VISSIM PROTOCOL FOR SIMULATION ON FREEWAYS

Oregon Department of Transportation – Region 1

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# TABLE OF CONTENTS

**Introduction** ................................................................. 1  

*Purpose of VISSIM Protocol* .................................................. 1

1  **Project Boundary Definition** .............................................. 2  

    1.1  Freeways ........................................................................ 2  

    1.2  Ramp Terminal Intersections ........................................... 2

2  **Data Collection** ............................................................... 3  

    2.1  Geometric Data .............................................................. 3  

    2.2  Control Data ................................................................. 3  

    2.3  Vehicular Fleet Data ....................................................... 4  

    2.4  Time Period Traffic Volume Data Requirements ................ 4  

    2.5  Traffic Volume Data ....................................................... 4  

    2.6  Origin-Destination Data .................................................. 5  

    2.7  Travel Time Data ........................................................... 5  

    2.8  Spot Speed Data ............................................................ 5  

    2.9  Queuing Data ............................................................... 5  

    2.10  Field Observation ......................................................... 6  

    2.11  Optional Data .............................................................. 6

3  **Model Development** ....................................................... 7  

    3.1  Vehicular Fleet Setup ..................................................... 7  

    3.2  Geometry Coding .......................................................... 7  

    3.3  Control Coding ............................................................. 9  

    3.4  Speed Control Coding .................................................... 9  

    3.5  Volume / Route Coding .................................................. 10  

    3.6  Driver Behavior Coding ................................................ 11  

    3.7  Time Step Requirement ................................................. 15

4  **Error Correction** .......................................................... 16  

    4.1  Correction of VISSIM Error Files .................................... 16  

    4.2  Animation Checking ....................................................... 16
Figure 7. Simulation Time Steps Dialog................................................................. 15
Figure 8. Example Speed Based Congestion Chart (from VISSIM results)............... 20
Introduction

ODOT has an interest in using VISSIM as a tool for freeway micro-simulation modeling. VISSIM is a microscopic, behavior-based, multi-purpose traffic simulation program. For many engineering disciplines, simulation has become an indispensable instrument for the optimization of complex technical systems. This is also true for transportation planning and traffic engineering where simulation is an invaluable cost-reducing tool. The past decade has seen a rapid evolution in the sophistication of the VISSIM model and its use. This protocol will provide practitioners with guidance on what to consider when performing traffic simulation analysis with VISSIM.

This protocol will allow consistent and reproducible application of VISSIM models and will further support the credibility of ODOT’s tools. Depending on the project-specific purpose, need, and scope, elements of the process described in this protocol may be enhanced or adapted to support the modeler and the project team. This document will be updated as needed when technological changes improve or processes change.

Purpose of VISSIM Protocol

ODOT has determined that in order to maintain consistency with VISSIM simulation models used on freeway networks, this protocol would be created to provide guidance for simulation models. This protocol will provide guidance on the following topics:

- Project Boundary Definition
- Data Collection
- Model Development
- Error Correction
- Calibration
- Data Output
- Reporting of Results
1 Project Boundary Definition

The project area boundary will be dependent on the “zone of influence” of the surrounding traffic network. The “zone of influence” could be greater than the minimum boundaries set for the purposes of the protocol, and should be determined along with the appropriate stakeholders of the project. It is important to understand the operational characteristics of the facility of the proposed project. This could range from one intersection from the end of the project to over two miles. This allows for the model to achieve real-world traffic behavior in the project area. Some general guidelines are given for freeway and ramp terminals.

1.1 Freeways

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

It is important to note that the additional area added to the project boundaries are not part of the “study area of interest”. No reporting of measures of effectiveness (MOE’s) should occur for the additional sections, as the driver behavior is not fully calibrated in this area. This additional area should, however, adhere to the VISSIM protocol and be prepared for future use.

1.2 Ramp Terminal Intersections

The VISSIM network shall include the ramp terminal intersections as part of the project. In order to correctly model the ramp terminal intersections, the VISSIM model shall include one intersection outside of the study intersections (if within ½ mile spacing). All intersections influencing the arrival pattern or the lane choice shall be included in the model. This may include unsignalized intersections, depending on the spacing and the influence the intersection has on operations in the ramp terminal area.

As with the additional freeway area, the additional intersections are not part of the “study area of interest” thus, performance measures should not be reported for these intersections.
2 Data Collection

There are various data required to build a VISSIM micro-simulation network. The data used in the model can be more important than the model coding itself. The often used phrase “garbage-in, garbage-out” applies to simulation modeling. It is important to have the appropriate amount of data to support project objectives, and if the data is not available, the project definition should either be redefined or the appropriate amount of data should be gathered. Instructions on how to perform traffic data collection studies can be found in ITE’s Manual of Transportation Engineering Studies.

2.1 Geometric Data

Detailed geometric data must be collected for the study area being modeled. The number of lanes, roadway gradient, locations of tapers, lengths of roadway segments, storage lengths, locations of user specific lanes (HOV, HOT, truck), are all required in building a VISSIM model. Much of this data can be obtained through GIS database files, aerial photographs, construction drawings or field surveys.

PTV provides high quality, regularly updated, street network data provided by NAVTEQ. NAVTEQ networks are very detailed, including neighborhood streets in every community in North America. PTV provides the data in "tiles", each of them including up to approximately 150,000 two-way links. These tiles can be broken down and then detailed into a sub-network. This sub-network will be an accurate network data set for the VISUM model, complete with capacities, turn restrictions, road names, and speeds. This network can then be transferred to VISSIM as a basis for the simulation network, which will then need to be refined to match exact geometry.

Aerial backgrounds or design drawings can also be used for geometric coding. The most important aspect to the geometric coding when using map based backgrounds is to be 100% certain the scale of the drawing is correct. Any GIS or aerial based geometric data should have some type of field verification for accuracy prior to coding a VISSIM network.

2.2 Control Data

The locations of the traffic controllers and their signal timings are required within the study area (typically the ramp-terminal intersections). This data is controlled by various agencies, but must be obtained and input to Synchro first and then imported into VISSIM for use in the simulation model.

Ramp metering information, including density/speed related signal timing inputs, must also be obtained from ODOT for input into the VISSIM model.
2.3 Vehicular Fleet Data

Traffic count data should include vehicle fleet type, and as a minimum, should be broken down into cars, small trucks and large trucks. If available, any additional vehicle fleet information (i.e. percentage of SUV’s, etc.) should be provided to ODOT. Typical ODOT data collection requirements include FHWA Scheme F. Although this is not required to build a VISSIM simulation model, this data set type can be quickly summarized into the needed fleet type for use in the VISSIM model.

In areas where available, percentage of high occupancy vehicles (vehicles with more than one person) should be collected. This is required when modeling areas with HOV lanes, and all VISSIM freeway models in the Portland Area shall have vehicle fleets that include SOV, HOV, small and large trucks.

2.4 Time Period Traffic Volume Data Requirements

In order to achieve reliable results within the peak hour or peak period, the data collection and simulation period should be extended to when the study area is not congested. Modeling the free-flowing period provides two major benefits: proper seeding (gets network to equilibrium) and proper queue/congestion modeling. If the model does not build the queuing/congestion in the same manner as it does in the real-world, then the MOE’s will not likely match during the peak period. The simulation period should also extend until after congestion has dissipated (back to when study area is not congested). For the purposes of modeling areas of the Portland freeway system, the following peak periods are recommended:

- AM Peak Period – 4 hours, starting at 6 am
- PM Peak Period – 5 hours, starting at 2 pm

2.5 Traffic Volume Data

Traffic volumes should be collected in 15-minute increments and summarized into balanced flow maps (with one hour maximum increments). The balanced traffic volume flow maps should account for seasonal and day of week adjustments; however, data collection should be made as close to these base conditions as possible. Seasonal impacts can vary greatly depending on the location, i.e. recreational routes will vary dramatically more than commuter routes. Research on existing surrounding VISSIM models should be done, and the model geometry and corresponding volumes should match these surrounding area models if there are any overlapping areas.

When modeling major weaving areas or conditions with lane utilization disparity, volume counts by lane are necessary. These counts should be detailed based on the previously defined required vehicle fleet and be broken down into 15-minute time periods.
2.6 Origin-Destination Data

Origin-destination (O-D) data should be collected or acquired. If an O-D study is performed, or survey data is collected, this information must be documented and provided to ODOT. If O-D data is not collected, the O-D data may be obtained through the Portland Metro travel demand model with a select link analysis, however, it is recommended that when developing O-D for use in the simulation model, PTV’s process using T Flow fuzzy (defined in model development) should be considered for final OD routing.

2.7 Travel Time Data

Corridor and/or movement travel times should be collected or obtained from ODOT or other agencies. This information should be collected from specific point location to specific point location. The use of GPS data collection devices increases the accuracy and the value of the data collected, as the data can be broken down into more detail. This data can be used for both calibration and future alternative comparisons, specific to locations collected. A minimum of ten peak period runs should be collected for calibration comparison purposes. These peak period runs should be clearly documented with the date and time collected.

2.8 Spot Speed Data

Spot speed data should be collected during off-peak or free-flow conditions for use in building speed profiles in VISSIM for the modeled corridor. Data should be collected at numerous locations (specific to each project) in the project area. This data should be collected during typical free-flowing driving conditions and should not be influenced by weather, sun glare, incidents, or anything else that may impede free-flowing traffic conditions.

Peak period spot speed data (congested conditions, weave areas, etc.) can also be valuable for use in the calibration step. This data should be collected by lane when calibrating speed differential and queuing.

ATR (automatic traffic recorder) data is often available on freeway networks. This data often has by lane volume and speed data collection capabilities, and should be used whenever possible. As with any data collection, the accuracy of the data should be verified.

2.9 Queuing Data

Queuing information should be collected during the peak period. The maximum length and the duration of the queuing should be clearly documented. This information is important for calibration of the modeling and can be compared with visual checks in the model.
2.10 Field Observation

Outside of typical volume and speed data collection, the simulation modeler should make field observations. How, when, where and why congestion occurs, weaving behavior, and other site specific operational issues are valuable for the observer when calibrating base conditions. Field observations should be made during the base conditions being modeled (or as close as possible day and time available).

2.11 Optional Data

2.11.1 Saturation Flow Data

If calibration at a signalized intersection (ramp terminal intersection) is critical, and driver behavior is atypical at the intersection, a saturation flow study may be beneficial to capturing the appropriate localized driving behavior to calibrate to. ODOT’s TPAU is currently (2007) collecting start-up lost time and vehicle headway data on a statewide level for calibration of simulation models.

2.11.2 Delay Data

As an alternate to a saturation flow study, a delay study may be beneficial to capturing the appropriate localized driving behavior to calibrate to.
3 Model Development

To limit the variability in coding techniques, and to simplify the review process, VISSIM simulation coding guidelines have been created. The ranges and coding suggestions provided are suggested freeway coding and are not standards set by the software vendor or as national standards; however, many of the guidelines and suggestions made are directly from PTV training classes and project modeling experiences.

3.1 Vehicular Fleet Setup

All freeway VISSIM models shall be coded with single occupancy vehicles (SOV), high occupancy vehicles (HOV), small and large trucks. Based on the FHWA classification counts, vehicle classes 4 through 7 are small trucks, 8 through 13 are large trucks. Corresponding vehicle model distributions, vehicle types and vehicle classes should be input to account for these classes of vehicles. An example of vehicle model distributions is shown in Figure 1.

Figure 1. Vehicle Model Distribution

3.2 Geometry Coding

3.2.1 Links and Connectors

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. It is also suggested to keep connector lengths as short as possible and have most results computed within links. Also, when using the spline command to create curves for turning
movements, keep in mind additional spline points will add to computation time: therefore, the amount of unnecessary spline points on links and connectors should be minimized as illustrated in Figure 2.

Figure 2. Connector Length

3.2.2 Freeway Merge, Diverge and Weave Coding

The coding of merging, diverging and weaving areas in VISSIM is generally controlled by the routing through the area. The suggested method of coding is to use the connector look-back (route lane-change) distance with a vehicle route to achieve the desired merging performance. This is later discussed in driver behavior coding. In order to properly code merging and weaving sections, the following points should be followed:

- The effective merging area should include the entire auxiliary lane (or lane add) to the farthest extent of the auxiliary lane taper. Vehicles in VISSIM will utilize the extra link length when necessary, which more accurately models the utilization of the taper area.

- The merge or weaving section should be one link with the number of lanes equal to the number of lanes on the main freeway plus the number of lanes merging onto the freeway.

- There should only be one connector at the end of the merge link or at the end of a lane drop section.
• The mainline freeway through movement must be following a route that must not end in the merge or weaving section. The Lane Change (discussed further in driver behavior) distance for the connector downstream from the merge or weaving link must be larger than the length of the merge link. (This should not be an issue if using O-D volumes for routing.)

• The routes of the merging traffic must also extend past the merge link. (This should not be an issue if using O-D volumes for routing.)

3.2.3 **High Occupancy Vehicles, High Occupancy Toll and Truck Only Lanes**

When coding HOV, HOT and truck lanes, it is necessary to have the appropriate geometric segments and the corresponding lane closures for those segments in order to capture the realistic driver behavior in and surrounding these sections. This is an instance where having additional links and connectors are necessary to properly code the changes in lane utilization. Vehicle classes need to be included for SOV, HOV and trucks even if there are not HOV, HOT and/or truck lanes in the area being modeled.

3.2.4 **Known Roadway Improvements / Changes**

When setting up the initial geometric coding it is also important to identify areas where planned or proposed improvements are likely to change the existing geometry, and have them coded or segmented appropriately. This will save time on splitting links and adding connectors, which leads to having to reset the output file configuration and possibly re-calibrating that area in the model.

3.3 **Control Coding**

VISSIM control measures such as signals, stop signs, and yield conditions (priority rules and/or conflict areas) should be modeled as closely to real-world conditions as possible. Traffic signal timing from the field should be used whenever possible. Stop bar locations should be modeled to replicate field conditions. Ramp meter timing should also be coded to match real-world conditions as well, as the demand on the freeway facility is directly related to the speed/density controlled flow rates on the ramps. The coding within VISSIM for a ramp meter can be a typical VAP program written for ODOT ramp metering signals. The critical information will be the location and the settings within the ramp meters themselves and the corresponding flow ramps entering on the ramps.

3.4 **Speed Control Coding**

Desired speed decisions should be used when the free-flow speeds of an area have a significant change due to speed limit signage, geometric change, or facility change. The coding should be based on spot-speed data that was collected in off-peak hours. This data should then have been created into “speed profile” format that can then be input into VISSIM. An example of speed distribution profile is shown in Figure 3.
Reduced speed areas can be used for ramps, turning movement and other areas that have short distance change of speeds. The reduced speed area coding for a ramp should be based on spot-speed data that was collected in off-peak hours. This data should then have been created into “speed profile” format that can then be input into VISSIM. Default speed profiles can be used for typical turning conditions (left, right, and diagonal) at intersections.

### 3.5 Volume / Route Coding

Vehicle inputs shall be coded in 15-minute demand increments. Each input location should have specific vehicular fleet characteristics. Routing decisions should be coded as origin-destinations (O-D). Point-to-point routing is not detailed enough to provide adequate vehicle driving behavior for most freeway conditions. Under point-to-point routing, vehicles do not follow the appropriate paths, which will lead to inaccurate weaving behavior and lane utilization in the simulation model.

One option to obtain an acceptable O-D matrix is by using PTV’s matrix estimation tool – TFlowFuzzy. TFlowFuzzy is a matrix estimation method used to adjust a given O-D matrix so the result of the assignment closely matches desired volumes at points within the network. Some TFlowFuzzy characteristics are:

- Link volumes, origin/destination travel demand and turning volumes can be combined for correction purposes.
- Counted data need not to be available 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 overcoming 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 situation which 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. If one knows, for example, that the volume on a freeway section fluctuates by up to ten percent on a day-to-day basis. This variability can be represented as bandwidths (i.e., tolerances). TFlowFuzzy then replaces the exact count values by Fuzzy Sets with varying bandwidths to solve the matrix-correction-problem.

TFlowFuzzy is applied within the context of an O-D assignment within VISUM. Consequently, VISUM assigns the demand between O-D pairs over a path or paths between the origin and destination. VISUM stores these paths, which can then be exported directly to VISSIM.

### 3.6 Driver Behavior Coding

#### 3.6.1 Car following Parameters

*Figure 4. Wiedemann 99 Car Following Model Dialog*

For freeway links, freeway driver behavior parameters and the Wiedemann 99 car following model should be used (dialog box shown in Figure 4). The default car following parameters are a good starting point for calibration, but at times, may need to be changed to better match real world conditions, especially when trying to match flow rates and achieve particular capacities. Any changes to these
parameters shall be documented with the reason and application for changing them. These adjustments may require an added link type that will apply only to a specific portion of the model (e.g., a merge or weave area). Suggested ranges for suggested calibration parameters for the ODOT freeway system in the Portland Metro Area are displayed in Table 1.

Table 1. Wiedemann 99 Car Following Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Unit</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC0 Standstill Distance</td>
<td>4.92126</td>
<td>ft</td>
<td>4.5 - 5.5</td>
</tr>
<tr>
<td>CC1 Headway Time</td>
<td>0.9</td>
<td>s</td>
<td>0.85 - 1.05</td>
</tr>
<tr>
<td>CC2 'Following' Variation</td>
<td>13.12336</td>
<td>ft</td>
<td>use default</td>
</tr>
<tr>
<td>CC3 Threshold for Entering 'Following'</td>
<td>-8</td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC4 Negative 'Following' Threshold</td>
<td>-0.35</td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC5 Positive 'Following' Threshold</td>
<td>0.35</td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC6 Speed Dependency of Oscillation</td>
<td>11.44</td>
<td>use default</td>
<td></td>
</tr>
<tr>
<td>CC7 Oscillation Acceleration</td>
<td>0.82021</td>
<td>ft/s²</td>
<td>use default</td>
</tr>
<tr>
<td>CC8 Standstill Acceleration</td>
<td>11.48294</td>
<td>ft/s²</td>
<td>use default</td>
</tr>
<tr>
<td>CC9 Acceleration at 50 mph</td>
<td>4.92126</td>
<td>ft/s²</td>
<td>use default</td>
</tr>
</tbody>
</table>

Changing the CC2-CC9 parameters is not recommended unless it is absolutely necessary for a specific calibration scenario. The reasons for any changes to these parameters should be clearly documented and approved by ODOT staff.

3.6.2 Lane Changing Parameters

Figure 5. Lane Change Driver Behavior Dialog
For lane changing on freeway links, default parameters are also good starting point for calibration (shown in Figure 5). However, the parameters could need to be altered in the calibration process to match real-world driving behavior, specifically when modeling merging, diverging and weaving areas. Any alterations from the parameters should be documented with the reason and application for the change.

It is suggested to set the waiting time before diffusion to 600 seconds. This will prevent unnecessary vehicle removal in congested conditions. Vehicles that are removed will appear in the .err file, and these errors should be investigated as to why they are not moving for five minutes, as this could be a coding error.

Suggested ranges for suggested calibration parameters for the ODOT freeway system in the Portland Metro Area are displayed in Table 2. Any values outside these ranges could provide erratic lane changing behavior and create collisions. Values used outside the ranges listed need to be approved by ODOT.

<table>
<thead>
<tr>
<th>Table 2. Suggested Lane Changing Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defaults</strong></td>
</tr>
<tr>
<td>General Behavior: Free Lane Selection</td>
</tr>
<tr>
<td>Necessary Lane Change (route)</td>
</tr>
<tr>
<td>Own unit</td>
</tr>
<tr>
<td>Maximum deceleration: -13.12 ft/s²</td>
</tr>
<tr>
<td>-1 ft/s² per distance: 200 ft</td>
</tr>
<tr>
<td>Accepted deceleration: -3.28 ft/s²</td>
</tr>
<tr>
<td>Waiting time before diffusion: 60 s</td>
</tr>
<tr>
<td>Min. headway (front/rear): 1.64 ft</td>
</tr>
<tr>
<td>To slower lane if collision time above: 0 s</td>
</tr>
<tr>
<td>Safety distance reduction factor: 0.6</td>
</tr>
<tr>
<td>Maximum deceleration for cooperative braking: -9.84 ft/s²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Suggested Range</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>General Behavior: Free Lane Selection</td>
</tr>
<tr>
<td>Necessary Lane Change (route)</td>
</tr>
<tr>
<td>Own unit</td>
</tr>
<tr>
<td>Maximum deceleration: -15 to -12 ft/s²</td>
</tr>
<tr>
<td>-1 ft/s² per distance: 150 to 250 ft</td>
</tr>
<tr>
<td>Accepted deceleration: -2.5 to -4 ft/s²</td>
</tr>
<tr>
<td>Waiting time before diffusion: 600 s</td>
</tr>
<tr>
<td>Min. headway (front/rear): 1.5 to 2 ft</td>
</tr>
<tr>
<td>To slower lane if collision time above: 0 to 0.5 s</td>
</tr>
<tr>
<td>Safety distance reduction factor: 0.25 to 0.80</td>
</tr>
<tr>
<td>Maximum deceleration for cooperative braking: -8 to -10 ft/s²</td>
</tr>
</tbody>
</table>

*NOTE: Waiting time before diffusion is set to a higher number (600 seconds) to avoid vehicle from being removed from the network. Lane change distances / speeds / geometry should be adjusted such that vehicles are not trapped at the end of links.*
3.6.3 Geometric Driver Reaction Coding ("Look back distance" – defined as route lane change distance on connectors)

The look back distance (connector dialog box shown in Figure 6) controls when the vehicles begin to react to the connector, which is a critical setting for ramps on freeways. A good starting point for this parameter is to have the distance set back so that it is located in concurrence with the sign location in the field (when possible). This often needs to be edited to match real-world driver reaction points, as commuters often react well before the sign locations. When sign locations are not available, the following ranges are suggested as a starting point for specific situations:

- System interchange (3,000 feet to 10,000 feet?) – Start at 5,000 feet
- Service interchange (1,320 feet to 7,500 feet?) – Start at 2,500 feet
- Lane drops (1,320 feet to 5,280 feet?) – Start at 2,000 feet
- Ramp Terminal / Arterial Intersections – (500 feet to 5,280 feet) Start at default ~ 656 feet

Figure 6. Connector Lane Change Look-Back Dialog
3.7 Time Step Requirement

In ODOT VISSIM simulation models, the modeler shall use ten (10) time steps per second. The dialog box is under ‘simulation,’ ‘simulation parameters,’ and the simulation resolution shall be set to 10, as shown in Figure 7.

Figure 7. Simulation Time Steps Dialog
4 Error Correction

Calibration of a model is often misunderstood. Calibration is neither error checking nor debugging a model. This is better referred to as validation. A model cannot be calibrated until it is validated. Once all of the inputs to the model are reviewed and a model has been debugged and visually checked for errors, than the calibration step can begin.

4.1 Correction of VISSIM Error Files

Some errors can be eliminated easily. VISSIM provides an error file (.err) in text format that usually details the exact location of the error, by the line number in the input file. Outside of fixing these errors, 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 decision points are properly coded and vehicles are reacting to the decision points)
   d. Check desired speed distributions
   e. Check intersection controls (check link/connector coding to ensure control points are properly coded and are effectively controlling traffic)
   f. Check for prohibited turns, lane closures, and lane restrictions

2. **Vehicular demand checks**
   a. Check vehicle mix proportions at each entry node/gate/zone
   b. Verify VISSIM link demand volumes against traffic counts flow maps
   c. Check vehicle occupancy distribution (if modeling HOVs)
   d. Check O-Ds of trips on the network

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

4.2 Animation Checking

The animation should be observed in close detail 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 potential issues should be explored as causes of the unrealistic animation:

*Error in Expectations*

First, it should be verified in the field that the correct vehicle behavior for the location and time period being simulated before deciding that the animation is
showing unrealistic vehicle behavior. Often times, expectations of realistic vehicle behavior are not matched by actual behavior in the field. Field inspection may reveal the 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.

Animation output enables viewing of vehicle behavior that is being modeled. This allows for assessment of the reasonableness of the microsimulation model itself. Reviewing the animation can be useful for identifying input coding errors, even with artificial demands. Inputs of a very low level of demand allows for following of individual vehicles through the network efficiently. Erratic vehicle behavior (such as sudden braking or stops) is an indicator that there are potential coding errors. A two-stage process can be followed in reviewing the animation output:

1. Run the animation at a low demand level (so low that there is no congestion). Trace single vehicles through the network and see if there are occasions when they unexpectedly slow down. These could indicate locations of minor network coding errors that disturb the movement of vehicles. This test may be repeated for several different volume or routing scenarios.

2. Once the low demand level tests have been completed, run the simulation at half of a peak hour demand level. At this volume level, demand should not be high enough to cause congestion. If congestion appears, it may be the result of coding errors that affect the distribution of vehicles across lanes or their headways. Check entry and exit link flows to verify that all demand is being correctly loaded and moved through the network. Also check routing decisions and look back distances to ensure they are properly coded and are not at locations that will cause unrealistic lane changes or weaving behavior.

A comparison of model animation to field design and operations cannot be overemphasized. Some of the most common issues 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.
• Operations that the model cannot explicitly replicate, such as a two-way left turn lane (TWLTL).

• Average travel speeds that exceed posted or legal speeds (use the observed average speed in the calibration process) – generally this is about five miles per hour over posted speed limit.

• Turn bays that cannot be fully utilized because of being blocked by through traffic.

• In general, localized problems that can result in a system-wide impact.
5 Calibration

Calibration is the adjustment of model parameters to match the driver behavior within the model to that of real-world, field collected localized driver behavior. Having good data is critical to shortening the calibration process. Choosing what to calibrate to can be project specific, however, volumes should always be the first step in calibration. Congestion level and duration, queue lengths, speeds, and travel times are common measures used in calibration.

5.1 Volume

The first step in calibrating the model is to have the input demand volumes (which should originate from counted volumes) match the output demand volumes. This can be verified on several levels, from network wide statistics all of the way down to link specific. The time period being verified can also vary, from volume for each 15 minute time slice to the entire peak period. It is important to do both types of volume verification, and use engineering judgment on what is reasonable for the specific project.

The percentage difference from the model output volume (link or spot location specific) should be no more than ten percent of the input demand volume for the peak period being compared for an existing, calibrated network. Locations within the network with low traffic volumes may be an exception.

If the volume is not matching due to excessive congestion or other reasons, appropriate calibration parameters should be changed until expected volume conditions are obtained.

5.2 Speed

Once the volume output is calibrated in the model, replication of driver behavior is then needed. The first step in getting the driver behavior calibrated is matching spot speeds.

The difference between the observed real-world spot speed data and the simulation model output spot speeds should be no more than ten percent for the time period being compared. If this is not achievable, a comparison between real-world and simulation based congestion charts can be used. If the areas showing congestion within the speed congestion chart (example shown in Figure 8) are similar for the critical areas being modeled, some variation in the outlying parts of the congested areas may be acceptable. This also applies to speeds taken over sections of roadway rather than at specific points.
Figure 8. Example Speed Based Congestion Chart (from VISSIM results)

PM SB Speed

- SB S. of I-5 (Swamp Crk)
- SB at SR 527
- SB S. of SR 527
- SB at NE 195th St
- SB S. of NE 195th St
- SB S. of SR 522 WB offramp
- SB at SR 522
- SB N. of NE 160th St
- SB at NE 160th St
- SB N. of NE 124th St
- SB at NE 124th St
- SB at NE 116th St
- SB N. of NE 85th St
- SB at NE 85th St
- SB N. of NE 70th St
- SB at NE 70th St
- SB N. of SR 520
- SB j/n of SR 520 WB Onramp
- SB j/n of SR 520 EB onramp
- SB S. of SR 520
- SB at NE 8th St
- SB at NE 4th St
- SB S. of NE 4th St
- SB at SE 8th St
- SB S. of SE 8th St
- SB at I-90
- SB N. of Coal Creek Pkwy
- SB at Coal Creek Pkwy
- SB S. of Coal Creek Pkwy
- SB at 112th Ave SE
- SB S. of 112th Ave SE
- SB at NE 44th St
- SB S. of NE 44th St
- SB at N 30th St
- SB S. of N 30th St
- SB at Park Ave
- SB S. of Park
- SB at Sunset
- SB at SR 169
- SB S. of SR 169
- SB at SR 167
- SB S. of SR 167
- SB at SR 181
- SB S. of SR 181

VISSIM Protocol
ODOT Region 1

ODOT Region 1
5.3 Travel Time

The cumulative average output for a select travel time section should have no more than ten percent difference when compared to the average of the real-world travel time runs. The time of day of the data collected versus the model output is critical in this comparison. Comparison across the entire peak period likely will result in poor correlation of real-world conditions to simulation results.

5.4 Queuing/Congestion level

Queue lengths and congestion levels are a good way to start calibration and identify problem areas. If congestion or queuing does not exist in areas of the simulation model that it should (or vise-versa), this is a good indication that there may need to be more area or link specific calibration done in this area. Speed profiles, roadway geometry, and control coding should be checked for accuracy in this situation prior to making driver behavior modifications.

5.5 Lane-by-Lane Volumes/Weaving Behavior

When modeling areas with major weaving, lane changing or in areas that have lane utilization imbalance, lane-by-lane volumes and speeds should be calibrated. The goal of the calibration in these modeling scenarios is to visually match driver behavior and congestion levels. Achieving ten percent variance on volume and speeds may not be achievable for each time period analyzed. Variance of over 20% would not be reasonable. The model should be calibrated to within 10-20% as a reasonable goal.

5.6 VISSIM Calibration Documentation

ODOT requires the procedures for calibration be documented for all VISSIM projects. The documentation should summarize the basic processes and procedures followed, assumptions made, problems encountered, and solutions devised during the study effort. Any calibration parameters changed from default settings should be clearly documented with a description of the reasons for those changes and how they improved the model replication of real-world conditions.
6 Data Output Setup

The data output format or the type of deliverable that will be provided is often an area of traffic simulation modeling that is often overlooked. In order to have a complete understanding of the results, it is critical that the user sets up the VISSIM output appropriately. VISSIM can report results based on specific locations (with data collection points) or be link or lane specific (link evaluation). VISSIM can aggregate statistics from as little as a specific point for a specific vehicle type for a one minute time step to as much as the entire network for every vehicle for the entire length of the simulation. Due to this flexibility, it is imperative that the modeler knows what information will be needed for output before setting up the data output files, or even doing the geometric and data collection coding. The post-processing of the output is typically the most time consuming portion of the simulation process.

6.1 Number of Required Runs

ODOT requires ten simulation runs for any freeway corridor simulation done in VISSIM. Standard statistical analysis should be reviewed for reasonableness of the results. This typically meets standard desired confidence and more than accounts for the typical daily variance of traffic volumes.

Appendix E section 1.4 of the FHWA Traffic Analysis Toolbox has outlined a method for computation of minimum repetitions. This method may be required when performing work that will require standards to meet these FHWA guidelines and should be considered prior to computing multiple run scenarios.

6.2 System Wide MOE’s

A good way of reviewing multiple runs, multiple scenarios or various alternatives is comparing the system-wide MOE’s. VISSIM provides several measures to collect, a few of which are: average speed, delay time, stops, travel time and number of vehicles. Using these statistics is an excellent approach to achieve a relative comparison between multiple alternatives.

6.3 Link Statistics

Link specific volume, speed and density information by user defined time periods can be obtained in VISSIM under link evaluation. The user can also specify to output this data per lane. This data can be directly exported to VISUM for GIS interface-type viewing and reporting.

6.4 Point Processing (Data collection points)

Coding data collection points in corresponding locations to ATR’s or other real-world data collection points and comparing the data is a great way to show calibration results. Data collection points in VISSIM can provide volume and speed information, among other point location/vehicular category specific data. This information is valuable in the
validation and calibration process, but the data can also be effectively displayed in tables, charts and maps as MOE’s.

6.5 Node Results

Results from VISSIM nodes can also be used for validation, calibration and MOE reporting. Nodes are typically used for intersection level MOE’s. Some of the measures that can be collected from a VISSIM node evaluation are:

- Volumes
- Delay / “LOS”
- Queue Length
- Stops

These data can be collected specific to each movement and aggregated into approach, intersection or even interchange level MOE’s.

6.6 Travel Time Results

Results from VISSIM travel time can also be used for calibration and MOE reporting. Travel time section data comparison is an excellent way of comparing model output to real world output, but it is also an efficient way of comparing existing year to future year congestion level. Travel time is also an effective measure used to compare alternatives.

6.7 V/C Ratio

Volume to capacity ratio is not a typical output not only of VISSIM, but of simulation models in general – V/C ratio is more of a macroscopic model MOE. The reason for this is that in simulation the volume and the capacity are both quite variable. The two components (volume and capacity) of the equation are dynamic in simulation, and while you can take a simulation model and determine the capacity at given time slices; that may not be the capacity at another given time within the simulation (due to the components that determine capacity being variable). Simulation also will not provide a “demand volume” that is over the capacity, rather, the simulation model produces congestion and queuing, which is what happens in the real world when volume exceeds capacity. What can be produced in simulation 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, all of which is more valuable than having a static V/C ratio.
7 Reporting of Results

One of the most common mistakes made in reporting of simulation of a congested network is not accounting for queued vehicles, or vehicles that were not allowed into the network. Ideally, the simulation results should have all of the congestion beginning and ending within the simulation study area. Also, the congestion should begin and end within the simulation period. This is important so the modeling of the congestion occurs in the same manner as it develops in the field. The parameters and settings used in the calibration are taken forward, which creates a more reliable queue building and congestion level modeling for future year simulation runs. For the existing Portland freeway system, this means the AM peak period shall be between 6:00 AM and 10:00 AM, and the PM peak period is 2:00 PM to 7:00 PM. It is also important that the “warm-up” or initialization time is not included in the output. All vehicles should be able to enter the network and not queue outside of the network for any step of the simulation period. Often this is not reasonable or feasible for a given situation being modeled (i.e. a 30 year forecast no-build scenario); however, if any of these conditions are not met, it is critical that it be noted when giving the results. Often, “percentage of vehicles served” becomes a critical MOE in the discussion of a congested network. There are also statistical methods that can help to adjust for missing vehicles. This is discussed in detail in Chapter 6 of the FHWA Guidelines for Applying Traffic Microsimulation Modeling Software.

It should be noted that HCM LOS calculations for delay, densities, etc. are not exactly the same as in simulation modeling. Simulation modeling captures data from individual vehicles being modeled over the course of given time periods, whereas macro-models such as HCS, use equations to estimate this. The thresholds for LOS are comparable enough that simulation results can be measured to these thresholds; however, it should be noted where the output results originated.

7.1 Standardized Reports, Tables, Graphs

Depending on the project, there are several types of output that can be provided. This output can now be controlled and formatted using VISSIM Analyzer, including:

- Tables with movement specific volumes, delays, queues and/or LOS (for intersections)
- Tables with link or lane specific speeds, densities and/or LOS (for freeways/ramps)
- Travel times for specific routes or corridors

Other useful output formats:

- Speed / volume / densities relationship charts
• “Brain Scan” – Congestion charts showing LOS, density or speed plots on a time vs. distance chart

• Graphics showing cumulative or average statistics of speed, density or other information on a stick figure or map (can be color coded). This can be obtained quickly in the VISSIM output to VISUM for link evaluation statistics. Graphics can also be displayed on an actual design or aerial map.
### Glossary

**ATR**  
Automatic Traffic Recorder

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

**Flow Bundle**  
Same as select link analysis. Volume distribution of origins or destinations from a selected link in VISUM.

**Initialization**  
“Warm-up” time for model. Also referred to as time to reach equilibrium.

**Microsimulation**  
Modeling of individual vehicle movements on a second or sub-second basis for the purpose of assessing the traffic performance of highway and street systems.

**Model**  
Specific combination of modeling software and modeler-developed input/parameters for a specific application. A single model may be applied to the same study area for several time periods and several existing and future improvement alternatives.

**MOE**  
Measure of Effectiveness

**NEMA**  
National Electrical Manufacturers Association. This is a type of standard signal control logic currently being used in VISSIM.

**Project**  
To reduce the chances of confusing the analysis of a project with the project itself, this report limits the use of the term “project” to the physical road improvement being studied. The evaluation of the impact of a project will be called an “analysis.”

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

**Validation**  
Process where the modeler checks the overall model-predicted traffic performance for a street/road system against field measurements of traffic performance, such as traffic volumes, travel times, average speeds, and average delays. Model validation is performed based on field data not used in the calibration process. This report presumes
that the software developer has already completed this validation of the software and its underlying algorithms in a number of research and practical applications.

**VAP**

Vehicle Actuated Programming is an optional add-on module of VISSIM for the simulation of programmable, phase or stage based, traffic actuated signal controls.

**Verification**

Process where the software developer and other researchers check the accuracy of the software implementation of traffic operations theory. This report provides no information on software verification procedures.
9 References

*Manual of Transportation Engineering Studies*, H.D. Robertson et al., ITE, 1994

*Trafﬁc Analysis Toolbox III: Guidelines for Applying Trafﬁc Microsimulation Modeling Software* (FHWA-HRT-04-040), US Department of Transportation, Federal Highway Administration, June 2004