

# 15 TRAFFIC SIMULATION MODELS



*This is the original APM v1 Chapter 7 text. An update is in progress.*

## 15.1 Purpose

Traffic simulation models are complex tools that can provide valuable information on the performance and potential improvement of transportation systems. Traffic simulation models are in a constant state of improvement and accordingly this chapter attempts to be adaptive with the changes in the industry. This chapter currently presents instruction on calibration of microsimulation models created in Trafficware's SimTraffic and a brief overview of the other simulation models and parameters used in ODOT projects. Topics covered include:

- Traffic Simulation Modeling – General Calibration Instructions
- SimTraffic – Overview and Calibration Instructions
- VISSIM – Overview
- Paramics - Overview
- CORSIM – Overview

## 15.2 Traffic Simulation Modeling – General Calibration Instructions

Traffic simulation models are computer programs that simulate traffic movements over a user-defined transportation network and present the results via animation and reports. The degree of user control over the simulation and the types of facilities that can be modeled will vary depending on the program being used. These should not be confused with urban travel demand models (Chapter 6), which use current and projected land use and transportation network data to estimate current and future travel demand and traffic patterns.

Traffic simulation models (meso or microscopic) are complex tools that generally require more labor than programs that perform capacity analysis at a macro level. Because of this, they are generally only used when the use of other types of analysis tools will not be adequate for a given project. Simulation models offer a greater degree of flexibility than most programs designed specifically for capacity analysis and can be used for a wide range of analysis needs such as examining the interactions between different modes of transportation, modeling the operations of HOV lanes or bus priority systems, and evaluating operations through measures of effectiveness not offered by most other types of analysis programs. Simulation models are also very useful for presentations, especially for those given to audiences lacking technical knowledge of traffic analysis, because it provides a visual basis for evaluating operations that most people can easily relate to and understand.

Simulation models are commonly used by ODOT to analyze corridors or networks under congested conditions, where upstream or downstream operations have a significant influence on

actual intersection operations (e.g., intersection blockage from queue spillback). It should be noted that simulation models use different methodologies for estimating queue lengths than other procedures described in this manual. These methodologies are typically based on observations of queues experienced during simulation, which are influenced by parameters such as driver characteristics, lane changing behavior and various traffic flow interactions. Capturing the impact of up and downstream operations on vehicle queues can make these models very effective at estimating queue lengths but underscores the importance of good model calibration. General guidelines for the application of simulation models have been published by the Federal Highway Administration, which can be found at the FHWA website under traffic analysis tools.

Depending on the specific program used, there may be numerous parameters that can be manipulated by the user to create a system that most accurately represents the one being analyzed. Before any simulation model is used to represent existing or future conditions, the existing conditions model created must be calibrated by adjusting operational parameters until the model provides a reasonable representation of existing conditions measured in the field. Existing conditions need to be replicated; otherwise future conditions will not be correct. Existing conditions should include only data, operations and measures known to currently exist in the project study area. Vehicle counts should be kept as close as possible to the original volumes obtained from the field. If all counts are available from the same day, vehicle counts used during calibration should be un-factored and unbalanced counts (this day should be as close to the 30<sup>th</sup> highest hour as possible). If counts cannot all be collected on the same day (or year), every effort should be made to collect counts at primary locations on a day that is on or closely represents, the 30<sup>th</sup> highest hour. The remaining counts can then be factored and balanced to this primary count day. If all counts occur on scattered days and none of the counts occur on the 30<sup>th</sup> highest hour or on a representative day, then short sample count should be conducted to factor the off-peak counts to the day the study area was visited. Use the seasonal factor methodology described in Chapter 5 to determine if the count is close enough to the 30<sup>th</sup> highest hour. If the primary counts for the study area occurred during a time that is less than 90% of the 30<sup>th</sup> highest hour for that area seasonal trend type, then a re-visit with a sample count is required for the calibration of the “existing” model.

These rules are established to help ensure that calibration volumes 1) are near the 30<sup>th</sup> highest hour and 2) represent conditions that have been witnessed in the field. The emphasis is placed on witnessed, as the analyst needs to visit the study area on or near the count day (30<sup>th</sup> highest hour) so that the visual check of the simulation (the first step in calibration) is based on conditions that occurred in the field during the count. The [Field Inventory Worksheet](#) shows all the measures from the field that should be input into the simulation and visually checked in the animation to help analysts in the data collection process. Note that the worksheet is intended to be printed multiple times for a given project area. The collection of worksheets can be placed in a three-ring binder providing a hard writing surface. Each copy of the worksheet can be used for each intersection or area of interest in the study and all copies can be neatly organized in a single project binder (see Chapter 3).

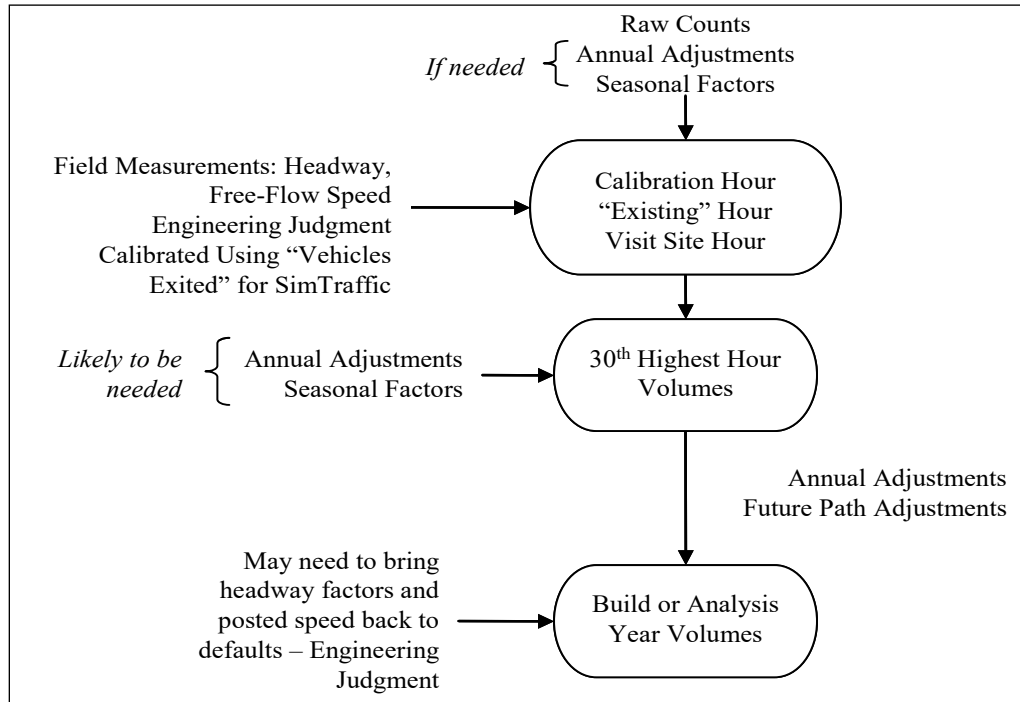
The site visit should occur as close as possible to the 30<sup>th</sup> highest hour. After the site visit a calibration scenario can be constructed. For calibration, the peak hour volumes from the counts should be seasonally adjusted to the time of the site visit. The calibration network should include all measurements taken and all operational behavior witnessed. Many of the behavioral issues

should be collected on the worksheet provided above. For Synchro and SimTraffic inputs refer to Chapters 12 and 13. Some of these sections refer specifically to Synchro/SimTraffic, but the list provided should include most of the measures that would have to be checked or adjusted in any software platform. Note that most microsimulations go into greater detail than SimTraffic, so there will likely be more measures to check and adjust. Also note that illegal behavior such as speeding, improperly using medians or shoulders as turn bays and improper lane changing distances should be accounted for in during calibration but should not be continued to be assumed in the future build scenarios. All non-calibration alternative analysis should assume that all drivers follow the rules of the road.

Once the “existing” inputs and behavior is coded into the simulation software, the analyst should run an animation to visually check the reasonability of the microsimulation. Any gross error like queues or blockages being much greater or much less than the field observations should be addressed by re-checking inputs. Further refinement may include measuring and adjusting saturation flow rates, driver reaction time and travel speed. A good place to start is by comparing simulated vehicle queues to those visually observed in the field. For some corridors, comparing simulated travel times or average speeds to actual observed conditions may be appropriate.

Good calibration is not only critical for accurate analysis but will establish credibility during presentations with technical advisory committees or public groups that have prior knowledge of existing problem areas. Exhibit 15-1 illustrates how the calibration process fits into the complete analysis. The calibration, existing and site visit hour refer to the same hour. In other words, the “calibration” data is collected in the study area in the “site visit” hour to represent “existing” conditions. For further information on calibration in general, consult the FHWA Analysis Toolbox. Section 15.3 has the detailed procedures on calibrating a SimTraffic model using SimTraffic for ODOT projects.

## Exhibit 15-1 Simulation Construction and Application Flow Chart



### 15.3 SimTraffic

#### 15.3.1 Overview

SimTraffic performs microsimulation and animation of vehicle traffic, modeling travel through signalized and unsignalized intersections and arterial networks, as well as freeway sections, with cars, trucks, pedestrians, and buses. SimTraffic includes the vehicle and driver performance characteristics developed by the Federal Highway Administration for use in traffic modeling. They were developed for CORSIM and Trafficware used them as they were published. Most of the input is entered through the Synchro program, but some parameters, such as the driver and vehicle characteristics, are modified through SimTraffic specifically.

SimTraffic can be used for all ODOT plans, projects and traffic impact studies. SimTraffic is primarily used by ODOT for the analysis of signal systems and vehicle queue estimation, especially in congested areas and locations where queue spillback may be a problem. For the estimation of signalized vehicle queues, SimTraffic is generally preferred in Regions 2 through 5 where v/c ratios exceed 0.70 and in Region 1 where v/c ratios exceed 0.90, but should always be used where v/c ratios exceed 0.90. SimTraffic should typically be used for the analysis of all coordinated signal systems. For isolated intersections, Synchro and SimTraffic should provide similar results. SimTraffic results will differ from Synchro most when the v/c ratio exceeds 0.90, when there are closely spaced intersections and other conditions that are not ideal. Overcapacity queues and metering conditions are identified in Synchro's Timing Window with a "#" or "m" symbol.

### 15.3.2 Simulation Calibration

As much as possible, operational field data should be obtained for the major facilities in the study area as close as possible to the design hour (see Appendix H). Beyond the field data listed in Chapter 3, additional field measures may be needed to achieve calibration of the microsimulation. If needed, saturation flow studies should be performed at the major intersections. Floating car travel time runs may need to be performed to ensure that observed and simulated travel times (and related speeds) are close. Free-flow link speeds using road-tube counters or speed guns (RADAR, LIDAR, etc.) may need to be collected and used in place of posted speed limits during calibration.

At the very least, the existing conditions network needs to be visually calibrated to the field conditions and the “vehicles exited” measure from SimTraffic should be reviewed. If everything is close, then the SimTraffic simulation should duplicate conditions seen in the field. Congested and free-flow areas in the field should be congested and free-flowing in the simulation.

If there is more congestion in the simulation than in the field, then one or more parameters may be off. For example, saturation flows and resulting headway factors may be too low, counts may be balanced too high, peak hour factors may be too low, link and turning speeds may be low, storage bays and taper lengths may be too short and intersection paths and lane change distances may be incorrect. If congestion is too low, then the reverse of these may be a cause.

To help determine the cause of inconsistencies with known conditions, any number of measures of effectiveness (MOE) may be reviewed, however as a minimum measure, “vehicles exited” needs to be checked to ensure that the model is calibrated.

“Vehicles Exited” represents the number of vehicles that make it through an intersection over a given period. This should equal the volume coded in the network for the “existing hour”. The calibration target for each intersection in the network is a tolerance of 1% over the analysis period based on the difference between the simulation and the input field-counted exiting (existing) hour volumes. However, at a minimum, the tolerances for any movement over 100 vph should be within 5% of the coded volume. Movements with less than 100 vph should be checked to make sure that the vehicles exiting is reasonable. These limits are required to achieve calibration for the calibration volume set (not required for the 30<sup>th</sup> highest hour or build year network). Exhibit 15-2 shows an excerpt from the Performance report showing the Vehicle Exited rates and calibration percentages. Note that all movements over 100 vph are under the 5% maximum tolerance and the entire intersection is under the 1% intersection tolerance.

## Exhibit 15-2 Example Vehicles Exited from Performance Report

1001: Route 20 & Spring Hill Drive Performance by movement Entire Run							
Movement	EBL	EBT	WBT	WBR	SBL	SBR	All
Total Stops	38	353	704	25	298	14	1432
Avg Speed (mph)	12	26	16	23	9	14	19
Vehicles Entered	39	1161	1198	476	317	19	3210
Vehicles Exited	39	1164	1200	476	320	19	3218
Hourly Exit Rate	39	1164	1200	476	320	19	3218
Input Volume	38	1169	1187	489	311	17	3211
% of Volume	103	100	101	97	103	112	100

Although calibration (fine-tuning) may take some time, it is necessary because if the existing conditions is not duplicating observed conditions, then the future conditions or build alternative performance will not be predicted very well. This is critical if any animated output is to be shown at public meetings. In achieving accurate calibration it is important that the SimTraffic parameter file is setup properly.

### 15.3.3 Simulation Preparation

In addition to setting up the SimTraffic parameter file, there are several Synchro settings that must be updated for simulations to work properly in SimTraffic. More signal timing detail must be added in the Phasing Window. These phasing details, settings and defaults are shown in Chapters 12 and 13. Project data needs to be entered into the Simulation Settings Window and the Detector Window. The Detector Window is covered under the Synchro sections in Chapter 13 because detector data is necessary if actuated signal functions are to be used in Synchro. The important Simulation Settings Window and the SimTraffic parameter data are included in Section 15.3.3 and 15.3.4, respectively. Earlier versions of SimTraffic only need to create the SimTraffic parameter file.

### 15.3.4 Simulation Settings Window

The following data is only used by SimTraffic and needs to be included for a proper simulation. This data allows for geometric refinement and operational behavior of the simulation. The data required by SimTraffic should be a part of the field collection/observation process and is included the [Field Inventory Worksheet](#).

- Storage Length (ft)** – The Storage Length is the length of a turning bay from the stop bar to the beginning of the taper. Storage Length is the area that can store vehicles and does not include tapers. If the Left or Right Turn lane goes all the way back to the previous intersection, enter "0". Storage Length data is used for analyzing potential blocking problems. Storage length is typically field measured or estimated from aerial photographs. If measurements are unknown or if the facility is new, the initial storage lengths of 100' for urban and 150' for rural can be used. SimTraffic outputs will be used to refine these lengths for build alternatives.
- Taper Length (ft)** – The Taper Length is the remaining length of the turning bay from the end of the storage length to where the outer edge of the turning bay meets the outer

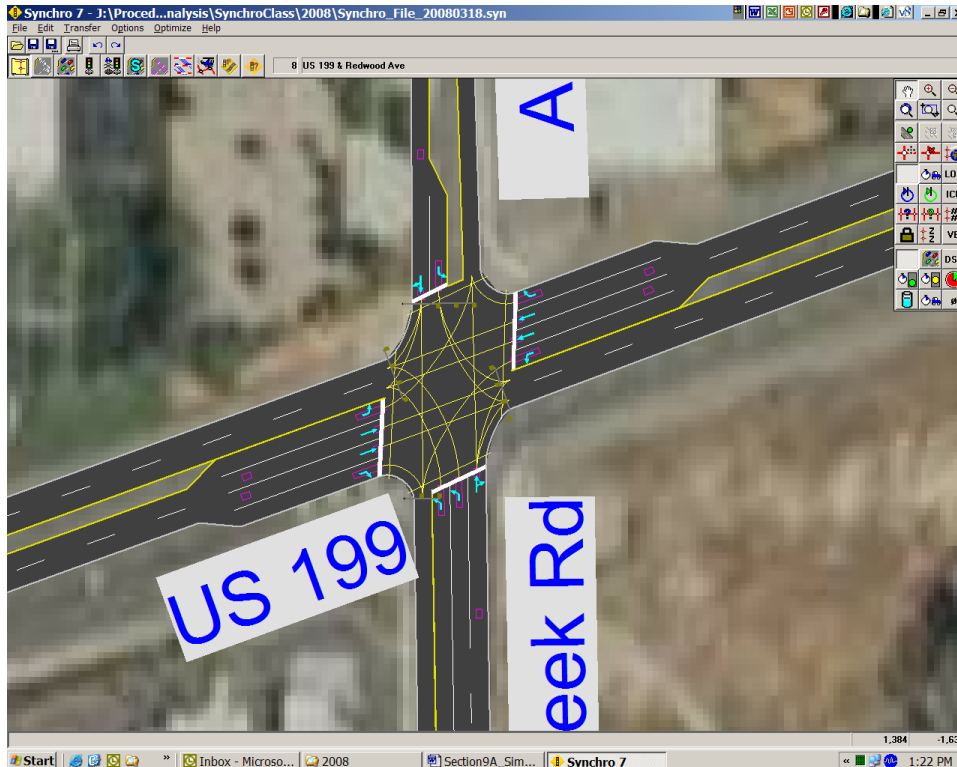
edge of the adjacent lane. This value is field-measured or estimated from aerial photographs. For state highways, the taper lengths can be obtained from the Highway Design Manual Figures 8-8 for right turn lanes and 8-9 for left turn lanes. This allows turning bays to store several more vehicles and allows a truer and a more consistent (with design) representation.

- **Lane Alignment** – The Lane alignment controls the vehicle paths in SimTraffic. When links are constructed, Synchro shows either a “Left” or “Right” alignment as default. This may not be correct especially if multilane approaches, skewed intersections, short links, free-flow ramp connections and merge/diverge/weaving sections make up a particular intersection.

Other choices are “L-NA” and “R-NA” which will force the vehicle path either left or right. To check the lane alignment, the Intersection Paths box must be checked under the Map Settings window. The default color or zoom level will likely need to be changed to clearly see the paths.

Exhibit 15-3 shows that Synchro defaults to single-lane turn lanes turning into a multilane leg with paths going to either departing lane. Unless lines are marked on the pavement guiding vehicles into different lanes Oregon vehicular code states that vehicles need to turn into the nearest lane. In most of these cases the Lane Alignment needs to be changed to “L-NA” or “R-NA” depending on the turn type.

## Exhibit 15-3 Default Lane Alignment



For the existing calibrated network, the legal setting may not need to be followed if the majority of field-observed vehicles turn into both lanes (although itself an improper lane choice). Design alternatives should always be coded legally.

Note that the northbound dual left turn lane shown in Exhibit 15-3 has the correct paths. The southbound left still needs to be changed to limit traffic to the inside through lane. In cases of acceleration lanes, merging traffic should be forced right using “R-NA” and through traffic forced left using “L-NA.” This will keep through vehicles out of the acceleration lane.

- **Enter Blocked Intersection** – This setting controls whether mainline or side-street traffic can enter a blocked intersection. In earlier versions of SimTraffic, vehicles did not block intersections. Default is “No” for intersections and “Yes” for bend nodes and ramp junctions. This factor is best obtained through field observation.

Along many busy roadways, minor intersections and driveways are frequently blocked by through traffic, so in this case the setting should be “Yes” for the through traffic. If “Do Not Block Intersection” signs exist, then the setting should remain “No” unless the signs are generally ignored. If there are intersections or accesses that are frequently blocked and through vehicles let side street vehicles out, then the side street movements can be set to “1 veh” which will allow one vehicle to enter. Use of the “2 veh” setting tends to cause the simulation to clog up.



- **Link Offset (ft)** – The Link Offset is used to set the roadway left or right of the natural centerline. This is typically used in creating “dogleg” or offset intersections without creating a second node.
- **Crosswalk Width (ft)** - this is the width of the crosswalk on an approach. This setting controls the placement of the stop bar which controls detector placement and link length. ODOT default crosswalk width is 12 feet (outside edge to outside edge) unless the adjoining sidewalk is wider. Local intersections should be measured.
- **Headway Factor** - The saturation flow rate in SimTraffic for intersection approaches is adjusted through the Headway Factor. The saturated flow rate calculated in Synchro is not used in SimTraffic; however, the corresponding headway factor is automatically calculated. In simulation calibration, the headway factor can be adjusted to help fine-tune (calibrate) the SimTraffic simulation. Exhibit 15-4 shows the equivalent headway factor for a given saturated flow rate. Earlier versions of Synchro/SimTraffic need to have the headway factor manually calculated in the Lane Window.

#### Exhibit 15-4 Headway Factors

Headway Factor	Saturated Flow Rate
1.2	1650 vphpl
1.1	1750 vphpl
1.0	1850 vphpl
0.9	2050 vphpl
0.8	2250 vphpl

- **Turning Speed (mph)** – This is the turning speed used by SimTraffic by movement. Higher speeds will increase the capacity of the SimTraffic simulation. Synchro default is 15 mph for left turns and 9 mph for right turns. The 9 mph right turn speed is too slow unless used for turning onto residential local streets or in a downtown central business district location.

ODOT default is 15 mph for left and right turns. Non-standard turns at skewed intersections, channelized turns and interchanges should have different values and can be estimated by recording speeds while driving through the subject intersections or using a speed gun to capture turning vehicle speeds. Turning speeds are also needed for merge/diverge sections at interchanges or bend nodes.

- **Lane Change Distances** - Changes to these calculated values can help calibrate the vehicle lane-changing operation. Changes may be necessary if vehicles are having difficulty completing lane changes ahead of intersections or off-ramps or if vehicles are artificially clogging up at lane drops after an intersection or a two-lane ramp merging into a single lane. High heavy vehicle percentages combined with a higher number of long vehicles and/or a congested network increases the chances that modifications will be required. Closely spaced intersections will have short lane change distances while interchanges will have longer lane change distances as many drivers move into the desired lane considerably ahead of an off-ramp. The analyst will need to experiment with these values, either longer or shorter until the traffic is flowing consistent to the observed conditions or flowing smoothly for future conditions. Modifying ramp geometry so that

the ramps enter the mainline as turns rather than as a straight-through movement makes for smoother operation and less need to modify these distances.

There are two different types of lane change distances: mandatory and positioning. The Mandatory Distance is the distance measured from the stop bar at which a lane change must occur. The Positioning distance is the distance measured back from the Mandatory Distance where a vehicle first attempts a lane change. The Mandatory and Position Distance 2's are extra distance added if a second lane change is necessary. All these distances can extend around corners. Adding to the challenge of changing these variables, is that the driver types in SimTraffic have a range of a 50% (aggressive) to a 200% (passive) multiplier to the set distances.

### 15.3.5 SimTraffic Parameter File

The SimTraffic parameter file controls the simulation operation and the defaults must be changed to reflect the proper impacts of queuing, travel time, etc. The parameter file has three major sections: Vehicles, Drivers and Intervals. The TPAU Analysis Tools webpage has a default SimTraffic template file with all the basic parameters set up. The following shows the variables that need to be changed. All other settings are left unchanged.

The Vehicles tab controls the type and physical vehicle characteristics.

- **Vehicle Occurrence (%)** - SimTraffic uses the Synchro heavy vehicle percentage to simulate the total number of heavy vehicles relative to all vehicles. When the simulation calls for a heavy vehicle, the vehicle type is represented by this factor which represents the percentage breakout of the global truck fleet. Likewise, when a car is called for, this factor will split the car types among the global car fleet percentages.
  - Earlier versions of SimTraffic defaulted to having the total vehicle percentages sum up to 100%.
  - SimTraffic 7 defaults total up to 100% for the car fleet and 100% for the truck (includes buses) fleet as shown in Exhibit 15-5.
  - Change the Vehicle Occurrence (%) for the different vehicle classes to match the composite average of your classification counts. If classification counts are unavailable, state highway vehicle classification segment data (available at [https://highway.odot.state.or.us/cf/highwayreports/traffic\\_parms.cfm](https://highway.odot.state.or.us/cf/highwayreports/traffic_parms.cfm)) can be used substituted. Average between multiple counts at the project boundaries and on different significant facilities both state and local. Note that while the heavy vehicle percentages per approach may vary largely, the heavy vehicle mix does not vary as much. The total truck fleet should total up to 100% and the total car fleet should total up to 100%.
    - Car1 represents the larger passenger vehicles in the fleet (i.e. SUV's, large pickups);
    - Car2 represents smaller passenger vehicles in the fleet;
    - TruckSU represents single unit trucks (i.e. delivery vans, dump trucks);
    - SemiTrk1 represents single tractor-trailer combinations;
    - SemiTrk2 represents shorter single tractor-trailer combinations;
    - Truck DB represents trucks with two trailers; Note: SemiTrk2 and Truck DB can be customized to fit other truck types like triple trailers.

- Bus represents buses in the fleet;
- Carpool1 & Carpool2 represents vehicles with the same characteristics as Car1 and 2 but with higher occupancies. Zero out the default Carpool1 and Carpool2 vehicles. These will have no effect on the simulation unless vehicle occupancy is used as an evaluation measure.

**Exhibit 15-5 SimTraffic Default Vehicle Parameters**

Vehicles Types	1	2	3	4	5	6	7	8	9	10
Vehicle Name	Car1	Car2	Truck SU	SemiTrk1	SemiTrk2	Truck DB	Bus	Carpool1	Carpool2	
Vehicle Occurrence (%)	0.64	0.16	0.60	0.10	0.05	0.05	0.20	0.16	0.04	0.00
Acceleration	File	File	File	File	File	File	File	File	File	File
Vehicle Length (ft)	16.0	14.0	35.0	53.0	53.0	64.0	40.0	16.0	14.0	16.0
Vehicle Width (ft)	6.0	6.0	8.0	8.0	8.0	8.0	8.0	6.0	6.0	6.0
Vehicle Fleet	Car	Car	Trk	Trk	Trk	Trk	Bus	Pool	Pool	Car
Occupancy (# people)	1.3	1.3	1.2	1.2	1.2	1.2	20.0	2.8	2.8	1.3
Graphics Shape	Car	Car	Truck	SemiTrk	SemiTrk	DBTruck	Bus	Car	Car	Car
Table Index (1 to 7)	1	2	3	4	5	6	7	1	2	1

These percentages should reflect the relative differences between vehicle classes in the manual counts.

- **Vehicle Length (ft)** – This parameter directly affects queuing distances. Leaving the length unchanged will result in the queues being underestimated. Change the vehicle length in the following vehicle types:
  - Car1 = 20 ft;
  - Car2 = 16 ft;
  - TruckSU = 30 ft;
  - SemiTrk1 = 75 ft.

The Drivers tab (Exhibit 15-6) controls the behavior characteristics for the 10 different driver types that make up the simulation from the passive to the aggressive. For example, Driver Type 1 has 15% lower link speeds and will take 200% more distance when making a lane change while Driver Type 10 will travel 15% faster than the link speed and have lane change distances 50% of the coded values. All of the factors in the Drivers tab remain the same with exception of the Green React (s) setting. This setting reflects the time from when the signal turns green to the time that the vehicle begins to move. This value can be captured in the field and used as a calibration parameter. TPAU research indicates that Oregon values are substantially different than the defaults in SimTraffic. Change the Green React times to match Exhibit 15-7.

Exhibit 15-6 SimTraffic Default Driver Parameters

Driver Types	1	2	3	4	5	6	7	8	9	10
Yellow Decel (ft/s <sup>2</sup> )	12.0	12.0	12.0	12.0	12.0	11.0	10.0	9.0	8.0	7.0
Speed Factor (%)	0.85	0.88	0.92	0.95	0.98	1.02	1.05	1.08	1.12	1.15
Courtesy Decel (ft/s <sup>2</sup> )	10.0	9.0	8.0	7.0	6.0	5.0	4.0	4.0	3.0	3.0
Yellow React (s)	0.7	0.9	1.0	1.0	1.2	1.3	1.3	1.4	1.4	1.7
Green React (s)	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.2
Headway @ 0 mph (s)	0.65	0.63	0.60	0.58	0.55	0.45	0.42	0.40	0.37	0.35
Headway @ 20 mph (s)	1.80	1.70	1.60	1.50	1.40	1.20	1.10	1.00	0.90	0.80
Headway @ 50 mph (s)	2.20	2.00	1.90	1.80	1.70	1.50	1.40	1.30	1.20	1.00
Headway @ 80 mph (s)	2.20	2.00	1.90	1.80	1.70	1.50	1.40	1.30	1.20	1.00
Gap Acceptance Factor	1.15	1.12	1.10	1.05	1.00	1.00	0.95	0.90	0.88	0.85
Positioning Advantage (veh)	15.0	15.0	15.0	15.0	15.0	2.0	2.0	2.0	1.2	1.2
Optional Advantage (veh)	2.3	2.3	2.3	1.0	1.0	1.0	1.0	1.0	0.5	0.5
Mandatory Dist Adj (%)	200	170	150	135	110	90	80	70	60	50
Positioning Dist Adj (%)	150	140	130	120	110	95	90	80	70	60

Buttons: OK, Cancel, Default, Vehicle and Driver Parameters

Reaction time at start of green (s)

Exhibit 15-7 ODOT Green React Times

Driver Type	1	2	3	4	5	6	7	8	9	10
Green React (s)	2.0	1.6	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.5

The Intervals tab controls the actual operation and data recording of the simulation. Exhibit 15-8 shows the ODOT interval defaults.

- Seeding “0” Interval** – The Seeding Interval fills the network before any statistics are recorded. This value must be long enough for vehicles to travel the length of the network. ODOT default is 10 minutes or the time to travel the longest trip on the network, whichever is longer.
- Recording Intervals** – Simulation statistics are recorded in these intervals. The ODOT default uses at least two intervals, one 15-minute in length to represent the peak 15-minute period and one 45-minute interval to fill out the hour simulation period. However, you can have more intervals if you would like. For future analysis networks, the 15-minute interval is preferably placed as the first recording interval because it most represents the peaking in the output reports, regardless of where it occurs in the actual peak hour. However, for the calibration network, the 15-minute peak period should be coded to represent the actual peak 15-minute period as it occurred during the counts. The names of the recording intervals can be anything as they have no impact on the results.
- Duration (min)** – Change to 10 minutes (time to cross the network if longer) for the seeding interval, 15 minutes for the first recording interval and 45 minutes for the second recording interval (or, if this is being applied to the calibration work, a distribution representing the peak as it occurred in the counts).

- **Start Time (hhmm)** – After Duration is specified, change the start time to reflect the hour being simulated.
- **Record Statistics** – Set to “Yes” for all recording intervals.
- **Growth Factor Adjust** – Set to “Yes” for all intervals.
- **PHF Adjust & AntiPHF Adjust** – The combination of these two settings creates a spike in the simulated hour. The PHF Adjust should be set to “Yes” during the seeding and the peak 15-minute intervals and the AntiPHF Adjust set to “No.”. The AntiPHF Adjust should be set to “Yes” and the PHF Adjust set to “No” for all other recording intervals.
- **Percentile Adjust** - Set to “No” for all intervals. Use of this setting will overestimate the queuing in the simulation.
- **Random Number Seed** – SimTraffic uses nine different simulation scenarios (1 through 9). If it is desired to produce duplicate results, select a non-zero setting. ODOT default is to set it to ‘0’ which will produce random arrival rates with each run.

**Exhibit 15-8 ODOT Intervals Defaults**

SimTraffic Parameters			
Vehicles Drivers Intervals Data Options			
Intervals	0	1	2
Interval Name	Seeding	Recording	Recording2
Start time (hhmm)	04:50 P	05:00 P	05:15 P
Duration (min)	10	15	45
Record Statistics	No	Yes	Yes
Growth Factor Adjust	Yes	Yes	Yes
PHF Adjust	Yes	Yes	No
AntiPHF Adjust	No	No	Yes
Percentile Adjust	No	No	No
Percentile Adjust (%ile)	—	—	—
Timing Plan ID	—	—	—
Data Start Time (hhmm)	—	—	—

Random Number Seed: 0

Insert Delete

OK Cancel Default Intervals

Enter time for volume data in data file.

**15.3.6 Simulation Execution**

Once all Synchro and SimTraffic settings are completed, the simulation is ready to be executed. Upon starting the simulation, the “Errors and Warnings” window will appear. This shows anything that is outside of the value ranges what SimTraffic expects to find. Errors are split into fatal and non-fatal errors. Fatal errors will not allow the simulation to run and must be corrected. Fatal errors usually are related to lanes and lane groups where no lanes exist on a link.

Non-fatal errors still allow a simulation to be run, but these need to be reviewed and corrected if possible, for best results. Some examples of non-fatal errors that need to be corrected are:

- “Detector too close to stop bar”;
- Minimum green /total split/pedestrian timing errors;
- Reference phase not in use errors;
- Storage lane and length errors.

Some examples of non-fatal errors that can be left alone as these are “how it is” are:

- “Angle between approaches less than 25 degrees.” Small angles will lengthen out an intersection area and may cause unpredictable operation.
- Any error referencing vehicle extensions or minimum gaps exceeding 111% of travel time between detectors. Errors such as these indicate that actuated signal operation will be not as efficient.
- “Volume-delay operation not recommended with long detection zone.” SimTraffic has issues generally with ODOT’s default phasing variables.

ODOT standard is to average together at least five (5) random acceptably working (no system gridlock) runs. If you have a congested or a large network, it is advisable to have 7-10 runs to allow for “blown” runs which are caused by system gridlock so there are at least five good runs averaged together at the end. The system gridlock is typically caused by the improper actions of simulated vehicles that end up getting stuck. If every run or a majority of runs have gridlock, then the analyst should further refine the simulation settings, especially the headway factors, blocked intersection and lane change distance parameters.

It can take 20-40 minutes a run (depending on network size, congestion level and computer speed). Make sure you have adequate available storage. Each simulation file can be in excess of 1 GB. If you run out of space during a multiple recording session, SimTraffic will continue to run, but the simulations will stop being recorded.

Once the runs are completed, check each simulation run by selecting each number in the drop-down run number box to make sure it is free of any system gridlock errors and that the simulation reflects what is expected. If there are bad runs, make note of the run number, so it may be skipped in the report process.

### **15.3.7 Simulation Outputs**

SimTraffic outputs are used for queue analysis, determination of storage lane lengths, travel times and other evaluation criteria. Many times in the evaluation of alternatives the typical v/c and LOS measures may have very small differences. It is common practice today to use additional MOE’s to describe an operation of an alternative. These MOE’s can include travel time, stopped delay, average speed and queue blocking. These are very useful in alternative comparisons because lower travel times, delays and stops coupled with higher average speeds, will indicate a more operationally efficient alternative.

Make sure before selecting any report to print or preview that a number is showing in the run number box. Otherwise, a message appears from SimTraffic saying that it needs to record the simulation again.

To preview a report, select the desired report(s) and make sure that the Multiple Runs box is checked. Select the desired .hst files (skipping any bad runs). Reports are generally broken down into sections by intersection and interval. The Summary of All Intervals section of the report is where information is pulled from for analysis. Check to make sure that content, headers and footers are correct before printing.

- **Simulation Summary Report** – Used to check whether that the runs look to have similar characteristics. Entering and exiting vehicles, total delay and total stops should be relatively consistent between runs. This is a second check of the run adequacy (the first is visual inspection). This report also gives system total MOE's which can be used in alternative comparisons.

**Queuing and Blocking Report** - The Queuing and Blocking report generates the 95<sup>th</sup> percentile queues which are used to design turn bay storage as well as document operation of the study area.

- Exhibit 15-9 shows a typical report.

This report shows three different queues: maximum, average and 95<sup>th</sup>. The reported maximum queue is the highest queue calculated every two minutes. The average queue (50<sup>th</sup> percentile) is the average of the calculated two-minute queues. The 95<sup>th</sup> Queue is the 95<sup>th</sup> percentile of the reported maximum queue over the simulated period. With the Random Number Seed set to zero, the queues in this report will be different from those in another set of simulation runs. When reporting out the estimated queue lengths, round up to the next 25 feet.

## Exhibit 15-9 Sample Queuing and Blocking Report

Queuing and Blocking Report				
Baseline				
2/7/2008				
<b>Intersection: 2: Redwood Ave &amp; US 199, Interval #1</b>				
Movement	WB	WB	NE	NE
Directions Served	L	LT	R	R
Maximum Queue (ft)	49	99	139	132
Average Queue (ft)	11	18	43	48
95th Queue (ft)	61	91	142	167
Link Distance (ft)	592	592	382	382
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				
<b>Intersection: 2: Redwood Ave &amp; US 199, Interval #2</b>				
Movement	WB	WB	NE	NE
Directions Served	L	LT	R	R
Maximum Queue (ft)	321	341	120	144
Average Queue (ft)	64	68	16	16
95th Queue (ft)	344	343	75	77
Link Distance (ft)	592	592	382	382
Upstream Blk Time (%)	3	5		
Queuing Penalty (veh)	25	49		
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				
<b>Intersection: 2: Redwood Ave &amp; US 199, All Intervals</b>				
Movement	WB	WB	NE	NE
Directions Served	L	LT	R	R
Maximum Queue (ft)	341	374	155	157
Average Queue (ft)	51	56	22	24
95th Queue (ft)	299	300	96	106
Link Distance (ft)	592	592	382	382
Upstream Blk Time (%)	2	4		
Queuing Penalty (veh)	19	37		
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

**95<sup>th</sup> Percentile Queues**

The Upstream Block Time and the Storage Block Time are of particular interest in helping describe the overall impact of queuing. While the 95<sup>th</sup> percentile queues may show how long a queue is, the block time shows for how long of the simulated hour the queue will block intersections or storage bays.

Even if queue spillback into adjacent intersections is not occurring, storage bays may be overflowing, causing local problems such as the blockage of adjacent lanes. A queue blockage or spillback condition is considered a problem when the duration exceeds five (5) percent of the peak hour. Spillback may also be a sign of cycle failure as there may not have been enough green time available to serve all waiting vehicles. Signals do not recover instantly, so one spillback cycle could affect the operation of the next two or three cycles which can be a significant portion of hourly cycles.

- Upstream Blk (Block) Time (%)** - This is an estimated percentage of the peak hour in which the queue from the subject node blocks an upstream node. This is especially useful when analyzing a complex Synchro network, to determine the extent of queuing on a system when reporting out results. It can also be used to determine if an alternative or option will provide the best progression.



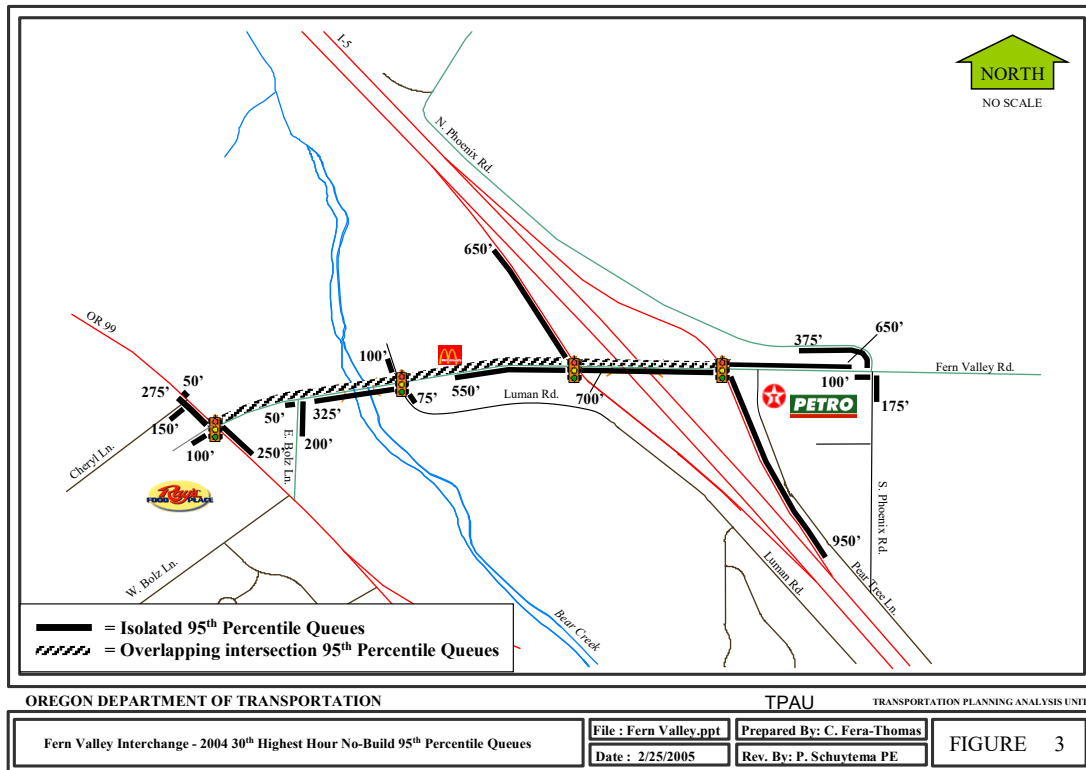
- **Storage Blk (Block) Time (%)** - This reports an estimated percentage of the peak hour in which the length of the through or turning queues exceeds the storage length. For build analysis, if your storage block time is significant (>5%), then it is recommended to enter a longer bay length, rerun the simulation, and continue this until you get a percentage less than 5%. Keep in mind that storage bays should adhere to the practical limit of 300 – 350 feet (most storage bays are 100 to 150 feet), so some alternatives and their simulations will still have significant storage block time.

Queues can be reported directly from the subject approach if the queue length is less than the link length. If a queue is longer than the link length, then the total actual queue length will be the link length(s) that are filled up plus the last queue length that does not exceed the link length. The analyst will need to trace the queue back from the intersection in question, so you will likely pass through multiple intersections and bend nodes to obtain the actual queue length. However, this queue is made up of contributions from other intersections that the subject queue spills back into which can make it hard to tell and report where exactly the queue originates. Queues are best reported graphically by identifying the queues under spillback conditions separately from the ones that do not exceed the link length.

Exhibit 15-10 shows a sample 95<sup>th</sup> percentile queuing diagram. To minimize reporting issues, link curvature should be used where possible to eliminate any unnecessary bend nodes.

The combination of the upstream and storage block times can also be used to report out the impacts of queuing at a higher level instead of reporting out the 95<sup>th</sup> percentile queues for intersection approaches.

## Exhibit 15-10 Sample Queuing Diagram



- Performance Report** - The Performance report (Exhibit 15-11) gives the MOE comparisons for each intersection by approach, movement or run; for each approach by run; or a total for the entire network. MOE's are summed over the entire hour (i.e., hours of delay). During calibration, "vehicles exited" needs to be used to ensure calibration, see Section 15.3.1 for more instruction.

## Exhibit 15-11 Sample Performance Report

SimTraffic Performance Report					
Baseline					
2: Redwood Ave & US 199 Performance by movement Entire Run					
Movement	WBL	WBT	NET	NER	All
Total Delay (hr)	2.8	2.6	0.0	1.6	7.0
Delay / Veh (s)	8.6	15.9	1.9	4.1	8.0
Total Stops	69	120	0	58	247
Travel Dist (mi)	147.4	72.6	0.4	112.2	332.5
Travel Time (hr)	6.2	4.3	0.0	4.3	14.8
Avg Speed (mph)	24	17	28	26	23
Fuel Used (gal)	6.4	3.3	0.0	3.8	13.5
HC Emissions (g)	259	121	0	155	534
CO Emissions (g)	8425	3399	11	4823	16658
NOx Emissions (g)	797	385	1	463	1645
Vehicles Entered	1176	597	9	1351	3133
Vehicles Exited	1177	598	9	1353	3137
Hourly Exit Rate	1177	598	9	1353	3137
Input Volume	1420	678	12	1475	3585
% of Volume	83	88	75	92	88
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	0	0	0	0

- **Arterial Report** – The Arterial Report (Exhibit 15-12) is another version of the Performance report but reports out travel time, delay, and speed along a roadway section on a per vehicle basis. This roadway must have at least two nodes for this report to be available for it and the roadway must have the same road name without any special characters (i.e. dashes) along all the reported sections. The presence of a mixture of one-way and two-way sections along an arterial corridor may require segmenting and the individual results summed.

**Exhibit 15-12 Sample Arterial report**

Arterial Level of Service: EB US 199, Entire Run					
Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Allen Creek Rd	5	18.5	26.2	0.1	12
Redwood Ave	8	8.6	22.5	0.2	27
US 199	2	4.4	11.0	0.1	27
Fairgrounds Rd	10	18.0	28.0	0.1	16
<b>Total</b>		<b>49.5</b>	<b>87.8</b>	<b>0.5</b>	<b>19</b>

### Animated Tracking

In the SimTraffic simulation, clicking on a vehicle will bring up a box (Exhibit 15-13) showing speed, acceleration, distance to next turn, etc. this will allow the analyst to track vehicles as they travel through the network. Clicking on the vehicle again will remove the tracking box. In addition, signalized intersections can be clicked on showing the signalized operation in action as it goes through the phases. Both can be useful in debugging a simulation. It is recommended that the simulation speed be set to real time or slower for best viewing.

**Exhibit 15-13 Animated Vehicle and Signal Tracking**

The screenshot shows a 3D simulation of an intersection between US 199 and Fairgrounds Rd. A tracking window is overlaid on the scene, displaying the following data:

Int:10 US 199 & Fairgrounds						
Ph	Dir	Time	Mn	Mx	Rcl	Gap
2	WBT	12.2	10	72.5	Min	3.8
6	EBT	3.2	10	73.5	Min	4.0
Calls:12_6			Ped Calls: _____			

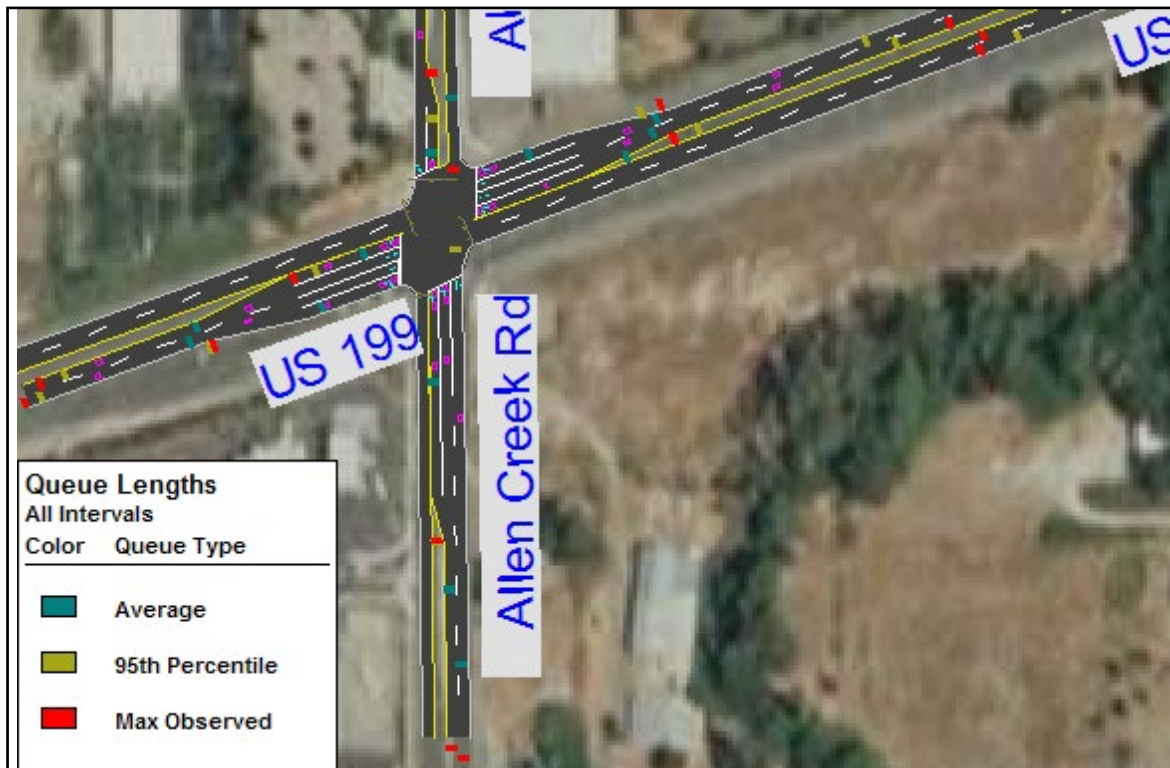
  

Vehicle ID#:	60	Next Turn:	Left
Vehicle Type:	Car2	2nd Turn:	Thru
Driver Type:	10	Speed (ft/s):	62.5
Node:	2	Accel (ft/s <sup>2</sup> ):	4.0
Upstream Node:	10	Current Lane:	1
Dist to SBar (ft):	345	Dest Lane:	1

### Static Graphics

Other reports include the “Static Graphics” reports (Exhibit 15-14). Select the Graphics tab and you will get a box showing reports such as total delay, percent time blocked queues, etc. These reports are based on the same information that the previous comprehensive reports use, but display the information in graphical form, rather than a table of numbers. These report out just the run number selected rather than an average of runs of the regular reports. These can be used to quickly visualize the issues for the analyst or for others.

Exhibit 15-14 Example Queue Length Static Report



### 15.4 Vissim - Overview

Vissim is a simulation program that can model multi-modal traffic flows including cars, trucks, buses, heavy rail and light rail transit (LRT) as well as model traffic management systems (ramp meters, toll roads, and special lanes) and transit priority systems. Vissim can also model trip assignment, over fixed routes or dynamically, where vehicles change routes in response to specified events and can animate traffic movements in 3-D. Vissim is a program that can stand alone but is data intensive to create files for use on its own. Alternatively, the files can be created in Visum (a travel demand model assignment program) that can then import the files into Vistro or Vissim for analysis. Vistro can be used as a “front-end” to add in geometric lane configurations and traffic control details to an imported Visum file or as a start to an eventual Vissim file. See APM version 2 [Appendix 8B](#) for guidance on creating networks using PTV

Vision Suite software (Visum, Vissim, and Vistro). Because most ODOT region offices do not perform travel demand modeling, it is important to note issues both with and without Visum.

Other advantages of Vissim include the rail-roadway interface, which requires Vissim Level 3 or 4 in order to model the effect of rail crossing blockages on queues and roadway operations. Another advantage is that Vissim has the capability of “dynamic traffic assignment” (DTA), which will reroute a vehicle on the network in case of a crossing blockage or an overcapacity situation. Note that this strength of the software comes at the price of larger study areas to allow for correct dynamic assignment and to address effects occurring potentially outside of the focus of the study area. DTA will likely require more data, measures, and resources to properly calibrate (see APM version 2 Chapter 8 for more information).

APM version 2 Addendum 15A is a link to the ODOT Vissim Protocol which governs documentation and creation of all Vissim models created for ODOT plans and projects. Where applicable, the ODOT Synchro defaults should be implemented in the Vissim model to the extent possible.

Vissim has the capability of performing analysis directly on Visum traffic volume assignments and includes a post-processing function. The results of this type of analysis may be acceptable for certain applications, such as sketch planning and alternative screening. However, for most types of analysis, DHVs are required. The function in Vissim does not create DHVs, therefore the post-processing procedures outlined in APM version 2 Chapter 6 are still necessary.

Vissim has been used in some research projects to evaluate the potential effects of connected and autonomous vehicles (CAVs), including the pooled fund study *Planning-Level Capacities for CAVs in the Highway Capacity Manual*, led by ODOT with the participation of nine other state DOTs. The pooled fund study simulated CAV behavior by adapting a model developed by the California PATH program to test various intra-platoon gap settings. The research team developed a custom model to simulate cooperative adaptive cruise control (CACC) platooning, called the UC micro-sim tool. While Vissim 11 includes pre-defined driving behaviors to reflect automated vehicles, the research team found that a custom model was needed to simulate the complexities of actual CAV applications. Details about the modeling approach used in the pooled fund study are available in the [Final Report](#) for the pooled fund study, available on the ODOT Research website.

## **15.5 Paramics - Overview**

Paramics and VISSIM share a lot of the same benefits in functionality and issues with complexity and time to achieve calibration. Paramics, like VISSIM, is a simulation program that can model multi-modal traffic flows including cars, trucks, buses, heavy rail and light rail transit (LRT) as well as model traffic management systems (ramp meters, toll roads and special lanes) and transit priority systems. Paramics can also model trip assignment, over fixed routes or dynamically, where vehicles change routes in response to specified events and can animate traffic movements in 3-D. Paramics is a program that can stand alone but is data intensive to create files for use on its own. Paramics does offer some importing functionality to bring networks in from other software, but it does not have a direct link to VISUM. However, all of Paramics’ inputs are text files, making it easy to customize automations (macros, scripts, etc.) to

take networks from other platforms and format the data into the text files Paramics requires. This creates many opportunities to bring networks from any software quickly into Paramics.

Arguably the biggest strength of any dynamic assignment software (like Paramics and VISSIM) is the “dynamic traffic assignment” (DTA) option, which will reroute a vehicle on the network in case of a rail crossing blockage or an overcapacity situation. Note that this strength of the software comes at the price of larger study areas to allow for correct dynamic assignment and to address effects occurring potentially outside of the focus of the study area. DTA will likely require more data, measures, and resources to properly calibrate.

Paramics has disadvantages like VISSIM since it does not produce signal coordination timing and can be very data intensive and time consuming to construct and calibrate a scenario, especially from scratch.

Some issues to consider when using Paramics for analysis are (based on ODOT’s assessment of version 5.2):

- The flexibility of Paramics means the analyst is required, in most cases, to write their own reports. Paramics does have a set of limited standardized reports. This would require exporting the queuing data to Excel or comparable software; creating functions to calculate the maximum queues for each time period, calculating averages and standard deviations and then calculating the 95<sup>th</sup> percentile queue on each approach for each run.
- Paramics does not do signal coordination/progression, so the network must be constructed in Synchro (or similar software) to develop the timing and progression, which can then be incorporated into Paramics.
- Paramics should not be used in a TIS process as there are too many parameters to change and is likely out of the capable review range of most Region analysts.
- To date, none of the ODOT offices own the Paramics software. Paramics submittals by consultants should include the Paramics model translated into Synchro files to enable effective ODOT review. The ODOT Synchro defaults should be implemented in the Paramics model to the extent possible.

Currently, Paramics is not practical enough for most ODOT applications. Model development is data intensive, requires detailed knowledge on many input parameters and has limited standardized output reports. The use of Paramics input text file format can speed up some of the work but requires a custom import/export process which can be very time consuming to develop.

## **15.6 CORSIM - Overview**

CORSIM is a microscopic traffic simulation program, applicable to surface streets, freeways, and integrated networks with a complete selection of control devices, i.e., stop/yield sign, traffic signals and ramp metering. CORSIM simulates traffic and traffic control systems using commonly accepted vehicle and driver behavior models and combines two traffic simulation models: NETSIM for surface streets and FRESIM for freeways. CORSIM allows for user control of trip assignment through the ability to set vehicle-type specific turn percentages and set predefined vehicles routes.