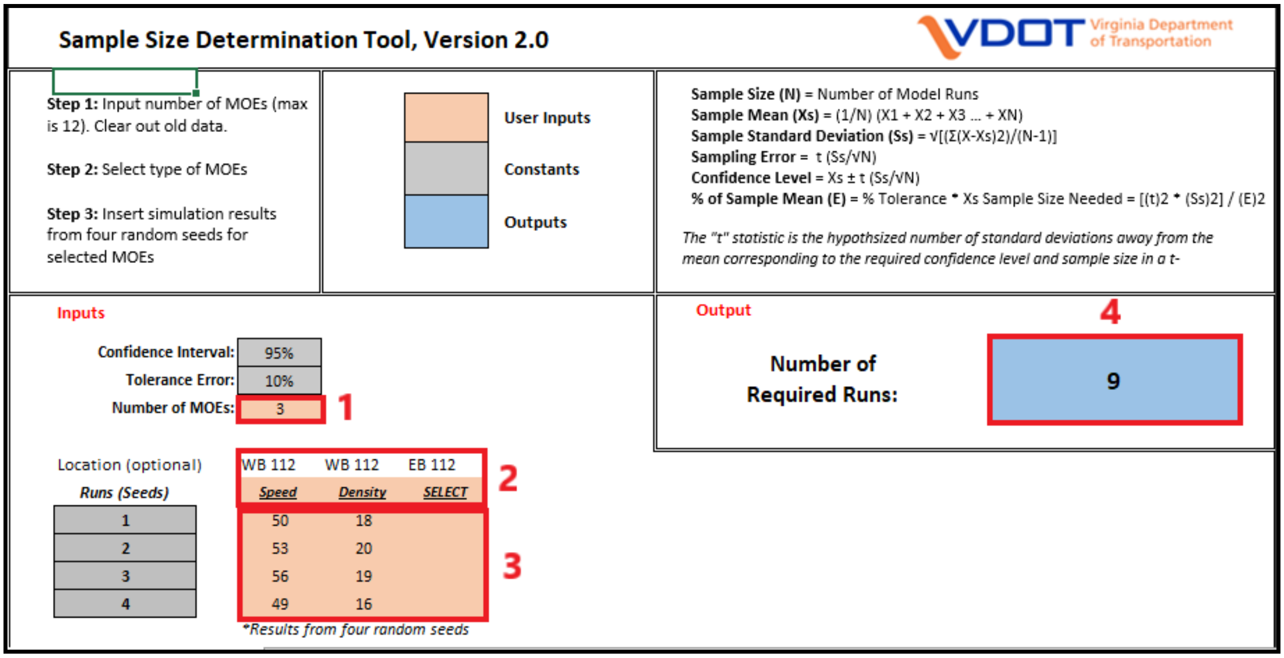
The user may format the print area of the results table using the "Set Print Area" button. This button will automatically set the printing extents to encompass the entire results table. Once the print area has been set, the user may use the "print" command in Excel.

Once the user has printed the results table or if the user wishes to start over, the "Clear Table" button may be used to clear the results table.

3 VDOT SAMPLE SIZE DETERMINATION TOOL (VERSION 2.0)

This chapter describes how to use the VDOT Sample Size Determination Tool (Version 2.0). Prior to running the traffic microsimulation model, identify an MOE and a location in the network to obtain the chosen MOE. The location(s) where MOEs are gathered from should be agreed upon with the project manager and be reflective of key areas in the model. Once the location(s) has been identified, an initial assessment of four microsimulation runs should be evaluated using this form. After processing the initial four runs, the following steps should be followed to determine the required number of traffic microsimulation runs for that scenario (**Figure 5**).

Figure 5: VDOT Sample Size Determination Tool (Version 2.0)



Sample Size Determination Tool, Version 2.0

Step 1: Input number of MOEs (max is 12). Clear out old data.

Step 2: Select type of MOEs

Step 3: Insert simulation results from four random seeds for selected MOEs

🟧 **User Inputs**
⬜ **Constants**
🟦 **Outputs**

Sample Size (N) = Number of Model Runs
Sample Mean (Xs) = (1/N) (X1 + X2 + X3 ... + XN)
Sample Standard Deviation (Ss) = √[(Σ(X-Xs)2)/(N-1)]
Sampling Error = t (Ss/√N)
Confidence Level = Xs ± t (Ss/√N)
% of Sample Mean (E) = % Tolerance * Xs Sample Size Needed = [(t)2 * (Ss)2] / (E)2

The "t" statistic is the hypothsized number of standard deviations away from the mean corresponding to the required confidence level and sample size in a t-

Inputs

Confidence Interval: 95%
Tolerance Error: 10%
Number of MOEs: 3

Location (optional)	WB 112	WB 112	EB 112
Runs (Seeds)	***Speed***	***Density***	***SELECT***
1	50	18	
2	53	20	
3	56	19	
4	49	16	

**Results from four random seeds*

Output

Number of Required Runs: 9

1 - Adjust Number of MOEs: In the Inputs Section, type the number of MOE's to analyze. This number corresponds to the quantity of columns that will be automatically formatted in pink in preparation for data entry. It must be larger than 0 and smaller than or equal to 12. If more than 12 MOEs are to be analyzed, multiple forms can be used.

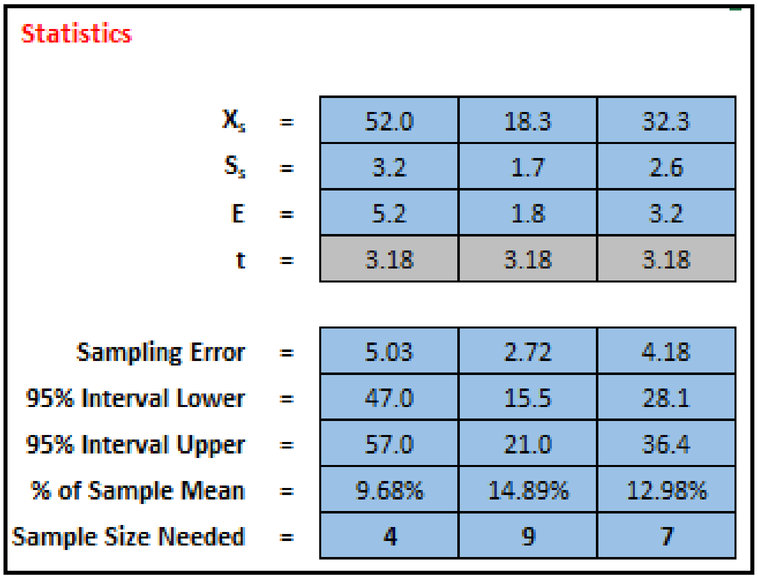
2 - Select the MOE type and Locations (optional): For each input column, click the dropdown and select one of the available MOEs: Speed, Volume, Travel Time, Density, or Queue. If the user collected data at multiple locations, she may specify those locations on the row above.

3 - Input MOE Values: Enter the MOE results for each run, for each MOE. If copying and pasting values in, use method "paste values only" to avoid changing the sheet's formatting.

4 - View Sample Size Output and Statistics: The Excel sheet will determine how many microsimulation runs are needed based on this initial run (up to a maximum of 30 runs) to meet the tolerance error threshold and confidence interval. Under the "Statistics" section (**Figure 6**). The overall "Number of Required Runs" will be the maximum of the "Sample Size Needed" for all MOEs.

Once completed, the sheet can be printed or exported to PDF in a single landscape sheet for submittal to VDOT and inclusion in the Vissim report.

Figure 6: Statistics Section



Statistics

X_s	=	52.0	18.3	32.3
S_s	=	3.2	1.7	2.6
E	=	5.2	1.8	3.2
t	=	3.18	3.18	3.18
Sampling Error	=	5.03	2.72	4.18
95% Interval Lower	=	47.0	15.5	28.1
95% Interval Upper	=	57.0	21.0	36.4
% of Sample Mean	=	9.68%	14.89%	12.98%
Sample Size Needed	=	4	9	7

Troubleshooting notes to consider:

Users should verify that each traffic microsimulation run has been reviewed for errors both visually and through error logging. It is important to ensure that erroneous traffic microsimulation runs are not included within the reported output results or the data sample. For example, traffic microsimulation runs with gridlocked conditions due to a nonfunctioning vehicle(s) should not be included in the reported output results or the data sample.

If excessively large values for the number of runs are reported, it is recommended to return to the Vissim model and evaluate for errors in model coding and model performance.

4 VISSIM MACROS

This chapter describes how to use two Excel-based macros when conducting traffic operational analyses using VISSIM, the VISSIM Intersection Data Processing Tool (Version 2.0) and the VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2). The macros are compatible with VISSIM, Versions 6, 7, 9 and 11 and Excel 2007 or higher.

4.1 VISSIM INTERSECTION DATA PROCESSING TOOL (VERSION 2.0)

This section describes the following steps and limitations associated with using the VISSIM Intersection Data Processing Tool (Version 2.0):

1. VISSIM Intersection Coding Setup
2. Process VISSIM Intersections
3. VISSIM Intersection Results (Microsimulation Delay Results Tab)
4. Processing Tool Limitations

4.1.1 *VISSIM Intersection Coding Setup*

After coding a VISSIM network, node evaluation must be developed for all intersections that require analysis. The following sections outline how to configure the node evaluation in VISSIM 11 to output the necessary files for processing.

*4.1.1.1 Exporting an *.ATT file from VISSIM 11*

1. **Review Nodes:** Ensure that each intersection for which analysis is required has a node. Nodes should be numbered and named (results will process in the order of selected numbers).
2. **Initiate Node Evaluation**
    a. Select “Evaluation” > “Configuration”
    b. Check the box for “Nodes” and input the analysis time interval
    c. Click “More” to change the definition of delay and queue measurement
3. **Configure Data to be Collected:** Define the data attributes to be collected for the desired vehicle type(s) in the following order (**Figure 7**):
    a. Simulation Run Number
    b. Time Interval
    c. Movement\Node\Number
    d. Movement\Node\Name
    e. Movement\Direction
    f. Vehicles (All veh. Types)
    g. Vehicle Delay (average) (All veh. Types)
4. **Filter Nodes for Evaluation** (**Figure 9**):
    a. Select “Evaluation” > “Configuration”

   b. Select time boundaries and interval according to analysis. These are measured in seconds from simulation initiation.

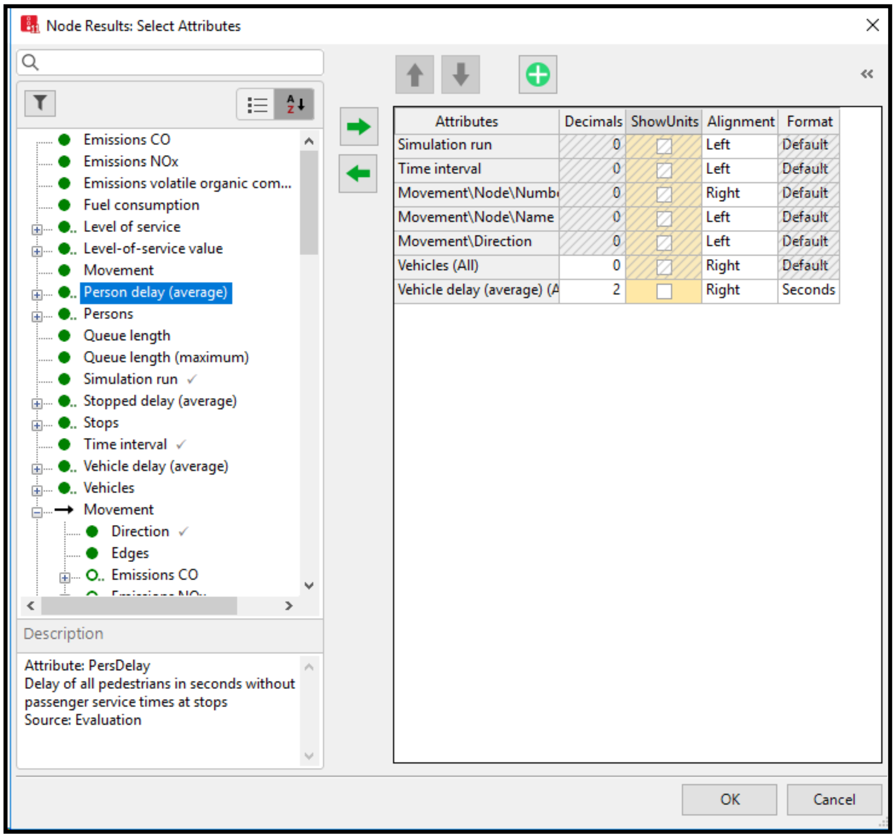
5. **Verify Output:** Verify that the nodes box is checked for outputs in the Evaluation configuration window. This will create results in Vissim list tables after running the model.

6. **Run Model:** Run the model using a single run or multiple runs.

   a. Files from different time periods or scenarios (i.e., AM, PM, build, no-build) should be stored in separate folders to prevent incorrect *.ATT files from being processed by the macro.

7. **Save Output File:** After the model runs are completed, click "Save to File". This will generate an *.ATT file with the average results across all microsimulation runs (**Figure 8**).

Figure 7: Node Evaluation - Configuration

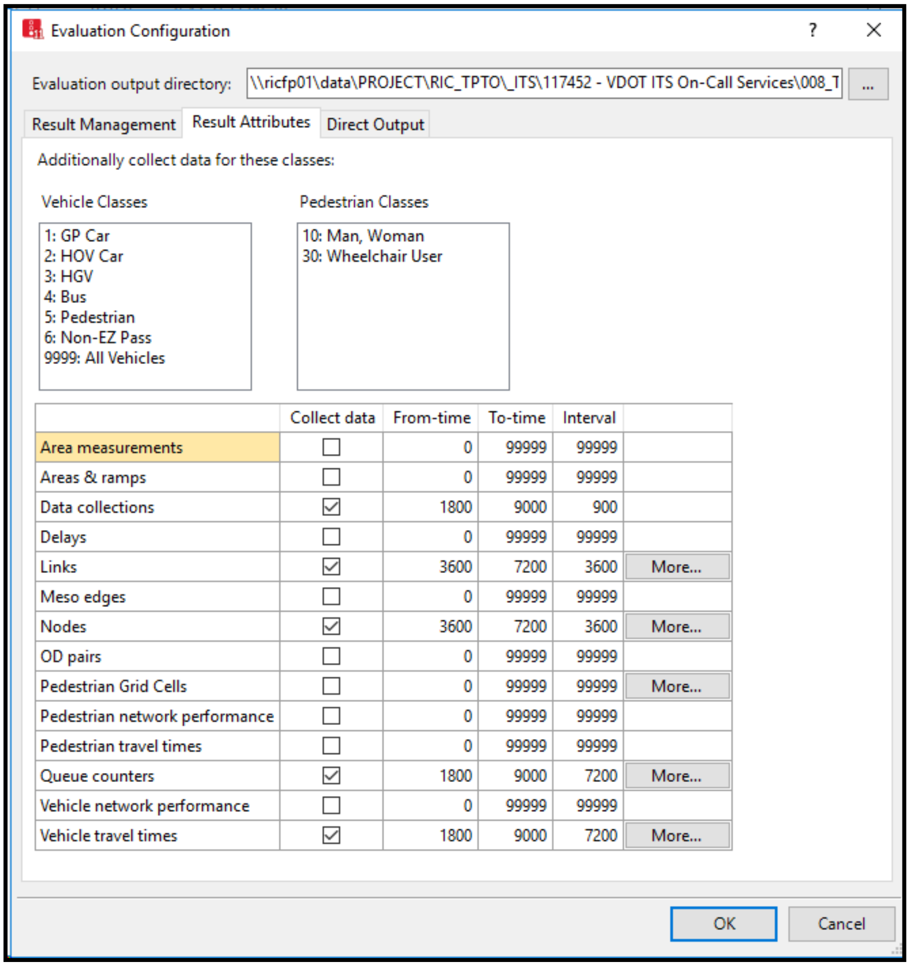


Attributes	Decimals	ShowUnits	Alignment	Format
Simulation run	0	☐	Left	Default
Time interval	0	☐	Left	Default
Movement\Node\Numb	0	☐	Right	Default
Movement\Node\Name	0	☐	Left	Default
Movement\Direction	0	☐	Left	Default
Vehicles (All)	0	☐	Right	Default
Vehicle delay (average) (A	2	☐	Right	Seconds

Attribute: PersDelay
Delay of all pedestrians in seconds without passenger service times at stops
Source: Evaluation

Figure 8: Node Evaluation - Save to File

Figure 9: Node Evaluation - Filter



Evaluation output directory: \\ricfp01\data\PROJECT\RIC_TPTO_ITS\117452 - VDOT ITS On-Call Services\008_T

Additionally collect data for these classes:

Vehicle Classes
1: GP Car
2: HOV Car
3: HGV
4: Bus
5: Pedestrian
6: Non-EZ Pass
9999: All Vehicles

Pedestrian Classes
10: Man, Woman
30: Wheelchair User

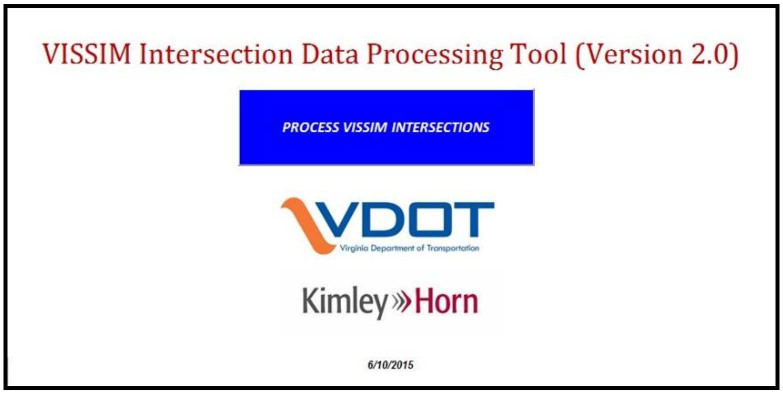
	Collect data	From-time	To-time	Interval	
Area measurements	☐	0	99999	99999	
Areas & ramps	☐	0	99999	99999	
Data collections	☑	1800	9000	900	
Delays	☐	0	99999	99999	
Links	☑	3600	7200	3600	More...
Meso edges	☐	0	99999	99999	
Nodes	☑	3600	7200	3600	More...
OD pairs	☐	0	99999	99999	
Pedestrian Grid Cells	☐	0	99999	99999	More...
Pedestrian network performance	☐	0	99999	99999	
Pedestrian travel times	☐	0	99999	99999	
Queue counters	☑	1800	9000	7200	More...
Vehicle network performance	☐	0	99999	99999	
Vehicle travel times	☑	1800	9000	7200	More...

4.1.2 Process VISSIM Intersections

Open the VISSIM Intersection Data Processing Tool (Version 2.0) after producing a VISSIM *.ATT file. Microsoft® Excel may produce a security warning message that some of the active content in the tool has been disabled. Select "Enable Content" to activate the macro. If the macro does not work after it has been enabled, verify that security settings have enabled all macros and that the version of Microsoft® Excel is compatible with the macro.

The following steps describe how to import data into the VISSIM Intersection Data Processing Tool (Version 2.0) as shown in **Figure 10**:

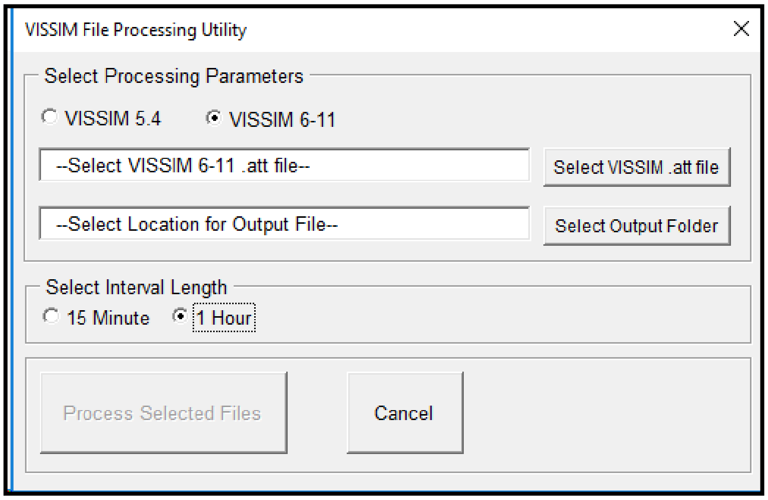
Figure 10: VISSIM Intersection Data Processing Tool (Version 2.0)



1. **Main Sheet**

   a. **Process VISSIM Intersections:** Select "PROCESS VISSIM INTERSECTIONS" and the "VISSIM File Processing Utility" menu will appear in a popup box (**Figure 11**).

Figure 11: VISSIM Intersection File Processing Utility Menu



○ VISSIM 5.4 ● VISSIM 6-11

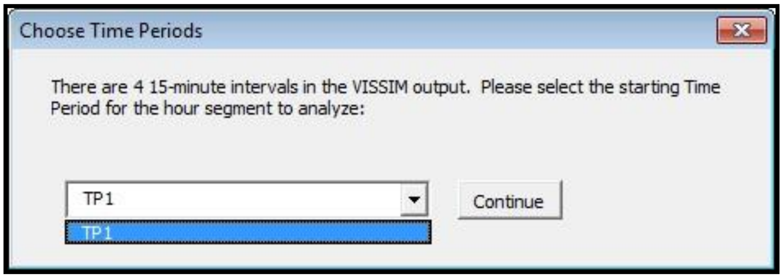
--Select VISSIM 6-11 .att file--

--Select Location for Output File--

○ 15 Minute ● 1 Hour

2. **VISSIM File Processing Utility Menu**
    a. **Select VISSIM Version:** Select the VISSIM Version used to run the microsimulation.
    b. **Select .ATT File:** Select the *.ATT file to be processed.
    c. **Select Output Folder:** Specify a folder location where the results file will automatically be saved. The current folder of the *.ATT file will be default.
    d. **Select Interval Length:** Specify whether volumes in VISSIM were entered in 15-minute or 1-hour intervals.
    e. **Process Selected Files:** Once folders have been selected, click “Process Selected Files” and the “Choose Time Periods” menu will appear in a popup window (**Figure 12**).

Figure 12: VISSIM Intersection Choose Time Periods



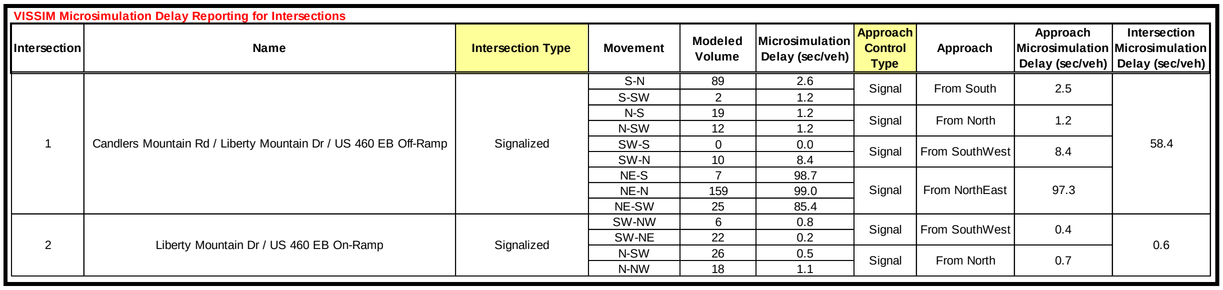
There are 4 15-minute intervals in the VISSIM output. Please select the starting Time Period for the hour segment to analyze:

3. **Choose Time Periods**
    a. **Select Starting Time Period:** Select the beginning time period from the drop-down menu (e.g., if the first hour of the analysis is required and volumes were entered in 15-minute intervals, select TP 1; however, if results are needed for the second hour, select TP 5).
    b. **Select Continue:** The macro will automatically create and save a file in the previously specified output folder.
4. **VISSIM Intersection Results File:** The following information will be included in the newly created Excel spreadsheet:
    a. **File Name:** The file will be titled VISSIMIntersectionResults_YYMMDDHHMMSS.xlsm. This unique file name with a time stamp will prevent files from being overwritten.
    b. **Time Period Tabs:** Separate tabs will be provided for each of the time periods in the microsimulation. Each tab will contain the following results for each intersection movement:
        - **Modeled Volume**
        - **Microsimulation Delay**

c. **Microsimulation Delay Results Tab:** The microsimulation delay results tab summarizes the following results for each intersection (**Figure 13**). Section 4.1.3 outlines the additional steps needed to finalize the reporting process.

- Modeled Volumes
- Microsimulation Delay by Movement
- Approach Microsimulation Delay
- Intersection Microsimulation Delay

Figure 13: Base Microsimulation Delay Results Table



VISSIM Microsimulation Delay Reporting for Intersections

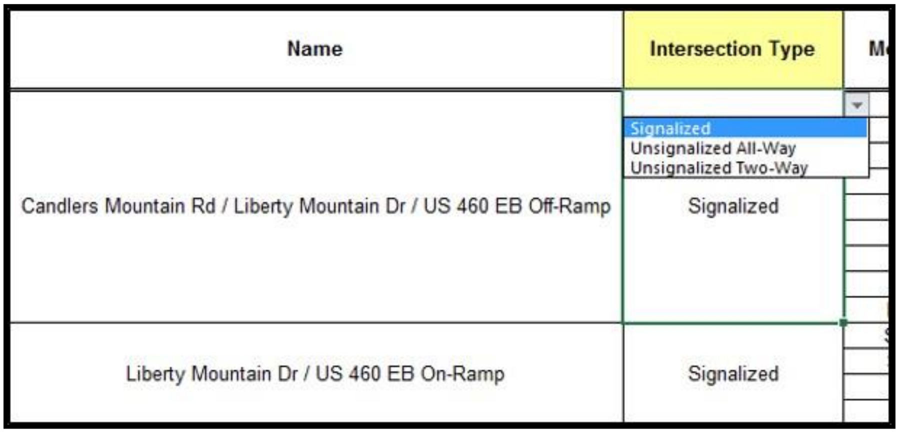
Intersection	Name	Intersection Type	Movement	Modeled Volume	Microsimulation Delay (sec/veh)	Approach Control Type	Approach	Approach Microsimulation Delay (sec/veh)	Intersection Microsimulation Delay (sec/veh)
1	Candlers Mountain Rd / Liberty Mountain Dr / US 460 EB Off-Ramp	Signalized	S-N	89	2.6	Signal	From South	2.5	58.4
			S-SW	2	1.2				
			N-S	19	1.2	Signal	From North	1.2	
			N-SW	12	1.2				
			SW-S	0	0.0	Signal	From SouthWest	8.4	
			SW-N	10	8.4				
			NE-S	7	98.7	Signal	From NorthEast	97.3	
			NE-N	159	99.0				
			NE-SW	25	85.4				
2	Liberty Mountain Dr / US 460 EB On-Ramp	Signalized	SW-NW	6	0.8	Signal	From SouthWest	0.4	0.6
			SW-NE	22	0.2				
			N-SW	26	0.5	Signal	From North	0.7	
			N-NW	18	1.1				

4.1.3 VISSIM Intersection Results (LOS Results Tab)

The following steps will describe how to finalize the LOS reporting process:

1. **Select Traffic Control Type:** Select the appropriate intersection type for each intersection from the drop-down menu (**Figure 14**). The following intersection types are available for selection:
   - Signalized (default)
   - Unsignalized All-Way Stop
   - Unsignalized Two-Way Stop

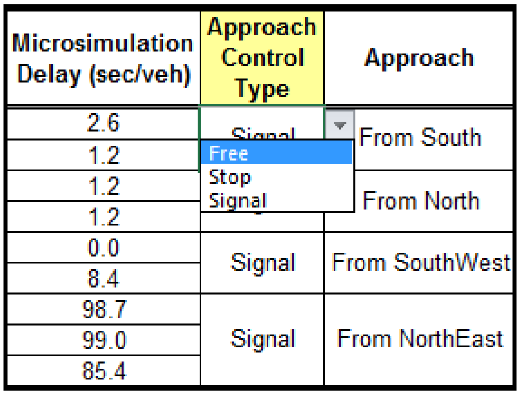
Figure 14: Select Intersection Type



Name	Intersection Type
Candlers Mountain Rd / Liberty Mountain Dr / US 460 EB Off-Ramp	Signalized
Liberty Mountain Dr / US 460 EB On-Ramp	Signalized

2. **Select Stop-Controlled Approaches:** For unsignalized two-way stop intersections, specify in the "Right-Of-Way" column which approaches are free movements and which approaches are stop-controlled (**Figure 15**). Free movements could include left-turn movements that yield to opposing through movements.

Figure 15: Specify Approach Movements



Microsimulation Delay (sec/veh)	Approach Control Type	Approach
2.6	Signal	From South
1.2		
1.2		From North
1.2		
0.0	Signal	From SouthWest
8.4		
98.7	Signal	From NorthEast
99.0		
85.4		

4.1.4 VISSIM Intersection Data Processing Tool (Version 2.0) Limitations

The VISSIM Intersection Data Processing Tool (Version 2.0) has the following known limitations:

- Intersections are limited to nodes with 3 or more inbound links.
- Users must manually specify intersection type.
- Nodes with midblock pedestrian crossings are not compatible with this macro
- Macro will not determine an HCM equivalent pedestrian LOS.
- There is a minimum requirement of one 60-minute time period or four 15-minute time periods for the tool to properly display results.
- The tool is bound by any limitations to VISSIM, Versions 5.40, 6, 7, 9 and 11. This tool may work on intermediary Vissim versions not listed here; however, these versions were not tested during macro development.

4.2 VISSIM CALIBRATION AND FREEWAY OUTPUT TEMPLATE PROCESSING TOOL (VERSION 2.2)

This section describes the following steps and limitations associated with using the VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2).

1. VISSIM Output Reporting Requirements
2. Format Freeway Template
3. Process VISSIM Freeways
4. VISSIM Freeway Schematics
5. Limitations
6. Troubleshooting

4.2.1 VISSIM Output Reporting Requirements

The VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2) requires VISSIM results to be reported in *.ATT format. The following procedures must be followed to properly export *.ATT files into a format compatible with this tool

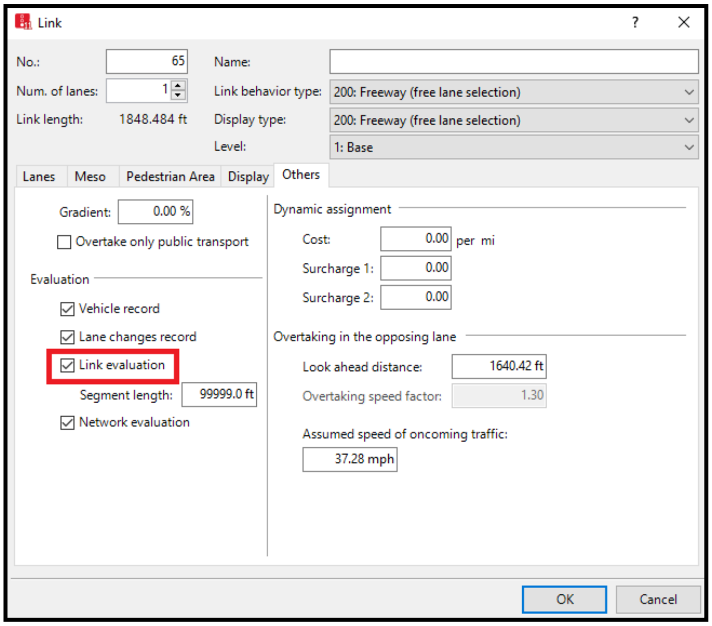
*4.2.1.1 Exporting *.ATT Files from VISSIM, Version 11.0*

VISSIM Versions 6.0 and higher require an *.ATT file to be processed within the tool. The instructions below pertain most directly to VISSIM, Version 11.0, but they can apply to Version 6.0 and higher.

To output an *.ATT file, the following steps must be completed prior to running a microsimulation:

1. **Select "Link Evaluation" on all links of interest.** On all links that the user wishes to collect data, "Link Evaluation" must be selected. To select "Link Evaluation", first double click on an individual link to open the Link Data window (**Figure 16**). Then, select the "Others" tab and check "Link Evaluation".
2. **Set evaluation configuration (Figure 17).** Ensure that the "Links" attribute under the "Result Attributes" tab is selected. Next, ensure that a "per lane segment" analysis is conducted by clicking "More" on the same row as "Links". In addition, set the link evaluation "Segment Length" to a value greater than or equal to the full length of the link. An arbitrarily large value—larger than any link in the network—may be determined and applied to all links.
3. **Select Attributes to evaluate:** Attributes are selected via the Link Segment Results table. If the Link Segment Results table is not already open, select "Evaluation" > "Result Lists" > "Link Results" (**Figure 18**) and the Link Segment Results table will appear (**Figure 19**). From the Link Segment Results table menu, click the Select Attributes button (**Figure 19** - #1) to open the Select Attributes window (**Figure 20**). The user should select the following attributes: microsimulation run, time interval, link evaluation segment\link\name, link evaluation segment\link\numb, link evaluation segment, density (all), delay (relative) (all), speed (all), volume (all).
4. **Save *.ATT file**. The user may save down an *.ATT file after all microsimulation runs have been completed (**Figure 19** - #2). The user may also toggle on the "Autosave After Simulation" button (**Figure 19** - #3) prior to the microsimulation so that an *.ATT file is automatically saved when the microsimulation is complete. If autosave is enabled, the user should select the last *.ATT file generated which will include all the results. Finally, ensure that the "Show Simulation Run Aggregates" is toggled on (**Figure 19** - #4).

Figure 16: Link Data Window



No.: 65
Name:
Num. of lanes: 1
Link behavior type: 200: Freeway (free lane selection)
Link length: 1848.484 ft
Display type: 200: Freeway (free lane selection)
Level: 1: Base

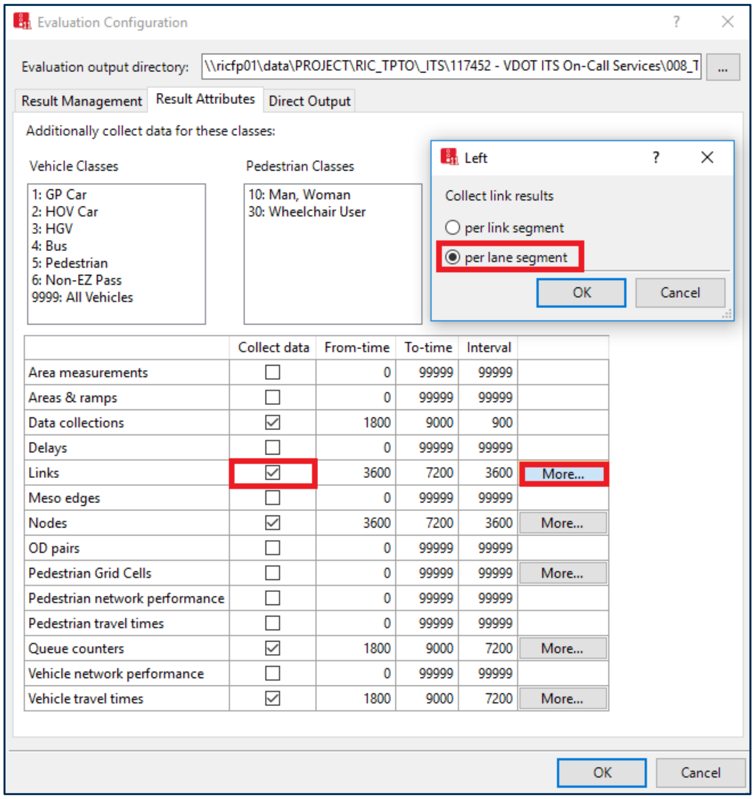
Gradient: 0.00 %
☐ Overtake only public transport

Evaluation
☑ Vehicle record
☑ Lane changes record
☑ Link evaluation
Segment length: 99999.0 ft
☑ Network evaluation

Dynamic assignment
Cost: 0.00 per mi
Surcharge 1: 0.00
Surcharge 2: 0.00

Overtaking in the opposing lane
Look ahead distance: 1640.42 ft
Overtaking speed factor: 1.30
Assumed speed of oncoming traffic: 37.28 mph

Figure 17: Evaluation Configuration Window with Link Collection Popup



Evaluation output directory: \\ricfp01\data\PROJECT\RIC_TPTO_ITS\117452 - VDOT ITS On-Call Services\008_T

Additionally collect data for these classes:

Vehicle Classes
1: GP Car
2: HOV Car
3: HGV
4: Bus
5: Pedestrian
6: Non-EZ Pass
9999: All Vehicles

Pedestrian Classes
10: Man, Woman
30: Wheelchair User

Collect link results
○ per link segment
● per lane segment

	Collect data	From-time	To-time	Interval	
Area measurements	☐	0	99999	99999	
Areas & ramps	☐	0	99999	99999	
Data collections	☑	1800	9000	900	
Delays	☐	0	99999	99999	
Links	☑	3600	7200	3600	More...
Meso edges	☐	0	99999	99999	
Nodes	☑	3600	7200	3600	More...
OD pairs	☐	0	99999	99999	
Pedestrian Grid Cells	☐	0	99999	99999	More...
Pedestrian network performance	☐	0	99999	99999	
Pedestrian travel times	☐	0	99999	99999	
Queue counters	☑	1800	9000	7200	More...
Vehicle network performance	☐	0	99999	99999	
Vehicle travel times	☑	1800	9000	7200	More...

Figure 18: Open Link Segment Results Table

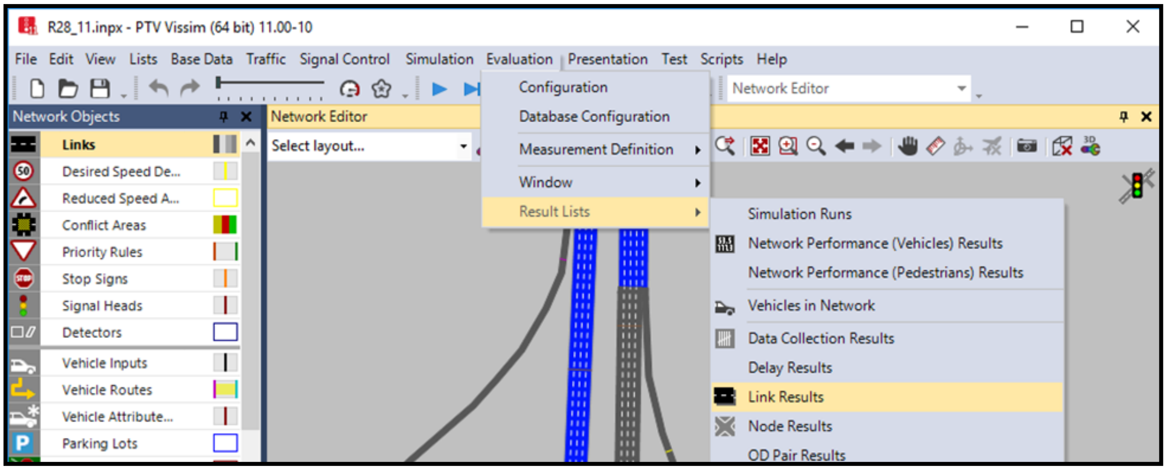


Figure 19: Link Segment Results Table

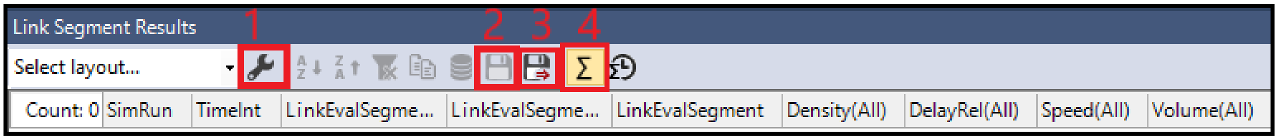
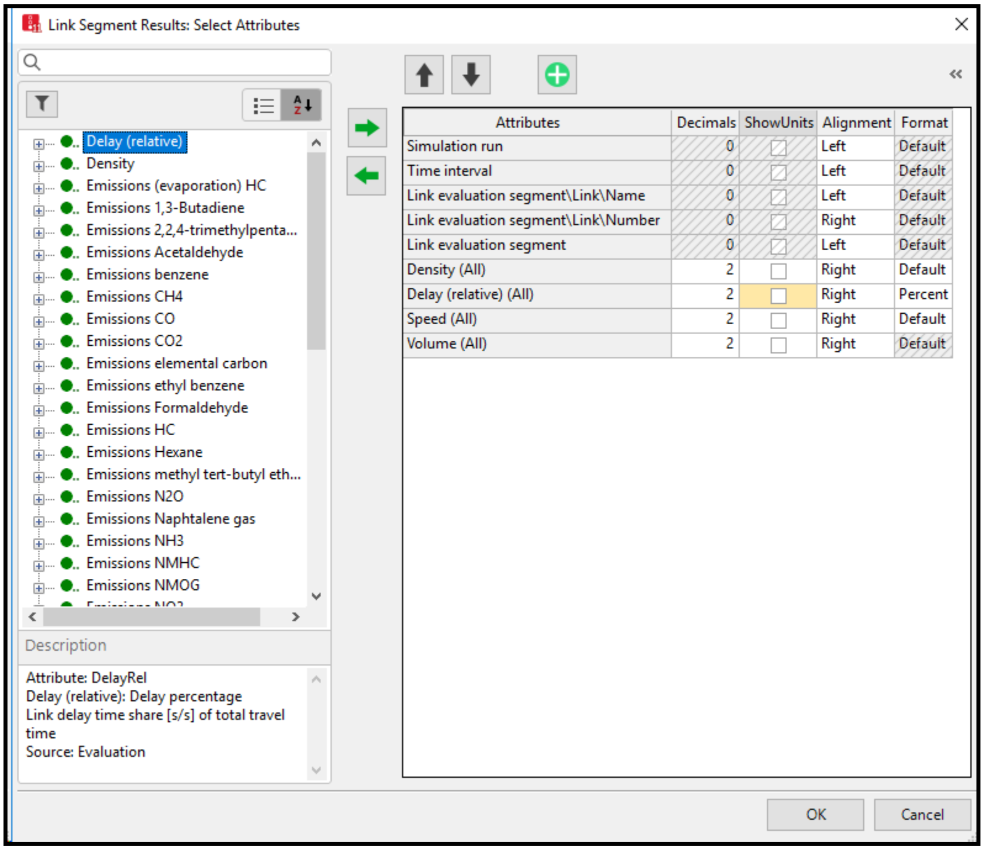


Figure 20: Select Attributes



Attributes	Decimals	ShowUnits	Alignment	Format
Simulation run	0	☐	Left	Default
Time interval	0	☐	Left	Default
Link evaluation segment\Link\Name	0	☐	Left	Default
Link evaluation segment\Link\Number	0	☐	Right	Default
Link evaluation segment	0	☐	Left	Default
Density (All)	2	☐	Right	Default
Delay (relative) (All)	2	☐	Right	Percent
Speed (All)	2	☐	Right	Default
Volume (All)	2	☐	Right	Default

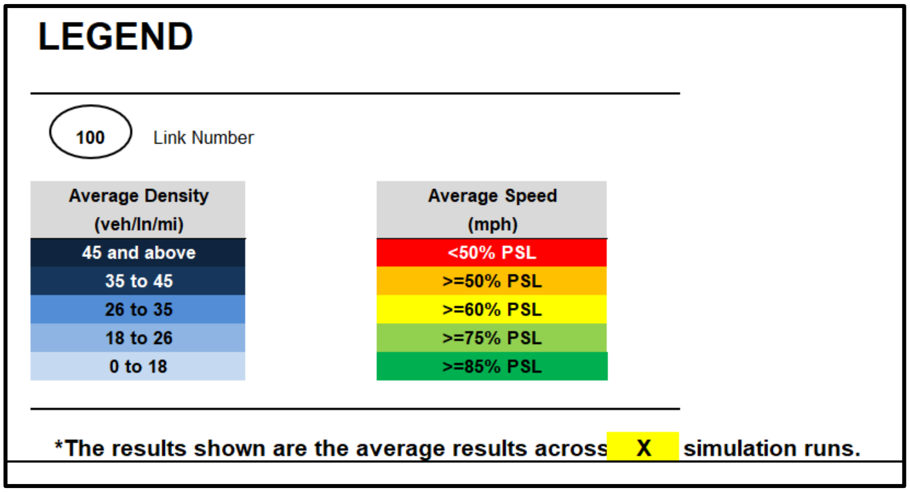
Attribute: DelayRel
Delay (relative): Delay percentage
Link delay time share [s/s] of total travel time
Source: Evaluation

4.2.2 Editing the Output Schematic Template

Open the VISSIM Calibration and Freeway Output Template Processing Tool after building a VISSIM freeway network and producing *.INP or *.INPX files. Microsoft® Excel may produce a security warning message that some of the active content in the tool has been disabled. Select "Enable Content" to activate the macro. If the macro does not work after it has been enabled, verify that security settings have enabled all macros and that the version of Microsoft® Excel is compatible with the macro.

Before processing the VISSIM output data, view the Freeway Template tab. This template may be preformatted if desired. Any changes to the format on the template, such as adding a company logo (**Figure 21**) will automatically carry over to each output worksheet. The ranges and color schemes for density (veh/ln/mi) may be edited; however, these edits will require the user to manually modify the conditional formatting on each freeway schematic to reflect any changes.

Figure 21: Preformatted VISSIM Freeway Template Worksheet



LEGEND

100 Link Number

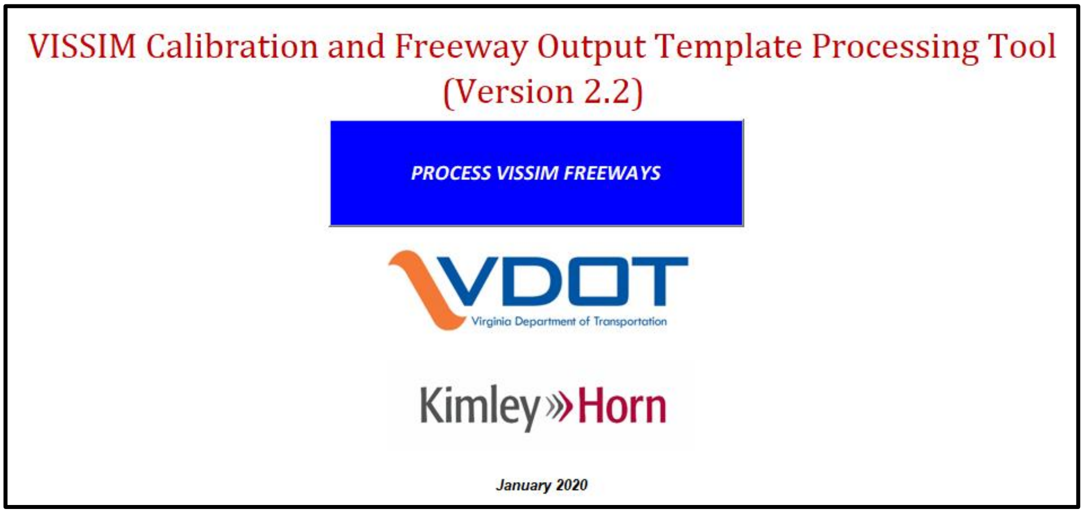
Average Density (veh/ln/mi)	Average Speed (mph)
45 and above	<50% PSL
35 to 45	>=50% PSL
26 to 35	>=60% PSL
18 to 26	>=75% PSL
0 to 18	>=85% PSL

*The results shown are the average results across X simulation runs.

4.2.3 Process VISSIM Freeways

The following steps document how to use the VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2) as shown in **Figure 22**.

Figure 22: VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2)



VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2)

January 2020

1. **Main Sheet**

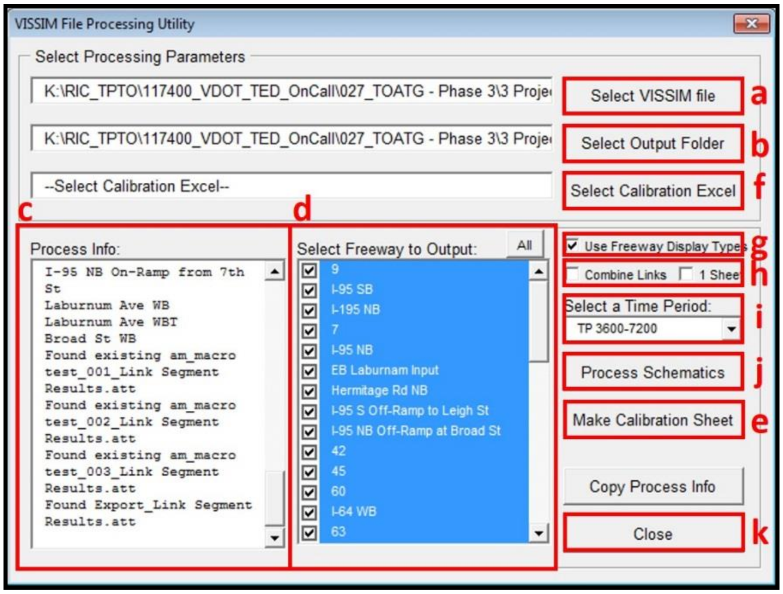
    a. **Process VISSIM Freeways:** Select "PROCESS VISSIM FREEWAYS" and the "VISSIM File Processing Utility" menu will appear in a popup box (**Figure 23**).

2. **VISSIM File Processing Utility Menu**

    a. **Select VISSIM File**: Select the *.INP or *.INPX file for the desired microsimulation run. Verify that VISSIM *.INP and *.INPX files are not located in the same folder directory and that the respective *.STR files (if *.INP is selected) or *.ATT files (if *.INPX is selected) are located in the same folder directory. Confirm that only the desired *.STR or *.ATT files are located in the same folder directory. The macro will average the results from every *.STR or *.ATT file in the folder.

    b. **Select Output Folder:** Specify a folder location where the lane schematic will automatically be saved. The folder containing the selected *.INP or *.INPX file will be selected as the default folder.

Figure 23: VISSIM File Processing Utility



K:\RIC_TPTO\117400_VDOT_TED_OnCall\027_TOATG - Phase 3\3 Proje

K:\RIC_TPTO\117400_VDOT_TED_OnCall\027_TOATG - Phase 3\3 Proje

--Select Calibration Excel--

Process Info:

```
I-95 NB On-Ramp from 7th
St
Laburnum Ave WB
Laburnum Ave WBT
Broad St WB
Found existing am_macro
test_001_Link Segment
Results.att
Found existing am_macro
test_002_Link Segment
Results.att
Found existing am_macro
test_003_Link Segment
Results.att
Found Export_Link Segment
Results.att
```

Select Freeway to Output:

☑ 9
☑ I-95 SB
☑ I-195 NB
☑ 7
☑ I-95 NB
☑ EB Laburnam Input
☑ Hermitage Rd NB
☑ I-95 S Off-Ramp to Leigh St
☑ I-95 NB Off-Ramp at Broad St
☑ 42
☑ 45
☑ 60
☑ I-64 WB
☑ 63

☑ Use Freeway Display Types
☐ Combine Links ☐ 1 Shee

Select a Time Period: TP 3600-7200

c. **Process Info:** A summary of output files, processing statistics, and warnings are provided in this space. Common error and warning messages are listed below with potential solutions.

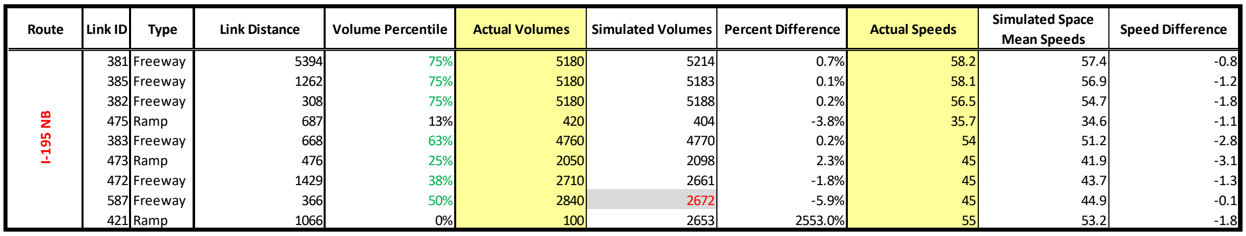
- "WARNING! Please select at least one route. WARNING!"
  Solution: The user will need to check the box next to at least one freeway route (Step 5) in the "Select Freeway to Output" window to generate output.
- "WARNING! 4 or more time periods are required to process hourly results. WARNING!"
  *Solution: This warning will only show when 3 or fewer 15-minute time periods are present in an *.ATT or *.STR file. Verify that there are enough time periods to produce hourly results.*
- "WARNING! Auxiliary lane required to accurately determine left or right ramp placement at link ID (linkID). WARNING!"
  *Solution: This warning will only show when there are no auxiliary lanes present on a freeway network in an *.INP or *.INPX file. Verify that ramps are provided with auxiliary lanes for proper identification.*
- "WARNING! Link ID (linkID) cannot have more than (number) thru lanes. WARNING!"
  Solution: The VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2) is limited to a maximum of 5 thru lanes on a freeway. A freeway with more than five through lanes may not display properly.

- "WARNING! Title information is missing. WARNING!"
  Solution: Verify that a title has been provided in the VISSIM file for display in the output schematic.
- "ERROR! No link found in (FILENAME) file ERROR!"
  Solution: Confirm that a freeway network is coded using VISSIM. The tool is not compatible with arterial links.
- "ERROR! No Time Period found in (FILENAME) ERROR!"
  Solution: Verify that the VISSIM microsimulation run was completed without any errors.
- "ERROR! Lane (NUMBER) not in link (linkID) with (TOTAL NUMBER OF LANES) lanes. ERROR!"
  *Solution: Verify that all of the *.ATT or *.STR files in the specified folder are from the same analysis scenario with matching geometry.*
- "ERROR! Cannot find link (linkID) ERROR!"
- *Solution: Verify that all of the *.ATT or *.STR files in the specified folder are from the same analysis scenario with matching geometry.*
- "ERROR! No *.ATT file found ERROR!"
  *Solution: Verify that *.ATT file is in the appropriate folder. Verify that the *.ATT file includes the aggregate summary of all simulation runs defined by "AVG" in the $MOVEMENTEVALUATION: SIMRUN column. This aggregate summary will appear when the "Show Simulation Run Aggregate" is checked in the Vissim link evaluation results window.*

d. **Select Freeway to Output:** Select all freeways to display in a lane schematic. By default, the macro will identify the freeways as coded in VISSIM. It is important to properly code each freeway name on the links in the model so that the results are correctly reported. Before creating a calibration sheet (Step E), all freeways must be selected.

e. **Make Calibration Sheet:** Prior to creating a calibration sheet, select all freeways in the "Select Freeway to Output" option (Step E). The macro will automatically create and save a calibration Excel spreadsheet with the name "VISSIMFreewayCalibration_YYMMDDHHMMSS.xlsx". Insert "actual volumes" and "actual speeds" for all links to accompany the simulated speeds and volumes from the VISSIM microsimulation. The calibration sheet will highlight green all values that fall within the top 85th percentile of network links based on volume and will highlight red (**Figure 24**) any simulated volumes or space mean speeds that do not meet the calibration thresholds outlined in the *TOSAM*. Be sure to save the spreadsheet once the "actual volumes" and "actual speeds" have been entered.

Figure 24: VISSIM Freeway Calibration Sheet



Route	Link ID	Type	Link Distance	Volume Percentile	Actual Volumes	Simulated Volumes	Percent Difference	Actual Speeds	Simulated Space Mean Speeds	Speed Difference
I-195 NB	381	Freeway	5394	75%	5180	5214	0.7%	58.2	57.4	-0.8
	385	Freeway	1262	75%	5180	5183	0.1%	58.1	56.9	-1.2
	382	Freeway	308	75%	5180	5188	0.2%	56.5	54.7	-1.8
	475	Ramp	687	13%	420	404	-3.8%	35.7	34.6	-1.1
	383	Freeway	668	63%	4760	4770	0.2%	54	51.2	-2.8
	473	Ramp	476	25%	2050	2098	2.3%	45	41.9	-3.1
	472	Freeway	1429	38%	2710	2661	-1.8%	45	43.7	-1.3
	587	Freeway	366	50%	2840	2672	-5.9%	45	44.9	-0.1
	421	Ramp	1066	0%	100	2653	2553.0%	55	53.2	-1.8

f. **Select Calibration Excel:** Select the calibration sheet prepared in Step E. The "actual volumes" and "actual speeds" manually entered into the calibration sheet will populated in the lane schematic.

g. **Use Freeway Display Types:** If this option is selected, the schematic will identify links in the schematic based on the display type coded into the Vissim model. **Table 1** lists the display types that are compatible with the tool. Using this feature assists the tool in identifying freeway, ramp, weave, and CD weave links for networks that also contain arterial links. Arterial features such as arterial links, crosswalks, and bridges will not be generated in the output schematic. The "Segment Type" column on **Table 1** identifies how each lane will be identified on the output schematic tool. Additionally, the tool also has the ability to identify HOV and shoulder lane closures. Closed lanes will be displayed on the schematic with a red fill. In the case where a legacy model does not use Freeway Display Types, uncheck this field and re-select the VISSIM file to view all available routes within the network.

h. **Combine Links / 1 Sheet:** Select "Combine Links" to merge consecutive links with the same geometry and volume inputs in the lane schematic. If links are merged, the average of the simulated values across the individual links will be displayed.

Select "1 Sheet" to create a continuous lane schematic on one tab instead of limiting each tab to 15 links (Section 4.2.4). If this option is selected, the schematic will not be preformatted for printing.

Table 1: Use Freeway Display Types Table

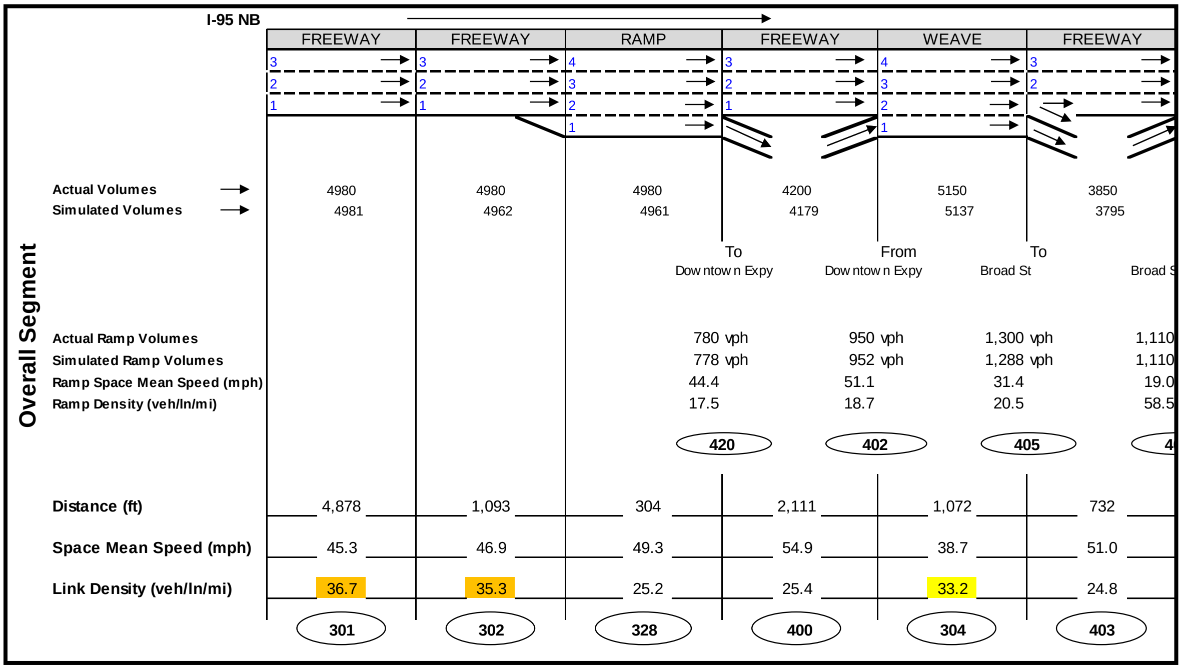
DISPLAYTYPE	Name	Color	Segment Type
1	Freeway GP Lanes	169 169 169	FREEWAY
2	Freeway HOV/HOT	255 128 128	FREEWAY
3	Arterial Links	211 211 211	N/A
4	Crosswalks	255 215 0	N/A
5	Ramps	0 192 192	N/A
6	Bridge	255 192 128	N/A
10	Freeway Merge1	RED	RAMP
11	Freeway Merge2	255 128 128	RAMP
12	Freeway-Freeway Ramp Merge	255 192 192	RAMP
13	Mainline Before Merge	255 224 192	RAMP
14	Freeway Weave1	255 192 128	WEAVE
15	Freeway Weave2	255 128 0	WEAVE
16	Mainline Downstream of Freeway - Freeway Ramp	192 64 0	RAMP
20	Urban (Aggressive Lane Change)	128 128 255	N/A
21	C-D Road Weave	0 192 192	CD WEAVE
22	Mainline Weave Merge	255 192 128	RAMP
28	Urban High Capacity - Default Driver Behavior	192 192 255	N/A
31	HOV Lane Closure (Left Most or Ramp)	255 192 255	FREEWAY (RED)
32	HOV Lane Closure (All Lanes)	PURPLE	FREEWAY (RED)
33	Shoulder Lane Closure	128 255 128	FREEWAY (RED)

i. **Select a Time Period:** Select the correct time period for analysis. The macro will process four 15-minute intervals or one-hour intervals. The time period selected is the beginning of the interval (i.e. TP1 2700-3600 represents the first 15-minute interval) as displayed by VISSIM. If the first interval is not 900 seconds (15 minutes), the macro will assume that the entire first interval represents data for an hourly time frame.

j. **Process Schematics:** Click "Process Schematics" to create lane schematics for VISSIM results. All lane schematics will be created and saved in an Excel spreadsheet titled *VISSIMFreewaySchematic_YYMMDDHHMMSS.xlsx*. An example schematic is shown in **Figure 25**.

k. **Close:** Exit macro.

Figure 25: VISSIM Freeway Schematic



Segment	FREEWAY	FREEWAY	RAMP	FREEWAY	WEAVE	FREEWAY
Actual Volumes	4980	4980	4980	4200	5150	3850
Simulated Volumes	4981	4962	4961	4179	5137	3795
Distance (ft)	4,878	1,093	304	2,111	1,072	732
Space Mean Speed (mph)	45.3	46.9	49.3	54.9	38.7	51.0
Link Density (veh/ln/mi)	36.7	35.3	25.2	25.4	33.2	24.8
	301	302	328	400	304	403

	To Downtown Expy	From Downtown Expy	To Broad St	Broad S
Actual Ramp Volumes	780 vph	950 vph	1,300 vph	1,110
Simulated Ramp Volumes	778 vph	952 vph	1,288 vph	1,110
Ramp Space Mean Speed (mph)	44.4	51.1	31.4	19.0
Ramp Density (veh/ln/mi)	17.5	18.7	20.5	58.5
	420	402	405	4

4.2.4 *VISSIM Freeway Schematics*

The Freeway Schematic Excel file will include a tab for each freeway in the VISSIM model. A maximum of 15 links will be shown on each tab. An additional freeway tab will be created for every set of 15 links as shown in **Figure 26**.

Figure 26: VISSIM Freeway Lane Schematic Tabs

Each VISSIM model is unique and the user will need to format the lane schematic template to customize for each specific project/scenario. The following steps explain how to customize the template for a project:

1. If a calibration sheet was identified in the VISSIM File Processing Utility window, actual freeway link volumes will populate based on the user-specified inputs in the calibration sheet. If a calibration sheet was not identified, the user must manually input freeway link and ramp volumes (**Figure 27**).
2. Confirm the freeway name and node numbers are correct.
3. Confirm that freeway, ramp and weave segments are correctly identified in row 3 as shown in **Figure 28**. Confirm that ramp and weave distances are correctly reported on the lane schematic.
4. The user may need to manually adjust shading and lines if freeway and ramp segments are not correctly represented in lane schematics. Elements to consider include number of lanes, acceleration lanes, deceleration lanes, auxiliary lanes, on ramps, and off ramps. The “RampTemplate” tab of the macro file depicts various configurations that can be used to properly display link geometry.

5. The legend in the bottom left corner of each tab displays a summary for the density thresholds that will be highlighted by-lane and by-link using built-in conditional formatting. These thresholds can be modified in Excel using conditional formatting.

Figure 27: VISSIM Freeway Schematic Values

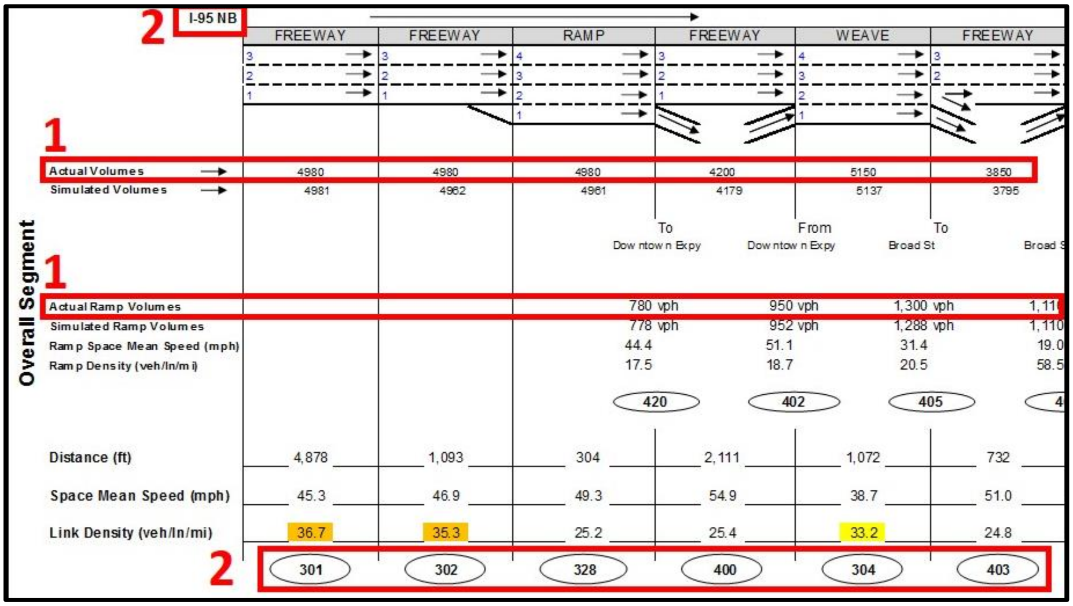
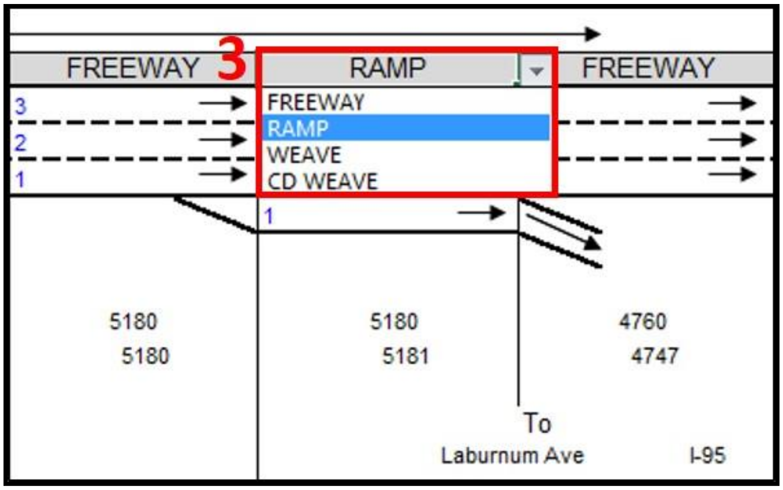


Figure 28: VISSIM Freeway Schematic Values (2)



6. The labels in the bottom right-hand corner of the lane schematic display the following information from the model (as shown in **Figure 29**):

   a. **Figure Number:** The user must manually change this value based on the report format.

   b. **Model Description:** This description is specified as the "Title" in VISSIM. If no description is provided in VISSIM, this defaults to the name of the *.INP or *.INPX file.

   c. **Freeway Route:** The freeway route name is automatically generated. This value is determined for each the first named link on each facility. If all of the links are unnamed, the macro will assign the first freeway node number as the route name. The user may manually change this value.

d. **Model File Name:** The macro will truncate an underscore (e.g., "_1") that typically depicts the microsimulation run number when multiple runs are generated.

Figure 29: VISSIM Freeway Schematic Labels

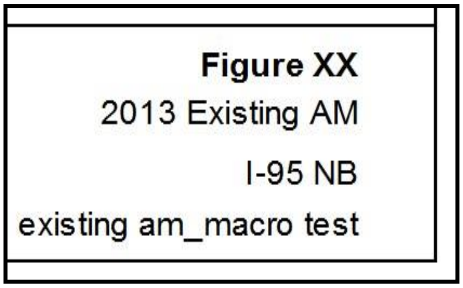


Figure XX
2013 Existing AM
I-95 NB
existing am_macro test

4.2.5 VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2) Limitations

The VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2) has the following known limitations:

- This macro does not report arterial analysis results.
- This macro does not report level of service results.
- Users must verify lane geometry and ramp configurations.
- Users must manually adjust lane geometry and ramp configurations to accurately represent each model.
- This macro will not report "actual volumes," users must manually input these values into the calibration sheet depicted on **Figure 24**.
- This macro will not create an output template for every possible lane configuration.
- The freeway route name is determined from the first named link on a facility. If all of the links are unnamed, the macro will assign the first freeway node number as the route name.
- This macro is designed for Excel 2007 or higher.
- This macro allows for only one off ramp or one on ramp on each link.
- This macro is not compatible with links that feature auxiliary lanes on both sides of the roadway.
- This macro limits the number of VISSIM freeway lanes to five.
- This macro requires an auxiliary lane on the previous upstream link for an off ramp on the left. An auxiliary lane is also required on the next downstream link for an off ramp on the left.
- The freeway must be coded with at least one-off ramp to be added to the selection list in *Step 5 of File Processing Utility Window*.
- There is a minimum requirement of one 60-minute time period or four 15-minute time periods for the tool to properly display results.
- The tool is bound by any limitations to VISSIM 5.40, VISSIM 6, VISSIM 7, VISSIM 9, and VISSIM 11.

4.2.6 VISSIM Calibration and Freeway Output Template Processing Tool (Version 2.2) Troubleshooting Common Problems

4.2.6.1 Issue #1 – Tool Does Not Process – Sheet is Not Created/Saved Properly

- Ensure that the *.ATT file is saved in the proper folder.
- The *.INPX and *.ATT file paths have a character limit of 255 characters, so ensure that both file paths are under this limit.

4.2.6.2 Issue #2 – Schematics Sheet Omits Lane Metrics like Density and Speed

- Ensure that a "Per Lane Segment" rather than a "Per Link Segment" collection type was performed (see **Figure 17**).

4.2.6.3 Issue #3 – Missing Freeways Segments from Schematics Sheet (Missing Tabs)

- While the Vissim Calibration and Freeway Output Template Processing Tool attempts to automatically recognize freeway routes in VISSIM, it is not always correct. It is suggested that the user manually set freeway routes to the freeway display types within the VISSIM Network. See page 20 Section 2.g.

This page is intentionally left blank.

APPENDIX G

Innovative Intersections Input Parameters

This page is intentionally left blank.

Manual Calculation of Experienced Travel Time

While HCS7 outputs ETT as an MOE for several innovative intersections and interchange types, ETT must be manually calculated for other intersection configurations or when using other traffic analysis tools. ETT is determined based on a combination of the control delay (expressed in seconds per vehicle) at signalized and unsignalized intersections and the extra distance travel time (the free-flow travel time required to traverse an interchange or alternative intersection minus the hypothetical shortest-path free-flow travel time making right-angle turns) for origin-destination paths. Some origin-destination paths may have multiple instances of control delay and/or extra distance travel time.

To manually calculate ETT:

1. **Determine the origin-destination paths for all intersection movements.**
   For example, the side street left-turn movement at an RCUT turns right at the main intersection, makes a U-turn at a crossover intersection, and then travels straight through the main intersection.
2. **For each origin-destination movement, compute the total control delay by summing the control delay experienced by this movement at each signalized and unsignalized intersection.**
   For the side street left-turn movement at an RCUT, the control delay would be the sum of the right-turn control delay at the main intersection, the U-turn control delay at the crossover intersection, and the through delay at the main intersection.
3. **For each origin-destination movement, compute the extra distance travel time by dividing the extra distance traveled in the new origin-destination path by the free flow speed**
   For the side street left-turn movement at an RCUT, the extra distance traveled would be the distance from the side street to the crossover plus the distance from the crossover back to the main intersection. This total distance would be divided by the free flow speed on the major street to calculate the extra distance travel time.
4. **For each origin-destination movement, compute the ETT by summing the total control delay (from step 2) with the extra distance travel time (from step 3).**

   To calculate the ETT for an intersection or interchange approach, take the weighted average of the ETT for each origin-destination movement.
   For example, the ETT for the northbound approach would be calculated with the following equation (where V=flow rate):

$$ETT_{NB} = \frac{(ETT_{NBL}\ x\ V_{NBL}) + (ETT_{NBT}\ x\ V_{NBT}) + (ETT_{NBR}\ x\ V_{NBR})}{(V_{NBL} + V_{NBT} + V_{NBR})}$$

5. **To calculate the ETT for the overall intersection or interchange, take the weighted average of the ETTs for each intersection or interchange approach:**

$$ETT = \frac{(ETT_{NB}\ x\ V_{NB}) + (ETT_{SB}\ x\ V_{SB}) + (ETT_{EB}\ x\ V_{EB}) + (ETT_{WB}\ x\ V_{WB})}{(V_{NB} + V_{SB} + V_{EB} + V_{WB})}$$

A spreadsheet may be used to expedite calculations.

EXAMPLE

The following example details the calculation of ETT for a RCUT using control delay outputs and link distances from Synchro. **Figure 1** and **Figure 2** show the study area and conventional intersection traffic volumes, respectively. **Figure 3** shows traffic volumes rerouted from the conventional intersection.

Figure 1: Study Area

Figure 2: Conventional Intersection Traffic Volumes

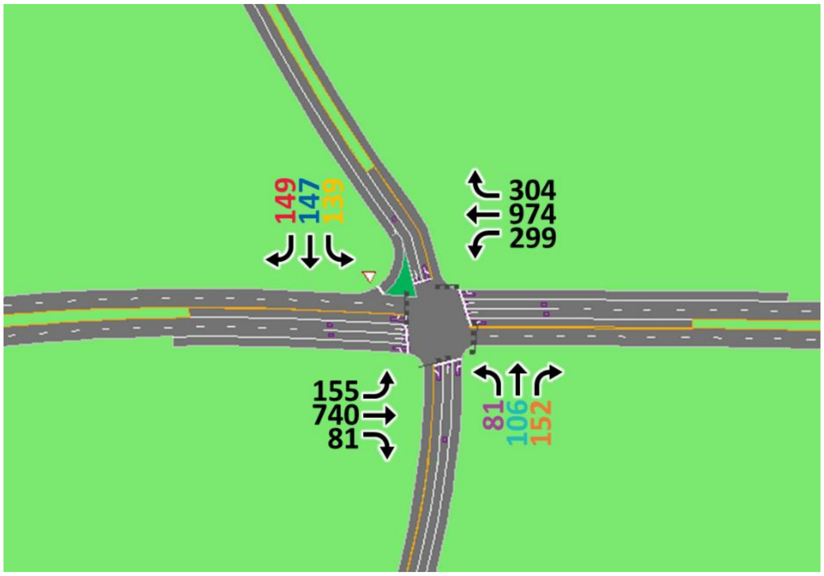
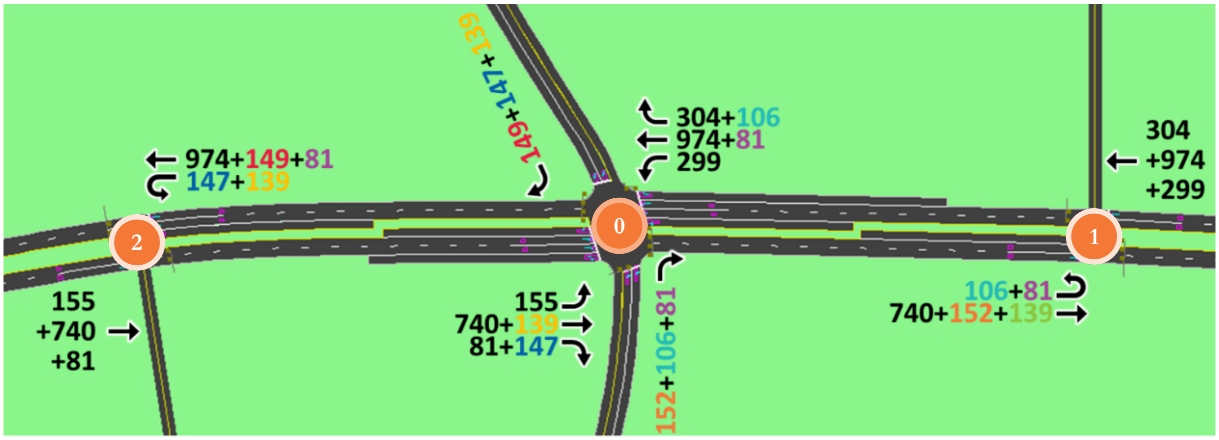


Figure 3: Rerouted RCUT Traffic Volumes



Step 1: Determine the origin-destination paths for all intersection movements, as shown in **Figure 4**.

Figure 4: O-D Paths, By Movement

Conventional Intersection O-D	RCUT O-D Movements *(numbers in parentheses correspond to intersection IDs in rerouted RCUT volumes exhibit)*
SBL	SBR (0) + WBU (2) + EBT (0)
SBT	SBR (0) + WBU (2) + EBR (0)
SBR	SBR (0)
NBL	NBR (0) + EBU (1) + WBT (0)
NBT	NBR (0) + EBU (1) + WBR (0)
NBR	NBR (0)
EBL	EBL (0)
EBT	EBT (0)
EBR	EBR (0)
WBL	WBL (0)
WBT	WBT (0)
WBR	WBR (0)

Step 2: For each origin-destination movement, compute the total control delay by summing the control delay experienced by this movement at each signalized and unsignalized intersection. **Figure 5** shows the Synchro delay results by movements. **Figure 6** shows the calculated control delay for each RCUT O-D movement defined in Step 1.

Figure 5: Synchro Delay Results By Movement

RCUT Movement	Delay
SBR (0)	23.6
NBR (0)	18.5
EBL (0)	21.1
EBT (0)	9.0
EBR (0)	7.4
WBL (0)	24.1
WBT (0)	7.3
WBR (0)	7.0
EBU (1)	24.2
EBT (1)	0.2
WBT (1)	8.4
WBU (2)	24.4
WBT (2)	0.3
EBT (2)	8.1

Figure 6: O-D Control Delay, By Movement

Conventional Intersection O-D	RCUT O-D Control Delay (sec)
SBL	23.6 + 24.4 + 9.0 = 57.0
SBT	23.6 + 24.4 + 7.4 = 55.4
SBR	23.6
NBL	18.5 + 24.2 + 7.3 = 50.0
NBT	18.5 + 24.2 + 7.0 = 49.7
NBR	18.5
EBL	21.1
EBT	9.0
EBR	7.4
WBL	24.1
WBT	7.3
WBR	7.0

Step 3: For each origin-destination movement, compute the extra distance travel time (EDTT) by dividing the extra distance traveled in the new origin-destination path by the free-flow speed (convert to feet per second). **Figure 7** shows the EDTT calculation for each crossover. **Figure 8** shows the resulting EDTT for each movement.

Figure 7: Extra Distance Travel Time Calculation

Eastern Crossover	Distance to/from eastern crossover (ft)	638 ft.
	Major street free-flow speed east of int (mi/hr)	60 mph
	Eastern Crossover EDTT	14.5 sec
Western Crossover	Distance to/from western crossover (ft)	653 ft.
	Major street free-flow speed west of int (mi/hr)	60 mph
	Western Crossover EDTT	14.8 sec

Figure 8: Extra Distance Travel Time, By Movement

Conventional Intersection O-D	EDTT*
SBL	14.8
SBT	14.8
NBL	14.5
NBT	14.5

**The remaining movements at the intersection do not experience EDTT*

Step 4: For each origin-destination movement, compute the ETT by summing the total control delay (from Step 2) with the extra distance travel time (from Step 3). **Figure 9** shows the ETT for each movement.

Figure 9: Experienced Travel Time, By Movement

Conventional Intersection O-D	ETT
SBL	57.0 + 14.8 = 71.8
SBT	55.4 + 14.8 = 70.2
SBR	23.6 + 0.0 = 23.6
NBL	50.0 + 14.5 = 64.5
NBT	49.7 + 14.5 = 64.2
NBR	18.5 + 0.0 = 18.5
EBL	21.1 + 0.0 = 21.1
EBT	9.0 + 0.0 = 9.0
EBR	7.4 + 0.0 = 7.4
WBL	24.1 + 0.0 = 24.1
WBT	7.3 + 0.0 = 7.3
WBR	7.0 + 0.0 = 7.0

Step 5: To calculate the ETT for an intersection or interchange approach, take the weighted average of the ETT for each origin-destination movement. **Figure 10** shows the resulting ETT by approach.

Figure 10: Experienced Travel Time, By Approach

Approach	Experienced Travel Time (ETT)
Example (approach "n")	$ETT_n = \dfrac{(ETT_{nL}\ x\ V_{nL}) + (ETT_{nT}\ x\ V_{nT}) + (ETT_{nR}\ x\ V_{nR})}{(V_{nL} + V_{nT} + V_{nR})}$
EB	$ETT_{EB} = \dfrac{(21.1\ x\ 155) + (9.0\ x\ 740) + (7.4\ x\ 81)}{(155 + 740 + 81)} = \mathbf{10.8}$
WB	$ETT_{WB} = \dfrac{(24.1\ x\ 299) + (7.3\ x\ 974) + (7.0\ x\ 304)}{(299 + 974 + 304)} = \mathbf{10.4}$
SB	$ETT_{SB} = \dfrac{(71.8\ x\ 139) + (70.2\ x\ 147) + (23.6\ x\ 149)}{(139 + 147 + 149)} = \mathbf{54.8}$
NB	$ETT_{NB} = \dfrac{(64.5\ x\ 81) + (64.2\ x\ 106) + (18.5\ x\ 152)}{(81 + 106 + 152)} = \mathbf{43.8}$

Step 6: To calculate the ETT for the overall intersection or interchange, take the weighted average of the ETTs for each intersection or interchange approach:

$$ETT = \frac{(ETT_{NB}\ x\ V_{NB}) + (ETT_{SB}\ x\ V_{SB}) + (ETT_{EB}\ x\ V_{EB}) + (ETT_{WB}\ x\ V_{WB})}{(V_{NB} + V_{SB} + V_{EB} + V_{WB})}$$

$$ETT = \frac{(43.8\ x\ 339) + (54.8\ x\ 435) + (10.8\ x\ 976) + (10.4\ x\ 1577)}{(339 + 435 + 976 + 1577)} = \mathbf{19.7}$$

Step 7: Determine the LOS for each movement, approach, and the overall intersection according to the *HCM*. **Figure 11** summarizes the LOS by movement and the overall intersection.

Figure 11: Level of Service Summary

Conventional Intersection O-D	ETT (s/veh)	LOS
SBL	71.8	E
SBT	70.2	E
SBR	23.6	C
NBL	64.5	E
NBT	64.2	E
NBR	18.5	B
EBL	21.1	C
EBT	9.0	A
EBR	7.4	A
WBL	24.1	C
WBT	7.3	A
WBR	7.0	A
EB Approach	10.8	B
WB Approach	10.4	B
SB Approach	54.8	D
NB Approach	43.8	D
Intersection	**19.7**	**B**

Software-Specific Considerations for Analysis of Innovative Intersections and Interchanges

HCS7 INPUT PARAMETER GUIDANCE

Several new input parameters were added to HCS 7 with the added functionality to analyze Restricted Crossing U-Turn (RCUT) intersections, Median U-Turn (MUT) intersections, and Displaced Left Turn (DLT) intersections. The following sections provide guidance on these new input parameters. The parameters are organized into three groups:

1. Input parameters that require specific direction or guidance for proper application, including typical values, acceptable ranges, and/or special notes
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application
3. Input parameters with default values that should not be modified without VDOT project manager approval

Unless otherwise stated, conventional guidance outlined in the TOSAM should be followed for all input parameters.

TWSC

1. Input parameters that require specific direction or guidance for proper application, including typical values, acceptable ranges, and/or special notes include:
    - **RCUT Alternative Intersection/Intersection Type** – When analyzing a RCUT with stop signs or merges, three TWSC files must be created (one file for the main intersection and one file for each crossover). For the main intersection file, select the "RCUT Alternative Intersection" checkbox and choose the appropriate intersection type based on the design ("RCUT with Stop Signs" or "RCUT with Merges"). Do not select the "RCUT Alternative Intersection" checkbox for the crossover intersection files.
    - **MUT/RCUT Crossover Intersection** – If the intersection is a MUT or RCUT, select the "MUT/RCUT Crossover Intersection" checkbox when creating a TWSC file for each crossover. Do not select this checkbox for the main intersection.
    - **Conventional Intersection Volumes** – Since the HCS7 TWSC module does not redistribute conventional volumes, conventional and innovative intersection volumes must be manually determined and entered into the main intersection file.
      For the RCUT with merges analysis, the conventional intersection volume is used to check the zero-merging delay assumption. If the demand combinations do not fall within the 'insignificant delay' constraints, an input error message will appear.
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application include:
    - Main Intersection Lanes
    - Crossover Intersection Lanes
    - Vehicle Volumes
    - RCUT Main Intersection Left- and Right-Turn Storage Lengths
    - Major Street Free-Flow Speed
    - Distances from Main Intersection to Crossovers
    - U-Turn Crossovers Storage Lengths

3. There are no additional input parameters with default values.

Streets

1. Input parameters that require specific direction or guidance for proper application, including typical values, acceptable ranges, and/or special notes include:
    - **Demand** – Enter the conventional intersection demand. The demand will be automatically redistributed based on the innovative intersection geometry.
    - **Alternative Intersection/Intersection Type** – Check "Alternative Intersection" in the Detailed Input Data section and select the appropriate intersection type from the drop-down list (MUT with TWSC, RCUT, or DLT).
2. Input parameters that are dependent on available data that do not require specific direction or guidance on their application include:
    - **RCUT**
        - i. U-Turn Crossover Median Width (in Additional RCUT Inputs)
        - ii. Field Free-Flow Speed (in Segment group box of the Detailed Input Data)
        - iii. Segment Length (in General group box of Primary Input Data)
    - **MUT with TWSC**
        - i. Segment Free-Flow Speeds (in Segment group box of Interchanges and Alternative Intersections)
        - ii. Segment Lengths (in Segment group box of Interchanges and Alternative Intersections)
    - **DLT**
        - i. Field Free-Flow Speed (in Segment group box of the Detailed Input Data)
        - ii. Segment Length (in General group box of Primary Input Data)
3. There are no additional input parameters with default values.

SYNCHRO INPUT PARAMETER GUIDANCE

The following sections summarize recommended approaches for coding specific types of innovative intersections to generate accurate outputs using the Synchro *HCM* reports.

Flashing Yellow Arrow (FYA)

Although it is not an innovative intersection, flashing yellow arrow (FYA) signal operation is becoming more prevalent across Virginia. When FYA signals are used for protected/permissive left-turn operations, either as an existing condition or a future-year analysis, the "Turn Type" in Synchro shall be set to the "D.P+P" (Dallas protected/permitted) turn type to assign the permissive left-turn phase to the opposing continue through movement.

It is acceptable to operate a FYA signal in the protected-only mode during peak hours. In these cases, the "Prot" turn type will be used when modeling those peak hours where the time-of-day protected-only operation is in effect (or proposed to be in effect in a future-year condition).

It is acceptable to operate a FYA signal in the permissive-only mode during off-peak hours. In those cases, the "D.Pm" (Dallas permissive-only) turn type will be used to assign the permissive left-turn phase to the opposing through movement if an off-peak period with permissive-only left-turn phasing is being analyzed.

The function of the "Permitted Flashing Yellow" checkbox is only to change the display graphics in the SimTraffic animation. It does not affect the programming of the permissive left-turn phase, which should be set to the opposing through movement (D.P+P) instead of the adjacent through movement (pm+pt).

For additional guidance, refer to the latest VDOT Instructional and Informational Memorandum (IIM) for Flashing Yellow Arrow.

Median U-Turn (MUT) and Restricted Crossing U-Turn (RCUT)

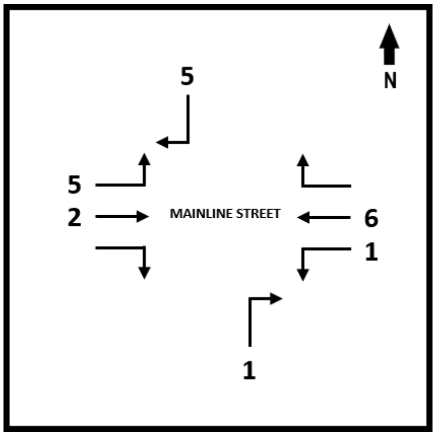
The major road along corridors that employ MUTs and/or RCUTs should be coded as two sets of one-way links. Crossovers, on the other hand, should be coded as short one-way links connecting the two sides of the divided highway. The origin-destination feature should be used to properly proportion movements at the crossover locations.

It may be possible to code the major road as a two-way link for existing roadways that feature a combination of conventional intersections and MUTs. For these configurations, assign U-turns to a T-intersection with a hidden link. Depending on the left-turning (U-turning) volume and the opposing through traffic volume, signal control may be necessary at the crossover intersection.

Since signalized intersections at RCUTs only stop one side of the minor road's traffic, code the major road as a two-way link, and the two sides of the minor road as two separate intersections, if possible, so as to allow the most combinations of signal offset optimization.

Figure 12 illustrates the RCUT Signal Phasing. The RCUT signals will use Phases 1, 2, 5, and 6 only. Phases 3, 4, 7, and 8 shall not be used. For an unsignalized through movement on the major road at an RCUT signal (e.g. a westbound U-turn movement stops EB through traffic but the WB through movement is not stopped by the signal), type the word "FREE" in the box for the protected phases of the unrestricted movement. The minor road right turns shall be coded to Phases 1 or 5, as appropriate.

Figure 12: RCUT Signal Phasing



U-turn movements at the MUT and RCUT directional crossover is considered to be a left-turn movement from a one-way street onto another one-way street, and is therefore permitted on red. If the major road is coded as two one-way links, refer to the Lane Settings dialog box. If the major road is coded as a two-way link, set the turn type as "D.P+P" the U-turn movement.

The *HCM* critical gap for a left turn and a U-turn are different. If we have a design that channelizes U-turning vehicles into a stop position perpendicular to traffic, then it may make sense to model as a left turn. If the U-turn design has a stop position parallel to opposing traffic, then the turn distance and, therefore, the gap acceptance would be greater. Such considerations regarding intersection geometry should guide the selection of the modeling approach.

For additional guidance, refer to the latest VDOT IIM for Signal Control Justification and Yellow Change and All Red Intervals.

Partial Restricted-Crossing U-Turn (RCUT) Intersection

There are two variations of a partial RCUT:

1. Variation 1, shown in **Figure 13**, allows all primary intersection left turns, right turns, and major road through movements. The minor road through movements are NOT allowed and will have to divert either to another roadway or to a U-turn crossover.
2. Variation 2, shown in **Figure 14**, allows three left turns, three through movements, and all four right turns from the primary intersection. One side of the minor road allows all movements (i.e. is one half of a split-phase operation), while the other side of the minor road has a mandatory right-turn movement and operates like a full RCUT intersection.

Figure 13: Partial RCUT Signal Phasing, Variation 1

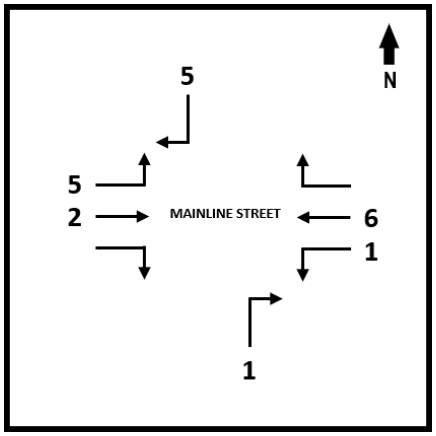
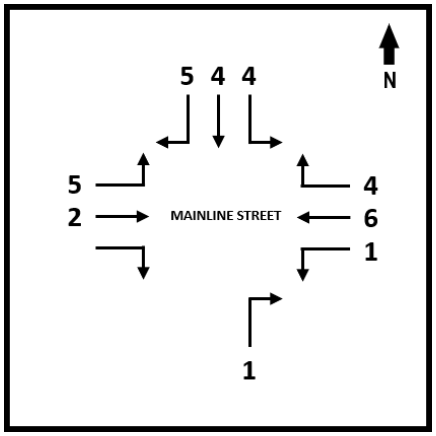


Figure 14: Partial RCUT Signal Phasing, Variation 2



When analyzing Variation 1, assign the major road left turns to Phases 1 and 5; the minor road left turns to Phases 3 and 7; and the minor road right turns to Phases 1 and 5, as appropriate. Phases 4 and 8 will not be used.

When analyzing Variation 2, assign the minor road approach with the mandatory right turn to Phase 1 or 5 as appropriate. The minor road approach with the full movements may be assigned to any of Phases 3, 4, 7, or 8.

Continuous Green-T Intersection

There are some concerns with modeling Continuous Green-T intersections when the major road is coded as a two-way link. To accurately model these intersections:

1. Code the uncontrolled through movement as "FREE".
2. Correctly program the "Lane Alignment" setting in the "Simulation Settings" dialog. Code the minor road left turn as "L-NA" and the bypass lanes on the major road as "R-NA".

In some cases, a U-turn movement in the Continuous Green-T intersection may exist. These movements can be accommodated if the median is wide enough. In these cases, set the lane alignment to "L-NA."

When using SimTraffic, users may still observe U-turn queues due to turning vehicles attempting to yield to oncoming through traffic. If this is observed, model the intersection with the major road as two one-way links. Then, code the side of the arterial that is free-flowing as a freeway link, with left-hand off-ramps and on-ramps.

When coding a Continuous Green-T intersection as two one-way links, consider the following:

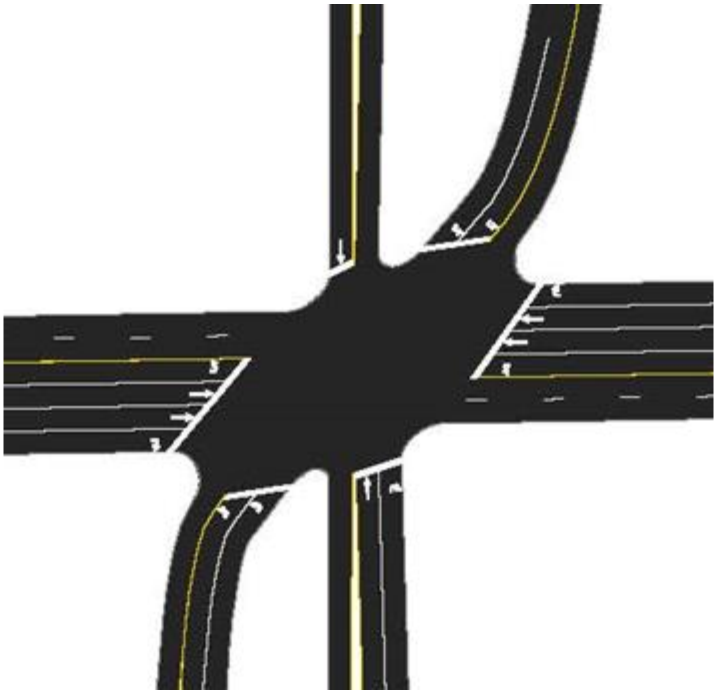
1. Code the approach orientation as cardinal directions at nodes where control delay will be reported.
2. In the "Simulation Settings" dialog, adjust the "Turning Speed" to match the "Link Speed" under the "Lane Settings" dialog for nodes where one-way links meet a two-way link. These are typically nodes where control delay will not be reported.
3. In the "Simulation Settings" dialog, program the "Lane Alignment" setting where the merge occurs between the side street left turn and bypass lanes on the major road. Code the lane alignment of the minor road as "L-NA" and the major road bypass lanes as "R-NA".

Displaced Left-Turn Intersection or Continuous-Flow Intersection (CFI)

A sample file of a full CFI is available through Trafficware. The available model has closely-spaced intersections and clustered signal control; the central intersection is coded “FREE” for all movements since the signal heads are on the inside.

For a partial CFI, a multi-leg intersection could be coded to approximate the geometry of the CFI. An example is illustrated in **Figure 15**. This eliminates the need for a cluster signal configuration with the partial CFI, which has two direct left turns at the central intersection.

Figure 15: Partial CFI Multi-Leg Intersection Configuration



Similar techniques could be used to model the synchronized split-phase intersection (Gilbert Chlewicki’s other design), the parallel-flow intersection, or other variations on this type of intersection.

One consideration is whether the auxiliary intersections at the CFI, double crossover, or similar intersection should be run on the same controller or on different controllers. The phasing will be more difficult if they are on the same controller and the phasing will need to be modeled correctly (i.e. it won’t be the same as with the 8-phase standard NEMA phasing).

The above coding can be considered for screening analyses of an intersection. Where traffic analyses are being completed as part of a comparative evaluation of different alternative intersections, conventional coding in Synchro should be performed by the traffic engineer to mimic the aforementioned sample files offered by Trafficware.