PROTOCOL FOR
VISSIM SIMULATION

Oregon Department of Transportation

July 2019
ACKNOWLEDGEMENTS

The following individuals were key contributors in the preparation of this document.

Oregon Department of Transportation
Chi Mai, P.E.
Christi McDaniel-Wilson, P.E.
Doug Norval, P.E.
Dorothy Upton, P.E.
Joseph Auth, P.E.
Peter Schuytema, P.E.
Sarah Abbott
Ray Delahannty (formerly with ODOT)

DKS Associates
Chris Maciejewski, P.E.
Michael Wobken, P.E., P.T.O.E
Miranda Wells, EIT
Xiaoping Zhang, P.E.

PTV America
Thomas Bauer, P.E., P.T.O.E
Jim Dale, P.E.
Karen Giese, P.E.
Jongsun Won
# TABLE OF CONTENTS

1. Project Understanding ............................................................................................................ 1
   1.1 Defining the Project Purpose .................................................................................. 1
   1.2 Is VISSIM the Right Tool? .................................................................................. 2
   1.3 What Else Should be Considered? ....................................................................... 3

2. Project Scoping .......................................................................................................................... 6
   2.1 Project Boundary Definition .................................................................................. 6
      2.1.1 Freeways and Ramp Terminals ..................................................................... 6
      2.1.2 Arterials ....................................................................................................... 7
   2.2 Project Study Period ............................................................................................... 8
      2.2.1 Freeways ..................................................................................................... 8
      2.2.2 Arterials ..................................................................................................... 9
   2.3 Project Schedule and Staffing Plan ........................................................................... 9
      2.3.1 Scheduling Considerations ......................................................................... 9
      2.3.2 Staffing Plan ............................................................................................... 9
      2.3.3 Project Milestones .................................................................................... 10
   2.4 Field Visit .................................................................................................................. 10
   2.5 Key Calibration Locations ....................................................................................... 11
   2.6 Data Collection Plan .............................................................................................. 11
   2.7 Project Methods and Assumptions .......................................................................... 11

3. Data Collection ....................................................................................................................... 14
   3.1 Geometric Data ...................................................................................................... 14
   3.2 Control Data ........................................................................................................ 15
   3.3 Traffic Volume Data ................................................................................................ 15
      3.3.1 Freeways .................................................................................................... 16
      3.3.2 Arterials .................................................................................................... 16
      3.3.3 Time-Varying Volume Profile Estimation ................................................. 16
      3.3.4 Adjustments for Design Hour Volumes ..................................................... 17
   3.4 Origin-Destination Data ......................................................................................... 17
   3.5 Travel Time Data .................................................................................................... 17
   3.6 Spot Speed Data ..................................................................................................... 19
      3.6.1 Freeways .................................................................................................... 19
      3.6.2 Arterials .................................................................................................... 19
   3.7 Queuing Data ......................................................................................................... 20
      3.7.1 Freeways .................................................................................................... 20
      3.7.2 Arterials .................................................................................................... 20
   3.8 Lane Utilization Data ............................................................................................... 20
   3.9 Transit Data ............................................................................................................ 20
   3.10 Saturation Flow Data ............................................................................................ 21
   3.11 Delay Data ............................................................................................................ 21
   3.12 Data Collection Summary .................................................................................... 22

4. Model Development ............................................................................................................... 23
   4.1 Possible Software Updates .................................................................................... 23
   4.2 General Network Parameters ................................................................................ 23
4.3 Vehicular Fleet Setup........................................................................................................... 23
4.4 Network Coding.................................................................................................................... 24
  4.4.1 Freeway Merge, Diverge and Weave Coding ................................................................. 24
  4.4.2 Arterials .......................................................................................................................... 25
  4.4.3 Roundabouts .................................................................................................................. 26
4.5 High Occupancy Vehicles, High Occupancy Toll, and Truck Only Lanes ......................... 29
4.6 Known Roadway Improvements / Changes........................................................................ 29
4.7 Control Coding.................................................................................................................... 29
  4.7.1 Ramp Meters .................................................................................................................. 29
  4.7.2 Signal Controller Settings .............................................................................................. 30
  4.7.3 Adaptive Signal Timing ................................................................................................. 31
  4.7.4 Unsignalized Intersections ............................................................................................ 31
4.8 Speed Control Coding.......................................................................................................... 31
  4.8.1 Freeways ....................................................................................................................... 32
  4.8.2 Arterials ........................................................................................................................ 33
4.9 Vehicle Inputs....................................................................................................................... 33
4.10 Vehicle Routing ................................................................................................................... 34
  4.10.1 Static Routes .................................................................................................................. 34
  4.10.2 Dynamic Routing .......................................................................................................... 35
  4.10.3 Origin-Destination (O-D) Based Vehicle Routing ......................................................... 35
  4.10.4 Dynamic Traffic Assignment (DTA) ............................................................................ 36
  4.10.5 TFlowFuzzy Guidelines .............................................................................................. 36
4.11 Driving Behavior Models in VISSIM .................................................................................. 37
  4.11.1 Car Following Parameters ............................................................................................ 38
  4.11.2 Lane Changing Parameters .......................................................................................... 44
  4.11.3 Geometric Driver Reaction Coding .............................................................................. 45
  4.11.4 Time Step Requirement ............................................................................................... 46
4.12 Non-Auto Modes Coding .................................................................................................... 46

5. Error Correction .................................................................................................................... 47
  5.1 Verify all VISSIM Inputs ..................................................................................................... 47
  5.2 Animation Checking .......................................................................................................... 48
  5.3 Correction of VISSIM Error Files ..................................................................................... 49

6. Calibration ............................................................................................................................ 50
  6.1 Volume/Density .................................................................................................................. 50
  6.2 Speed .................................................................................................................................. 51
  6.3 Travel Time ........................................................................................................................ 53
  6.4 Queuing .............................................................................................................................. 53
  6.5 Weaving Behavior .............................................................................................................. 53
  6.6 Lane Utilization .................................................................................................................. 53
  6.7 Transit Travel Times .......................................................................................................... 53
  6.8 Visual Inspection ................................................................................................................ 54
  6.9 Minimum Number of Simulation Runs .............................................................................. 54
  6.10 VISSIM Calibration Documentation ................................................................................. 55

7. Additional Base Year Scenarios ........................................................................................... 56
  7.1 Model Development .......................................................................................................... 56
8. Alternatives ........................................................................................................ 57
  8.1 Developing Volumes for the No-Build Scenario .............................................. 57
  8.2 Model Development ....................................................................................... 57
  8.3 Changes to the VISSIM Model ....................................................................... 58
  8.4 Error Checking ............................................................................................... 58
  8.5 Initial Assessment of the No-Build Model ..................................................... 58
  8.6 Developing Volumes for Alternative Scenarios .............................................. 59
  8.7 Model Development ....................................................................................... 59

9. Reporting ........................................................................................................... 60
  9.1 Required Data Outputs ................................................................................. 60
      9.1.1 Node Evaluation ...................................................................................... 60
      9.1.2 Queue Counters ..................................................................................... 60
      9.1.3 Data Collection Points ........................................................................... 62
      9.1.4 Travel Time ........................................................................................... 62
  9.2 Optional Output Data ..................................................................................... 63
      9.2.1 V/C Ratio ............................................................................................... 63
      9.2.2 Network Performance Evaluation ............................................................ 63
      9.2.3 Link Evaluation ....................................................................................... 63
      9.2.4 Speed Contour Plots .............................................................................. 64
      9.2.5 Emissions ............................................................................................... 64
      9.2.6 Lane Changes .......................................................................................... 64
      9.2.7 Travel Time (for O-D Data) ..................................................................... 65
      9.2.8 Managed Lanes ....................................................................................... 65
      9.2.9 Delay Segments ..................................................................................... 65
      9.2.10 Green Time Distribution ....................................................................... 66
      9.2.11 Vehicle Record ..................................................................................... 66
      9.2.12 PT Waiting Time ................................................................................... 66
  9.3 Post Processing .............................................................................................. 66
      9.3.1 HCM Compliant Level of Service Results .............................................. 67
  9.4 Sample Report Format ................................................................................... 67

10. Reviewing ....................................................................................................... 69
LIST OF FIGURES

Figure A: Sample Review/Check-in Process for Typical Project
Figure 4-1: Typical Freeway Entrance Ramp Merge Area
Figure 4-2: Suggested Coding of a Freeway Merge Area
Figure 4-3: Example Conflict Area at Roundabouts
Figure 4-4: Example of the Ring Barrier Controller Interface
Figure 4-5: Example of Speed Distribution Profile
Figure 4-6: 35 mph Speed Distribution Profile for Arterials
Figure 4-7: Recommended Routing Decision Placement
Figure 4-8: Example of the Combine Routes Feature
Figure 4-9: Wiedemann 99 Car Following Model Dialog
Figure 4-10: Standstill Distance Parameter (CC0)
Figure 4-11: Headway Time (CC1)
Figure 4-12: Following Variation Parameter (CC2)
Figure 4-13: Maximum Flow Rate vs. CC1
Figure 4-14: Maximum Flow Rate vs. CC1 and CC2
Figure 4-15: Wiedemann 74 Car Following Model Dialog
Figure 4-16: Saturation Flow Rate vs. Desired Safety Distance Parameters
Figure 4-17: Lane Change Driver Behavior Dialog
Figure 9-1: Queue Measurement Evaluation Configuration
Figure 9-2: Travel Time Segment Placement for OD Data

LIST OF TABLES

Table 4-1: Suggested 3D Models by FHWA Vehicle Class for Heavy Vehicles
Table 4-2: Wiedemann 99 Car Following Parameters (U.S. Customary Unit)
Table 4-3: Suggested Lane Changing Parameters
Table 6-1: GEH Statistic Guidelines
Table 6-2: Traffic Volume Calibration Criteria
Table 6-3: Travel Time Calibration Criteria
**LIST OF APPENDICES**

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Decision Making Tools Excerpts from the FHWA’s Traffic Analysis Toolbox Volume II.</td>
</tr>
<tr>
<td>B</td>
<td>Scoping Checklist</td>
</tr>
<tr>
<td>C</td>
<td>Seeding Period Excerpts from FHWA’s Traffic Analysis Toolbox Volume III</td>
</tr>
<tr>
<td>D</td>
<td>Example Model Development Flow Chart</td>
</tr>
<tr>
<td>E</td>
<td>Example Speed Plots</td>
</tr>
<tr>
<td>F</td>
<td>Ramp Meter Signal Timing Example</td>
</tr>
<tr>
<td>G</td>
<td>Signal Timing Checklist</td>
</tr>
<tr>
<td>H</td>
<td>Example Calibration Report</td>
</tr>
<tr>
<td>I</td>
<td>95th Percentile Queue Example</td>
</tr>
<tr>
<td>J</td>
<td>Sample Report Formatting</td>
</tr>
</tbody>
</table>
TERMINOLOGY

**Bottleneck:** A specific location where roadway performance is reduced due to a physical or temporary constraint, which when activated reduces the throughput of the roadway segment.

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

**Car Following Model:** Driver behavior model that controls how a following vehicle adjusts its speed in relation to the leading vehicle.

**Dynamic Traffic Assignment (DTA):** A process for assigning vehicle routes in a simulation model based on network conditions. It is an iterative process that converges to a path assignment based on vehicle travel time and delay between origin and destination (O-D) points in the network. While sometimes used in practice to refer to the macro- or mesoscopic traffic assignment in a travel demand model such as VISUM, for the purposes of this document, DTA refers to the microscopic dynamic traffic assignment within VISSIM.

**Free-Flow Speed:** The mean speed at which traffic would travel if there were no congestion or any other adverse condition to lower speed.

**Gap:** The time or distance between the back end of a leading vehicle and the front end of the following vehicle.

**Managed Lanes:** A lane that is restricted or controlled for a particular purpose (e.g., HOV lanes, bus only lanes, and toll lanes).

**Microsimulation:** Modeling of individual vehicle movements on a second or sub-second basis for the purpose of assessing the traffic performance of a transportation network.

**MOE:** Measure of effectiveness.

**Model Area:** The total area to be modeled in order to accurately analyze the study area (an area equal to or greater than the study area).

**NEMA:** National Electrical Manufacturers Association, which refers to VISSIM’s default emulator for standard signal controller logic (prior to VISSIM version 5.0). NEMA was developed internally by PTV America to replicate the common features of a signal controller.

**Random Seed:** The parameter in VISSIM that initializes the random number generator.

**RBC:** Ring Barrier Controller, which refers to VISSIM’s default emulator for standard signal controller logic (since VISSIM version 5.0). RBC is a direct implementation of an actual real world signal controller firmware (D4) and includes more advanced features than the NEMA emulator.

**Seeding Period:** The time between the start of the simulation and when the network has the necessary number of vehicles in the system for the representative time period.

**Sinks and Sources:** Locations that replicate an access or accesses (public or private) that is not directly included in the model network. At these locations, volumes can either be added or taken away from the network. A sink location would be where traffic is taken away and a source location would be where traffic is added.

**Study Area:** The area to be analyzed as part of a project or study.

**TFlowFuzzy:** A matrix estimation utility used to adjust a given O-D matrix in such a way that the result of the assignment closely matches desired volumes at points within the network.

**Validation:** Process where the modeler checks the overall model-predicted traffic performance for a network against field measurements of traffic performance (utilizing data not used in the calibration process).
INTRODUCTION

For many engineering disciplines, simulation has become an indispensable tool to design complex technical systems and this is also true for transportation planning and traffic engineering. VISSIM is a microscopic, behavior-based, multi-purpose traffic simulation program useful in modeling complex transportation projects. Complex transportation projects include but are not limited to congested freeway networks, light rail operations, and unique roadway configurations. The protocol described in this document provides practitioners with guidance on what to consider when performing traffic simulation analysis with VISSIM. It is an update to the original protocol document *VISSIM Protocol for Simulation on Freeways*, HDR Engineering, released in 2007, which focused only on freeway networks. This expanded protocol document applies lessons learned through three years of application of the original document. It now includes arterial street networks and can be applicable statewide.

PURPOSE

This updated version of the VISSIM protocol maintains the original purpose of promoting consistency among VISSIM applications from one project to the next and between modelers. However, this protocol makes a significant step beyond just providing guidance on coding of networks. This protocol provides a process for scoping and reviewing a VISSIM application that offers consistency, efficiency, and quality for ODOT staff.

The goal of scoping is to specify all ODOT expectations, guidelines, and requirements at the outset of the project in order to reach agreement from all parties involved and eliminate as many unexpected issues as possible later in the project. In an effort to maintain transparency throughout the VISSIM project, the protocol includes a list of project milestones and deliverables. This is intended to foster greater collaboration between ODOT staff and the consultant and allows ODOT to gain a better understanding of the model and thereby improve the speed and quality of their review process. The additional feedback from the client will also benefit the consultant by minimizing the number of network revisions necessary based on their review. This overall model development and check-in process for a typical project is summarized in Figure 1.

Depending on the project-specific purpose, need, and scope, elements of the process described in this protocol, with prior approval from ODOT, may be enhanced or adapted to support the modeler and the project team. This procedures manual is also a living document, which can be updated as technological and/or agency needs change.
Figure 1: Sample Review/Check-in Process for Typical Project
Before you use VISSIM for analysis on an ODOT facility, careful consideration of the need for this type of evaluation shall be coordinated with ODOT staff. As described in Chapter 1, the level of effort required to build, review, and present results from VISSIM is significant and may not be within the project budget or overall needs.

It should be noted that this entire document is meant not only as a manual for consultants to use for guidance on building VISSIM models, but it also for agencies to use for guidance and review during the VISSIM modeling process.
1. **PROJECT UNDERSTANDING**

This section of the protocol outlines the steps and considerations leading to the development of a project that includes VISSIM models. It is anticipated that in most cases the Project Problem Statement will be completed by the project sponsor (e.g., the public agency on a public project) before a project is fully developed. This process will be used to clarify the intent and intended outcome of the project while preparing the RFP or other project scoping documents. For this reason, it is recommended that this process be completed in a group setting that includes all pertinent agency staff members to reach internal agreement on key project goals early in the process. The components of the Project Problem Statement are described in detail below.

1.1 **Defining the Project Purpose**

To provide a clear guide for the project and ensure that goals and objectives are met, the purpose of the project shall be described, including addressing questions such as:

1. What agencies are involved in the project? What is their involvement?
2. In general, what is the purpose of the project (i.e., what decisions are being made and what questions needs to be answered)?
3. What type of process will this evaluation be used for (system planning, improvement project development, TIA, EIS, etc.)?
4. What type of study area is being considered (sub-area, corridor, or focus area)?
5. What type of transportation network will be evaluated (modes, controls/facility type, etc.)?
6. What types of transportation alternatives will be evaluated? What evaluation criteria will be used?
7. What key issues are known about the study area from prior studies or observations of existing conditions? What analysis tools were previously utilized?
8. What types of outputs/MOE's are important for the decision making process? Is the purpose of the evaluation detailed technical evaluation and/or visual simulation? Who is the decision making body that will review the findings?
9. What are the schedule and budget constraints, including agency review needs, for this effort?
1.2 **Is VISSIM the Right Tool?**

VISSIM is an attractive option due to its 3D animation capabilities and advanced microsimulation features. However, it is not always the most cost effective tool. It may not even be necessary for some studies, considering VISSIM’s level of complexity and required outputs/measures of effectiveness (MOEs). In many cases, a simpler deterministic software package such as Synchro or HCS or a simpler microscopic model such as SimTraffic may provide sufficient information to meet the needs of the project. To facilitate the decision about what analysis tools are the best fit for the study, the following questions should be answered by the sponsor agency as part of the Project Problem Statement.

<table>
<thead>
<tr>
<th>QUESTIONS FOR DETERMINING APPROPRIATE ANALYSIS TOOL</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is microsimulation needed to adequately provide analysis outputs/MOEs? (i.e., data cannot adequately be obtained from a simpler software package (e.g., Synchro/SimTraffic or HCS))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Is the study area an oversaturated situation so that HCS or other deterministic software cannot provide the answer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Are there complex network/operational components that justify microsimulation (queue interaction, freeway interchanges, complex weaving conditions, multiple modes, complex roundabouts, transit signal priority, conditions conducive to route choice simulation, etc.)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Does the use of microsimulation fit within the schedule and budget constraints of the project?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the answers to any of these four questions are yes, it may suggest that using VISSIM for microsimulation is justified.

The next concern is if any advanced software features are recommended (e.g., microscopic dynamic assignment, integration with VISUM for forecasting, and/or O-D matrix estimation using TFlowFuzzy)? If so, the following questions should be answered about the advanced features (note that these questions would typically be answered in coordination with the VISSIM modeler, which may occur after the draft Project Problem Statement is developed in an RFP process; ODOT must approve the use of any advanced software features):
1. **What is the purpose of the advanced feature?**

2. **Has this feature been used/applied successfully on a project? Have there been any issues or technical difficulties with the use of this advanced feature in the past?**

3. **In project experience, what have been the advantages of using this feature?**

Based on the project understanding and consideration of the appropriate evaluation tools, what is the recommended package of software tools for this project? If VISSIM is one of the selected tools then the Project Problem Statement (see page 4) should be completed by the sponsor agency. This is the first step in beginning a project that involves VISSIM and it will help in defining the next elements of the project as well.

### 1.3 What Else Should be Considered?

If completing the Project Problem Statement does not clearly identify a software tool, FWHA’s *Traffic Analysis Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools*¹ should be reviewed. The supporting scoring process for selection of a traffic analysis tool (see Appendix A) may be used as supplemental information to the Project Problem Statement. However, ODOT ultimately needs to approve the selection of software tools for the project.

For many projects, the use of more than one analysis tool may be necessary. The type and application of each analysis tool should be fully documented in the Project Methods and Assumptions document as outlined in Section 2.

VISSIM has been used in the past to evaluate the duration and extent of congested periods, however, due to the level of effort and cost, as well as limitations of assigning static traffic volumes, VISSIM may not be the best tool to evaluate the duration of congestion. Other options such as ODOT Region 1’s Hours of Congestion Methodology or a mesoscopic tool such as Metro’s Regional Travel Demand Model may be more appropriate.

---

VISSIM Project Problem Statement

Answer the questions below before completing the project problem statement.

1. What agencies are involved with the project? What is their involvement?

2. In general, what is the purpose of the project (i.e., what decisions are being made and what questions needs to be answered)?

3. What type of process will this evaluation be used for? (e.g., system planning, environmental impact statement, or development review)

4. What type of study area is being considered?
   - Arterial
   - Freeway
   - Combination

5. What type of transportation network/modes will be evaluated?

6. What types of transportation alternatives will be evaluated? What modes?

7. What key issues are known about the study area from prior studies or observations of existing conditions? What analysis tools were previously utilized?

8. What types of outputs/MOEs are important for the decision making process? Is the purpose of the evaluation detailed technical evaluation and/or visual simulation? Who
is the decision making body that will review the findings? What might the model be used for in the future?

9. What are the schedule and budget constraints, including agency review needs, for this effort?

Answer the following questions to help determine if VISSIM is an appropriate tool for this project.

1. Can all the desired analysis outputs/MOEs be adequately provided from a simpler software package? If so what software package?

2. What are some complex network features that are included as part of this project?
   - Unusual Roadway Geometry
   - Advanced Signal Timing
   - Transit Operations
   - Freeway Operations
   - Railroad Preemption
   - Weaving Sections
   - Multi-Modal Interaction
   - Ramp Metering
   - Other: __________

3. Will 3D animations be required as part of this project? What level of detail would be needed? What is the purpose of the animation?

4. Will the project need advanced features (e.g., dynamic traffic assignment, integration with VISUM for forecasting, and/or O-D matrix estimation using TFlowFuzzy) that only work with VISSIM?

Based on the answers to the above questions, state in a few sentences the reason(s) for this project and why VISSIM should be used. Include the question(s) that will need to be answered and how VISSIM will be used to answer them.
2. PROJECT SCOPING

To facilitate the project scoping process, an example of a Scoping Checklist form that includes all steps recommended by ODOT for a VISSIM project is available in Appendix B. Each item on this checklist is described in detail below.

2.1 Project Boundary Definition

The project area boundary depends on the “zone of influence” of the surrounding traffic network. The zone of influence is the study area plus the surrounding traffic network that has an impact on the operations in the study area (which should include consideration of future network conditions). The zone of influence may be greater than the minimum study area boundaries and should be determined with input of the appropriate analysts and stakeholders of the project. It is important to understand the operational characteristics of the facilities within the proposed project. This could range from one intersection from the end of the project to over two miles. This allows for the model to achieve real-world traffic behavior in the project area. Some general guidelines for determining a zone of influence are given for freeway and arterials.

2.1.1 Freeways and Ramp Terminals

The VISSIM network should extend at least one interchange and/or two miles outside of the study area. When modeling system interchange areas, this zone of influence could be much greater. Special consideration should be taken to ensure correct lane-choice behavior, which could mean extending the zone of influence further than two miles. Special consideration may also be required in areas of significant weaving. The distance required to capture correct weaving behavior depends greatly on the surrounding interchanges configuration and the level of congestion.

The network should extend far enough to prevent vehicle queues from spilling back off the network. It is important to note that the additional freeway area needed to capture the back of the queue is part of the zone of influence and not the study area. Therefore, MOEs do not need to be reported for the zone of influence but only for the study area. The zone of influence should adhere to the VISSIM protocol for network coding with the exception of the furthest extents, outside of the study area. In some cases, in order to keep budget and time frame reasonable, special coding may be allowed at the end of models, outside of the study area, to mimic bottlenecks and congestion that may not be included in the model study area.

The VISSIM network should include ramp terminal intersections as part of the project and, in order to model them correctly, should include, at minimum, one intersection outside of the study intersections (if within half-mile spacing). If the next intersection is
beyond half a mile, the project team should determine if this intersection should be included in the model. All intersections that have a significant influence on the arrival pattern or the lane choice of vehicles entering the network shall be included in the model. This may include unsignalized intersections, depending on the spacing and the influence the intersection has on operations in the ramp terminal area. Similar to the freeway zone of influence, these additional intersections are not part of the study area. Thus, performance measures do not need to be reported for these intersections. All boundaries shall be reviewed through field observations and discussions with ODOT staff to ensure that they are logical break points in the roadway network.

2.1.2 Arterials

VISSIM networks that include arterial surface streets will have similar requirements to those described above for ramp terminal intersections. The VISSIM model shall include, at minimum, one intersection outside of the study intersections (if within half-mile spacing). If the next intersection is beyond half a mile, the project team should determine if this intersection should be included in the model. However, all intersections influencing the arrival pattern or the lane choice should be included in the model. Typically, this requires extending the network upstream to the next intersection with a major cross street. This may include unsignalized intersections, depending on the spacing and the influence of the intersection on operations at the study intersections. Other considerations include:

- Queue spillback into study intersections from downstream bottlenecks
- Upstream bottlenecks that meter traffic coming into the study area

If any of these conditions exist, the bottleneck causing the problem should be included in the model if possible. Ideally, all network boundaries should be segments with free flow traffic conditions and be far enough upstream to prevent vehicle queues from spilling back off the network. If any of these conditions are not practical, then the modeling strategy to replicate the conditions at the boundary should be submitted to ODOT for approval as part of the Project Methods and Assumptions document described in Section 2.7. All boundaries shall be reviewed through field observations and discussed with ODOT staff to ensure that they are logical break points in the roadway network.

If the project includes a proposal to modify or add a traffic signal on an existing or proposed coordinated signal-corridor, the study area shall consider including the entire coordinated signal-corridor unless otherwise directed by ODOT staff. Analyzing the entire corridor allows ODOT to determine whether the new or modified traffic signal impacts another intersection and/or the bandwidth on the corridor. The optimizing of signal timing and offsets for the corridor should be done using Synchro. See ODOT's Analysis Procedures Manual for guidance on using Synchro and conducting a “progression analysis.”

Once ODOT staff agrees to the signal timing used in Synchro for the project alternatives, the signal timing can be placed into VISSIM. ODOT staff and the modeler will determine
whether all or some of the intersections from Synchro need to be incorporated into the VISSIM model.

As with freeways, the network should extend far enough to prevent vehicle queues from spilling back off the network. Any location where this cannot be prevented shall be reported in the Project Methods and Assumptions document described in Section 2.7.

### 2.2 Project Study Period

The following section outlines the project study periods, which vary for freeways and arterials. However, the guidelines for determining the seeding period are consistent for both types of models and follow the guidelines outlined in the FHWA’s Traffic Analysis Toolbox:

The seeding period should be the longest of the following four criteria:

1. A minimum of 15 minutes
2. The number of vehicles in the network levels off. In highly congested networks, the rate of increase may slow down, but the number of vehicles still continues to increase throughout the simulation. (See Appendix C for additional guidance.)
3. Equal to or greater than twice the estimated free flow travel time from one end of the network to the other
4. Vehicle queue lengths in the model at the end of the seeding period replicate real-world observations at that time of day

Final determination of the study period shall not be finalized until field observations document the duration of congestion and the length of vehicle queues. In addition, the study period should extend through the peak hour until congestion starts to dissipate.

#### 2.2.1 Freeways

For the purposes of modeling freeways, a minimum study period of two hours is recommended. Generally, this is from 7 AM to 9 AM for the AM peak and 4 PM to 6 PM for the PM peak. The length of time needed to seed the network should also be considered when determining the total simulation period. For large models with heavy congestion during the peak periods, a seeding period of one to two hours may be needed to reach the full level of congestion for the study period. Field observations and/or analysis of queue and count data should be used to help determine the appropriate time period that should be modeled.

In less urban areas, it may be acceptable to model a shorter time period. Historical traffic data and field observations should be used to determine the appropriate peak hours of the freeway network for the study area. The proposed study period shall be submitted to ODOT for their approval as part of the Data Collection Plan described in Section 2.6.
2.2.2 **Arterials**

Arterial networks usually require a shorter study period than freeway networks. Traffic control devices in the model cause congestion to build faster, which reduces the need for a long seeding period. A typical intersection vehicle delay and level of service (LOS) analysis in macroscopic deterministic software packages such as Synchro or HCS focus on one hour of data, or more accurately, an hourly traffic flow that is adjusted upwards by peak hour factors to replicate the highest 15-minute period. However, in some cases congestion and vehicle queuing issues extend beyond the peak hour of delay. For example, when a signalized intersection reaches capacity, the un-served demand begins to form a queue. After the demand begins to subside, the queue dissipates. The longest queues may occur just after the peak hour of traffic demand and should be included in the simulation period.

Similar to freeway simulations, the typical study period should include the seeding period plus two hours of simulation for each peak period. However, in some cases it may be necessary to model only one hour of the peak period if the congestion starts to dissipate within that hour.

2.3 **Project Schedule and Staffing Plan**

The following section identifies items to consider when developing the schedule and allocating staff to a project and describes deliverables required for each project.

2.3.1 **Scheduling Considerations**

Developing a project schedule for a VISSIM project can be challenging because the usual engineering work plan techniques do not apply to VISSIM. A large number of qualified staff does not necessarily allow a consultant to commit to an aggressive schedule. To be done correctly, the effort required to build the network (especially in the early stages) needs to follow a very linear critical path. To maintain consistency between scenarios, usually only one modeler at a time should be working on the network. To encourage this linear workflow, ODOT requires multiple check-in points through the coding process prior to beginning the next step in development of the model. This reduces the need to make the same revision in multiple network files in response to agency comments and at the same time maintain consistency. It also allows ODOT to stay involved in the coding process.

2.3.2 **Staffing Plan**

As part of the Project Methods and Assumptions document, the consultant shall be required to submit a detailed staffing plan that includes:

1. Names of everyone contributing significant effort to the project
2. A brief description of their VISSIM experience
3. Their role on the project (e.g., data collection or scenarios they will be leading)
4. The office location where most of their work will be completed

The purpose of this staffing plan is to ensure that ODOT is aware of who is working on the models and to help assure that model scenarios are being developed sequentially from.
the same base files and none in parallel. It is also preferable to have at least one modeler located within the state of Oregon to increase understanding of the study area and facilitate field observations. If staffing changes are desired during the course of a project, ODOT must be notified and authorize the change.

### 2.3.3 Project Milestones

As described above, multiple check-in points and deliverables representing key points in the model development must be completed before the next stage of development can begin. Frequent check-ins will help avoid having to make the same revision in multiple network files in response to comments as well as maintain consistency between scenarios. Frequent check-ins also should require shorter agency review periods by focusing the effort on specific areas of the model. The date of the check-ins and the associated deliverables are to be submitted must be included in the Methods and Assumptions document.

The following items are typical milestones corresponding to the deliverables for each VISSIM project. Each deliverable at the milestones must be reviewed and accepted by ODOT before proceeding to the next step in the process:

1. Project Problem Statement
2. Data Collection Plan and Project Methods and Assumptions Document
3. Data Collection Summary
4. VISSIM Model with Geometry and Control Coding
5. Calibrated Base Model and Calibration and Results Report
6. Additional Base Year VISSIM Models and Updated Calibration and Results Report
7. Future No-Build Forecasted Volumes
8. Future No-Build Model with Corresponding Documentation
10. Future Alternative Models with Corresponding Documentation
11. Final Report with all Alternative Models

### 2.4 Field Visit

As part of the scoping process the consultant shall perform at least one site visit to the study area to determine any project specific considerations as outlined previously. These may include but are not limited to:

- Lane imbalances (e.g., dual turn lanes or drop lanes)
- Downstream or upstream bottlenecks
- Major queuing locations

These project specific considerations will help determine if the model area needs to be extended beyond the initial study area. They can also help determine what data will need
to be collected, what the model should be calibrated to, and where the model should be calibrated.

2.5 **Key Calibration Locations**

Calibration requirements for the study area are described in detail in Chapter 6. These thresholds require that a certain percentage of the entire network meet each of the criteria (volumes, speed, travel time, etc.). The limitation of this methodology is that there is no guarantee that the most important areas of the model are fully calibrated. For example, volumes could meet the calibration criteria on 85% of links, but the most important 15% of the model could potentially be those links that didn’t match. Therefore, as an additional quality check, a list of key calibration locations in the network should be identified that will be required to meet all calibration criteria. These key locations within the network should be identified at the start of the project for more specific attention and reporting based on the field visit(s) and potentially from review of existing archived data. The list of locations shall be submitted for approval by ODOT. The purpose of identifying these locations during the scoping process is to ensure that the required data is collected at these points in the network. Results for the calibration of these links shall be individually reported in the Project Methods and Assumptions document as outlined in Section 6.10.

2.6 **Data Collection Plan**

A detailed description of data types typically needed for a VISSIM project is included in Section 3. Based on the project needs outlined in the previous sections and the field visit, the Data Collection Plan shall be submitted for ODOT review. This detailed description of all proposed data collection for the project must include:

- Types of data collected
- Locations of data collection
- Time increments of data collected

2.7 **Project Methods and Assumptions**

After all the steps in this section have been completed, the Project Methods and Assumptions document shall be developed to provide a summary of the methodology for completing the project and any known assumptions before modeling begins. The VISSIM specific assumptions made during model development will be documented in a later document (Calibration Methodology and Results Report). The following information must be included in the Project Methods and Assumptions memorandum:

1. **Project Description**

   The project description will include, but is not limited to, purpose of the project, Project Problem Statement, background information, location, and funding status.
2. **Operations Analysis Tools**
   This may include additional tool(s) beyond VISSIM for analysis. This section shall document which tools will be used on this project, which version of these tools will be used, and for what purpose each tool will be used.

3. **Study Area and Model Area**
   The study area and the model area may vary in size based on the surrounding network. The reasons for variance between the two must be documented. This will also include the list of key calibration locations.

4. **Analysis Years/Periods to be Modeled**
   This section will summarize which years and analysis periods will be used for the project. A flow chart outlining the development of these models shall be included (see Appendix D for an example of the flow chart).

5. **Data to be Collected**
   This section will be a summary of the Data Collection Plan as outlined in Section 2.6.

6. **Use of Data**
   This section will document what data will be used for model development and what will be used for calibration purposes.

7. **Calibration Targets**
   This section will document what calibration targets will be used for this project.

8. **Selection of Measures of Effectiveness (MOEs)**
   As with data to be collected, there are specific MOEs that must be collected for each model and, depending on the project, data may need to be collected for additional MOEs. This section will document what MOEs will be collected.

9. **Assumptions**
   This section will include any known assumptions that will be made for existing and future year models. Some examples are roadway improvements that will be modeled in future alternatives, signal timing assumptions that will be made for future conditions, methodology and assumptions that will be used for developing future volumes, and existing and/or proposed transit speeds.

10. **Deviations/Justifications**
    Any known deviations from standard protocol needed to complete the project should be listed with the justification for deviating. It is important to note that the VISSIM calibration-specific changes determined during model development will be documented in the Calibration and Results report, which will be submitted with the Calibrated models.
11. Project Schedule and Staffing Plan

This section will summarize the project schedule and staffing plan and will include all the project milestones and deliverables expected to be submitted.

This Project Methods and Assumptions document will be used to define (or refine) the scope of work for building the model. It should be noted that the budget for the project should be finalized once the scope of work has been finalized in this process.
3. DATA COLLECTION

Section 3 of the ODOT Analysis Procedures Manual (APM)\(^2\) provides details on the base data that should be collected for traffic operations analysis. The base data used to build a VISSIM model is similar to that of any other simulation tool, but due to the complexity of VISSIM models and the level of calibration required, additional data may be needed to develop a quality VISSIM model. This section is therefore provided as a supplement to the APM specifically for the development of VISSIM models. The model’s purpose (e.g., range of alternatives and desired MOEs) and study area also play a role in what data is needed and how that data should be collected.

3.1 Geometric Data

Detailed geometric data must be collected for all types of models for the entire study area. Much of this data is available via aerial photographs and construction drawings; this data collection should be considered a starting point and not by itself adequate. The modeler is required to visit the field and verify this data.

Geometric data to be collected must include:

- Number of lanes
- Lengths of roadway segments
- Lengths of storage bays and tapers

Additional geometric data that may need to be collected depending on the project may include:

- Locations and dimensions of freeway ramp tapers
- Details of user specific lanes (e.g., High Occupancy Vehicles [HOV], Truck, Bus, Bikes)
- Sidewalk locations and widths
- Crosswalk locations, widths, and lengths
- Raised median, pedestrian refuges, and islands
- Parking locations and dimensions
- Significant grades that could affect flow rates
- Transit facility locations
- Freight rail crossing locations and number and duration of crossing events
- Acceleration and deceleration lengths for ramps and turn lanes
- Curve and super elevation (e.g., sharp curves that may affect vehicle speed)
- Radii at intersections for right-turning vehicles

---

• Sight distance at conflict points, for example, how far upstream a driver stopped at a stop sign can see on the cross street in order to make a gap acceptance decision

3.2 **Control Data**
Control data must be collected for both arterials and freeways in all locations within the study area. These will all be used as input to the model and are checkpoints that control the flow and movement of vehicles. Data to be collected must include:

• Posted speed or speed limits
• Intersection controls
• Traffic signal characteristics (e.g., protected/permitted phasing, overlaps)
• Signal timing (e.g., cycle length, green time, pedestrian minimum times)
• Movement permissions (e.g., right turn on red, no turn on red, U-turn permitted)
• Stop bar locations

Some models may require that the following control/operational data be collected:

• Detection zones
• Rail crossing control and usage
• Ramp meter timing
• Freeway guide sign locations
• Transit signal priority parameters

3.3 **Traffic Volume Data**
For both arterial and freeway models, traffic volume data collection must follow the guidelines outlined in the APM. Some of the APM’s key requirements are that all traffic data must be no more than three years old, unless otherwise agreed upon with ODOT staff, and that the volume data should be collected during the peak month and day of the week and not weeks that contain holidays. Traffic volumes must also be collected in 15-minute increments for the entire study period. If feasible, traffic volumes should be collected on the same day throughout the entire study area and should coincide with other data collection and field observations (e.g., vehicle speeds and queuing). Once data collection has been completed, the consultant must review the data for errors and balance traffic volumes following the APM guidelines.

When collecting traffic volume data in congested networks, data collection and observation locations must consider how to capture vehicle throughput as well as vehicle demand. In locations such as major bottlenecks where congestion/queuing occurs, upstream data collection may be required to capture actual demand levels (via queuing) in order to properly model the level of congestion and queuing that is observed in the field. Upstream traffic counts should be collected at the less congested entry points into the network/corridor to capture the vehicle arrival/demand profile, as opposed to limiting the volume data to what is delivered through the bottleneck. In these cases, care should be taken to avoid balancing traffic counts collected on either side of a known bottleneck location.
3.3.1 Freeways
Vehicle classification data must be collected at a minimum of one location in the study area, which has been determined through coordination with ODOT during the scoping process. Vehicle classification counts may need to be collected at more locations depending on the purpose and location of the model; ODOT and the consultant will determine the need for this additional data during the scoping process.

In addition to collecting new traffic volume counts, archived traffic data (e.g., Portland State University's PORTAL database) may be a resource for additional data locations as well as information on traffic data variation. Archived traffic volume data may be used to validate traffic counts and, in some cases, as traffic counts data sources for creating a model if ODOT agrees to the validity of the count data for use.

3.3.2 Arterials
Vehicle classification must be collected at a minimum of one major intersection within the study area. Vehicle classification counts may need to be collected at more locations depending on the purpose and location of the model. The need for this additional data will be determined by ODOT through the scoping process.

Pedestrian and bicycle count data should be collected for all arterial networks to be modeled in VISSIM. This data must also be collected in 15-minute increments and for the entire study period.

3.3.3 Time-Varying Volume Profile Estimation
In some cases, multi-hour simulations may be necessary to seed a congested network and to build up (and then dissipate) reasonable levels of congestion. Traffic volume data may not be available for these shoulder hours from either traffic counts or from the regional demand model. Therefore, a process is needed to reasonably estimate time-varying volumes. The simplest method would be to apply a network-wide adjustment factor to all traffic volumes to ramp up the volumes leading into the peak period and then reduce them afterwards. However, in some cases it may not be realistic to assume that all traffic movements in the model change at the same rate, especially on larger networks. Certain areas of the network (or O-D pairs) could potentially change at a much faster rate than others. The methodology used to develop traffic volumes for the shoulder hours shall be approved by ODOT for each application. One possible procedure could include:

- Estimate a peak period O-D matrix for the model area using a travel demand model, TFlowFuzzy, and/or O-D surveys (see sections 3.4 and 4.9.2 for additional detail).
- Develop hourly volume profiles for study area links from sources such as roadway tube-counts or nearby traffic data recorders or from estimates such as ODOT Region 1's Hours of Congestion Methodology.
- Adjust the O-D matrix developed for the peak period to calibrate to the hourly volume profiles developed for the non-peak hours (i.e., utilize TFlowFuzzy).
3.3.4 Adjustments for Design Hour Volumes

For many traffic studies, agency standards require an evaluation of operations that occur under design hour conditions (e.g., 30th-highest hour volume). When using deterministic methodologies (e.g., Highway Capacity Manual Methodology), traffic volume data collected outside of the design hour can be factored per the guidance in ODOT’s APM. However, factoring of traffic volumes for developing VISSIM models should not be done during model development and calibration. Instead, the model should be calibrated for the period during which data was collected. Traffic volume adjustments can then be applied and an estimated design hour scenario can be developed from the calibrated base.

3.4 Origin-Destination Data

Origin-Destination (O-D) information may be important data for correctly coding lane-changing, weaving, and related types of driver behavior in a VISSIM model. However, O-D data can be difficult to collect in the field and, as a result, has historically been expensive to collect. Depending on the type of model being developed and the level of detail/accuracy required for the O-D information, the following sources are most commonly used by ODOT, but other sources may be utilized:

- Travel Demand Models (for general O-D patterns, lowest cost)
- MAC ID/Bluetooth surveys (for sampling O-D patterns between multiple gateways, moderate cost)
- License Plate Surveys (for detailed sampling between two or more gateways, highest cost)

Because of the range of data collection methods with varying accuracy and varying cost, O-D data collection should be carefully considered and coordinated with ODOT staff. Detailed O-D data collection is only recommended for locations where the O-D data could cause a significant impact to the roadway network operations and analysis (e.g., a large freeway corridor with complex weaving sections).

3.5 Travel Time Data

Travel time data is one of the most important types of data that must be collected for all VISSIM models. The two methods most familiar to ODOT are floating car runs and MAC ID/Bluetooth data collection. These or other methods may be used for collecting travel time as new sources become available. The selected method should be outlined during the scoping process and accepted by ODOT.

Floating car runs is currently the most common method for collecting travel time data. Data is collected by either having a GPS unit record location and time or by having a passenger record data with a stop watch. In both, a vehicle is driven along the study corridor multiple times at the average speed of the vehicles on the roadway.
MAC ID/Bluetooth data collection is a relatively new method for collecting travel time data and involves setting up a sensor at both ends of the study corridor. The sensor collects the unique MAC ID information from Bluetooth devices (e.g., cell phones) in vehicles traveling along the corridor. This data can then be matched to individual travel time from two points along the corridor for multiple observations over the peak study period.

There are some factors to consider when deciding between floating car travel or Bluetooth time methods. One is that Bluetooth data collection provides a larger data set than floating car surveys, but lacks information about traffic operations between the start and end points. Bluetooth information cannot be isolated to individual travel lanes if that information is required for a particular model. Bluetooth surveys also may not be effective in rural locations with low traffic volumes that would limit sample sizes.

The type of project and the nature of the traffic in the field will influence the decision to choose one travel time collection method over the other. A field visit to the site must be conducted before determining the appropriate method for collecting the data. ODOT must agree to the chosen method during the scoping process.

If during evaluation of traffic in the field there are significant differences in travel time by lane, travel time data should be collected by lane for multiple runs. The floating car method is likely the most accurate, providing the car(s) stay in one lane per run.

Bluetooth should generally be used for longer corridors where a large number of vehicles travel from one end of the study area to the other. Bluetooth data provides a large data set that can easily be collected over multiple days. In any Bluetooth survey, sensor placement is a key item to isolate the sample area from other nearby roadways. Ultimately the locations of the sensors should be approved by ODOT and documented in the Data Collection Plan.

It is recommended that a minimum of 10 travel time runs be collected in each direction for each hour to be simulated (and each lane where lane imbalances occur) for both freeways and arterials. The 10 travel time runs should be collected during the same time as other data collection if possible but can be collected over multiple days if necessary. Collecting data over multiple days may help provide an understanding of daily fluctuations in traffic. The travel time runs can also be a combination of the floating car and Bluetooth data methods. Similar to volume data, travel time runs should not include data collected within the week of a holiday, when there have been crashes that affect travel in the immediate study area, and/or in inclement weather.
For VISSIM models of complex corridors with long travel times, ODOT may require the statistical calculation outlined in the FHWA’s Traffic Analysis Toolbox to determine the required number of travel time runs in order to reach a certain confidence interval. As provided in the Traffic Analysis Toolbox:

\[
N = \left(2 \times t_{0.025,N-1} \frac{S}{R}\right)^2
\]

Notes:
- \(R\) = 95-Percent confidence interval for the true mean (acceptable margin of error approved by ODOT, e.g. +/- 5 seconds, +/- 10%)
- \(t_{0.025,N-1}\) = Student’s t-statistic for 95-percent confidence – two-sided error of 2.5 percent (totals 5 percent) with N-1 degrees of freedom (for four runs, \(t = 3.2\); for six runs, \(t = 2.6\); for 10 runs, \(t = 2.3\))
  (Note: There is one less degree of freedom than car runs when looking up the appropriate value of \(t\) in the statistical tables)
- \(S\) = standard deviation of the floating car runs
- \(N\) = number of required floating car runs

The chosen methodology, number of runs, and locations of data collection must be approved by ODOT before travel time data collection begins.

### 3.6 Spot Speed Data

Collecting spot speed data on corridors has two purposes. Collecting during the off-peak or free-flow conditions can help set the desired speed for that segment of the network. Spot speed data during peak periods can also provide data for the calibration process. The data should preferably be collected when there is no influence from weather, incidents, and/or other factors that may impede free-flowing traffic in the study area.

#### 3.6.1 Freeways

For freeways, spot speed data should be collected at multiple locations in the project area as determined during the scoping process. Archived traffic data (e.g., Portland State University’s PORTAL database) may be a resource for spot speed data that can provide additional data locations as well as provide historical information on traffic speed variations over a much longer period of time. Archived data can be used to develop speed plots that can provide a graphical representation of traffic speeds at specified locations throughout the day. The plots are useful in both the development of the model and the calibration of the model. Example plots are provided in Appendix E.

#### 3.6.2 Arterials

Spot speed data collection for arterial networks is typically much more limited. It is not required or even recommended on small grids with closely spaced intersections or short travel distances. Spot speed data can only be collected in areas of free-flow conditions, which may not exist in some arterial networks. If the intersections are spaced far enough apart to allow vehicles to reach free-flow, spot speed data should be collected to help set the desired speed in VISSIM. Due to the friction usually associated with arterial
networks, corridor travel times are usually better than spot speed data for calibration purposes. However, a field visit should be conducted to determine if there are any locations where spot speed data should be collected due to unique geometry that results in significant changes in vehicle speed from what is posted.

3.7 Queuing Data
Queue observations should be conducted during the scoping process to determine if queuing data needs to be collected. Generally, detailed queuing data (field measurements of 95th-percentile queuing) is not required for the development of VISSIM models, but queuing should always be used as a visual comparison to verify that the VISSIM model is replicating field conditions. Field inspections of queues should be notated on an aerial or a network sketch to compare with the VISSIM model. The need for quantitative queuing data will be project specific and will be determined from the field visit during the scoping process. If possible, queuing data should be collected at the same time as other data.

3.7.1 Freeways
Field visits during the scoping process can provide an understanding of queues and the possible links between bottlenecks and congestion. Archived traffic data (e.g., Portland State University’s PORTAL database) may also be a resource that can provide corridor level congestion maps that indicate the approximate time and extent of vehicle queuing. The visual inspection of freeway queuing should always be compared with the VISSIM model to validate that the model is replicating field conditions.

3.7.2 Arterials
When quantitative queuing data is required, queue lengths should be collected by recording the maximum queue per 120 second intervals. The raw queuing data can be compiled in the form of the average number of cars in the queue or the percentile length of the queue for comparison with VISSIM outputs.

3.8 Lane Utilization Data
The need for lane utilization data must be determined through field inspection of traffic operations during the scoping process. If lane imbalances could affect calibration of the VISSIM model, lane utilization data must be collected during the study period. Lane utilization data may also need to be collected at the following locations:

- Lane drop locations
- Multiple turn lanes
- Truck climbing lanes
- Weaving sections
- Managed lanes
- Closely spaced intersections

3.9 Transit Data
Transit data is generally specific to arterial models and what should be collected depends on the level of detail needed to address the Project Problem Statement. For all arterial
models, the location of transit stops in the study area and transit headways (via transit schedules) must be compiled.

If an arterial VISSIM model is being built to focus on the evaluation of transit operations, the consultant and ODOT should work together to determine which transit data is reasonable and necessary to collect. This data may include but is not limited to:

- Transit vehicle acceleration and deceleration
- Transit vehicle width and length
- Headway data
- Number of boarding and alighting passengers
- Boarding and alighting time per passenger
- Dwell time at transit stop
- Number of passengers on transit entering the network
- Boarding and alighting location on transit vehicle
- Traffic signal priority
- Transit gate-crossing time:
  - Vehicle clearance time
  - Gate closing time
  - Transit crossing time
  - Gate opening time

3.10 Saturation Flow Data
VISSIM does not allow a hardcoded saturation flow rate at intersections like Synchro does. Deterministic models such as Synchro rely on empirical parameters for saturation flow rate and adjustment factors for various network features such as lane utilization, transit activity, or lane width. Because VISSIM is a microscopic simulation model, it models most network features explicitly and does not rely on adjustment factors. As such, intersection specific saturation flow data collection is generally not used for the development of a VISSIM model, especially on arterial networks (for saturation flow parameters, refer to section 4.10.1.2). It is expected that the VISSIM model will replicate field saturation flow conditions due to the extensive amount of other data that is collected.

If a location in the model area is of significant concern and if driver behavior is believed to be atypical at an intersection, ODOT may require saturation flow data to be collected. Collection of saturation flow data shall following Highway Capacity Manual Methodology.

3.11 Delay Data
Delay data is generally not needed for the development of most VISSIM models; however, there may be some models and locations for which ODOT may require delay data to be collected. If required, delay data should be collected following the methodology outlined in the FHWA’s Traffic Analysis Toolbox.
3.12 Data Collection Summary
Once data is collected, the consultant must review the data for errors. The data shall be compiled in a Data Collection Summary with a graphical representation provided to ODOT. ODOT staff must review and approve the Data Collection Summary before Model Development can begin. The Data Collection Summary document must include, at a minimum, the following to be used as model input data set:

- Lane schematics
- Final balanced traffic volumes (for freeways, it will include volumes on ramps and mainline sections in-between ramps) for all scenarios
- Travel time data
- Speed data
- Sink and source locations
- Any assumptions that will be made with any other data

Traffic volumes for all scenarios should be included in the Data Collection Summary, including seasonally factored volumes if a seasonally factored model is to be developed as part of the project. The development of the traffic volumes for all scenarios should follow all guidelines outlined in the APM. The Data Collection Summary must also clearly present the locations and corresponding data to be used for model calibration. In many instances, the calibrated area is more focused and the calibrated locations and corresponding data will be a subset of the model input data set.
4. MODEL DEVELOPMENT

VISSIM is a highly complex modeling tool that allows for the selection of many variables and inputs. To limit the variability in coding techniques, and to simplify the review process, VISSIM simulation coding guidelines are described in the following sections. These ranges and coding techniques are suggestions and are not standards set either by the software vendor or as national standards; however, many of the guidelines and suggestions are directly from training classes and project modeling experiences.

4.1 Possible Software Updates
The modeler should be aware of any build upgrades. If a newer version (or build) of the software is available, then the modeler should upgrade to that version (or build) to incorporate enhancements and new features. However, whatever version and build the model is originally calibrated in should be the version and build that the future models are built in, unless otherwise directed by ODOT.

4.2 General Network Parameters
The network shall be created in English units (e.g., feet and mph). It is recommended that the modeler use an ortho-rectified aerial photo as a background for developing the model. VISSIM does not import drawings to scale; therefore, it is important that the modeler use care to accurately scale the aerial photo to the network.

4.3 Vehicular Fleet Setup
If a vehicle classification count is not performed as part of the study, then the individual vehicle model percentages within the Car and HGV distribution as well as the percentage of heavy vehicles in the vehicle composition should be based on field observations and engineering judgment. These percentages must be approved by ODOT. The “Car” and “HGV” (or heavy vehicles) vehicle distribution fleet found in the NorthAmericanDefault.inp file is acceptable in the absence of any other vehicle classification data. The “NorthAmericanDefault.inp” file can be found in the “Example” folder in VISSIM installation (C:\Program Files\PTV_Vision\VISSIM530\Examples\Training\NorthAmericaDefault). It includes a range of ten vehicle models under the Car distribution, and six types of trucks under HGV. These car models range from midsize cars to pickups and SUVs, while the HGV models include box trucks, flatbed trailers, and various sizes of tractor-trailers. The vehicle makeup is based on FHWA research. However, if changes are made to the vehicle fleet settings, the following 3D models (shown in Table 4-1) are recommended for each AASHTO vehicle classification:
## Table 4-1: Suggested 3D Models by FHWA Vehicle Class for Heavy Vehicles

<table>
<thead>
<tr>
<th>#</th>
<th>AASHTO Vehicle Class</th>
<th>VISSIM 3D Model Tractor</th>
<th>VISSIM 3D Model Trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Buses</td>
<td>bus.v3d</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2 Axle, 6 Tire, Single Unit Trucks</td>
<td>van.v3d</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3 Axle Single Unit Trucks</td>
<td>truck.v3d</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4 or more Axle Single Unit Trucks</td>
<td>HGV_flatbed_truck.v3d</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Four or Fewer Axle Single-Trailer Trucks</td>
<td>HGV_wb40_tractor.v3d</td>
<td>HGV_wb40_trailer.v3d</td>
</tr>
<tr>
<td>9</td>
<td>Five-Axle Single-Trailer Trucks</td>
<td>HGV_wb50_tractor.v3d</td>
<td>HGV_wb50_trailer.v3d</td>
</tr>
<tr>
<td>10</td>
<td>Six or More Axle Single-Trailer Trucks</td>
<td>HGV_wb65_tractor.v3d</td>
<td>HGV_wb65_trailer.v3d</td>
</tr>
<tr>
<td>11</td>
<td>Five or fewer Axle Multi-Trailer Trucks</td>
<td>HGV_wb67d_tractor.v3d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGV_wb67d_trailer.v3d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGV_wb67d_trailer_conn.v3d</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Six-Axle Multi-Trailer Trucks</td>
<td>HGV_wb50_tractor.v3d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGV_wb67d_trailer.v3d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGV_wb67d_trailer_conn.v3d</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Seven or More Axle Multi-Trailer Trucks</td>
<td>HGV_wb50_tractor.v3d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGV_wb67d_trailer.v3d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGV_wb67d_trailer_conn.v3d</td>
<td></td>
</tr>
</tbody>
</table>

If HOV operations are required by the study, an HOV category should be added to the Vehicle Types and the “Car” model distribution shall be used as the category and vehicle model. A global estimate of HOV vehicles in the traffic stream can be obtained from a regional demand model or from classification counts, but should be coordinated with ODOT and the results documented.

### 4.4 Network Coding

Links should be created to represent road segments that carry the through movements and general curvature of the roadway. Links should proceed through a corridor with similar geometry and not be unnecessarily segmented. A connector is a type of link used to join two areas of a single link or to join two areas of two links. Connectors have additional characteristics that affect driver behavior, specifically lane changing, so it is important when coding to take this into consideration and eliminate the excessive use of connectors.

#### 4.4.1 Freeway Merge, Diverge and Weave Coding

The coding of merging, diverging, and weaving areas in VISSIM such as the entrance ramp depicted in Figure 4-1 is generally controlled by the routing through the area and lane change distance parameters.
The suggested method of coding is to use the connector lane change distance with a vehicle route to achieve the desired merging performance. This is discussed later in driver behavior coding (Section 4.10). In order to properly code merging and weaving sections, these points should be followed:

- The effective merging area should include the entire auxiliary lane (or lane drop) to the farthest extent of the auxiliary lane taper and capture the full effective length utilized by vehicles. Vehicles in VISSIM will utilize the extra link length when necessary, which more accurately models the utilization of the taper area.
- The merge or weaving section should be one link with the number of lanes equal to the number of lanes on the main freeway plus the number of lanes merging onto the freeway.
- There should only be one connector at the end of the merge link or at the end of a lane drop section (refer to connector A in Figure 4-2).

**4.4.2 Arterials**

Turn bays shall be coded as separate parallel links to ensure vehicles enter the turn bay at the beginning of the bay and that no unrealistic lane changing occurs between the through and turning vehicles. Connectors should also start at the beginning of the taper and end at the point the bay reaches its full width (not necessarily where the striping begins).

It should be noted that when using the ANM import from either VISUM, TRAFFIX, or Synchro, turn bays are coded as an additional lane of the through link. The desired lane change behavior is replicated by the import automatically adjusting the turning connector's emergency stop distance equal to the turn bay length minus 10 meters (32.8 feet).
All right turn connectors at signalized intersections should be coded as Right-Turn-on-Red (RTOR) where permitted and be signal controlled where no right turn on reds are permitted.

### 4.4.3 Roundabouts

Roundabouts can be modeled with either conflict areas or priority rules. Both methods provide benefits. Conflict areas provide more realistic and complex driver behavior and decision-making. While priority rules allow for more control over input parameters such as minimum gap times, the minimum headways, and placement of where these interactions should take place. When modeling roundabouts, conflict areas should generally be the first choice. Where conflict areas are not able to replicate real-world interactions, priority rules may provide the flexibility needed to calibrate the model. Guidelines for utilizing conflict areas and priority rules are described below.

**Conflict Areas**

Conflict areas can be defined anywhere two links/connectors overlap in the network, such as at the entry point of a roundabout as shown in Figure 4-3. Depending on the geometry of the roundabout, additional conflict areas may need to be defined. Priority is designated by the user. In the case of roundabouts, priority will be given to the circulating traffic. Entering traffic looks downstream as it approaches the conflict area. If a circulating vehicle is approaching the conflict area or is in the conflict area, the entering vehicle will slow down or stop to give way to the circulating vehicle. The entering vehicle then proceeds through the conflict area after satisfying the gap conditions (front gap, rear gap, and/or safety distance).
If the conflict area is a crossing conflict, front gap and rear gap parameters must be defined. The front gap determines how soon after a vehicle clears the area an entering vehicle will proceed. The default value for this parameter is 0.5 seconds; however, values as low as zero may be acceptable as this reflects the tendency to enter a roundabout very close to the circulating vehicle.

The rear gap is the amount of time a vehicle will leave behind itself before another approaching vehicle will enter the conflict area. These values are coupled with the vehicle’s acceleration rate to determine the total gap time a vehicle needs to traverse the entire conflict area safely. The default value for this parameter is 0.5 seconds but values may be increased or decreased to values generally between 0.0 and 1.0, depending on the specific roundabout design attributes and engineering judgment.

If the conflict area is a merging conflict, the safety distance factor must be defined. This factor multiplies the individual vehicle’s safe following distance by a factor during this merge to allow enough time to safely enter the traffic stream with minimal impact to other vehicles. The default value for this parameter is 1.50. In roundabouts, as vehicles often follow more closely and merge more aggressively, this value may need to be decreased slightly (generally as low as 1.0).

The benefit of the conflict area is that each vehicle determines the total gap time it requires to proceed through the conflict area, based on its own specific vehicle attributes such as acceleration and deceleration capabilities. In addition, with conflict areas, the vehicle that has the right of way is also able to see and respond to vehicles that may have entered the conflict area erroneously and adjust speeds to avoid collisions.
In addition to the front and rear gap definitions, visibility distance can be defined for each link approaching the conflict area. This distance is set to a default of 100 meters (328 feet) but should be adjusted to reflect the actual visibility along each link based on the design of the roundabout.

**Priority Rules**

Priority rules do not offer the interactive driver behavior decision-making that conflict areas provide. This means that priority is given to one movement over another and only the non-priority movement sees the priority rule and is required to stop. Therefore, in the case of roundabouts, if a vehicle enters the circulating roadway and is not able to clear the point of conflict, a circulating vehicle will not slow down or stop to avoid collision. Priority rules do, however, allow for added flexibility by defining the exact location and gap times required for vehicles to cross over the point of conflict. Typically, the gap times are based on the distance a vehicle must travel to pass through the entire point of conflict. For roundabouts, this means that vehicles entering the interior lane of a dual-lane roundabout require a slightly larger gap than a vehicle entering in the outer lane of the roundabout.

Gap times of between 2.5 seconds and 3 seconds yield very similar capacity in a dual lane roundabout and values within this range can provide results very similar to real-world data. Therefore the modeler should consider using these values as a starting point when establishing priority rules for roundabouts. Higher or lower gap times may be considered if calibration to field data justifies these values.

While the gap time can be easily defined, the placement of priority rules is more difficult. The decision point (red bar) of the priority rule should normally be located at the yield line location for all vehicles, but in order to represent the appropriate behavior of vehicles entering with acceptable gaps and headways, the conflict markers (green bar) might not be placed exactly at the first point of conflict. In addition, separate priority rules for cars and heavy vehicles should be coded independently.

Roundabout analysis is also affected by operational speeds. The NCHRP Report 672 or field collected speed data at roundabouts of similar characteristics should be used to determine the appropriate speeds for entering and exiting vehicles. Collecting speed data at similar roundabouts in the field will provide more detail of the locations where reduced speed areas and desired speeds should be placed. In addition, the actual proposed design of the roundabout should be taken into consideration, including the size of the circulating roadway and various turn radii. The method to determine operational speeds and any additional assumptions that will be used in developing a roundabout for a VISSIM project should be outlined in the Project Methods and Assumptions Report.
4.5 **High Occupancy Vehicles, High Occupancy Toll, and Truck Only Lanes**
When coding High Occupancy Vehicles (HOV), High Occupancy Toll (HOT), and truck only lanes, it is necessary to have the appropriate geometric segments and their corresponding lane closures in order to capture realistic driver behavior. This is an instance where having additional links and connectors are necessary to properly code the changes in lane utilization.

4.6 **Known Roadway Improvements / Changes**
When setting up the initial geometric coding, it is important to identify areas where planned or proposed improvements are likely to change the existing geometry. If coded or segmented appropriately, splitting links and adding connectors will not have to be reset in the output file configuration.

4.7 **Control Coding**
VISSIM control measures such as signals, stop signs, and yield conditions (conflict areas and/or priority rules) should be modeled as closely to real-world conditions as possible. Traffic signal timing from the field should be used to code signals in VISSIM. Conflict areas and/or priority rules should also be used at all intersections to correctly replicate vehicle interactions. Adjustments to gap times and other conflict area and priority rule parameters may be required to correctly model vehicle interactions but these changes do not need to be documented because they are expected to vary by size and type of intersection.

4.7.1 **Ramp Meters**
For VISSIM models that evaluate ramp meter operations, the timing should be coded to match real-world conditions as closely as possible. Ramp meters can be coded through a Vehicle-Actuated Signal Controller Program (VAP), which is written to replicate the speed/density logic used in ODOT ramp metering signals. If a VAP program is used, it is critical to accurately reflect the location and settings within the ramp meters themselves, as well as for the corresponding flow entering on the ramps. Proposed ramp metering logic shall be submitted to ODOT for approval at the start of the project.

If field data indicates the ramp meter operates at a fixed rate during the study period, or if the project is not focused on ramp meter operations, a fixed-time signal controller can be used in VISSIM instead of a VAP controlled ramp meter. It should be noted that the rates can change during the simulation period as long as the switch time is fixed and the rates do not fluctuate in between. An example of VAP ramp metering coding is provided in Appendix F. Coordination with ODOT should be conducted to determine any alternative ramp signal timing that will be used in alternative models.
4.7.2 Signal Controller Settings
The Ring Barrier Controller (RBC) is the preferred method for coding traffic signals. It includes all the parameters of a real-world signal controller and accurately models actuated-coordinated signal operations. It also includes advanced features such as detector settings and signal priority/preemption. RBC controllers can be directly created when importing Synchro files with optimized signal timings or can be directly coded into VISSIM. Figure 4-4 shows an example of the RBC interface. Submissions of all existing conditions models must include source documentation for all signal timing, typically in the form of controller timesheets. It is important to note that the frequency of the RBC file match the VISSIM time steps per second. The checklist ODOT will utilize for the review of this timing is included in Appendix G and may be helpful in the coding process.

The preferred method for coding future traffic signal timing is to optimize signal timing using Synchro or another accepted signal timing optimization package and import or manually code the signal timing into the RBC. It is not required that future signal timing be developed in Synchro; however, whichever method is used should be outlined in the scoping process and verified by ODOT.

Vehicle interactions with yellow lights vary among states, and even among cities. As outlined in the APM, adjustments to driver reactions at signals may be required to better reflect the less aggressive nature often found in drivers in Oregon; however, VISSIM
does not offer parameter changes specific to driver’s reactions at signals. If the model does not accurately reflect interactions at traffic signals, one possible adjustment is to consider moving one second of yellow time to red time.

4.7.3 Adaptive Signal Timing

When modeling adaptive signal control systems (ATCS), the modeler shall use the source code for the adaptive signal control software that has been chosen for field implementation. A few of the ATCS vendors have already developed emulators to run in the VISSIM environment. However, if the project requires a specific emulator that does not exist, it could be developed as a virtual controller to run inside VISSIM (software-in-the-loop) or through a direct hardware-in-the-loop connection to signal controllers and adaptive control modules. This means, in order to model correctly, a significant amount of additional software and possibly hardware would be needed. Due to this level of effort, modeling adaptive signal control is not recommended unless specifically required by the project requirements.

4.7.4 Unsignalized Intersections

For intersections operating with stop control, the stop signs should be coded at the same locations as the stop bars in the field in addition to the conflict areas/priority rules at the actual vehicle/vehicle conflict zone. For intersections with yielding control (e.g., roundabouts or right turns entering a roadway), vehicle interactions should be controlled with just conflict areas and/or priority rules. As with roundabouts, coding of unsignalized intersections should start with conflict areas and if it is necessary to better replicate real-world conditions, priority rules can be used instead. Conflict areas/priority rules should be coded at the actual vehicle conflict zone.

4.8 Speed Control Coding

To control the speed of vehicles in VISSIM, the modeler can apply a “speed decision” or “reduced speed” on a network link. Desired speed decisions change the desired speed of vehicles that cross it, and should be used when the free-flow speeds of an area have a significant change due to the posted speed limit, geometric changes, topography, or facility changes. Reduced speed areas are temporary zones with a reduced speed and should be used to code small sections where vehicles have a significant change in speed due to reduced speed locations in the field (e.g., ramps, turning movements). Desired speed decisions and/or reduced speed areas should never be used to mimic congestion in the calibration area. The only locations where speed decisions and/or reduced speed areas may be used to replicate congestion from bottlenecks is at the very ends of models, completely out of the study and calibration area and they can only be used to mimic congestion from upstream bottlenecks not included in the model and that are not anticipated to be fixed by the year of the future models.
4.8.1 Freeways
For freeway models, spot speed data or archived speed data should be used to code the desired speed decisions. This data should then be converted into a “speed profile” format that can be input into VISSIM. An example of a speed distribution profile is shown in Figure 4-5. If the model is being developed in the Portland area, speed flow maps developed from PORTAL may also be used to develop speed distribution profiles. As with spot speed data, the speed distribution profile must be developed based on the off-peak (free-flow) speeds. Whatever method is used to develop the speed distribution profiles must be documented and verified with ODOT as part of the Methods and Assumptions Document.

Figure 4-5: Example of Speed Distribution Profile
4.8.2 Arterials

Most arterial networks have very few roadway segments that achieve true free flow conditions. Friction from traffic control devices and other vehicles have much more of an impact to the actual speed of traffic. For this reason, detailed speed profiles on arterial networks are usually unnecessary. In most cases, a speed profile that is linearly plus and minus five miles of the posted speed is sufficient. Figure 4-6 provides an example of the speed profile that would be developed for a 35 mph roadway.

Figure 4-6: 35 mph Speed Distribution Profile for Arterials

For turn movements at intersections, reduced speed areas should be used for both left and right turn movements. Suggested values for the reduced speed distributions are 15 mph for left turns and between 9 and 15 mph for right turns. The length of the reduced speed area and the appropriate turning speed is to be determined by the modeler and may vary by intersection. Anything outside of these parameters must be field verified and documented as part of the Calibration Methodology and Results Report.

4.9 Vehicle Inputs

Vehicle inputs should be coded in 15-minute demand increments; however, in some cases hour increments may be acceptable if volumes are consistent throughout the hour. If necessary, each input location should have specific vehicular fleet characteristics (e.g., truck percentages). For
freeway networks, a global estimate of HGV vehicles in the traffic stream can be estimated from a regional demand model or, if necessary, for the specific project from classification counts. Because results will be based on the average of multiple simulation runs, the default input setting of “exact” is recommended.

4.10 Vehicle Routing
Vehicle routes should also be coded in 15-minute demand increments. However, in some cases hour increments may be acceptable if volumes are consistent throughout the hour. There are three different methods for coding vehicle routing. The most common method is static routes, which is used for most arterial networks. Static routes can pass through one intersection, several intersections, or from one end of the network to the other. Dynamic routes are used to reroute vehicles if a certain condition occurs, such as a parking lot destination becomes full or a gated crossing is blocked. In this case, vehicles can be reassigned using a VAP script. The third alternative is an origin-destination (O-D) matrix based approach.

4.10.1 Static Routes
Traffic volumes in arterial networks can usually be coded as traditional intersection-to-intersection turning movement routing decisions. All vehicles exiting one intersection are then assigned as left turns, through movements, or right turns at the next downstream intersection. Routing decisions should be placed as far upstream on a link as possible to allow for maximum weaving and/or merging distance. Figure 4-7 illustrates the recommended placement of routing decisions.

Figure 4-7: Recommended Routing Decision Placement

In some cases, this simplistic approach cannot replicate real-world conditions. If intersections are spaced too closely, there will not be enough time for vehicles to change lanes to make their assigned turn. At closely spaced intersections, it might be necessary to
route vehicles through multiple intersections to eliminate unrealistic turning movements. For example, with routing decisions coded as shown in Figure 4-7, a westbound vehicle in the right lane leaving the upstream intersection attempting to get to the left turn may not have enough time to change lanes to reach the connector for the left-turn bay. The Combine Routes feature of VISSIM should be utilized to create more realistic turning movements (Figure 4-8). The combine routes features is not recommended to be used for more than five intersections and should start from the furthest intersection downstream to the last intersection upstream.

**Figure 4-8: Example of the Combine Routes Feature**

4.10.2 Dynamic Routing
Dynamic routing (not to be confused with Dynamic Traffic Assignment) requires the coding of static routes using the VISSIM user interface; however, the proportion of those routes can be changed during the simulation based on events within the simulation. Though dynamic routing should not be used for most VISSIM projects, a possible acceptable application is an at-grade gate crossing with a parallel grade-separated crossing. Vehicles are routed through the gate while it is up, but are rerouted via the grade-separated crossing while the gate is down. The dynamic route allocation change is done using a dummy VAP signal with the VAP code reflecting the desired decision logic. Use of dynamic routing for a project should be decided upon during the scoping process.

4.10.3 Origin-Destination (O-D) Based Vehicle Routing
The static routing option is less effective when the number of lanes increases along the roadway. Using the Combine Routes feature with static routes for too many consecutive intersections can lead to unexpected results. This is true for both multi-lane arterial networks with many closely spaced intersections and freeway networks with closely spaced interchanges. In both situations, intersection-to-intersection (or ramp-to-ramp) routing is not detailed enough to provide adequate vehicle driving behavior. Vehicles do not have enough warning to make proper lane changes, which can lead to inaccurate weaving behavior and lane utilization in the simulation model.

A vehicle should be assigned one complete route upon entering the network that continues until the vehicle leaves the network. However, if the network includes both arterial and freeway links, it is acceptable to have separate O-D matrices for each
roadway type. For example, one matrix routes arterial traffic to and from each freeway ramp, while the freeway matrix routes vehicles from entrance ramp to exit ramp.

If the freeway network is small enough, it may be possible to create manual static routes that extend from each entrance ramp to all downstream exit ramps. However, in most cases a more automated process to develop O-D routing is recommended. There are two options for automated O-D routing in VISSIM. Option 1 uses VISUM to macroscopically assign the O-D matrix to the network (including mesoscopic methods such as DynusT) and then uses the ANM data transfer from VISUM to VISSIM to export all generated O-D paths (including DynusT resulting paths) as fixed routes to VISSIM. With this option, even very large numbers of static routes (over 10,000) can be managed and coded efficiently. Option 2 uses VISSIM’s Dynamic Traffic Assignment to generate the O-D routes.

4.10.4 Dynamic Traffic Assignment (DTA)

Because the macroscopic or mesoscopic assignment process described in Option 1 above takes place in VISUM (or DynusT), it is not able to fully take into account the finer details of the network such as actuated signal timing, queue interaction, and gap acceptance. Vehicles are assigned to match count data at selected locations and as a result have the potential to assign more demand to an intersection or movement than can be accommodated in the full microscopic simulation. If the path assignment from VISUM or DynusT is not producing realistic conditions, Dynamic Traffic Assignment (DTA) should be considered. DTA is an iterative assignment process within VISSIM that attempts to match both volumes and travel times. However, application of the DTA feature should be used with caution and ODOT must verify its use during the scoping process.

4.10.5 TFlowFuzzy Guidelines

If the VISSIM network was created by importing a subarea from VISUM, typically an O-D matrix already exists. Traffic count data collected for the study area can be used to fine-tune the O-D matrix to more closely match real-world conditions. If the VISSIM network was not created through a direct import from VISUM, the O-D matrix can be developed based on count data using an automated Origin-Destination Matrix Estimation (ODME) process such as TFlowFuzzy.

TFlowFuzzy is a matrix estimation method in VISUM used to adjust a given O-D seed matrix so that the result of the assignment more closely matches desired volumes at points within the network. Some TFlowFuzzy characteristics are:

- Link volumes, O-D travel demand, and turning volumes can be combined into one consistent data set.
- Count data is not needed for all links, zones, and/or turning movements.
- The statistical uncertainty of the count figures can be modeled explicitly by interpreting the figures as Fuzzy sets of input data.

One of the primary challenges with solving the matrix-correction problem is to overcome the fact that traffic counts are inherently variable from one day to the next. If this
variability is not taken into account, the traffic counts obtain an inappropriate weight since any count only provides a snapshot of the situation that is subject to a considerable sampling error. For this reason, TFlowFuzzy employs an approach that models the counts as imprecise values based on Fuzzy Sets theory. For example, if the volume on a freeway section fluctuates by up to ten percent on a day-to-day basis, this variability can be represented as tolerances. TFlowFuzzy then replaces the exact count values by Fuzzy Sets with varying tolerances to solve the matrix-correction problem.

For study areas with extremely high levels of congestion (i.e., queues and latent demand spilling past one hour), using TFlowFuzzy to account for locations of observed demand vs. observed bottleneck throughput may be helpful to develop a model with realistic volume sets that calibrate more accurately with field conditions.

All TFlowFuzzy output should be evaluated for multiple zone flow bundles to ensure that traffic is not being routed on unexpected paths, particularly where large amounts of traffic are being added to minor streets. Flow bundles should be provided to ODOT for approval before traffic volumes are input into a VISSIM model.

4.11 Driving Behavior Models in VISSIM

Driving behavior in VISSIM consists of two behavior models:

- Car following model
- Lane change model

Parameters within these models can be adjusted during either the initial coding process (if supported by the information gathered through field visits or the data collection process) or the calibration process described in Section 6. However, changes to these parameters should be made by experienced modelers with caution. The following sections provide guidance on which parameters are most commonly changed and typical ranges for those values. Note that parameter ranges provided in this section have been found to reflect typical traffic conditions but there may be traffic conditions that require adjustment of parameters outside of the ranges provided. Therefore, parameters can be adjusted to have value outside of suggested ranges when necessary; however, any adjustments outside suggested ranges, along with justification for the change, must be approved by ODOT.
4.11.1 Car Following Parameters

The traffic flow model in VISSIM is a discrete, stochastic model that contains a psycho-physical car following model for all interactions along the same lane. Car following model in VISSIM consists of two models applicable to different conditions:

- Wiedemann 99 Model (Freeway Traffic)
- Wiedemann 74 Model (Arterial / Urban Traffic)

Freeways (Wiedemann 99 Model)

For freeway links and connectors, the Wiedemann 99 model should be selected for car following model (dialog box shown in Figure 4-9). The default car following parameter set is a good starting point but it may need to be adjusted to better match real-world conditions, especially when trying to match flow rates and achieve particular capacities. Any changes to these parameters should be documented with its reason and application and shall be reported to ODOT staff.

![Figure 4-9: Wiedemann 99 Car Following Model Dialog](image)

Changes to the parameters may require adding a link type that will apply only to a specific portion of the model (e.g., a merge or weave area) and/or specific vehicle classes. Suggested ranges for calibration parameters for most typical freeway models are displayed in Table 4-2 (U.S. Customary).
### Table 4-2: Wiedemann 99 Car Following Parameters (U.S. Customary Unit)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Unit</th>
<th>Suggested Range</th>
<th>Merging / Weaving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Segment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC0 Standstill Distance</td>
<td>4.92</td>
<td>ft</td>
<td>4.5 - 5.5</td>
<td>&gt; 4.92</td>
</tr>
<tr>
<td>CC1 Headway Time</td>
<td>0.9</td>
<td>s</td>
<td>0.85 - 1.05</td>
<td>0.90 1.50</td>
</tr>
<tr>
<td>CC3 Threshold for Entering 'Following'</td>
<td>-8</td>
<td></td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC4 Negative 'Following' Threshold</td>
<td>-0.35</td>
<td></td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC5 Positive 'Following' Threshold</td>
<td>0.35</td>
<td></td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC6 Speed Dependency of Oscillation</td>
<td>11.44</td>
<td></td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC7 Oscillation Acceleration</td>
<td>0.82</td>
<td>ft/s²</td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC8 Standstill Acceleration</td>
<td>11.48</td>
<td>ft/s²</td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC9 Acceleration at 50 mph</td>
<td>4.92</td>
<td>ft/s²</td>
<td>use default</td>
<td></td>
</tr>
</tbody>
</table>

CC0 (Standstill Distance), CC1 (Headway Time), and CC2 (Following Variation) have the greatest influence on car following behavior in VISSIM. They are the most intuitive in terms of their impact on following behavior because those are key parameters used to determine desired safety distance. Details on CC0, CC1, and CC2 parameters are shown in Figures 4-10 through 4-12.

**CC0 (Standstill Distance):** Desired rear-bumper to front-bumper distance between stopped cars. This parameter has greater impact to desired safety distance (maximum flow rate) when traffic is in jam condition (speed equals zero).

![Figure 4-10: Standstill Distance Parameter (CC0)](image)

**CC1 (Headway Time):** The distance (in seconds) that the following driver wishes to keep. The desired safety distance (shown in Figure 4-14) is determined every time step based on the following equation:

\[
\text{Desired Safety Distance} = CC0 + (CC1 \times \text{speed})
\]
CC2 (Following Variation): The longitudinal oscillation during following condition. In other words, it defines how much more distance than the desired safety distance before the driver intentionally moves closer to the lead vehicle.

While a driver is following the vehicle, the following distance that the driver tries to maintain can vary from “Desired safety distance” to “Desired safety distance + Following variation.”
Even though car following model parameters described above have the greatest influence on capacity (especially when the traffic volume level is high), it is also important to check other aspects such as desired speed, heavy vehicle percentage, etc. Due to the microscopic nature of VISSIM, it is not possible to explicitly code an ideal saturation flow rate or to simply use the CC1 headway parameter to calculate it. This is demonstrated in Figure 4-13, which illustrates that the simulated maximum flow rate changes significantly as the CC1 parameter changes. It should be noted that maximum flow rate was measured from a basic freeway segment of an example network and the highest maximum flow rate was achieved at the default setting (CC1: 0.9). Note that different networks with different traffic conditions (e.g., heavy vehicle percentage and lane change frequency) may show different relationships between CC1 and the maximum flow rate.

**Figure 4-13: Maximum Flow Rate vs. CC1**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of Lanes</th>
<th>Desired Speed (km/h)</th>
<th>Right-side Rule</th>
<th>Heavy Vehicle Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>80</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>80</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>120</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>120</td>
<td>Yes</td>
<td>0</td>
</tr>
</tbody>
</table>
Research has also been conducted on the relationship between the CC1 and CC2 parameters and maximum flow rate for a basic freeway segment. The findings of this research, presented in a contour plot as shown in Figure 4-14, can be referenced to determine appropriate CC1 and CC2 parameter ranges to achieve the desired sustained maximum flow rate in free flow condition. Note that maximum flow rate at any given CC1 and CC2 combination may vary when other aspects (e.g., heavy vehicle percentage, desired speed, and heavy weave/merge behavior) change.

![Figure 4-14: Maximum Flow Rate vs. CC1 and CC2](https://trid.trb.org/view.aspx?id=881912)

Changing the CC3 through CC9 parameters is not recommended unless it is absolutely necessary for a specific calibration scenario. The reasons for any changes to these parameters should be clearly documented and approved by ODOT staff.

**Arterials (Wiedemann 74 Model)**

For most arterial links and connectors, the Wiedemann 74 car following model should be applied. As shown in Figure 4-15, there are three parameters available for this model: average standstill distance, additive part of safety distance, and the multiplicative part of safety distance.
As with the freeway model, the default parameters are a good starting point. The first parameter, “Average Standstill Distance,” corresponds to the CC0 parameter in the freeway Wiedemann 99 behavior model. The other two Wiedemann 74 parameters work together to determine the target desired safety distance (which has a direct relationship with saturation flow rate). Figure 4-16 illustrates the impact of changing the parameters. As shown, a greater parameter value will result in a greater desired safety distance, thus reducing the saturation flow rate.
4.11.2 Lane Changing Parameters

The available lane changing parameters are the same for both freeway and arterial links and are applied on the same link type basis as the car following model. As shown in Figure 4-17, the default parameters are a good starting point. However, the parameters may need to be changed in the calibration process to match real-world driving behavior, specifically when modeling merging, diverging, and weaving areas. Any changes from the parameters should be documented with the reason and application and reported to ODOT staff.

Figure 4-17: Lane Change Driver Behavior Dialog

The parameter for general behavior should be set to “Free Lane Selection” except when heavy vehicles are restricted to travel only on right-side lanes, in which case the right-side rule is appropriate.

The parameter for waiting time before diffusion should be set to 60 seconds for both freeway and arterial links. Vehicles that are removed will appear in the error file (.err). Because there may be a coding error, these vehicles should be investigated as to why they are not moving for one minute. If necessary, this value may be changed from the default. This change should be documented and reported to ODOT.

Ranges for suggested lane change parameter changes are displayed in Table 4-3. Any values outside these ranges could provide erratic lane changing behavior and create collisions. Values used outside the ranges listed need to be approved by ODOT.
Table 4-3: Suggested Lane Change Parameters

<table>
<thead>
<tr>
<th>DEFAULTS</th>
<th>SUGGESTED RANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Behavior</strong></td>
<td><strong>Free Lane Selection</strong></td>
</tr>
<tr>
<td>Necessary Lane Change (route)</td>
<td>Own</td>
</tr>
<tr>
<td>Maximum deceleration:</td>
<td>-13.12</td>
</tr>
<tr>
<td>-1 ft/s² per distance:</td>
<td>200</td>
</tr>
<tr>
<td>Accepted deceleration:</td>
<td>-3.28</td>
</tr>
<tr>
<td>Waiting time before diffusion:</td>
<td>60</td>
</tr>
<tr>
<td>Min. headway (front/rear):</td>
<td>1.64</td>
</tr>
<tr>
<td>To slower lane if collision time above:</td>
<td>0</td>
</tr>
<tr>
<td>Safety distance reduction factor:</td>
<td>0.6</td>
</tr>
<tr>
<td>Maximum deceleration for cooperative braking:</td>
<td>-9.84</td>
</tr>
<tr>
<td>Overtake reduced speed areas:</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>General Behavior</strong></th>
<th><strong>Free Lane Selection</strong></th>
<th><strong>Trailing Vehicle</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Necessary Lane Change (route)</td>
<td>Own</td>
<td>Unit</td>
</tr>
<tr>
<td>Maximum deceleration:</td>
<td>-15 to -12</td>
<td>ft/s²</td>
</tr>
<tr>
<td>-1 ft/s² per distance:</td>
<td>150 to 250</td>
<td>ft</td>
</tr>
<tr>
<td>Accepted deceleration:</td>
<td>-2.5 to -4</td>
<td>ft/s²</td>
</tr>
<tr>
<td>Waiting time before diffusion:</td>
<td>60</td>
<td>s</td>
</tr>
<tr>
<td>Min. headway (front/rear):</td>
<td>1.5 to 2</td>
<td>ft</td>
</tr>
<tr>
<td>To slower lane if collision time above:</td>
<td>0 to 0.5</td>
<td>s</td>
</tr>
<tr>
<td>Safety distance reduction factor:</td>
<td>0.25 to 1.00</td>
<td></td>
</tr>
<tr>
<td>Maximum deceleration for cooperative braking:</td>
<td>-8 to -15</td>
<td>ft/s²</td>
</tr>
<tr>
<td>Overtake reduced speed areas:</td>
<td>☐</td>
<td></td>
</tr>
</tbody>
</table>

* Leave box un-checked

4.11.3 Geometric Driver Reaction Coding

Geometric driver reaction coding is controlled by the “lane change distance,” which is defined as route lane change distance on connectors. The lane change distance controls when vehicles begin to react to the downstream connector, a critical setting for exit ramps on freeways and for downstream connectors at merge areas. A good starting point for this parameter is to set back the distance so that it concurs with the guide sign locations in the field (when possible) or based on field observations. This may need to be edited to match real-world driver reaction points, because commuters often react well before the sign locations. The lane change distance can also be defined “per lane” to better represent freeway exit induced lane changes for multi-lane (3+) facilities. It is important to note that the lane change distance works in conjunction with the vehicle routing. In order for the lane change distance to be effective, the routing decision needs to be set at a distance upstream of the connector that is greater than the lane change distance of the connector.
4.11.4 Time Step Requirement
In ODOT VISSIM simulation models, the modeler shall use ten time steps per second. The dialog box is under “simulation / simulation parameters” and the simulation resolution shall be set to 10.

4.12 Non-Auto Modes Coding
Non-auto modes may include but are not limited to:

- Heavy Rail
- Light Rail Transit
- Streetcar
- Pedestrians
- Bicycles

Unless any of these modes are the primary focus of the project, default parameters may be used. If more accuracy is needed to code these modes, then more detailed data should be collected. For transit studies, it is recommended to use the transit data that is collected (see Section 3.9). Speed profiles should be developed for pedestrians and bicycles. These profiles should be developed using data from past pedestrian and bicycle studies in similar areas.
5. ERROR CORRECTION

After the initial coding is complete, the model should be checked for errors. This is a four-step process to identify known software errors, double-check the inputs, run the model (i.e., watch the animation for problems or check the output files), and review the VISSIM error file that is generated. This last step is strictly a verification that the model inputs were coded correctly and should not be confused with calibration, which means matching the model behavior with real-world conditions. For quality assurance and to check the modeler, a person independent from the model development, should review the model.

5.1 Verify all VISSIM Inputs

Upon completion of the network coding process, all network inputs should be double-checked, preferably by a modeler not responsible for the majority of the network coding. Any changes or assumptions not in line with what was previously documented in the Project Methods and Assumptions Report or the Data Collection Summary must be documented in the Calibration and Results Report. The following checklist should be followed to verify the accuracy of the coded input data:

1. Geometry, speed and control checks
   a. Check basic network connectivity (any missing connectors?)
   b. Check link geometry (lengths, number of lanes, link types, etc.)
   c. Check free-flow speed coding (location of desired speed decisions and reduced speed areas, check for link/connector coding to ensure speed decision points are properly placed and that they influence vehicle speed as intended)
   d. Check desired speed distributions
   e. Check coding and placement of intersection controls to ensure vehicles are reacting as intended
   f. Check for prohibited turns, right turn on red restrictions, lane closures, and lane use restrictions
   g. Check conflict area settings

2. Vehicular demand checks
   a. Check vehicle compositions at each entry link/node/zone
   b. Verify VISSIM freeway link demand volumes against traffic counts flow maps
   c. Verify VISSIM arterial routing decisions including connector look back distances match turning movement input data
   d. Check vehicle occupancy distribution (if modeling HOVs)
   e. Check O-D zone/parking lot coding and placement in the network
   f. Check contents of O-D trip matrices

3. Vehicle type and behavior
a. Check traffic compositions
b. Check vehicle model distributions
c. Check vehicle types and vehicle classes
d. Check link types for appropriate behavior model

ODOT will also use this checklist when reviewing the first submittal of the network.

5.2 **Animation Checking**

Many errors become more obvious when the simulation is running. The animation should be observed in close detail for the full seeding and simulation time at key congestion points to determine if the animated vehicle behavior is realistic. If the observed vehicle behavior appears to be unrealistic, then the following issues should be explored as potential causes of the unrealistic animation:

### Error in Expectations

First, correct vehicle behavior should be verified for the location and time period being simulated before deciding that the animation is showing unrealistic vehicle behavior. Often, expectations of realistic vehicle behavior are not matched by actual behavior in the field. Field inspection may reveal causes of vehicle behavior that are not apparent when coding the network from plans and aerial photographs. These causes need to be coded into the model if the model is expected to produce realistic behavior.

### Data Coding Errors

The modeler should check for data coding errors that may be causing the simulation model to represent travel behavior incorrectly. Minor data coding errors are the most frequent cause of unrealistic vehicle behavior.

### Route Assignment Errors

A review of the animation may show a higher number of vehicles taking a roadway than what would be expected in the field. This may be a result of importing a VISUM network into VISSIM and the route assignment that VISUM assigned to the network.

Reviewing the model animation of vehicle behavior allows for assessment of the reasonableness of the microsimulation model itself and can be useful for identifying input coding errors. Excessive congestion (or lack of congestion) that may not reflect real-world conditions and erratic vehicle behavior (such as sudden braking or stops) are indicators of potential coding errors.

A comparison of model animation to field design and operations cannot be overemphasized. Some of the most common issues found in the field that may need special attention when modeling in VISSIM are:
Overlooked data values that need refinement
Irregular vehicle operations (e.g., drivers using shoulders as turning or travel lanes, etc.)
Previously unidentified points of ingress or egress
Complex driver behavior, such as the interactions in a two-way left turn lane (TWLT)
Average travel speeds that exceed posted or legal speeds (the average speed measured in the field should be used in the calibration process)
Turn bays that cannot be fully utilized because they are blocked by through traffic
Localized problems that can result in a system-wide impact
Stopped vehicles in flowing traffic
Frequent lane changes or lane changes in unrealistic locations
Vehicles turning at inappropriate times or locations
Vehicles taking long or risky gaps
Signal timing and coordination errors
Large number of vehicles routed on minor streets

5.3 Correction of VISSIM Error Files
At the end of the simulation, VISSIM provides an error file (.err) in text format that details the exact location of the error. The errors are listed either by the line number in the input file or with the link number and time step in the simulation. The modeler should review each entry in the .err file and ensure that the error condition is not impacting the model results. Three error message types indicate potentially significant issues in the model:

- An entry link that did not generate all vehicles (congestion spillback off the network)
- A vehicle left its route because the distance between the routing decision and the first connector on its path was too short
- A vehicle was removed from the network because it had reached the maximum lane change waiting time (time before diffusion)

These errors typically indicate locations of congestion in the model, which should be given special attention to ensure the congestion is not the result of a coding error. Errors such as these may be further reduced during the calibration process described in the next section.

The VISSIM “.err” file can help pinpoint problems in the model that could result in invalid results
6. CALIBRATION

The calibration is the process used to achieve adequate reliability or validity of the model by establishing suitable parameter values so that the model replicates local traffic conditions as closely as possible. The choice of parameter values can be specific to the project and good data is critical to limiting the duration of the calibration process. The first step in calibration should be to compare input and output traffic volumes. However, meeting volume targets is not in and of itself sufficient for calibration. Spot speeds and/or travel time measurements from the model must reflect existing field conditions. Visual inspections of congestion levels and duration, queue lengths, and overall driver behavior should also be compared against field observations.

The procedures and assumptions made to develop a calibrated model and all results shall be documented in the Assumptions and Calibration Report and submitted to ODOT for review. The modeler shall meet all calibration requirements for the study periods as outlined in the Project Methods and Assumptions Report. The calibration results will be based on the average of multiple simulation runs with different random number seeds.

6.1 Volume/Density

The first measure of proof of calibration is how closely field volumes (as provided to ODOT in the Data Collection Summary) match simulation output volumes. A simple percentage difference is not a fair comparison of the wide range of link or turning movement volumes possible in the model. For example, a 10 percent tolerance would allow a freeway link with 4,000 vehicles per hour (vph) to vary by 400 vph, but a left-turn movement with 30 vph at an intersection could vary by only 3 vph to meet the criteria.

The best universal measure to compare simulation inputs and outputs is the GEH formula. This continuous volume tolerance formula was developed to overcome the wide range in volume data described in the previous paragraph.

For hourly flows, the GEH formula is:

$$GEH = \sqrt{\frac{2(m-c)^2}{m+c}}$$

Notes:
- $m$ = output traffic volume from the simulation model (vph)
- $c$ = input traffic volume (vph)

Calibration of the model should use the GEH formula, calculated to a value of 5 or lower.
Table 6-1 provides guidance on interpreting the calculated GEH statistic. The volume calibration criteria are listed in Table 6-2.

### Table 6-1: GEH Statistic Guidelines

| GEH < 5.0 | Acceptable fit |
| 5.0 <= GEH <= 10.0 | Caution: possible model error or bad data |
| GEH > 10.0 | Unacceptable |

### Table 6-2: Traffic Volume Calibration Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Acceptance Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEH &lt; 5.0</td>
<td>At least 85% of freeway links within the calibration area</td>
</tr>
<tr>
<td>GEH &lt; 5.0</td>
<td>All entry and exit locations within the calibration area</td>
</tr>
<tr>
<td>GEH &lt; 5.0</td>
<td>All entrance and exit ramps within the calibration area</td>
</tr>
<tr>
<td>GEH &lt; 5.0</td>
<td>All intersection turn movements greater than 100 vehicles per hour</td>
</tr>
<tr>
<td>Individual flows within ±400 vehicles per hour for flows exceeding 2,700 vehicles per hour</td>
<td>At least 85% of applicable mainline links</td>
</tr>
<tr>
<td>Sum of all link flows within the calibration area</td>
<td>Within 5%</td>
</tr>
</tbody>
</table>

GEH statistics shall be calculated for all mainline links and ramps and for all intersection turns at study intersections identified in the scope of work. In addition, the GEH statistic must be calculated for all traffic volumes at all entry and exit locations in the calibration area of the model. Parameters may need to be adjusted in the calibration process to match the volume criteria; changes must be documented in the Calibration and Results Report. It should be noted that this calibration target of volumes is intended for comparison of both expected and actual throughput in the model. Unmet demand will affect speed and travel times throughout the model. As a result, calibration of those targets should match real-world data if the unmet demand matches.

### 6.2 Speed

After volume output is calibrated in the model, replication of driver behavior is needed. The first step is to match spot speeds. This usually pertains to freeway segments because it is difficult to measure accurate speed data on arterials due to the influence of signalized intersections.
At all points identified in the List of Key Calibration Locations, spot speeds in the model should be within 10 percent of observed real-world spot speed data. If detailed network-wide travel speeds are available from sources such as the PORTAL database, then speeds in the model shall be within 10 mph of observed real-world spot speed data on at least 85 percent of all freeway links where real-world speed is available for comparison. Spot speed charts similar to the example shown in Figure 6-1, which compares simulation results to real-world field data, shall be prepared for all freeway corridors. Locations and durations of speeds within the chart should replicate locations of available data from PORTAL or other sources. These results should also be presented in table format in the Calibration Methodology and Results Report. If detailed network-wide real-world speed data is not available, this comparison shall be based on field observations of existing conditions.

Figure 6-1: Example of a Speed Comparison Table

<table>
<thead>
<tr>
<th>Location</th>
<th>4:00 PM</th>
<th>4:15 PM</th>
<th>4:30 PM</th>
<th>4:45 PM</th>
<th>5:00 PM</th>
<th>5:15 PM</th>
<th>5:30 PM</th>
<th>5:45 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB 0.76</td>
<td>53</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>48</td>
<td>38</td>
<td>45</td>
</tr>
<tr>
<td>SB 1.92</td>
<td>52</td>
<td>38</td>
<td>35</td>
<td>33</td>
<td>31</td>
<td>30</td>
<td>33</td>
<td>31</td>
</tr>
<tr>
<td>SB 2.55</td>
<td>50</td>
<td>45</td>
<td>43</td>
<td>39</td>
<td>40</td>
<td>40</td>
<td>41</td>
<td>42</td>
</tr>
<tr>
<td>SB 3.12</td>
<td>51</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>51</td>
<td>50</td>
<td>51</td>
</tr>
<tr>
<td>SB 4.35</td>
<td>52</td>
<td>52</td>
<td>53</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>SB 5.11</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>50</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>SB 5.95</td>
<td>52</td>
<td>52</td>
<td>53</td>
<td>52</td>
<td>52</td>
<td>48</td>
<td>44</td>
<td>39</td>
</tr>
</tbody>
</table>

4pm 5pm

<table>
<thead>
<tr>
<th>Location</th>
<th>SOUTHBOUND Average Speeds - (Vissim Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4:00 PM</td>
</tr>
<tr>
<td>SB 0.76</td>
<td>53</td>
</tr>
<tr>
<td>SB 1.92</td>
<td>52</td>
</tr>
<tr>
<td>SB 2.55</td>
<td>50</td>
</tr>
<tr>
<td>SB 3.12</td>
<td>51</td>
</tr>
<tr>
<td>SB 4.35</td>
<td>52</td>
</tr>
<tr>
<td>SB 5.11</td>
<td>52</td>
</tr>
<tr>
<td>SB 5.95</td>
<td>52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>SOUTHBOUND Speeds - (Portal Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4:00 PM</td>
</tr>
<tr>
<td>SB 0.76</td>
<td>53</td>
</tr>
<tr>
<td>SB 1.92</td>
<td>57</td>
</tr>
<tr>
<td>SB 2.55</td>
<td>51</td>
</tr>
<tr>
<td>SB 3.12</td>
<td>56</td>
</tr>
<tr>
<td>SB 4.35</td>
<td>59</td>
</tr>
<tr>
<td>SB 5.11</td>
<td>60</td>
</tr>
<tr>
<td>SB 5.95</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>SOUTHBOUND Average Speeds - Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4:00 PM</td>
</tr>
<tr>
<td>SB 0.76</td>
<td>1%</td>
</tr>
<tr>
<td>SB 1.92</td>
<td>10%</td>
</tr>
<tr>
<td>SB 2.55</td>
<td>3%</td>
</tr>
<tr>
<td>SB 3.12</td>
<td>9%</td>
</tr>
<tr>
<td>SB 4.35</td>
<td>12%</td>
</tr>
<tr>
<td>SB 5.11</td>
<td>14%</td>
</tr>
<tr>
<td>SB 5.95</td>
<td>14%</td>
</tr>
</tbody>
</table>

4pm 5pm
6.3 **Travel Time**  
Calibration criteria for travel times in the model shall also be met for the highest peak demand hour for all segments identified in the Data Collection Plan in the simulation. The travel time criteria are listed in Table 6-3.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Acceptance Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeled travel time within ±1 minute for routes with observed travel times less than 7 minutes.</td>
<td>All routes identified in the Data Collection Plan</td>
</tr>
<tr>
<td>Modeled travel time within ±15% for routes with observed travel times greater than 7 minutes.</td>
<td>All routes identified in the Data Collection Plan</td>
</tr>
</tbody>
</table>

*Source: FHWA Traffic Analysis Toolbox Volume III (Wisconsin Department of Transportation)*

6.4 **Queuing**  
Queue lengths in the model should be compared to field observations of existing conditions to ensure the proper operation at intersections. Excessive queuing or lower than expected queues may indicate improper coding of intersection control or vehicle demand. Once these inputs have been verified, if there is still a significant difference between field queues and model queues, parameters may be changed to realistically model the study area queuing. A quantitative comparison of queue lengths with real-world conditions is not typically required unless otherwise dictated by project requirements or requested by ODOT staff. However, a qualitative comparison is always required.

6.5 **Weaving Behavior**  
In areas where there is heavy weaving and where O-D data has been collected or is provided by planning models, travel time segments in VISSIM should be used to obtain traffic volume data that can verify a match with O-D data. The volumes should also be calibrated to the criteria defined in Section 6.1 with a GEH less than 5.0. When weaving is modeled where no O-D data is available, the model should visually match field observed driver behavior and congestion levels.

6.6 **Lane Utilization**  
If lane utilization data was required to be collected in the field and calibrated as part of the scoping process, then lane-by-lane volume data should be collected from the VISSIM models at the same field locations. The lane-by-lane volumes should follow the criteria defined in Section 6.1 and a comparison of lane utilization percentages between the model and the field should be provided.

6.7 **Transit Travel Times**  
Transit travel times shall also be calibrated for key routes identified in the List of Key Locations for Calibration. The criteria listed in Table 6-3 should be used.
6.8 Visual Inspection
A visual inspection of the calibrated base model shall be performed and compared to observations of field operations to verify that the model is accurately replicating field conditions.

6.9 Minimum Number of Simulation Runs
All model results reported shall be an average of a minimum of 10 simulation runs with different random number seeds. The actual seed values for each run shall be documented so that the results can be replicated later. Reporting the average results of multiple runs is necessary due to the random nature of microsimulation, but in order to ensure that the value reported is a true statistical representation of the average, the following formula for a 95 percent confidence interval shall be applied:

\[ N = \left( \frac{2 \times t_{0.025,N-1}}{R} \right)^2 \]

R = 95-percent confidence interval for the true mean
\[ t_{0.025,N-1} \] = Student’s t-statistic for two-sided error of 2.5 percent (totals 5 percent) with N-1 degrees of freedom
s = standard deviation of about the mean for selected MOE
N = number of required simulation runs

It is not practical to test the statistical significance of the average of every data output. For simplicity, this calculation should only be conducted for one or two measures of effectiveness that are deemed most important to the outcome of the project, such as average vehicle delay at one intersection or travel time through the corridor. Most data points can be tested at the discretion of the modeler, but all locations must be approved by ODOT.

This statistical process requires an initial data set to be generated, which in this case will be the required 10 runs. In most cases, these 10 runs will generate a large enough sample size to produce the true statistical average, but this must be verified by the equation. Based on the standard deviation of the key chosen MOE(s), the minimum number of runs needed to achieve a 95% confidence interval must be determined on a case by case basis depending on the MOE chosen and be approved by ODOT. In most cases an interval of +/- 10% will be acceptable. The t value can be found in any statistics manual, but based on the data set of 10 runs, t = 2.3. A percent confidence of 95% must be used unless ODOT specifies otherwise.

This calculation is only required for the base model scenario. For consistency, all subsequent alternatives will use the same number of runs. Review of the standard deviations of all model outputs from all simulation runs should be reviewed to determine locations of significant variance. If any significant variances cannot be justified, the model should be evaluated to determine the need for more calibration.
6.10 VISSIM Calibration Documentation

ODOT requires that a Calibration and Methodology Results Report be submitted with the calibrated base model. The report shall summarize the basic processes and procedures followed, assumptions made, problems encountered, and solutions devised during the study effort. Any calibration parameters changed from default settings should be clearly documented with a description of the reasons for the changes and how the changes improved the model replication of real-world conditions. At a minimum, quantitative comparisons between real-world data and model output results are required for volumes, speeds, and travel times. A qualitative comparison of queuing and driver behavior is also required. Any other calibration targets outlined in the Project Methods and Assumptions report must also be provided in this document. The raw data output shall be provided either in the appendix of this document or submitted as electronic files to ODOT. A sample Calibration Methodology and Results Report is provided in Appendix H.
7. ADDITIONAL BASE YEAR SCENARIOS

Once the calibrated model and Calibration Methodology and Results Report has been reviewed and approved by ODOT, the modeler may begin building any additional base year models. Depending on the project, this may include a PM peak, AM peak, midday peak, and/or seasonally factored models. The data used to code the additional base year scenarios should have been provided in the previously submitted Data Collection Summary as outlined in Section 3.12 of this protocol.

7.1 Model Development

A copy of the calibrated model shall be used to create the additional base year models. Traffic demand inputs and routing, signal timing, and any time-of-day specific lane use restrictions should be the only changes to the network. Once the new inputs have been coded, the model shall go through the error checking process again.

Once the model has been reviewed for errors, a check for calibration must be completed on the additional base year scenario models. For non-seasonally factored models this should include all the calibration parameters used for the first calibrated model. Any further calibration adjustments to driver behavior should be avoided. If it becomes necessary to make additional changes during the calibration process of the other base conditions models, the adjustments should be made to all base models.

The Calibration Methodology and Results Report must be updated to include any new changes in driver behavior or assumptions that were made with the additional base year models and must also include proof of calibration as outlined in Section 6 for the additional base year scenario models. The additional models must be submitted with the updated memorandum.
8. ALTERNATIVES

Once all base year models have been reviewed, the modeler may develop the No-Build model, which will be used to develop all the alternative models previously outlined in the scoping process.

8.1 Developing Volumes for the No-Build Scenario

The process for developing future no-build volumes is outlined in the Analysis Procedures Manual (APM). The APM has a detailed description of the recommended methodology for developing future no-build traffic volumes, including descriptions of travel demand modeling, cumulative analysis, or trend-line forecasting. If the volume development outlined in the APM results in traffic volumes that have locations where severe congestion is anticipated in future year scenarios (i.e., peak hour operations significantly exceeding a v/c ratio of 1.0), consideration should be given for peak period travel demand "spreading" in order to create reasonable volume inputs for microsimulation. For these situations, travel forecasting should be performed with a travel demand model to account for route choice changes (e.g., trips diverting from congested corridors). Adjustments for peak "spreading" may consider trips moving to the shoulder hours of the peak period, but should conserve daily trip demand. If used, ODOT staff shall approve the peak period “spreading” adjustment methodology.

Volume forecasting and post-processing methodology for any alternatives (e.g., future years, network alternatives, and modal alternatives) shall be approved by ODOT during the scoping process. Before coding the no-build model, the new traffic volume data set shall be developed and submitted in graphical format to ODOT for approval.

8.2 Model Development

A copy of the calibrated model shall be used to create the no-build model. The future no-build model may include improvement projects that are assumed to be funded and constructed within the project planning horizon. The modeler should coordinate with ODOT Region staff to identify these projects. Typically, such projects would be listed in the Statewide Transportation Improvement Program (STIP), city or county Transportation System Plans (TSP), or Metropolitan Planning Organization’s (MPO) Regional Transportation Plans (RTP). See Oregon’s Transportation Planning Rule for more information. The only coding changes expected within the VISSIM model for a no-build model would be traffic demand inputs and routing, signal timing, any time-of-day specific lane use restrictions, and any proposed improvements. Signal timing changes should be documented and provided for ODOT review and approval upon submittal of

---

4 Transportation Planning Rule (TPR),
the model. Once completed, the no-build model can be used to develop all additional alternative models.

**8.3 Changes to the VISSIM Model**

Changes to driver behavior and parameters in a VISSIM model will vary depending on the level of network changes between base models and alternatives. When the no-build scenario includes only minor network changes, there should be no changes in driver behavior and parameters.

In cases where major changes to the network are included as part of an alternative, the modeler is in essence building a new model. Therefore, the development of the no-build scenario with major changes to the network must follow the steps outlined in the Model Development section. As part of this, the modeler must also provide additional documentation of changes and assumptions made to develop the model.

Regardless of the level of network changes, **in most cases it is expected that the driver behavior parameters should not change**. However, if the changes in volume or roadway network are significant enough to justify an adjustment to driver behavior parameters, this change must be documented and submitted with the no-build model. This documentation should cite real-world examples or research that demonstrate the basis for the value chosen.

**8.4 Error Checking**

The no-build model must go through the error checking process as outlined in Section 5 before initial assessment of the models can begin. The error checking process includes a check for VISSIM software updates, a verification of VISSIM inputs, a review of the animation, and a correction of the VISSIM error files.

**8.5 Initial Assessment of the No-Build Model**

When modeling future conditions, it is no longer possible to calibrate the model because there are no observed conditions against which to compare. However, the modeler can perform an easy check of how the model is operating by comparing input and output volumes. This comparison is a simple error check to confirm that the intended input volumes are actually reaching their intended route. The check will be much like the one in the calibration process for the mainline links, ramps, study intersections, and entry and exit locations. However, unlike the base conditions models, the input and output volumes will not necessarily match and are not required to meet a GEH value. Growth in traffic demand or other changing conditions may create bottlenecks and congestion that do not exist in the base models. This volume comparison will quickly identify the location of the bottlenecks, provide guidance on their severity and impact to the corridor, and summarize actual throughput compared to demand. This comparison with any findings shall be documented and provided to ODOT with the submittal of the no-build model.
8.6  **Developing Volumes for Alternative Scenarios**

The process for developing alternative scenario volumes is outlined in the Analysis Procedures Manual (APM) and should also follow additional steps described in section 8.1. The volume set for all alternative scenarios should be provided in graphical format for ODOT approval.

8.7  **Model Development**

Once the no-build model has been completed and approved by ODOT, it can be used to develop alternative scenario models. The development of these models should follow the same steps outlined for developing the no-build model (section 8.2, 8.3, and 8.4). When completed, these models should also go through the initial assessment as performed on the no-build model. The alternative models should be submitted for review with a summary of any changes, a summary of the input and output volumes, and any preliminary findings from the models.
9. REPORTING

There are many data output options available in VISSIM, ranging from network-wide statistics to individual intersection movement delays. The modeler must know from the start of the project what data will be collected and code the network appropriately. These MOEs should have been identified at the start of the project in the Project Problem Statement and in the scope of work.

Data output should be reported for the entire simulation period, as defined in the Project Methods and Assumptions Report. ODOT may require the data be submitted by hourly, half-hourly, or 15-minute increments.

9.1 Required Data Outputs

The outputs listed in this section are required data for all freeway and arterial models in all regions of ODOT.

9.1.1 Node Evaluation

Node evaluation data is obtained by placing “nodes” throughout the network. All study intersections, ramp terminals, and any other study locations outlined in the Methods and Assumptions document must have nodes placed around them with Node Evaluation toggled on. The MOEs for all nodes shall be reported using the Node Evaluation feature. Results shall be reported for each movement at the node and aggregated together for the entire node. At a minimum, the following MOEs shall be reported:

- Node Number
- Movement
- Number of Vehicles (throughput)
- Average Delay
- Stops

9.1.2 Queue Counters

There are many options for collecting and reporting queues. The recommended method is to use queue counters. Queue counters should be placed at the stop line of each movement at all study intersections and any other locations outlined in the scope. Because queue counters are independent of the nodes, it is possible to collect queues back through multiple intersections. Queue measurement using queue counters behaves similarly to nodes in that it measures back upstream to the next queue counter. However, as outlined in the VISSIM User Manual, “If the queue backs up onto multiple different approaches the queue counter will record information for all of them and report the longest as the maximum queue length.” To ensure that the reported queue is the queue for the actual roadway and does not include side streets that are modeled, queue counters...
must be placed on the side street approaches, even if the queue is not required to be reported from that movement.

Generally, the queue counters should be placed at stop bar locations or close to where traffic is expected to begin queuing. The queue measurement evaluation options should be set to collect the queue using the default “end” and “begin” parameters as shown in Figure 9-1. With these defaults the queue will start being measured for vehicles traveling less than 3.1 mph and will stop recording them as part of the queue once they are traveling 6.2 mph. The max headway provided in the default queue definition for VISSIM is 65.6 feet and should remain unchanged unless ODOT requests use of an alternate headway. The max queue length shall be changed to 99,999 feet for all models unless otherwise directed by ODOT. The time interval of the queue measurement should be changed to collect data for 120 seconds. The “from” and “until” values will vary depending on the seeding time and simulation time of the model.

Another option for collecting queues is through Node Evaluation. This method does not report the 95th percentile queue directly. To obtain the 95th percentile queue through node evaluation the data collection intervals need to be changed from the interval that was used to collect other data (generally hourly) to the 120-second interval used to collect queues from VISSIM. Through post processing the user can calculate the 95th percentile queue in the recommended method as outlined in section 9.1.2.1.

The Data Analyzer does calculate 95th percentile queue during post-processing; however, the data analyzer has size constraints, can sometimes take additional time to process, and does not currently calculate the 95th percentile queue in the same method outlined in this document. It is therefore not recommend for reporting queues at this time but may be used in the future if the queue output reports 95th percentile queues in accordance with ODOT methodologies. Guidance for calculating the 95th percentile queue can be found in the following section.
Calculating the Average and 95th Percentile Queues

Both the queue counters and the node evaluation can report average and maximum queues for the specified time interval, but they do not report the 95th percentile queue directly. To calculate the 95th percentile queue in VISSIM, queuing information shall be recorded in 120-second intervals. The data set provided from the queue counters over the multiple simulation runs must be compiled and the list of all maximum queues for each movement must be averaged together to get the “average of the max.” The standard deviation from this data set must also be calculated. With these two values the 95th percentile queue can be calculated using the formula (same calculation as SimTraffic):

\[
95\text{th percentile queue} = \text{average of the max queues} + 1.65 \times \text{standard deviation}
\]

Values from the multiple runs must not be averaged. An example of the post processing spreadsheet is provided in Appendix H.

Extended Turn Pocket Queue Testing

Often, queues from turning lanes may extend beyond the available storage during the simulation period. This queue can spill over into the through movement and cause the queue counters to record queues based on a combination of the turning vehicles and the through movements that have backed up behind the spillover. For analysis purposes, ODOT may require that a model be simulated with a storage pocket (turn link) to be extended (a distance to be determined on a project by project basis) to determine the true queue length for the turning movement and the ideal storage length to prevent spillback from blocking the adjacent through lane.

9.1.3 Data Collection Points

Data collection points shall be placed at all entry and exit locations within the calibration area of a model. If archived speed or volume data is being used for calibration and evaluation of alternatives then these data collection points must be placed at the same location in the model as they had been being collected in the field. Points on multilane links shall be aggregated together as one data point, unless lane specific volume or speed is being evaluated. At a minimum, the following MOEs should be reported:

- Number of Vehicles
- Speed (mean)

Speed Comparison Tables

Data collection points can be used to develop speed tables which allow a comparison of existing archived field data with model outputs. An example of these tables can be found in Section 6.2.

9.1.4 Travel Time

All travel time segments identified in the Data Collection Plan and/or included in the List of Key Calibration Locations shall be coded as Travel Time Segments. At a minimum, the following MOEs shall be reported:
- Number of Vehicles for all vehicle types
- Travel Time

The simulation travel time results shall have a minimum sample size of 25 vehicles for each travel time segment. Ideally, the travel time segment limits should match the start and end points of the travel time runs collected in the field. If the corridor is long and only a few cars travel the entire corridor in the simulation, the corridor should be broken up into multiple travel time segments to ensure collection of a large enough sample size. To more closely replicate the end-to-end travel time runs, travel time segments must be placed in the middle of each intersection/node on the through movement connector/link in order to capture only vehicles traveling through the study section and not ones turning in from some intermediate point. The vehicles that turn in will experience a different amount of delay than vehicles that traveled the entire length of the corridor.

9.2 Optional Output Data

Output data listed in this section is optional and the need for it shall be determined through coordination with ODOT during the scoping process.

9.2.1 V/C Ratio

Volume to capacity (v/c) ratio is not an output found in VISSIM and other microsimulation software. It is typically found as an MOE in deterministic software. The reason is that in microsimulation both volume and capacity are quite variable. While it is possible to determine the capacity at any given time slice in the microsimulation run, that value may not represent the capacity at another given time within the simulation (due to the components that determine the variability of capacity). Microsimulation also will not provide a “demand volume”, rather, the simulation model produces congestion and queuing, which is what happens in the real world when volume exceeds capacity. What microsimulation can produce are volume/speed/density relationship curves at given locations, congestion duration at variable traffic volume flow levels, and system-wide effects of congestion and queuing.

9.2.2 Network Performance Evaluation

Network Performance Evaluation is an overall snapshot of the network useful for quickly comparing alternatives. It is an aggregation of all vehicles on the network independent of any node or travel time segment definitions. In addition to the standard MOEs such as vehicle delay and stops, Network Performance Evaluation provides such additional information as the number of vehicles that could not enter the network or are waiting outside the network and the latent delay time of those vehicles.

9.2.3 Link Evaluation

If freeway Highway Capacity Manual (HCM) Level of Service (LOS) is required, all freeway links shall be coded with Link Evaluation “active”. Statistics should be collected on a link-by-link basis (segment length set to value longer than longest link in the network). At a minimum, the following MOEs should be reported:
• Volume
• Speed
• Density (non-HCM compliant – see next paragraph)

It should be noted that the density in VISSIM is a measured density, which can be used as a direct measure of effectiveness. This is not, however, density as defined by the Highway Capacity Manual (HCM). The HCM equivalent value, if desired, must be calculated in post-processing from the measured volume and speed. The calculated density value can then be used through post-processing to assign an HCM LOS letter grade. The modeler should refer to the HCM for definitions of freeway LOS.

9.2.4 Speed Contour Plots
The Link Evaluation statistics for freeway links can also be used to create speed contour plots. This can be done using the link-by-link statistics or, if needed, can be rerun with shorter segment lengths to increase the resolution of the plot.

9.2.5 Emissions
Currently, ODOT has not adopted methodologies for utilizing microsimulation data for air quality analysis. VISSIM can generate emissions output for CO, NOx, and VOC through node evaluation; however, this module is not currently consistent with EPA approved methods and should only be used if approved by ODOT. If EPA compliant emissions results are required for the project, VISSIM does allow for an interface to external emissions models, which may be utilized if approved by ODOT.

9.2.6 Lane Changes
When comparing different alternatives for weaving sections, the Lane Changes output can be useful. This output option records each lane change maneuver with a time stamp and both the “To” and “From” lane on a link. This data can be used to determine which weaving section alternative results in the fewest lane changes. This feature should be used with caution because it is not possible to filter the results by link number before recording, so every lane change in the network is recorded and the data must be filtered during post-processing. This can create very large data files.
9.2.7 **Travel Time (for O-D Data)**

As a validation “double-check” of O-D volumes through a weaving section can be done through the use of travel time segments in VISSIM. Four travel time segments would be needed as shown in Figure 9-2:

- From A to C
- From A to D
- From B to C
- From B to D

These travel time segments can be used simply to collect the number of vehicles traveling from one entry point to one exit point in a weaving section.

9.2.8 **Managed Lanes**

If the managed lane add-on module is used to model HOV or other managed lanes, the managed lane output option can be used to record additional information about performance. Available MOEs from this option include:

- Average speed on the managed lanes
- Average speed on the general purpose lanes
- Travel time savings for the managed lanes route
- Tolls collected in the managed lanes by vehicle class (e.g., HOV, HOV2, SOV)

9.2.9 **Delay Segments**

Delay segments can be used to collect intersection MOEs at locations with unusual geometry, delays for a movement through multiple intersections, or the delay along one specific path through the network. Delay segments can also be used as a network-wide
alternative to the node evaluation method for networks with a non-standard street system. This method allows the modeler to explicitly define the start and end of the delay segment and assigns it a number instead of the automated process of assigning “From-To” directions to a movement. This is accomplished by defining travel time segments for each movement and then aggregating them as delay segments. While this method requires a more upfront coding effort, it gives the modeler complete control over the definition of the delay segment for each analyzed movement.

9.2.10 Green Time Distribution
If the VISSIM network includes signalized intersections where the timing changes from cycle to cycle, either from regular vehicle actuation or from transit signal priority or railroad preemption, it may be useful to record the Green Time Distribution. It reports the average green and red times for each signal phases, as well as a summary table of each value of green and red times recorded, similar to a pivot table in a spreadsheet program.

9.2.11 Vehicle Record
The vehicle record output option allows the modeler to select from many vehicle performance characteristics to report every vehicle in the network for every time step. Examples of these characteristics include the position (x, y, z coordinates), instantaneous speed and acceleration, desired speed, and lane. This record of vehicle paths is typically collected for export to a third-party software package such as 3DS Max for visualization purposes.

9.2.12 PT Waiting Time
The PT (Public Transport) waiting time option records each event when a transit vehicle stops for any reason other than a transit stop or a stop sign coded with a dwell time. An event would be reported when a transit vehicle stops at traffic signals and for congestion.

9.3 Post Processing
The preferred method for post-processing data from VISSIM is to collect the raw simulation data from multiple simulation runs with different random number seeds. Due to the random nature of microsimulation, the results from multiple runs must be averaged together to reach the true representation of the conditions in the model. Because the model outputs are generated in delimited text files, a spreadsheet is the best tool for post-processing. The modeler should document the random number seeds used so that the results can be replicated. No simulation runs shall be “thrown out” unless ODOT agrees it is appropriate.

The raw data should be post-processed to generally provide the average of all the simulation runs with the exception of the 95th-percentile queue, which will be calculated as described previously. Additionally, standard deviations for all data should be provided where feasible. The methodology for compiling the data may vary between modeler; however, the method must be outlined in the Methods and Assumptions document. Spreadsheets outlining the method and demonstrating the format that will be used to
report results must also be provided to ODOT in the Methods and Assumptions document.

Another option for post processing data is the Data Analyzer feature provided in VISSIM. The built-in Data Analyzer is the only method for getting a prepackaged report from VISSIM. It can generate formatted reports from Node Evaluation and Travel Times data. While the Data Analyzer reduces the need for the modeler to sort through large amounts of raw data, it does take a significant amount of time to collect the data and run the data analyzer to obtain a report. Additionally, the modeler should still examine the raw data to determine standard deviations and identify data outliers.

### 9.3.1 HCM Compliant Level of Service Results

Intersection vehicle delay results generated by microsimulation models such as VISSIM are not HCM compliant. HCM calculations are based on control delay and stopped delay that directly contributes to the traffic control devices. VISSIM directly measures the total delay, which consists of control delay, stopped delay, and other delay incurred in the vicinity of the traffic control device, such as vehicles slowing down for turn movements. However, for simplicity, the differences are usually negligible. The same LOS thresholds can be applied in both cases. If so, it should be noted in the results summary that the results are not HCM compliant.

This difference does not infer that microscopic simulation-based delay results are less accurate. Delays from properly calibrated microscopic simulation models are actually more indicative of field results. This difference means only that they should not be reported as HCM delay results or translated to HCM LOS values.

As stated above, properly calibrated microscopic simulation models will produce delays (and other performance measures) that more accurately reflect field operations related to the given network geometry, multimodal volumes, and control strategies than deterministic equation based methods like those included in the HCM. VISSIM explicitly models vehicle-vehicle (vehicle-pedestrian, auto-transit, etc.) interactions, queue interactions, freeway and signalized arterial interactions, arterial actuated signal control operations, events (e.g., railroad preemption), ramp metering, etc., unlike the deterministic approaches. Unlike VISSIM, HCM procedures tend to break down as the intersection reaches capacity.

If the project scope specifically requires HCM compliant results, the modeler shall use a HCM-based software tool approved by ODOT.

### 9.4 Sample Report Format

The final report for a VISSIM project should at a minimum include the following sections:

- Project Description
- Study Area and Model Area Description
• Scope of Work
• Description of Alternatives Analyzed
• Description of Problem Areas and/or Bottlenecks Discovered in Analysis
• Opportunities Discovered in Analysis
• Summary of Results and Recommended Decisions

Additionally, the document must contain in the Appendix the detailed results from the VISSIM analysis. A sample of the desired format for all ODOT VISSIM projects is included in Appendix J.
10. REVIEWING

This section details the steps ODOT staff will use when reviewing submittals. The modeler should refer to this section before submittal of each deliverable to ensure all proper requirements have been met. The check-in milestones of this structure, which are set up to encourage the linear sequence of events for the project, gives ODOT staff opportunities to review and provide concurrence for each step before the modeler continues to the next step. Not all deliverables listed below will be required for every project.

**ODOT VISSIM Reviewing Checklist**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Protocol Section</th>
<th>Items to Check</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scoping</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Problem Statement</td>
<td>1.1</td>
<td>□ The goals of the project are clearly stated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Proposed MOEs provide the necessary information to answer the Project Problem Statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Field visit has been conducted</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Collection Plan</td>
<td>2.6</td>
<td>□ Summary of a field visit to determine data collection needs has been provided in a graphical format</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Summary of real-world observations (and historical data if available) showing congestion locations have been provided</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Time periods for data collection have been determined and documented</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Type of data to be collected and locations that they will be collected are documented in tabular and graphical format</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Methods and Tools</td>
<td>2.7</td>
<td>□ Project understanding, including the problem statement, is described</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Software tools to be used for this project and their use have</td>
</tr>
</tbody>
</table>
## Assumptions

- Model area, calibration area, and study area have been defined
- Project study period and years for analysis have been defined
- The types of data to be collected, location of collection, and the time increment and period that they will be collected are provided
- Documentation of if the data collected will be used for model development and/or calibration purposes
- A complete list of MOEs that will be collected from the model is included
- Calibration targets have been outlined for this project.
- Any known assumptions associated with this project have been outlined
- Any known deviations from the protocol guidelines are documented with justification
- A project schedule demonstrating a linear sequence of milestones is provided
- VISSIM experience of the staff that will be working on the project are described

## Comments:

### Data Collection Summary

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.12</td>
<td>Development of input volume data sets have been documented</td>
</tr>
<tr>
<td></td>
<td>Sink and source locations are identified in graphical format</td>
</tr>
<tr>
<td></td>
<td>Lane schematics in graphical format</td>
</tr>
<tr>
<td></td>
<td>Documentation of any errors found in data and the assumptions that were made in accordance with the errors</td>
</tr>
<tr>
<td></td>
<td>Traffic volumes to be used in analysis of all existing conditions are provided in graphical format</td>
</tr>
<tr>
<td></td>
<td>Posted speeds and any localized segments of adjusted desired speeds are provided in graphical format</td>
</tr>
<tr>
<td></td>
<td>Any lane imbalance locations that require special coding are documented and described graphically</td>
</tr>
<tr>
<td></td>
<td>Summary of travel time and speed data</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td><strong>Model Coding</strong></td>
<td></td>
</tr>
<tr>
<td>Base VISSIM Model</td>
<td></td>
</tr>
<tr>
<td>4.2 - 4.11</td>
<td></td>
</tr>
<tr>
<td>□ Lane geometry correct at all intersections</td>
<td></td>
</tr>
<tr>
<td>□ Locations of freeway lane drops/adds correct</td>
<td></td>
</tr>
<tr>
<td>□ Merge/(diverge) locations coded correctly per Section 4.2.1</td>
<td></td>
</tr>
<tr>
<td>□ Desired Speed Decisions coded at all locations of change in posted speed</td>
<td></td>
</tr>
<tr>
<td>□ Reduced Speed Areas at all turns and areas of temporary speed reductions</td>
<td></td>
</tr>
<tr>
<td>□ Conflict Areas/Priority Rules coded at all intersections and other conflict points</td>
<td></td>
</tr>
<tr>
<td>□ Stop Signs coded at proper locations</td>
<td></td>
</tr>
<tr>
<td>□ Traffic signals coded at correct intersections</td>
<td></td>
</tr>
<tr>
<td>□ Traffic signal stop bars and detectors coded at proper locations</td>
<td></td>
</tr>
<tr>
<td>□ Traffic signal timing matches field timing <em>(see Traffic Signal Timing Checklist)</em></td>
<td></td>
</tr>
<tr>
<td>□ Nodes coded at all study intersections with Node Evaluation toggled on</td>
<td></td>
</tr>
<tr>
<td>□ Queue Counters coded for all movements at all intersections in the List of Key Calibration Locations</td>
<td></td>
</tr>
<tr>
<td>□ Max Queue Value increased from default value to include longest possible queue</td>
<td></td>
</tr>
<tr>
<td>□ Data Collection Points coded on all entry and exit links</td>
<td></td>
</tr>
<tr>
<td>□ Travel Time Segments coded for all sections identified in the Data Collection Plan</td>
<td></td>
</tr>
<tr>
<td>□ Transit routes, headways, and dwell time parameters match real-world conditions</td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
</tbody>
</table>
### Additional Base Year Scenarios

<table>
<thead>
<tr>
<th>Calibration Methodology and Results Report</th>
<th>6.1 – 6.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model animations match expected driver behavior and conditions observed in the field</td>
<td></td>
</tr>
<tr>
<td>Model output volumes satisfy GEH statistic requirements (GEH &lt; 5) in Section 6.1</td>
<td></td>
</tr>
<tr>
<td>Model link speeds meet speed calibration requirements in Section 6.2</td>
<td></td>
</tr>
<tr>
<td>Model travel time results meet calibration requirements in Section 6.3</td>
<td></td>
</tr>
<tr>
<td>Model queuing replicates real-world conditions</td>
<td></td>
</tr>
<tr>
<td>Calibration results are based on the average of the minimum number of simulation runs calculated as shown in Section 6.9</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

<table>
<thead>
<tr>
<th>Additional Base Year Models and Updated Calibration Methodology and Results Reports</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration Methodology and Results report has been expanded to provide proof of calibration for additional base year models</td>
<td></td>
</tr>
<tr>
<td>Model animations match expected driver behavior and conditions observed in the field</td>
<td></td>
</tr>
<tr>
<td>Model output volumes satisfy GEH statistic requirements (GEH &lt; 5) in Section 6.1</td>
<td></td>
</tr>
<tr>
<td>Model link speeds meet speed calibration requirements in Section 6.2</td>
<td></td>
</tr>
<tr>
<td>Model travel time results meet calibration requirements in Section 6.3</td>
<td></td>
</tr>
<tr>
<td>Model queuing replicates real-world conditions</td>
<td></td>
</tr>
<tr>
<td>Calibration results are based on the average of the minimum number of simulation runs calculated as shown in Section 6.9</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:
<table>
<thead>
<tr>
<th>Alternatives</th>
<th>8.1</th>
<th>No-Build Forecasted Input Volumes</th>
<th>Methodology for developing traffic volumes has been provided</th>
<th>Any assumptions made during volume development have been outlined</th>
<th>Traffic volumes to be used in analysis are provided in graphical format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.2-8.5</td>
<td>No-Build Models and Corresponding Documentation</td>
<td>Summary of input and output vs. demand is documented with any reasons for variation</td>
<td>Any preliminary findings from the models are documented</td>
<td>Signal timing matches agency guidelines</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td>Methodology for developing traffic volumes has been provided</td>
<td>Any assumptions made during volume development have been outlined</td>
<td>Traffic volumes to be used in analysis are provided in graphical format</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Summary of input and output vs. demand is documented with any reasons for variation</td>
<td>Any preliminary findings from the models are documented</td>
<td>Signal timing matches agency guidelines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Methodology for developing traffic volumes has been provided</td>
<td>Any assumptions made during volume development have been outlined</td>
<td>Traffic volumes to be used in analysis are provided in graphical format</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td>Methodology for developing traffic volumes has been provided</td>
<td>Any assumptions made during volume development have been outlined</td>
<td>Traffic volumes to be used in analysis are provided in graphical format</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Summary of input and output vs. demand is documented with any reasons for variation</td>
<td>Any preliminary findings from the models are documented</td>
<td>Signal timing matches agency guidelines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Methodology for developing traffic volumes has been provided</td>
<td>Any assumptions made during volume development have been outlined</td>
<td>Traffic volumes to be used in analysis are provided in graphical format</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td>Methodology for developing traffic volumes has been provided</td>
<td>Any assumptions made during volume development have been outlined</td>
<td>Traffic volumes to be used in analysis are provided in graphical format</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Summary of input and output vs. demand is documented with any reasons for variation</td>
<td>Any preliminary findings from the models are documented</td>
<td>Signal timing matches agency guidelines</td>
</tr>
</tbody>
</table>
Section 10: Reviewing

All proposed network changes coded correctly
Animation of the network looks feasible

Comments:

**Reporting**

<table>
<thead>
<tr>
<th>Final Report</th>
<th>9.4</th>
<th>Project description is provided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Scope of work is outlined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alternatives are adequately described</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bottlenecks and other problem areas have been clearly documented</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opportunities and recommendations are included</td>
</tr>
</tbody>
</table>

Comments:

Date: ________________                                         Initials:________________
Appendix A:
Decision Making Tools Excerpts for the FHWA’s Traffic Analysis Toolbox Volume II
Appendix B:
Scoping Checklist
Appendix C:
Seeding Period Excerpts from FHWA’s Traffic Analysis Toolbox
Volume III
Appendix D:
Example Model Development Flow Chart
Appendix E:
Example Speed Plots
Appendix F:
Ramp Meter Signal Timing Example
Appendix G:
Signal Timing Checklist
Appendix H:
Example Calibration Report
Appendix I:
95th Percentile Queue Example
Appendix J:
Sample Report Formatting