PROTOCOL FOR VISSIM SIMULATION

Washington State Department of Transportation

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[1] Protocol for Vissim Simulation, C. Mai, C. McDaniel-Wilson, D. Noval, et al. (http://www.oregon.gov/ODOT/TD/TP/APM/AddC.pdf)

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INTRODUCTION

This Protocol relied heavily on a publication previously released by ODOT in June 2011 *Protocol for Vissim Simulation*[2]. The ODOT publication was used as a starting point for this WSDOT Protocol.

Vissim is a microscopic, behavior-based, stochastic, multi-purpose traffic microsimulation program useful for modeling complex transportation projects. This includes congested freeway networks, light rail operations, and other unique roadway configurations. The protocol is intended to provide guidance and lessons learned through several years of FHWA, ODOT, and WSDOT experience. It applies to arterial street and freeway networks and is intended for use statewide.

Models are not always created for the purpose of reporting analytical results or comparing alternatives, the purpose of some models is purely to assist in public outreach or to utilize the video capabilities. This protocol is tailored to models that have been created to assist in comparing alternatives and reporting analytical results. For models that have been created for visualization purposes, it is not necessary (although it may be helpful) to follow all of the check-in points and produce all of the deliverables mentioned in this protocol. Although it is important to ensure that the video created for animation is loosely representative of the expected operations.

This Protocol is also a living document, which can be updated as technological and/or agency needs change. The latest version can be found at on the WSDOT Traffic Analysis website (http://www.wsdot.wa.gov/Design/Traffic/Analysis/).

PURPOSE

This document has been created to communicate expectations and reduce misunderstanding between agencies and regions and among model developers and project leadership. In addition, it will promote consistent Vissim application and provide guidance for model development during the various stages of projects which will promote efficiency and quality control.

The Protocol provides specific guidance on issues like network coding, model adjustments, analysis methods, and assumptions. It also provides a process for scoping and reviewing Vissim applications. Scoping also specifies WSDOT and project proponent expectations, guidelines, and requirements at the outset of a project which promotes clarity, transparency, and understanding about agreements from all parties involved. This will help to eliminate many unexpected issues, delays, and extra costs.

FIRST STEP

In an effort to maintain transparency throughout a Vissim project, the protocol includes a list of project milestones and deliverables. These are intended to foster greater collaboration between WSDOT staff and consultants. They also allow WSDOT to gain a better understanding of model details and thus improve the speed and quality of the review process.

An overall model development and check-in process for a typical project is summarized in Figure A. Depending on the project-specific purpose, need, and scope, elements of the process described in this protocol, with prior approval from WSDOT, may be enhanced or modified to support the modeler and the project team. All agreed upon decisions need to be documented in the Analysis Methods and Assumptions Document.

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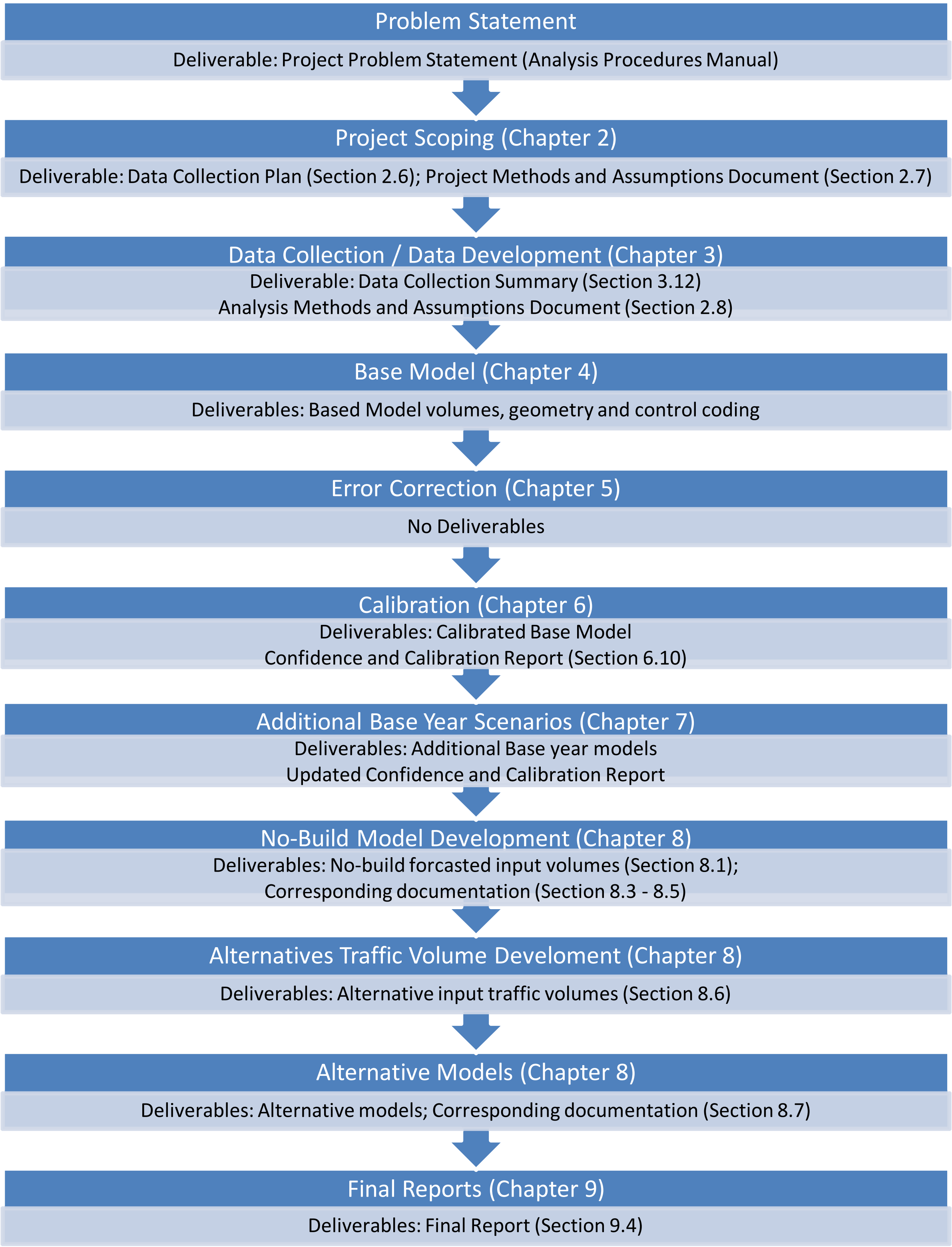
[2] Protocol for Vissim Simulation, C. Mai, C. McDaniel-Wilson, D. Noval, et al. (http://www.oregon.gov/ODOT/TD/TP/APM/AddC.pdf)

Figure A – Sample Review / Check-in Process for Typical Project



Problem Statement

Deliverable: Project Problem Statement (Analysis Procedures Manual)

Project Scoping (Chapter 2)

Deliverable: Data Collection Plan (Section 2.6); Project Methods and Assumptions Document (Section 2.7)

Data Collection / Data Development (Chapter 3)

Deliverable: Data Collection Summary (Section 3.12)
Analysis Methods and Assumptions Document (Section 2.8)

Base Model (Chapter 4)

Deliverables: Based Model volumes, geometry and control coding

Error Correction (Chapter 5)

No Deliverables

Calibration (Chapter 6)

Deliverables: Calibrated Base Model
Confidence and Calibration Report (Section 6.10)

Additional Base Year Scenarios (Chapter 7)

Deliverables: Additional Base year models
Updated Confidence and Calibration Report

No-Build Model Development (Chapter 8)

Deliverables: No-build forcasted input volumes (Section 8.1);
Corresponding documentation (Section 8.3 - 8.5)

Alternatives Traffic Volume Develoment (Chapter 8)

Deliverables: Alternative input traffic volumes (Section 8.6)

Alternative Models (Chapter 8)

Deliverables: Alternative models; Corresponding documentation (Section 8.7)

Final Reports (Chapter 9)

Deliverables: Final Report (Section 9.4)

Chapter Summaries

1. Project Understanding

Prior to creating a Vissim model, it is assumed that a Project Problem Statement has been completed (see WSDOT APM for outline), which identified the need for a microsimulation model. This chapter gives detail about what to consider before suggesting Vissim.

2. Project Scoping

This chapter helps to define the project boundary (based on the type of roadways), study period (including seeding period and model duration), the required project milestones (identifying who is responsible for reviewing and approving each milestone), items suggested during a field visit, and an outline for the Data Collection Plan.

These are all items that should be a part of either the Project or the Analysis Methods and Assumptions Document. The purpose of these two documents is discussed in this chapter, as well as the location of where you can find a detailed outline for each.

3. Data Collection/Data Development

This chapter identifies the data to consider collecting (the lists should be considered a starting point) and approved/recommended methods of collection.

4. Base Model Development

There are several ways to code each type of intersection and many parameters to consider for each road type, this chapter outlines the methods and parameters preferred by WSDOT. Any method or parameter that isn't listed as being preferred by WSDOT will need to be documented and approved by WSDOT.

5. Error Correction

This chapter outlines the steps to correcting errors in a Vissim file: verify all Vissim inputs, check animation, and correct any errors found. Before continuing on it is necessary to ensure none of the listed errors are present in the base model. This is also the majority of the items on the list that will be used to review the models.

6. Calibration

After the model has been checked for errors and approved by WSDOT to continue on to calibration, this chapter will help outline which parameters should be documented as well as examples, such as charts, tables, and figures, on how to present the calibration information. For certain parameters the target criteria is outlined. Any additional parameters that will be used to calibrate a model which are not already a part of this chapter should be outlined in the Analysis Methods and Assumptions Document.

7. Additional Base Year Scenarios

This is a short chapter outlining the appropriate steps for creating additional base models.

8. Future year Models (No-Build and Alternatives)

This chapter not only outlines the steps for developing the alternatives, but also the No-Build Design Year Base Model. Essentially, this chapter outlines which steps from Chapter 2 through Chapter 6 should be reevaluated for the alternative models, and which should not be changed.

9. Reporting

This chapter outlines the parameters that could be a part of the final report, depending on the size of your network and roadways in your network. The parameters to be reported should be outlined in the Analysis Methods and Assumptions document.

10. Reviewing

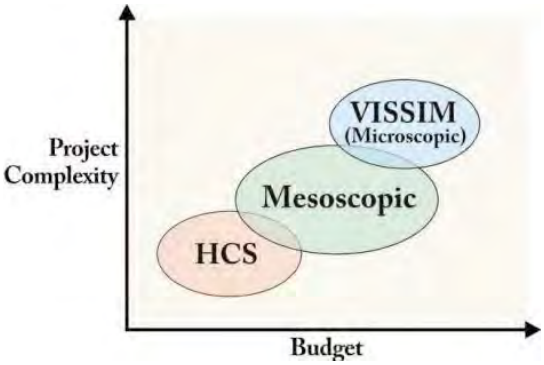
This chapter contains the checklist that is used to evaluate each deliverable required from Chapter 1 through Chapter 9.

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 (examples include HQ Access and Hearings, Assistant State Design Engineer, region representative for projects on non-NHS routes, and HQ Traffic Office for projects on the NHS routes) to reach internal agreement on key project goals early in the process. The components of the Project Problem Statement are described in the WSDOT Analysis Procedures Manual (http://www.wsdot.wa.gov/Design/Traffic/Analysis/).

1.1 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, SIDRA, or HCS 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 please see the WSDOT Analysis Procedures Manual (APM).



If microsimulation is desired, further decisions will be needed concerning advanced software features such as 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 (see Figure 1 - Reviewing Authority):

1. What data needs do you have that the advanced feature will provide?
2. Has this feature been used / applied successfully on a project by the agency that will be responsible for producing the Vissim model? What issues or technical difficulties with the use of this advanced feature have been encountered in the past, and how were they overcome?
3. In project experience, what have been the advantages of using this feature?

4. Based on the project analysis needs 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 should be completed by the sponsor agency scoping team. 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. The Project Problem Statement is discussed and outlined in the Analysis Procedures Manual.

1.2 What Else Should be Considered?

For many projects, the use of more than one analysis tool may be necessary. Use the least complex and data intensive software reasonable for any give project. Use the latest software version, with the exception of PTV products. For Vissim, use version 5.40 (with the most current service pack). For Visum, use version 12.5 (with the most current service pack). The type and application of each analysis tool should be fully documented in the Analysis Methods and Assumptions Document.

Vissim can be used 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 always be the best tool to evaluate the duration of congestion. Other options such as a mesoscopic, or a macroscopic model may be used but have limitations as well.

2. Project Scoping

To facilitate the project scoping process, an example of a Scoping Checklist form that includes all steps recommended by WSDOT for a Vissim project is available in Appendix C. 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 (including consideration of future network conditions). This could range from one intersection from the end of the project to over two miles outside the project boundary. This allows for the model to achieve real-world traffic behavior in the project area. The zone of influence may be greater than the minimum study area boundaries and should be determined with the 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. The following are some general guidelines for determining a zone of influence for freeways and arterials.

A “zone of influence” defines the project boundary where analysis will occur, and includes the study area as well as a surrounding buffer area.

2.1.1 Freeways and Ramp Terminals

The Vissim network should extend at least one interchange (including ramp terminals), or at least two more miles outside of the study area. When modeling system interchange areas, this zone of influence could be much greater. In addition, special consideration should be taken to allow for correct lane-choice behavior including neighboring 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. However, reporting the calibration should include the zone of influence. 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 within budget and time constraints, 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. Any special coding like this should be discussed in the Confidence and Calibration Report (Section 6.10) and it must be demonstrated that this will not have an influence on the study area in both the base year and future year models.

The Vissim network should include ramp terminal intersections as part of the project and, in order to model them correctly, should extend, 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 influence the intersection has on operations in the ramp terminal area. Similar to the freeway zone of influence, these additional intersections might not be a part of the study area. Thus, performance measures might not need to be reported for these intersections. All boundaries shall be reviewed through field observations and discussions with WSDOT 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 extend, 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 either of these conditions exists, 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 WSDOT for approval as part of the Analysis Methods and Assumptions (A-M-A) document, described in the WSDOT APM. All boundaries shall be reviewed through field observations, discussed with WSDOT staff, and outlined in the A-M-A to ensure that they are logical break points in the roadway network. Projects where an interstate is involved requires HQ review, all remaining projects requires at minimum region review (see Figure 1 - Reviewing Authority).

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 WSDOT staff. Analyzing the entire corridor allows WSDOT 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 WSDOT's Analysis Procedures Manual for guidance on using Synchro and conducting a "progression analysis."

Once WSDOT staff agrees to the signal timing used in Synchro for the project alternatives, the signal timing can be placed into Vissim. WSDOT 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 Analysis Methods and Assumptions document described the WSDOT APM.

2.2 Project Study Period

The model study period is the seeding period plus model duration. Final determination of the simulation 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 begin prior to onset of congestion / queuing, extend through the peak hour, and continue until congestion starts to dissipate.

2.2.1 Seeding Period

The seeding period should be the longest of the following four criteria (see Appendix D for additional guidance):

1. A minimum of 10 minutes.
2. The number of vehicles in the network levels off, or in highly congested networks, the rate of increase may slow down but the number of vehicles still continues to increase throughout the simulation.
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.

The project study period should include a seeding time that is long enough to capture the congestion period occurring in the field.

2.2.2 Model Duration

Freeways

Field observations and/or analysis of queue and count data should be used to help determine the appropriate time period that should be modeled.

Historical traffic data and field observations should be used to determine the appropriate peak period of the freeway network for the study area. The proposed study period shall be submitted to WSDOT for approval as part of the Analysis Methods and Assumption Document described in the WSDOT Analysis Procedures Manual.

Arterials

A typical near-term/opening year intersection vehicle delay, v/c, and level of service (LOS) analysis using deterministic software packages such as Synchro, SIDRA, or HCS focus on one hour of data. More often, the 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. 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 but the longest queues may occur just after the peak hour of traffic demand. When that is the case, a peak hour model is not sufficient for analysis. In general, when queues extend geographically or temporally beyond the peak hour, HCM methods will rarely be able to add value. To emulate a PHF a simulation should define volume bins in 900 second increments. These bins should be populated mathematically and or by count data.

Similar to freeway simulations, the typical study period should include a seeding period plus the simulation period. However, in some cases it may be adequate to measure only the peak hour of the peak period if the congestion starts to dissipate within that hour.

2.2.3 "Special Cases"

In some cases the study period identified is much longer than what is reasonable to model based on available data. For example, if the time between the onset of congestion, through the peak period, until the congestion starts to dissipate is 3 hours or more there should be discussions amongst the stakeholders to determine if the existing data available is sufficient enough to calibrate over multiple hours.

If data is limited, preloading the network is a possible solution. This involves artificially increasing the volumes prior to the peak period to more rapidly seed the model. Models that employ this technique should use caution when calibrating and reporting results.

2.3 Project Schedule and Staffing Plan

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

2.3.1 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 following table lists the typical milestones corresponding to the deliverables for each Vissim project. Each deliverable or milestone must be reviewed and accepted by the representative or group identified in the table below before proceeding to the next step in the process:

Figure 1 - Reviewing Authority

Milestone	Projects on NHS Routes*	Projects on non-NHS Routes
1. Project Problem Statement	Stakeholders Group	Stakeholders Group
2. Data Collection Plan and Project Methods and Assumptions Document	HQ Traffic	Region Traffic
3. Data Collection Summary and Analysis Methods and Assumptions Document	HQ Traffic	Region Traffic
4. Base Model (Geometry, Volumes, and Control Coding	HQ Traffic	Region Traffic
5. Calibrated Base Model; Confidence and Calibration Report	HQ Traffic	Region Traffic
6. Additional Base Year Models and Updated Confidence and Calibration Methodology Report	HQ Traffic	Region Traffic
7. Future No-Build Volumes	HQ Traffic	Region Traffic
8. Future No-Build Model with Corresponding Documentation	HQ Traffic	Region Traffic
9. Future Alternative Traffic Volumes	HQ Traffic	Region Traffic
10. Future Alternative Models with Corresponding Documentation	HQ Traffic	Region Traffic
11. Final Analysis Report with all Alternative Models	Stakeholders Group	Stakeholders Group

*Federal funding or federal purview (i.e. Stewardship agreement).

2.3.2 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 well, 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, it is recommended that only one modeler at a time be working on the network. To encourage this linear workflow, WSDOT requires multiple check-in points through the coding process prior to beginning the next step in development of the model, which will reduce 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 WSDOT to stay current in the coding process. A flow chart outlining the development of all models throughout the course of a project can be found in Appendix E. The preliminary date of the check-ins and the associated deliverables to be submitted must be included in the Analysis Methods and Assumptions document, understanding these deadlines are subject to change (allow for reasonable review time between milestones).

2.3.3 Staffing Plan

As part of the Analysis Methods and Assumptions document, the consultant shall be required to submit a detailed staffing plan, see WSDOT APM for an outline.

The purpose of this staffing plan is to ensure that WSDOT 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 Washington (or near the project area, for projects located near a state border) to increase understanding of the study area and facilitate field observations. If a change in modelers is desired during the course of a project, WSDOT should be notified.

2.4 Field Visit

As part of the scoping process the consultant shall perform at least one site visit to the study area during peak and/or projected design period traffic conditions to determine any project specific considerations as outlined previously (it is preferred that this field visit be performed by the modeler(s)). 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
- Site specific congestion dynamics
- Any special or complex signal timing features
- Non-motorized operations
- Special modes (e.g., transit, unique design vehicles)

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 data needs, calibration target issues and goals, and where the model should be calibrated.

2.5 Key Calibration Locations

Calibration criteria for the study area are described in detail in Chapter 6. These criteria require that a certain percentage of the entire network be within certain thresholds for volumes, speed, travel time, etc. The locations that do not meet the criteria should be discussed in the Confidence and Calibration Report. As an additional quality check, a list of key calibration locations in the network (both existing and future) 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 purpose of identifying these locations during the scoping process is to ensure that the required data is collected at these points in the network. The list of locations shall be determined by the stakeholders group and included in the Analysis Methods and Assumptions Document. Results from the calibration of these links shall be individually reported in the Confidence and Calibration Report as outlined in Section 6.3.

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 WSDOT 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
- Time and Date of collected data
- Means of projecting previously collected data to Base Year

<u>Deliverable</u>: Data Collection Plan

2.7 Project Methods and Assumptions Document

A Project Methods and Assumptions document shall be developed and includes information such as: Project Description, Study Area, Analysis Years, any known project assumptions and deviations, and a schedule. A detailed outline can be found in the WSDOT Design Manual, Chapter 550 – Interchange Justification Report.

2.8 Analysis Methods and Assumptions Document

An Analysis Methods and Assumptions Document (A-M-A) shall be developed and include information such as (note: each project is unique, this is not an exhaustive list, there may be additional information that is appropriate to establish upfront in this A-M-A):

Chapter 1

- 1.2 – Identify type and application of each analysis tool

Chapter 2

- 2.1.2 – Indicate strategy for replicating any spillback or bottlenecks that aren't fully contained in the study area
- 2.2.2 – Describe proposed study period
- 2.3.2 – Provide preliminary schedule for check-ins and deliverables
- 2.3.3 – Provide staffing plan
- 2.5 – Indicate key calibration locations

Chapter 3

- 3.6 – Indicate speed spot data to be used

Chapter 4

- 4.1 – Indicate proposed version and build of all software that will be used
- 4.3 – Provide whether a vehicle classification count will be conducted
- 4.8.1 – Describe the methodology that will be used to develop the speed distribution profile

Chapter 6

- 6.2.3 – Describe the methodology for calibrating a multi-hour model
- 6.2.4 – Outline any proposed revisions to the calibration criteria
- 6.2.4.3 – Establish the segments and travel intervals to be evaluated during calibration
- 6.2.4.5 – List potential weaving locations
- 6.2.4.7 – Identify calibration targets for transit

Chapter 9

- 9.1 – List additional required data outputs for freeway and arterials
- 9.3 – Outline methodology for compiling data

After the A-M-A has been signed, if there is a need for an amendment all stakeholders must agree on any changes. A detailed outlined can be found in the WSDOT Analysis Procedures Manual.

This Analysis 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.

The Vissim specific assumptions made during model development should be discussed with the stakeholders group and documented in a later document (Confidence and Calibration Report).

3. DATA COLLECTION / DATA DEVELOPMENT

Section 3 of the WSDOT Analysis Procedures Manual (APM)[3] 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, desired MOEs, or a simulation

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[3] Add WSDOT APM reference

recording for a public meeting) 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. A field visit is required to verify this data, it is preferred that this be completed by the modeler(s).

Geometric data to be collected must include:

- Number and width of lanes
- Significant grades that could affect flow rates (>3%, <-3%)
- 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 and bike locations and widths
- Crosswalk locations, widths, and lengths raised median, pedestrian refuges, and islands parking locations and dimensions
- Transit facility locations
- Roundabout inscribed diameter, circulating lane width, entry angles
- 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 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 for 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 should include:

- Posted speed or speed limits and free flow speeds
- Intersection controls
- Traffic signal characteristics
- Signal timing / time of day plans (e.g., cycle length, green time, and pedestrian minimum times). Time of day plans should be obtained from either the region or local agencies, when available.
- Movement permissions (e.g., right turn on red, no turn on red, U-turn permitted, protected/permitted phasing, overlaps)
- Stop bar locations
- Detection zones

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

- Rail crossing control and usage
- Ramp meter timing
- Freeway guide sign locations
- Transit signal priority parameters
- Toll plaza information (e.g. capacity, number of booths, etc.)
- HOT lanes information (e.g. hours of operations, lane use definition, fee structure, etc.)

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 WSDOT staff and the volume data should be collected during the peak month and day of the week (Typically Tuesday – Thursday) excluding weeks that contain holidays. In addition, the week before and the week after a holiday should be avoided.

To use data over three years old concurrence from WSDOT staff is required. A sensitivity analysis must be conducted to determine the regional and/or local growth rates that have occurred over the period of time in question. If it is determined that little to no growth has taken place, and WSDOT staff agrees, volumes older than three years may be used.

It is preferred that traffic volumes be collected in 15-minute increments for the entire study period. If feasible, traffic volumes should be collected on the same day at all locations throughout the entire study area and should coincide with other data collection and field observations (e.g., vehicle speeds, travel time, duration of congestion, queuing, etc.).

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). 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. This is needed in order to properly model the level of congestion and queuing that is observed in the field.

Once data collection has been completed, the consultant must review the data for errors and balance traffic volumes following the APM guidelines.

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 WSDOT during the scoping process. Vehicle classification counts may need to be collected at more locations depending on the purpose and location of the model; WSDOT 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., TDGO) may be used as 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 WSDOT 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 WSDOT through the scoping process.

Pedestrian and bicycle count data should be collected for all arterial networks to be modeled in Vissim. This data must be collected in 15-minute increments for the entire study period and consist of crossing events, regardless if it is a pedestrian or cyclist.

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 WSDOT for each application. One possible procedure could include:

- estimating 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).
- developing hourly volume profiles for study area links from sources such as roadway tube-counts or nearby traffic data recorders
- adjusting 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 Balancing

The suggested method for balancing volumes differs based on the collection method. When volumes are collected using a combination of PTR's, tube counts, and hand counts. It is recommended that volumes from TDGO, such as volumes from the PTR and tube counts, be adjusted as little as possible since they have already been post processed by TDGO. However, for locations with recurring congestion special care needs to be given to balancing and adjustments of traffic counts as counts are likely measuring throughput volumes instead of actual demand volumes. It is possible for a PTR location to be counting constrained throughput volumes, and using such a PTR location as a fixed volume could lead to under stated congestion in the calibration model.

When volumes are collected from a travel demand model, although the volumes are balanced, they should be checked for reasonableness. Specifically the turning movements at intersections, to ensure the volumes seem realistic.

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 WSDOT, 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 WSDOT 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 WSDOT 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 WSDOT.

Two travel time data collection techniques can be used. The method to select depends on the type of data being collected.

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. WSDOT 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 WSDOT 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, WSDOT may require the statistical calculation outlined in the FHWAs' 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:

$$N = \left(2 * t_{0.025, N-1} \frac{s}{R} \right)^2$$

Notes:

- R = 95-Percent confidence interval for the true mean (acceptable margin of error approved by WSDOT, e.g. +/- 5 seconds, +/- 10%)
- T0.025,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

A simple method that can be used to double check the above methodology with existing conditions involves the general matching of congestion from Google Maps Traffic via their history selection. This is very generalized but the calibrated model should not be far from what Google Maps shows.

The chosen methodology, number of runs, and locations of data collection must be approved by WSDOT 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.

In the absence of any available spot speed data a speed near the posted speed may be proposed to be used as the free-flow condition or during the calibration process. The proposed speed must be documented in the Analysis Methods and Assumptions Document.

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., TDGO) 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 F as well as Figure 30.

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 (measured in the field) should always be used as a visual comparison to verify that the Vissim model (over multiple runs) 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., TDGO) 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 (over multiple runs) 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 at some given interval. This interval could be the cycle length for a critical intersection or 120 seconds as a default. 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

The transit data collected depends on the level of detail needed to address the Project Problem Statement. For all arterial models where transit currently exists or is proposed to be implemented, the location of transit stops in the study area and transit headways (via transit schedules) must be compiled. For freeway models, transit headways, location of flyer stops and park and rides must be compiled.

If an arterial Vissim model is being built to focus on the evaluation of transit operations, the consultant and WSDOT 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
- 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
- Transit signal priority
- Schedule variability
- 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 4.11.1.2). 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, WSDOT may require saturation flow data to be collected. Collection of saturation flow data shall follow HCM 2010 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 WSDOT 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 WSDOT. WSDOT staff must review and approve the Data Collection Summary before Model Development can begin. The Data Collection Summary document should 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
- Vehicular classification breakdown by percentage
- Travel time data
- Speed data (not required for most arterial networks)

- Sink and source locations
- Any assumptions that will be made with any other data

Possible additional information, where applicable:

- Congestion maps (i.e. brain scans)
- O-D characteristics
- Queue findings

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 WSDOT APM. The Data Collection Summary must also clearly present the location 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.

Deliverable: Data Collection Summary

4. BASE MODEL DEVELOPMENT

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.

4.1 Possible Software Updates

The proposed version and build of the software must be documented in the Analysis Methods and Assumption Document. Until further notice WSDOT should not approve any software higher than version 5.40-11.

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 (Caution: GoogleEarth is not ortho-rectified). Vissim versions 5.4 and prior do not import drawings to scale; therefore, it is important that the modeler use care to accurately scale the aerial photo to the network.

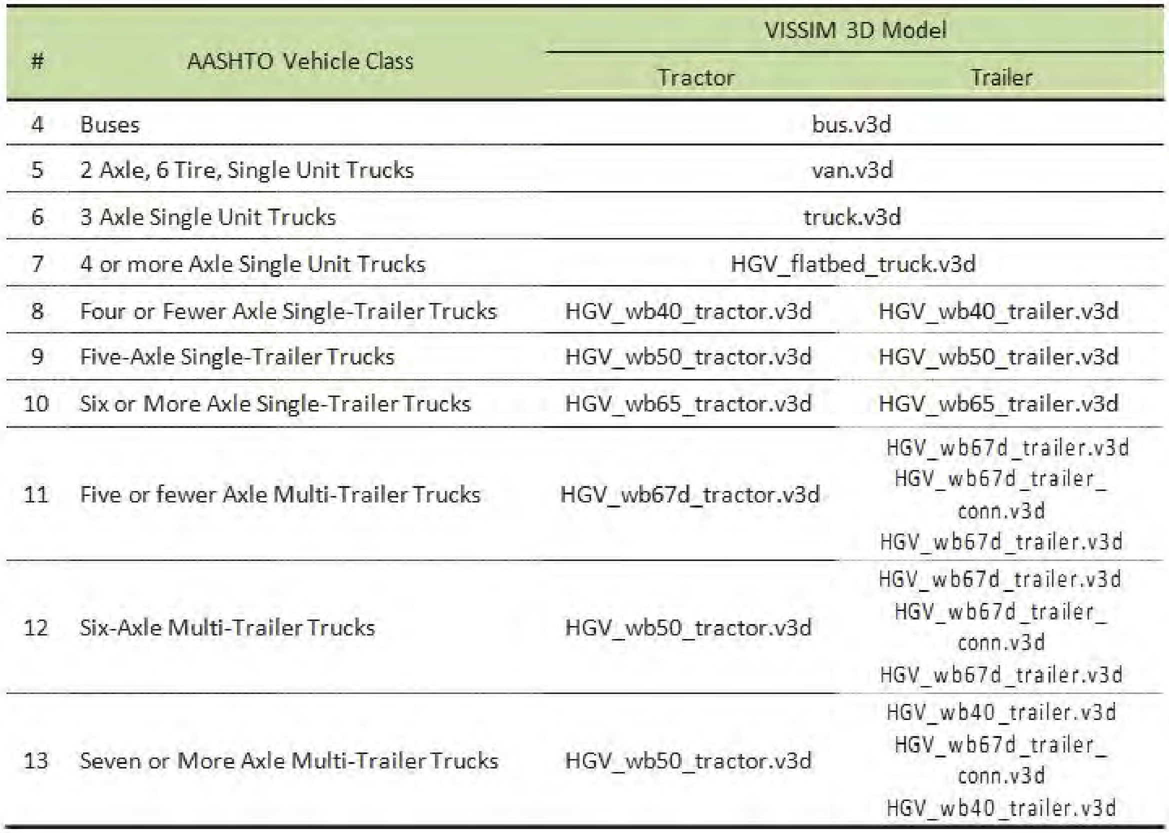
4.3 Traffic Compositions

A vehicle classification count is highly recommended. If this is not part of the study, justification must be outlined in the Analysis Methods and Assumptions Document and approved by WSDOT.

The preferred method of conducting a vehicle classification count is by means of gathering data from PTR (contact TDGO), tube counts, or manual counts in combination with field observations and engineering judgment.

The "Car" and "HGV" 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 on the WSDOT Traffic Analysis website (http://www.wsdot.wa.gov/Design/Traffic/Analysis/). 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.

The following 3D models (shown in Table 1) are recommended for each AASHTO vehicle classification:



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

Table 1 - Suggested 3D Models by FHWA Vehicle Class for Heavy Vehicles

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 occupancy counts, but should be coordinated with WSDOT 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 2 is generally controlled by the routing through the area and lane change distance parameters. Connector lengths should be minimized for freeway coding.

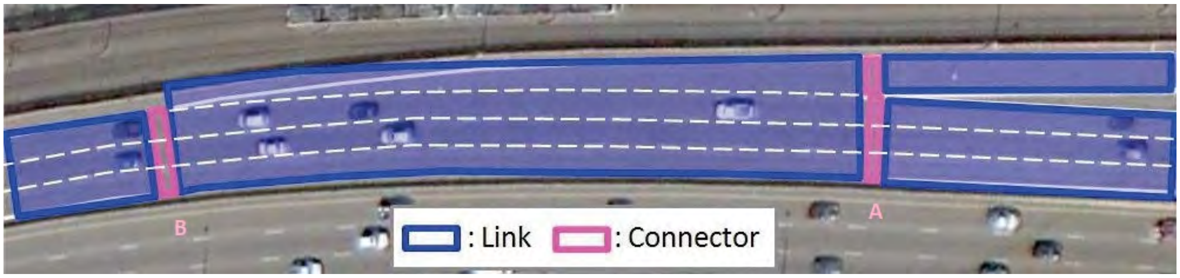
Figure 2 - Typical Freeway Entrance Ramp Merge Area

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 downstream of the merge link (see connector B in Figure 3) or at the end of a lane drop section.
- There should be two connectors upstream of the merge link (see connectors at location A in Figure 3), one for the ramp link and one for the main freeway link.
- One of two options should be implemented to avoid unrealistic lane changes on mainline into the acceleration lane:
    - Ensure that the “Lane Change” distance, in the Connector dialog box, for the connector B (in Figure 3) is longer than the length of the merge area.

      OR
    - Indicate “no lane change” for the appropriate lane, using the Link dialog box

Figure 3 - Suggested Coding of a Freeway Merge Area



In order to properly code diverging sections, first identify whether the diverge section is functioning as a parallel (Figure 4) or taper ramp (Figure 6). To function as a parallel ramp diverge area in Vissim, the ramp lane will typically extends 700 ft or more.

Figure 4 - Typical Freeway Exit Ramp Diverge Area (parallel)

For coding a parallel Freeway Exit Ramp diverge area, these points should be followed:

- The effective diverging area should include the entire auxiliary lane (or drop lane) starting at the taper and continuing to the painted gore point.
- The diverge section will be one link with the number of lanes equal to the number of lanes on the main freeway plus the number of lanes diverging off the freeway.
- There should only be one connector upstream of the diverge link (see connector A in Figure 5).
- There should be two connectors downstream of the merge link (see connector B and C in Figure 5), one for the ramp link and one for the main freeway link.

Figure 5 - Suggested Coding of a Freeway Diverge Area (parallel)

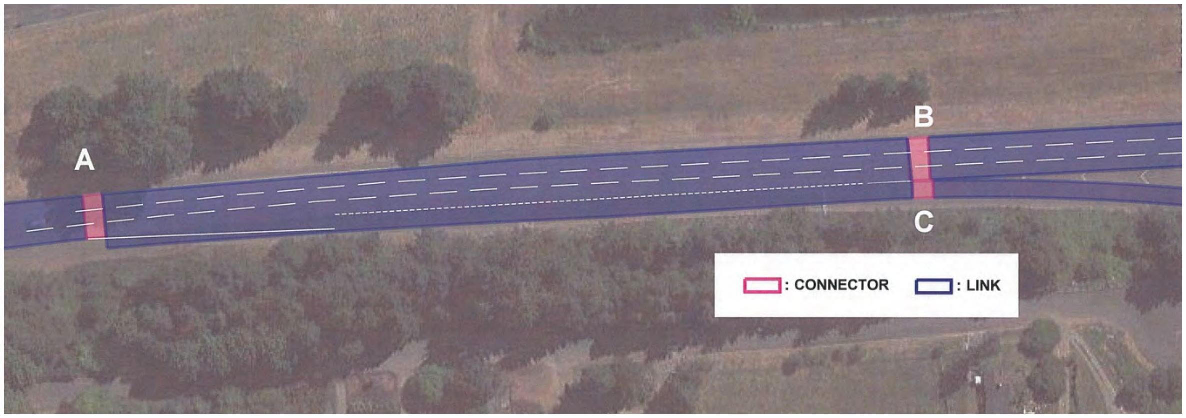
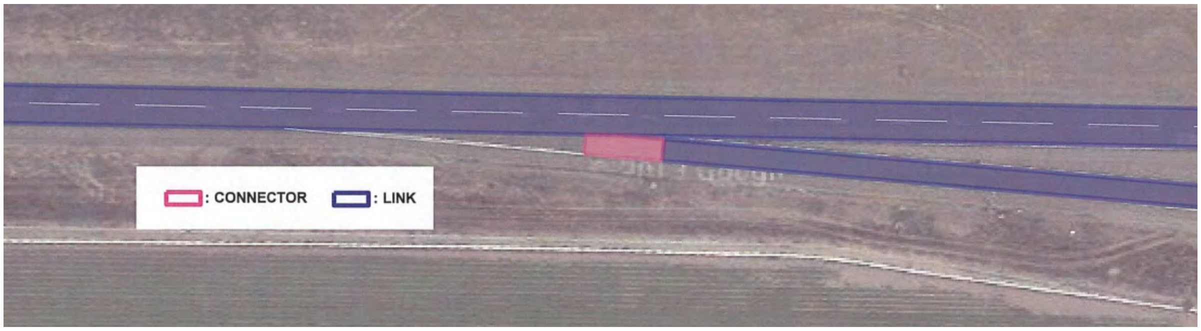


Figure 6 - Typical Freeway Exit Ramp Diverge Area (taper)

For coding a taper Freeway Exit Ramp diverge area (Figure 7), these points should be followed:

- There is no need to break the main freeway link with a connector
- There should be one connector placed at the painted gore point connecting the main freeway link to the ramp link.

Figure 7 - Suggested Coding of a Freeway Diverge Area (taper)

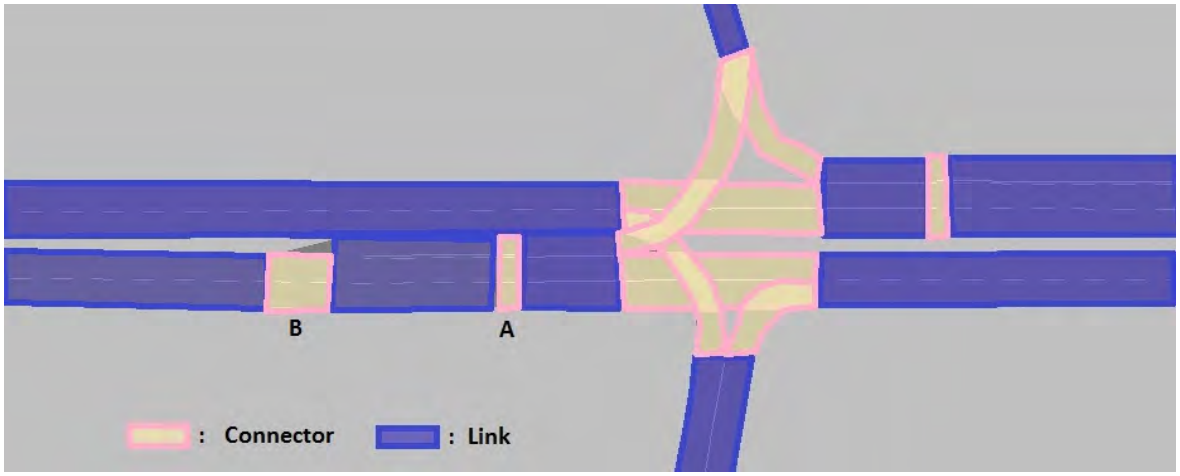


4.4.2 Arterials

There are two options for coding turning bays. The first option is coding a turning bay similar to the merging and weaving areas. In this option connectors should start at the beginning of the taper and end at the point the bay reaches its full width (not necessarily where the striping begins). The section of roadway adjacent to the turn bay should be one link with the number of lanes equal to the number of lanes on the mainline plus the number of lanes in the turn bays. To ensure there is no unrealistic lane changes between the through and turning vehicles these points should be followed (see Figure 8):

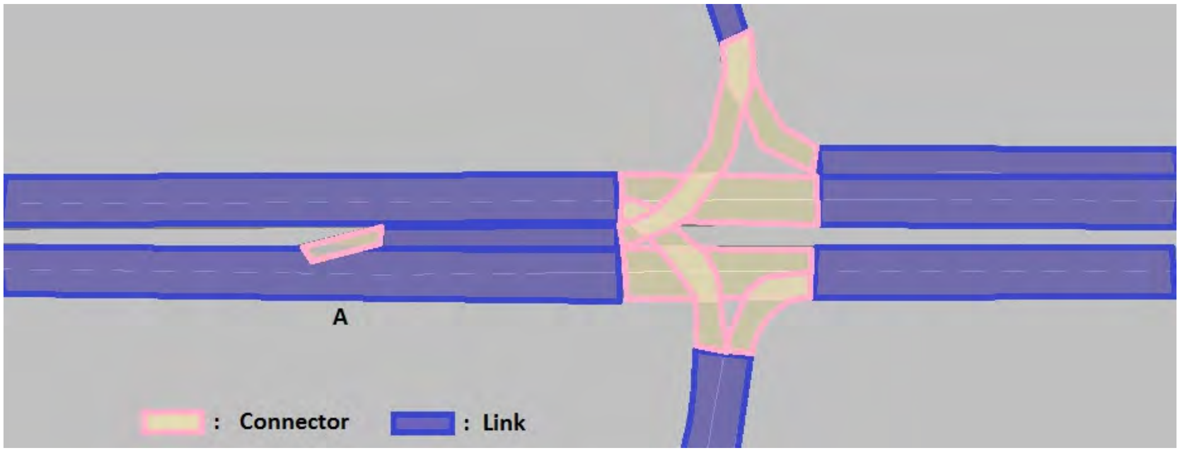
- Break link with turn bay about 50 ft from the stop bar (see connector A in Figure 8).
- In the link with the turn bay closest to the intersection code, "no lane change" both in and out of the turn bay, in the Link Data dialog box.
- In the link with the turn bay farther from the intersection, code "no lane change" only out of the turn bay, in the Link Data dialog box.
- In the Connector dialog box for the connector attached to the end of the turn bay (Connector A in Figure 8), enter an emergency stop to be about the length of the turn bay minus 35 ft. In the same dialog box enter the lane change to be well beyond the length of the turn bay, this should point back to the location that it would be logical for a vehicle to consider turning left (ex: location of a directional sign).

Figure 8 - Suggested Coding of a Turning Bay (Option 1)



The second option is coding a turning bay as a separate parallel links (see Figure 9) where vehicles enter the turn bay at the beginning of the bay, which helps ensure that no unrealistic lane changing occurs between the through and turning vehicles. In this option 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).

Figure 9 - Suggested Coding of a Turning Bay (Option 2)



It should be noted that when using the ANM import from Visum, Vistro, or Synchro, turn bays are coded as an additional lane of the through link (option 1). 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. See HQ Traffic for special overlap issues, placement of artificial stop signs, and other coding.

4.4.3 Roundabouts

Roundabouts can be modeled with either conflict areas or priority rules. Both methods provide benefits. Typically, either method is acceptable for single lane roundabouts and priority rules are recommended for multi-lane roundabouts (with minimal conflict area use). Conflict areas provide more realistic and complex driver behavior and decision-making. 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, priority rules are the recommended choice. 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 10. 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).

Figure 10 - Example Conflict Area at Roundabout

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 aggressively 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.

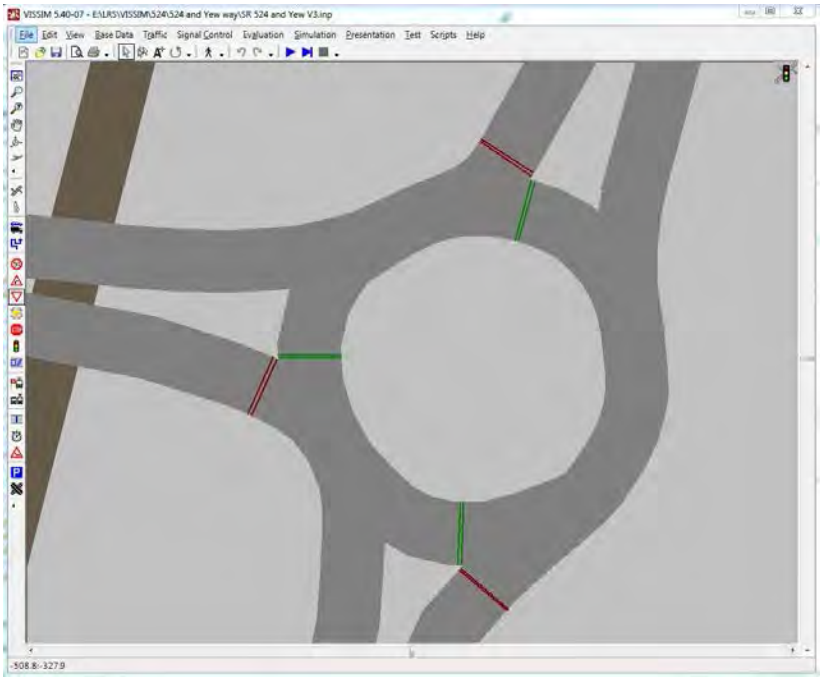
Calibration of volumes and settings will need to be demonstrated for existing roundabouts. If the analysis is for a proposed roundabout, settings used on a similar calibrated roundabout will need to be verified and submitted.

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 multi-lane roundabouts, consider coding the interior and exterior lane with different gap times, if appropriate.   Gap times of between 3 and 4 seconds are recommended for cars and HGV, respectively. These values 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. Since proposed roundabouts cannot be calibrated to field data, existing gap times for roundabouts similar to the proposed roundabout may be approved by WSDOT.

While the gap time can be easily defined, the placement of priority rules is more difficult (see Figure 11 for example). 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, this allows for separate gap times to be assigned. When large trucks are expected to take both approach lanes, opposite priority rules need to be placed upstream of the yield point so that only one truck stages to enter the roundabout at a time (this is meant to mimic the real world scenario that trucks use both lanes of a multi-lane roundabout). Contact HQ Traffic for details.

Figure 11 - Example Priority Rules at Single Lane Roundabout



Operational Speeds

Roundabout analysis is also affected by operational speeds. The NCHRP Report 672 or field collected speed data at roundabouts of similar characteristics should be referenced 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 (see Section 4.8 for more details on reduced speed areas and desired speed decisions). 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. These design elements will help determine desired operational speeds. 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 Confidence and Calibration Report. When coding a roundabout remember there are three basic yield practices experienced in real world situations:

1. Enter at speed: a vehicle approaches a roundabout without the need to slow down beyond the entrance speed because a gap is present at the time of arrival
2. Enter via follow-up: vehicle #1 approaches a roundabout where vehicle #2 is just starting to move off of the yield line, so vehicle #1 must slow down lower than the entrance speed, but not to a complete stop, before entering the roundabout
3. Enter after full stop: a vehicle approaches a roundabout and must come to a complete stop to wait for a gap, then start from a full stop to enter the roundabout

Each of these conditions has different microsimulation time and distance gap characteristics. Replicating these conditions requires dynamic gap acceptance, which is found in an operational analysis tools like SIDRA. Only when roundabouts exist or are proposed at locations which will affect or be affected by other infrastructure related traffic dynamics, is microsimulation the recommended analysis approach.

Condition 1 can have short time and distance gap settings. Condition 2 needs to be a little longer, and condition 3 can result in the aforementioned gap settings of 3 sec. for cars, 4 sec. for trucks. Since Vissim can only set one time and distance gap for each priority rule, it is recommended to code condition 3. Conditions 1 and 2 will be hindered by the longer condition 3 gap settings, so Vissim will be very conservative for flow in the transition period from no congestion to congestion. It is possible to set multiple priority rules for mode and arrival speed but that would be very complicated and non-traditional.

Again, an operational analysis tool capable of dynamic gap acceptance, such as SIDRA, would better understand when traffic is likely to begin queuing and needing longer gaps to enter the circulating lanes and therefore would reflect this in a much more realistic output. But unlike SIDRA, Vissim can break the volume sets into sub-hour increments. Neither software is perfect but some understanding of when queuing begins is important because once it starts, the gap acceptance changes dramatically and queue lengths and durations can be greatly affected. This is especially important when queue length and duration is a project MOEs.

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. Keep in mind any future lane utilization and how the network may need to be revised to accommodate it. The methodology used to encourage appropriate vehicles into the HOV/HOT/Truck Only lane should be documented in the Confidence and Calibration Report.

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 (funded) and 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 or local agency/state time of day plans 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.

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 WSDOT 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 WSDOT 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 G. Coordination with WSDOT should be conducted to determine any alternative ramp signal timing that will be used in alternative models.

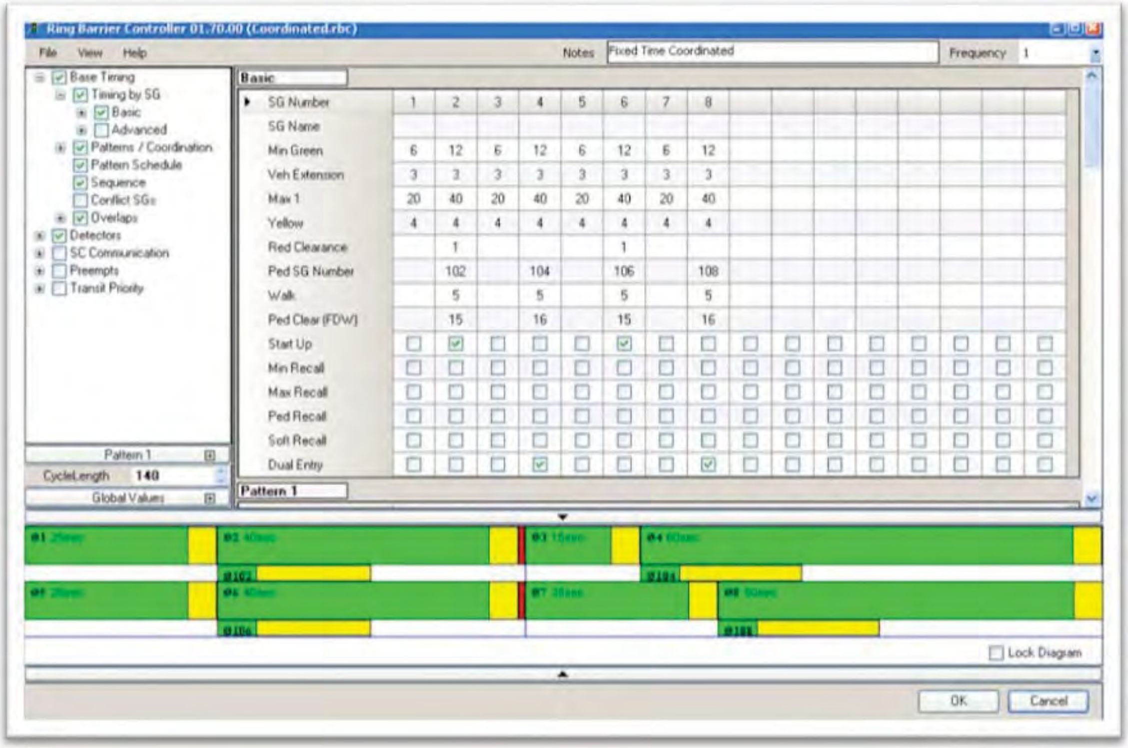
If static meter rates are used, consideration should be given to their operation in seeding times or times outside of measurement windows as inappropriate use can create unrealistic ramp queues during those times that can compound the situation during measurement times.

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 or Vistro files with optimized signal timings or can be directly coded into Vissim or Visum. Figure 12 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 be a factor of the simulation resolution (under Simulation/Simulation Parameters, change “Simulation resolution”). The checklist WSDOT will utilize for the review of this timing is included in Appendix H 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 (approved software can be found on the WSDOT Traffic Analysis website http://www.wsdot.wa.gov/Design/Traffic/Analysis/) 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 M-A and verified by WSDOT.

Figure 12 - Example of the Ring Barrier Controller Interface



Notes: Fixed Time Coordinated

Frequency: 1

- ☑ Base Timing
  - ☑ Timing by SG
    - ☑ Basic
    - ☐ Advanced
  - ☑ Patterns / Coordination
  - ☑ Pattern Schedule
  - ☑ Sequence
  - ☐ Conflict SGs
  - ☑ Overlaps
- ☑ Detectors
- ☐ SC Communication
- ☐ Preempts
- ☐ Transit Priority

Pattern 1

CycleLength: 140

SG Number	1	2	3	4	5	6	7	8								
SG Name																
Min Green	6	12	6	12	6	12	6	12								
Veh Extension	3	3	3	3	3	3	3	3								
Max 1	20	40	20	40	20	40	20	40								
Yellow	4	4	4	4	4	4	4	4								
Red Clearance		1				1										
Ped SG Number		102		104		106		108								
Walk		5		5		5		5								
Ped Clear (FDW)		15		16		15		16								
Start Up	☐	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	☐	☐	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐

Vehicle interactions with yellow lights vary among states, and even among cities. As outlined in the WSDOT APM, adjustments to driver reactions at signals may be required to better reflect the less aggressive nature often found in drivers in some areas, such as rural eastern Washington. 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, when coding a stop signs it should be placed 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. A conflict area and priority rule should not be used for the same conflict or movement.

Unlike 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. In some cases coding a stop sign in the model does not accurately replicate field conditions (resulting in more delay or longer queues). An additional parameter that will most likely need to be increased for these types of intersections is the number of Observed Vehicles (found in the Driving Behavior Parameter Sets). An alternative to coding a stop sign is to use a lower than typical reduced speed area (2-4 mph) in combination with conflict areas/priority rules to replicate a rolling stop.

4.8 Speed Control Coding

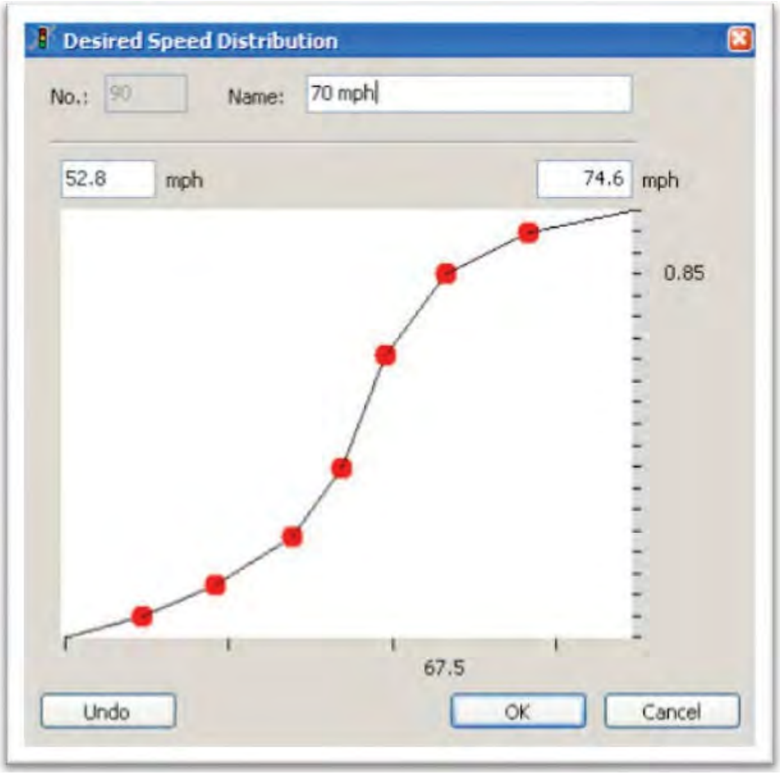
To control the speed of vehicles in Vissim, the modeler can apply a "speed decision" or "reduced speed" on a network link. Desired speed decisions change the desired speed of vehicles that cross it, and should be used when the free-flow speeds of an area have a significant change due to the posted speed 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). Vehicles reduce their speed to that coded prior to reaching the zone and maintain that speed through the zone, then increase to link speed after.

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 (both upstream and downstream), completely out of the study and calibration area and that are not anticipated to be fixed by the year of the future models. Vertical and horizontal curves can impart reduced speed zone issues. WSDOT approval is required when using desired speed decisions or reduced speed areas for these situations, for both existing and future year 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 inputted into Vissim. An example of a speed distribution profile is shown in Figure 13. Check with TDGO for speed flow maps in the project area. They may 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 WSDOT as part of the Analysis Methods and Assumptions Document.

Figure 13 - Example of Speed Distribution Profile



No.: 90

Name: 70 mph

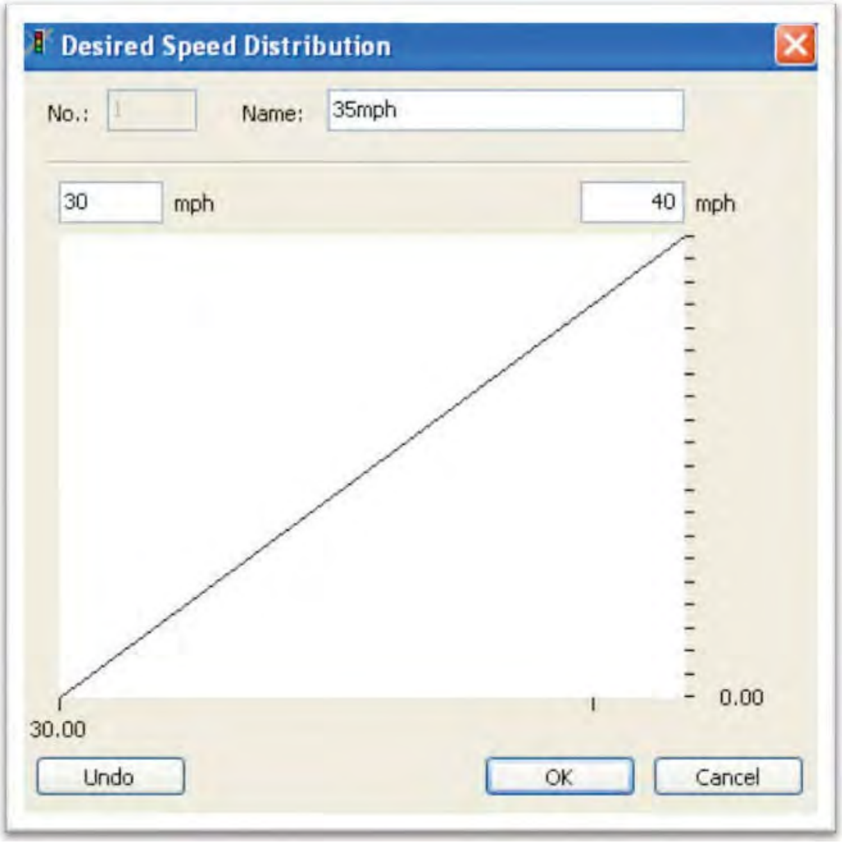
52.8 mph

74.6 mph

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 mph of the posted speed is sufficient. Figure 14 provides an example of the speed profile that would be developed for a 35 mph roadway.

Figure 14 - 35 mph Speed Distribution Profile for Arterials



Desired Speed Distribution

No.: 1 Name: 35mph

30 mph 40 mph

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 for cars are 15 mph for left turns and 9 mph for right turns, the reduced speed distribution for HGV is slightly less, at 10 mph for left and 5 mph for right turns, adjustments can be made within reason. The location and length of a reduced speed area is typically localized to the apex of the curve. The length of the reduced speed area (typically around 10 ft long) 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 Confidence and Calibration 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: static, dynamic, and origin-destination.

4.10.1 Static Routes

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. Traffic volumes in smaller networks with adequate intersection spacing can usually be coded as traditional intersection-to-intersection (point to point) 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 15 illustrates the recommended placement of routing decisions.

Figure 15 - Recommended Routing Decision Placement for Point to Point Static Routes

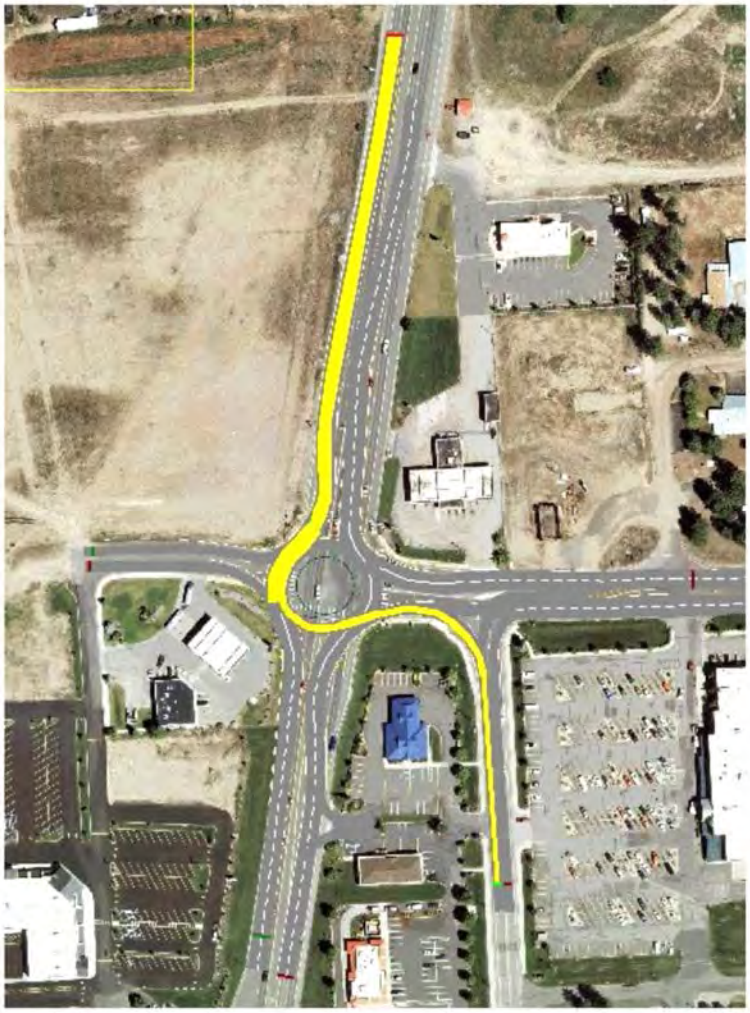
In some cases, such as freeways and corridors, this simplistic approach cannot replicate real-world conditions. If intersections or decision locations, such as a weave section, are spaced too closely, there will not be enough time for vehicles to change lanes to make their next assigned move. At closely 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 15, 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 16).

Figure 16 - Example of the Combine Routes Feature

For some models it might be more appropriate to route vehicles through the entire model (Figure 17).

Figure 17 - Example of Static Route through an entire network



4.10.2 Dynamic Routing

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. 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.

4.10.3.1 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 WSDOT must verify its use during the scoping process.

4.10.3.2 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 WSDOT 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 WSDOT.

4.11.1 Car Following Parameters

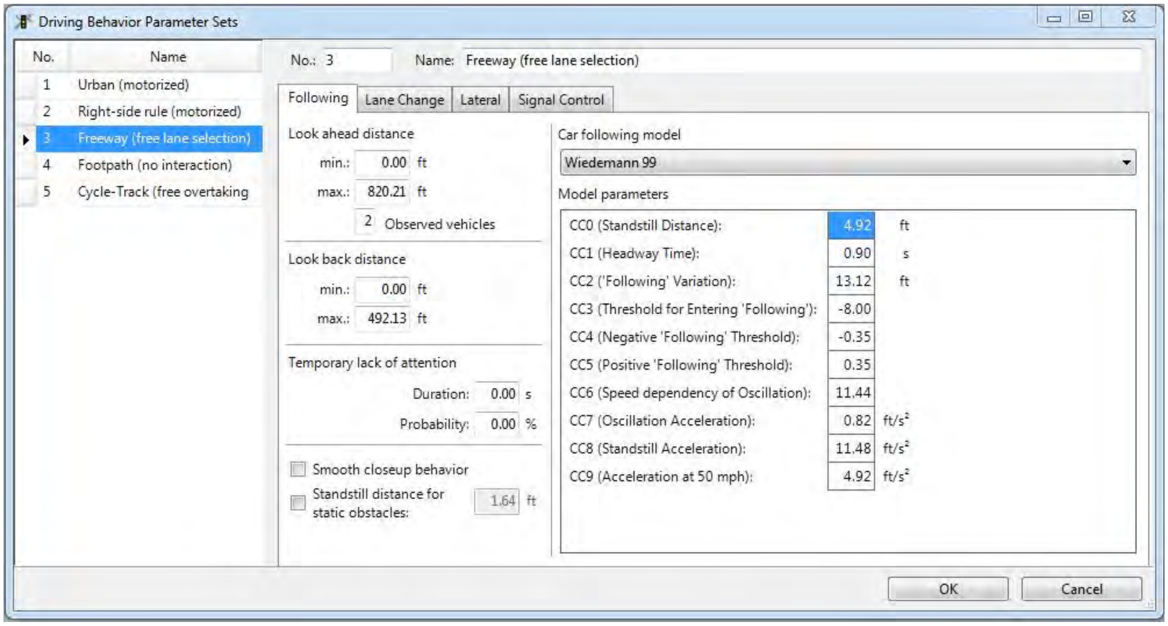
The traffic flow model in Vissim is a discrete, stochastic model that contains a psycho-physical car following model for all interactions along the same lane. Car following model in Vissim consists of two models applicable to different conditions:

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

4.11.1.1 Freeways (Weidemann 99 Model)

For freeway links and connectors, the Wiedemann 99 model should be selected for car following model (dialog box shown in Figure 18). 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 suggested values for these parameters that are outside the proposed ranges (see Table 2) should be documented with its reason and application in the Confidence and Calibration Report.

Figure 18 - Wiedemann 99 Car Following Model Dialog (NOTE: This figure is an example of the dialog box, for suggested defaults and ranges of values, see Table 2)



Driving Behavior Parameter Sets

No.	Name
1	Urban (motorized)
2	Right-side rule (motorized)
3	Freeway (free lane selection)
4	Footpath (no interaction)
5	Cycle-Track (free overtaking

No.: 3
Name: Freeway (free lane selection)

Following | Lane Change | Lateral | Signal Control

Look ahead distance
min.: 0.00 ft
max.: 820.21 ft
2 Observed vehicles

Look back distance
min.: 0.00 ft
max.: 492.13 ft

Temporary lack of attention
Duration: 0.00 s
Probability: 0.00 %

☐ Smooth closeup behavior
☐ Standstill distance for static obstacles: 1.64 ft

Car following model
Wiedemann 99

Model parameters

Parameter	Value	Unit
CC0 (Standstill Distance):	4.92	ft
CC1 (Headway Time):	0.90	s
CC2 ('Following' Variation):	13.12	ft
CC3 (Threshold for Entering 'Following'):	-8.00	
CC4 (Negative 'Following' Threshold):	-0.35	
CC5 (Positive 'Following' Threshold):	0.35	
CC6 (Speed dependency of Oscillation):	11.44	
CC7 (Oscillation Acceleration):	0.82	ft/s²
CC8 (Standstill Acceleration):	11.48	ft/s²
CC9 (Acceleration at 50 mph):	4.92	ft/s²

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 2 (U.S. Customary). Another parameter to consider adjusting, specifically for link types such as merge/diverge/weave areas, is the Observed Vehicles. Typically, this is increased to 4 for such areas.

				Suggested Range	
		Default	Unit	Basic Segment	Merging/ Diverging
CC0	Standstill Distance	4.92	Ft	4.5 - 5.5	> 4.92
CC1	Headway Time	0.9	S	0.85 - 1.05	0.90 1.50
CC2*	Following Variation	13.12	ft	6.56 - 22.97	13.12 - 39.37
CC3	Threshold for Entering Following	-8		Use default	
CC4	Negative Following Threshold	-0.35		Use default	
CC5	Positive Following Threshold	0.35		Use default	
CC6	Speed Dependency of Oscillation	11.44		Use default	
CC7	Oscillation Acceleration	0.82	ft/s2	Use default	
CC8	Standstill Acceleration	11.48	ft/s2	Use default	
CC9	Acceleration at 50 mph	4.92	ft/s2	Use default	

***Adjustments to CC2 default should only be made after CC0 and CC1 parameters have been adjusted and it is concluded those adjustments do not accurately replicate field conditions.**

Table 2 - Wiedemann 99 Car Following Parameters (U.S. Customary Unit)

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 Figure 19 through Figure 21.

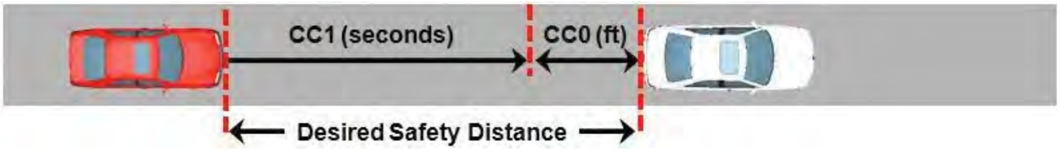
CC0 (Standstill Distance): Desired rear-bumper to front-bumper distance between stopped cars. This parameter has greater impact to desired safety distance (maximum flow rate) when traffic is in jam condition (speed equals zero).

Figure 19 - Standstill Distance Parameter (CC0)

CC1 (Headway Time): The distance (in seconds) that the following driver wishes to keep. The desired safety distance (shown in Figure 20) is determined every time step based on the following equation:

Desired Safety Distance = CC0 + (CC1 x speed)

Figure 20 - Headway Time (CC1)



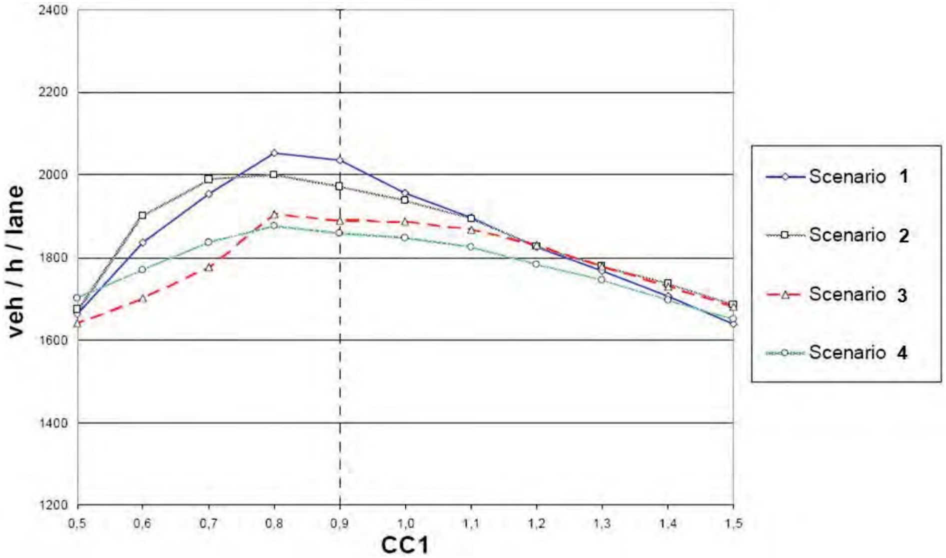
CC2 (Following Variation): The longitudinal oscillation during following condition. In other words, it defines how much more distance than the desired safety distance before the driver intentionally moves closer to the lead vehicle.

Figure 21 - Following Variation Parameters (CC2)

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 22 (using an example network, results not representative of all basic freeway segments), 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.

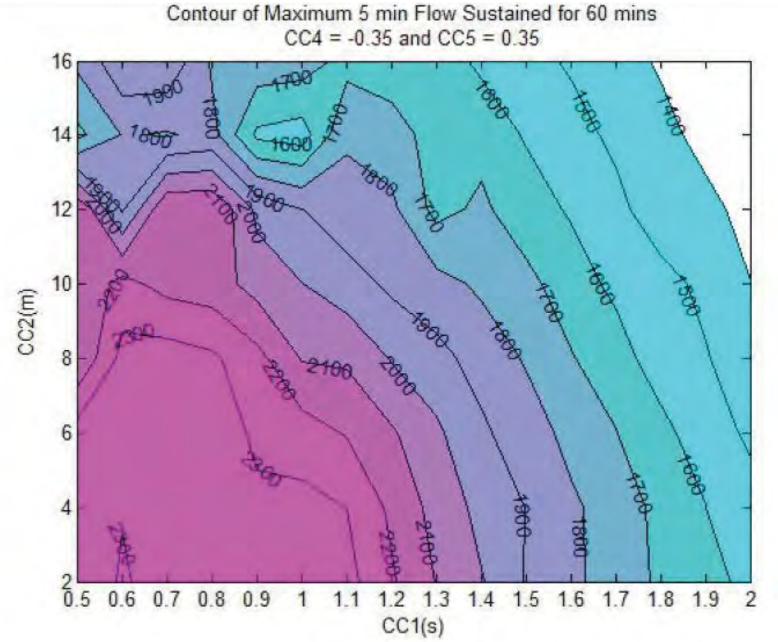
Figure 22 - Maximum Flow Rate vs. CC1



Scenario	Number of Lanes	Desired Speed (km/hr)	Right side Rule	Heavy Vehicle %
1	2	80	No	0
2	2	80	Yes	0
3	2	120	Yes	0
4	3	120	Yes	0

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 23, 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 23 - Maximum Flow Rate vs. CC1 and CC2[4]



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 in the Confidence and Calibration Report and approved by WSDOT staff.

4.11.1.2 Arterials (Wiedemann 74 Model)

For most arterial links and connectors, the Wiedemann 74 car following model should be applied. As shown in Figure 24, there are three parameters available for this model: average standstill distance, additive part of safety distance, and the multiplicative part of safety distance.

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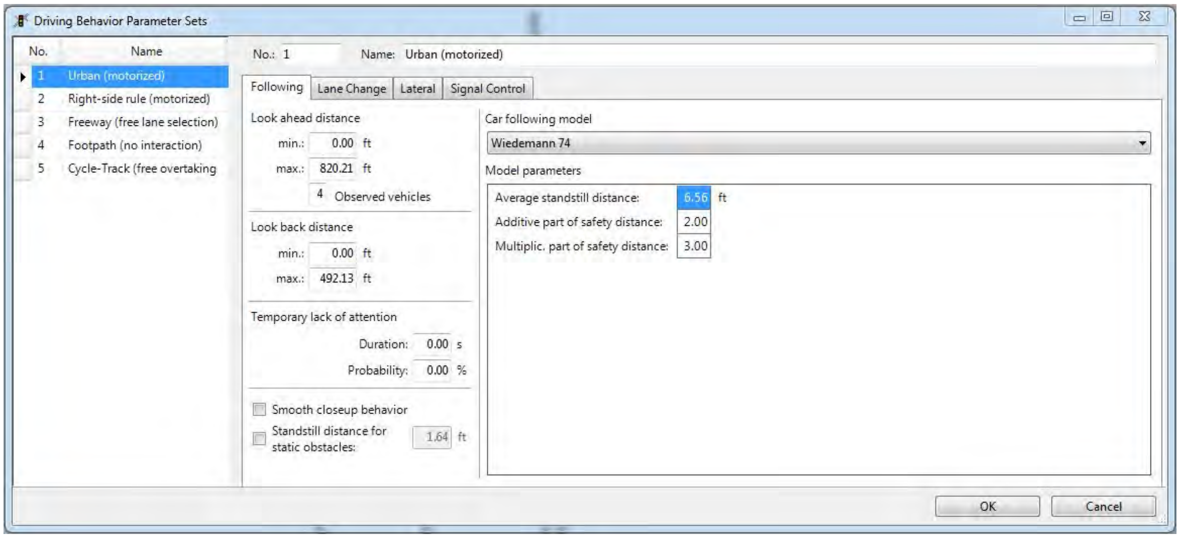
[4] Analysis of Wiedemann 74 and 99 Driver Behavior Parameters, S. Menneni, C. Sun, and P. Vortisch (http://www.ptvamerica.com/fileadmin/files_ptvamerica.com/An_Integrated_Microscopic_and_Macroscopic_Calibrati on_for_Psycho-Physical_Car_Following_Models.pdf)

Figure 24 - Wiedemann 74 Car Following Model Dialog



No.	Name
1	Urban (motorized)
2	Right-side rule (motorized)
3	Freeway (free lane selection)
4	Footpath (no interaction)
5	Cycle-Track (free overtaking

No.: 1 Name: Urban (motorized)

Look ahead distance
min.: 0.00 ft
max.: 820.21 ft
4 Observed vehicles

Look back distance
min.: 0.00 ft
max.: 492.13 ft

Temporary lack of attention
Duration: 0.00 s
Probability: 0.00 %

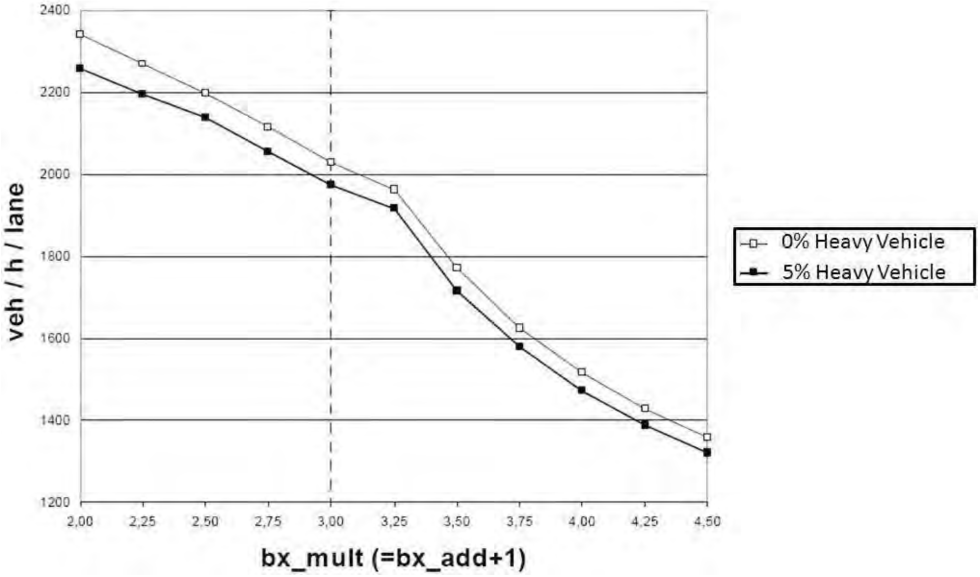
☐ Smooth closeup behavior
☐ Standstill distance for static obstacles: 1.64 ft

Car following model
Wiedemann 74

Model parameters
Average standstill distance: 6.56 ft
Additive part of safety distance: 2.00
Multiplic. part of safety distance: 3.00

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 25 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.

Figure 25 - Saturation Flow Rate vs. Desired Safety Distance Parameters

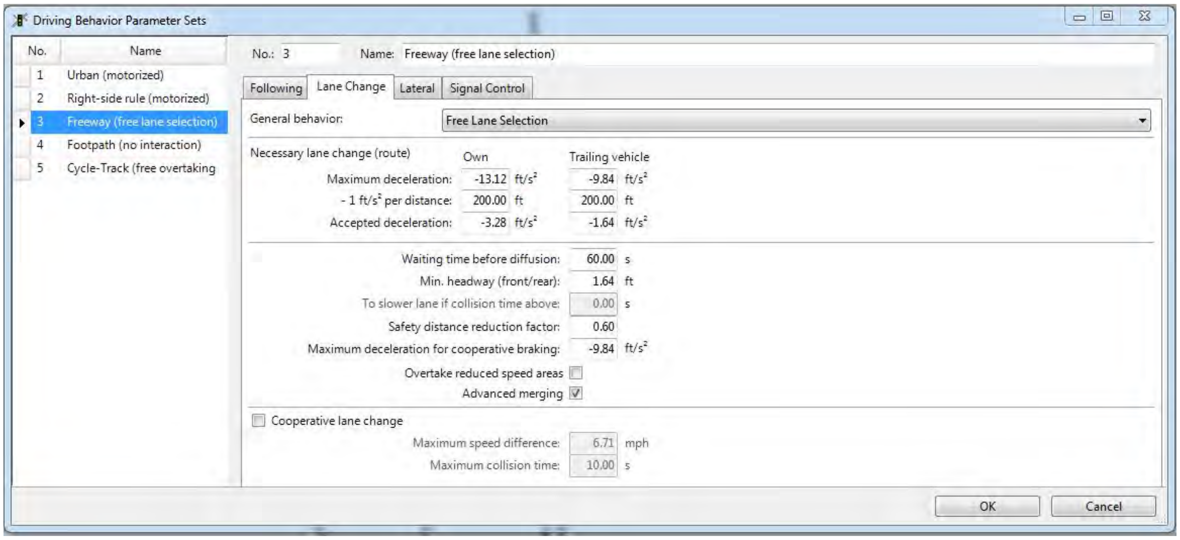


4.11.2 Lane Changing Parameters

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 26, the default parameters are a good starting point. However, some parameters may need to be changed in the calibration process to match real-world driving behavior, specifically when modeling merging, diverging, and weaving areas, such as Overtake Reduced Speed Areas, Advanced Merging, and Cooperative Lane Change.

Any changes from the parameters should be documented with the reason and application and reported, in the Confidence and Calibration Report, to WSDOT staff.

Figure 26 - Lane Change Driver Behavior Dialog (NOTE: This figure is an example of the dialog box, for suggested defaults and ranges of values, see Table 3)



No.	Name
1	Urban (motorized)
2	Right-side rule (motorized)
3	Freeway (free lane selection)
4	Footpath (no interaction)
5	Cycle-Track (free overtaking

No.: 3 Name: Freeway (free lane selection)

General behavior: Free Lane Selection

Necessary lane change (route)	Own		Trailing vehicle	
Maximum deceleration:	-13.12	ft/s²	-9.84	ft/s²
- 1 ft/s² per distance:	200.00	ft	200.00	ft
Accepted deceleration:	-3.28	ft/s²	-1.64	ft/s²

Waiting time before diffusion: 60.00 s

Min. headway (front/rear): 1.64 ft

To slower lane if collision time above: 0.00 s

Safety distance reduction factor: 0.60

Maximum deceleration for cooperative braking: -9.84 ft/s²

Overtake reduced speed areas ☐

Advanced merging ☑

☐ Cooperative lane change

Maximum speed difference: 6.71 mph

Maximum collision time: 10.00 s

The parameter for general behavior should be set to "Free Lane Selection." When heavy vehicles are restricted to travel in the right two lanes, for mainlines with more than three lanes, (as stated in WAC 468-510-020) use the “Lane Closure” found in the Connector dialog to set the restriction.

The parameter for waiting time before diffusion should be set to 200 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. If a value less than 200 seconds is proposed it should be documented in the Confidence and Calibration Report and requires concurrence from WSDOT.

Ranges for suggested lane change parameter changes are displayed in Table 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 WSDOT.

General Behavior Necessary Lane Change (route)	Free Lane Selection Own	Unit	Trailing Vehicle	Unit
Maximum deceleration:	-13.12	ft/s2	-9.84	ft/s2
-1 ft/s2 per distance:	200	ft	200	ft
Accepted deceleration:	-3.28	ft/s2	-1.64	ft/s2
Waiting time before diffusion:			60	s
Min. headway (front/rear):			1.64	ft
To slower lane if collision time above:			0	s
Safety distance reduction factor:			0.6	
Maximum deceleration for cooperative braking:			-9.84	ft/s2
Overtake reduced speed areas:			D*	

SUGGESTED RANGES

General Behavior Necessary Lane Change (route)	Free Lane Selection Own	Unit	Trailing Vehicle	Unit
Maximum deceleration:	-15 to -12	ft/s2	-12 to -8	ft/s2
-1 ft/s2 per distance:	150 to 250	ft	150 to 250	ft
Accepted deceleration:	-2.5 to -4	ft/s2	-1.5 to -2.5	ft/s2
Waiting time before diffusion:			200	s
Min. headway (front/rear):			1.5 to 2	ft
To slower lane if collision time above:			0 to 0.5	s
Safety distance reduction factor:			0.25 to 1.00	
Maximum deceleration for cooperative braking:			-8 to -15	ft/s2
Overtake reduced speed areas:			D*	

*** Leave box un-checked**

Table 3 - Suggested Lane Change Parameters

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 WSDOT Vissim simulation models, the preferred value is 10 steps per second, with approval from WSDOT values between 10 – 5 steps per second may be approved with reasonable justification. The dialog box is under "simulation / simulation parameters."

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. The minimum speed for a typical blend of pedestrians crossing an intersection, per the MUTCD, is 2.4 mph (3.5 ft/s), this should be reflected in the desired speed distribution. For areas with over 15% of the pedestrian population young or aging, a more appropriate minimum would be between 4 - 5 ft/s.

Deliverable: Base Model with Geometry and Control Coding

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

WSDOT will also use this checklist when reviewing the first submittal of the network. The size of the model will help determine the appropriate review time needed.

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 (for multiple simulation runs) 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 (TWLTL)
- 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.

NOTE: The Vissim ".err" file can help pinpoint problems in the model that could result in invalid results.

6. MODEL VALIDATION

There are two separate criteria that must be met in order to justify the validity of a particular model and its usefulness in evaluating the transportation system.

- Confidence – Ensuring that the reported model results are representative of the model
- Calibration – Matching the model results to real world conditions
-

The proposed confidence and calibration targets within this chapter are provided as guidance to assist Technical Advisory Committee members as they develop their project specific goals. The goals provided are encouraged to be modified in order to meet the unique scope of each project and right size the analysis to promote the efficient use of time and resources for all parties involved in the analysis.

The modeler shall meet all calibration requirements for the study periods as outlined in the Analysis Methods and Assumption Document.

The methodology used to validate the model will be documented in the Confidence and Calibration Report (see Section 6.3) along with all modeling results. This report will be submitted to WSDOT for review.

6.1 CONFIDENCE

Given the varying results that inherently exist between microsimulation runs (due to the random seed number), every model is required to evaluate its reported results to ensure that they are representative of the model and not skewed towards a statistical outlier. This is critical since the true average of the model results is unknown.

Confidence, as outlined in this section, is intended to demonstrate that the microsimulation runs that have been conducted have an average that is representative of the true average of the model. This does not mean to imply that the model is representative of real world conditions. The calibration portion of this chapter (section 6.2) details the steps that should be taken in order to determine if the model is representative of real world conditions.

6.1.1 Initial Number of Simulation Runs

To determine the level of confidence in the reported results, an initial sampling of the model outputs is required. The initial sample will consist of the results of several simulation runs. The number of simulation runs must be large enough to reduce the impact that an atypical run will have on the sample average. To account for this, it is recommended that all model results be reported based on a minimum of 11 simulation runs.

Each run must use different random number seeds starting at one and advancing sequentially. Using an odd number of runs will allow the modeler to quickly identify the run that represents the median conditions which can be used to review the model or create demonstrative videos for presentations.

6.1.2 Required Number of Simulation Runs

In order to ensure that the results reported are representative of the unknown model average, the following formula for a 95 percent confidence level shall be applied:

$$N = \left(2 * t_{0.025,N-1} \frac{s}{R} \right)^2$$

R = 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 (this is related to a 95% Confidence Level)

s = Standard Deviation about the mean for selected MOE

N = Number of required simulation runs

The value of the student-t statistic can be found in any statistics manual, but based on the data set of 11 runs, t = 2.228. A confidence level of 95% must be used unless WSDOT specifies otherwise.

The goal of this effort is to determine if the number of runs conducted is sufficient enough to produce an average result that falls within a certain range of values (confidence interval) in which we believe (confidence level) the unknown true mean of the model lies.

This statistical process requires the generation of an initial data set, which in this case will be the aforementioned 11 runs. In most cases, these 11 runs will generate a large enough sample size to meet our desired confidence criteria.

The standard deviation of the initial sample must be evaluated by the equation above to determine if a sufficient number of runs have been conducted to provide the target confidence that the sample average is located within an acceptable range of the true model average. The acceptable range is referred to as the confidence interval. A range of values is needed as a target because the true average is unknown. The length of the confidence interval is at the discretion of the analyst and may vary according to the purposes for which the results will be used. In order to evaluate alternatives with similar results a small confidence interval will need to be used. For alternatives with greater differences, a larger confidence interval may be acceptable.

Since the amount of variation that exists between the alternatives is unknown, it is difficult to determine an appropriate confidence interval range prior to the analysis. In order to have confidence that the true mean of the model will lie within the calibration targets described in Section 6.2.4, it is recommended the allowable variation between the model and real world observations should be used as a minimum when determining the confidence interval.

This process can be fairly confusing and complex to determine. *To help assist analysts with determining the appropriate number of runs, WSDOT had developed a spreadsheet that will automate this calculation.* These spreadsheets can be found on the WSDOT Traffic Analysis website (http://www.wsdot.wa.gov/Design/Traffic/Analysis/).

Based on the standard deviation of the key chosen MOEs, the minimum number of runs needed to achieve a 95% confidence level must be determined on a case by case basis depending on the MOE chosen and be approved by WSDOT.

At this time, 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 a few measures of effectiveness (MOEs) that are deemed more important to the outcome of the project.* These MOEs will be initially identified in the Analysis Methods and Assumptions Document, but additional statistical significance testing may be requested at the discretion of the reviewer. Typical MOEs selected to determine the required number of runs include: throughput volumes or travel times through the corridor.

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.

6.1.3 Influence on Alternative Analysis

While models used for alternative analysis may be developed from the same base model, the network revisions could vary the model results significantly from one another. Therefore, the calculation to determine the required number of simulation runs must be conducted for all model scenarios. An example of this could be evaluating the intersection improvements of a roundabout versus a signal. These two intersection control types will be coded and operate differently from one another. Because these alternatives will have varying results and standard deviations, the confidence of one model’s results may not correspond with that of another model. In turn, this requires that the calculation for number of runs be conducted for both alternatives.

In order to evaluate alternatives that are anticipated to have similar results, the allowable variation (confidence interval) will have to be fairly tight. This is required in order to identify the subtle differences that may exist between the alternatives. This is also true for results that may fall near certain thresholds, such as level of service.

6.1.4 Documentation

The actual seed values for each run shall be documented in the Confidence and Calibration Report. The purpose is two-fold. First, it will allow the results to be able to be replicated later. Second, it will confirm that the seed values were not handpicked during the error correction and calibration process. An excel spreadsheet that documents the aggregate of the model outputs shall be submitted along with all model files. All run specific error files will be submitted as well. Additional data regarding individual run data may be requested at the discretion of the reviewer.

To help with reviewing the alternatives analysis, the confidence intervals for critical MOEs should be provided in an appendix. This will help the reviewer assess whether two alternatives are statistically different from one another. Coordination between the modeler and reviewer is needed throughout the modeling process as the required confidence targets may change as the model results become known.

6.2 CALIBRATION

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 goal of performing calibration is to create a model that replicates real world conditions. The calibrated model can then be used with confidence to evaluate potential changes in the transportation network. These changes could be in geometry, traffic demand, driver behavior, signal timing, etc.

Since the calibration process requires real world data to be thoroughly performed, it is typically only conducted for the existing conditions scenario(s).

6.2.1 Minimum Requirements

In order for the calibration process to be effective, there needs to be at least two calibration goals focusing on two different measures of effectiveness (MOE). At a minimum, it is strongly recommended that the following MOEs be used as calibration goals for all traffic models:

- Traffic Volumes
- Speed/Travel Times

These MOEs are suggested to be prioritized, given their influence on the many other operational characteristics of the transportation network, such as density and delay. Field data for these MOEs are also relatively quick to obtain. This can be useful if an older model is desired to be used for a study, since the model's validity can be quickly reassessed.

If the model being created is large, complex, or detail oriented, additional calibration goals should be considered.

For some projects, the proposed improvement being evaluated will significantly change the characteristics of the roadway network compared to the existing conditions. For these instances, collecting field data within the study area will only partially aid in the calibration of the traffic model. To ensure that the model is representative of future conditions, it is recommended that data and observations from locations similar to the proposed network be considered when developing the traffic model.

6.2.2 Data Limitations

For many projects, the data available to describe the existing conditions may be limited. Information for different MOEs may not necessarily correlate with each other. An example of this would be using throughput volume information with travel time data that were collected on different dates. Both data sources may representative of the existing conditions, but the MOEs may not relate to each other. This could make calibration of the base conditions difficult.

Limitations in the field data should be recognized and discussed with the project stakeholders throughout the modeling process. Below is a list of check-in times and questions that should be answered:

- Kickoff Meeting
    - What information is currently available?
    - What data should we collect?
- Analysis Methods and Assumptions Document (see Section 2.8 for more details)
    - Will any of the existing data be adjusted to represent a more specific existing condition? (i.e. adjusting to design hour volumes)
    - What impact will this change have on the calibration of the other MOEs collected?
    - What confidence and calibration targets will be used to validate the model?
- Data Collection Summary (see Section 3.12 for more details)
    - Does the data gathered appear representative of the existing conditions?
- Confidence and Calibration Report
    - Did we meet all of the previously identified calibration targets outlined in the Analysis Methods and Assumptions Document? If not, describe why the model is still representative of the existing conditions.
    - Is the model still useful in determining the impacts of a project?

Depending on the size and scope of the project, additional data may need to be gathered to assist with the calibration process.

6.2.3 Multi-Hour Evaluations

For projects that require a multi-hour analysis, the calibration criteria provided should only be applied to the peak hour. Typically, the available data for the shoulders of the peak hour is limited. Due to these data constraints, the calibration goals for these adjacent timeframes may be revised to be more lenient. The methodology for calibrating multi-hour models should be documented in the Analysis Methods and Assumptions Document.

6.2.4 Calibration Targets

The calibration targets within this section are provided as guidance to assist Technical Advisory Committee members as they develop their project specific goals. The targets provided are encouraged to be modified in order to meet the unique scope of each project and right size the analysis to promote the efficient use of time and resources for all parties involved in the analysis.

The calibration criteria were also developed with the intent that the model will be used to help determine mitigation requirements for developments or other projects on the state transportation system.

6.2.4.1 Throughput Volumes

The first measure of proof of calibration is how closely throughput volumes from the field (as provided to WSDOT in the Data Collection Summary) match simulation output volumes.

For the calibration process, the term "field" or "real world" throughput volumes does not necessarily imply traffic volumes taken directly from observations of the existing conditions. Oftentimes volume information comes from short counts (about 1 week of data). These volumes are then adjusted to incorporate vehicle classification, seasonal adjustments, and other factors. In addition, WSDOT typically prefers to use Design Hour Volumes (DHV) which are based on the 30th highest hour. These adjusted throughput volumes may no longer correlate to the traffic volumes present when the data was collected for the other MOEs. This could create issues with the calibration process, thereby causing a need to generate two models: one model to calibrate to field data directly and another to represent the base conditions. The Technical Advisory Committee tasked with developing the Analysis Methods and Assumptions document should assess whether or not calibration issues could arise from using the adjusted throughput volumes in conjunction with other MOEs collected in the field. For most instances, it will be sufficient to utilize a singular existing conditions model using the adjusted throughput volumes.

A simple percentage difference is not a fair comparison of the wide range of mainline segment or turning movement throughput volumes possible in the model. For example, a 10 percent tolerance would allow a freeway segment with 2,000 vehicles per hour (veh/h/ln) to vary by 200 veh/h/ln, but a left- turn movement with 30 veh/h/ln at an intersection could vary by only 3 veh/h/ln to meet the criteria.

The best universal measure to compare field data and simulation 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.

GEH statistics shall be calculated for all mainline segments and ramps identified in the scope of work. In addition, the GEH statistic must be calculated for all throughput 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 throughput volume criteria; changes must be documented in the Confidence and Calibration Report.

For hourly throughput volumes, the GEH formula is:

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

Notes:

Calibration of the model should use the GEH formula, calculated to a value of 3 or lower

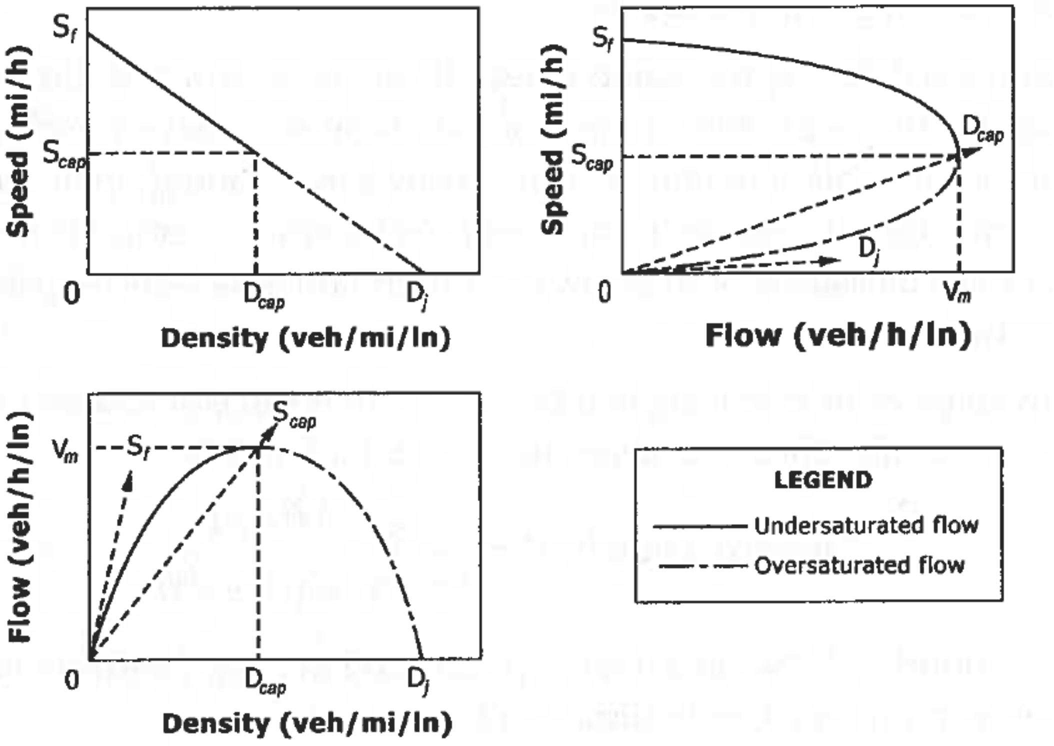
m = output traffic throughput volumes from the simulation model (veh/h/ln)

c = traffic throughput volumes based on field data (veh/h/ln)

Revision to Previous GEH Methodology

While the GEH formula above was originally intended to evaluate total hourly volumes (vph), WSDOT has determined that the equation can also evaluate hourly lane volumes (veh/h/ln). Utilizing hourly lane volumes makes it easier to target areas of congestion, regardless of the facility type. Hourly lane volumes also have a direct relationship to speed and density as is demonstrated in Exhibits 4-3 and 4-4 of the Highway Capacity Manual 2010 (shown in Figure 27 below).

Figure 27 - Generalized Relationship Among Speed, Density, and Flow Rate on Uninterrupted Flow Facilities[5]



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[5] Source: Highway Capacity manual 2010 (Exhibit 4-3)

Table 4 provides guidance on interpreting the calculated GEH statistic. The throughput traffic volume calibration criteria are listed in Table 5.

GEH Statistic	Guidance
< 3.0	Acceptable Fit
3.0 to 5.0	Acceptable: For Local Roadway Facilities
> 5.0	Unacceptable

Table 4 - GEH Statistic Guidelines

Criteria	Acceptable Targets
GEH < 3.0	All state facility segments within the calibration area
GEH < 3.0	All entry and exit locations within the calibration area
GEH < 3.0	All entrance and exit ramps within the calibration area
GEH < 5.0	At least 85% of applicable local roadway segments
Sum of all segment flows within the calibration area	Within 5%

Table 5 - Throughput Traffic Volume (veh/h/ln) Calibration Criteria

Difficultly Meeting Calibration Criteria

Meeting the Throughput Volume Calibration Criteria outlined above may prove to be difficult and time consuming depending on the modeling effort. Should all of the calibration criteria not be met, further adjustments to the model may not necessarily be required. If the locations that fail the criteria are demonstrated to only have a negligible influence on the desired model outputs, then the model may still be considered calibrated to throughput volumes.

In addition, increasing the GEH threshold from 3.0 to 5.0 may be acceptable for certain projects. A higher GEH could be acceptable on facilities where a higher variation in volume is expected. Any revisions to the calibration criteria will require approval from the Technical Advisory Committee and documentation in the Analysis Methods and Assumptions Document.

It should be noted that this calibration target of flows 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.

6.2.4.2 Speed

After the throughput volume outputs are calibrated in the model, replication of driver behavior is needed. One method 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.

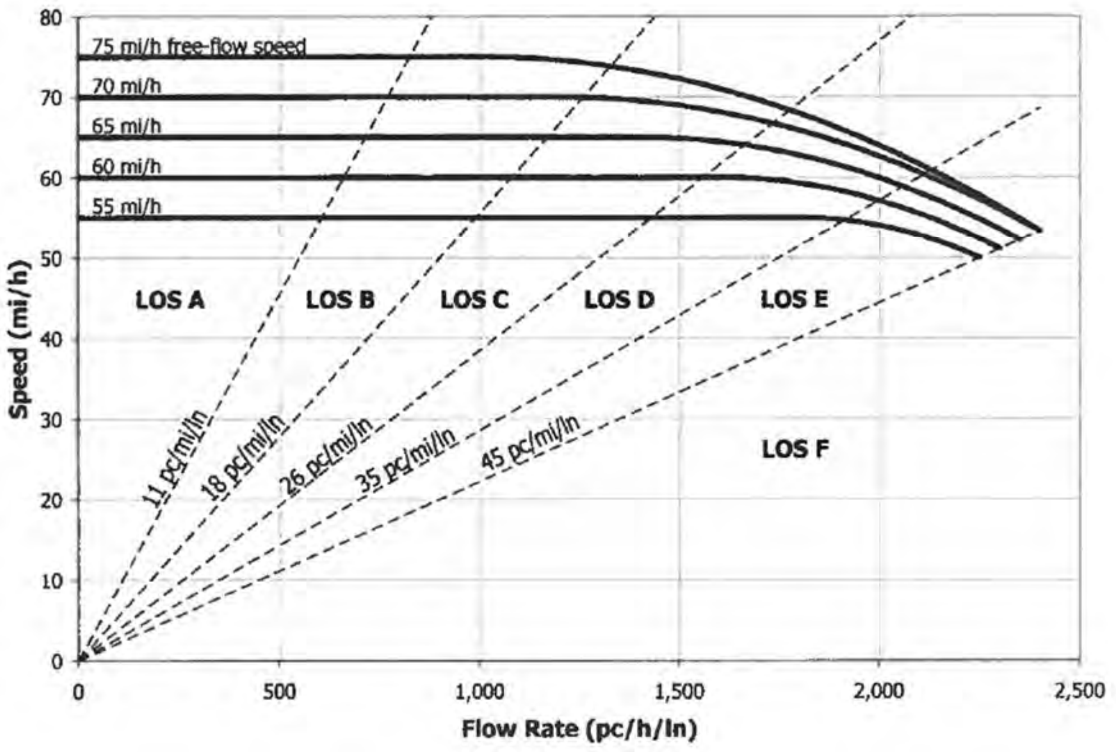
The method used to collect field measured speed data should be considered when trying to replicate speeds in the model. For example, if spot speeds are collected in the field via a radar gun at a specific location, then a data collection point should be used to obtain similar model speed data at the same location.

The speed data can also be measured and compared at various time intervals. This will most likely be dictated by the available field data. The time intervals selected for this calibration criteria should be included in the Analysis Methods and Assumptions Document.

Uninterrupted Flow Facility Speeds

Spot speeds for uninterrupted flow facilities in the model shall be within 3 mph of observed real-world spot speed data on all freeway links where real-world speed is available for comparison. This calibration threshold was selected using information provided in the Highway Capacity Manual 2010. In the Basic Freeway Segments chapter, Exhibit 11-6 (shown below in Figure 28) demonstrates a relationship between LOS and speed. For a typical 60 mph freeway segment, the difference in speed between the LOS D and E thresholds is approximately 3 mph. Using this range as a calibration target will allow us to accurately match the model speeds and LOS to real world operations.

Figure 28 - Highway Capacity Manual 2010: LOS for Basic Freeway Segments[6]



Spot speed charts similar to the example shown in Figure 29, which compares simulation results to real-world data, shall be prepared for all freeway corridors, where data allows. Locations and durations of speeds within the chart should replicate locations of available data from TDGO or other sources. These results should also be presented in table format in the Confidence and Calibration Report. If detailed network-wide real-world speed data is not available, this comparison shall be based on spot speed information collected in the field.

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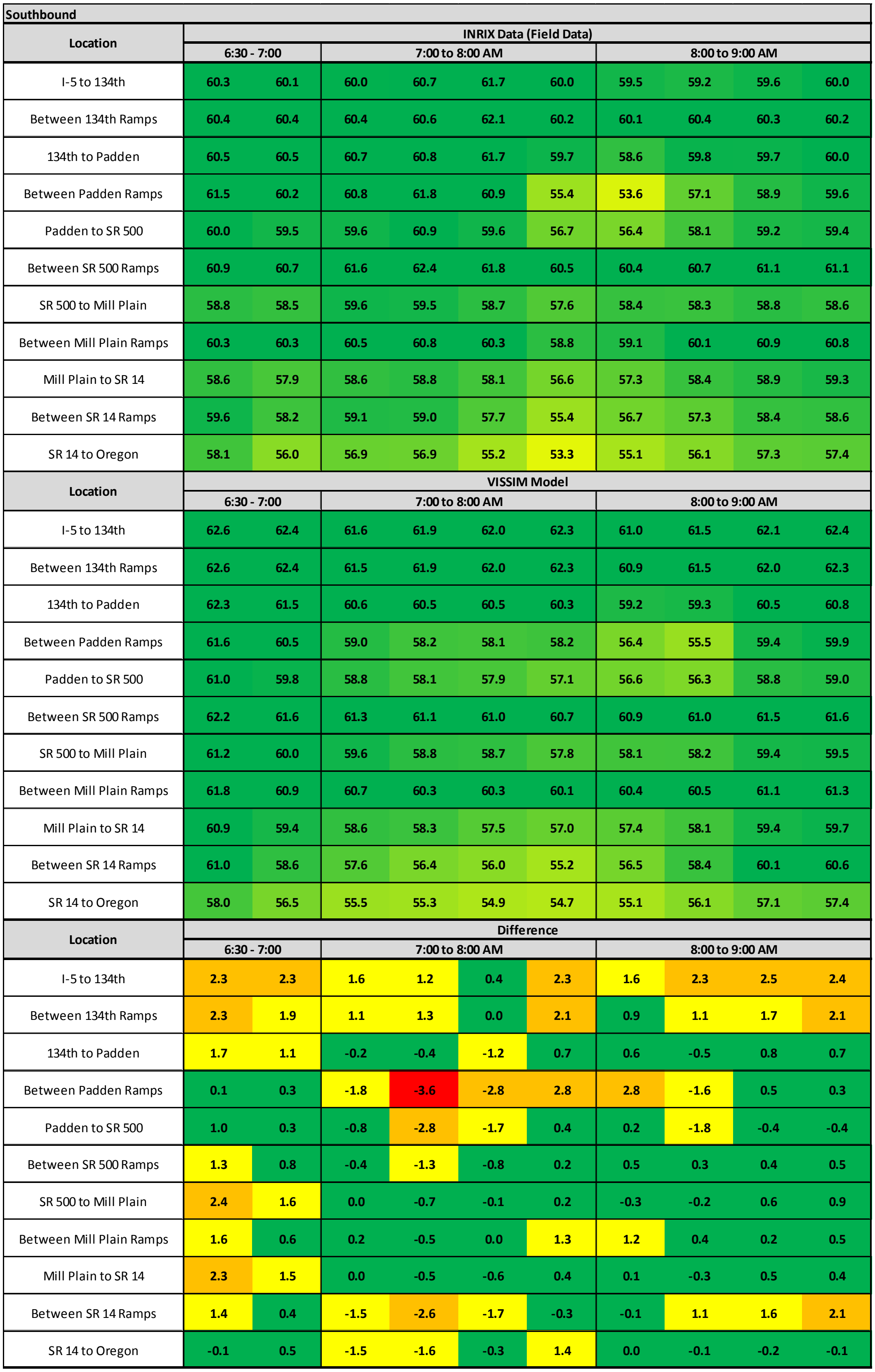
[6] Source: Highway Capacity Manual 2010 (Exhibit 11-6)

Figure 29 - Example of Speed Comparison Table for Freeways

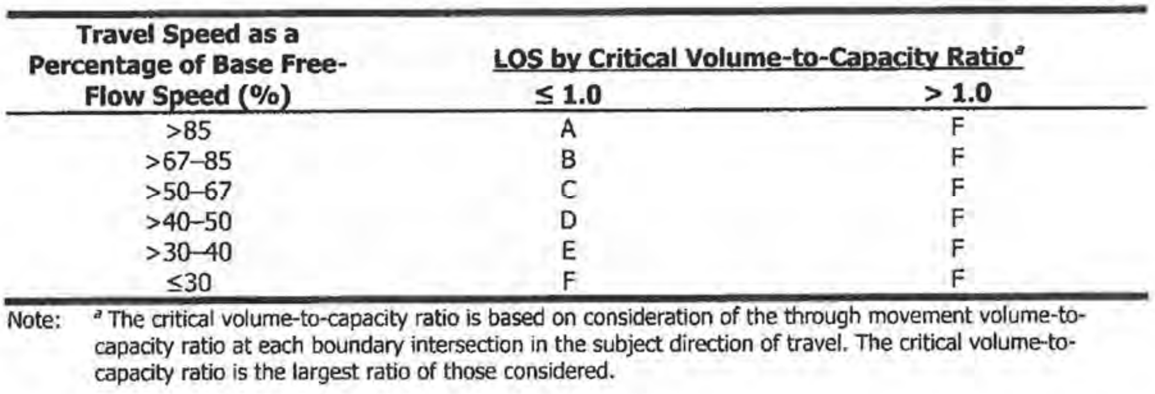


Southbound										
Location	INRIX Data (Field Data)									
	6:30 - 7:00		7:00 to 8:00 AM				8:00 to 9:00 AM			
I-5 to 134th	60.3	60.1	60.0	60.7	61.7	60.0	59.5	59.2	59.6	60.0
Between 134th Ramps	60.4	60.4	60.4	60.6	62.1	60.2	60.1	60.4	60.3	60.2
134th to Padden	60.5	60.5	60.7	60.8	61.7	59.7	58.6	59.8	59.7	60.0
Between Padden Ramps	61.5	60.2	60.8	61.8	60.9	55.4	53.6	57.1	58.9	59.6
Padden to SR 500	60.0	59.5	59.6	60.9	59.6	56.7	56.4	58.1	59.2	59.4
Between SR 500 Ramps	60.9	60.7	61.6	62.4	61.8	60.5	60.4	60.7	61.1	61.1
SR 500 to Mill Plain	58.8	58.5	59.6	59.5	58.7	57.6	58.4	58.3	58.8	58.6
Between Mill Plain Ramps	60.3	60.3	60.5	60.8	60.3	58.8	59.1	60.1	60.9	60.8
Mill Plain to SR 14	58.6	57.9	58.6	58.8	58.1	56.6	57.3	58.4	58.9	59.3
Between SR 14 Ramps	59.6	58.2	59.1	59.0	57.7	55.4	56.7	57.3	58.4	58.6
SR 14 to Oregon	58.1	56.0	56.9	56.9	55.2	53.3	55.1	56.1	57.3	57.4
Location	VISSIM Model									
	6:30 - 7:00		7:00 to 8:00 AM				8:00 to 9:00 AM			
I-5 to 134th	62.6	62.4	61.6	61.9	62.0	62.3	61.0	61.5	62.1	62.4
Between 134th Ramps	62.6	62.4	61.5	61.9	62.0	62.3	60.9	61.5	62.0	62.3
134th to Padden	62.3	61.5	60.6	60.5	60.5	60.3	59.2	59.3	60.5	60.8
Between Padden Ramps	61.6	60.5	59.0	58.2	58.1	58.2	56.4	55.5	59.4	59.9
Padden to SR 500	61.0	59.8	58.8	58.1	57.9	57.1	56.6	56.3	58.8	59.0
Between SR 500 Ramps	62.2	61.6	61.3	61.1	61.0	60.7	60.9	61.0	61.5	61.6
SR 500 to Mill Plain	61.2	60.0	59.6	58.8	58.7	57.8	58.1	58.2	59.4	59.5
Between Mill Plain Ramps	61.8	60.9	60.7	60.3	60.3	60.1	60.4	60.5	61.1	61.3
Mill Plain to SR 14	60.9	59.4	58.6	58.3	57.5	57.0	57.4	58.1	59.4	59.7
Between SR 14 Ramps	61.0	58.6	57.6	56.4	56.0	55.2	56.5	58.4	60.1	60.6
SR 14 to Oregon	58.0	56.5	55.5	55.3	54.9	54.7	55.1	56.1	57.1	57.4
Location	Difference									
	6:30 - 7:00		7:00 to 8:00 AM				8:00 to 9:00 AM			
I-5 to 134th	2.3	2.3	1.6	1.2	0.4	2.3	1.6	2.3	2.5	2.4
Between 134th Ramps	2.3	1.9	1.1	1.3	0.0	2.1	0.9	1.1	1.7	2.1
134th to Padden	1.7	1.1	-0.2	-0.4	-1.2	0.7	0.6	-0.5	0.8	0.7
Between Padden Ramps	0.1	0.3	-1.8	-3.6	-2.8	2.8	2.8	-1.6	0.5	0.3
Padden to SR 500	1.0	0.3	-0.8	-2.8	-1.7	0.4	0.2	-1.8	-0.4	-0.4
Between SR 500 Ramps	1.3	0.8	-0.4	-1.3	-0.8	0.2	0.5	0.3	0.4	0.5
SR 500 to Mill Plain	2.4	1.6	0.0	-0.7	-0.1	0.2	-0.3	-0.2	0.6	0.9
Between Mill Plain Ramps	1.6	0.6	0.2	-0.5	0.0	1.3	1.2	0.4	0.2	0.5
Mill Plain to SR 14	2.3	1.5	0.0	-0.5	-0.6	0.4	0.1	-0.3	0.5	0.4
Between SR 14 Ramps	1.4	0.4	-1.5	-2.6	-1.7	-0.3	-0.1	1.1	1.6	2.1
SR 14 to Oregon	-0.1	0.5	-1.5	-1.6	-0.3	1.4	0.0	-0.1	-0.2	-0.1

Interrupted Flow Speeds

Spot speeds in the model for local roadways with interrupted flow can be allowed to vary by 10 percent of the base free-flow speed when compared to the observed real-world spot speed data. This calibration threshold was selected using information provided in the Highway Capacity Manual 2010. In the Urban Street Facilities chapter, Exhibit 16-4 (shown below in Table 6) demonstrates a relationship between LOS and Free-Flow Speed. For a typical urban segment, the difference in speed between the LOS D and E thresholds is approximately 10 percent of the Free-Flow Speed. Using this threshold (+/- 10 percent of the Free-Flow Speed) as a calibration target will allow us to accurately match the model speeds and LOS to real world operations.

For example, an interrupted flow facility has a free-flow speed of 40 mph. The allowable variation for this facility will be +/- 4 mph (10% of the free-flow speed). Since this range is based on free-flow speed of the facility, it will remain constant regardless of the observed speeds collected in the field during congested periods. This means that if the facility operates at 20 mph during peak congestion, the allowable variation when comparing field data to the model outputs will still remain +/- 4 mph.



Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Critical Volume-to-Capacity Ratio[a]	
	≤ 1.0	> 1.0
>85	A	F
>67–85	B	F
>50–67	C	F
>40–50	D	F
>30–40	E	F
≤30	F	F

Note: [a] The critical volume-to-capacity ratio is based on consideration of the through movement volume-to-capacity ratio at each boundary intersection in the subject direction of travel. The critical volume-to-capacity ratio is the largest ratio of those considered.

Table 6 - Highway Capacity Manual 2010: LOS Criteria - Automobile Mode[7]

In some instances, WSDOT may specify more refined spot speed calibration criteria than those stated above. WSDOT approval on the spot speed calibration criteria should be obtained prior to the endorsement of the Analysis Methods and Assumptions Document.

Difficultly Meeting Calibration Criteria

Similar to the Throughput Traffic Volume Calibration Criteria, the Speed Calibration Criteria above may prove to be difficult and time consuming depending on the modeling effort. Should all of the calibration criteria not be met, further adjustments to the model may not necessarily be required. If a particular calibration target is not met, the modeler may provide reasoning for not meeting the criteria and explain why the model is still applicable to evaluate the current project.

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[7] Source: Highway Capacity Manual 2010 (Exhibit 16-4)

6.2.4.3 Travel Time

Calibration criteria for travel times in the model should also be met for all segments and time intervals established in the Analysis Methods and Assumptions document. The travel time criteria are consistent with the Speed Calibration Targets above and are listed in Table 6-3. The Travel Time Criteria are separated into two types of facilities: Uninterrupted Flow and Interrupted Flow. The amount of allowable travel time variation will need to be calculated for each time interval as speeds (travel times) fluctuate through the analysis period. For Interrupted Flow, the allowable travel time variation is established using the free flow speed of the corridor. If the free flow speed (FFS) is unknown, the posted speed limit may be used.

Facility Type	Equation
Free-Flowing	$\Delta = \dfrac{1}{\dfrac{1}{t} - \dfrac{4.4}{L}} - t$
Interupted Flow	$\Delta = \dfrac{1}{\dfrac{1}{t} - \dfrac{0.1 * 5280\,S}{3600\,L}} - t$

Δ = Allowable Travel Time Variation (+/- seconds)
t = Real World Travel Time (seconds)
L = Length (feet)
S = Free Flow Speed (mph); Posted Speed may be used for FFS if unknown

Table 7 - Travel Time Calibration Criteria

In some instances, WSDOT may specify more refined Travel Time Calibration Criteria than those listed in Table 7. WSDOT approval on the travel time calibration criteria should be obtained prior to the endorsement of the Analysis Methods and Assumptions Document.

Difficultly Meeting Calibration Criteria

The Travel Time Calibration Criteria above may prove to be difficult and time consuming depending on the modeling effort. Should all of the calibration criteria not be met, further adjustments to the model may not necessarily be required. If a particular calibration target is not met, the modeler may provide reasoning for not meeting the criteria and explain why the model is still applicable to evaluate the current project.

6.2.4.4 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 one of the following coding issues: intersection control, vehicle demand, vehicle classification (truck percentage), or vehicle model (car/truck length). 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 WSDOT staff. However, a qualitative comparison discussing the similar characteristics between the model and real world queues may be required.

6.2.4.5 Weaving Behavior

Areas where there is heavy weaving will be identified in the Analysis Methods and Assumptions Document. Origin-Destination data can be collected or provided by planning models for these weaving sections. Travel time segments in Vissim should be used to obtain traffic volume data that can match and verify the O-D data. The volumes should also be calibrated to the criteria defined in Section 6.2.4.1 with a GEH less than 3.0. When weaving is modeled where no O-D data is available, a qualitative comparison discussing the similar characteristics between the model and real world driver behavior and congestion levels may be required.

6.2.4.6 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 6.2.4.1 and a comparison of lane utilization percentages between the model and the field should be provided.

6.2.4.7 Transit

Transit should also be calibrated for key routes identified in the List of Key Calibration Locations (Section 2.5). The level of calibration required to validate transit data can vary depending on the scope of the project. Calibration Targets for transit should be discussed with the Technical Advisory Committee and be documented in the Analysis Methods and Assumptions Document.

6.2.4.8 Visual Inspection

One of the tools that microsimulation models offer is the ability to see individual vehicles interacting with each other. A visual inspection of the traffic model can be used to support and aid the calibration process. An inspection of the calibrated base model should be performed and compared to field operations to verify that the model is accurately replicating field conditions.

Be advised that a single run may not reflect the average conditions of the model. For this reason, it is not sufficient by itself to determine the validity of a model.

6.3 CONFIDENCE AND CALIBRATION REPORT

WSDOT requires that a Confidence and Calibration Report be submitted with every model. The report shall summarize:

- Basic processes and procedures followed
- Assumptions made
- Problems encountered
- Solutions devised during the study effort

- Confidence in model results
- Comparison of model results to real world data
- Identify calibration targets that were not met and why the results are still valuable

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 may also be required. Any other calibration targets outlined in the Analysis Methods and Assumptions Document must also be discussed. The raw data outputs shall be provided as electronic files to WSDOT. A sample Confidence and Calibration Report is provided in Appendix I.

Deliverable: Confidence and Calibration Report

7. ADDITIONAL BASE YEAR SCENARIOS

Once the calibrated model and Confidence and Calibration Report has been reviewed and approved by WSDOT, 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, although not common, consider whether the adjustments should be made to all base models.

The Confidence and Calibration 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.

Deliverable: Additional Calibrated Base Year Models and Updated Confidence and Calibration Report

8. FUTURE YEAR MODELS (NO BUILD AND 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 WSDOT 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 WSDOT 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, WSDOT 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 WSDOT and included in the M-A. Before coding the no-build model, the new traffic volume data set shall be developed and submitted in graphical format to WSDOT for approval.

Deliverable: No-Build Traffic Volumes

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 WSDOT 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). 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 WSDOT review and approval upon submittal of 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 or volumes changes, there should be no changes in driver behavior and parameters.

In cases where major changes to the network or volumes are included as part of an alternative (or the expected future volumes), 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 (Section 8.2). 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 demonstrates 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 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 WSDOT with the submittal of the no-build model.

Deliverable: No-Build Model with Corresponding Documentation

8.6 Developing Volumes for Alternative Scenarios

The process for developing alternative scenario volumes is outlined in the WSDOT 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 WSDOT approval.

Deliverable: Alternative Scenarios, Traffic Volumes

8.7 Model Development

Once the no-build model has been completed and approved by WSDOT, 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.

Deliverable: Alternative Scenarios Models with Corresponding Documentation

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 model duration, as defined in the Project Methods and Assumptions Report. WSDOT may require the data be submitted by multi-hour, 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 WSDOT, unless otherwise stated in the Analysis Methods and Assumption Document.

9.1.1 Node Evaluation

Node evaluation data is obtained by placing "nodes" at locations throughout the network. All study intersections, ramp terminals, and any other study locations outlined in the Analysis 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 (note: Node Evaluation will only capture delay to the next upstream node)
- Stops

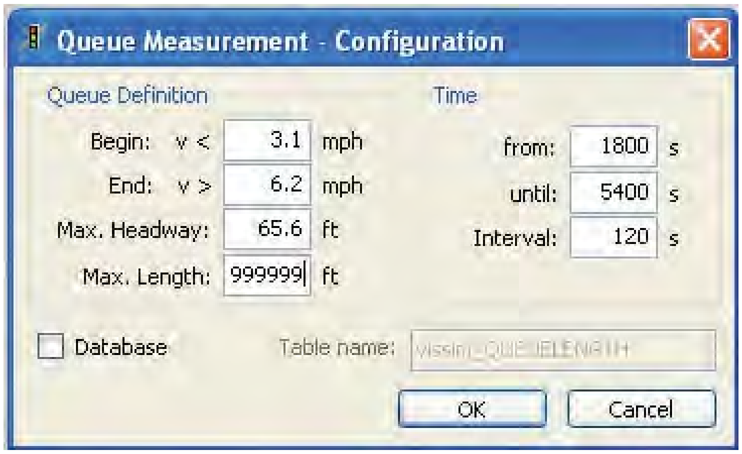
9.1.2 Queue Counters

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 30. 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 WSDOT requests use of an alternate headway. The max queue length shall be changed to 99,999 feet for all models unless otherwise directed by WSDOT. It is suggested that the time interval of the queue measurement is not a multiple of cycle lengths in the model. This will ensure queues are collected at varying points in the cycle. The "from" and "until" values will vary depending on the seeding time and simulation time of the model.

Figure 30 - Queue Measurement Evaluation Configuration



Queue Measurement - Configuration

Queue Definition

Begin: v < 3.1 mph

End: v > 6.2 mph

Max. Headway: 65.6 ft

Max. Length: 999999 ft

Time

from: 1800 s

until: 5400 s

Interval: 120 s

☐ Database

Table name: vissim_QUEUELENGTH

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. Guidance for calculating the 95th percentile queue can be found in the following section.

9.1.2.1 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 95th percentile can be determined using a percentile function.

9.1.2.2 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, WSDOT 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 a more realistic queue length for the turning movement and therefore a more realistic storage length to prevent spillback from blocking the adjacent through lane. However, keep in mind that there is less confidence in the accuracy the queue data gathered from models than in other MOEs (especially in future year models).

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 collected in the field. Great care should be given to placing these points with an understanding that any additional points could affect the ability to auto group and will likely affect any spreadsheets set up to manage output. Be sure to name each point clearly as this will save much confusion during spreadsheet work. Points on multilane links shall be aggregated together as one data point. If further specifics are desired near a grouping of points, for example: densities of lanes that feed turning links, then additional collection points are to be used. At a minimum, the following MOEs should be reported:

- Number of Vehicles
- Speed (mean)

9.1.3.1 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 WSDOT 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 (and reality) 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 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 Highway Capacity Manual 2010 (HCM 2010) Level of Service (LOS) is required for freeways, 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 (spot mean speed and/or space mean speed)

- Data Collection Intervals
- Segment Length for data collection
- 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. Keep in mind that for design year analysis, the goal is to compare scenarios and not an attempt to define actual density, therefore Vissim density should be considered for straight reporting rather than attempting to recreate any HCM metric.

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, WSDOT has not adopted methodologies for utilizing Vissim microsimulation data for air quality analysis. Vissim can generate emissions output for CO, NOx, VOC, and inputs needed for EPA MOVES through node evaluation; however, this module is not currently consistent with EPA approved methods and should only be used if approved by WSDOT. 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 WSDOT. Again, with the goal of comparing scenarios, precise methods and output for emissions may not be necessary.

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.

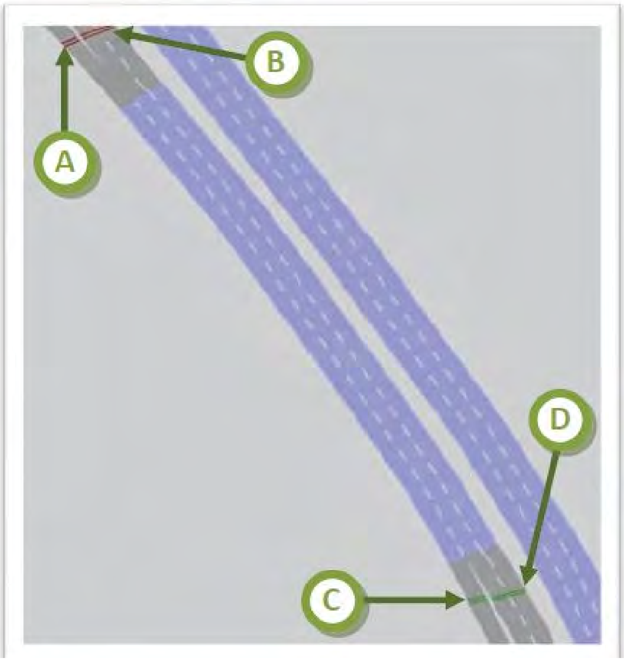
9.2.7 Travel Time (for O-D Data)

Travel time segments in Vissim can be used as a validation "double-check" of O-D volumes through a weaving section. Four travel time segments would be needed as shown in Figure 31:

- From A to C

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

Figure 31 - Travel Time Segment Placement for O-D Data



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 (documented in the A-M-A). 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 WSDOT 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 Analysis Methods and Assumptions document.

Spreadsheets outlining the method and demonstrating the format that will be used to report results must also be provided to WSDOT in the Analysis 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 2010 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 expected field results for operational models. This difference means only that they should not be reported as HCM delay results or translated to HCM LOS values. Much less expectations should be placed on the results from planning level or future year (design year) models.

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. However, when project volumes dramatically exceed a microsimulation network's ability to handle said volumes, some trip timing and re-routing would likely occur in real world. For this reason much caution should be used with microsimulation models involving inordinate amounts of delay.

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

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
- Confidence and Calibration Report

Additionally, the document must contain in the Appendix the detailed results from the Vissim analysis. A sample of the desired format for all WSDOT Vissim projects is included in Appendix K.

10. REVIEWING

This section details the steps WSDOT 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 WSDOT 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.

WSDOT Vissim Reviewing Checklist:

Project:
Name of Modeler:
Name of Reviewer:

Milestone	Protocol Section	Items to Check
Scoping		
Project Problem Statement	1.1	☐ The goals of the project are clearly stated
		☐ Proposed MOEs provide the necessary information to answer the Project Problem Statement
		☐ Field visit has been conducted
Comments:		
Data Collection Plan	2.6	☐ Summary of a field visit to determine data collection needs has been provided in a graphical format
		☐ Summary of real-world observations (and historical data if available) showing congestion locations have been provided
		☐ Time periods for data collection have been determined and documented
		☐ Type of data to be collected and locations that they will be collected are documented in tabular and graphical format
Comments:		
Project Methods and Assumptions	2.7	☐ Project understanding, including the problem statement, is described
		☐ Software tools to be used for this project and their use have been outlined
		☐ 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		
Data Collection Summary	3.12	☐ Development of input volume data sets have been documented
		☐ Sink and source locations are identified in graphical format
		☐ Lane schematics in graphical format
		☐ Documentation of any errors found in data and the assumptions that were made in accordance with the errors
		☐ Traffic volumes to be used in analysis of all existing conditions are provided in graphical format
		☐ Posted speeds and any localized segments of adjusted desired speeds are provided in graphical format
		☐ Any lane imbalance locations that require special coding are documented and described graphically
		☐ Summary of travel time and speed data
Comments:		
Model Coding		
Base Vissim Model	4.2 - 4.12	☐ Lane geometry correct at all intersections
		☐ Locations of freeway lane drops/adds correct
		☐ Merge/diverge locations coded correctly per Section 4.3.1
		☐ Desired Speed Decisions coded at all locations of change in posted speed

		☐ Reduced Speed Areas at all turns and areas of temporary speed reductions
		☐ Conflict Areas/Priority Rules coded at all intersections and other conflict points
		☐ Stop Signs coded at proper locations
		☐ Traffic signals coded at correct intersections
		☐ Traffic signal stop bars and detectors coded at proper locations
		☐ Traffic signal timing matches field timing (see Traffic Signal Timing Checklist)
		☐ Nodes coded at all study intersections with Node Evaluation toggeled on
		☐ Queue Counters coded for all movements at all intersections in the List of Key Calibration Locations
		☐ Max Queue Value increased from default value to include longest possible queue
		☐ Data Collection Points coded on all entry and exit links
		☐ Travel Time Segments coded for all sections identified in the Data Collection Plan
		☐ Transit routes, headways, and dwell time parameters match real-world conditions
Comments:		
Calibration		
Calibrated base Model and Confidence and Calibration Report	6.1 - 6.3	☐ Confidence and Calibration Report submitted
		☐ Model animations match expected driver behavior and conditions observed in the field
		☐ Model output volumes satisfy GEH statistic requirements in Section 6.2.4.1
		☐ Model link speeds meet speed calibration requirements in Section 6.2.4.2
		☐ Model travel time results meet calibration requirements in Section 6.2.4.3
		☐ Model queuing replicates real-world conditions
		☐ Calibration results are based on the average of the minimum number of simulation runs calculated as discussed in Section 6.2.1 (a copy of the spreadsheet has been provided)
Comments:		

Additional Base year Scenarios		
Additional Base Year Models and Updated Confidence and Calibration Reports	7	☐ Confidence and Calibration Report has been expanded to provide proof of calibration for additional base year models
		☐ Model animations match expected driver behavior and conditions observed in the field
		☐ Model output volumes satisfy GEH statistic requirements in Section 6.2.4.1
		☐ Model link speeds meet speed calibration requirements in Section 6.2.4.2
		☐ Model travel time results meet calibration requirements in Section 6.2.4.2
		☐ Model queuing replicates real-world conditions
		☐ Calibration results are based on the average of the minimum number of simulation runs calculated as discussed in Section 6.2.1 (a copy of the spreadsheet has been provided)
Comments:		
Alternatives		
No-Build Forecasted Input Volumes	8.1	☐ Methodology for developing traffic volumes has been provided
		☐ Any assumptions made during volume development have been outlined
		☐ Traffic volumes to be used in analysis are provided in graphical format
No-Build Models and Corresponding Documentation	8.2 - 8.5	☐ Summary of input and output vs. demand is documented with any reasons for variation
		☐ Any preliminary findings from the models are documented
		☐ Signal timing matches agency guidelines
		☐ Assumptions and parameter changes are documented
		☐ All proposed network changes coded correctly
		☐ Animation of the network looks feasible
Comments:		
Alternative Input Traffic Volumes	8.6	☐ Methodology for developing traffic volumes has been provided
		☐ Any assumptions made during volume development have been outlined
		☐ Traffic volumes to be used in analysis are provided in graphical format
Comments:		

Alternative Models and Corresponding Documentation	8.7	☐ Summary of input and output vs. demand is documented with any reasons for variation
		☐ Any preliminary findings from the models are documented
		☐ Signal timing matches agency guidelines
		☐ Assumptions and parameter changes are documented
		☐ All proposed network changes coded correctly
		☐ Animation of the network looks feasible
Comments:		
Reporting		
Final Report	9.4	☐ Project description is provided
		☐ Scope of work is outlined
		☐ Alternatives are adequately described
		☐ Bottlenecks and other problem areas have been clearly documented
		☐ Opportunities and recommendations are included
Comments:		
Date:		Initials: