

PROTOCOL FOR VISSIM SIMULATION



Oregon Department of Transportation

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TERMINOLOGY

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

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

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

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

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

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

HGV: VISSIM abbreviation for heavy vehicles such as trucks

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

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

MOE: Measure of effectiveness.

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

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

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

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

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

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

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

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

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

INTRODUCTION

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

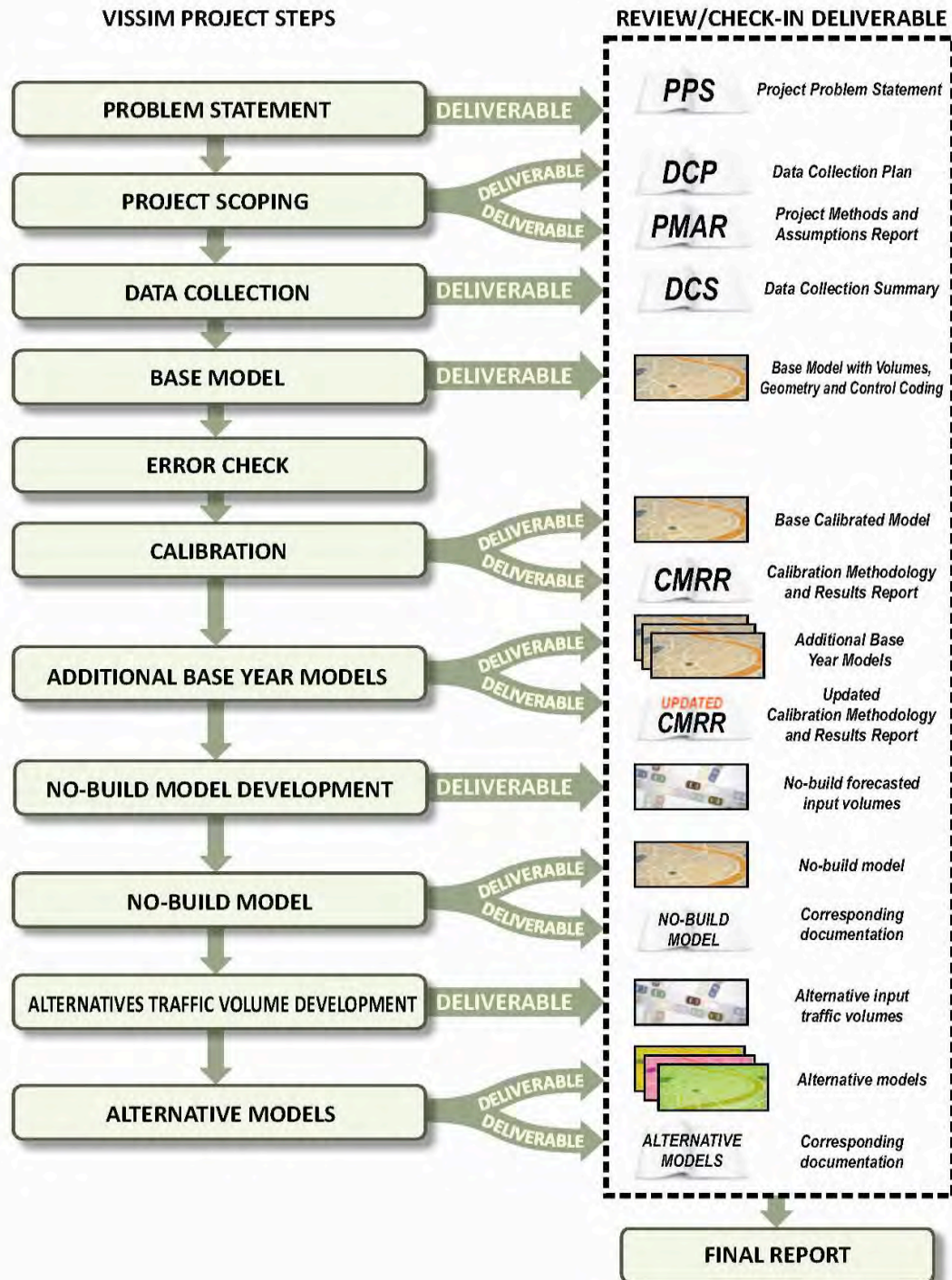
PURPOSE

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

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

Depending on the project-specific purpose, need, and scope, elements of the process described in this protocol, with prior approval from ODOT, may be enhanced or adapted to support the modeler and the project team. This procedures manual is also a living document, which can be updated as technological and/or agency needs change.

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



~ PLEASE READ ~

Before you use VISSIM for analysis on an ODOT facility, careful consideration of the need for this type of evaluation shall be coordinated with ODOT staff. As described in Chapter 1, the level of effort required to build, review, and present results from VISSIM is significant and may not be within the project budget or overall needs.

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

1. PROJECT UNDERSTANDING

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

1.1 Defining the Project Purpose

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

QUESTIONS FOR DEFINING PROJECT PURPOSE/NEED

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

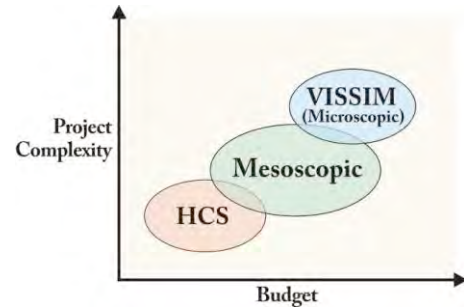
1.2 Is VISSIM the Right Tool?

VISSIM is an attractive option due to its 3D animation capabilities and advanced microsimulation features.

However, it is not always the most cost effective tool.

It may not even be necessary for some studies, considering VISSIM's level of complexity and required outputs/measures of effectiveness (MOEs). In many cases, a simpler deterministic software package such as Synchro or HCS or a simpler microscopic model such as SimTraffic may provide sufficient information to meet the needs of the project.

To facilitate the decision about what analysis tools are the best fit for the study, the following questions should be answered by the sponsor agency as part of the Project Problem Statement.



QUESTIONS FOR DETERMINING APPROPRIATE ANALYSIS TOOL

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

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

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

QUESTIONS ABOUT ADVANCED SOFTWARE FEATURES

1. *What is the purpose of the advanced feature?*
2. *Has this feature been used/applied successfully on a project? Have there been any issues or technical difficulties with the use of this advanced feature in the past?*
3. *In project experience, what have been the advantages of using this feature?*

Based on the project understanding and consideration of the appropriate evaluation tools, what is the recommended package of software tools for this project? If VISSIM is one of the selected tools then the Project Problem Statement (see page 4) should be completed by the sponsor agency 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.

Deliverable:
*Project Problem
Statement*

1.3 What Else Should be Considered?

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

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

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

¹ *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools*, US Department of Transportation, Federal Highway Administration, Publication No. FHWA-HRT-04-039, July 2004.

VISSIM Project Problem Statement

Answer the questions below before completing the project problem statement.

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

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

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

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

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

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

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

8. What types of outputs/MOEs are important for the decision making process? Is the purpose of the evaluation detailed technical evaluation and/or visual simulation? Who

is the decision making body that will review the findings? What might the model be used for in the future?

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

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

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

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

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

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

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

2. PROJECT SCOPING

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

2.1 Project Boundary Definition

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



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

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

The VISSIM network should include ramp terminal intersections as part of the project and, in order to model them correctly, should include, at minimum, one intersection outside of the study intersections (if within half-mile spacing). If the next intersection is beyond half a mile, the project team should determine if this intersection should be included in the model. All intersections that have a significant influence on the arrival

pattern or the lane choice of vehicles entering the network shall be included in the model. This may include unsignalized intersections, depending on the spacing and influence the intersection has on operations in the ramp terminal area. Similar to the freeway zone of influence, these additional intersections are not part of the study area. Thus, performance measures do not need to be reported for these intersections. All boundaries shall be reviewed through field observations and discussions with ODOT staff to ensure that they are logical break points in the roadway network.

2.1.2 Arterials

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

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

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

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

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

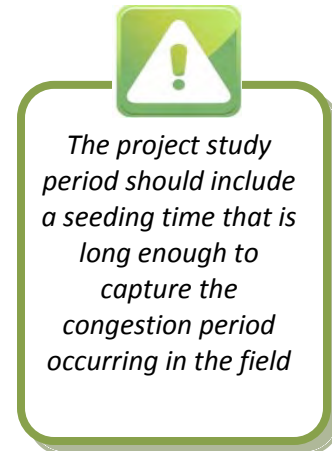
As with freeways, the network should extend far enough to prevent vehicle queues from spilling back off the network. Any location where this cannot be prevented shall be reported in the Project Methods and Assumptions document described in Section 2.7.

2.2 Project Study Period

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

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

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



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

2.2.1 Freeways

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

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

2.2.2 Arterials

Arterial networks usually require a shorter study period than freeway networks. Traffic control devices in the model cause congestion to build faster, which reduces the need for

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

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

2.3 Project Schedule and Staffing Plan

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

2.3.1 Scheduling Considerations

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

2.3.2 Staffing Plan

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

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

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

2.3.3 Project Milestones

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

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

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

2.4 Field Visit

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

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

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

2.5 Key Calibration Locations

Calibration requirements for the study area are described in detail in Chapter 6. These thresholds require that a certain percentage of the entire network meet each of the criteria

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

2.6 Data Collection Plan

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

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

Deliverable:
Data Collection Plan

2.7 Project Methods and Assumptions

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

1. Project Description

The project description will include, but is not limited to, purpose of the project, Project Problem Statement, background information, location, and funding status.

2. Operations Analysis Tools

This may include additional tool(s) beyond VISSIM for analysis. This section shall document which tools will be used on this project, which version of these tools will be used, and for what purpose each tool will be used.

3. Study Area and Model Area

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

4. Analysis Years/Periods to be Modeled

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

5. Data to be Collected

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

6. Use of Data

This section will document what data will be used for model development and what will be used for calibration purposes.

7. Calibration Targets

This section will document what calibration targets will be used for this project.

8. Selection of Measures of Effectiveness (MOEs)

As with data to be collected, there are specific MOEs that must be collected for each model and, depending on the project, data may need to be collected for additional MOEs. This section will document what MOEs will be collected.

9. Assumptions

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

10. Deviations/Justifications

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

11. Project Schedule and Staffing Plan

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

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

Deliverable:
*Project Methods
and Assumptions
Document*

3. DATA COLLECTION

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

3.1 Geometric Data

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

Geometric data to be collected must include:

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

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

- Locations and dimensions of freeway ramp tapers
- Details of user specific lanes (e.g., High Occupancy Vehicles [HOV], Truck, Bus, Bikes)
- Sidewalk locations and widths
- Crosswalk locations, widths, and lengths
- Raised median, pedestrian refuges, and islands
- Parking locations and dimensions
- Significant grades that could affect flow rates
- Transit facility locations
- Freight rail crossing locations and number and duration of crossing events
- Acceleration and deceleration lengths for ramps and turn lanes
- Curve and super elevation (e.g., sharp curves that may affect vehicle speed)
- Radii at intersections for right-turning vehicles
- Sight distance at conflict points, for example, how far upstream a driver stopped at a stop sign can see on the cross street in order to make a gap acceptance decision

² *ODOT Analysis Procedures Manual*, April 2006, <https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx>

3.2 Control Data

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

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

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

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

3.3 Traffic Volume Data

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

When collecting traffic volume data in congested networks, data collection and observation locations must consider how to capture vehicle throughput as well as vehicle demand. In locations such as major bottlenecks where congestion/queuing occurs, upstream data collection may be required to capture actual demand levels (via queuing) in order to properly model the level of congestion and queuing that is observed in the field. Upstream traffic counts should be collected at the less congested entry points into the network/corridor to capture the vehicle arrival/demand profile, as opposed to limiting the volume data to what is delivered through the bottleneck. In these cases, care should be taken to avoid balancing traffic counts collected on either side of a known bottleneck location.

3.3.1 Freeways

Vehicle classification data must be collected at a minimum of one location in the study area, which has been determined through coordination with ODOT during the scoping process. Vehicle classification counts may need to be collected at more locations depending on the purpose and location of the model; ODOT and the consultant will determine the need for this additional data during the scoping process.

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

3.3.2 Arterials

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

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

3.3.3 Time-Varying Volume Profile Estimation

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

- 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 or from estimates such as ODOT Region 1's Hours of Congestion Methodology.
- 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 Adjustments for Design Hour Volumes

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

3.4 Origin-Destination Data

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

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

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

3.5 Travel Time Data

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

Floating car runs is currently the most common method for collecting travel time data. Data is collected by either having a GPS unit record location and time or by having a passenger record data with a stop watch. In both, a vehicle is driven along the study corridor multiple times at the average speed of the vehicles on the roadway.



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

MAC ID/Bluetooth data collection is a relatively new method for collecting travel time data and involves setting up a sensor at both ends of the study corridor. The sensor collects the unique MAC ID information from Bluetooth devices (e.g., cell phones) in vehicles traveling along the corridor. This data can then be matched to individual travel time from two points along the corridor for multiple observations over the peak study period.

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

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

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

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

It is recommended that a minimum of 10 travel time runs be collected in each direction for each hour to be simulated (and each lane where lane imbalances occur) for both freeways and arterials. The 10 travel time runs should be collected during the same time as other data collection if possible but can be collected over multiple days if necessary. Collecting data over multiple days may help provide an understanding of daily fluctuations in traffic. The travel time runs can also be a combination of the floating car and Bluetooth data methods. Similar to volume data, travel time runs should not include data collected within the week of a holiday, when there have been crashes that affect travel in the immediate study area, and/or in inclement weather.

For VISSIM models of complex corridors with long travel times, ODOT may require the statistical calculation outlined in the FHWA's *Traffic Analysis Toolbox* to determine the required number of travel time runs in order to reach a certain confidence interval. As provided in the *Traffic Analysis Toolbox*:

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

Notes:

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

$T_{0.025, N-1}$ = Student's t-statistic for 95-percent confidence – two-sided error of 2.5 percent (totals 5 percent) with N-1 degrees of freedom (for four runs, t = 3.2; for six runs, t = 2.6, for 10 runs, t = 2.3) (Note: There is one less degree of freedom than car runs when looking up the appropriate value of t in the statistical tables)

S = standard deviation of the floating car runs

N = number of required floating car runs

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

3.6 Spot Speed Data

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

3.6.1 Freeways

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

3.6.2 Arterials

Spot speed data collection for arterial networks is typically much more limited. It is not required or even recommended on small grids with closely spaced intersections or short travel distances. Spot speed data can only be collected in areas of free-flow conditions, which may not exist in some arterial networks. If the intersections are spaced far enough apart to allow vehicles to reach free-flow, spot speed data should be collected to help set the desired speed in VISSIM. Due to the friction usually associated with arterial

networks, corridor travel times are usually better than spot speed data for calibration purposes. However, a field visit should be conducted to determine if there are any locations where spot speed data should be collected due to unique geometry that results in significant changes in vehicle speed from what is posted.

3.7 Queuing Data

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

3.7.1 Freeways

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

3.7.2 Arterials

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

3.8 Lane Utilization Data

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

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

3.9 Transit Data

Transit data is generally specific to arterial models and what should be collected depends on the level of detail needed to address the Project Problem Statement. For all arterial

models, the location of transit stops in the study area and transit headways (via transit schedules) must be compiled.

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

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

3.10 Saturation Flow Data

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

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

3.11 Delay Data

Delay data is generally not needed for the development of most VISSIM models; however, there may be some models and locations for which ODOT may require delay data to be collected. If required, delay data should be collected following the methodology outlined in the FHWA's *Traffic Analysis Toolbox*.

3.12 Data Collection Summary

Once data is collected, the consultant must review the data for errors. The data shall be compiled in a Data Collection Summary with a graphical representation provided to ODOT. ODOT staff must review and approve the Data Collection Summary before Model Development can begin. The Data Collection Summary document must include, at a minimum, the following to be used as model input data set:

- Lane schematics
- Final balanced traffic volumes (for freeways, it will include volumes on ramps and mainline sections in-between ramps) for all scenarios
- 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

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

Deliverable:
*Data Collection
Summary*

4. MODEL DEVELOPMENT

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

4.1 Possible Software Updates

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

4.2 General Network Parameters

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

4.3 Vehicular Fleet Setup

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

Table 4-1: Suggested 3D Models by FHWA Vehicle Class for Heavy Vehicles

#	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_conn.v3d
			HGV_wb67d_trailer.v3d
			HGV_wb40_trailer.v3d
13	Seven or More Axle Multi-Trailer Trucks	HGV_wb50_tractor.v3d	HGV_wb67d_trailer_conn.v3d
			HGV_wb40_trailer.v3d
			HGV_wb40_trailer.v3d

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 ODOT and the results documented.

4.4 Network Coding

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

4.4.1 Freeway Merge, Diverge and Weave Coding

The coding of merging, diverging, and weaving areas in VISSIM such as the entrance ramp depicted in Figure 4-1 is generally controlled by the routing through the area and lane change distance parameters.

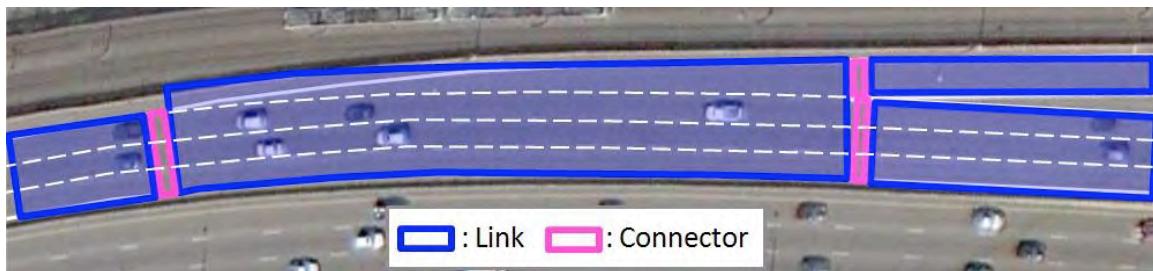
Figure 4-1: Typical Freeway Entrance Ramp Merge Area



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 at the end of the merge link or at the end of a lane drop section (refer to connector A in Figure 4-2).

Figure 4-2: Suggested Coding of a Freeway Merge Area



4.4.2 Arterials

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

It should be noted that when using the ANM import from either VISUM, TRAFFIX, or Synchro, turn bays are coded as an additional lane of the through link. The desired lane change behavior is replicated by the import automatically adjusting the turning connector's emergency stop distance equal to the turn bay length minus 10 meters (32.8 feet).

All right turn connectors at signalized intersections should be coded as Right-Turn-on-Red (RTOR) where permitted and be signal controlled where no right turn on reds are permitted.

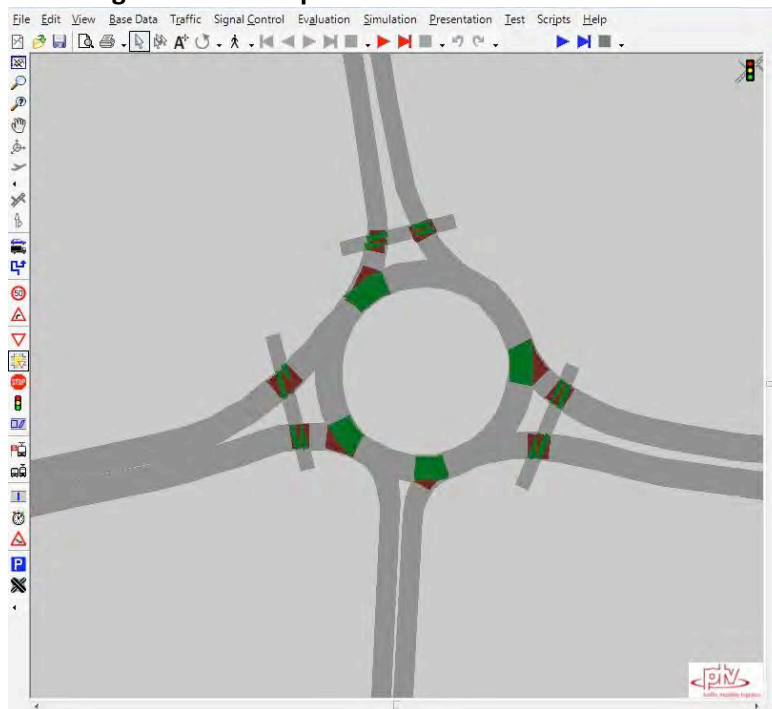
4.4.3 Roundabouts

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

Conflict Areas

Conflict areas can be defined anywhere two links/connectors overlap in the network, such as at the entry point of a roundabout as shown in Figure 4-3. Depending on the geometry of the roundabout, additional conflict areas may need to be defined. Priority is designated by the user. In the case of roundabouts, priority will be given to the circulating traffic. Entering traffic looks downstream as it approaches the conflict area. If a circulating vehicle is approaching the conflict area or is in the conflict area, the entering vehicle will slow down or stop to give way to the circulating vehicle. The entering vehicle then proceeds through the conflict area after satisfying the gap conditions (front gap, rear gap, and/or safety distance).

Figure 4-3: Example Conflict Area at Roundabouts



If the conflict area is a crossing conflict, front gap and rear gap parameters must be defined. The front gap determines how soon after a vehicle clears the area an entering vehicle will proceed. The default value for this parameter is 0.5 seconds; however, values as low as zero may be acceptable as this reflects the tendency to enter a roundabout very close to the circulating vehicle.

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

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

The benefit of the conflict area is that each vehicle determines the total gap time it requires to proceed through the conflict area, based on its own specific vehicle attributes such as acceleration and deceleration capabilities. In addition, with conflict areas, the vehicle that has the right of way is also able to see and respond to vehicles that may have entered the conflict area erroneously and adjust speeds to avoid collisions.

In addition to the front and rear gap definitions, visibility distance can be defined for each link approaching the conflict area. This distance is set to a default of 100 meters (328 feet) but should be adjusted to reflect the actual visibility along each link based on the design of the roundabout.

Priority Rules

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

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

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

Roundabout analysis is also affected by operational speeds. The NCHRP Report 672 or field collected speed data at roundabouts of similar characteristics should be used to determine the appropriate speeds for entering and exiting vehicles. Collecting speed data at similar roundabouts in the field will provide more detail of the locations where reduced speed areas and desired speeds should be placed. In addition, the actual proposed design of the roundabout should be taken into consideration, including the size of the circulating roadway and various turn radii. The method to determine operational speeds and any additional assumptions that will be used in developing a roundabout for a VISSIM project should be outlined in the Project Methods and Assumptions Report.

4.5 High Occupancy Vehicles, High Occupancy Toll, and Truck Only Lanes

When coding High Occupancy Vehicles (HOV), High Occupancy Toll (HOT), and truck only lanes, it is necessary to have the appropriate geometric segments and their corresponding lane closures in order to capture realistic driver behavior. This is an instance where having additional links and connectors are necessary to properly code the changes in lane utilization.

4.6 Known Roadway Improvements / Changes

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

4.7 Control Coding

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

4.7.1 Ramp Meters

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

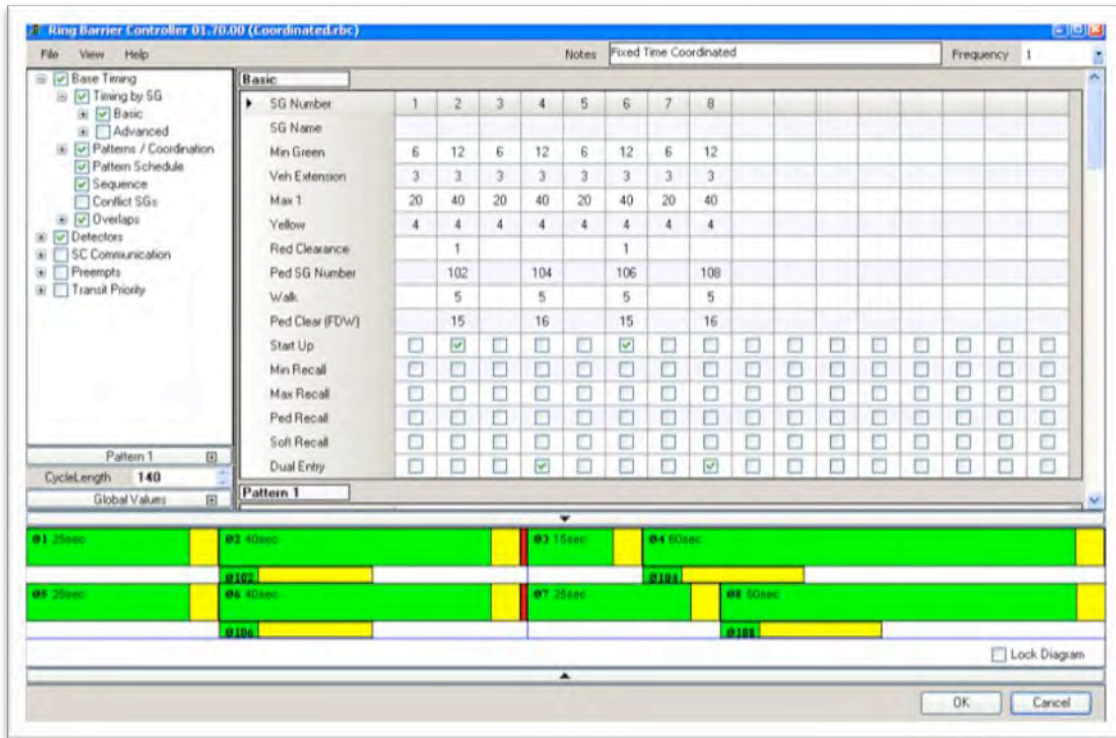
If field data indicates the ramp meter operates at a fixed rate during the study period, or if the project is not focused on ramp meter operations, a fixed-time signal controller can be used in VISSIM instead of a VAP controlled ramp meter. It should be noted that the rates can change during the simulation period as long as the switch time is fixed and the rates do not fluctuate in between. An example of VAP ramp metering coding is provided in Appendix F. Coordination with ODOT should be conducted to determine any alternative ramp signal timing that will be used in alternative models.

4.7.2 Signal Controller Settings

The Ring Barrier Controller (RBC) is the preferred method for coding traffic signals. It includes all the parameters of a real-world signal controller and accurately models actuated-coordinated signal operations. It also includes advanced features such as detector settings and signal priority/preemption. RBC controllers can be directly created when importing Synchro files with optimized signal timings or can be directly coded into VISSIM. Figure 4-4 shows an example of the RBC interface. Submissions of all existing conditions models must include source documentation for all signal timing, typically in the form of controller timesheets. It is important to note that the frequency of the RBC file match the VISSIM time steps per second. The checklist ODOT will utilize for the review of this timing is included in Appendix G and may be helpful in the coding process.

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

Figure 4-4: Example of the Ring Barrier Controller Interface



Vehicle interactions with yellow lights vary among states, and even among cities. As outlined in the APM, adjustments to driver reactions at signals may be required to better reflect the less aggressive nature often found in drivers in Oregon; however, VISSIM

does not offer parameter changes specific to driver's reactions at signals. If the model does not accurately reflect interactions at traffic signals, one possible adjustment is to consider moving one second of yellow time to red time.

4.7.3 Adaptive Signal Timing

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

4.7.4 Unsignalized Intersections

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

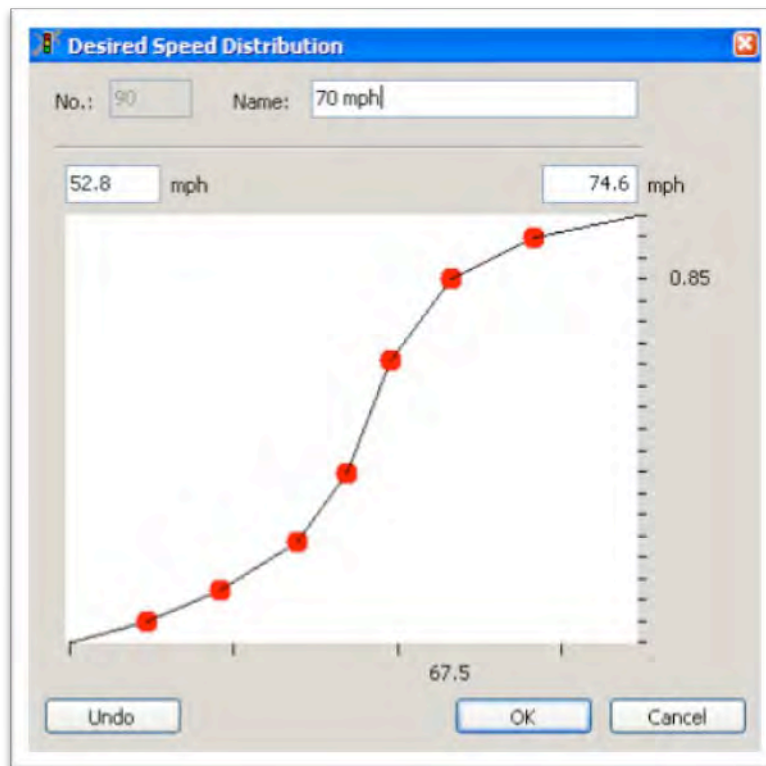
4.8 Speed Control Coding

To control the speed of vehicles in VISSIM, the modeler can apply a "speed decision" or "reduced speed" on a network link. Desired speed decisions change the desired speed of vehicles that cross it, and should be used when the free-flow speeds of an area have a significant change due to the posted speed limit, geometric changes, topography, or facility changes. Reduced speed areas are temporary zones with a reduced speed and should be used to code small sections where vehicles have a significant change in speed due to reduced speed locations in the field (e.g., ramps, turning movements). **Desired speed decisions and/or reduced speed areas should never be used to mimic congestion in the calibration area.** The only locations where speed decisions and/or reduced speed areas may be used to replicate congestion from bottlenecks is at the very ends of models, completely out of the study and calibration area and they can only be used to mimic congestion from upstream bottlenecks not included in the model and that are not anticipated to be fixed by the year of the future models.

4.8.1 Freeways

For freeway models, spot speed data or archived speed data should be used to code the desired speed decisions. This data should then be converted into a “speed profile” format that can be inputted into VISSIM. An example of a speed distribution profile is shown in Figure 4-5. If the model is being developed in the Portland area, speed flow maps developed from PORTAL may also be used to develop speed distribution profiles. As with spot speed data, the speed distribution profile must be developed based on the off-peak (free-flow) speeds. Whatever method is used to develop the speed distribution profiles must be documented and verified with ODOT as part of the Methods and Assumptions Document.

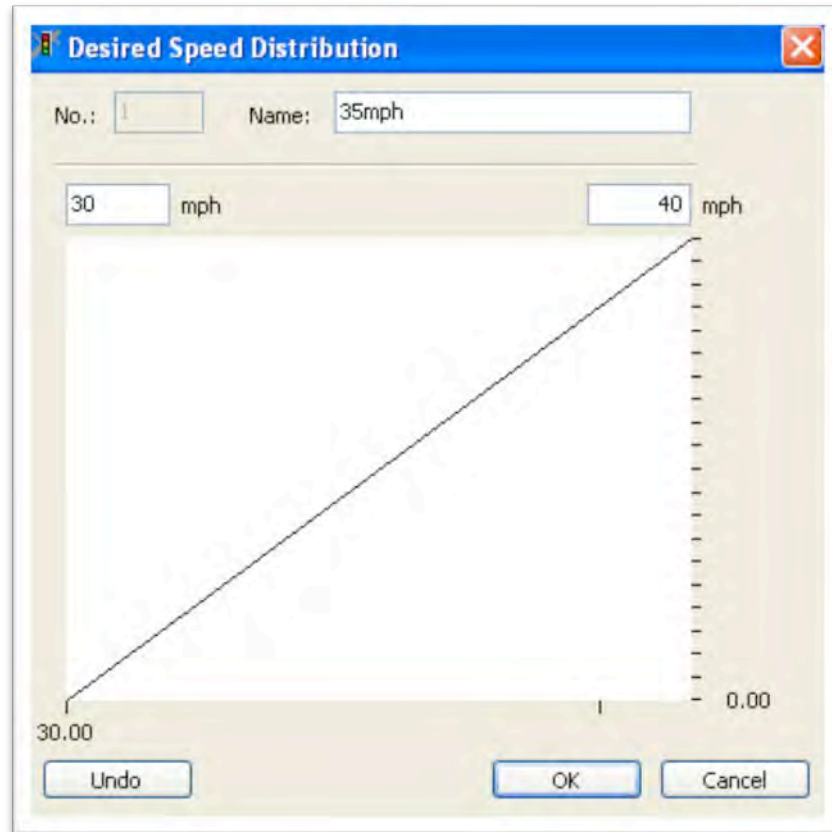
Figure 4-5: Example of Speed Distribution Profile



4.8.2 Arterials

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

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



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

Deliverable:
Base Model with
Geometry and
Control Coding

4.9 Vehicle Inputs

Vehicle inputs should be coded in 15-minute demand increments; however, in some cases hour increments may be acceptable if volumes are consistent throughout the hour. If necessary, each input location should have specific vehicular fleet characteristics (e.g., truck percentages). For

freeway networks, a global estimate of HGV vehicles in the traffic stream can be estimated from a regional demand model or, if necessary, for the specific project from classification counts. Because results will be based on the average of multiple simulation runs, the default input setting of “exact” is recommended.

4.10 Vehicle Routing

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

4.10.1 Static Routes

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

Figure 4-7: Recommended Routing Decision Placement



In some cases, this simplistic approach cannot replicate real-world conditions. If intersections are spaced too closely, there will not be enough time for vehicles to change lanes to make their assigned turn. At closely spaced intersections, it might be necessary to route vehicles through multiple intersections to eliminate unrealistic turning movements.

For example, with routing decisions coded as shown in Figure 4-7, a westbound vehicle in the right lane leaving the upstream intersection attempting to get to the left turn may not have enough time to change lanes to reach the connector for the left-turn bay. The Combine Routes feature of VISSIM should be utilized to create more realistic turning movements (Figure 4-8). The combine routes features is not recommended to be used for more than five intersections and should start from the furthest intersection downstream to the last intersection upstream.

Figure 4-8: Example of the Combine Routes Feature



4.10.2 Dynamic Routing

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

4.10.3 Origin-Destination (O-D) Based Vehicle Routing

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

A vehicle should be assigned one complete route upon entering the network that continues until the vehicle leaves the network. However, if the network includes both arterial and freeway links, it is acceptable to have separate O-D matrices for each

roadway type. For example, one matrix routes arterial traffic to and from each freeway ramp, while the freeway matrix routes vehicles from entrance ramp to exit ramp.

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

4.10.4 Dynamic Traffic Assignment (DTA)

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

4.10.5 TFlowFuzzy Guidelines

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

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

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

One of the primary challenges with solving the matrix-correction problem is to overcome the fact that traffic counts are inherently variable from one day to the next. If this

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

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

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

4.11 Driving Behavior Models in VISSIM

Driving behavior in VISSIM consists of two behavior models:

- Car following model
- Lane change model

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

4.11.1 Car Following Parameters

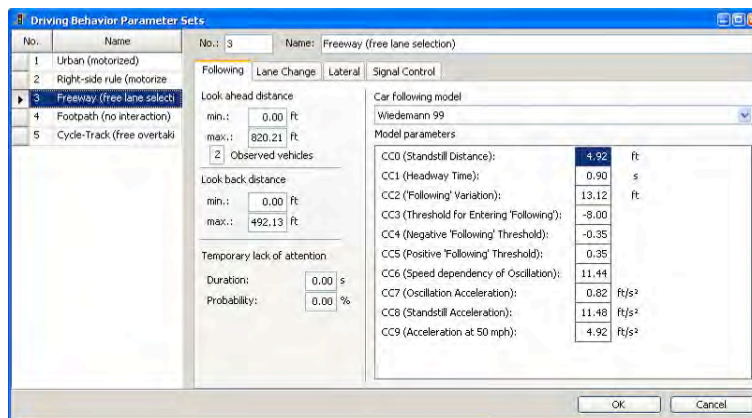
The traffic flow model in VISSIM is a discrete, stochastic model that contains a psycho-physical car following model for all interactions along the same lane. Car following model in VISSIM consists of two models applicable to different conditions:

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

4.11.1.1 Freeways (Wiedemann 99 Model)

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

Figure 4-9: Wiedemann 99 Car Following Model Dialog



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 Tables 4-2 (U.S. Customary).

Table 4-2: Wiedemann 99 Car Following Parameters (U.S. Customary Unit)

	Default	Unit	Suggested Range	
			Basic Segment	Merging / Weaving
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/s ²	use default	
CC8 Standstill Acceleration	11.48	ft/s ²	use default	
CC9 Acceleration at 50 mph	4.92	ft/s ²	use default	

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

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

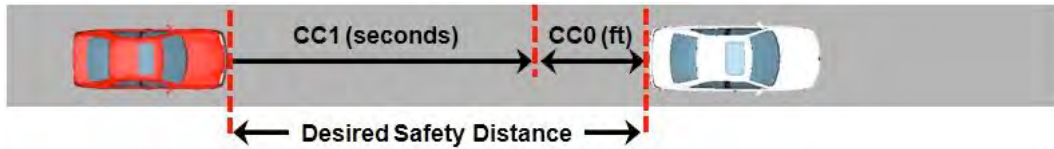
Figure 4-10: Standstill Distance Parameter (CC0)



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

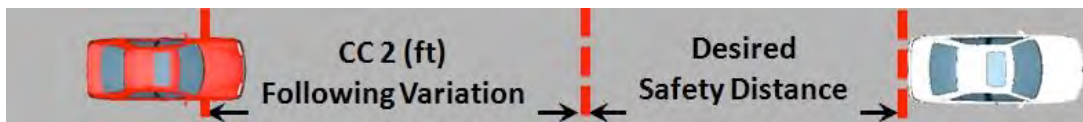
$$\text{Desired Safety Distance} = CC0 + (CC1 \times \text{speed})$$

Figure 4-11: 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.

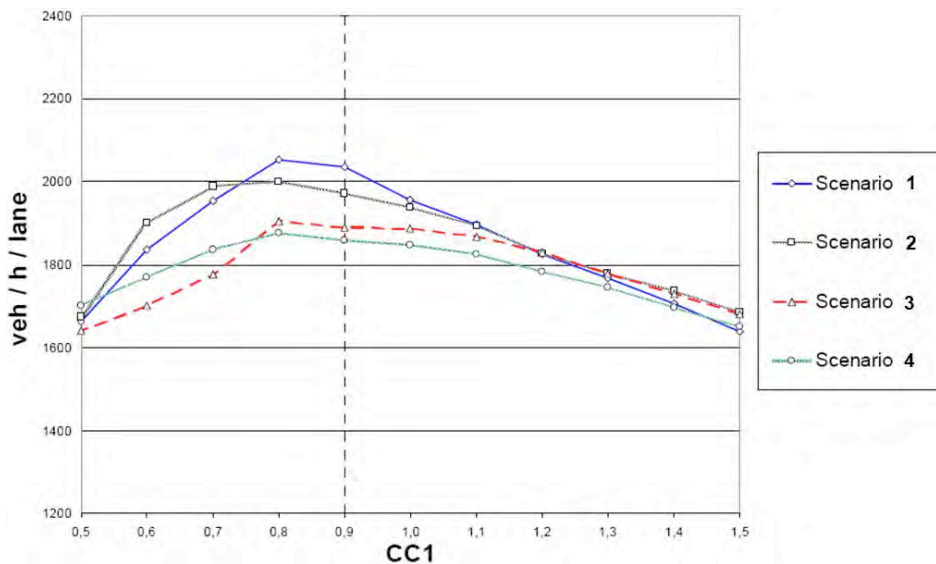
Figure 4-12: Following Variation Parameter (CC2)



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 4-13, which illustrates that the simulated maximum flow rate changes significantly as the CC1 parameter changes. It should be noted that maximum flow rate was measured from a basic freeway segment of an example network and the highest maximum flow rate was achieved at the default setting (CC1: 0.9). Note that different networks with different traffic conditions (e.g., heavy vehicle percentage and lane change frequency) may show different relationships between CC1 and the maximum flow rate.

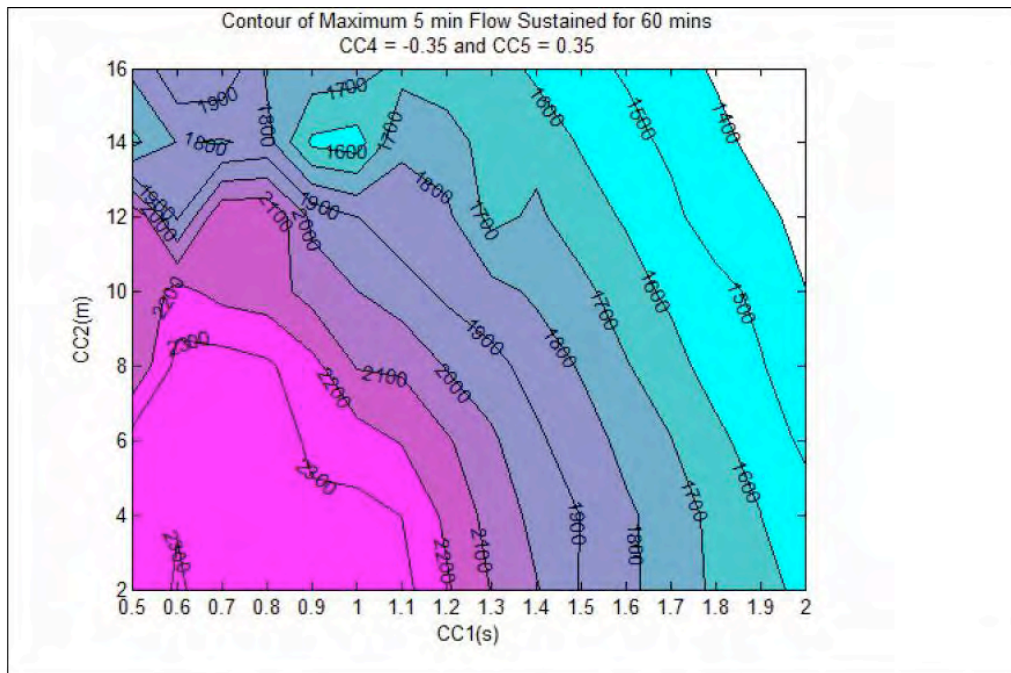
Figure 4-13: Maximum Flow Rate vs. CC1



Scenario	Number of Lanes	Desired Speed (km/h)	Right-side Rule	Heavy Vehicle Percentage
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 4-14, can be referenced to determine appropriate CC1 and CC2 parameter ranges to achieve the desired sustained maximum flow rate in free flow condition. Note that maximum flow rate at any given CC1 and CC2 combination may vary when other aspects (e.g., heavy vehicle percentage, desired speed, and heavy weave/merge behavior) change.

Figure 4-14: Maximum Flow Rate vs. CC1 and CC2³



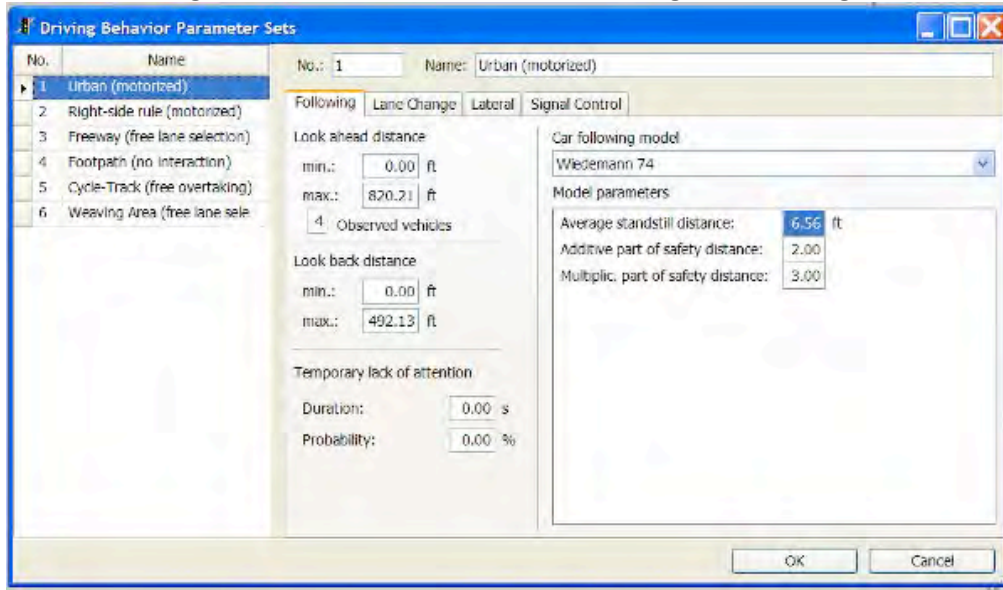
Changing the CC3 through CC9 parameters is not recommended unless it is absolutely necessary for a specific calibration scenario. The reasons for any changes to these parameters should be clearly documented and approved by ODOT staff.

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 4-15, there are three parameters available for this model: average standstill distance, additive part of safety distance, and the multiplicative part of safety distance.

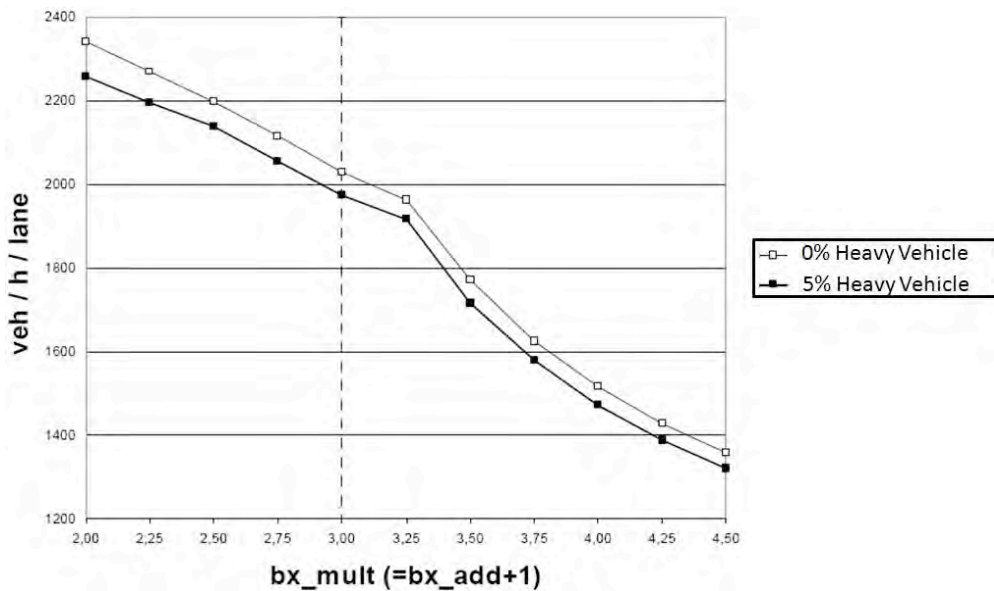
³ Analysis of Wiedemann 74 and 99 Driver Behavior Parameters, S. Menneni, C. Sun, and P. Vortisch (<https://trid.trb.org/view.aspx?id=881912>)

Figure 4-15: Wiedemann 74 Car Following Model Dialog



As with the freeway model, the default parameters are a good starting point. The first parameter, “Average Standstill Distance,” corresponds to the CC0 parameter in the freeway Wiedemann 99 behavior model. The other two Wiedemann 74 parameters work together to determine the target desired safety distance (which has a direct relationship with saturation flow rate). Figure 4-16 illustrates the impact of changing the parameters. As shown, a greater parameter value will result in a greater desired safety distance, thus reducing the saturation flow rate.

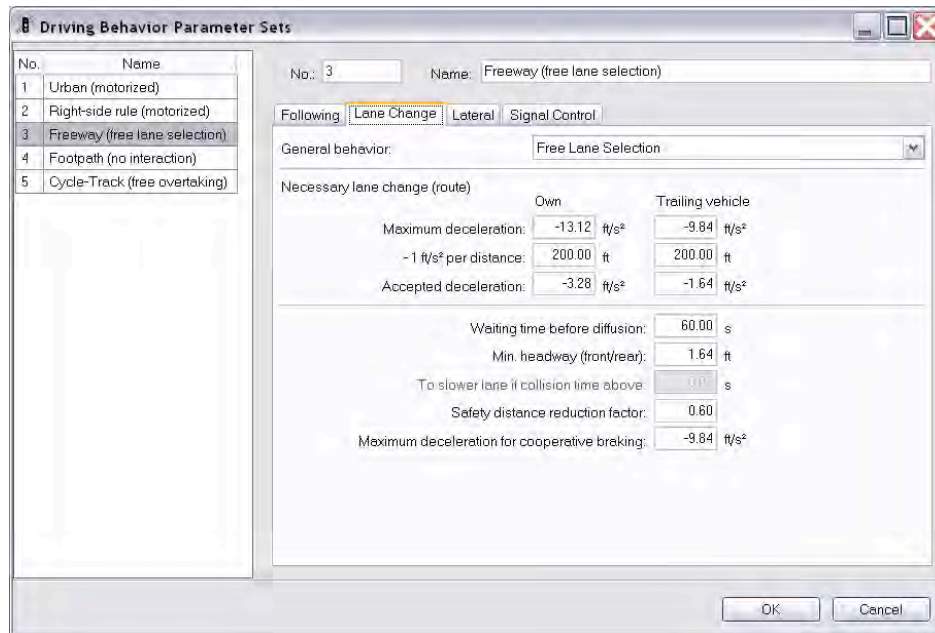
Figure 4-16: Saturation Flow Rate vs. Desired Safety Distance Parameters



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 4-17, the default parameters are a good starting point. However, the parameters may need to be changed in the calibration process to match real-world driving behavior, specifically when modeling merging, diverging, and weaving areas. Any changes from the parameters should be documented with the reason and application and reported to ODOT staff.

Figure 4-17: Lane Change Driver Behavior Dialog



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

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

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

Table 4-3: Suggested Lane Change Parameters

DEFAULTS				
General Behavior		Free Lane Selection		
Necessary Lane Change (route)	Own	Unit	Trailing Vehicle	Unit
Maximum deceleration:	-13.12	ft/s ²	-9.84	ft/s ²
-1 ft/s ² per distance:	200	ft	200	ft
Accepted deceleration:	-3.28	ft/s ²	-1.64	ft/s ²
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/s ²
Overtake reduced speed areas:			<input type="checkbox"/>	*
SUGGESTED RANGES				
General Behavior		Free Lane Selection		
Necessary Lane Change (route)	Own	Unit	Trailing Vehicle	Unit
Maximum deceleration:	-15 to -12	ft/s ²	-12 to -8	ft/s ²
-1 ft/s ² per distance:	150 to 250	ft	150 to 250	ft
Accepted deceleration:	-2.5 to -4	ft/s ²	-1.5 to -2.5	ft/s ²
Waiting time before diffusion:			60	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/s ²
Overtake reduced speed areas:			<input type="checkbox"/>	*

* Leave box un-checked

4.11.3 Geometric Driver Reaction Coding

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

4.11.4 Time Step Requirement

In ODOT VISSIM simulation models, the modeler shall use ten time steps per second. The dialog box is under “simulation / simulation parameters” and the simulation resolution shall be set to 10.

4.12 Non-Auto Modes Coding

Non-auto modes may include but are not limited to:

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

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

5. ERROR CORRECTION

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

5.1 Verify all VISSIM Inputs

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

- 1 *Geometry, speed and control checks*
 - a. Check basic network connectivity (any missing connectors?)
 - b. Check link geometry (lengths, number of lanes, link types, etc.)
 - c. Check free-flow speed coding (location of desired speed decisions and reduced speed areas, check for link/connector coding to ensure speed decision points are properly placed and that they influence vehicle speed as intended)
 - d. Check desired speed distributions
 - e. Check coding and placement of intersection controls to ensure vehicles are reacting as intended
 - f. Check for prohibited turns, right turn on red restrictions, lane closures, and lane use restrictions
 - g. Check conflict area settings
- 2 *Vehicular demand checks*
 - a. Check vehicle compositions at each entry link/node/zone
 - b. Verify VISSIM freeway link demand volumes against traffic counts flow maps
 - c. Verify VISSIM arterial routing decisions including connector look back distances match turning movement input data
 - d. Check vehicle occupancy distribution (if modeling HOVs)
 - e. Check O-D zone/parking lot coding and placement in the network
 - f. Check contents of O-D trip matrices
- 3 *Vehicle type and behavior*
 - a. Check traffic compositions
 - b. Check vehicle model distributions

- c. Check vehicle types and vehicle classes
- d. Check link types for appropriate behavior model

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

5.2 Animation Checking

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

Error in Expectations

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

Data Coding Errors

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

Route Assignment Errors

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

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

A comparison of model animation to field design and operations cannot be overemphasized. Some of the most common issues found in the field that may need special attention when modeling in VISSIM are:

- Overlooked data values that need refinement

- Irregular vehicle operations (e.g., drivers using shoulders as turning or travel lanes, etc.)
- Previously unidentified points of ingress or egress
- Complex driver behavior, such as the interactions in a two-way left turn lane (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.



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

6. CALIBRATION

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

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

6.1 Volume/Density

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

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

For hourly flows, the GEH formula is:

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

Notes:

m = output traffic volume from the simulation model (vph)

c = input traffic volume (vph)



Calibration of the model should use the GEH formula, calculated to a value of 5 or lower

Table 6-1 provides guidance on interpreting the calculated GEH statistic. The volume calibration criteria are listed in Table 6-2.

Table 6-1: GEH Statistic Guidelines

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

Table 6-2: Traffic Volume Calibration Criteria

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

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

6.2 Speed

After volume output is calibrated in the model, replication of driver behavior is needed. The first step is to match spot speeds. This usually pertains to freeway segments because it is difficult to measure accurate speed data on arterials due to the influence of signalized intersections.

At all points identified in the List of Key Calibration Locations, spot speeds in the model should be within 10 percent of observed real-world spot speed data. If detailed network-wide travel speeds are available from sources such as the PORTAL database, then speeds in the model shall be within 10 mph of observed real-world spot speed data on at least 85 percent of all freeway links where real-world speed is available for comparison. In some instances, ODOT may specify more refined spot speed calibration criteria than those stated above. ODOT approval on the spot speed calibration criteria should be obtained prior to the completion of the Methods and Assumptions Report.

Spot speed charts similar to the example shown in Figure 6-1, which compares simulation results to real-world field data, shall be prepared for all freeway corridors. Locations and durations of speeds within the chart should replicate locations of available data from PORTAL or other sources. These results should also be presented in table format in the Calibration Methodology and Results Report. If detailed network-wide real-world speed data is not available, this comparison shall be based on field observations of existing conditions.

Figure 6-1: Example of a Speed Comparison Table

	4:00 PM	4:15 PM	4:30 PM	4:45 PM	5:00 PM	5:15 PM	5:30 PM	5:45 PM	
SOUTHBOUND Average Speeds - (Vissim Data)									Location
SB 0.76	53	52	52	52	52	48	38	45	Ramp #1
SB 1.92	52	38	35	33	31	30	33	31	Ramp #2
SB 2.55	50	45	43	39	42	49	41	42	Ramp #3
SB 3.12	51	50	50	50	50	51	50	51	Ramp #4
SB 4.35	52	52	52	52	52	52	52	50	Ramp #5
SB 5.11	52	52	52	52	52	52	50	43	Ramp #6
SB 5.95	52	52	52	52	52	46	44	39	Ramp #7
4pm	5pm								
SOUTHBOUND Speeds - (Portal Data)									Location
SB 0.76	53	53	50	47	50	49	36	40	Ramp #1
SB 1.92	57	41	41	42	40	25	34	30	Ramp #2
SB 2.55	51	48	44	41	40	48	39	41	Ramp #3
SB 3.12	56	47	48	49	50	52	48	52	Ramp #4
SB 4.35	59	56	57	58	54	54	56	56	Ramp #5
SB 5.11	60	52	57	59	55	53	48	42	Ramp #6
SB 5.95	60	52	58	59	58	48	42	38	Ramp #7
4pm	5pm								
SOUTHBOUND Average Speeds - Percent Difference									Location
SB 0.76	1%	1%	5%	11%	4%	2%	6%	11%	Ramp #1
SB 1.92	10%	6%	17%	25%	25%	17%	3%	4%	Ramp #2
SB 2.55	3%	7%	3%	5%	4%	2%	6%	2%	Ramp #3
SB 3.12	9%	7%	5%	2%	0%	2%	5%	3%	Ramp #4
SB 4.35	12%	7%	9%	11%	4%	4%	7%	11%	Ramp #5
SB 5.11	14%	0%	9%	13%	6%	2%	3%	2%	Ramp #6
SB 5.95	14%	0%	12%	13%	12%	5%	4%	2%	Ramp #7
4pm	5pm								

6.3 Travel Time

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

Table 6-3: Travel Time Calibration Criteria

Criteria	Acceptance Targets
Modeled travel time within ± 1 minute for routes with observed travel times less than 7 minutes.	All routes identified in the Data Collection Plan
Modeled travel time within $\pm 15\%$ for routes with observed travel times greater than 7 minutes.	All routes identified in the Data Collection Plan

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

In some instances, ODOT may specify more refined travel time calibration criteria than those listed in Table 6-3. ODOT approval on the travel time calibration criteria should be obtained prior to the completion of the Methods and Assumptions Report.

6.4 Queuing

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

6.5 Weaving Behavior

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

6.6 Lane Utilization

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

6.7 Transit Travel Times

Transit travel times shall also be calibrated for key routes identified in the List of Key Locations for Calibration. The criteria listed in Table 6-3 should be used.

6.8 Visual Inspection

A visual inspection of the calibrated base model shall be performed and compared to observations of field operations to verify that the model is accurately replicating field conditions.

6.9 Minimum Number of Simulation Runs

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

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

R = 95-percent confidence interval for the true mean

$t_{0.025, N-1}$ = Student's t-statistic for two-sided error of 2.5 percent (totals 5 percent) with N-1 degrees of freedom

s = standard deviation of about the mean for selected MOE

N = number of required simulation runs

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

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

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

6.10 VISSIM Calibration Documentation

ODOT requires that a Calibration and Methodology Results Report be submitted with the calibrated base model. The report shall summarize the basic processes and procedures followed, assumptions made, problems encountered, and solutions

Deliverable:
*Calibration
Methodology and
Assumptions Report*

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

7. ADDITIONAL BASE YEAR SCENARIOS

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

7.1 Model Development

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

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

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

Deliverable:
*Additional Calibrated Base
Year Models and
Updated Calibration
Methodology Results Report*

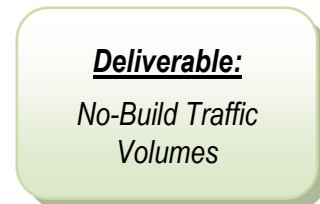
8. ALTERNATIVES

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

8.1 Developing Volumes for the No-Build Scenario

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

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



8.2 Model Development

A copy of the calibrated model shall be used to create the no-build model. The future no-build model may include improvement projects that are assumed to be funded and constructed within the project planning horizon. The modeler should coordinate with ODOT Region staff to identify these projects. Typically, such projects would be listed in the Statewide Transportation Improvement Program (STIP), city or county Transportation System Plans (TSP), or Metropolitan Planning Organization's (MPO) Regional Transportation Plans (RTP). See Oregon's Transportation Planning Rule⁴ for more information. The only coding changes expected within the VISSIM model for a no-build model would be traffic demand inputs and routing, signal timing, any time-of-day specific lane use restrictions, and any proposed improvements. Signal timing changes should be documented and provided for ODOT review and approval upon submittal of the model. Once completed, the no-build model can be used to develop all additional alternative models.

⁴ [Transportation Planning Rule \(TPR\)](#).

8.3 Changes to the VISSIM Model

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

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

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

8.4 Error Checking

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

8.5 Initial Assessment of the No-Build Model

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

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

Deliverable:
*Alternative Scenarios
Traffic Volumes*

8.7 Model Development

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

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

9.1 Required Data Outputs

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

9.1.1 Node Evaluation

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

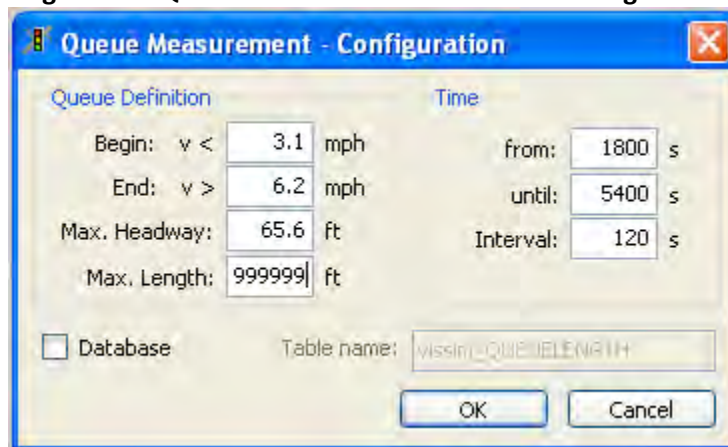
- Node Number
- Movement
- Number of Vehicles (throughput)
- Average Delay
- Stops

9.1.2 Queue Counters

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

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

Figure 9-1: Queue Measurement Evaluation Configuration



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

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

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 list of all maximum queues for each movement must be averaged together to get the “average of the max.” The standard deviation from this data set must also be calculated. With these two values the 95th percentile queue can be calculated using the formula (same calculation as SimTraffic):

$$95^{\text{th}} \text{ percentile queue} = \text{average of the max queues} + 1.65 * \text{standard deviation}$$

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

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, ODOT may require that a model be simulated with a storage pocket (turn link) to be extended (a distance to be determined on a project by project basis) to determine the true queue length for the turning movement and the ideal storage length to prevent spillback from blocking the adjacent through lane.

9.1.3 Data Collection Points

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

- Number of Vehicles
- Speed (mean)

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 ODOT during the scoping process.

9.2.1 V/C Ratio

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

9.2.2 Network Performance Evaluation

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

9.2.3 Link Evaluation

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

- Volume
- Speed
- Density (non-HCM compliant – see next paragraph)

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

9.2.4 Speed Contour Plots

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

9.2.5 Emissions

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

9.2.6 Lane Changes

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

9.2.7 Travel Time (for O-D Data)

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 9-2:

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

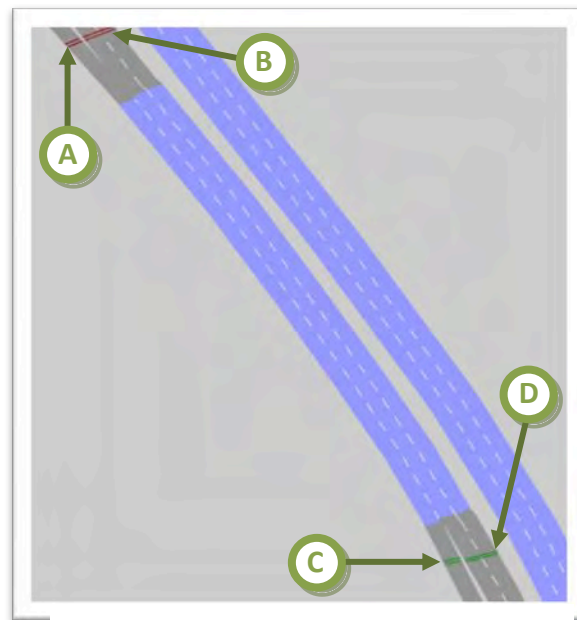


Figure 9-2: Travel Time Segment Placement for OD Data

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

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

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

9.3.1 HCM Compliant Level of Service Results

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

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

As stated above, properly calibrated microscopic simulation models will produce delays (and other performance measures) that more accurately reflect field operations related to the given network geometry, multimodal volumes, and control strategies than

deterministic equation based methods like those included in the HCM. VISSIM explicitly models vehicle-vehicle (vehicle-pedestrian, auto-transit, etc.) interactions, queue interactions, freeway and signalized arterial interactions, arterial actuated signal control operations, events (e.g., railroad preemption), ramp metering, etc., unlike the deterministic approaches. Unlike VISSIM, HCM procedures tend to break down as the intersection reaches capacity.

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

9.4 Sample Report Format

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

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

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

10. REVIEWING

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

ODOT VISSIM Reviewing Checklist

Milestone	Protocol Section	Items to Check
<i>Scoping</i>		
Project Problem Statement	1.1	<input type="checkbox"/> The goals of the project are clearly stated <input type="checkbox"/> Proposed MOEs provide the necessary information to answer the Project Problem Statement <input type="checkbox"/> Field visit has been conducted
Comments:		
Data Collection Plan	2.6	<input type="checkbox"/> Summary of a field visit to determine data collection needs has been provided in a graphical format <input type="checkbox"/> Summary of real-world observations (and historical data if available) showing congestion locations have been provided <input type="checkbox"/> Time periods for data collection have been determined and documented <input type="checkbox"/> 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	<input type="checkbox"/> Project understanding, including the problem statement, is described <input type="checkbox"/> Software tools to be used for this project and their use have been outlined

		<input type="checkbox"/> Model area, calibration area, and study area have been defined <input type="checkbox"/> Project study period and years for analysis have been defined <input type="checkbox"/> The types of data to be collected, location of collection, and the time increment and period that they will be collected are provided <input type="checkbox"/> Documentation of if the data collected will be used for model development and/or calibration purposes <input type="checkbox"/> A complete list of MOEs that will be collected from the model is included <input type="checkbox"/> Calibration targets have been outlined for this project. <input type="checkbox"/> Any known assumptions associated with this project have been outlined <input type="checkbox"/> Any known deviations from the protocol guidelines are documented with justification <input type="checkbox"/> A project schedule demonstrating a linear sequence of milestones is provided <input type="checkbox"/> VISSIM experience of the staff that will be working on the project are described
Comments:		
<i>Data collection</i>		
Data Collection Summary	3.12	<input type="checkbox"/> Development of input volume data sets have been documented <input type="checkbox"/> Sink and source locations are identified in graphical format <input type="checkbox"/> Lane schematics in graphical format <input type="checkbox"/> Documentation of any errors found in data and the assumptions that were made in accordance with the errors <input type="checkbox"/> Traffic volumes to be used in analysis of all existing conditions are provided in graphical format <input type="checkbox"/> Posted speeds and any localized segments of adjusted desired speeds are provided in graphical format <input type="checkbox"/> Any lane imbalance locations that require special coding are documented and described graphically <input type="checkbox"/> Summary of travel time and speed data

Comments:		
<i>Model Coding</i>		
Base VISSIM Model	4.2 - 4.11	<input type="checkbox"/> Lane geometry correct at all intersections <input type="checkbox"/> Locations of freeway lane drops/adds correct <input type="checkbox"/> Merge/diverge locations coded correctly per Section 4.3.1 <input type="checkbox"/> Desired Speed Decisions coded at all locations of change in posted speed <input type="checkbox"/> Reduced Speed Areas at all turns and areas of temporary speed reductions <input type="checkbox"/> Conflict Areas/Priority Rules coded at all intersections and other conflict points <input type="checkbox"/> Stop Signs coded at proper locations <input type="checkbox"/> Traffic signals coded at correct intersections <input type="checkbox"/> Traffic signal stop bars and detectors coded at proper locations <input type="checkbox"/> Traffic signal timing matches field timing (<i>see Traffic Signal Timing Checklist</i>) <input type="checkbox"/> Nodes coded at all study intersections with Node Evaluation toggled on <input type="checkbox"/> Queue Counters coded for all movements at all intersections in the List of Key Calibration Locations <input type="checkbox"/> Max Queue Value increased from default value to include longest possible queue <input type="checkbox"/> Data Collection Points coded on all entry and exit links <input type="checkbox"/> Travel Time Segments coded for all sections identified in the Data Collection Plan <input type="checkbox"/> Transit routes, headways, and dwell time parameters match real-world conditions
Comments:		

<i>Calibration</i>		
Calibrated Base Model and Calibration Methodology and Results Report	6.1 – 6.10	<input type="checkbox"/> Calibration Methodology and Results Report submitted <input type="checkbox"/> Model animations match expected driver behavior and conditions observed in the field <input type="checkbox"/> Model output volumes satisfy GEH statistic requirements (GEH < 5) in Section 6.1 <input type="checkbox"/> Model link speeds meet speed calibration requirements in Section 6.2 <input type="checkbox"/> Model travel time results meet calibration requirements in Section 6.3 <input type="checkbox"/> Model queuing replicates real-world conditions <input type="checkbox"/> Calibration results are based on the average of the minimum number of simulation runs calculated as shown in Section 6.9
Comments:		
<i>Additional Base Year Scenarios</i>		
Additional Base Year Models and Updated Calibration Methodology and Results Reports	7	<input type="checkbox"/> Calibration Methodology and Results report has been expanded to provide proof of calibration for additional base year models <input type="checkbox"/> Model animations match expected driver behavior and conditions observed in the field <input type="checkbox"/> Model output volumes satisfy GEH statistic requirements (GEH < 5) in Section 6.1 <input type="checkbox"/> Model link speeds meet speed calibration requirements in Section 6.2 <input type="checkbox"/> Model travel time results meet calibration requirements in Section 6.3 <input type="checkbox"/> Model queuing replicates real-world conditions <input type="checkbox"/> Calibration results are based on the average of the minimum number of simulation runs calculated as shown in Section 6.9
Comments:		

<i>Alternatives</i>		
No-Build Forecasted Input Volumes	8.1	<input type="checkbox"/> Methodology for developing traffic volumes has been provided <input type="checkbox"/> Any assumptions made during volume development have been outlined <input type="checkbox"/> Traffic volumes to be used in analysis are provided in graphical format
No-Build Models and Corresponding Documentation	8.2-8.5	<input type="checkbox"/> Summary of input and output vs. demand is documented with any reasons for variation <input type="checkbox"/> Any preliminary findings from the models are documented <input type="checkbox"/> Signal timing matches agency guidelines <input type="checkbox"/> Assumptions and parameter changes are documented <input type="checkbox"/> All proposed network changes coded correctly <input type="checkbox"/> Animation of the network looks feasible
Comments:		
Alternatives Input Traffic Volumes	8.6	<input type="checkbox"/> Methodology for developing traffic volumes has been provided <input type="checkbox"/> Any assumptions made during volume development have been outlined <input type="checkbox"/> Traffic volumes to be used in analysis are provided in graphical format
Comments:		
Alternative Models and Corresponding Documentation	8.7	<input type="checkbox"/> Summary of input and output vs. demand is documented with any reasons for variation <input type="checkbox"/> Any preliminary findings from the models are documented <input type="checkbox"/> Signal timing matches agency guidelines <input type="checkbox"/> Assumptions and parameter changes are documented

Appendix A:
**Decision Making Tools Excerpts for the FHWA's Traffic Analysis
Toolbox Volume II**

Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools

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2.0 Criteria for Selecting the Appropriate Type of Traffic Analysis Tool

This section identifies criteria that can be considered in the selection of an appropriate traffic analysis tool and helps identify under what circumstances a particular tool should be used. Section 3.0 of this document contains guidance on how to use this information to select the appropriate tool.

Sections 2.1 and 2.2 present the criteria a user should consider when selecting a type of traffic analysis tool. The first step is identification of the analytical context for the task—planning, design, or operations/construction. Seven additional criteria are necessary to help identify the analytical tools that are most appropriate for a particular project. Depending on the analytical context and the project’s goals and objectives, the relevance of each criterion may differ. The criteria include:

1. Ability to analyze the appropriate **geographic scope** or study area for the analysis, including isolated intersection, single roadway, corridor, or network.
2. Capability of modeling various **facility types**, such as freeways, high-occupancy vehicle (HOV) lanes, ramps, arterials, toll plazas, etc.
3. Ability to analyze various **travel modes**, such as single-occupancy vehicle (SOV), HOV, bus, train, truck, bicycle, and pedestrian traffic.
4. Ability to analyze various **traffic management strategies and applications**, such as ramp metering, signal coordination, incident management, etc.
5. Capability of estimating **traveler responses** to traffic management strategies, including route diversion, departure time choice, mode shift, destination choice, and induced/foregone demand.
6. Ability to directly produce and output **performance measures**, such as safety measures (crashes, fatalities), efficiency (throughput, volumes, vehicle-miles of travel (VMT)), mobility (travel time, speed, vehicle-hours of travel (VHT)), productivity (cost savings), and environmental measures (emissions, fuel consumption, noise).
7. **Tool/cost-effectiveness** for the task, mainly from a management or operational perspective. Parameters that influence cost-effectiveness include tool capital cost, level of effort required, ease of use, hardware requirements, data requirements, animation, etc.

Each analytical tool category was evaluated against each criterion to identify whether or not a category of analytical tool was appropriate for use. This evaluation is presented in the form of matrices. In each matrix cell, a value has been assigned to each tool category

according to its relevance or applicability to the corresponding criterion. A *solid circle* (●) indicates that the particular tool category adequately addresses the criterion. An *empty circle* (○) indicates that the traffic analysis tool category poorly addresses the specific criterion. A *null symbol* (∅) indicates that some tools within the tool category may address the criterion and others may not. *Not applicable* (N/A) indicates that the particular tool category does not address the corresponding criterion at all and should not be used for the analysis.

Figure 2 below summarizes the criteria that may be considered for the selection of a tool category.

The steps for selecting the appropriate type of analytical tool are:

1. Users should begin by identifying the project's analytical context (discussed in section 2.1).
2. Next, users should filter through criteria 1 through 6 to limit the appropriate tool categories to one or two options (as discussed in sections 2.2.1 through 2.2.6).
3. Finally, criterion 7 (tool/cost effectiveness) should be used to select the final tool category (presented in section 2.2.7) based on parameters outside of the technical context of the analysis, such as tool cost, training, hardware requirements, etc.

Step-by-step guidance for the tool selection process is presented in section 3.0. An automated tool that implements the guidance can be found at the FHWA Traffic Analysis Tools Web site at:

<https://ops.fhwa.dot.gov/trafficanalysistools/index.htm>

Finally, a listing of available tools for each category and their Web site links are provided in section 4.0.

2.1 Analytical Context

The first step in selecting the appropriate type of traffic analysis tool is the identification of the analytical context of the project. Figure 2 illustrates a typical transportation analysis process, which contains several analytical phases, including:

- **Planning:** This phase includes short- or long-term studies or other State, regional, or local transportation plans (e.g., master plans, congestion management plans, ITS strategic plans, etc.).

**Analysis Context:
Planning, Design, or Operations/Construction**

1	2	3	4	5	6	7
Geographic Scope	Facility Type	Travel Mode	Management Strategy	Traveler Response	Performance Measures	Tool/Cost-Effectiveness
<p>What is your study area?</p> <ul style="list-style-type: none"> ● Isolated Location ● Segment ● Corridor/Small Network ● Region 	<p>Which facility types do you want to include?</p> <ul style="list-style-type: none"> ● Isolated Intersection ● Roundabout ● Arterial ● Highway ● Freeway ● HOV Lane ● HOV Bypass Lane ● Ramp ● Auxiliary Lane ● Reversible Lane ● Truck Lane ● Bus Lane ● Toll Plaza ● Light Rail Line 	<p>Which travel modes do you want to include?</p> <ul style="list-style-type: none"> ● SOV ● HOV (2, 3, 3+) ● Bus ● Rail ● Truck ● Motorcycle ● Bicycle ● Pedestrian 	<p>Which management strategies should be analyzed?</p> <ul style="list-style-type: none"> ● Freeway Mgmt ● Arterial Intersections ● Arterial Mgmt ● Incident Mgmt ● Emergency Mgmt ● Work Zone ● Spec Event ● APTS ● ATIS ● Electronic Payment ● RRX ● CVO ● AVCSS ● Weather Mgmt ● TDM 	<p>Which traveler responses should be analyzed?</p> <ul style="list-style-type: none"> ● Route Diversion <ul style="list-style-type: none"> - Pre-Trip - En-Route ● Mode Shift ● Departure Time Choice ● Destination Change ● Induced/Foregone Demand 	<p>What performance measures are needed?</p> <ul style="list-style-type: none"> ● LOS ● Speed ● Travel Time ● Volume ● Travel Distance ● Ridership ● AVO ● v/c Ratio ● Density ● VMT/PMT ● VHT/PHT ● Delay ● Queue Length ● # Stops ● Crashes/Duration ● TT Reliability ● Emissions/Fuel Consump ● Noise ● Mode Split ● Benefit/Cost 	<p>What operational characteristics are necessary?</p> <ul style="list-style-type: none"> ● Tool Capital Cost ● Effort (Cost/Training) ● Ease of Use ● Popular/Well-Trusted ● Hardware Requirements ● Data Requirements ● Computer Run Time ● Post-Processing ● Documentation ● User Support ● Key Parameters ● User Definable ● Default Values ● Integration ● Animation/Presentation

Figure 2. Criteria for selecting a traffic analysis tool category.

- **Design:** This phase includes approved and funded projects that are going through analysis of the alternatives or preliminary design to determine the best option for implementation. This phase also includes the analysis of roadway features needed to operate at a desired level of service (LOS). Full design projects (e.g., horizontal/vertical alignments, pavement design, etc.) are not included in this category.
- **Operations/Construction:** These projects share many similar characteristics with design projects, but are performed to determine the best approach for optimizing or evaluating *existing* systems.

Table 1 presents the general relevance of each tool category for each analytical context, including planning, design, and operations/construction.

Table 1. Relevance of traffic analysis tool categories with respect to analytical context.

Analytical Context	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/Deterministic Tools (HCM-Based)	Traffic Optimization	Macroscopic Simulation	Mesososcopic Simulation	Microscopic Simulation
Planning	●	●	∅	○	∅	∅	○
Design	N/A	∅	●	●	●	●	●
Operations/Construction	∅	○	●	●	●	●	●

- Notes:**
- Specific context is generally addressed by the corresponding analytical tool/methodology.
 - ∅ Some of the analytical tools/methodologies address the specific context and some do not.
 - The particular analytical tool/methodology does not generally address the specific context.
 - N/A The particular methodology is not appropriate for use in addressing the specific context.

Notes and Assumptions:

- The role of these tools may vary according to the analytical context. For example, the use of simulation can differ considerably for planning versus operations. In planning, the system does not exist and modeling or simulation is necessary for analyzing alternatives. However, when considering traffic-responsive control measures for an existing system, real measurements should first be considered, while simulation plays a secondary role.

2.2 Criteria for Analytical Tool Selection and Assessment of Tool Capabilities

Criteria 1 through 7 from figure 2 are discussed in the following sections, with the first six criteria focusing on the various technical aspects of the analysis (e.g., facility type, travel

mode, management strategy, etc.), while criterion 7 helps to identify the best tool category from a management/operational perspective.

2.2.1 Study Area/Geographic Scope

Traffic analysis tools have varying degrees of capabilities with respect to the analytical environment and geographic scope of the project. Table 2 summarizes the general relevance of each tool category based on the study area/geographic scope appropriate for the task. Four types of study areas are included:

- **Isolated Location:** Limited study area, such as a single intersection or interchange.
- **Segment:** Linear or small-grid roadway network.
- **Corridor/Small Network:** Expanded study area that typically includes one major corridor with one or two parallel arterials and their connecting cross-streets, typically less than 520 square kilometers (km²) (200 square miles (mi²)).
- **Region:** Citywide or countywide study area involving all freeway corridors and major arterials, typically 520 km² (200 mi²) or larger.

Notes and Assumptions:

- The study area/geographic scope is the only criterion that has varying relevance with respect to the analytical context. The user should identify both the analytical context and the study area type for this matrix.
- For the traffic simulation tool categories (macroscopic, mesoscopic, and microscopic simulations), the geographic area relevance factors are identical because, in general, simulation tools feature the same geographic areas (e.g., segment, corridor, etc.), but with varying levels of detail.
- Typically, analytical/deterministic tools are based on the HCM procedures, which are more focused on single roadways or isolated locations rather than on a network or a roadway grid system.

Table 2. Relevance of traffic analysis tool categories with respect to study area/geographic scope.

Analytical Context/ Geographic Scope	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/Deterministic Tools (HCM-Based)	Traffic Optimization	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Planning							
Isolated Location	○	○	●	∅	○	○	○
Segment	●	○	● ¹	○	∅	∅	∅
Corridor/Small Network	∅	●	○	○	∅	∅	∅
Region	∅	●	N/A	N/A	N/A	N/A	N/A
Design							
Isolated Location	N/A	N/A	●	●	●	∅	●
Segment	N/A	○	●	∅	●	●	●
Corridor/Small Network	N/A	∅	○	○	●	●	●
Region	N/A	∅	N/A	N/A	○	○	∅
Operations/Construction							
Isolated Location	N/A	N/A	●	●	●	∅	●
Segment	∅	○	●	●	●	●	●
Corridor/Small Network	N/A	∅	○	∅	●	●	●
Region	N/A	∅	N/A	N/A	∅	○	∅

Notes: ● Specific context is generally addressed by the corresponding analytical tool/methodology.
 ∅ Some of the analytical tools/methodologies address the specific context and some do not.
 ○ The particular analytical tool/methodology does not generally address the specific context.
 N/A The particular methodology is not appropriate for use in addressing the specific context.
¹For linear networks

2.2.2 Facility Type

This section discusses the ability of the tools to analyze various facility types. Definitions for the facility types were based on HCM 2000. The relevance of the analytical tool categories with respect to the facility-type criterion is presented in table 3. The facility types include:

Table 3. Relevance of traffic analysis tool categories with respect to facility type.

Facility Type	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/Deterministic Tools (HCM-Based)	Traffic Optimization	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Isolated Intersection	○	∅	●	●	●	●	●
Roundabout	○	○	●	○	∅	○	∅
Arterial	●	●	●	●	●	●	●
Highway	●	●	●	∅	●	●	●
Freeway	∅	●	●	∅	●	●	●
HOV Lane	∅	●	∅	○	●	●	●
HOV Bypass Lane	○	●	○	∅	∅	∅	●
Ramp	∅	●	●	●	●	●	●
Auxiliary Lane	○	○	∅	∅	●	●	●
Reversible Lane	○	∅	○	○	○	○	∅
Truck Lane	○	●	∅	∅	∅	○	●
Bus Lane	○	●	○	○	∅	○	●
Toll Plaza	○	∅	∅	○	○	○	●
Light-Rail Line	○	●	○	○	○	○	●

Notes: ● Specific context is generally addressed by the corresponding analytical tool/methodology.
 ∅ Some of the analytical tools/methodologies address the specific context and some do not.
 ○ The particular analytical tool/methodology does not generally address the specific context.

- **Isolated Intersection:** Single crossing point between two or more roadway facilities.
- **Roundabout:** Unsignalized intersection with a circulatory roadway around a central island with all entering vehicles yielding to circulating traffic.
- **Arterial:** Signalized street that primarily serves through traffic and that secondarily provides access to abutting properties (signal spacing of 3.2 kilometers (km) (2 miles (mi)) or less).
- **Highway:** High-speed roadway connecting major areas or arterials, with little or no traffic signal interruption (e.g., two-lane highway, expressway).
- **Freeway:** Multilane, divided highway with a minimum of two lanes for the exclusive use of traffic in each direction and full control of access without traffic interruption.

- **HOV Lane:** Exclusive highway or street lane for vehicles with a defined minimum number of occupants (more than one), including buses, taxis, or carpools (may be used by other traffic under certain circumstances, such as during off-peak hours, for making a right or left turn, or by motorcycles, depending on the jurisdiction's traffic laws).
- **HOV Bypass Lane:** Exclusive on-ramp lane for vehicles with a defined minimum number of occupants (more than one), including buses, taxis, carpools, for specified time periods.
- **Ramp:** Short segment of roadway connecting two roadway facilities.
- **Auxiliary Lane:** Additional lane on a freeway to connect an on-ramp and an off-ramp.
- **Reversible Lane:** Roadway lane that changes directions during different hours of the day (reversible lanes are typically used to help alleviate congestion by accommodating the peak direction of traffic).
- **Truck Lane:** Designated lane for commercial vehicles, but not for public transit vehicles.
- **Bus Lane:** Highway or street lane reserved primarily for buses during specified periods (may be used by other traffic under certain circumstances, such as for making a right or left turn, or by taxis, motorcycles, or carpools that meet the requirements of the jurisdiction's traffic laws).
- **Toll Plaza:** Facility where payment transaction for the use of the roadway takes place (may be located upstream or downstream of the toll facility).
- **Light-Rail Line:** Electric-powered railway system operating single cars or short trains on a variety of alignment types on a partially controlled right-of-way.

Notes and Assumptions:

- Generally, it is not appropriate to optimize a two-lane highway or roundabout.

2.2.3 Travel Mode

Table 4 presents a matrix rating the appropriateness of each tool category in analyzing the different travel modes. The definitions for the travel modes are based on HCM 2000:

- **SOV:** Vehicle with the driver as the only occupant.
- **HOV:** Vehicle with a defined minimum number of occupants (more than one), including buses, taxis, carpools, and vanpools.
- **Bus:** Self-propelled, rubber-tired road vehicle designed to carry a substantial number of passengers and commonly operated on streets and highways.

Table 4. Relevance of traffic analysis tool categories with respect to travel mode.

Travel Mode	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/Deterministic Tools (HCM-Based)	Traffic Optimization	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
SOV	●	●	●	●	●	●	●
HOV	∅	●	∅	∅	∅	●	●
Bus	∅	●	∅	∅	∅	●	●
Rail	∅	●	○	○	○	∅	∅
Truck	∅	∅	∅	∅	∅	∅	∅
Motorcycle	○	∅	○	○	○	○	○
Bicycle	∅	∅	∅	○	○	○	∅
Pedestrian	∅	○	∅	∅	∅	∅	∅

Notes: ● Specific context is generally addressed by the corresponding analytical tool/methodology.
 ∅ Some of the analytical tools/methodologies address the specific context and some do not.
 ○ The particular analytical tool/methodology does not generally address the specific context.

- **Rail:** Transit system using trains operating in exclusive or shared rights-of-way (includes both light and heavy rail systems).
- **Truck:** Heavy vehicle engaging primarily in the transport of goods and materials or in the delivery of services other than public transportation.
- **Motorcycle:** Self-propelled vehicle with two wheels in tandem that may be ridden by a maximum of two persons.
- **Bicycle:** Vehicle with two wheels in tandem that is propelled by human power and is usually ridden by one person.
- **Pedestrian:** Individual traveling on foot.

2.2.4 Management Strategy and Applications

The following are the major classifications of transportation management strategies (adapted from the National ITS Architecture):

- **Freeway Management:** Controls, guides, and warns traffic in order to improve the flow of people and goods on limited-access facilities. Examples of freeway management include the integration of surveillance information with freeway road

geometry; vehicle control, such as ramp metering; dynamic message signs (DMS); and highway advisory radio (HAR).

- **Arterial Intersections:** Includes intersection or arterial operations, such as geometric improvements, parking adjustments, and signal timing for individual intersections. These improvements would typically involve capacity analysis, LOS analysis, and unsignalized and signalized intersection studies.
- **Arterial Management:** Applies State and local planning, capital, and regulatory and management tools to enhance and/or preserve the transportation functions of the arterial roadway through the use of surveillance devices, advanced signal algorithms, and coordination.
- **Incident Management:** Manages unexpected incidents so that the impact on the transportation network and traveler safety is minimized. Includes incident detection capabilities through roadway surveillance devices and incident response through coordination with freeway service patrols and emergency response agencies.
- **Emergency Management:** Represents public safety and other agency systems that support coordinated emergency response, including police, fire, emergency medical services, hazardous materials (HazMat) response teams, Mayday service providers, and security/surveillance services that improve traveler security in public areas.
- **Work Zones:** Uses traffic control devices (signs, channeling devices, barriers, etc.) and traveler information to maximize the availability of roadways during construction or maintenance while minimizing the impact on the traveling public and highway workers.
- **Special Events:** Manages planned events so that the impact on the transportation network and traveler safety is minimized through coordination with other traffic management, maintenance and construction management, and emergency management centers, and event promoters.
- **Advanced Public Transportation System (APTS):** Applies advanced technologies to the operations, maintenance, customer information, planning, and management functions for the transit agency. APTS includes advanced communications between the transit departments and the public, personnel and other operating entities such as emergency response services, and traffic management systems; automatic vehicle locator (AVL); traffic signal priority; transit operations software; advanced transit scheduling systems (ATSS); transit security; and fleet maintenance.
- **Advanced Traveler Information System (ATIS):** Ranges from simply providing fixed transit schedule information to multimodal traveler information, including real-time traffic conditions and transit schedules, and information to support mode and route selection.

- **Electronic Payment System:** Allows travelers to pay for transportation services by electronic means, including tolls, transit fares, and parking.
- **Rail Grade Crossing Monitors:** Manages traffic at highway-rail intersections where operational requirements demand advanced features. Includes the capabilities from the Standard Rail Crossing equipment package and augments these with additional safety features, including positive barrier systems and wayside interface equipment that detects or communicates with the approaching train.
- **Commercial Vehicle Operations (CVO):** Performs advanced functions that support commercial vehicle operations, including communications between drivers, fleet managers, and roadside officials; automates identification and safety processing at mainline speeds; and timely and accurately collects HazMat cargo information after a vehicle incident.
- **Advanced Vehicle Control and Safety System (AVCSS):** Includes vehicle safety systems such as vehicle or driver safety monitoring; longitudinal, lateral, or intersection warning control or collision avoidance; pre-crash restraint; and automated highway systems.
- **Weather Management:** Includes automated collection of weather condition data and the use of that data to detect hazards such as ice, high winds, snow, dense fog, etc. This information can be used to provide road condition information and more effectively deploy maintenance and construction resources.
- **Travel Demand Management (TDM):** TDM strategies are designed to maximize person throughput or influence the need for or time of travel. They are typically implemented in urban areas to reduce traffic congestion and air pollution, and to increase the efficiency of the transportation system. TDM strategies include employer trip reduction programs, vanpool programs, the construction of park-and-ride lots, and alternative work schedules.

Table 5 summarizes tool category relevance for analyzing major traffic management strategies. A more detailed listing of management strategies, which can be helpful in the selection of a specific traffic analysis tool, is presented in appendix C.

Notes and Assumptions:

- Some analytical/deterministic tools can estimate the impact of incidents, work zones, special events, and weather through reductions in capacity for specific times and locations. However, they cannot model the temporal and spatial effects of congestion.
- Macroscopic and mesoscopic models assume macroscopic traffic behavior (e.g., all vehicles travel at the same average speed). Therefore, they are not well suited to evaluate traffic management strategies that require the sensing of individual vehicles (e.g., adaptive control at individual intersections or arterials).

Table 5. Relevance of traffic analysis tool categories with respect to management strategy and applications.

Management Strategy and Applications	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/Deterministic Tools (HCM-Based)	Traffic Optimization	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Freeway Management	●	∅	∅	●	●	●	●
Arterial Intersections	○	○	●	●	●	●	●
Arterial Management	∅	∅	∅	●	●	●	●
Incident Management	∅	○	∅	○	●	●	●
Emergency Management	∅	○	∅	○	∅	∅	∅
Work Zones	∅	○	●	○	●	●	●
Special Events	∅	○	●	○	∅	∅	∅
Advanced Public Transportation System	∅	○	○	○	○	○	∅
Advanced Traveler Information System	∅	○	○	○	∅	∅	∅
Electronic Payment System	∅	○	○	○	○	○	●
Rail Grade Crossing Monitors	∅	○	○	○	○	○	●
Commercial Vehicle Operations	∅	○	○	○	○	○	∅
Advanced Vehicle Control and Safety System	∅	○	○	○	○	○	∅
Weather Management	○	○	○	○	∅	∅	∅
Travel Demand Mgmt	●	●	∅	○	∅	∅	∅

Notes: ● Specific context is generally addressed by the corresponding analytical tool/methodology.
 ∅ Some of the analytical tools/methodologies address the specific context and some do not.
 ○ The particular analytical tool/methodology does not generally address the specific context.

Appendix B: Scoping Checklist

VISSIM Scoping Checklist

Project Name: _____

Staffing Plan

- Names of modelers: _____
- Location of modelers: _____
- Names of people that will be reviewing the models: _____

Project Schedule

Includes:

- Milestones
- Check-in points
- Review time for agency

Project Study Period Definition

Period to Study	Weekday	Saturday	Simulation Length
AM			
PM			
Midday			
Other			

Alternatives

- Alternative Study Years: _____
- Proposed Alternative #1: _____
- Proposed Alternative #2: _____
- Proposed Alternative #3: _____
- Proposed Alternative #4: _____

Field Review (ODOT and Consultant Together)

- Locate any upstream or downstream bottlenecks
List: _____
- Locate any significant lane imbalances
List: _____
- Locate any spots with significantly high truck use
List: _____

Project Boundary Definition

Figure with:

- Project study area
- Model area
- Calibration area(s)

Data Collection

Geometric Data:

- Number of Lanes
- Lane Widths
- Taper Locations and Lengths
- Lengths of Roadway Segments

- Sidewalk Locations
- Parking Locations
- Lengths of Roadway Segments
- Control/Operational Data
 - Speed Limits
 - Intersection Controls
 - Signal Characteristics
 - Rail Crossing Locations
 - Signal Timing
 - Ramp Meter Timing
 - Right Turn on Red Locations
- Traffic Volume Data
 - Turn Movement Counts
 - Vehicle Classification
 - Bike and Pedestrian Counts
- Other
 - Origin Destination Data
 - Travel Time Data
 - Spot Speed Data
 - Queuing Data
 - Transit Data
 - Saturation Flow Data
 - Lane Utilization Data
 - Aerials

Definition of Calibration Targets

- Traffic Volumes Within: _____
- Spot Speed Within: _____
- Travel Time Within: _____
- Queue Comparison
 - Visual
 - Numerical Results
- Freeway Capacity
- Other: _____

Selection of Measure of Effectiveness (MOEs)

- Delay
 - Vehicles
 - Transit
 - Pedestrians
 - Bicycle
- Travel Time
 - Vehicles
 - Transit
 - Pedestrians
 - Bicycle
- Other
 - Traffic Volume Throughput
 - Queuing
 - Other: _____

Appendix C:
Seeding Period Excerpts from FHWA's Traffic Analysis Toolbox
Volume III

Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software

PUBLICATION NO. FHWA-HRT-04-040

JULY 2004



U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296



Appendix C: Estimation of the Simulation Initialization Period

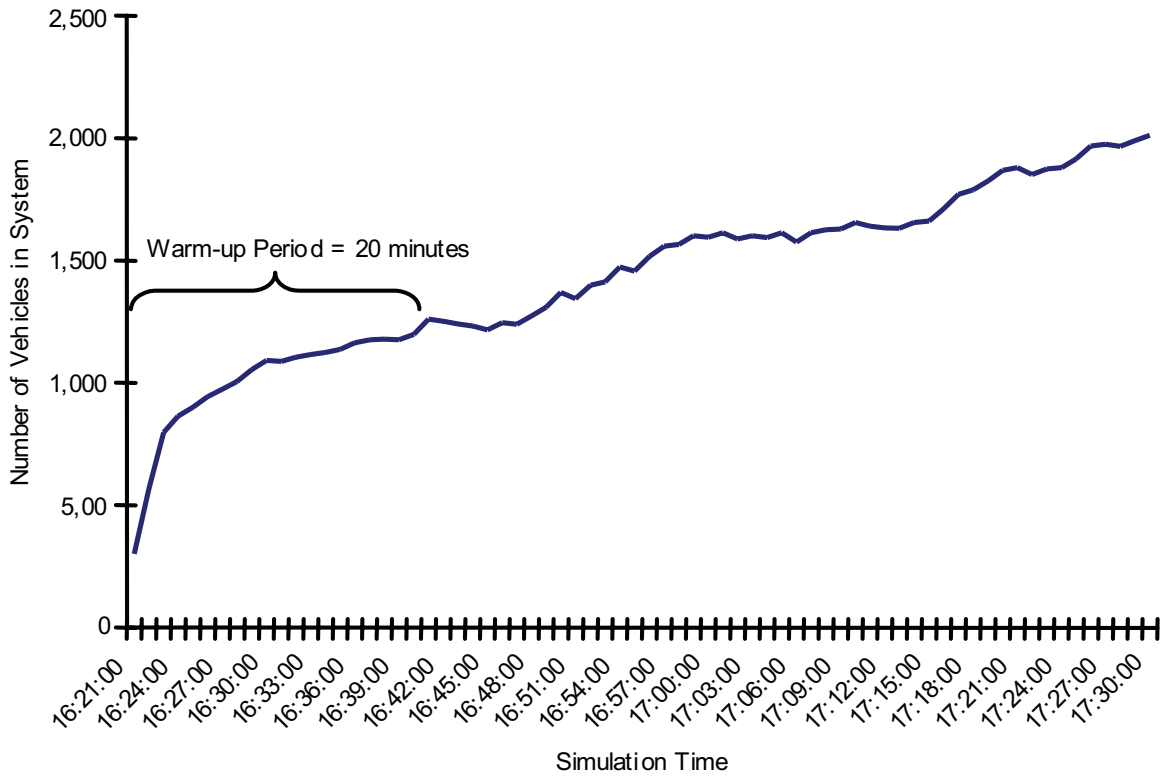
Simulation model runs usually start with zero vehicles on the network. If the simulation output is being compared to field measurements (as in calibration), then the artificial period where the simulation model starts out with zero vehicles (the warmup period) must be excluded from the reported statistics for system performance. Some software programs will do this automatically. For others, the warmup period must be computed offline by the analyst. This section explains how to identify the warmup period.

The number of vehicles present at any one time on the network is used to determine whether the model has reached equilibrium and, therefore, can start tallying performance statistics for the network. Once the number of vehicles present on the network ceases to increase by a minimum specified amount, then the warmup period is deemed to have been concluded (see figure 15).

If the number of vehicles and the mean speed do not level off within the first 15 min, it could be that the demand coded by the analyst for the system is greater than the system capacity. In this case, congestion will never level off. This will result in less accurate congestion statistics since the system never clears the congestion. The analyst should consider extending the starting and end times of the simulation to incorporate lower demand periods before and after the peak period.

If it is not feasible to extend the simulation period to uncongested time periods, the analyst should choose a warmup period that is equal to at least twice the estimated travel time at free-flow conditions to traverse the length of the network. For example, if the freeway being modeled is 8.1 km (5 mi) long, it takes roughly 5 min to traverse its length at the free-flow speed, so the warmup period is set at 10 min.

Note that in this example, the number of vehicles in the system is generally steadily increasing. The system never reaches equilibrium. Initialization is achieved when the number of vehicles entering the system is approximately equal to the number leaving the system (even though this slight decline is later superceded by greater increases). The generally increasing trend in the number of vehicles present in the system suggests that the simulation period should be extended earlier and later to incorporate lower demand periods at the beginning and the end of the peak period.



Source: I-680/I-580 Interchange Microsimulation Model, Dowling Associates, 2002

Figure 15. Illustration of warmup period.

Appendix D: Example Model Development Flow Chart

Appendix D: Examples of a Model Development Flow Chart

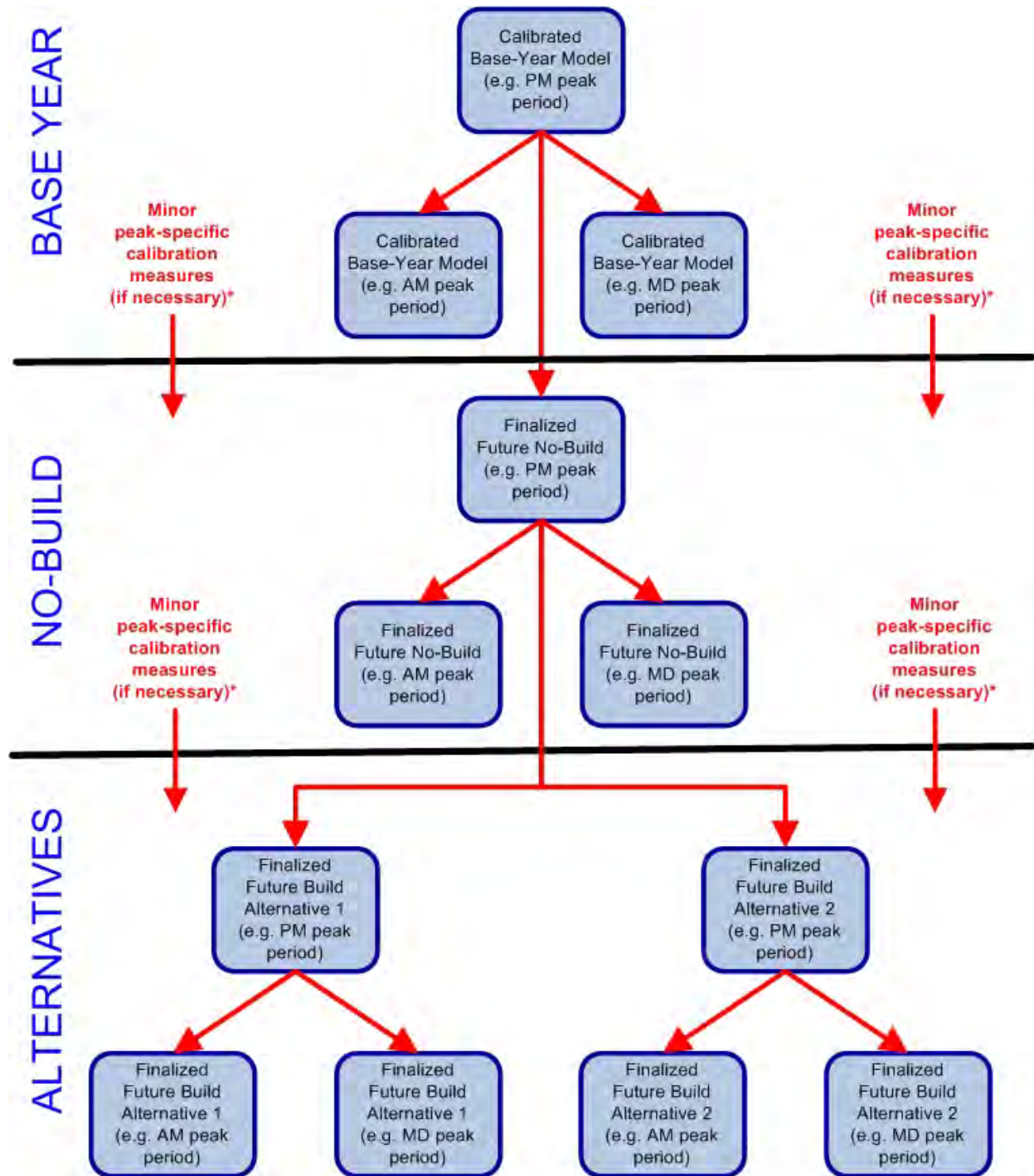
The purpose of a model development flow chart is to create a simple diagram of the model development process. The most important component of this diagram is the points at which a version of the network is copied to create multiple scenarios with the same geometry, such as different peak periods. The goal of this exercise is to emphasize the linear nature of the development process, control the number of forks in the development path, and minimize the number of network changes that must be repeated in multiple files.

Depending on the type of project, this could mean starting each stage in the modeling process (base, no-build, alternatives) by focusing on one peak period and getting it fully calibrated and functional before creating the other peak periods. This method would be used for those networks that have very few differences between peaks and the calibration measures required for one peak would apply to all of them. For example, as shown in **Figure 1**, one peak period should be fully calibrated and functional before the model is copied to create the other peak period scenarios. This ensures that the network geometry in each model is exactly the same. Furthermore, all scenarios in each stage should be completed before moving onto the next, which is depicted as the horizontal lines in the diagram. This should be the best approach for most projects. On the other hand, there could be other projects where each peak period is so different from the others that the calibration measures would not be common to all of them. The goal is to minimize the number of changes that have to be repeated in multiple files, so in the case the work flow depicted in **Figure 2** would be more appropriate.

Creating forks in the development process too soon can have severe consequences. It can be tempting to meet an aggressive project schedule by developing alternative models in parallel to the base conditions. By fully calibrating one peak period of the base year model first, these changes to the network will only need to be done once. This also applies to future alternatives. Calibration measures in the base year will need to be carried forward in all subsequent models. Having to repeat network changes multiple times can significantly increase the level of effort required to complete the project. In addition, this premature forking of the model results in diverging models that do not truly represent a comparison of alternatives. It is very difficult to code link/connector changes (e.g. adding a dedicated turn lane) to the network exactly the same twice. Very minute differences that are not visually detectable can have an effect on the results generated by the simulation. The modeler should delay creating copies of a model for additional peak periods as long as possible to maintain consistency.

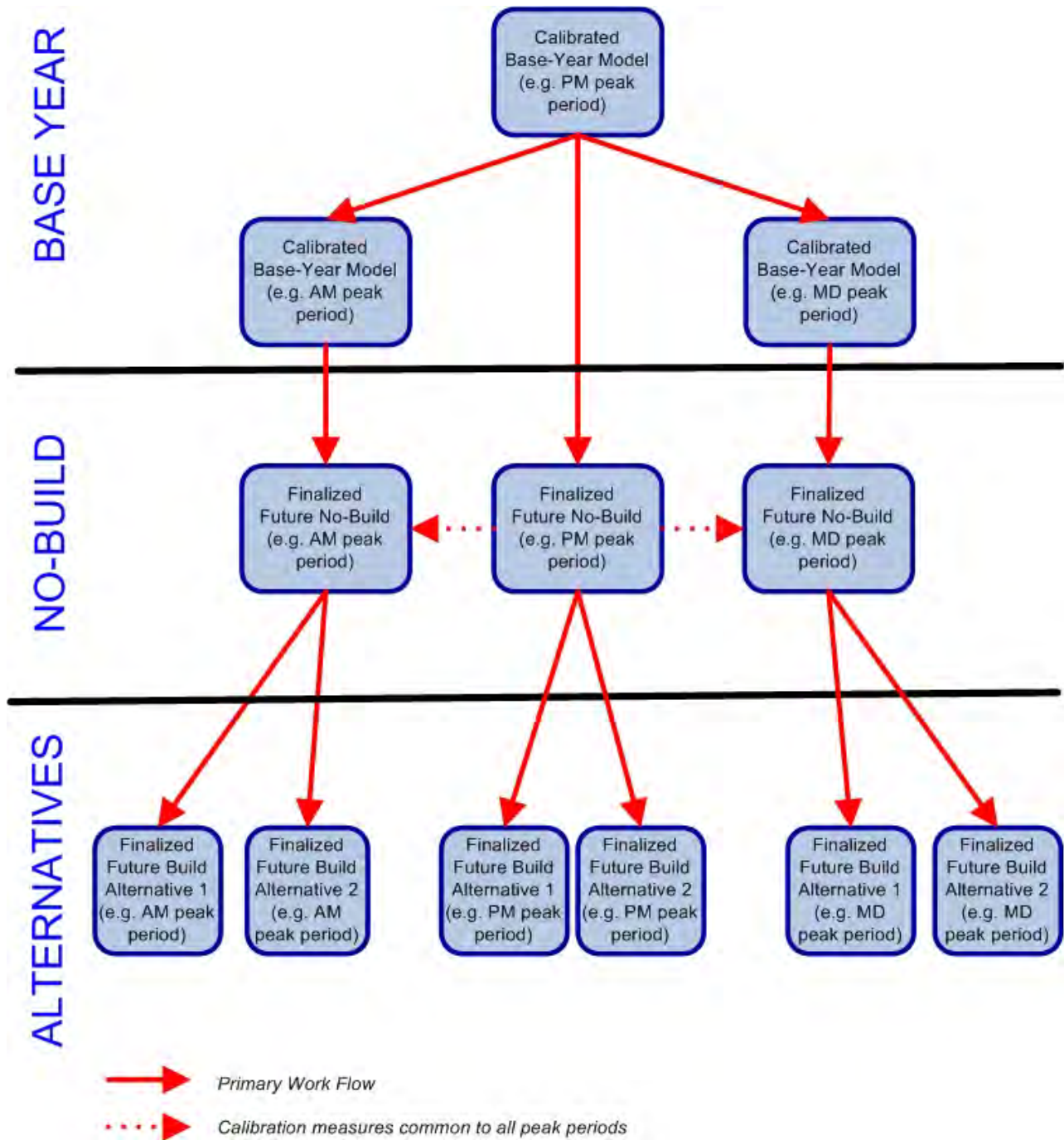
This simple exercise of preparing the model development flow chart during the scoping process gives both the modeler and ODOT staff a clear picture of the critical path for the project and facilitates the creation of realistic and prudent schedule to complete the project on-time and on-budget.

Figure 1 | Model Development Tree (Example 1)



* The vast majority of calibration measures should apply to all peak periods. In order to maintain the highest level of consistency between models, these changes should be made only once in each modeling stage (base, no-build, alternatives) before copies are made to create the other peak periods. Peak-specific network changes should be minimal and will typically require less effort to recreate in each phase than the network calibration measures.

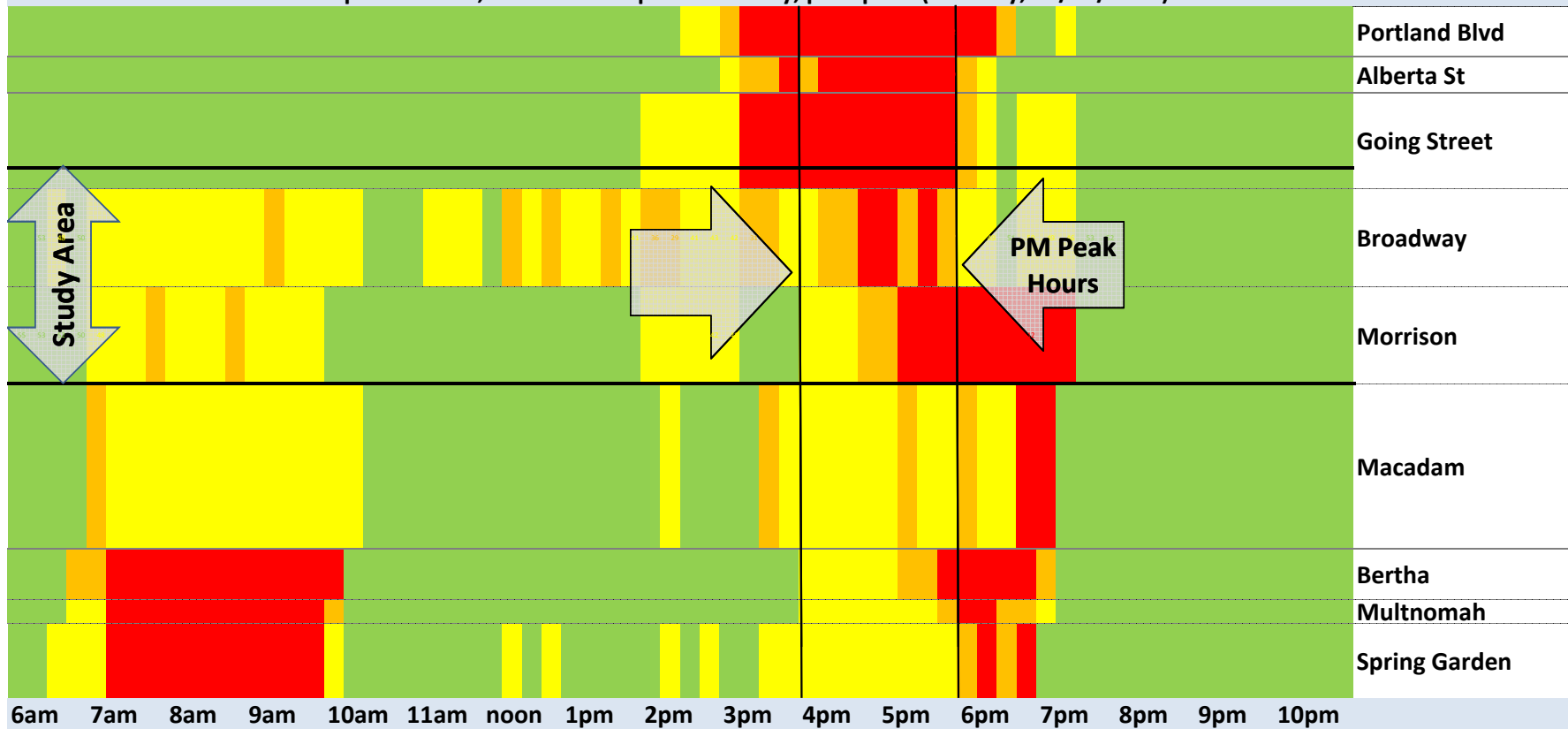
Figure 2 | Model Development Tree (Example 2)



Appendix E: Example Speed Plots



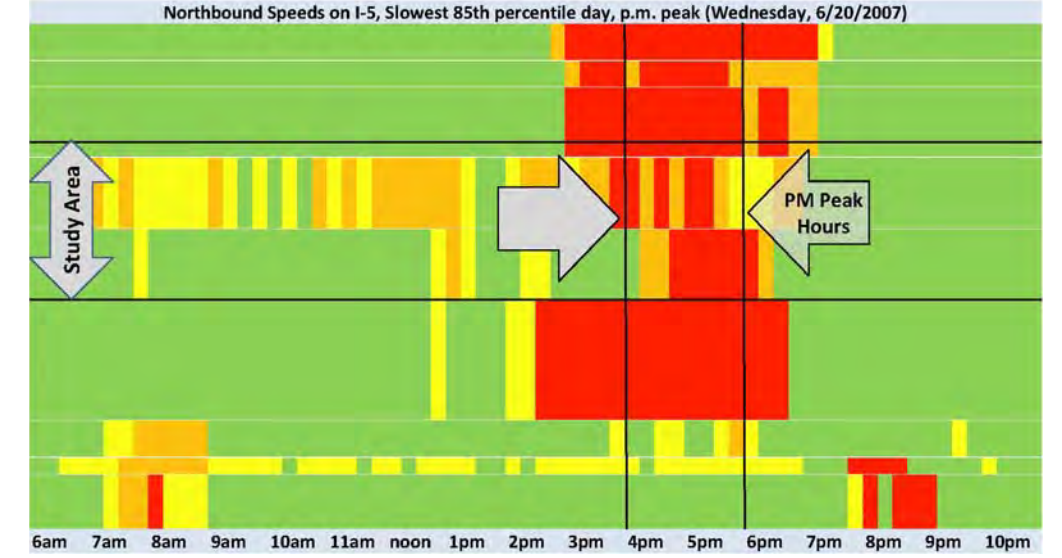
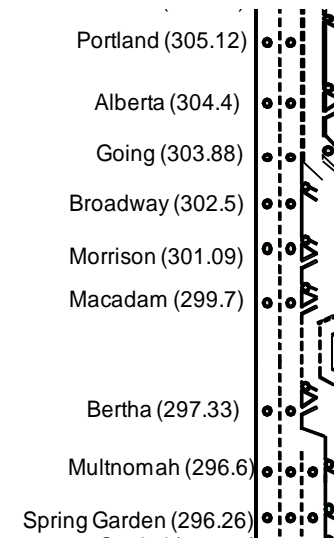
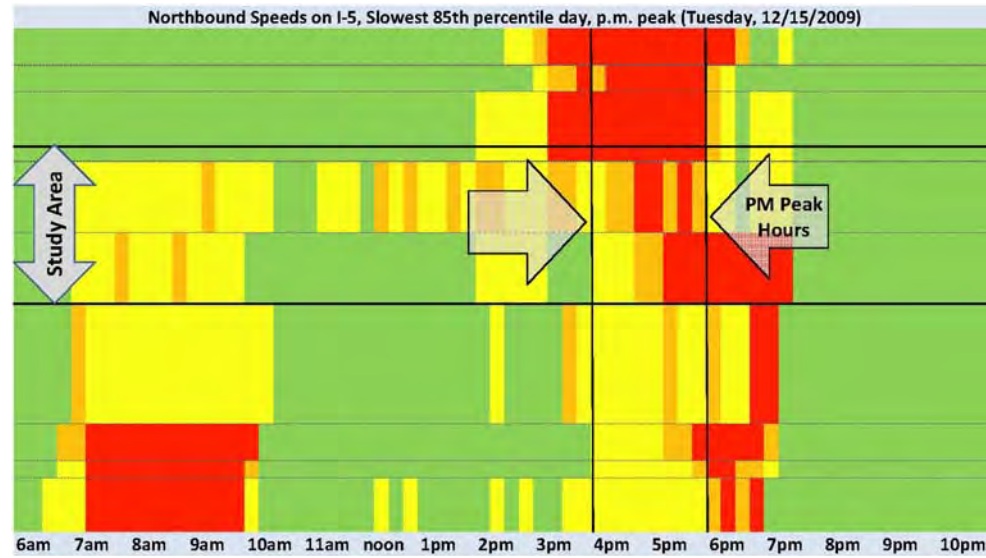
Northbound Speeds on I-5, Slowest 85th percentile day, p.m. peak (Tuesday, 12/15/2009)



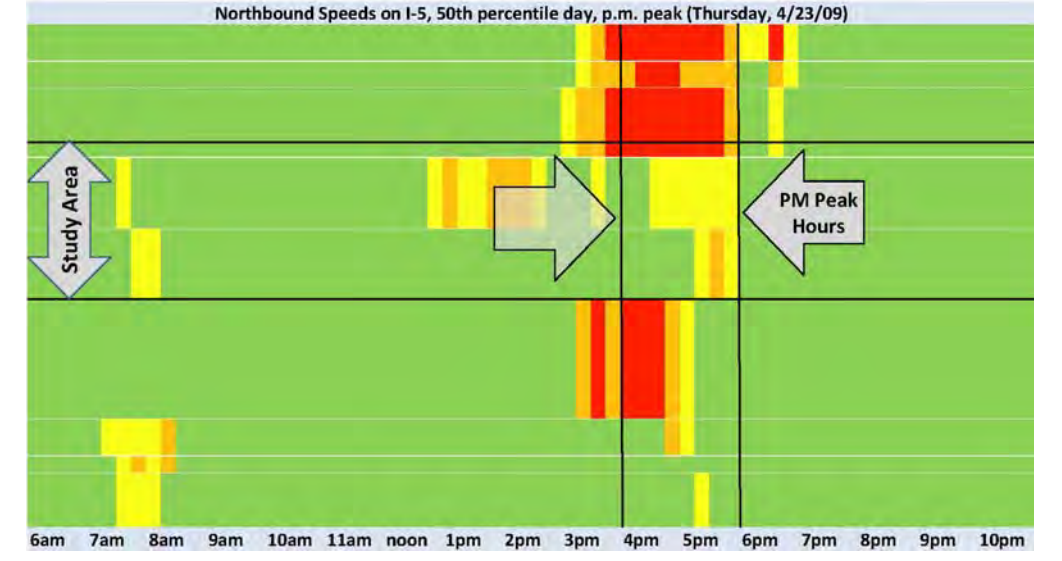
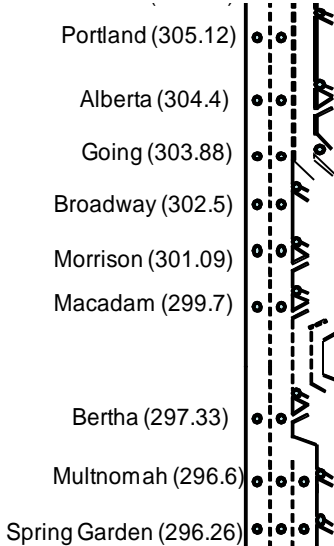
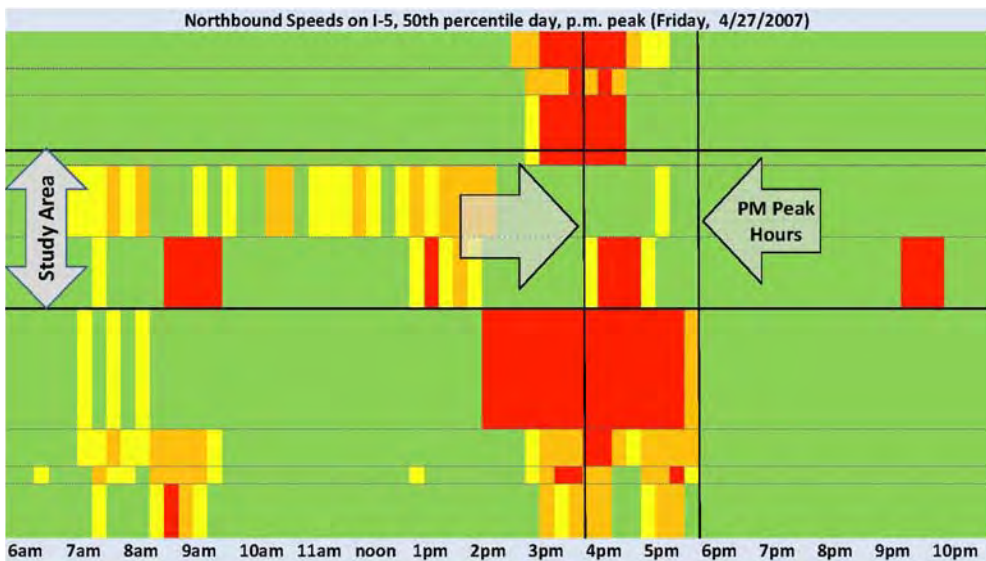
2007

2009

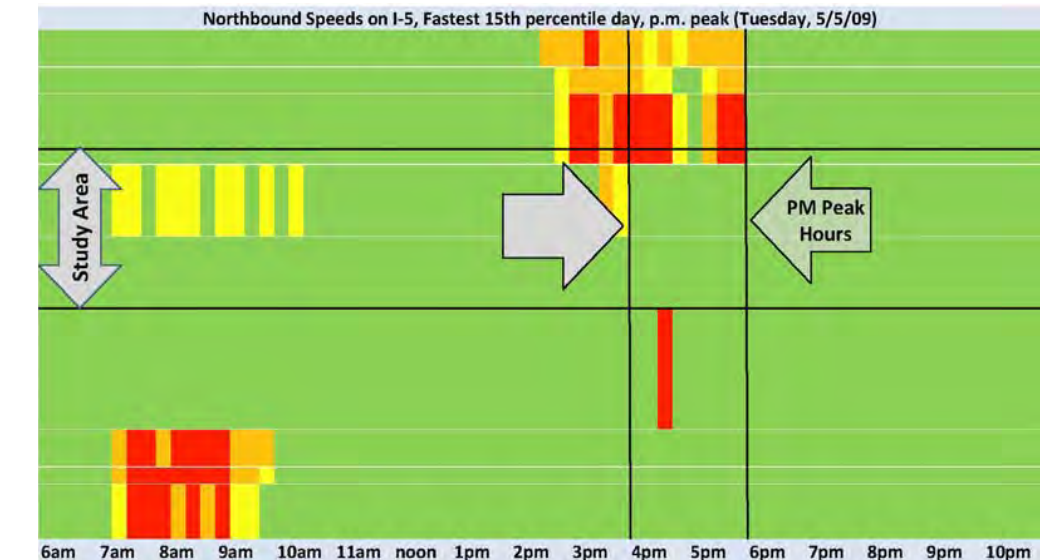
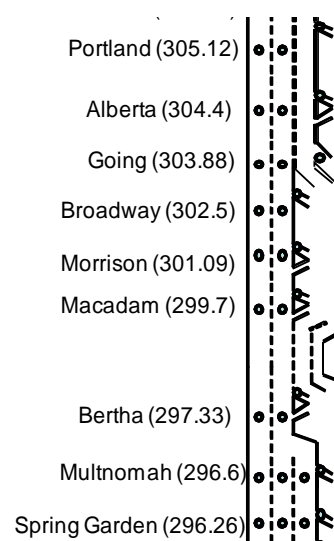
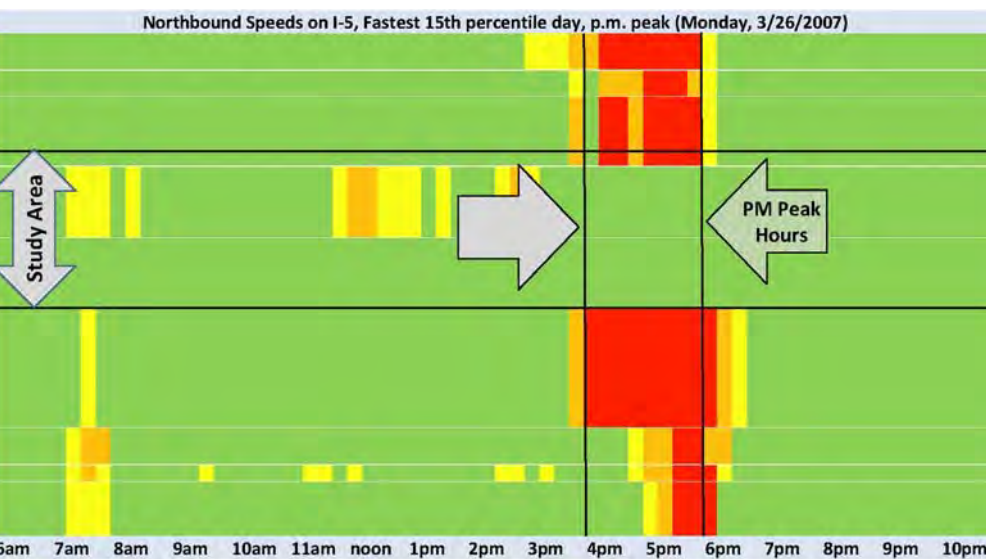
85th
Percentile
Day
(Slowest)



50th
Percentile
Day

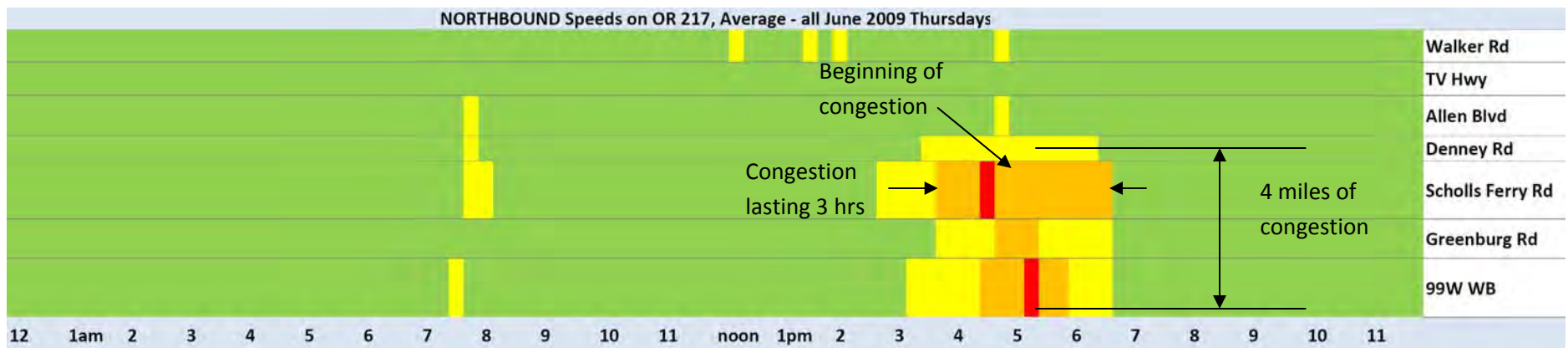
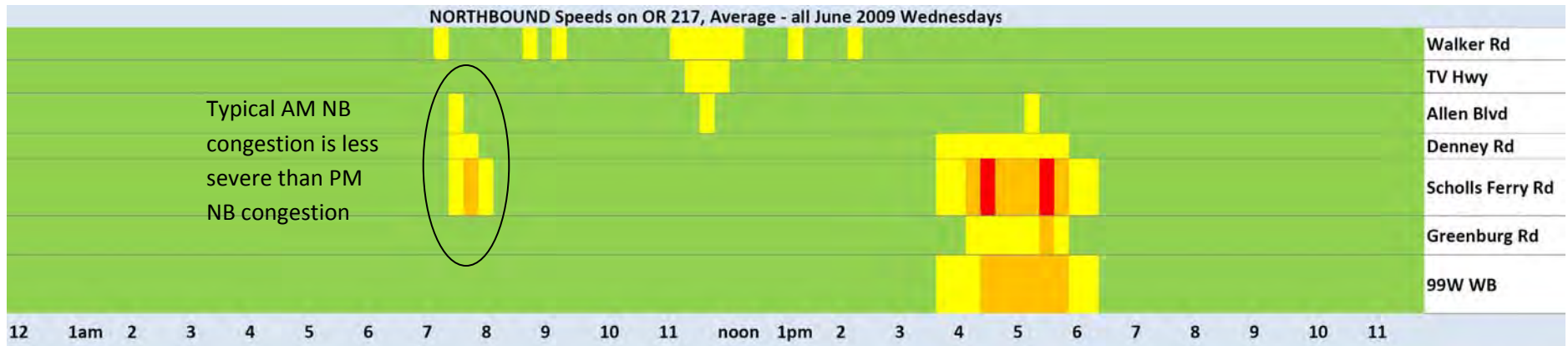
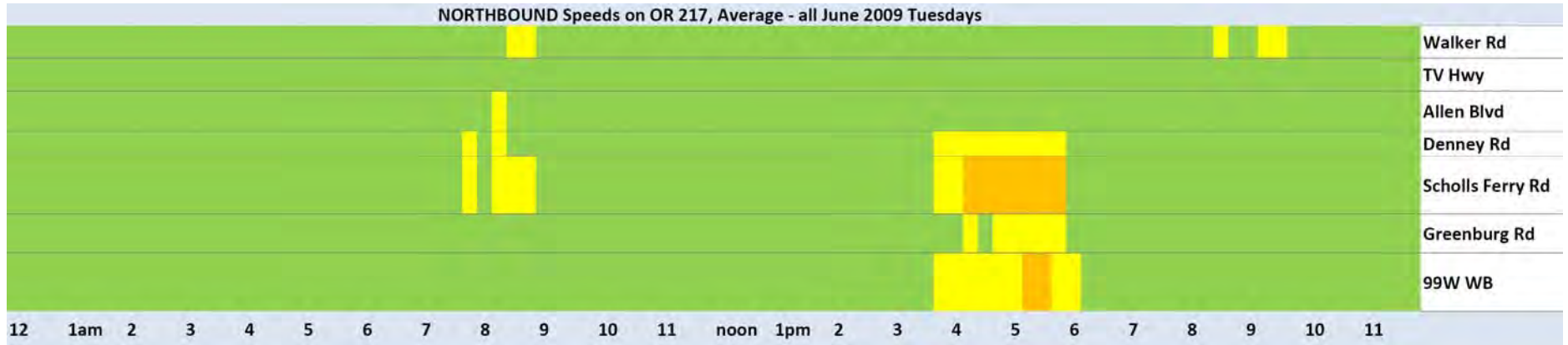


15th
Percentile
Day
(Fastest)

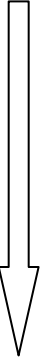
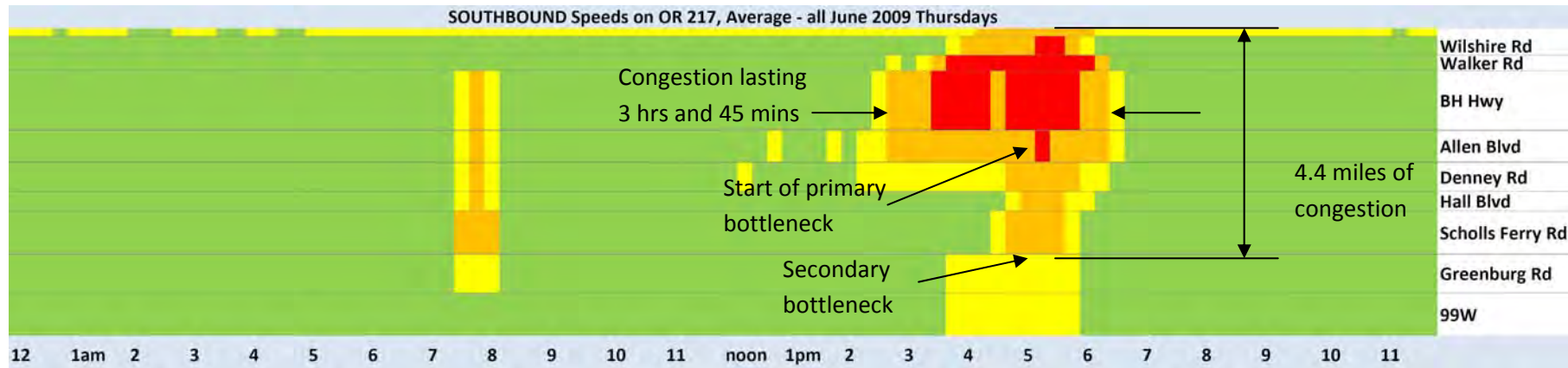
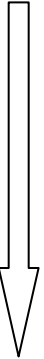
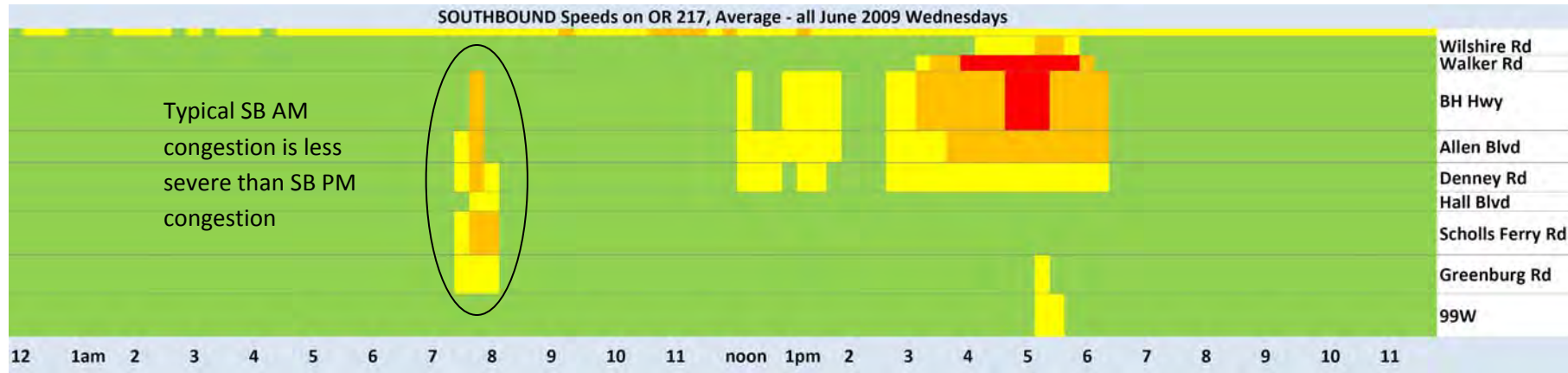
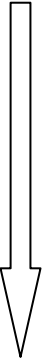
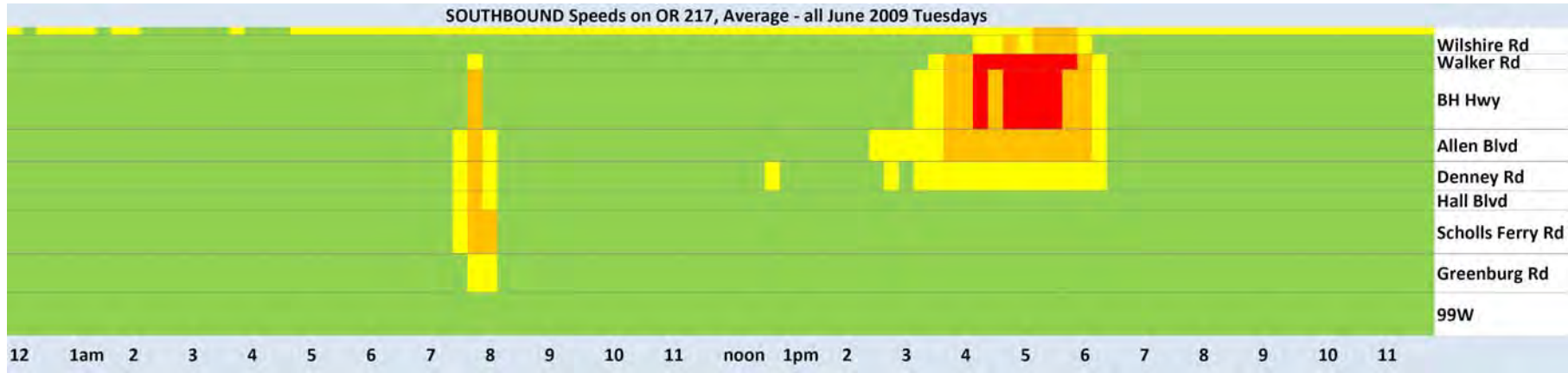


Speed range	Legend
> 50 mph	Green
40 to 50 mph	Yellow
25 to 40 mph	Orange
0 to 25 mph	Red

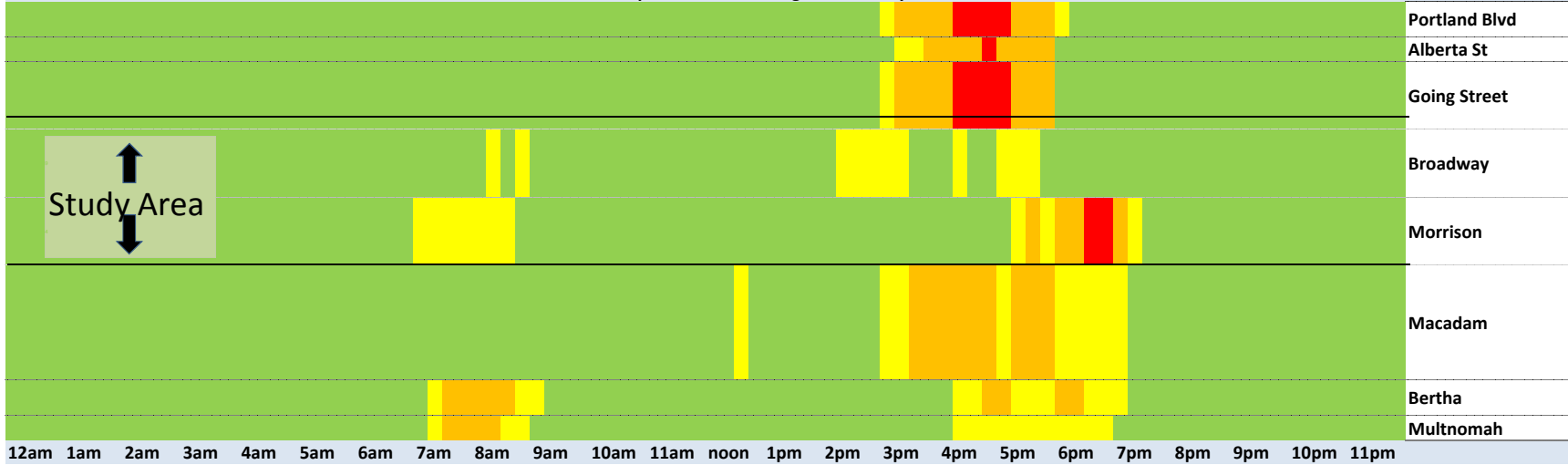
NORTHBOUND Speed Data for OR 217



SOUTHBOUND Speed Data for OR 217



NORTHBOUND Speeds on I-5, Average - Game Day



Appendix F: Ramp Meter Signal Timing Example

1 RAMP METERING

VISSIM can accommodate a broad range of ramp metering algorithms. These include simple, fixed metering rates that only respond to vehicles on the ramp to more elaborate approaches that consider freeway traffic flow characteristics, ramp queues, upstream arterial street operations and/or neighboring ramp metering conditions to determine the metering rate. VISSIM's flexibility to analyze various ramp metering control strategies compliments its ability to model a diverse set of ramp geometries – single lane, multi lane, HOV bypass lanes, etc.

The following sections illustrate the steps necessary to code a single-lane ramp meter. VISSIM users can apply the basic principles in these steps to develop more complicated ramp metering strategies. The following sections address:

- Example background
- Ramp metering algorithm
- Ramp meter signal heads
- Detectors
- Calibration

1.1 Example Background

The figure below illustrates the single-lane ramp meter used to develop the text for the following sections. Traffic travels in the eastbound direction. The cross-section consists of three freeway lanes and a single lane entrance ramp. At the ramp's gore point, the lanes merge into a contiguous 4-lane cross section. The three freeway lanes continue and the entrance ramp transitions to an acceleration lane that terminates further downstream causing ramp traffic to merge into the main lanes.

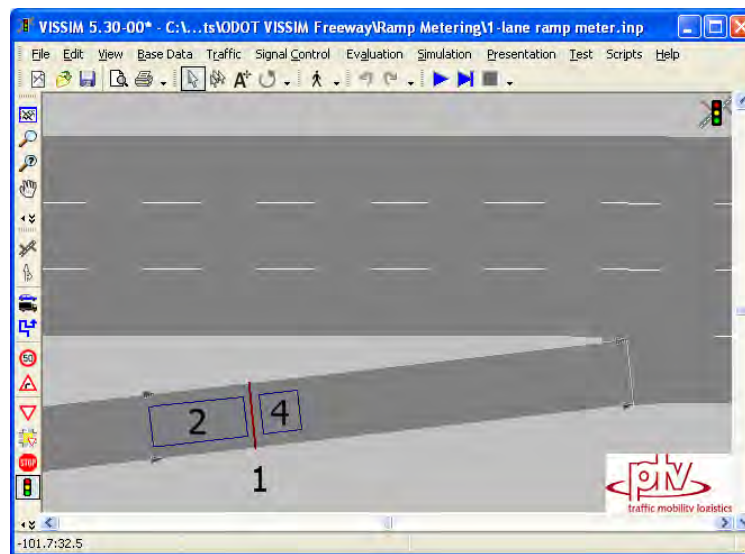


Figure 1. Single Lane Ramp Metering Example

1.2 Ramp Metering Algorithm

Once the ramp geometry is coded, the first step is to define the ramp metering logic and assign it to a signal controller (SC) in VISSIM. The ramp metering logic in this example is coded in VAP - VISSIM's signal control language. Users also have the choice to code the logic in C++ and compile the logic in the form of a DLL to run within VISSIM.

For this example, the general ramp metering logic will cause the ramp meter signal (signal head #1 in Figure 1) to turn green when an approaching vehicle is detected (detector #2 in Figure 1). The signal will remain green until the vehicle reaches the departure detector (detector #4 in Figure 1). Upon reaching the departure detector, a red indication is displayed. The signal will remain red until three conditions are satisfied simultaneously:

1. A vehicle is detected on the approach detector,
2. The departing vehicle is no longer detected on the departure detector, and
3. The ramp meter signal has been red for at least three seconds (based on a user defined threshold of three seconds).

This process repeats for each approaching vehicle. The VAP code that reflects this process is provided in the last section under Ramp Metering. This code needs to be saved as a text file with a .VAP extension. The VAP file also requires a PUA file that contains signal and interstage definitions. The PUA file code is also shown in the last section and needs to be saved as a text file as well.

The clearance timer setting (three seconds in this example) is adjusted to achieve the desired ramp metering capacity. Longer values reduce the capacity while shorter values increase it. The Calibration section discusses steps to measure ramp metering capacity.

Next, the VAP and PUA files need to be linked to a signal controller in VISSIM, which is similar to setting up any actuated signal controller in VISSIM. Referring to Figure 2, the VAP file is assigned in the LOGIC FILE field and the PUA file in the INTERSTAGE FILE field. Once coded as a signal controller, the user can define which signal head and detectors are tied to the ramp metering logic via the signal controller.

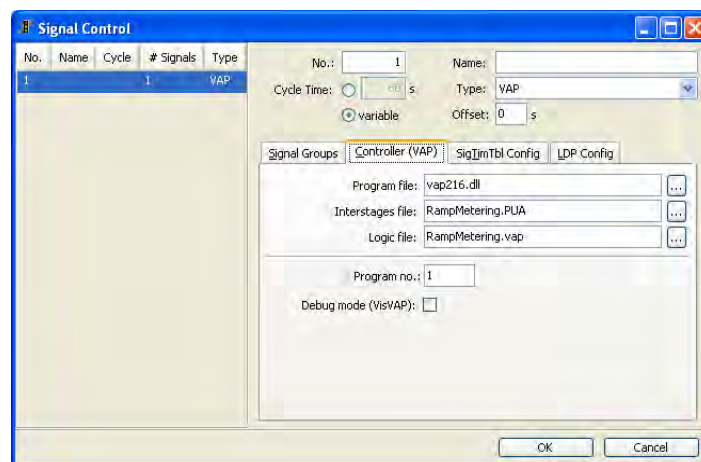


Figure 2. Signal Controller Setup for Ramp Metering VAP and PUA Files

1.3 Ramp Meter Signal Head

Coding a ramp meter signal head is similar to coding any other signal head in VISSIM. First, the user needs to define the signal group (1 in this example) under the Signal Groups tab in Figure 2. Next, the signal head should be placed at the ramp meter stop line or the location where it is desired to have vehicles stop while a red indication is displayed. In the signal head dialogue box, the user then needs to assign the signal controller and signal group number associated with the given ramp meter. In this example, the ramp meter signal controller is number one and the VAP uses signal group 1 for the ramp meter.

1.4 Detectors

This ramp metering example uses an approach detector (5m) and departure detector (2m). The approach detector is used to place a call to the ramp meter signal controller. Basically, it lets the controller know a vehicle has arrived and is requesting a green signal.

The departure detector is used to control the length of the green indication. Once a vehicle is detected on the departure detector the ramp meter displays a red indication. Some may think that an alternative approach to terminate the green would be to fix the length of the green indication in the VAP. However, if the green indication is too long, multiple vehicles may enter the freeway during one green signal. If the green indication is too short in the simulation, a vehicle that is slow to accelerate (freight truck) may have to wait through multiple green signals before it can pass through the ramp meter. The departure detector removes any guess work in determining how long to set the duration of the green signal.

1.5 Calibration

Most projects require the ramp metering rate to produce a desired capacity. It is important to note that this capacity will vary not only by adjusting the clearance timer mentioned above, but also based on driver behavior parameter settings, truck percentages, approach and departure detector lengths, etc. It is recommended to adjust the ramp metering capacity by adjusting the clearance interval timer in the VAP.

The following table was created using the example shown in Section 1.1. which was based on the default settings in the NorthAmericaDefault.INP. This .INP can be found in the following directory: C:\Program Files\PTV_Vision\VISSIM520\Examples\Training\NorthAmericaDefault (Note: The .INP only contains default parameters and settings, but not a network). The truck percentage is set to two percent with the desired speed for all traffic set to 33 mph (50 km/h). The demand volume on the ramp was set to 3,000 vph to ensure the ramp was over capacity throughout the simulation period. Volumes were set to generate exact volumes. Freeway volumes were not coded. A data collection point was placed immediately downstream of the ramp meter signal head to collect throughput. The throughput was measured for one hour between 300 and 3900 seconds over five runs with varying random seeds. The average capacity is shown below in Table 1.

Table 1. Average Ramp Capacity

Clearance Interval (sec)	3	6	9
Run	Throughput (vph)		
1	658	412	300
2	660	412	300
3	659	412	300
4	659	413	300
5	658	412	300
Average Capacity (vph)	659	412	300

The clearance interval represents the minimum time the ramp meter is coded to remain red between successive green signals. The actual clearance interval will be slightly longer due to the time it takes vehicles to move up to the approach detector, to depart the stop line and to leave the departure detector.

1.6 Ramp Metering Code

1.6.1 VAP File Code

```
PROGRAM RAMPMETER;  
  
SUBROUTINE Ramp_Meter;  
  
Call2:= presence(2) or occupancy(2);  
Call4:= presence(4) or occupancy(4);  
  
IF (call4) THEN  
    set_sg(1,Red);  
    start(ClearanceTimer);  
ELSE  
    IF ((Call2) and (ClearanceTimer >= 3)) THEN  
        set_sg(1,Green);  
        stop(ClearanceTimer);  
        reset(ClearanceTimer);  
    END;  
END.  
  
GOSUB Ramp_Meter.
```

1.6.2 PUA File Code

```
$SIGNAL_GROUPS  
$  
K1 1  
  
$STAGES  
$  
Stage_1 K1  
  
$STARTING_STAGE  
$  
Stage_1  
  
$END
```

Appendix G: Signal Timing Checklist

ODOT VISSIM Signal Timing Checklist

Project Name: _____

<p>General</p>	<p><input type="checkbox"/> Signal control type defined as Fixed Time, Ring Barrier Controller, or VAP</p> <p><input type="checkbox"/> Unique data file (SIG, RBC, VAP) for each signal</p>
<p>Signal Layout</p>	<p><input type="checkbox"/> VISSIM signal heads and detectors are associated with the correct signal controller number</p> <p><input type="checkbox"/> VISSIM signal head phase assignments for each movement match signal plans/timing sheet</p> <p><input type="checkbox"/> Check VISSIM signal head placement near any overlap between links and connectors to ensure they are not placed on the link downstream of the start of the connector (unless for RTOR)</p>
<p>Fixed Time Signal Parameters <i>(General)</i></p>	<p><input type="checkbox"/> All Signal Groups have Default Sequence set to Red-green-amber</p> <p><input type="checkbox"/> All Signal Groups have correct values in Default durations for red, green, and amber per timing documentation</p> <p><input type="checkbox"/> Signal Program has correct Cycle Length and Offset</p> <p><input type="checkbox"/> Offset has been converted to “start of green”, if necessary</p>
<p>Fixed Time Signal Parameters <i>(Stage-based Signal Program only)</i></p>	<p><input type="checkbox"/> Intergreen Matrix values equal to Yellow + All-Red values for each signal group</p> <p><input type="checkbox"/> Stages defined correctly</p> <p><input type="checkbox"/> Stage Sequence is correct</p> <p><input type="checkbox"/> Signal Program has correct Start and End times for each stage</p> <p><input type="checkbox"/> Interstages defined correctly</p> <p><input type="checkbox"/> First stage in sequence includes the coordinated phase</p>
<p>Fixed Time Signal Parameters <i>(Signal Group-based Signal Program only)</i></p>	<p><input type="checkbox"/> Signal Program has correct Start and End times for each signal group</p> <p><input type="checkbox"/> Signal Program has correct yellow times for each signal group</p> <p><input type="checkbox"/> Coordinated phase starts at time zero in the signal cycle</p>

**Ring Barrier Controller
Signal Parameters**
(General)

- Frequency value matches Time step(s) / Sim sec. in VISSIM Simulation Parameters
- Global Values -> OffsetReference matches field signal controller

Base Timing -> Timing by SG -> Basic

- All signal phases defined in SG Number field

Check parameter values against field timing documentation:

- Min Green
- Veh Extension
- Max 1
- Yellow
- Red Clearance
- Walk
- Ped Clear (FDW)
- Ped SG Number defined for each crosswalk

Check global settings against field timing documentation:

- Start Up (if setting cannot be found in documentation, use main street through phases)
- Min Recall
- Max Recall
- Ped Recall
- Dual Entry

Base Timing -> Sequence

- Matches default ring sequence per documentation

Base Timing -> Conflict SGs

- Signal phases on opposite sides of the barrier (on opposite street) are programmed as conflicting

Base Timing -> Overlaps

- Signal heads defined as overlaps are associated with the correct signal group (SG)
- Parent phases coded correctly per documentation

<p>Ring Barrier Controller Signal Parameters (Coordinated)</p>	<p>Check left-column settings (typically Pattern 1):</p> <ul style="list-style-type: none"> <input type="checkbox"/> Cycle Length <input type="checkbox"/> Offset <input type="checkbox"/> MaxGreenMode (use MaxInhibit unless otherwise stated in documentation) <p>Base Timing -> Patterns/Coordination -> (typically Pattern 1):</p> <ul style="list-style-type: none"> <input type="checkbox"/> Splits <input type="checkbox"/> Coordinated <input type="checkbox"/> Min Recall <input type="checkbox"/> Max Recall <input type="checkbox"/> Lead <p>Base Timing ->Pattern Schedule</p> <ul style="list-style-type: none"> <input type="checkbox"/> Pattern Number = defined pattern (typically Pattern 1)
<p>Ring Barrier Controller Signal Parameters (Detectors)</p>	<p>Detectors -> Vehicle</p> <ul style="list-style-type: none"> <input type="checkbox"/> Detector Number – all detectors defined in VISSIM network <input type="checkbox"/> Call – phase(s) called by this detector <input type="checkbox"/> Extend SGs – phases extended by this detector <input type="checkbox"/> Other settings per documentation (i.e. Delay, Extend, Yellow Lock, Red Lock, XSwitch SGs) <p>Detectors -> Pedestrian</p> <ul style="list-style-type: none"> <input type="checkbox"/> Detector Number – all pedestrian detectors defined in VISSIM network <input type="checkbox"/> Call Peds – correct Ped Phase defined
<p>Ring Barrier Controller Signal Parameters (Preempt)</p>	<p>Preempts -> Preempt</p> <p>At a minimum, the following settings must be defined:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Enabled <input type="checkbox"/> Preempt Inputs <input type="checkbox"/> Track Clearance 1 (length of Track Clearance interval) <input type="checkbox"/> TC1 Veh SGs (Track Clearance phases) <input type="checkbox"/> TC1 Ped SGs (Track Clearance ped phases, if any) <input type="checkbox"/> TC1 Ovl SGs (Track Clearance overlap phases, if any) <input type="checkbox"/> Dwell Veh SGs (Dwell phases during preempt)

	<input type="checkbox"/> Dwell Ped SGs (Dwell ped phases, if any) <input type="checkbox"/> Dwell Ovl SGs (Dwell overlap phases, if any) <input type="checkbox"/> Exit Veh SGs <input type="checkbox"/> Exit Ped SGs <p><i>Preempts -> Preempt Inputs</i></p> <input type="checkbox"/> Detector Type <input type="checkbox"/> Correct VISSIM detector number for Presence, Check-in, or Check-out
<p>Ring Barrier Controller Signal Parameters <i>(Transit Priority)</i></p>	<p><i>At a minimum, the following settings must be defined:</i></p> <p><i>Transit Priority -> Transit Inputs</i></p> <input type="checkbox"/> Call <input type="checkbox"/> Call Transit SGs (if any) <input type="checkbox"/> Checkout Detectors (if any) <input type="checkbox"/> Travel Time <input type="checkbox"/> Define Presence or Checkin/Checkout Detectors <input type="checkbox"/> VISSIM detector numbers match correct inputs

Appendix H: Example Calibration Report

Technical Memorandum

TO: Linda Small, Clark County

FROM: Peter Coffey, PE
John Bosket
Miranda Wells

DATE: February 24, 2010
Updated: April 29, 2010

SUBJECT: **NE 179th Street (NE Delfel Road to NE 15th Avenue)**
VISSIM Model Development and Calibration

P09154-000

The purpose of this memorandum is to document the methods used in the development of the VISSIM microsimulation models for the NE 179th Street project near Interstate 5 and to provide documentation of the model calibration to actual conditions.

Model Development

The Federal Highway Administration's (FHWA's) *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*¹ were used as a guideline for the development of the project VISSIM models. As outlined in the FHWA report, four steps must be completed before calibrating a VISSIM model:

1. Project Scope
2. Data Collection
3. Base Model Development
4. Error Checking

This section outlines the details of how these four steps were applied to the NE 179th Street (NE Delfel Road to NE 15th Ave) project VISSIM models.

Project Scope

The project scope was developed through coordination between Clark County, the Washington State Department of Transportation (WSDOT), and DKS Associates. This scope outlined a study area along NE 179th Street between NW 11th Avenue and NE 15th Avenue including the following as study intersections for modeling purposes:

- NW 11th Avenue/NW 179th Street
- Main Amphitheatre Entrance/NW 179th Street
- NE Delfel Road (South)/NE 179th Street
- NE Delfel Road (North)/NE 179th Street

¹ *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*, Federal Highway Administration, August 2003.

- I-5 Southbound Ramps/NE 179th Street
- I-5 Northbound On-Ramp/NE 179th Street
- I-5 Northbound Off-Ramp/NE 10th Avenue/NE 179th Street
- NE Union Road/NE 179th Street
- NE 15th Avenue/NE 179th Street

Additionally, for the VISSIM models the intersection of NE 2nd Avenue/NE 179th Street has been added.

As outlined in the scope, the I-5 mainline just north and south of the NE 179th Street interchange and the NE 179th Street interchange ramps were modeled in VISSIM. These VISSIM models have been developed for three analysis scenarios: Existing a.m. peak hour, Existing p.m. peak hour, and Existing pre-event peak hour (the pre-event model will be developed in the summer of 2010).

Data Collection

The second step in the development of a VISSIM model is the data collection process. The data required between different simulation tools and projects varies. For the development of the VISSIM models as part of this project, vehicle turn movement counts, posted speeds, roadway geometry, and signal timing data were collected. Queue length data was collected at ramp terminals only because at other intersections the observed queues were very short. I-5 lane utilization data near the NE 179th Street overcrossing was also collected for calibration purposes.

Base Model Development

The next step in the development of a VISSIM model is the development of the base model that will be used for calibration and development of subsequent scenarios and future alternatives. The base model development for this project began with coding in geometry (number of lanes, lane widths, link behavior type, and link lengths) over an aerial of the study area. The freeway was coded with VISSIM's default "freeway" link behavior type and the local street network was coded with VISSIM's default "urban" link behavior type.

Once the geometric network was created, desired speeds were coded into the network. The desired speeds were based on the posted speeds in the field and the desired speed distributions were coded as plus and minus five miles per hour from the posted speed. An additional speed parameter that was coded into the network was the reduced speed turning zones for turns. The reduced speed zones were coded with a desired speed distribution of plus or minus 1 mile per hour from 9 miles per hour for right turns and 15 miles per hour for left turns (consistent with Synchro).

The next step was coding intersection control. The p.m. peak hour signal timing data was used in development of the base model. Signal timing, as provided by WSDOT and Clark County, was coded into the VISSIM model at study intersections using the VISSIM-provided NEMA controllers. Detector plans were provided for one intersection (NE 15th Avenue/NE 179th Street). Detectors at that intersection were coded to operate as shown on the provided plan and detectors at all other signalized intersections were coded assuming a similar layout. Right turns

on red were coded in where allowed in the field using VISSIM's right turn on red feature. Stop signs were coded in at intersections that are stop controlled using the default stop parameters of VISSIM.

Next, conflict points and priority rules were coded into VISSIM. Conflict points were coded in locations where links/connectors cross and have the potential for vehicles to cross paths. The default parameters were maintained in the base model development for conflict points, with the exception of the "avoid blocking" parameter. For locations where a vehicle would be anticipated to enter the conflict point zone and possibly block it, the "avoid blocking" parameter was coded to 0 (allows vehicles to enter zone). Additionally, priority rules were incorporated into the model in some locations where it was determined that a conflict point would not sufficiently replicate the behavior of conflicting vehicles. The priority rule parameters were set to values that are anticipated to properly reflect actual field conditions.

Traffic entering the system (vehicle inputs) was the next item coded into the base model. The vehicle inputs include two parameters: traffic volumes (hourly flow rate) and vehicle compositions. The traffic volumes were based on existing p.m. peak hour turn movement counts. The vehicle compositions were based on the posted speed and the types of vehicles on the road, such as heavy vehicles and passenger vehicles. No heavy vehicle data was provided for the turn movement counts at the study intersections. Heavy vehicle data was provided from tube counts that were collected at a few locations in the study area on 179th Street and from WSDOT for I-5. From the tube counts it was determined that the heavy vehicle percentage was relatively low on NE 179th Street during both the a.m. and p.m. peak hours; therefore all the vehicle compositions assumed a heavy vehicle percentage of 2% for entering and exiting links along 179th Street. WSDOT provided a truck percentage of 12% for I-5 both northbound and southbound traffic in the a.m. and p.m. peak hours. Therefore all vehicle compositions entering and exiting from I-5 were assumed to have 12% heavy vehicles.

For routing traffic through the VISSIM network, VISSIM's static routing feature was used and the volumes coded into the vehicle input portion of the network were based on the p.m. peak hour turn movement counts. At locations with closely spaced intersections, static routes were combined to reduce unrealistic weaving in these areas. Where the combine route feature resulted in traffic exiting the freeway and then entering back onto the freeway traffic volumes were adjusted to keep traffic exiting the freeway on 179th Street and traffic entering the freeway coming from 179th Street.

The final step in developing the base model was to determine the seeding period (initialization period) for the VISSIM models. A VISSIM model starts with zero vehicles on the network, which is not how the peak hour actually begins in the field. Therefore, some time period must be added onto the beginning of the simulation period to allow vehicles to be on the network by the time data collection begins. As suggested by the FHWA's *Traffic Analysis Toolbox*, the seeding period should be equal to or greater than twice the estimated travel time at free flow conditions to travel the entire network. Based on distance and posted speed, it would take approximately 3 minutes to travel the network, so a minimum of 9 minutes should be used as the seeding period. To be conservative, 15 minutes was used as the seeding period for the NE 179th Street VISSIM models.

Error Checking

The error checking portion of the model development focused on fixing coding errors before the calibration process began. Error checking is a process that includes a review of the coded data and a review of the animation. All coded data (geometry, speeds, signal timing data, and traffic volumes) was reviewed by the model developer and by a quality control reviewer.

The review of the animation was conducted to determine locations where conflict points or priority rules might be missing, where signal timing may not be operating correctly, or any other locations where general coded parameters may have been overlooked. Some parameters in the model were adjusted based on the modeler's judgment to accurately reflect the interactions of vehicles on the network as part of this review. A list of these adjustments is provided in Attachment A.

Calibration

Once the error checking process had been completed, calibration of the model began. The calibration process involved a review of model parameters and possible adjustments to these parameters to get the model to replicate field conditions. The first step in the calibration process was to collect data output from VISSIM (traffic volumes and travel time) and compare it to field collected data. In the preliminary steps of calibration, an average of the data from 12 simulation runs was used for comparison purposes. Using engineering judgment, default parameters and geometry was adjusted in the model where necessary to reflect field operating conditions. A list of these adjustments is provided in Attachment A.

Confidence Interval

Once parameters had been adjusted so that the outputs from VISSIM were close to measured field data (no more than 10% difference for entering and exiting volumes greater than 100), the confidence interval was calculated to determine the number of simulation runs that should be conducted to provide a desired confidence. The calculation used for obtaining the confidence interval is outlined in the FHWA's *Toolbox* and is as follows:

$$CI_{1-\alpha\%} = 2 * t_{(1-\alpha/2), N-1} \frac{s}{\sqrt{N}}$$

Where:

$CI_{1-\alpha\%}$ = Confidence interval for the true mean, where alpha equals the probability of the true mean not lying within the confidence interval

N = Number of Repetitions

S = Standard Deviation

$t_{(1-\alpha/2), N-1}$ = t-statistic for the probability of a two-sided error summing to alpha with N-1

The FHWA's *Toolbox* was followed to help determine the confidence intervals and the desired confidence to be used in determining the total number of simulation runs that should be conducted. To obtain the standard deviation to be used in the confidence interval calculation, the standard deviation for traffic volumes was determined from the preliminary 12 simulation

runs. Based on the confidence interval calculation and the preliminary model results, a total of 10 simulation runs should be conducted to obtain the desired confidence (95%). The final results from the calibration model and the existing conditions models are reported using 10 simulation runs. Detailed calculations are provided in Attachment B and have been agreed upon within the project group.

Base Model Calibration Results

Once the confidence interval had been calculated, an iterative process of making adjustments in the model and comparing the VISSIM data outputs to the field collected data was conducted until calibration targets were met. This section outlines the calibration targets, the results of the calibration process, and provides documentation of the calibrated VISSIM outputs.

One of the calibration targets set was for traffic volumes. As outlined in the *Methods and Assumptions*² report, the model was calibrated to within 5 percent accuracy of the overall network traffic volumes within the study corridor. Individual turn movement, entry, and exit volumes were calibrated within 10 percent of counted levels for locations that exceed 100 vehicles per hour. Volumes that are less than this 100 vehicles/hour threshold that did not calibrate within 10 percent are documented and will be addressed individually with Clark County and WSDOT staff. Provided in Table 3 is a comparison of the field volumes to the calibrated VISSIM outputs from the 12 simulation runs for entry and exit location, the detailed turn movement traffic volumes are provided in Attachment C.

² NE 179th Street (NE Delfel Road to NE 15th Avenue) *Methods and Assumptions for Interchange Justification Report – Draft v4*, March 2010

Table 1 – Traffic Volume Calibration Results for the PM Peak Hour Base Model

Model Entrance And Exit Locations	Data Collection Point	Number of Vehicles (VISSIM)*	Balanced Field Volumes	Difference Between VISSIM and Field	Percent Difference
179th EB On	1	127	130	-3	-2.4%
179th WB Off	2	141	130	11	7.8%
11th SB Off	3	42	40	2	4.8%
11th NB On	4	39	40	-1	-2.6%
11th SB On	5	32	35	-3	-9.4%
11th NB Off	6	73	70	3	4.1%
S Delfel SB Off	7	43	45	-2	-4.7%
S Delfel NB On	8	65	65	0	0.0%
N Delfel SB On	9	95	100	-5	-5.3%
N Delfel NB Off	10	132	145	-13	-9.8%
Freeway SB Off	11	4184	4175	9	0.2%
Freeway NB On	14	5190	5166	24	0.5%
Freeway SB On	17	3911	3880	31	0.8%
Freeway NB Off	20	4473	4441	32	0.7%
10th SB On	23	168	175	-7	-4.2%
10th NB Off	24	446	460	-14	-3.1%
Union SB Off	25	80	80	0	0.0%
Union NB On	26	51	55	-4	-7.8%
15th SB Off	27	153	150	3	2.0%
15th NB On	28	223	230	-7	-3.1%
2nd SB Off	29	6	5	1	16.7%
2nd NB On	30	5	5	0	0.0%
179 th EB On	31	206	210	-4	-1.9%
179 th EB Off	32	331	330	1	0.3%
Total Network		20,216	20,162	54	0.27%

*Data represents an average of 12 simulation runs

As can be seen in Table 3, all locations fall within the calibration target of being within 10% of the coded field traffic volumes for all movements that have volumes greater than 100 vehicles. Additionally the total network traffic volumes fall within the calibration target of being within 5% of the total coded traffic volumes.

Another calibration target used was for travel times along NE 179th Street between NW 11th Avenue and NE 15th Avenue. As outlined in the *Methods and Assumptions* report, corridor travel times in VISSIM were calibrated within 15 percent or one minute (whichever is greater)³ of field

³ This threshold is based on the freeway calibration example in FHWA's *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*.

measured data. Because the travel times obtained from the field were less than 4 minutes in length the 1 minute difference threshold was used for calibrating purposes. Table 4 provides a comparison of the VISSIM collected travel times to the field collected (Bluetooth data, and GPS floating car) travel times.

**Table 2 – Travel Time Calibration Results for PM Peak Hour Base Model
(NE 179th Street Between NW 11th Avenue and NE 15th Avenue)**

Scenario	Travel Time (min:sec)	Travel Time (min:sec)
	Eastbound	Westbound
PM Peak (VISSIM)*	3:02	2:40
All Day (Bluetooth)	2:50	2:31
Difference (Bluetooth and VISSIM)	0:12	0:09
PM Peak (Travel Time Runs)	2:38	2:34
Difference (Travel Time Runs and VISSIM)	0:24	0:06
Average of Field Data (Bluetooth and Travel Time Runs)	2:44	2:33
Average Field Data - VISSIM	0:18	0:07

*Data represents an average of 10 simulation runs

As shown in Table 4, the Bluetooth data was summarized over the whole day, this is because the sample sizes of travel times for the p.m. peak hour were less than 5 vehicles. Additionally, when looking at the all day blue tooth data, the travel times throughout the corridor were very consistent throughout the day. So to provide a better sample size, all the Bluetooth data collected was averaged for comparison against the VISSIM model. To further validate the VISSIM model, travel time data was also compared to the p.m. floating car travel time runs and an average of both field measured data. For all three of these comparisons the VISSIM data differed by less than one minute from the field data, showing that the VISSIM model is calibrated for travel time.

Additionally, queuing data was also collected in the field and compared with the visual simulations from VISSIM to provide an assessment of queuing. The number of vehicles in the queue at the start of green was recorded in the field and in VISSIM and compared showing a difference of no more than one car on average over the p.m. peak hour. Based on this comparison, it can be concluded that the base VISSIM model is realistically replicating the field conditions (see Attachment D).

Lane utilization data was collected on I-5 near the NE 179th Street overcrossing for both the southbound and northbound directions. The field collected lane utilization data describes how the I-5 freeway lanes near NE 179th Street are being used. At the time of data collection (March 2010), the freeway was operating at approximately 65% of capacity. However, the traffic volumes modeled in VISSIM represent design hour volumes that are larger than those observed in March. It is expected that as traffic volumes increase and begin to reach the freeway's capacity, lane utilization will become more balanced than suggested by the field data. Therefore, the collected lane utilization data was used as a guide to make adjustments in the base model that replicate operating conditions on I-5 in the vicinity of the project.

Table 5 shows the VISSIM results in comparison to the field collected lane utilization. As can be seen, the VISSIM lane utilization is within 6% of the field collected values. Therefore, it can be concluded that the base VISSIM model is realistically replicating field conditions.

Table 3 – Lane Utilization Results for PM Peak Hour Base Model

I-5 Southbound (at SB On-Ramp Gore)	VISSIM* Lane Volumes	VISSIM Utilization	Field Collected Utilization	Difference
Inside Lane	1,640	43.6%	37.9%	5.6%
Middle Lane	1,439	38.3%	44.8%	-6.5%
Outside Lane	679	18.1%	17.3%	0.9%
I-5 Northbound (2000' South NB Off-Ramp Gore)	VISSIM* Lane Volumes	VISSIM Utilization	Field Collected Utilization	Difference
Inside Lane	1,971	38.0%	31.9%	6.0%
Middle Lane	1,660	32.0%	35.1%	-3.1%
Outside Lane	1,559	30.0%	33.0%	-3.0%

*Data represents an average of 10 simulation runs

Based on the calibration targets and visual inspections of the field in comparison with the base VISSIM model, it was determined that the base model is adequately calibrated. This base model will be used as the foundation for other VISSIM models developed for this project.

At the time of this memorandum both the a.m. and p.m. peak hour VISSIM models with the factored up traffic volumes have been developed. Both these models were required to be within 5 percent accuracy of the overall network traffic volumes within the study corridor and to have entry and exit volumes within 10 percent of counted levels for locations that exceed 100 vehicles per hour. Attachment E provides a summary of traffic volumes, travel times, lane utilization, and queuing from the a.m. and p.m. peak hour factored models.

Attachment A

List of Changes from Default Parameters and Customized Parameters

Default Change and Customized Parameters in VISSIM – 179th Interchange Project

- Speed Distributions - + and – 5 mph of the posted speed
- Vehicle Compositions – assumes 2% heavy vehicle
- 15 min seeding period
- Reduced speeds zones – 9 mph = right turns 15mph = left turn
- Conflict Zone changes – avoid blocking from 1 to 0 in some cases
- Lane change parameter for northbound link north of intersection 6 adjusted
- Look back distances for connectors onto ramps from freeways increased
- Driving behavior for weaving area created for SB on-ramp merge and NB off-ramp weaving area

Attachment B

Minimum Number of Repetitions Calculations

Confidence Intervals

179th Street: Calibrated VISSIM Model Check

Data Collection Pt	Counts	VISSIM	Difference	% Difference from Counts	Standard Deviation (S)	Confidence Interval (CI)	Desired Range (CI/S)	Student t Statistic 95%*	# of Runs for 95% Confidence
1	130	128	2	1.9%	14	20	1.4	2.201	10.1
2	130	142	-12	2.3%	9	20	2.3	2.201	3.6
3	40	43	-3	2.0%	6	-	-	2.201	-
4	40	39	1	1.8%	8	-	-	2.201	-
5	35	34	1	1.0%	9	-	-	2.201	-
6	70	72	-2	0.4%	9	-	-	2.201	-
7	45	44	1	1.6%	7	-	-	2.201	-
8	65	65	0	3.5%	10	-	-	2.201	-
9	100	94	6	-2.8%	12	20	1.7	2.201	6.8
10	145	133	12	0.9%	10	20	1.9	2.201	5.2
11	4175	4198	-23	1.3%	60	205	3.4	2.201	1.6
14	5166	5195	-29	0.7%	60	235	3.9	2.201	1.3
17	3880	3922	-42	0.1%	63	190	3.0	2.201	2.2
20	4441	4479	-38	-0.6%	70	220	3.1	2.201	2.0
23	175	169	6	1.9%	15	25	1.6	2.201	7.2
24	460	449	11	-3.2%	29	40	1.4	2.201	10.1
25	80	81	-1	-1.0%	5	20	3.7	2.201	1.4
26	55	54	1	-2.9%	8	-	-	2.201	-
27	150	153	-3	-0.6%	11	20	1.8	2.201	6.2
28	230	226	4	0.6%	17	25	1.4	2.201	9.3
29	5	6	-1	1.9%	4	-	-	2.201	-
30	5	5	0	1.8%	2	-	-	2.201	-
31	210	208	2	0.0%	14	25	1.8	2.201	6.1
32	330	333	-3	1.1%	12	30	2.5	2.201	3.2
Total	20162	19720	442	0.56%	279	700	2.5	2.201	3.1
Minimum Number of Runs for Confidence in the Model									10.1

Volume Confidence Intervals (CI)

Volume Range (vph)	CI
0 - 25	-
25 - 75	-
75 - 175	20
175 - 325	25
325 - 450	30
450 - 600	40
600 - 775	50
775 - 975	60
975 - 1200	70
1200 - 1450	80
1450 - 1725	90
1725 - 2025	100
2025 - 2350	115
2350 - 2700	130
2700 - 3075	145
3075 - 3475	160
3475 - 3900	175
3900 - 4350	190
4350 - 4825	205
4825 - 5325	220
5325 - 5850	235
5850 - 6400	250
6400 - 10000	265
> 10000	700

25
75
175
325
450
600
775
975
1200
1450
1725
2025
2350
2700
3075
3475
3900
4350
4825
5325
5850
6400
10000

*Based on 12 initial simulation runs

Attachment C

Turn Movement Traffic Volumes

Intersection Results by Movement - PM Existing

Int	Name		Mvmt	Delay (sec)	LOS	# Vehicles	Input Volumes	Difference	% Difference	
1	179th	11th	1	NBLT	7.7	A	7	5	2	40%
			6	NB THRU	11.3	B	14	15	-1	-7%
			9	NBRT	4.8	A	19	20	-1	-5%
			5	SBLT	6.8	A	10	10	0	0%
			2	SB THRU	11.0	B	9	10	-1	-10%
			10	SBRT	4.9	A	14	15	-1	-7%
			3	EBLT	1.3	A	6	5	1	20%
			8	EB THRU	0.1	A	117	120	-3	-3%
			11	EBRT	0.5	A	5	5	0	0%
			7	WBLT	2.5	A	29	25	4	16%
			4	WB THRU	1.9	A	121	120	1	1%
			12	WBRT	1.7	A	54	50	4	8%
2	179th	Delfel (S)	X 1	NBLT	18.7	B	7	5	2	40%
			X 9	NBRT	3.7	A	59	60	-1	-2%
			X 8	EB THRU	2.4	A	139	145	-6	-4%
			X 11	EBRT	1.7	A	6	5	1	20%
			X 7	WBLT	8.3	A	38	40	-2	-5%
			X 4	WB THRU	1.5	A	196	195	1	1%
3	179th	Delfel (N)	5	SBLT	8.3	A	90	95	-5	-5%
			10	SBRT	5.5	A	6	5	1	20%
			3	EBLT	2.6	A	5	5	0	0%
			8	EB THRU	2.0	A	194	200	-6	-3%
			4	WB THRU	0.2	A	228	230	-2	-1%
			12	WBRT	0.0	A	128	140	-12	-9%
4	179th	SB Ramp	X 5	SBLT	34.3	C	89	90	-1	-1%
			X 2	SB THRU	0.0	A	0	0	0	0%
			X 10	SBRT	7.1	A	64	65	-1	-2%
			X 8	EB THRU	32.5	C	104	105	-1	-1%
			X 11	EBRT	0.0	A	180	190	-10	-5%
			X 7	WBLT	2.1	A	248	260	-12	-5%
			X 4	WB THRU	6.6	A	292	305	-13	-4%
5	179th	NB On-Ramp	3	EBLT	2.4	A	39	35	4	11%
			8	EB THRU	8.2	A	154	160	-6	-4%
			4	WB THRU	0.2	A	539	565	-26	-5%
			12	WBRT	0.0	A	71	80	-9	-11%
6	179th	NB Off-Ramp	X 1	NBLT	10.7	B	227	235	-8	-3%
			X 6	NB THRU	12.7	B	386	395	-9	-2%
			X 9	NBRT	11.1	B	211	210	1	0%
			X 5	SBLT	38.6	D	35	35	0	0%
			X 10	SBRT	6.9	A	133	140	-7	-5%
			X 3	EBLT	8.2	A	27	30	-3	-10%
			X 8	EB THRU	6.3	A	127	130	-3	-2%
			X 4	WB THRU	21.8	C	251	270	-19	-7%
			X 12	WBRT	6.1	A	35	35	0	0%
7	179th	Union	1	NBLT	13.9	B	26	35	-9	-26%
			9	NBRT	6.6	A	25	25	0	0%
			8	EB THRU	0.9	A	313	315	-2	-1%
			11	EBRT	0.0	A	59	60	-1	-2%
			7	WBLT	2.0	A	21	20	1	5%
8	179th	15th	4	WB THRU	6.0	A	260	270	-10	-4%
			X 1	NBLT	9.1	A	124	130	-6	-5%
			X 9	NBRT	4.9	A	99	100	-1	-1%
			X 8	EB THRU	6.1	A	234	240	-6	-3%
			X 11	EBRT	4.9	A	105	100	5	5%
			X 7	WBLT	5.6	A	49	50	-1	-2%
9	179th	2nd	1	NBLT	0.0	A	0	0	0	0%
			9	NBRT	6.6	A	5	5	0	0%
			8	EB THRU	0.3	A	140	145	-5	-3%
			11	EBRT	0.3	A	6	5	1	20%
			7	WBLT	0.0	A	0	0	0	0%
			4	WB THRU	0.4	A	202	200	2	1%
Total Network						6538	6720	-182	-3%	

Attachment D

Queuing Observations and Comparison Results

I-5 NB Ramp Terminal

Field Collected

	SB		WB		NB				EB
	↓	↘	↖	←	↙	↖	↑	↗	↖
1	0	0	4	0	0	0	0	0	0
0	1	0	0	0	0	1	0	0	0
0	0	1	1	1	0	0	0	0	1
0	0	0	1	1	1	0	0	0	0
0	0	1	1	1	0	1	0	0	0
0	0	2	0	0	0	1	1	1	0
4	1	2	1	0	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0
1	0	0	1	1	0	0	0	0	0
2	0	1	0	0	1	0	1	1	0
0	0	0	2	2	0	0	0	0	0
3	0	2	2	2	0	0	0	0	0
0	0	1	0	1	1	0	0	0	1
1	0	0	1	1	0	0	0	0	2
0	0	1	1	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0
3	0	1	0	0	0	0	1	1	3
0	0	2	2	0	0	1	1	1	1
1	0	2	0	0	0	1	1	1	1
3	0	1	2	0	0	1	1	1	0
0	0	1	0	1	1	0	0	0	0
1	0	0	0	0	0	0	1	0	1
0	2	0	3	0	0	0	0	0	0
0	1	1	1	0	0	1	0	0	0
0	0	1	2	0	0	0	0	0	0
0	0	1	4	0	0	0	0	0	2
1	0	2	1	0	0	0	0	0	0
1	1	3	4	0	2	0	0	0	0

Average # Vehicles
Queue Length
VISSIM Queue Length
Difference

1	0	1	1	0	0	0	0	0
25	0	25	25	0	0	0	0	0
0	0	25	25	25	0	0	25	25
-25	0	0	0	25	0	0	25	25

Notes:

- SB right movement often has a rolling stop except when WB traffic is present
- Signal seems coordinated with western intersection, eastbound movement was hitting green most of the time
- Exiting the freeway most cars are hitting greens for through movements and the double lefts.

I-5 NB Ramp Terminal

Calibrated VISSIM Collected

	SB		WB		NB				EB
	↓	↘	↖	←	↙	↖	↑	↗	↖
4	1	0	1	1	1	0	1	2	0
0	2	1	1	0	0	0	0	0	0
0	0	0	2	0	0	0	1	1	0
0	0	1	1	1	0	0	0	0	0
1	0	1	1	0	0	1	2	0	0
2	0	1	3	1	0	0	0	0	1
0	0	0	0	2	0	1	2	1	1
2	1	1	0	0	0	1	1	1	1
0	0	3	3	1	0	0	1	0	0
0	0	1	2	2	0	0	0	0	0
1	1	0	2	0	0	0	0	1	0
0	0	1	1	1	0	0	1	1	1
0	0	0	0	0	0	0	0	1	1
1	0	1	1	1	1	0	1	1	1
0	0	2	3	1	0	0	1	0	0
0	0	0	1	1	0	0	0	1	2
0	0	0	1	0	0	0	0	1	0
0	0	0	2	1	0	0	0	1	2
0	0	1	1	0	0	0	1	1	2
0	0	0	0	1	0	0	0	1	1
0	0	0	0	0	0	0	2	1	1
1	0	0	1	0	0	0	1	1	1
0	0	1	1	1	0	0	0	0	1
0	0	1	1	0	0	1	0	0	0
0	0	1	0	1	0	0	2	1	1
0	0	1	1	0	0	0	1	0	0
0	0	1	1	0	0	0	1	0	0
0	0	1	3	1	0	0	2	1	1
0	0	0	2	2	0	0	0	0	1







Average # Vehicles
Queue Length

0	0	1	1	1	0	0	1	1
0	0	25	25	25	0	0	25	25

Queuing Observations 2/18/2010 PM peak Hour
Queuing Observations 3/2/2010 PM peak Hour
 4:30 to 6:00 pm

I-5 NB Ramp Terminal

Field Collected

SB	WB		NB		EB
					
2	3	3	1	2	1
1	3	3	2	2	0
0	3	3	2	2	0
0	4	4	2	1	2
1	2	2	2	1	2
1	3	3	1	1	0
3	1	1	2	1	0
1	4	4	2	1	0
0	4	5			0
2	5	5			1
0	0	0			0
1	3	2			0
0	1	1			1
0	3	3			0
	0	6			4
					0
					5

Average # Vehicles
 Queue Length
 VISSIM Queue Length
 Difference







1	3	3	2	1	1
25	75	75	50	25	25
25	50	50	50	50	25
0	-25	-25	0	25	0

Notes:

- SBR & SBL separate phases
- SBR usually goes to red first then SBL
- Ramps Coordinated
- Even lane utilization in WB direction
- Queue for SB Left was always a rolling queue
- v/c ratio should be less than 0.50
- 75 second cycle
- Most EB vehicles arrive on green
- Off-ramp has periods of green with no vehicles

I-5 NB Ramp Terminal

Calibrated VISSIM Collected

SB	WB		NB		EB
					
0	0	2	1	1	1
0	1	2	2	2	0
1	5	1	1	1	1
0	2	3	1	2	0
1	4	7	1	3	1
1	2	2	1	3	4
1	1	2	1	0	0
0	5	2	2	3	0
1	1	1	1	3	2
0	3	5	2	1	1
0	0	1	3	2	1
1	2	3	3	2	1
3	3	1	2	3	2
0	1	1	1	3	

Average # Vehicles
 Queue Length

1	2	2	2	2	1
25	50	50	50	50	25

I-5 SB Ramp Terminal

Field Collected

	WB			SB	EB
	↙	↖	←	↓	→
	0	0	4	1	5
	2	2	3	2	3
	0	2	2	3	3
	2	3	2	2	3
	0	2	2	1	3
	3	0	0	1	3
				4	4
				7	1
				0	1
				7	3
				1	
				5	

Average # Vehicles	1	2	2	3	3
Queue Length	25	50	50	75	75
Calibrated VISSIM Queue Len	25	50	50	50	75
Difference	0	0	0	-25	0
Difference	0	0	0	-25	0

Notes:

Split phasing
 WB Green times (sec): 54, 49, 42, 42
 SB Green times (sec): 7, 10, 6
 EB Green times(sec): 7, 10, 12
 75 second cycle

I-5 SB Ramp Terminal

Calibrated VISSIM Collected

	WB			SB	EB
	↙	↖	←	↓	→
	1	2	1	3	3
	2	2	2	2	3
	1	1	0	1	0
	1	1	3	1	7
	2	2	2	3	2
	3	3	2	1	2
	1	1	0	4	2
	1	1	2	1	2
	1	1	1	2	2
	1	3	2	2	2

Average # Vehicles	1	2	2	2	3
Queue Length	25	50	50	50	75

I-5 SB Ramp Terminal

Field Collected

	WB			SB		EB	
	←	↙	→	↘	↓	→	↘
2	1	1	0	0	0	0	
2	1	0	1	1	1	2	
3	1	1	0	2	1	0	
1	0	1	0	1	2	0	
3	0	1	0	0	0	0	
4	0	0	0	0	0	0	
0	0	0	0	1	3	0	
4	1	0	0	1	0	0	
0	1	2	0	0	0	0	
2	0	0	0	3	1	0	
3	0	0	0	4	1	0	
3	1	0	1	2	0	0	
0	0	2	0	1	3	0	
0	0	0	0	1	0	0	
1	0	0	1	0	0	0	
1	0	0	0	0	0	0	
0	0	0	0	0	1	0	
0	0	0	0	1	1	0	
2	0	0	0	1	0	0	
3	0	0	0	2	0	0	
3	1	0	0	0	2	0	
2	1	0	0	1	1	0	
2	0	0	0	0	0	0	
4	2	0	0	1	1	0	
3	3	0	0	1	1	0	
6	2	0	0	0	0	0	
4	0	1	0	1	1	0	
1	1	0	0	2	0	0	
3	1	2	0	2	0	0	
0	0	0	0	0	0	0	
0	0	1	0	0	0	0	
1	0	0	0	0	0	0	
3	0	3	0	1	1	0	
1	0	0	0	1	0	0	
0	0	0	0	0	1	0	
3	0	0	0	0	1	0	
5	1	0	0	0	0	0	
4	1	0	0	2	2	0	
0	0	0	0	1	0	0	
2	0	0	0	0	0	0	
0	0	0	0	1	0	0	

Average # Vehicles
 Queue Length
 Calibrated VISSIM Queue Length
 Difference
 Difference

2	0	0	0	1	1	0
50	0	0	0	25	25	0
25	25	0	0	25	25	0
-25	25	0	0	0	0	0
-25	25	0	0	0	0	0

I-5 SB Ramp Terminal

Calibrated VISSIM Collected

	WB			SB		EB	
	←	↙	→	↘	↓	→	↘
2	1	0	0	0	0	1	0
0	1	0	0	2	0	0	0
1	1	0	1	0	0	0	0
0	0	0	0	0	1	0	0
2	2	0	0	1	1	0	0
3	3	0	0	1	0	0	0
0	0	0	0	0	1	0	0
1	1	1	1	1	1	1	0
0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0
0	2	0	0	1	0	0	0
0	0	0	0	1	2	0	0
0	0	0	0	0	1	0	0
0	1	0	0	0	1	0	0
1	1	0	0	0	0	1	0
1	1	0	0	0	0	0	0
0	2	0	1	0	1	1	0
3	1	0	0	1	2	0	0
1	1	0	0	0	1	0	0
0	1	0	0	0	1	0	0
2	2	0	0	0	1	0	0
1	2	2	0	1	1	0	0
0	1	1	0	1	1	0	0
2	3	1	0	3	1	0	0
3	1	0	0	0	0	0	0
0	0	0	0	1	1	0	0
1	0	0	0	0	1	1	0
1	0	0	0	1	1	0	0
2	1	1	0	0	0	0	0
2	1	0	0	1	1	0	0
0	1	0	0	1	1	0	0
2	2	0	1	1	2	0	0
3	2	1	0	0	2	0	0
2	0	1	0	0	0	0	0
2	1	0	0	1	0	0	0
1	0	1	0	0	1	0	0
3	3	0	0	1	0	0	0
1	1	2	0	1	1	0	0
1	1	1	0	0	0	0	0
0	1	0	0	0	1	0	0
4	4	1	0	1	1	0	0

Average # Vehicles
 Queue Length

1	1	0	0	1	1	0
25	25	0	0	25	25	0

Notes:
 - Most cars are making EB right without stopping
 - Cars are rolling through the SB right movement

Attachment E

Existing Conditions Results

Intersection Results by Movement - AM Existing (Factored by 18%)

Int	Name			Mvmt	Delay (sec)	LOS	# Vehicles	Input Volumes	Difference	% Difference	
1	179th	11th		1	NBLT	7.5	A	8	6	2	33%
				6	NB THRU	11.3	B	18	18	0	0%
				9	NBRT	5.5	A	50	53	-3	-6%
				5	SBLT	6.8	A	14	12	2	17%
				2	SB THRU	11.0	B	18	18	0	0%
				10	SBRT	4.9	A	23	24	-1	-4%
				3	EBLT	0.4	A	7	6	1	17%
				8	EB THRU	0.2	A	147	153	-6	-4%
				11	EBRT	0.5	A	7	6	1	17%
				7	WBLT	1.7	A	33	30	3	10%
				4	WB THRU	0.9	A	45	47	-2	-4%
				12	WBRT	0.8	A	11	12	-1	-8%
2	179th	Delfel (S)	X	1	NBLT	9.4	A	6	6	0	0%
			X	9	NBRT	3.1	A	34	35	-1	-3%
			X	8	EB THRU	2.5	A	196	207	-11	-5%
			X	11	EBRT	1.5	A	12	12	0	0%
			X	7	WBLT	7.8	A	42	47	-5	-11%
X	4	WB THRU	0.9	A	87	89	-2	-2%			
3	179th	Delfel (N)		5	SBLT	8.8	A	184	189	-5	-3%
				10	SBRT	7.0	A	5	6	-1	-17%
				3	EBLT	1.4	A	6	6	0	0%
				8	EB THRU	2.1	A	225	236	-11	-5%
				4	WB THRU	0.3	A	124	130	-6	-5%
	12	WBRT	0.0	A	68	65	3	5%			
4	179th	SB Ramp	X	5	SBLT	14.5	B	105	106	-1	-1%
			X	2	SB THRU	0.0	A	0	0	0	0%
			X	10	SBRT	6.7	A	39	41	-2	-5%
			X	8	EB THRU	13.7	B	102	100	2	2%
			X	11	EBRT	0.0	A	307	325	-18	-6%
			X	7	WBLT	7.5	A	386	395	-9	-2%
X	4	WB THRU	8.1	A	154	153	1	1%			
5	179th	NB On-Ramp		3	EBLT	3.1	A	59	59	0	0%
				8	EB THRU	5.8	A	147	148	-1	-1%
				4	WB THRU	0.2	A	541	549	-8	-1%
				12	WBRT	0.0	A	73	94	-21	-22%
6	179th	NB Off-Ramp	X	1	NBLT	17.1	B	94	106	-12	-11%
			X	6	NB THRU	16.2	B	106	106	0	0%
			X	9	NBRT	7.5	A	55	53	2	4%
			X	5	SBLT	21.0	C	24	24	0	0%
			X	10	SBRT	6.3	A	232	236	-4	-2%
			X	3	EBLT	9.1	A	14	12	2	17%
			X	8	EB THRU	8.3	A	133	136	-3	-2%
			X	4	WB THRU	10.2	B	288	301	-13	-4%
X	12	WBRT	2.1	A	24	24	0	0%			
7	179th	Union		1	NBLT	9.0	A	31	35	-4	-11%
				9	NBRT	5.8	A	6	6	0	0%
				8	EB THRU	1.1	A	169	171	-2	-1%
				11	EBRT	0.0	A	42	41	1	2%
				7	WBLT	1.4	A	19	18	1	6%
	4	WB THRU	2.7	A	282	289	-7	-2%			
8	179th	15th	X	1	NBLT	7.6	A	67	71	-4	-6%
			X	9	NBRT	3.7	A	23	24	-1	-4%
			X	8	EB THRU	3.8	A	85	89	-4	-4%
			X	11	EBRT	3.4	A	90	89	1	1%
			X	7	WBLT	3.6	A	53	53	0	0%
			X	4	WB THRU	2.9	A	234	236	-2	-1%
9	179th	2nd		1	NBLT	0.0	A	0	0	0	0%
				9	NBRT	6.7	A	6	6	0	0%
				8	EB THRU	0.4	A	203	212	-9	-3%
				11	EBRT	0.6	A	7	6	1	20%
				7	WBLT	0.9	A	6	6	0	0%
	4	WB THRU	0.2	A	87	89	-2	1%			
Total Network							5663	5822	159	3%	

Existing AM Peak Hour (Factored by 18%)

Location	Data Collection Point	Start Time	End Time	Average Vehicles - VISSIM	Rounded	Coded Number of Vehicles	Difference	% Difference
179th EB On	1	900	4500	161	161	165	-4	-2.5%
179th WB Out	2	900	4500	74	74	77	-3	-4.1%
11th SB Out	3	900	4500	55	55	54	1	1.8%
11th NB On	4	900	4500	74	74	77	-3	-4.1%
11th SB On	5	900	4500	53	53	54	-1	-1.9%
11th SB Off	6	900	4500	35	35	36	-1	-2.9%
S Delfel SB Off	7	900	4500	53	53	59	-6	-11.3%
S Delfel NB On	8	900	4500	40	40	41	-1	-2.5%
N Delfel SB On	9	900	4500	188	188	195	-7	-3.7%
N Delfel NB Off	10	900	4500	74	74	71	3	4.1%
Freeway SB Off	11	900	4500	5023	5023	5018	5	0.1%
Freeway NB On	14	900	4500	3003	3003	2993	10	0.3%
Freeway SB ON	17	900	4500	4472	4472	4446	26	0.6%
Freeway NB Off	20	900	4500	2875	2875	2880	-5	-0.2%
10th SB On	23	900	4500	255	255	260	-5	-2.0%
10th NB Off	24	900	4500	142	142	142	0	0.0%
Union SB Off	25	900	4500	60	60	59	1	1.7%
Union NB On	26	900	4500	37	37	41	-4	-10.8%
15th SB Off	27	900	4500	142	142	142	0	0.0%
15th NB On	28	900	4500	90	90	95	-5	-5.6%
2nd SB Off	29	900	4500	12	12	12	0	0.0%
2nd NB On	30	900	4500	6	6	6	0	0.0%
17th WB On	31	900	4500	285	285	289	-4	-1.4%
17th EB Off	32	900	4500	108	108	113	-5	-4.6%
Total Network				16906	16924	16923	1	0.01%

I-5 SB	Data Collection Point	Start	End	Average VISSIM	Rounded	Utilization	Expected Utilization	Difference
Inside	35	900	4500	1704.60	1705	39.4%	37.9%	1.5%
Middle	34	900	4500	1564.30	1564	36.1%	44.8%	-8.7%
Outside	33	900	4500	1060.90	1061	24.5%	17.3%	7.2%
Total		900	4500	4329.80	4330	100.0%	100.0%	0.0%
I-5 NB	Data Collection Point	Start	End	Average VISSIM	Rounded	Utilization	Expected Utilization	Difference
Inside	38	900	4500	1101.70	1102	36.7%	31.93%	4.8%
Middle	37	900	4500	970.90	971	32.3%	35.06%	-2.7%
Outside	36	900	4500	930.40	930	31.0%	33.01%	-2.0%
Total		900	4500	3003.00	3003	100.0%	100.00%	0.0%

Existing AM Peak Hour (Factored by 18%)

		Trav	#Veh	Trav	#Veh
		Eastbound		Westbound	
AM Peak - VISSIM	Seconds	172.8	1	150.14	2
AM Peak - VISSIM	Minutes	2.88	1	2.50	2
All Day - Blue Tooth	Minutes	2.83	8	2.52	5
Blue Tooth - VISSIM (Minutes)		-0.05	-	0.02	-
% Difference Between Blue Tooth and VISSIM		-1.77%	-	0.70%	-
PM Peak - Travel Time Runs	Minutes	2.63	6	2.57	6
Travel Time Runs - VISSIM (Minutes)		-0.25	-	0.07	-
% Difference Between Blue Tooth and VISSIM		-9.51%	-	2.63%	-
Average of Field Data	Minutes	2.73	-	2.55	-
Average Field Data - VISSIM (Minutes)		-0.15	-	0.04	-
% Difference Between Average Field Data and VISSIM		-5.49%	-	1.68%	-

Intersection Results by Movement - PM Existing (Factored by 18%)

Int	Name			Mvmt	Delay (sec)	LOS	# Vehicles	Input Volumes	Difference	% Difference	
1	179th	11th		1	NBLT	9.4	A	8	6	2	33%
				6	NB THRU	11.9	B	18	18	0	0%
				9	NBRT	5.1	A	24	24	0	0%
				5	SBLT	7.1	A	13	12	1	8%
				2	SB THRU	10.3	B	11	12	-1	-8%
				10	SBRT	4.9	A	17	18	-1	-6%
				3	EBLT	1.0	A	7	6	1	17%
				8	EB THRU	0.1	A	127	142	-15	-11%
				11	EBRT	0.5	A	6	6	0	0%
				7	WBLT	2.4	A	31	30	1	3%
				4	WB THRU	2.4	A	140	142	-2	-1%
				12	WBRT	1.8	A	56	59	-3	-5%
2	179th	Delfel (S)	X	1	NBLT	17.3	B	5	6	-1	-17%
			X	9	NBRT	3.9	A	70	71	-1	-1%
			X	8	EB THRU	2.6	A	157	171	-14	-8%
			X	11	EBRT	1.8	A	7	6	1	17%
			X	7	WBLT	7.7	A	47	47	0	0%
			X	4	WB THRU	1.5	A	222	230	-8	-3%
3	179th	Delfel (N)		5	SBLT	8.6	A	110	112	-2	-2%
				10	SBRT	6.6	A	6	6	0	0%
				3	EBLT	2.4	A	6	6	0	0%
				8	EB THRU	2.2	A	220	236	-16	-7%
				4	WB THRU	0.3	A	264	271	-7	-3%
				12	WBRT	0.0	A	156	165	-9	-5%
4	179th	SB Ramp	X	5	SBLT	34.2	C	99	106	-7	-7%
			X	2	SB THRU	0.0	A	0	0	0	0%
			X	10	SBRT	7.2	A	72	77	-5	-6%
			X	8	EB THRU	32.6	C	117	124	-7	-6%
			X	11	EBRT	0.0	A	214	224	-10	-4%
			X	7	WBLT	2.8	A	299	307	-8	-3%
5	179th	NB On-Ramp		3	EBLT	2.7	A	40	41	-1	-2%
				8	EB THRU	6.3	A	177	189	-12	-6%
				4	WB THRU	0.2	A	647	667	-20	-3%
				12	WBRT	0.0	A	92	94	-2	-2%
6	179th	NB Off-Ramp	X	1	NBLT	12.3	B	268	277	-9	-3%
			X	6	NB THRU	14.8	B	465	466	-1	0%
			X	9	NBRT	13.2	B	252	248	4	2%
			X	5	SBLT	38.1	D	38	41	-3	-7%
			X	10	SBRT	7.6	A	164	165	-1	-1%
			X	3	EBLT	6.3	A	34	35	-1	-3%
			X	8	EB THRU	3.9	A	143	153	-10	-7%
			X	4	WB THRU	20.2	C	307	319	-12	-4%
7	179th	Union		1	NBLT	18.1	C	36	41	-5	-12%
				9	NBRT	7.3	A	32	30	2	7%
				8	EB THRU	0.3	A	364	372	-8	-2%
				11	EBRT	0.1	A	67	71	-4	-6%
				7	WBLT	2.5	A	26	24	2	8%
				4	WB THRU	7.2	A	311	319	-8	-3%
8	179th	15th	X	1	NBLT	10.2	B	151	130	21	16%
			X	9	NBRT	5.1	A	114	100	14	14%
			X	8	EB THRU	6.8	A	277	283	-6	-2%
			X	11	EBRT	5.6	A	118	100	18	18%
			X	7	WBLT	6.5	A	59	50	9	18%
			X	4	WB THRU	5.3	A	187	189	-2	-1%
9	179th	2nd		1	NBLT	0.0	A	0	0	0	0%
				9	NBRT	6.8	A	6	6	0	0%
				8	EB THRU	0.3	A	158	171	-13	-3%
				11	EBRT	0.3	A	6	6	0	20%
				7	WBLT	0.0	A	0	0	0	0%
				4	WB THRU	0.4	A	227	236	-9	1%
Total Network							7681	7864	-183	-2%	

Existing PM Peak Hour (Factored by 18%)

Location	Data Collection Point	Start Time	End Time	Average Vehicles - VISSIM	Rounded	Coded Number of Vehicles	Difference	% Difference
179th EB On	1	900	4500	137	137	142	-5	-3.6%
179th WB Out	2	900	4500	163	163	166	-3	-1.8%
11th SB Out	3	900	4500	46	46	48	-2	-4.3%
11th NB On	4	900	4500	48	48	48	0	0.0%
11th SB On	5	900	4500	40	40	42	-2	-5.0%
11th SB Off	6	900	4500	79	79	83	-4	-5.1%
S Delfel SB Off	7	900	4500	54	54	53	1	1.9%
S Delfel NB On	8	900	4500	73	73	77	-4	-5.5%
N Delfel SB On	9	900	4500	114	114	118	-4	-3.5%
N Delfel NB Off	10	900	4500	160	160	171	-11	-6.9%
Freeway SB Off	11	900	4500	4275	4275	4256	19	0.4%
Freeway NB On	14	900	4500	5337	5337	5317	20	0.4%
Freeway SB ON	17	900	4500	3937	3937	3908	29	0.7%
Freeway NB Off	20	900	4500	4488	4488	4462	26	0.6%
10th SB On	23	900	4500	202	202	206	-4	-2.0%
10th NB Off	24	900	4500	536	536	542	-6	-1.1%
Union SB Off	25	900	4500	92	92	95	-3	-3.3%
Union NB On	26	900	4500	67	67	71	-4	-6.0%
15th SB Off	27	900	4500	177	177	177	0	0.0%
15th NB On	28	900	4500	265	265	271	-6	-2.3%
2nd SB Off	29	900	4500	5	5	6	-1	-20.0%
2nd NB On	30	900	4500	6	6	6	0	0.0%
17th WB On	31	900	4500	246	246	248	-2	-0.8%
17th EB Off	32	900	4500	391	391	401	-10	-2.6%
Total Network				20289	20938	20914	24	0.12%

I-5 SB	Data Collection Point	Start	End	Average VISSIM	Rounded	Utilization	Expected Utilization	Difference
Inside	35	900	4500	1637.80	1638	43.5%	37.9%	5.6%
Middle	34	900	4500	1447.80	1448	38.4%	44.8%	-6.4%
Outside	33	900	4500	680.20	680	18.1%	17.3%	0.7%
Total		900	4500	3765.80	3766	100.0%	100.0%	0.0%
I-5 NB	Data Collection Point	Start	End	Average VISSIM	Rounded	Utilization	Expected Utilization	Difference
Inside	38	900	4500	2047.90	2048	38.4%	31.93%	6.4%
Middle	37	900	4500	1687.50	1688	31.6%	35.06%	-3.4%
Outside	36	900	4500	1601.60	1602	30.0%	33.01%	-3.0%
Total		900	4500	5337.00	5337	100.0%	100.00%	0.0%

Existing PM Peak Hour (Factored by 18%) Travel Time

		Trav	#Veh	Trav	#Veh
		Eastbound		Westbound	
PM Peak - VISSIM	Seconds	184.36	6	171.66	4
PM Peak - VISSIM	Minutes	3.07	6	2.86	4
All Day - Blue Tooth	Minutes	2.83	8	2.52	5
Blue Tooth - VISSIM (Minutes)		-0.24	-	-0.34	-
% Difference Between Blue Tooth and VISSIM		-8.57%	-	-13.53%	-
PM Peak - Travel Time Runs	Minutes	2.63	6	2.57	6
Travel Time Runs - VISSIM (Minutes)		-0.44	-	-0.29	-
% Difference Between Blue Tooth and VISSIM		-16.83%	-	-11.32%	-
Average of Field Data	Minutes	2.73	-	2.55	-
Average Field Data - VISSIM (Minutes)		-0.34	-	-0.32	-
% Difference Between Average Field Data and VISSIM		-12.55%	-	-12.42%	-

Appendix I: 95th Percentile Queue Example

Project Name: 12th Street Redevelopment
 Model: PM Peak Hour - 2035
 Date: 10/15/2010
 Company: DKS Associates
 Document: Future 2035 Analysis Results

95th Percentile Queue
 from Max Column Should
 be Reported

Time No.:	Avg. 1	max 1	Stop 1	Avg. 2	max 2	Stop 2	Avg. 3	max 3	Stop 3	Avg. 4	max 4	Stop 4	Avg. 9	max 9	Stop 9	Avg. 10	max 10	Stop 10	Avg. 11	max 11	Stop 11
	12th Street/A Street									12th Street/B Street											
	NB			SB			EB			WB			NBLT			NBTh/RT			EBTh		
95th Percentile	777	778	15	684	703	11	59	177	5	158	579	22	9	31	1	132	283	18	135	294	23
Average	442	466	7	337	366	5	7	28	1	42	192	7	2	10	0	44	126	8	74	185	14
Standard Dev	204	190	5	212	206	4	31	90	3	71	236	9	4	13	1	54	96	6	37	67	5

Time No.:	Avg. 1	max 1	Stop 1	Avg. 2	max 2	Stop 2	Avg. 3	max 3	Stop 3	Avg. 4	max 4	Stop 4	Avg. 9	max 9	Stop 9	Avg. 10	max 10	Stop 10	Avg. 11	max 11	Stop 11	
Run 1	1020	6	34	5	5	52	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	1140	47	120	14	2	20	4	0	0	0	0	0	0	0	0	0	1	40	1	7	40	
	1260	58	140	11	2	44	3	0	0	0	0	0	0	0	0	0	2	44	1	21	110	
	1380	5	45	7	2	22	3	0	0	0	0	0	0	0	0	0	0	0	0	39	104	
	1500	4	31	6	1	19	2	102	207	9	0	0	0	0	0	4	36	2	5	42	1	
	1620	10	35	3	23	42	4	11	57	2	0	0	0	0	0	7	62	3	9	39	5	
	1740	2	26	Interval was Set to Collect every 120 seconds	19	2	0	0	0	0	0	0	0	0	0	1	39	2	29	82	6	
	1860	19	4	32	3	0	0	0	0	0	0	0	0	0	0	0	0	0	12	59	7	
	1980	6	37	10	13	53	5	0	0	0	0	0	0	0	0	0	0	0	15	65	3	
	2100	11	55	8	7	45	4	0	0	0	0	0	0	0	0	0	0	0	23	83	7	
	2220	82	144	15	23	54	7	0	0	0	0	0	0	0	0	23	81	4	65	199	14	
	2340	13	46	11	1	21	1	0	0	0	0	0	0	0	0	16	104	1	55	173	15	
	2460	16	108	8	1	22	2	0	0	0	0	0	0	0	0	77	167	8	17	87	6	
	2580	12	80	7	1	21	3	0	0	0	0	0	0	0	0	44	165	1	38	141	9	
	2700	3	43	5	1	20	3	0	0	0	129	454	23	1	18	1	14	63	4	81	190	11
	2820	10	47	9	2	20	4	0	0	0	0	0	1	17	0	34	130	5	60	206	15	
	2940	3	44	5	3	34	3	0	0	0	0	0	0	0	0	12	82	3	61	143	10	
	3060	16	53	7	1	21	3	0	0	0	0	0	0	0	0	1	37	1	25	103	6	
	3180	39	118	7	1	31	2	0	0	0	0	0	0	0	0	1	29	1	36	103	11	
	3300	76	128	12	3	53	4	0	0	0	0	0	0	0	0	3	53	2	64	158	16	
	3420	42	115	17	0	19	2	0	0	0	0	0	0	0	0	54	168	12	56	165	12	
	3540	41	110	13	42	73	5	0	0	0	0	0	7	22	1	87	190	6	90	247	15	
	3660	36	86	14	5	37	6	0	0	0	2	61	2	1	19	0	33	135	8	68	168	11
	3780	15	53	10	2	30	2	0	0	0	0	0	0	0	0	28	155	2	62	182	14	
	3900	12	46	5	0	19	1	0	0	0	0	0	0	0	0	0	0	0	44	133	9	
	4020	18	47	6	1	20	3	0	0	0	0	0	0	0	0	6	66	6	62	162	12	
	4140	6	33	7	1	19	2	0	0	0	0	0	2	21	1	1	32	1	22	81	8	
	4260	2	20	4	1	22	2	0	0	0	0	0	0	18	0	3	54	3	48	165	13	
	4380	13	73	5	32	73	5	0	0	0	0	45	1	2	19	1	2	43	1	17	58	4
	4500	68	165	14	28	69	3	0	0	0	1	40	3	1	17	0	3	65	1	10	48	3
Run 2	1020	16	79	9	1	21	3	0	0	0	1	37	1	0	0	1	32	1	50	135	8	
	1140	25	144	8	10	35	3	0	0	0	0	0	10	21	1	1	37	1	12	61	4	
	1260	55	140	14	0	19	1	0	0	0	0	0	0	0	0	0	0	0	27	84	7	
	1380	4	46	6	7	57	5	0	0	0	1	48	2	0	0	6	57	3	63	176	15	
	1500	13	58	9	0	19	1	0	0	0	1	39	1	12	19	1	0	0	9	81	2	
	1620	3	31	5	1	22	3	0	0	0	0	0	0	0	0	2	39	2	4	39	4	
	1740	5	32	7	1	20	2	0	0	0	0	0	0	0	0	0	0	0	56	149	11	
	1860	4	24	7	2	45	4	0	0	0	0	0	0	0	0	1	34	1	32	106	12	
	1980	2	22	4	1	21	3	0	0	0	0	0	6	19	1	7	58	3	117	241	17	
	2100	38	83	12	44	115	7	0	0	0	16	131	6	1	16	0	1	35	1	14	60	5
	2220	55	169	17	32	92	7	3	32	1	4	80	3	0	0	1	35	2	12	62	3	
	2340	116	160	11	6	45	5	0	0	0	1	39	1	14	20	1	1	35	1	21	79	8
	2460	81	158	17	1	19	2	0	0	0	0	0	1	17	0	35	110	11	72	247	19	
	2580	37	68	5	0	18	1	56	172	7	0	0	0	0	0	32	147	9	70	127	8	
	2700	112	138	9	1	21	2	1	165	0	25	218	7	0	0	18	88	3	42	82	8	
	2820	124	207	16	1	21	3	0	0	0	0	0	0	0	0	6	81	3	76	168	10	
	2940	56	116	10	3	35	1	0	0	0	2	79	1	0	0	0	0	0	36	119	8	
	3060	1	22	2	1	19	2	0	0	0	0	0	0	0	0	24	112	6	27	104	5	
	3180	19	60	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	105	10	
	3300	17	74	11	1	18	2	0	0	0	0	0	0	0	0	5	45	2	26	102	10	
	3420	14	67	6	1	18	2	0	0	0	8	96	2	5	20	1	20	104	3	34	107	7
	3540	54	105	13	1	20	2	0	0	0	0	0	1	18	0	4	54	2	48	120	8	

Excel Formula:
 =1.64*M13+M12
 M12=Average of the Max
 M13=Standard Deviation of the Max

Appendix J: Sample Report Formatting

Project Name: 12th Street Redevelopment
 Model: PM Peak Hour - Calibrated
 Date: 10/15/2010
 Company: DKS Associates
 Document: Calibrated Base Model Results

		Trav	#Veh	Trav	#Veh
		12th Street Eastbound		12th Street Westbound	
PM Peak - VISSIM	Seconds	813.9	75	738.3	75
PM Peak - VISSIM	Minutes	13.56	75	12.30	75
All Day - Blue Tooth	Minutes	12.75	100	13.01	100
Blue Tooth - VISSIM (Minutes)		-0.81	-	0.71	-
% Difference Between Blue Tooth and VISSIM		-6.39%	-	5.42%	-
PM Peak - Floating Car	Minutes	13.88	15	12.98	15
Floating Car - VISSIM (Minutes)		0.32	-	0.68	-
% Difference Between Floating Car and VISSIM		2.27%	-	5.20%	-
Average of Field Data	Minutes	13.32	-	13.00	-
Average Field Data - VISSIM (Minutes)		-0.25	-	0.69	-
% Difference Between Average Field Data and VISSIM		-1.87%	-	5.31%	-
Standard Deviation	Seconds	13.5		15.1	

Run 1

Time	Trav	#Veh	Trav	#Veh
VehC	All			
No.:	1	1	2	2
Name	EB 12th	EB 12th	WB 12th	WB 12th
	4500	800.5	75	750.5

Run 2

Time	Trav	#Veh	Trav	#Veh
VehC	All			
No.:	1	1	2	2
Name	EB 12th	EB 12th	WB 12th	WB 12th
	4500	823.3	75	725.5

Run 3

Time	Trav	#Veh
VehC	All	
No.:		
Name		
		4500

Calculated from the output over all the simulation runs

Trav	#Veh	Trav	#Veh
All		All	
1	1	2	2
EB 12th	EB 12th	WB 12th	WB 12th
828	75	722.3	75

4

Time	Trav	#Veh	Trav	#Veh
VehC	All		All	
No.:	1	1	2	2
Name	EB 12th	EB 12th	WB 12th	WB 12th
4500	829.4	75	745.7	75

5

Time	Trav	#Veh	Trav	#Veh
VehC	All		All	
No.:	1	1	2	2
Name	EB 12th	EB 12th	WB 12th	WB 12th
4500	805.7	75	765.3	75

6

Time	Trav	#Veh	Trav	#Veh
VehC	All		All	
No.:	1	1	2	2
Name	EB 12th	EB 12th	WB 12th	WB 12th
4500	801.1	75	745.3	75

7					
Time	Trav	#Veh	Trav	#Veh	
VehC	All				
No.:		1	1	All	2
Name	EB 12th	EB 12th	WB 12th	WB 12th	2
	4500	798.8	75	729.8	75

8					
Time	Trav	#Veh	Trav	#Veh	
VehC	All				
No.:		1	1	All	2
Name	EB 12th	EB 12th	WB 12th	WB 12th	2
	4500	800.5	75	750.5	75

9					
Time	Trav	#Veh	Trav	#Veh	
VehC	All				
No.:		1	1	All	2
Name	EB 12th	EB 12th	WB 12th	WB 12th	2
	4500	823.3	75	725.5	75

10					
Time	Trav	#Veh	Trav	#Veh	
VehC	All				
No.:		1	1	All	2
Name	EB 12th	EB 12th	WB 12th	WB 12th	2
	4500	828	75	722.3	75

Overall Intersection Results - PM Existing

Node #	Street 1	Street 2	Sig	Delay (sec)	LOS	VISSIM Vehicles Output	Input Demand	GEH Value	Standard Deviation
1	12th Ave	A Street		2.4	A	401	400	0.0	25
2	12th Ave	B Street	X	2.9	A	442	450	0.4	20
3	12th Ave	C Street		1.8	A	649	675	1.0	23
4	12th Ave	D Street	X	9.5	A	976	1015	1.2	19
5	12th Ave	E Street		1.7	A	802	840	1.3	16
6	12th Ave	F Street	X	13.0	B	1427	1480	1.4	30
7	12th Ave	G Street		3.4	A	725	725	0.8	21
8	12th Ave	H Street	X	5.9	A	765	768	0.1	20

Calculation provided in Section 6

Calculated from the output over all the simulation runs

Intersection Results by Movement - PM Existing

Node #	Street 1	Street 2	Sig	Movement	Delay (sec)	LOS	VISSIM Vehicles Output	Direction	Delay (sec)	LOS	Input Demand	Difference (Output vs. Input)	GEH Value	Standard Deviation					
1	12th Ave	A Street		1	NBLT	7.7	A	7	NB	7.6	A	5	2	0.8	2.9				
				6	NB THRU	11.3	B	14					15	-1	0.3	5.0			
				9	NBRT	2.8	A	19					20	-1	0.2	4.7			
				5	SBLT	6.8	A	10	SB	7.1	A	10	10	0	0.0	2.9			
				2	SB THRU	11.0	B	9					10	-1	0.3	4.3			
				10	SBRT	4.9	A	14					15	-1	0.3	3.4			
				3	EBLT	1.3	A	6	EB	0.2	A	5	5	1	0.4	2.7			
								EB THRU	0.1	A	117			120	-3	0.3	15.2		
								EBRT	0.5	A	5			5	0	0.0	2.1		
								WBLT	2.5	A	29	WB	1.9	A	25	4	0.8	4.6	
								WB THRU	1.9	A	121			120	1	0.1	6.8		
								WBRT	1.7	A	54			50	4	0.6	5.5		
2	12th Ave	B Street	X	1	NBLT	18.7	B	7	NB	5.3	A	5	2	0.8	4.2				
				9	NBRT	3.7	A	59			60	-1	0.1	7.6					
				8	EB THRU	2.4	A	139	EB	-	-	145	-6	0.5	13.3				
				11	EBRT	1.7	A	6			5	1	0.4	2.3					
				7	WBLT	8.3	A	38	WB	2.6	A	40	-2	0.3	7.1				
				4	WB THRU	1.5	A	196			195	1	0.1	8.6					
3	12th Ave	C Street		5	SBLT	8.3	A	90	SB	8.1	A	95	-5	0.5	6.6				
				10	SBRT	5.5	A	6			5	1	0.4	2.0					
				3	EBLT	2.6	A	5	EB	1.1	A	5	0	0.0	2.1				
				8	EB THRU	2.0	A	194			200	-6	0.4	16.2					
				4	WB THRU	0.2	A	228	WB	-	-	230	-2	0.1	7.8				
				12	WBRT	0.0	A	128			140	-12	1.0	11.7					
4	12th Ave	D Street	X	5	SBLT	34.3	C	89	SB	22.9	C	90	-1	0.1	7.6				
				10	SBRT	7.1	A	64			65	-1	0.1	6.8					
				8	EB THRU	32.5	C	104	EB	11.9	B	105	-1	0.1	11.9				
				11	EBRT	0.0	A	180			190	-10	0.7	13.1					
				7	WBLT	2.1	A	248	WB	4.5	A	260	-12	0.8	12.2				
				4	WB THRU	6.6	A	292			305	-13	0.8	12.1					
5	12th Ave	E Street		3	EBLT	2.4	A	39	EB	7.0	A	35	4	0.7	4.8				
				8	EB THRU	8.2	A	154			160	-6	0.5	9.9					
				4	WB THRU	0.2	A	539	WB	0.2	A	565	-26	1.1	13.4				
				12	WBRT	0.0	A	71			80	-9	1.0	7.0					
				1	NBLT	10.7	B	227	NB	5.8	A	235	-8	0.5	12.3				
				6	NB THRU	12.7	B	386			395	-9	0.5	19.8					
6	12th Ave	F Street	X	9	NBRT	11.1	B	211			210	1	0.1	14.4					
				5	SBLT	38.6	D	35	SB	13.5	B	35	0	0.0	5.3				
				10	SBRT	6.9	A	133			140	-7	0.6	11.9					
				3	EBLT	8.2	A	27	EB	6.6	A	30	-3	0.6	6.1				
				8	EB THRU	6.3	A	127			130	-3	0.3	9.0					
				4	WB THRU	21.8	C	251	WB	19.9	B	270	-19	1.2	5.7				
				12	WBRT	6.1	A	35			35	0	0.0	6.9					
				7	12th Ave	G Street		1	NBLT	13.9	B	26	NB	10.3	B	35	-9	1.6	3.8
								9	NBRT	6.6	A	25			25	0	0.0	5.6	
								8	EB THRU	0.9	A	313	EB	0.8	A	315	-2	0.1	14.7
								11	EBRT	0.0	A	59			60	-1	0.1	7.1	
								7	WBLT	2.0	A	21	WB	5.7	A	20	1	0.2	4.0
4	WB THRU	6.0	A					260			270	-10	0.6	7.4					
8	12th Ave	H Street	X	1	NBLT	9.1	A	124	NB	7.2	A	130	-6	0.5	10.2				
				9	NBRT	4.9	A	99			100	-1	0.1	11.9					
				8	EB THRU	6.1	A	234	EB	5.7	A	240	-6	0.4	11.4				
				11	EBRT	4.9	A	105			100	5	0.5	9.7					
				7	WBLT	5.6	A	49	WB	5.6	A	50	-1	0.1	6.4				
				4	WB THRU	4.3	A	157			160	-3	0.2	13.6					
Total Network							6185	-	-	-	6365	-180	2.3	-					

Calculated based on HCM rankings for Level of

Average of all simulation runs								
Node	Movement	Ref #	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)	StDev Vol
1	E-S	107	2.53	0.00	0.00	0.04	28.30	4.6
1	E-S	104	1.88	0.00	0.00	0.00	121.00	6.8
1	E-W	112	1.73	0.00	0.00	0.00	53.40	5.5
1	E-N	108	0.13	0.00	0.00	0.00	116.40	15.2
1	W-E	111	0.50	0.00	0.00	0.00	4.70	2.1
1	W-S	103	1.29	0.00	0.00	0.24	5.70	2.7
1	W-N	106	11.28	0.00	11.83	0.51	13.90	5.0
1	S-N	109	4.82	0.00	11.83	0.21	18.90	4.7
1	S-E	101	7.66	0.00	11.83	0.74	6.20	2.9
1	S-W	110	4.88	0.00	7.82	0.33	13.70	3.4
1	N-W	105	6.77	0.00	7.82	0.39	9.90	2.9
1	N-E	102	10.99	0.00	7.82	0.83	8.90	4.3
1	N-S	100	2.38	0.00	15.32	0.09	401.00	24.5
2	All	204	1.48	0.66	56.37	0.60	195.50	8.6
2	E-W	207	8.29	1.16	55.27	2.96	37.50	7.1
2	E-S	209	3.68	0.00	12.62	0.14	58.50	7.6
2	S-E	201	18.70	0.63	28.16	14.34	6.20	4.2
2	S-W	211	1.73	0.00	0.00	0.12	5.10	2.3
2	W-S	208	2.38	0.11	47.35	0.73	138.90	13.3
2	W-S	200	2.90	0.54	68.84	0.98	441.70	19.8
3	All	305	8.25	1.58	53.19	0.77	89.70	6.6
3	N-E	310	5.48	1.58	53.19	0.29	5.20	2.0
3	N-W	312	0.00	0.27	30.55	0.01	127.70	11.7
3	E-N	304	0.23	0.27	30.55	0.00	228.00	7.8
3	E-W	308	2.01	0.00	0.00	0.18	193.40	16.2
3	W-E	303	2.55	0.00	0.00	0.17	4.20	2.1
3	W-N	300	1.83	0.62	67.06	0.18	648.20	22.8
4	All	410	7.06	4.59	118.63	0.52	64.00	6.8
4	N-W	402	0.00	15.85	144.40	0.00	0.00	0.0
4	N-S	405	34.29	15.85	144.40	25.72	88.90	7.6
4	N-E	411	0.00	3.23	103.85	0.00	179.70	13.1
4	W-S	408	32.51	17.89	147.01	26.62	103.90	11.9
4	W-E	407	2.11	6.06	107.35	1.20	247.20	12.2
4	E-S	404	6.58	6.06	107.35	3.07	291.80	12.1
4	E-W	400	9.49	9.93	166.01	6.44	975.50	18.8
5	All	512	0.00	0.83	82.79	0.00	70.50	7.0
5	E-N	504	0.20	0.83	82.79	0.00	539.00	13.4
5	E-W	508	8.15	0.52	66.10	3.83	153.90	9.9
5	W-E	503	2.36	0.02	10.78	0.18	38.40	4.8
5	W-N	500	1.74	0.55	93.84	0.74	801.80	15.6
6	All	609	11.07	5.29	151.95	1.39	210.20	14.4
6	S-E	610	6.88	4.82	76.72	0.49	133.00	11.9
6	N-W	605	38.60	6.46	71.44	32.49	34.20	5.3
6	N-E	612	6.11	11.64	124.98	3.85	34.40	6.9
6	E-N	604	21.79	25.66	149.34	17.17	250.20	5.7
6	E-W	601	10.67	5.88	102.07	4.00	226.20	12.3
6	S-W	606	12.73	12.17	175.48	4.11	385.10	19.8
6	S-N	603	8.15	7.85	118.09	4.46	26.70	6.1
6	W-N	608	6.29	7.85	118.09	2.66	126.90	9.0
6	W-E	600	13.02	9.74	182.64	6.19	1426.90	29.4
7	All	711	0.01	3.83	140.32	0.01	58.90	7.1
7	W-S	708	0.90	3.83	140.32	0.02	312.40	14.7
7	W-E	707	2.00	0.12	36.17	0.39	20.90	4.0
7	E-S	704	6.02	0.12	36.17	2.60	259.30	7.4
7	E-W	701	13.93	0.04	30.72	5.29	25.90	3.8
7	S-W	709	6.59	0.04	30.72	0.56	25.00	5.6
7	S-E	700	3.40	1.34	140.32	1.19	702.40	20.3
8	All	807	5.61	1.96	63.55	1.51	48.30	6.4
8	E-S	804	4.31	1.96	63.55	0.90	156.60	13.6
8	E-W	809	4.87	2.59	69.52	0.34	98.50	11.9
8	S-E	811	4.92	3.03	131.52	0.32	104.10	9.7
8	S-W	808	6.12	3.14	123.70	0.84	233.30	11.4
8	W-E	801	9.05	4.25	83.76	4.21	123.80	10.2
8	S-W	800	5.86	2.83	135.77	1.29	764.60	19.5
0	All	0	6.09	3.08	193.21	2.77	6513.40	121.9

Random Number 1							
Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)	
1	E-S	3.2	0	0	0.1	26	
1	E-S	1.6	0	0	0	121	
1	E-W	1.3	0	0	0	47	
1	E-N	0.1	0	0	0	93	
1	W-E	0.6	0	0	0	1	
1	W-S	2.5	0	0	1.5	7	
1	W-N	12.1	0	39.9	0.5	11	
1	S-N	4.2	0	39.9	0.2	13	
1	S-E	9.8	0	39.9	2.2	5	

Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)
1		2.7	0	0	0	35
1	E-S	2.1	0	0	0	130
1	E-W-N	1.4	0	0	0	54
1		0.1	0	0	0	107
1	W-W-S	0.5	0	0	0	8
1	W-N	0.4	0	0	0	2
1		11.3	0	0	0.6	15
1	S-N	4.6	0	0	0.2	14
1	S-E	7.7	0	0	0.2	1
1	S-W	4.6	0	0	0.2	13
1	N-W	5.8	0	0	0.2	8
1	N-E	11.5	0	0	1.6	4
1	N-S ^{All}	2.2	0	0	0.1	391
2		1.7	0.7	49.5	0.5	209
2	E-W	8.1	0.7	51.3	2.4	23
2	E-S	3.3	0	0	0.1	57
2	S-E	13.8	0.6	42.7	9.4	10
2	S-W-S	0.4	0	0	0	4
2	W-E	3	0.9	51.2	0.8	127
2		2.9	0.5	51.3	0.9	430
3	All	8.4	1.7	47.9	0.6	89
3	N-E	5.3	1.7	47.9	0.2	6
3	N-W-N	0	0	0	0	124
3		0.2	0	0	0	225
3	E-W	2	0	0	0.1	179
3	W-W-N	1.5	0	0	0	2
3		1.9	0.6	47.9	0.1	625
4	All	5.8	6.8	180	0.3	61
4	N-W	0	18	205.8	0	0
4	N-S	34.6	18	205.8	26.9	97
4	N-E	0	2	99.2	0	170
4	W-S	32.5	17.2	142.4	26.3	101
4	W-E	2.1	7.8	111.4	1.2	269
4	E-S	8.4	7.8	111.4	4.3	289
4	E-W	10.1	11.1	205.8	7	987
4	All	0	1.2	89.3	0	80
4	E-N	0.2	1.2	89.3	0	558
4	E-W	6.6	0.1	47.1	2.5	165
4	W-E	2.7	0	28.2	0.1	33
4	W-N	1.4	0.6	89.3	0.5	836
6	All	12.9	8.8	170.6	2.4	210
6	S-E	7.8	5.9	87.8	0.7	150
6	N-W	41.5	7	83.2	35.3	35
6	N-E	6.8	11.8	112.3	4.3	41
6	E-N	20.9	24.5	136.4	16.3	250
6	E-W	11.3	6.1	109.9	4.3	238
6	S-W	14.7	16.5	194.4	5	395
6	S-N	3.9	6.4	111.9	0.9	32
6	W-N	6.3	6.4	111.9	2.9	133
6	W-E	13.7	10.4	194.4	6.4	1484
7	All	0	3.8	150.9	0	51
7	W-S	0.9	3.8	150.9	0	326
7	W-E	1	0	22.1	0	23
7	E-S	6	0	22.1	2.7	265
7	E-W	13.5	0	24.1	4.9	25
7	S-W	5.9	0	24.1	0.3	19
7	S-E	3.3	1.3	150.9	1.2	709
8	All	4.7	1.9	70.4	1.2	55
8	E-S	4.4	1.9	70.4	0.8	161
8	E-W	4.9	2.8	69.4	0.3	106
8	S-E	5.5	3.9	147.8	0.3	108
8	W-S	6.5	3.7	140	0.9	238
8	W-E	9.1	4.4	68.2	4.3	126
8	S-W ^{''}	6	3.1	147.8	1.3	794
0	All	6.4	3.3	205.8	2.9	6605

Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)
1		1.3	0	0	0	21
1	E-S	1.4	0	0	0	124
1	E-W-N	1	0	0	0	60
1		0.1	0	0	0	129
1	W-W-S	0.5	0	0	0	6
1	W-N	0.4	0	0	0	3
1		12.1	0	0	0.5	20
1	S-N	4.9	0	0	0.2	19
1	S-E	5.9	0	0	0.2	5
1	S-W	4.3	0	0	0.2	10
1	N-W	7	0	0	0.2	8
1	N-E	10.5	0	0	0.2	8
1	N-S ^{All}	2	0	0	0	413
2		0.7	0.2	20	0.2	196
2	E-W	8.8	1.2	89.2	3.2	30
2	E-S	3.6	0	0	0.1	45
2	S-E	7	0.3	22	1.9	6
2	S-W-S	0.9	0	0	0	6
2	W-E	2.2	0.7	42.8	0.7	142
2		2.2	0.4	89.2	0.6	425
3	All	8	1.4	48.2	0.8	89
3	N-E	5.3	1.4	48.2	0.2	5
3	N-W-N	0	0	0	0	149
3		0.2	0	0	0	223
3	E-W	2.1	0	0	0.3	187
3	W-W-N	4.8	0	0	0.4	2
3		1.8	0.5	48.2	0.2	655
4	All	6.3	3.1	104.7	0.7	61
4	N-W	0	13.2	130.5	0	0
4	N-S	31	13.2	130.5	22.7	86
4	N-E	0	3.6	84.1	0	180
4	W-S	33.8	17.7	127.3	27.8	96
4	W-E	2.7	6.3	114.9	1.5	238
4	E-S	6.5	6.3	114.9	3.1	314
4	E-W	9.2	9.1	130.5	6.1	975
4	All	0	0.5	76.1	0	63
4	E-N	0.2	0.5	76.1	0	550
4	E-W	5.2	0	20.8	1.5	141
4	W-E	1.7	0	0	0	40
4	W-N	1.1	0.3	76.1	0.3	794
6	All	10.2	4	155.8	1	215
6	S-E	6.4	4.4	92.2	0.3	126
6	N-W	35.2	5.3	68	28.7	32
6	N-E	5.8	11.2	115.8	3.5	28
6	E-N	21.9	24.9	139.8	17.1	251
6	E-W	9.5	4.6	73.8	3	236
6	S-W	12.3	11	179.6	3.8	405
6	S-N	11.2	5.7	113.1	6.9	27
6	W-N	5.8	5.7	113.1	2.2	113
6	W-E	12.6	8.5	179.6	5.8	1433
7	All	0	4	130.7	0.1	59
7	W-S	0.8	4	130.7	0	301
7	W-E	1.8	0.5	92.4	0.1	26
7	E-S	5.8	0.5	92.4	2.4	252
7	E-W	9.6	0	25	1.8	29
7	S-W	6.2	0	25	0.4	31
7	S-E	3.2	1.5	130.7	1	698
8	All	4.7	1.6	49.7	1	51
8	E-S	3.8	1.6	49.7	1	136
8	E-W	4.2	2.3	69.2	0.2	101
8	S-E	5.4	2.7	123	0.4	107
8	W-S	6	2.6	115.2	0.9	223
8	W-E	8.6	4.6	96.7	3.9	143
8	S-W ^{''}	5.7	2.6	123	1.3	761
0	All	5.7	2.8	179.6	2.5	6516

Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)
1		1.2	0	0	0	27
1	E-S	1.8	0	0	0	113
1	E-W-N	2	0	0	0	56
1		0.2	0	0	0	117
1	W-W-S	0.4	0	0	0	4
1	W-N	2	0	0	0.5	9
1		12	0	24.2	0.7	19
1	S-N	5.3	0	24.2	0.2	27
1	S-E	5.9	0	24.2	0.2	5
1	S-W	4.6	0	0	0.2	15
1	N-W	5.3	0	0	0.2	8
1	N-E	10.2	0	0	0.3	5
1	N-S ^{All}	2.4	0	24.2	0.1	405
2		0.9	0.4	48.2	0.3	189
2	E-W	7	1	48.8	1.9	41
2	E-S	4.2	0	22.4	0.2	51
2	S-E	23.8	1	49.2	17.5	7
2	S-W-S	1.9	0	0	0.5	6
2	W-E	2.4	0.8	52.4	0.7	148
2		2.7	0.5	52.4	0.8	442
3	All	7.8	1.3	47.7	0.7	79
3	N-E	4.1	1.3	47.7	0.2	1
3	N-W-N	0	2.6	133.1	0.1	126
3		0.2	2.6	133.1	0	229
3	E-W	1.7	0	0	0	197
3	W-W-N	3.5	0	0	0	5
3		1.5	1.3	133.1	0.1	637
4	All	9.8	5.1	114.7	1.3	68
4	N-W	0	16.2	140.4	0	0
4	N-S	32.8	16.2	140.4	23.9	93
4	N-E	0	2.8	63.7	0	179
4	W-S	33	16.6	106.8	26.9	97
4	W-E	2.9	6.1	114.1	1.7	257
4	E-S	6.7	6.1	114.1	3.1	287
4	E-W	9.7	9.9	140.4	6.4	981
4	All	0	0.9	76.3	0	65
4	E-N	0.2	0.9	76.3	0	544
4	E-W	9.2	0.1	46.3	5	149
4	W-E	2.1	0	0	0	39
4	W-N	1.9	0.5	76.3	0.9	797
6	All	10.4	5.3	114.6	1.1	203
6	S-E	6.8	4.8	71.8	0.6	132
6	N-W	42.3	7.1	66.1	36.4	33
6	N-E	5.8	10.3	138.5	3.5	38
6	E-N	20.8	24.3	162.6	16.3	256
6	E-W	10.3	5.1	93.2	3.6	222
6	S-W	13.1	12.4	138.3	4.4	398
6	S-N	7.9	10.2	120.8	3.7	28
6	W-N	6.3	10.2	120.8	2.8	120
6	W-E	12.9	10	162.6	6.2	1430
7	All	0	5.2	152.1	0	65
7	W-S	0.8	5.2	152.1	0	291
7	W-E	3	0	30	1	22
7	E-S	5.5	0	30	2.2	269
7	E-W	13.5	0.1	51.2	5.5	23
7	S-W	7.2	0.1	51.2	0.4	23
7	S-E	3.2	1.8	152.1	1.1	693
8	All	6.3	2	74.8	1.5	49
8	E-S	4.3	2	74.8	0.8	172
8	E-W	4.8	2.4	70.4	0.5	88
8	S-E	4.6	2.1	107.4	0.3	80
8	W-S	5	2.7	99.6	0.8	234
8	W-E	9.8	4.5	66.6	4.7	119
8	S-W ^{''}	5.6	2.6	107.4	1.4	742
0	All	6	3.2	162.6	2.8	6480

Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)
1		3.8	0	0	0.3	32
1	E-S	1.3	0	0	0	122
1	E-W-N	1.7	0	0	0	57
1		0.1	0	0	0	128
1	W-W-S	0.5	0	0	0	5
1	W-N	2.6	0	0	0	2
1		11.4	0	0	0.5	15
1	S-N	5	0	0	0.3	24
1	S-E	9.9	0	0	1.9	10
1	S-W	5.7	0	20.7	0.5	19
1	N-W	7.3	0	20.7	0.4	9
1	N-E	9.9	0	20.7	0.3	12
1	N-S	2.5	0	20.7	0.1	435
2	All	0.8	0.2	46.5	0.1	211
2	E-W	8	1.2	50.6	2.5	36
2	E-S	3.5	0	0	0.1	55
2	S-E	0.2	0	0	0	1
2	S-W-S	1.6	0	0	0	9
2	W-E	2.7	1	46.1	0.9	153
2		2.3	0.4	50.6	0.5	465
3	All	8.9	1.3</			

				7							8							9							10						
maxQueue	tStopd(All)	Veh(All)		Node	Movement	Delay(All)	aveQueue	maxQueue	tStopd(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStopd(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStopd(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStopd(All)	Veh(All)
0	0	31		1		1.6	0	0	0	28	1		2.1	0	0	0	34	1		3.1	0	0	0	26	1		2.6	0	0	0	23
0	0	119		1	E-S	2.9	0	0	0	123	1	E-S	1.8	0	0	0	115	1	E-S	1.4	0	0	0	111	1	E-S	2.5	0	0	0	132
0	0	42		1	E-W	1.9	0	0	0	53	1	E-W	2.2	0	0	0	54	1	E-W	1.8	0	0	0	52	1	E-W	1.7	0	0	0	59
0	0	125		1	E-N	0.1	0	0	0	127	1	E-N	0.1	0	0	0	127	1	E-N	0.2	0	0	0	88	1	E-N	0.1	0	0	0	123
0	0	3		1	W-E	0.5	0	0	0	7	1	W-E	0.5	0	0	0	3	1	W-E	0.5	0	0	0	5	1	W-E	0.5	0	0	0	5
0	0	7		1	W-S	1.9	0	0	0.4	8	1	W-S	0.4	0	0	0	5	1	W-S	0.6	0	0	0	5	1	W-S	1.7	0	0	0	9
0	0.2	6		1	W-N	10.6	0	0	0.4	9	1	W-N	10.4	0	0	0.7	11	1	W-N	12.2	0	40.6	0.8	21	1	W-N	10.1	0	13.6	0.2	12
0	0.2	20		1	S-N	4.8	0	0	0.2	23	1	S-N	4.9	0	0	0.2	14	1	S-N	5.4	0	40.6	0.2	19	1	S-N	4.9	0	13.6	0.2	16
0	0.4	8		1	S-E	9.5	0	0	1.7	8	1	S-E	7.5	0	0	0.2	3	1	S-E	6.5	0	40.6	0.2	9	1	S-E	7	0	13.6	0.2	8
14.2	0.2	19		1	S-W	4.7	0	0	0.5	15	1	S-W	4.7	0	0	0.3	9	1	S-W	4.8	0	28.1	0.4	12	1	S-W	5.6	0	0	0.6	13
14.2	0.2	13		1	N-W	6.6	0	0	0.3	14	1	N-W	8.1	0	0	1.5	8	1	N-W	7.8	0	28.1	0.3	11	1	N-W	5.8	0	0	0.2	6
14.2	1.2	15		1	N-E	9.9	0	0	0.2	16	1	N-E	9.6	0	0	0.2	5	1	N-E	11.1	0	28.1	0.6	10	1	N-E	11.3	0	0	0.7	5
14.2	0.1	408		1	N-S	2.6	0	0	0.1	431	1	N-S	2	0	0	0.1	388	1	N-S	2.8	0	40.6	0.1	369	1	N-S	2.3	0	13.6	0	411
68.4	0.2	187		2	All	2.8	1.4	88.7	1.3	193	2	All	3.1	1.7	104.9	1.9	198	2	All	0.9	0.3	47	0.2	185	2	All	2.2	1	68.7	1	195
49.1	3.3	37		2	E-W	6.7	0.9	48.8	1.6	43	2	E-W	8.8	1.6	50.4	3.4	48	2	E-W	7.9	1	50	2.9	37	2	E-W	11	1.6	50.3	6	37
22.4	0.1	70		2	E-S	3.8	0	19.6	0.1	69	2	E-S	3.6	0	22.3	0.2	61	2	E-S	3.8	0	21.2	0.2	61	2	E-S	3.8	0	0	0.2	56
19.9	16.6	4		2	S-E	16	0.3	22.4	10.8	5	2	S-E	30.7	0.7	40.9	26.5	5	2	S-E	25.8	0.5	22.3	20.8	4	2	S-E	30.6	2.3	39.5	25.5	16
0	0.1	4		2	S-W	1	0	0	0	5	2	S-W	0.4	0	0	0	8	2	S-W	1.8	0	0	0.1	3	2	S-W	3	0	0	0.3	5
22.7	0.4	154		2	W-E	2.1	0.8	48.3	0.6	154	2	W-E	2.2	0.6	72.5	0.5	137	2	W-E	1.8	0.5	43	0.6	121	2	W-E	3	1.1	46	1.2	132
68.4	0.7	456		2	All	3.2	0.6	88.7	1	469	2	All	3.8	0.8	104.9	1.6	457	2	All	2.5	0.4	50	0.7	411	2	All	4.4	1	68.7	2.2	441
43.8	0.5	84		3	All	9.1	1.9	46.9	1.2	99	3	All	8.6	1.8	48.5	0.9	96	3	All	8.8	2.2	106.8	0.7	98	3	All	7.8	1.5	48.6	0.7	92
43.8	0.7	9		3	N-E	7	1.9	46.9	0.2	4	3	N-E	6.3	1.8	48.5	0.3	6	3	N-E	4.8	2.2	106.8	0.2	5	3	N-E	5.2	1.5	48.6	0.2	6
0	0	125		3	N-W	0	0	0	0	122	3	N-W	0	0	0	0	141	3	N-W	0	0	0	0	113	3	N-W	0	0	25.6	0	140
0	0	217		3	E-N	0.2	0	0	0	232	3	E-N	0.3	0	0	0	238	3	E-N	0.2	0	0	0	218	3	E-N	0.3	0	25.6	0	227
0	0	222		3	E-W	2.1	0	0	0.3	215	3	E-W	2.5	0	0	0.4	193	3	E-W	1.9	0	0	0.2	175	3	E-W	1.9	0	0	0.2	183
0	0.2	4		3	W-E	1.7	0	0	0	9	3	W-E	0.2	0	0	0	2	3	W-E	1.6	0	0	0	5	3	W-E	3.1	0	0	0	5
43.8	0.1	661		3	W-N	2.1	0.6	46.9	0.3	681	3	W-N	2	0.6	48.5	0.2	676	3	W-N	2	0.7	106.8	0.2	614	3	W-N	1.7	0.5	48.6	0.2	653
118.1	0.7	58		4	All	6.8	5.2	153	0.3	69	4	All	7.7	3.8	115.2	0.6	77	4	All	6.2	4.5	87.5	0.2	55	4	All	5.4	4.7	129.2	0.2	57
143.9	0	0		4	N-W	0	17.5	178.7	0	0	4	N-W	0	14	141	0	0	4	N-W	0	17.2	113.2	0	0	4	N-W	0	16	155	0	0
143.9	26.9	84		4	N-S	33.4	17.5	178.7	25.7	101	4	N-S	33.2	14	141	24.4	77	4	N-S	34.3	17.2	113.2	25.9	92	4	N-S	34.6	16	155	26.2	91
61.6	0	199		4	N-E	0	4.8	158.7	0	201	4	N-E	0	5.5	159.7	0	168	4	N-E	0	1.7	86.1	0	188	4	N-E	0	3.3	61.3	0	181
104.7	27.5	106		4	W-S	33.6	20.8	201.9	27.7	116	4	W-S	32.5	22.4	202.9	26.7	124	4	W-S	30.1	12.8	129.3	24.5	86	4	W-S	36.8	18.4	104.4	30.6	93
104	1.5	242		4	W-E	2	5.7	89.6	1	237	4	W-E	2.4	6.6	115.3	1.3	237	4	W-E	1.9	5.3	112.2	1.1	264	4	W-E	1.6	6.3	96	1	247
104	2.3	282		4	E-S	6.9	5.7	89.6	3.4	286	4	E-S	7	6.6	115.3	3.7	302	4	E-S	6.3	5.3	112.2	2.8	276	4	E-S	6.1	6.3	96	2.7	307
143.9	6.4	971		4	E-W	10	11	201.9	7	1010	4	E-W	10	10.4	202.9	6.8	985	4	E-W	8.6	9.1	129.3	5.8	961	4	E-W	9.3	10.1	155	6.5	976
76	0	74		5	All	0	0.9	101.6	0	62	5	All	0	0.6	76.8	0	80	5	All	0	1.2	76.7	0	70	5	All	0	0.8	76.8	0	68
76	0	525		5	E-N	0.2	0.9	101.6	0	522	5	E-N	0.2	0.6	76.8	0	540	5	E-N	0.2	1.2	76.7	0	540	5	E-N	0.2	0.8	76.8	0	552
34	4.1	145		5	E-W	8.2	1.4	148.4	3.8	167	5	E-W	8.7	0.2	79	3.4	166	5	E-W	8.7	0.2	39.3	4.6	142	5	E-W	8.2	0.8	57.2	4.2	150
22.5	0	45		5	W-E	1.9	0	0	0	48	5	W-E	2.7	0	0	0	35	5	W-E	1.8	0	0	0.1	36	5	W-E	2.3	0	0	0.3	34
76	0.8	789		5	W-N	1.9	0.8	148.4	0.8	799	5	W-N	1.9	0.4	79	0.7	821	5	W-N	1.7	0.6	76.7	0.8	788	5	W-N	1.7	0.6	76.8	0.8	804
112.1	1.7	206		6	All	11.9	5.5	247.9	1.1	218	6	All	11.4	6.4	156.3	1.9	203	6	All	10.2	4.2	134.2	1.3	200	6	All	10.3	4.6	196.6	1.4	201
70.4	0.5	138		6	S-E	6.7	4.1	70.5	0.5	110	6	S-E	6.6	4.6	70.5	0.4	131	6	S-E	7.3	5.6	71.1	0.6	151	6	S-E	6.7	4.6	71.6	0.5	135
86.3	32.1	41		6	N-W	37.5	5.2	66.1	31.8	29	6	N-W	41.4	9	83.9	35.4	45	6	N-W	34.1	6.3	65.7	27.9	36	6	N-W	35.6	5.4	65.4	29.4	32
149.5	3.1	38		6	N-E	4.6	13.8	140	3.3	33	6	N-E	6.6	10.6	111.8	4.2	33	6	N-E	9.4	12	134.8	6.6	25	6	N-E	5.3	12	111.7	3.3	48
173.5	16.6	240		6	E-N	23.4	28.5	164	18.6	252	6	E-N	21.4	24.9	139	16.8	247	6	E-N	22.2	26.5	158.9	17.6	249	6	E-N	22.1	26.2	135.8	17.5	246
121.2	4.4	220		6	E-W	9.2	5.3	99.5	3.5	222	6	E-W	11.5	7.1	93.2	4.9	242	6	E-W	9.6	5.8	96.8	3.7	210	6	E-W	12.7	8.6	143.9	5	239
133.3	3.7	409		6	S-W	12.6	12.4	271.7	4.1	385	6	S-W	13.4	13.2	180.1	4.6	362	6	S-W	12	11.3	158	3.8	358	6	S-W	12.8	11.4	220.4	4.1	398
113.9	3.3	25		6	S-N	4.3	9	138.5	1.5	20	6	S-N	8.1	9.2	113.6	4.7	39	6	S-N	16	8.2	113.3	11.3	19	6	S-N	10	6.4	135.5	5.6	20
113.9	2.4	120		6	W-N	7.3	9	138.5	3.5	146	6	W-N	7.8	9.2	113.6	4	127	6	W-N	5.6	8.2	113.3	2.1	123	6	W-N	5	6.4	135.5	1.4	130
173.5	6	1437		6	W-E	13.1	10.3	271.7	6.3	1415	6	W-E	13.7	10.5	180.1	6.9	1429	6	W-E	12.7	9.8	158.9	6.2	1371	6	W-E	13	9.5	220.4	6.1	1449
130.7	0	63		7	All	0.1	4.9	152.2	0	58	7	All	0	2.9	126.2	0	64	7	All	0	4.7	152	0	56	7	All	0	3.1	124.6	0	55
130.7	0	304		7	W-S	0.9	4.9	152.2	0	336	7	W-S	0.9	2.9	126.2	0	311	7	W-S	1.2											

3					4					5					6					7												
aveQueue	maxQueue	tStopt(All)	Veh(All)	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStopt(All)	Veh(All)	Node	Movement	Delay(All)						
0	0	0	35	1		1.3	0	0	21	1		1.2	0	0	0	27	1		3.8	0	0	0.3	32	1		3.7	0	0	31	1		1.6
0	0	0	130	1 E-SE-W	1.4	0	0	0	124	1 E-SE-W	1.8	0	0	0	113	1 E-SE-W	1.3	0	0	0	122	1 E-SE-W	2	0	0	0	119	1 E-SE-W	2.9			
0	0	0	54 Node	1 E-N	1	0	0	0	60 Node	1 E-N	2	0	0	0	56	1 E-N	1.7	0	0	0	57	1 E-N	2.3	0	0	0	42	1 E-N	1.9			
0	0	0	107	1 W-EV-S	0.1	0	0	0	129	1 W-EV-S	0.2	0	0	0	117	1 W-EV-S	0.1	0	0	0	128	1 W-EV-S	0.2	0	0	0	125	1 W-EV-S	0.1			
0	0	0	8	1 W-N	0.5	0	0	0	6	1 W-N	0.4	0	0	0	4	1 W-N	0.5	0	0	0	5	1 W-N	0.5	0	0	0	3	1 W-N	0.5			
0	0	0	2	1 S-N	0.4	0	0	0	3	1 S-N	2	0	0	0.5	9	1 S-N	2.6	0	0	0	2	1 S-N	0.4	0	0	0	7	1 S-N	1.9			
0	0	0.6	15	1 S-E	12.1	0	0	0.5	20	1 S-E	12	0	24.2	0.7	19	1 S-E	11.4	0	0	0.5	15	1 S-E	10.6	0	0	0.2	6	1 S-E	10.6			
0	0	0.2	14	1 S-W	4.9	0	0	0.2	19	1 S-W	5.3	0	24.2	0.2	27	1 S-W	5	0	0	0.3	24	1 S-W	4.2	0	0	0.2	20	1 S-W	4.8			
0	0	0.2	1	1 N-W	5.9	0	0	0.2	5	1 N-W	5.9	0	24.2	0.2	5	1 N-W	9.9	0	0	1.9	10	1 N-W	6.9	0	0	0.4	8	1 N-W	9.5			
0	0	0.2	13	1 N-E	4.3	0	0	0.2	10	1 N-E	4.6	0	0	0.2	15	1 N-E	5.7	0	20.7	0.5	19	1 N-E	4.6	0	14.2	0.2	19	1 N-E	4.7			
0	0	0.2	8	1 N-S	7	0	0	0.2	8	1 N-S	5.3	0	0	0.2	8	1 N-S	7.3	0	20.7	0.4	9	1 N-S	7.7	0	14.2	0.2	13	1 N-S	6.6			
0	0	1.6	4	1 All	10.5	0	0	0.2	8	1 All	10.2	0	0	0.3	5	1 All	9.9	0	20.7	0.3	12	1 All	11.3	0	14.2	1.2	15	1 All	9.9			
0	0	0.1	391	2 E-W	2	0	0	0	413	2 E-W	2.4	0	24.2	0.1	405	2 E-W	2.5	0	20.7	0.1	435	2 E-W	2.5	0	14.2	0.1	408	2 E-W	2.6			
0.7	49.5	0.5	209	2 E-S	0.7	0.2	20	0.2	196	2 E-S	0.9	0.4	48.2	0.3	189	2 E-S	0.8	0.2	46.5	0.1	211	2 E-S	0.8	0.3	68.4	0.2	187	2 E-S	2.8			
0.7	51.3	2.4	23	2 E-S	8.8	1.2	89.2	3.2	30	2 E-S	7	1	48.8	1.9	41	2 E-S	8	1.2	50.6	2.5	36	2 E-S	8.8	1.2	49.1	3.3	37	2 E-S	6.7			
0	0	0.1	57	2 S-E	3.6	0	0	0.1	45	2 S-E	4.2	0	22.4	0.2	51	2 S-E	3.5	0	0	0.1	55	2 S-E	3.7	0	22.4	0.1	70	2 S-E	3.8			
0.6	42.7	9.4	10	2 S-W-S	7	0.3	22	1.9	6	2 S-E	23.8	1	49.2	17.5	7	2 S-E	0.2	0	0	0	1	2 S-E	19.3	0.3	19.9	16.6	4	2 S-E	16			
0	0	0	4	2 W-E	0.9	0	0	0	6	2 S-W-S	1.9	0	0	0.5	6	2 S-W-S	1.6	0	0	0	9	2 S-W-S	1.8	0	0	0.1	4	2 S-W-S	1			
0.9	51.2	0.8	127	3 All	2.2	0.7	42.8	0.7	142	2 W-E	2.4	0.8	52.4	0.7	148	2 W-E	2.7	1	46.1	0.9	153	2 W-E	1.6	0.5	22.7	0.4	154	2 W-E	2.1			
0.5	51.3	0.9	430	3 N-E	2.2	0.4	89.2	0.6	425	3 All	2.7	0.5	52.4	0.8	442	3 All	2.3	0.4	50.6	0.5	465	3 All	2.3	0.4	68.4	0.7	456	3 All	3.2			
1.7	47.9	0.6	89	3 N-W	8	1.4	48.2	0.8	89	3 N-E	7.8	1.3	47.7	0.7	79	3 N-E	8.9	1.3	46.8	1.2	83	3 N-E	7.8	1.4	43.8	0.5	84	3 N-E	9.1			
1.7	47.9	0.2	6	3 N-W-N	5.3	1.4	48.2	0.2	5	3 N-W	4.1	1.3	47.7	0.2	1	3 N-W	5.9	1.3	46.8	0.5	6	3 N-W	5	1.4	43.8	0.7	9	3 N-W	7			
0	0	0	124	3 E-W	0	0	0	0	149	3 N-W-N	0	2.6	133.1	0.1	126	3 N-W-N	0	0	80.7	0	118	3 N-W-N	0	0	0	0	125	3 N-W-N	0			
0	0	0	225	3 W-EV-N	0.2	0	0	0	223	3 E-W	0.2	2.6	133.1	0	229	3 E-W	0.2	0	80.7	0	241	3 E-W	0.2	0	0	0	217	3 E-W	0.2			
0	0	0.1	179	4 All	2.1	0	0	0.3	187	3 W-EV-N	1.7	0	0	0	197	3 W-EV-N	2.3	0	0	0.3	205	3 W-EV-N	1.8	0	0	0	222	3 W-EV-N	2.1			
0	0	0	2	4 N-W	4.8	0	0	0.4	2	4 All	3.5	0	0	0	5	4 All	3.2	0	0	1.1	5	4 All	3.3	0	0	0.2	4	4 All	1.7			
0.6	47.9	0.1	625	4 N-S	3	1.8	0.5	48.2	655	4 N-W	1.5	1.3	133.1	0.1	637	4 N-W	1.9	0.4	80.7	0.3	658	4 N-W	1.7	0.5	43.8	0.1	661	4 N-W	2.1			
6.8	180	0.3	61	4 N-S	6.3	3.1	104.7	0.7	61	4 N-S	9.8	5.1	114.7	1.3	68	4 N-S	8	4.5	93.6	0.5	68	4 N-S	7.7	3.7	118.1	0.7	58	4 N-S	6.8			
18	205.8	0	0	4 W-S	0	13.2	130.5	0	0	4 N-S	0	16.2	140.4	0	0	4 N-S	0	15.2	119.4	0	0	4 N-S	0	15.1	143.9	0	0	4 N-S	0			
18	205.8	26.9	97	4 W-E	31	13.2	130.5	22.7	86	4 W-S	32.8	16.2	140.4	23.9	93	4 W-S	39.2	15.2	119.4	29.4	79	4 W-S	35.8	15.1	143.9	26.9	84	4 W-S	33.4			
2	99.2	0	170	4 W-E	0	3.6	84.1	0	180	4 N-E	0	2.8	63.7	0	179	4 N-E	0	4	159.9	0	169	4 N-E	0	2.6	61.6	0	199	4 N-E	0			
17.2	142.4	26.3	101	4 W-E	4 W-S	33.8	17.7	127.3	27.8	96	4 W-S	33	16.6	106.8	26.9	97	4 W-S	28.7	18.3	203	23.2	117	4 W-S	33.4	18.5	104.7	27.5	106	4 W-S	33.6		
7.8	111.4	1.2	269	4 E-S	4 W-E	2.7	6.3	114.9	1.5	238	4 W-E	2.9	6.1	114.1	1.7	257	4 W-E	1.4	4.8	69.4	0.7	247	4 W-E	2.3	5.4	104	1.5	242	4 W-E	2		
7.8	111.4	4.3	289	4 E-S	4 E-S	6.5	6.3	114.9	3.1	314	4 E-S	6.7	6.1	114.1	3.1	287	4 E-S	5.7	4.8	69.4	2.7	292	4 E-S	5.5	5.4	104	2.3	282	4 E-S	6.9		
11.1	205.8	7	987	4 E-W	4 E-W	9.2	9.1	130.5	6.1	975	4 E-W	9.7	9.9	140.4	6.4	981	4 E-W	9.2	9.5	203	6.2	972	4 E-W	9.3	9.4	143.9	6.4	971	4 E-W	10		
1.2	89.3	0	80	5 All	0	0.5	76.1	0	63	5 All	0	0.9	76.3	0	65	5 All	0	0.6	76.9	0	65	5 All	0	0.9	76	0	74	5 All	0			
1.2	89.3	0	558	5 E-N	0.2	0.5	76.1	0	550	5 E-N	0.2	0.9	76.3	0	544	5 E-N	0.2	0.6	76.9	0	541	5 E-N	0.2	0.9	76	0	525	5 E-N	0.2			
0.1	47.1	2.5	165	5 E-W	5.2	0	20.8	1.5	141	5 E-W	9.2	0.1	46.3	5	149	5 E-W	12.4	2.3	138.4	7.1	158	5 E-W	8.2	0	34	4.1	145	5 E-W	8.2			
0	28.2	0.1	33	5 W-E	1.7	0	0	0	40	5 W-E	2.1	0	0	0	39	5 W-E	3.4	0.1	30.6	0.8	38	5 W-E	2.6	0	22.5	0	45	5 W-E	1.9			
0.6	89.3	0.5	836	5 W-N	1.1	0.3	76.1	0.3	794	5 W-N	1.9	0.5	76.3	0.9	797	5 W-N	2.7	0.9	138.4	1.4	802	5 W-N	1.7	0.4	76	0.8	789	5 W-N	1.9			
8.8	170.6	2.4	210	6 All	10.2	4	155.8	1	215	6 All	10.4	5.3	114.6	1.1	203	6 All	11.3	3.8	113.7	0.9	199	6 All	11.6	5.3	112.1	1.7	206	6 All	11.9			
5.9	87.8	0.7	150	6 S-E	6.4	4.4	92.2	0.3	126	6 S-E	6.8	4.8	71.8	0.6	132	6 S-E	7	4.8	90.3	0.4	129	6 S-E	6.8	4.9	70.4	0.5	138	6 S-E	6.7			
7	83.2	35.3	35	6 N-W	35.2	5.3	68	28.7	32	6 N-W	42.3	7.1	66.1	36.4	33	6 N-W	40.1	5.6	65.1	34	29	6 N-W	38.4	7.8	86.3	32.1	41	6 N-W	37.5			
11.8	112.3	4.3	41	6 N-E	5.8	11.2	115.8	3.5	28	6 N-E	5.8	10.3	138.5	3.5	38	6 N-E	6.2	12.4	111.7	3.8	29	6 N-E	5	11	149.5	3.1	38	6 N-E	4.6			
24.5	136.4	16.3	250	6 E-N	21.9	24.9	139.8	17.1	251	6 E-N	20.8	24.3	162.6	16.3	256	6 E-N	23.2	26.9	135.7	18.6	250	6 E-N	21.1	24.6	173.5	16.6	240	6 E-N	23.4			
6.1	109.9	4.3	238	6 E-W	9.5	4.6	73.8	3	236	6 E-W	10.3	5.1	93.2	3.6	222	6 E-W	9	3.9	91.4	2.4	226	6 E-W	12	6.1	121.2	4.4	220	6 E-W	9.2			
16.5	194.4	5	395	6 S-W	12.3	11	179.6	3.8	405	6 S-W	13.1	12.4	138.3	4.4	398	6 S-W	12.1	10.1	137.5	3.7	385	6 S-W	12.7	12.7	133.3	3.7	409	6 S-W	12.6			
6.4	111.9	0.9	32	6 S-N	11.2	5.7	113.1	6.9	27	6 S-N	7.9	10.2	120.8	3.7	28	6 S-N	6	11.6	113.5	2.8	28	6 S-N	6.6	7.2	113.9	3.3	25	6 S-N	4.3			
6.4	111.9	2.9	133	6 W-W-E	5.8	5.7	113.1	2.2	113	6 W-W-E	6.3	10.2	120.8	2.8	120	6 W-W-E	7.4	11.6	113.5	3.4	130	6 W-W-E	6	7.2	113.9	2.4	120	6 W-W-E	7.3			
10.4	194.4	6.4	1484	7 All	12.6	8.5	179.6	5.8	143																							

8					9					10							
aveQueue	maxQueue	tStoptd(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStoptd(All)	Veh(All)	Node	Movement	Delay(All)	aveQueue	maxQueue	tStoptd(All)	Veh(All)
0	0	0	28	1		2.1	0	0	0	34	1		2.6	0	0	0	23
0	0	0	123	1	E-S	1.8	0	0	0	115	1	E-S	2.5	0	0	0	132
0	0	0	53	1	E-W	2.2	0	0	0	54	1	E-W	1.7	0	0	0	59
0	0	0	127	1	E-N	0.1	0	0	0	127	1	E-N	0.1	0	0	0	123
0	0	0	7	1	W-E-S	0.5	0	0	0	3	1	W-E-S	0.5	0	0	0	5
0	0	0.4	8	1	W-N	0.4	0	0	0	5	1	W-N	1.7	0	0	0	9
0	0	0.4	9	1		10.4	0	0	0.7	11	1		10.1	0	13.6	0.2	12
0	0	0.2	23	1	S-N	4.9	0	0	0.2	14	1	S-N	4.9	0	13.6	0.2	16
0	0	1.7	8	1	S-E	7.5	0	0	0.2	3	1	S-E	7	0	13.6	0.2	8
0	0	0.5	15	1	S-W	4.7	0	0	0.3	9	1	S-W	5.6	0	0	0.6	13
0	0	0.3	14	1	N-W	8.1	0	0	1.5	8	1	N-W	5.8	0	0	0.2	6
0	0	0.2	16	1	N-E	9.6	0	0	0.2	5	1	N-E	11.3	0	0	0.7	5
0	0	0.1	431	1	N-S	2	0	0	0.1	388	1	N-S	2.3	0	13.6	0	411
1.4	88.7	1.3	193	2	All	3.1	1.7	104.9	1.9	198	2	All	2.2	1	68.7	1	195
0.9	48.8	1.6	43	2	E-W	8.8	1.6	50.4	3.4	48	2	E-W	11	1.6	50.3	6	37
0	19.6	0.1	69	2	E-S	3.6	0	22.3	0.2	61	2	E-S	3.8	0	0	0.2	56
0.3	22.4	10.8	5	2	S-E	30.7	0.7	40.9	26.5	5	2	S-E	30.6	2.3	39.5	25.5	16
0	0	0	5	2	S-W-S	0.4	0	0	0	8	2	S-W-S	3	0	0	0.3	5
0.8	48.3	0.6	154	2		2.2	0.6	72.5	0.5	137	2		3	1.1	46	1.2	132
0.6	88.7	1	469	2	W-E	3.8	0.8	104.9	1.6	457	2	W-E	4.4	1	68.7	2.2	441
1.9	46.9	1.2	99	3	All	8.6	1.8	48.5	0.9	96	3	All	7.8	1.5	48.6	0.7	92
1.9	46.9	0.2	4	3	N-E	6.3	1.8	48.5	0.3	6	3	N-E	5.2	1.5	48.6	0.2	6
0	0	0	122	3	N-W-N	0	0	0	0	141	3	N-W-N	0	0	25.6	0	140
0	0	0	232	3		0.3	0	0	0	238	3		0.3	0	25.6	0	227
0	0	0.3	215	3	E-W	2.5	0	0	0.4	193	3	E-W	1.9	0	0	0.2	183
0	0	0	9	3	W-E-N	0.2	0	0	0	2	3	W-E-N	3.1	0	0	0	5
0.6	46.9	0.3	681	3		2	0.6	48.5	0.2	676	3		1.7	0.5	48.6	0.2	653
5.2	153	0.3	69	4	All	7.7	3.8	115.2	0.6	77	4	All	5.4	4.7	129.2	0.2	57
17.5	178.7	0	0	4	N-W	0	14	141	0	0	4	N-W	0	16	155	0	0
17.5	178.7	25.7	101	4	N-S	33.2	14	141	24.4	77	4	N-S	34.6	16	155	26.2	91
4.8	158.7	0	201	4	N-E	0	5.5	159.7	0	168	4	N-E	0	3.3	61.3	0	181
20.8	201.9	27.7	116	4	W-S	32.5	22.4	202.9	26.7	124	4	W-S	36.8	18.4	104.4	30.6	93
5.7	89.6	1	237	4	W-E	2.4	6.6	115.3	1.3	237	4	W-E	1.6	6.3	96	1	247
5.7	89.6	3.4	286	4	E-S	7	6.6	115.3	3.7	302	4	E-S	6.1	6.3	96	2.7	307
11	201.9	7	1010	4	E-W	10	10.4	202.9	6.8	985	4	E-W	9.3	10.1	155	6.5	976
0.9	101.6	0	62	5	All	0	0.6	76.8	0	80	5	All	0	0.8	76.8	0	68
0.9	101.6	0	522	5	E-N	0.2	0.6	76.8	0	540	5	E-N	0.2	0.8	76.8	0	552
1.4	148.4	3.8	167	5	E-W	8.7	0.2	79	3.4	166	5	E-W	8.2	0.8	57.2	4.2	150
0	0	0	48	5	W-E	2.7	0	0	0	35	5	W-E	2.3	0	0	0.3	34
0.8	148.4	0.8	799	5	W-N	1.9	0.4	79	0.7	821	5	W-N	1.7	0.6	76.8	0.8	804
5.5	247.9	1.1	218	6	All	11.4	6.4	156.3	1.9	203	6	All	10.3	4.6	196.6	1.4	201
4.1	70.5	0.5	110	6	S-E	6.6	4.6	70.5	0.4	131	6	S-E	6.7	4.6	71.6	0.5	135
5.2	66.1	31.8	29	6	N-W	41.4	9	83.9	35.4	45	6	N-W	34.1	6.3	65.7	27.9	36
13.8	140	3.3	33	6	N-E	6.6	10.6	111.8	4.2	33	6	N-E	5.3	12	111.7	3.3	48
28.5	164	18.6	252	6	E-N	21.4	24.9	139	16.8	247	6	E-N	22.1	26.2	135.8	17.5	246
5.3	99.5	3.5	222	6	E-W	11.5	7.1	93.2	4.9	242	6	E-W	12.7	8.6	143.9	5	239
12.4	271.7	4.1	385	6	S-W	13.4	13.2	180.1	4.6	362	6	S-W	12.8	11.4	220.4	4.1	398
9	138.5	1.5	20	6	S-N	8.1	9.2	113.6	4.7	39	6	S-N	10	6.4	135.5	5.6	20
9	138.5	3.5	146	6	W-W-E	7.8	9.2	113.6	4	127	6	W-W-E	5	6.4	135.5	1.4	130
10.3	271.7	6.3	1415	6		13.7	10.5	180.1	6.9	1429	6		13	9.5	220.4	6.1	1449
4.9	152.2	0	58	7	All	0	2.9	126.2	0	64	7	All	0	3.1	124.6	0	55
4.9	152.2	0	336	7	W-S	0.9	2.9	126.2	0	311	7	W-S	0.9	3.1	124.6	0	308
0.2	42.5	0.2	24	7	W-E	2.1	0	0	0.3	15	7	W-E	2.7	0	21.5	0.7	22
0.2	42.5	3.2	259	7	E-S	5.7	0	0	2.4	265	7	E-S	6.5	0	21.5	2.9	267
0	25.7	4.3	28	7	E-W	16.7	0	30.4	7.5	17	7	E-W	14.5	0	0	6.1	29
0	25.7	0.7	26	7	S-W	7	0	30.4	0.6	28	7	S-W	6.6	0	0	0.7	15
1.7	152.2	1.3	731	7	S-E	3.2	1	126.2	1.1	700	7	S-E	3.7	1	124.6	1.4	696
2.1	66.9	2.5	45	8	All	6	2.1	65	1.8	49	8	All	5.5	2.2	65.1	1.2	43
2.1	66.9	0.8	144	8	E-S	4.1	2.1	65	0.8	170	8	E-S	4.4	2.2	65.1	1	172
2.7	69.3	0.4	93	8	E-W	4.7	2.6	69.6	0.3	101	8	E-W	5.1	2.5	70.8	0.3	94
3.9	178.2	0.5	109	8	S-E	5.3	3.2	155.4	0.6	109	8	S-E	4	3	149.8	0.1	107
3.5	170.4	0.7	251	8	W-S	6.7	3.7	147.6	1	228	8	W-S	5.4	2.8	141.9	0.8	221
5.4	110.8	5.1	136	8	W-E	8.6	3.6	64.8	3.7	112	8	W-E	7.9	3.4	68.3	3.4	118
3.3	178.2	1.5	778	8	S-W	5.9	2.9	155.4	1.2	769	8	S-W	5.3	2.7	149.8	1.1	755
3.4	271.7	2.9	6678	0	All	6.3	3.2	202.9	3	6579	0	All	6.1	3.1	220.4	2.9	6546

Project Name: 12th Street Redevelopment
 Model: PM Peak Hour - Calibrated
 Date: 10/15/2010
 Company: DKS Associates
 Document: Calibrated Base Model Results

Run 1

Location	Data Collection Point	VISSIM Vehicles Output	Input Demand	Difference (Output vs. Input)	GEH Value	STD Dev	Heavy Vehicle (HV)	HV%
12th St WB Entry	1	1007	1050	-43	1.3	10.6	20	2.0%
12th St WB Exit	2	1007	1025	-18	0.6	10.6	20	2.0%
12th St EB Exit	3	1007	975	32	1.0	10.6	20	2.0%
12th St EB Entry	4	1007	1000	7	0.2	10.6	20	2.0%
A St NB Entry	5	249	250	-1	0.1	4.6	5	2.0%
A St NB Exit	6	249	225	24	1.6	4.6	5	2.0%
A St SB Exit	7	249	200	49	3.3	4.6	5	2.0%
A St Entry	8	249	275	-26	1.6	4.6	5	2.0%
B St NB Entry	9	249			1.6	4.6	5	2.0%
B St NB Exit	10	249			0.1	4.6	5	2.0%
B St SB Exit	11	249			0.1	4.6	5	2.0%
B St Entry	12	249	225	24	1.6	4.6	5	2.0%
C St NB Entry	13	249	200	49	3.3	4.6	5	2.0%
C St NB Exit	14	249	275	-26	1.6	4.6	5	2.0%
D St SB Exit	15	249	275	-26	1.6	4.6	5	2.0%
D St Entry	16	249	250	-1	0.1	4.6	5	2.0%
E St NB Entry	17	249	250	-1	0.1	4.6	5	2.0%
E St NB Exit	18	249	225	24	1.6	4.6	5	2.0%
E St SB Exit	19	249	200	49	3.3	4.6	5	2.0%
E St Entry	20	249	275	-26	1.6	4.6	5	2.0%
F St NB Entry	21	249	275	-26	1.6	4.6	5	2.0%
F St NB Exit	22	249	250	-1	0.1	4.6	5	2.0%
G St SB Exit	23	249	250	-1	0.1	4.6	5	2.0%
G St Entry	24	249	225	24	1.6	4.6	5	2.0%
H St NB Entry	25	249	200	49	3.3	4.6	5	2.0%
H St NB Exit	26	249	275	-26	1.6	4.6	5	2.0%
H St SB Exit	27	249	275	-26	1.6	4.6	5	2.0%
H St Entry	28	249	250	-1	0.1	4.6	5	2.0%
Total Network		10004	9950	54	0.5	110.7	180	1.8%

Measur.	from	to	all veh. types		HGV
1	900	4500	1000	20	
2	900	4500	1000	20	
3	900	4500	1000	20	
4	900	4500	1000	20	
5	900	4500	250	5	
6	900	4500	250	5	
7	900	4500	250	5	
	900	4500	250	5	
	900	4500	250	5	
	900	4500	250	5	
	900	4500	250	5	
12	900	4500	250	5	
13	900	4500	250	5	
14	900	4500	250	5	
15	900	4500	250	5	
16	900	4500	250	5	
17	900	4500	250	5	
18	900	4500	250	5	
19	900	4500	250	5	
20	900	4500	250	5	
21	900	4500	250	5	
22	900	4500	250	5	
23	900	4500	250	5	
24	900	4500	250	5	
25	900	4500	250	5	
26	900	4500	250	5	
27	900	4500	250	5	
28	900	4500	250	5	
Total			10000		

Calculated from the output over all the simulation runs

2

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1025	21
2	900	4500	1025	21
3	900	4500	1025	21
4	900	4500	1025	21
5	900	4500	245	5
6	900	4500	245	5
7	900	4500	245	5
8	900	4500	245	5
9	900	4500	245	5
10	900	4500	245	5
11	900	4500	245	5
12	900	4500	245	5
13	900	4500	245	5
14	900	4500	245	5
15	900	4500	245	5
16	900	4500	245	5
17	900	4500	245	5
18	900	4500	245	5
19	900	4500	245	5
20	900	4500	245	5
21	900	4500	245	5
22	900	4500	245	5
23	900	4500	245	5
24	900	4500	245	5
25	900	4500	245	5
26	900	4500	245	5
27	900	4500	245	5
28	900	4500	245	5
			9980	

3

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1010	20
2	900	4500	1010	20
3	900	4500	1010	20
4	900	4500	1010	20
5	900	4500	255	5
6	900	4500	255	5
7	900	4500	255	5
8	900	4500	255	5
9	900	4500	255	5
10	900	4500	255	5
11	900	4500	255	5
12	900	4500	255	5
13	900	4500	255	5
14	900	4500	255	5
15	900	4500	255	5
16	900	4500	255	5
17	900	4500	255	5
18	900	4500	255	5
19	900	4500	255	5
20	900	4500	255	5
21	900	4500	255	5
22	900	4500	255	5
23	900	4500	255	5
24	900	4500	255	5
25	900	4500	255	5
26	900	4500	255	5
27	900	4500	255	5
28	900	4500	255	5
			10160	

4

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	995	20
2	900	4500	995	20
3	900	4500	995	20
4	900	4500	995	20
5	900	4500	250	5
6	900	4500	250	5
7	900	4500	250	5
8	900	4500	250	5
9	900	4500	250	5
10	900	4500	250	5
11	900	4500	250	5
12	900	4500	250	5
13	900	4500	250	5
14	900	4500	250	5
15	900	4500	250	5
16	900	4500	250	5
17	900	4500	250	5
18	900	4500	250	5
19	900	4500	250	5
20	900	4500	250	5
21	900	4500	250	5
22	900	4500	250	5
23	900	4500	250	5
24	900	4500	250	5
25	900	4500	250	5
26	900	4500	250	5
27	900	4500	250	5
28	900	4500	250	5
			9980	

5

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1000	20
2	900	4500	1000	20
3	900	4500	1000	20
4	900	4500	1000	20
5	900	4500	240	5
6	900	4500	240	5
7	900	4500	240	5
8	900	4500	240	5
9	900	4500	240	5
10	900	4500	240	5
11	900	4500	240	5
12	900	4500	240	5
13	900	4500	240	5
14	900	4500	240	5
15	900	4500	240	5
16	900	4500	240	5
17	900	4500	240	5
18	900	4500	240	5
19	900	4500	240	5
20	900	4500	240	5
21	900	4500	240	5
22	900	4500	240	5
23	900	4500	240	5
24	900	4500	240	5
25	900	4500	240	5
26	900	4500	240	5
27	900	4500	240	5
28	900	4500	240	5
			9760	

6

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1010	20
2	900	4500	1010	20
3	900	4500	1010	20
4	900	4500	1010	20
5	900	4500	255	5
6	900	4500	255	5
7	900	4500	255	5
8	900	4500	255	5
9	900	4500	255	5
10	900	4500	255	5
11	900	4500	255	5
12	900	4500	255	5
13	900	4500	255	5
14	900	4500	255	5
15	900	4500	255	5
16	900	4500	255	5
17	900	4500	255	5
18	900	4500	255	5
19	900	4500	255	5
20	900	4500	255	5
21	900	4500	255	5
22	900	4500	255	5
23	900	4500	255	5
24	900	4500	255	5
25	900	4500	255	5
26	900	4500	255	5
27	900	4500	255	5
28	900	4500	255	5
			10160	

7

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1000	20
2	900	4500	1000	20
3	900	4500	1000	20
4	900	4500	1000	20
5	900	4500	250	5
6	900	4500	250	5
7	900	4500	250	5
8	900	4500	250	5
9	900	4500	250	5
10	900	4500	250	5
11	900	4500	250	5
12	900	4500	250	5
13	900	4500	250	5
14	900	4500	250	5
15	900	4500	250	5
16	900	4500	250	5
17	900	4500	250	5
18	900	4500	250	5
19	900	4500	250	5
20	900	4500	250	5
21	900	4500	250	5
22	900	4500	250	5
23	900	4500	250	5
24	900	4500	250	5
25	900	4500	250	5
26	900	4500	250	5
27	900	4500	250	5
28	900	4500	250	5
			10000	

8

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1000	20
2	900	4500	1000	20
3	900	4500	1000	20
4	900	4500	1000	20
5	900	4500	250	5
6	900	4500	250	5
7	900	4500	250	5
8	900	4500	250	5
9	900	4500	250	5
10	900	4500	250	5
11	900	4500	250	5
12	900	4500	250	5
13	900	4500	250	5
14	900	4500	250	5
15	900	4500	250	5
16	900	4500	250	5
17	900	4500	250	5
18	900	4500	250	5
19	900	4500	250	5
20	900	4500	250	5
21	900	4500	250	5
22	900	4500	250	5
23	900	4500	250	5
24	900	4500	250	5
25	900	4500	250	5
26	900	4500	250	5
27	900	4500	250	5
28	900	4500	250	5
			10000	

9

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1025	21
2	900	4500	1025	21
3	900	4500	1025	21
4	900	4500	1025	21
5	900	4500	245	5
6	900	4500	245	5
7	900	4500	245	5
8	900	4500	245	5
9	900	4500	245	5
10	900	4500	245	5
11	900	4500	245	5
12	900	4500	245	5
13	900	4500	245	5
14	900	4500	245	5
15	900	4500	245	5
16	900	4500	245	5
17	900	4500	245	5
18	900	4500	245	5
19	900	4500	245	5
20	900	4500	245	5
21	900	4500	245	5
22	900	4500	245	5
23	900	4500	245	5
24	900	4500	245	5
25	900	4500	245	5
26	900	4500	245	5
27	900	4500	245	5
28	900	4500	245	5
			9980	

10

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1005	20
2	900	4500	1005	20
3	900	4500	1005	20
4	900	4500	1005	20
5	900	4500	250	5
6	900	4500	250	5
7	900	4500	250	5
8	900	4500	250	5
9	900	4500	250	5
10	900	4500	250	5
11	900	4500	250	5
12	900	4500	250	5
13	900	4500	250	5
14	900	4500	250	5
15	900	4500	250	5
16	900	4500	250	5
17	900	4500	250	5
18	900	4500	250	5
19	900	4500	250	5
20	900	4500	250	5
21	900	4500	250	5
22	900	4500	250	5
23	900	4500	250	5
24	900	4500	250	5
25	900	4500	250	5
26	900	4500	250	5
27	900	4500	250	5
28	900	4500	250	5
			10020	

Project Name: 12th Street Redevelopment
 Model: PM Peak Hour - 2035
 Date: 10/15/2010
 Company: DKS Associates
 Document: Future 2035 Analysis Results

Location	Data Collection Point	VISSIM Vehicles Output	Input Demand	Difference (Output vs. Input)	STD Dev	Heavy Vehicle (HV)	HV%
12th St WB Entry	1	1007	1050	-43	10.6	20	2.0%
12th St WB Exit	2	1007	1025	-18	10.6	20	2.0%
12th St EB Exit	3	1007	975	32	10.6	20	2.0%
12th St EB Entry	4	1007	1000	7	10.6	20	2.0%
A St NB Entry	5	249	250	-1	4.6	5	2.0%
A St NB Exit	6	249	225	24	4.6	5	2.0%
A St SB Exit	7	249	200	49	4.6	5	2.0%
A St Entry	8	249	275	-26	4.6	5	2.0%
B St NB Entry	9	249	275	-26	4.6	5	2.0%
B St NB Exit	10	249	250	-1	4.6	5	2.0%
B St SB Exit	11	249	250	-1	4.6	5	2.0%
B St Entry	12	249	225	24	4.6	5	2.0%
C St NB Entry	13	249	200	49	4.6	5	2.0%
C St NB Exit	14	249	275	-26	4.6	5	2.0%
D St SB Exit	15	249	275	-26	4.6	5	2.0%
D St Entry	16	249	250	-1	4.6	5	2.0%
E St NB Entry	17	249	250	-1	4.6	5	2.0%
E St NB Exit	18	249	225	24	4.6	5	2.0%
E St SB Exit	19	249	200	49	4.6	5	2.0%
E St Entry	20	249	275	-26	4.6	5	2.0%
F St NB Entry	21	249	275	-26	4.6	5	2.0%
F St NB Exit	22	249	250	-1	4.6	5	2.0%
G St SB Exit	23	249	250	-1	4.6	5	2.0%
G St Entry	24	249	225	24	4.6	5	2.0%
H St NB Entry	25	249	200	49	4.6	5	2.0%
H St NB Exit	26	249	275	-26	4.6	5	2.0%
H St SB Exit	27	249	275	-26	4.6	5	2.0%
H St Entry	28	249	250	-1	4.6	5	2.0%
Total Network		10004	9950	54	110.7	180	1.8%

Run 1

Measur.	from	to	all veh. types	HGV		
1	900	4500	1000	20		
2	900	4500	1000	20		
3	900	4500	1000	20		
4	900	4500	1000	20		
5	900	4500	250	5		
6	900	4500	250	5		
7	900	4500	250	5		
Calculated from the output over all the simulation runs			900	4500	250	5
			900	4500	250	5
			900	4500	250	5
12	900	4500	250	5		
13	900	4500	250	5		
14	900	4500	250	5		
15	900	4500	250	5		
16	900	4500	250	5		
17	900	4500	250	5		
18	900	4500	250	5		
19	900	4500	250	5		
20	900	4500	250	5		
21	900	4500	250	5		
22	900	4500	250	5		
23	900	4500	250	5		
24	900	4500	250	5		
25	900	4500	250	5		
26	900	4500	250	5		
27	900	4500	250	5		
28	900	4500	250	5		
Total			10000			

2

Measur.	from	to	all veh. types	HGV
1	900	4500	1025	21
2	900	4500	1025	21
3	900	4500	1025	21
4	900	4500	1025	21
5	900	4500	245	5
6	900	4500	245	5
7	900	4500	245	5
8	900	4500	245	5
9	900	4500	245	5
10	900	4500	245	5
11	900	4500	245	5
12	900	4500	245	5
13	900	4500	245	5
14	900	4500	245	5
15	900	4500	245	5
16	900	4500	245	5
17	900	4500	245	5
18	900	4500	245	5
19	900	4500	245	5
20	900	4500	245	5
21	900	4500	245	5
22	900	4500	245	5
23	900	4500	245	5
24	900	4500	245	5
25	900	4500	245	5
26	900	4500	245	5
27	900	4500	245	5
28	900	4500	245	5
			9980	

3

Measur.	from	to	all veh. types	HGV
1	900	4500	1010	20
2	900	4500	1010	20
3	900	4500	1010	20
4	900	4500	1010	20
5	900	4500	255	5
6	900	4500	255	5
7	900	4500	255	5
8	900	4500	255	5
9	900	4500	255	5
10	900	4500	255	5
11	900	4500	255	5
12	900	4500	255	5
13	900	4500	255	5
14	900	4500	255	5
15	900	4500	255	5
16	900	4500	255	5
17	900	4500	255	5
18	900	4500	255	5
19	900	4500	255	5
20	900	4500	255	5
21	900	4500	255	5
22	900	4500	255	5
23	900	4500	255	5
24	900	4500	255	5
25	900	4500	255	5
26	900	4500	255	5
27	900	4500	255	5
28	900	4500	255	5
			10160	

4

Measur.	from	to	all veh. types	HGV
1	900	4500	995	20
2	900	4500	995	20
3	900	4500	995	20
4	900	4500	995	20
5	900	4500	250	5
6	900	4500	250	5
7	900	4500	250	5
8	900	4500	250	5
9	900	4500	250	5
10	900	4500	250	5
11	900	4500	250	5
12	900	4500	250	5
13	900	4500	250	5
14	900	4500	250	5
15	900	4500	250	5
16	900	4500	250	5
17	900	4500	250	5
18	900	4500	250	5
19	900	4500	250	5
20	900	4500	250	5
21	900	4500	250	5
22	900	4500	250	5
23	900	4500	250	5
24	900	4500	250	5
25	900	4500	250	5
26	900	4500	250	5
27	900	4500	250	5
28	900	4500	250	5
			9980	

5

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1000	20
2	900	4500	1000	20
3	900	4500	1000	20
4	900	4500	1000	20
5	900	4500	240	5
6	900	4500	240	5
7	900	4500	240	5
8	900	4500	240	5
9	900	4500	240	5
10	900	4500	240	5
11	900	4500	240	5
12	900	4500	240	5
13	900	4500	240	5
14	900	4500	240	5
15	900	4500	240	5
16	900	4500	240	5
17	900	4500	240	5
18	900	4500	240	5
19	900	4500	240	5
20	900	4500	240	5
21	900	4500	240	5
22	900	4500	240	5
23	900	4500	240	5
24	900	4500	240	5
25	900	4500	240	5
26	900	4500	240	5
27	900	4500	240	5
28	900	4500	240	5
			9760	

6

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1010	20
2	900	4500	1010	20
3	900	4500	1010	20
4	900	4500	1010	20
5	900	4500	255	5
6	900	4500	255	5
7	900	4500	255	5
8	900	4500	255	5
9	900	4500	255	5
10	900	4500	255	5
11	900	4500	255	5
12	900	4500	255	5
13	900	4500	255	5
14	900	4500	255	5
15	900	4500	255	5
16	900	4500	255	5
17	900	4500	255	5
18	900	4500	255	5
19	900	4500	255	5
20	900	4500	255	5
21	900	4500	255	5
22	900	4500	255	5
23	900	4500	255	5
24	900	4500	255	5
25	900	4500	255	5
26	900	4500	255	5
27	900	4500	255	5
28	900	4500	255	5
			10160	

7

Measur.	from	to	all veh.	
			types	HGV
1	900	4500	1000	20
2	900	4500	1000	20
3	900	4500	1000	20
4	900	4500	1000	20
5	900	4500	250	5
6	900	4500	250	5
7	900	4500	250	5
8	900	4500	250	5
9	900	4500	250	5
10	900	4500	250	5
11	900	4500	250	5
12	900	4500	250	5
13	900	4500	250	5
14	900	4500	250	5
15	900	4500	250	5
16	900	4500	250	5
17	900	4500	250	5
18	900	4500	250	5
19	900	4500	250	5
20	900	4500	250	5
21	900	4500	250	5
22	900	4500	250	5
23	900	4500	250	5
24	900	4500	250	5
25	900	4500	250	5
26	900	4500	250	5
27	900	4500	250	5
28	900	4500	250	5
			10000	

8

Measur.	from	to	all veh.		HGV
			types		
1	900	4500	1000		20
2	900	4500	1000		20
3	900	4500	1000		20
4	900	4500	1000		20
5	900	4500	250		5
6	900	4500	250		5
7	900	4500	250		5
8	900	4500	250		5
9	900	4500	250		5
10	900	4500	250		5
11	900	4500	250		5
12	900	4500	250		5
13	900	4500	250		5
14	900	4500	250		5
15	900	4500	250		5
16	900	4500	250		5
17	900	4500	250		5
18	900	4500	250		5
19	900	4500	250		5
20	900	4500	250		5
21	900	4500	250		5
22	900	4500	250		5
23	900	4500	250		5
24	900	4500	250		5
25	900	4500	250		5
26	900	4500	250		5
27	900	4500	250		5
28	900	4500	250		5
			10000		

9

Measur.	from	to	all veh.		HGV
			types		
1	900	4500	1025		21
2	900	4500	1025		21
3	900	4500	1025		21
4	900	4500	1025		21
5	900	4500	245		5
6	900	4500	245		5
7	900	4500	245		5
8	900	4500	245		5
9	900	4500	245		5
10	900	4500	245		5
11	900	4500	245		5
12	900	4500	245		5
13	900	4500	245		5
14	900	4500	245		5
15	900	4500	245		5
16	900	4500	245		5
17	900	4500	245		5
18	900	4500	245		5
19	900	4500	245		5
20	900	4500	245		5
21	900	4500	245		5
22	900	4500	245		5
23	900	4500	245		5
24	900	4500	245		5
25	900	4500	245		5
26	900	4500	245		5
27	900	4500	245		5
28	900	4500	245		5
			9980		

10

Measur.	from	to	all veh.		HGV
			types		
1	900	4500	1005		20
2	900	4500	1005		20
3	900	4500	1005		20
4	900	4500	1005		20
5	900	4500	250		5
6	900	4500	250		5
7	900	4500	250		5
8	900	4500	250		5
9	900	4500	250		5
10	900	4500	250		5
11	900	4500	250		5
12	900	4500	250		5
13	900	4500	250		5
14	900	4500	250		5
15	900	4500	250		5
16	900	4500	250		5
17	900	4500	250		5
18	900	4500	250		5
19	900	4500	250		5
20	900	4500	250		5
21	900	4500	250		5
22	900	4500	250		5
23	900	4500	250		5
24	900	4500	250		5
25	900	4500	250		5
26	900	4500	250		5
27	900	4500	250		5
28	900	4500	250		5
			10020		