16-20-1 Basic Principles **September 2019**

1.1 Introduction

Microscopic traffic simulation, or microsimulation, refers to traffic analysis tools that analyze the movement of individual vehicles as they travel through a network. As the simulation progresses, it updates factors such as the vehicle's position and its need to increase/decrease speed or change lanes several times a second. Accordingly, these tools are suitable for evaluating the interaction of different components of the transportation network, such as queues from an intersection that cause lane blockages upstream or complex weaving and merging behaviors. Additionally, the visual animation of traffic flows can make microsimulation traffic models useful for public outreach and stakeholder presentations. Typical situations where microsimulation traffic analysis may be appropriate include scenarios that macroscopic tools cannot or do not address well, such as:

- Complex weaving along freeways and arterials
- Arterial and freeway interaction (e.g., spill-back from an arterial onto the freeway at an exit ramp)
- Non-traditional or alternative interchange/intersection analysis (e.g., diverging diamond interchanges and continuous flow intersections)
- Turn-lane spillover
- Oversaturated conditions
- Signal and roundabout interaction
- Vehicle/transit/pedestrian interaction

The primary purpose of traffic modeling is to simulate the transportation system under various volume and geometric conditions to assess what (if any) improvements are necessary. Most often, the models represent projected (or future) traffic conditions. Although analysts typically use traffic models to assess the impact of potential capacity/expansion improvements, they can also use microsimulation models to assess non-expansion improvements such as managed lanes, channelization optimizations (e.g., removing shared lane movements), and additional transit service.

WisDOT supports the use of microsimulation traffic models; however, it is important to match the analysis methods with the scale, complexity, and technical requirements of the project. Microsimulation modeling work typically requires significantly more time, data, and effort than other traffic analysis tools. Thus, prior to selecting microsimulation as the analysis tool, the project team *should* assess whether less resource-intensive traffic analysis tools can sufficiently meet the needs of the project. The project team *should* also consider the project schedule and budget to ensure that they can adequately accommodate the development and review of the microsimulation traffic models. TEOpS 16-10-5 provides additional information and guidance on selecting the most appropriate traffic analysis tool(s).

1.2 Calibration vs. Validation

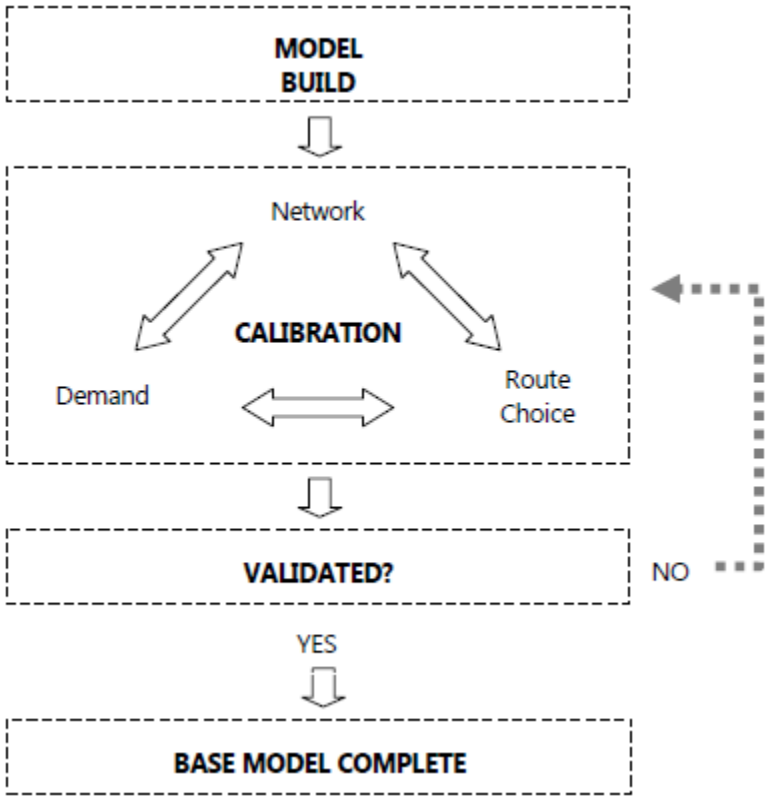
Microsimulation models contain multiple parameters that the analyst can modify to reflect varying degrees of driver behavior, vehicle characteristics, and roadway conditions. Developing a traffic model with a reasonably accurate representation of real-world local traffic conditions requires calibration and validation of the model where, for purposes of WisDOT policy, calibration and validation have the following definitions.

Calibration: The process where the analyst adjusts selected input parameters within the traffic model (typically driver behavior elements including headway and reaction times, driver aggressiveness, etc. and roadway elements like sign posting) such that the traffic model represents field conditions. See TEOpS 16-20-5 for additional details on the calibration process.

Validation: The independent process where the analyst checks the traffic model outputs against benchmark data for traffic volumes, travel speeds, travel times, intersection queuing, and trip-making patterns (e.g., weaving volumes), among others. See TEOpS 16-20-8 for additional details on the validation process.

Calibration and validation are part of an iterative cycle. If, after the initial round of calibration, the model results do not satisfy the validation thresholds, the analyst must conduct additional model calibration and recheck the updated model results against the validation targets. This process continues until the model results meet the validation targets and the traffic model has reached a level of fidelity that is acceptable. Figure 1.1, taken from the New South Wales (NSW) Government Transport Roads & Maritime Services (RMS) 2013 *Traffic Modelling Guidelines* (1), illustrates the iterative relationship between model calibration and validation.

Figure 1.1 Traffic Model Calibration and Validation Process



Source: NSW Transport Roads & Maritime Services 2013 *Traffic Modelling Guidelines*, Figure 11.3 (1)

1.3 Purpose of Calibration & Validation

The process of developing a microsimulation model starts with an existing conditions model and then transitions into the development of various scenarios representing future-year alternatives. The only way to determine that a traffic model depicts real-world traffic conditions is to compare the existing conditions traffic model to traffic conditions observed in the field. If the existing conditions traffic model cannot reproduce the existing traffic conditions with a reasonable degree of accuracy, then analyses of other scenarios will be highly suspect. Therefore, prior to using the model outputs for project or study decisions, especially any related to critical aspects of the design, the analyst **shall** calibrate and validate the microsimulation traffic model in accordance with TEOpS 16-20-5 and TEOpS 16-20-8, respectively. Additionally, the traffic model *should* undergo the peer review process in accordance with TEOpS 16-25, prior to the commencement of work on any other traffic model scenarios or alternatives (e.g., design year no-build traffic model). Conducting the peer review process at the proper time will limit the potential of needing to modify multiple models to address reviewer comments.

After completion of the calibration, validation, and peer review processes, the analyst can use the existing conditions model as the starting point for future-year alternative models. Most of the parameters calibrated in the existing conditions model *should* be transferable to the future-year models; however, the analyst may need to modify some parameters to account for changes in roadway geometry and the associated driver behavior. The calibration, validation, and peer review processes (TEOpS 16-20-5, TEOpS 16-20-8 and TEOpS 16-25, respectively) are applicable for all future-year model alternatives and the analyst *should* apply them as appropriate.

16-20-2 Traffic Model Development May 2021

2.1 Traffic Model Boundaries

Confusion about the purpose, objectives, or physical boundaries of the traffic model can cause delays and other potential problems such as:

- Misunderstandings or ambiguities regarding the purpose/objectives of the traffic modeling effort
- Mission creep or unplanned expansion of the traffic model that could delay the delivery of results, such as unexpected enlargement of the geographical boundaries
- Misapplication of the traffic model (e.g., attempting to use the traffic model beyond the level of detail initially intended)
- Inappropriate sequencing of activities (e.g., starting to develop the build scenarios before the existing conditions traffic model has been properly calibrated and validated)

Although the above problems can apply to all types of traffic analyses, the complexities associated with microsimulation traffic models only exacerbate the issues. To ensure that there is a clear understanding of the traffic analysis requirements, the project team **shall** work with WisDOT regional traffic staff to define the preliminary traffic model boundaries. After coordinating with WisDOT regional traffic staff, the project team *should* organize a meeting with other key stakeholders to finalize the traffic model boundaries and review/update the DT2290 Traffic Model Scope form as appropriate. In addition to the meeting, it may be beneficial to conduct an organized visit to the site to familiarize the team with the current traffic conditions/issues.

Typically, the traffic analysis kick-off meeting will include only those internal stakeholders, and applicable consultant team representatives, who will be involved in the development or review of the traffic model. It may be beneficial to promote early involvement with the Bureau of Traffic Operations – Traffic Analysis and Safety Unit (BTO-TASU) and the Federal Highway Administration (FHWA), as appropriate, by inviting them to this initial meeting. This is especially true for mega projects, high profile projects, and FHWA Projects of Division Interest (PoDI). At a minimum, the project team **shall** invite the FHWA Wisconsin Division Operations Program Manager to the initial kick-off meeting for any interstate project that has a scope of work greater than pavement replacement. Refer to the FHWA/WisDOT "Risk-Based Project Stewardship and Oversight Agreement", provided in FDM 11-5-2-1, for details on FHWA and WisDOT stewardship and oversight of federal-aid projects.

Refer to TEOpS 16-25-2 for additional guidance on determining who *should* participate in the review of the traffic model. In general, BTO-TASU **shall** be involved with the review of all models where FHWA participation is desired or required. It is also advisable to include BTO-TASU when dealing with new, unique, or complex modeling concepts or analysis tools, especially if the region does not have the necessary knowledge or resources. Direct any questions regarding the need to involve BTO-TASU to the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

After the traffic-analysis kick-off meeting and any site visits, key stakeholders, including the consultant team as applicable, *should* have a good grasp on the following:

- Purpose and objective of the traffic model(s)
- Traffic issues/concerns for the study area
- Applicable traffic analysis method(s) and tool(s)
- Temporal and spatial boundaries of the traffic model(s)
- Analysis scenarios (e.g., existing, no-build, build, etc.)
- Potential data needs and sources

If, after the meeting, there are still components of the DT2290 form that are unknown, the project team *should* coordinate further discussions between WisDOT regional traffic staff, the traffic analyst (i.e., consultant team), and BTO-TASU as appropriate. The following provides additional details on how to define the model limits (spatial and temporal) and analysis scenarios.

2.1.1 Traffic Model Spatial Limits

The limits of the microsimulation traffic model *should* encompass not only the limits of the specific transportation project under study, but it *should* also include all parts of the surrounding transportation network (or zone of influence) that may significantly influence the operations of the study area. When setting the limits of the traffic model, the analyst *should* consider the potential impact of planned/proposed roadway improvement projects and strategies, especially if the future improvement may result in a shift in travel patterns. Other adjacent or nearby improvement projects may have a significant impact on the spatial limits of the traffic model, especially if the

projects are proceeding concurrently (e.g., it may be necessary to extend the traffic model to incorporate the adjacent projects or portions of the traffic model may overlap with the model of an adjacent project, etc.). Thus, it is critical to have early coordination with any adjacent or nearby projects.

Where practically feasible, the spatial boundaries of the traffic model *should* capture all congestion, existing and future, in the area. Where it is not possible to capture the congestion spatially, evaluate whether extending the temporal limits of the model will allow the traffic model to reflect the traffic congestion (see TEOpS 16-25-2.1.2). In situations where resource or other constraints prevent the extension of the traffic model (spatially or temporally) to capture all congestion, coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to set the traffic model limits. Include discussion on the potential risk of not being able to identify the full extent of congestion for future/alternative scenarios. All key stakeholders *should* agree on the approach to use to compensate for any congestion that occurs outside the established model limits. Initial discussions on the spatial limits of the traffic model *should* occur during project scoping.

The analyst *should* take care not to extend the model limits out further than necessary, as the larger the model, the more complex and time-consuming it will be to calibrate and validate. One way to measure the complexity of the traffic model is to consider the size of its origin-destination (O-D) matrix, which represents each location (or zone) where vehicles can enter or exit the model. The O-D matrix increases with the square of the number of traffic zones included in a model: a 25-zone model has 625 O-D pairs (25X25 = 625) while a 50-zone model has 2,500 O-D pairs (50X50 = 2,500). The time to complete the network coding, calibration, and validation processes increase with every O-D pair added to the traffic model. Therefore, depending on the size of the study area, it may make more sense to break the traffic model into two or more smaller models rather than to develop one large model. (Coordinate with WisDOT regional traffic staff to assess whether to break one large model into smaller models. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.) All boundaries of the traffic model *should* occur at logical break points in the roadway network (e.g., locations where the traffic volumes naturally drop-off or locations where traffic attributes such as travel speeds normalize or return to free-flow speeds). Avoid breaking the model at critical study area locations (e.g., avoid breaking the model in the middle of a complex weaving segment between two large interchanges).

Depending on the operational characteristics, it is possible for the limits of the traffic model to extend beyond the end of the project termini. Additionally, microsimulation analysis may only be necessary for a portion of the project study area such that the limits of the microsimulation model are smaller than the project limits. For example, if a project study area encompasses three interchanges (interchange A, B and C), of which only one (interchange A) involves complex weaving maneuvers and requires microsimulation analyses, the limits of the microsimulation model would only need to extend far enough to capture the weaving traffic behavior at interchange A. The analyst could then use an HCM-based analysis tool to evaluate the traffic conditions at interchanges B and C. Due to this variability, there is no standard set of guidance for determining the spatial limits of a traffic model. Rather, the geographical boundaries for a microsimulation traffic model needs to be determined on a project-by-project basis. FHWA's 2004 publication of the *Traffic Analysis Toolbox Volume III (TAT III)* (2) provides some general guidance on determining the spatial limits for a microsimulation model.

The analyst *should not* finalize the spatial limits of the traffic model until field observations document the extent of congestion and length of vehicle queues within the study area. Provide a brief discussion of the geographical traffic model boundaries within DT2290. Document all assumptions and methods regarding the geographical limits for the traffic model within the modeling methodology report and other project memoranda as appropriate.

2.1.2 Temporal Model Limits

The temporal limits of the traffic model are dependent on the location of the project and the experienced levels of congestion, and therefore, must be determined on a project-by-project basis. Some general guidance on defining the temporal model limits follows.

2.1.2.1 Temporal Analysis Periods

Depending on the purpose and objectives of the project, the microsimulation traffic model may need to address two or more temporal analysis periods (TAPs) where each TAP could encompass anywhere from one to six or more consecutive hours. Typical TAPs addressed with microsimulation models include the following, among others:

AM Peak Period (AM): This typically comprises of one or two hours of each weekday between 6 a.m. and 9 a.m., although in severely congested areas it could comprise of four or more hours.

Midday Peak Period (MD): This period is relevant in areas where traffic patterns peak in the non-traditional

commuting hours such as a school or restaurant district. If applicable, it typically is one hour between 11 a.m. and 3 p.m.

PM Peak Period (PM): This typically comprises of two or three hours of each weekday between 4 p.m. and 7 p.m., although in severely congested areas it could comprise of six or more hours.

Friday Peak Period (Fri): This period is relevant in areas that experience higher traffic patterns during the Friday peak period versus the typical weekday commute, typically due to the combination of both commuter and recreational traffic.

Sunday Peak Period (Sun): This period is relevant in areas where there is higher traffic than the typical weekday commute on a Sunday afternoon/early evening as travelers return home from a recreational weekend trip.

Seasonal/Special Event (SP): This period is relevant in areas that experience unusual traffic patterns due to holidays, tourism, or special events. This may coincide with the Friday or Sunday peak period.

The length of the TAP is dependent on the extent of congestion in the study area. Although the TAP will vary depending on local field conditions, FHWA's 2004 publication of TAT III (2) and 2007 publication of TAT IV (3) provide general guidance for determining the appropriate TAPs for a traffic model.

When selecting the TAPs, consider existing field data for traffic volumes, speeds, and queues, along with anticipated future traffic volumes and levels of congestion. Where practically feasible, the TAP *should* encompass the entire extent of the congestion (existing and future). If it is not feasible to extend the TAP to capture all congestion, coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to set the TAPs. Include discussion on the potential risk of not being able to identify the full extent of congestion for future/alternative scenarios. All key stakeholders *should* agree on the approach to use to compensate for any congestion that occurs outside the established TAPs.

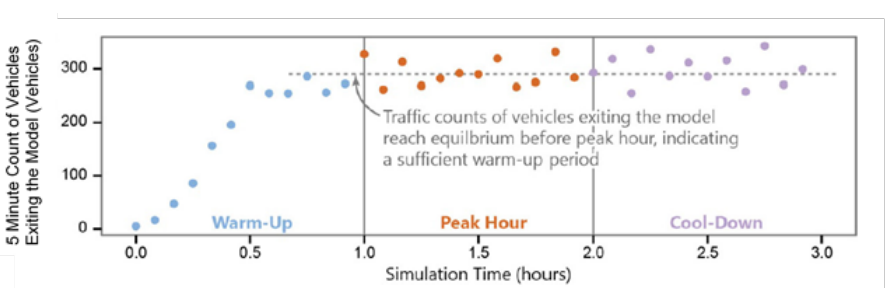
Provide a brief discussion of the TAPs within DT2290. Document all assumptions and methods regarding the TAPs for the traffic model within the modeling methodology report and other project memoranda as appropriate.

2.1.2.2 Warm-Up/Cool-Down Periods

In addition to the analysis period, microsimulation models **shall** also include a warm-up period and *should* include a cool-down period to allow for the build-up and dissipation of congestion. The warm-up period is essential because the roadway network within the traffic model is initially empty and requires some time for the network to reach conditions that reflect the start of the analysis period. Essentially, the first vehicles to enter the study area are driving under free flow conditions. Without a warm-up period, data from the beginning of the analysis period would have a strong bias toward smaller delays (lower congestion) and may not reflect real-world conditions. The exact length of the warm-up period will vary from project-to-project; however, as referenced in FHWA's 2004 publication of TAT III (2), a good way to approximate the minimum warm-up period, for at least the initial model runs, is to double the free-flow travel time from one end of the network to the other. After completing one or more model runs, verify the adequacy of the warm-up period and extend as appropriate.

The warm-up period is adequate when conditions at the end of the warm-up period reflect the field conditions at the start of the analysis period. One way to assess adequacy of the warm-up period is to review the number of vehicles present at any one time on the network to determine whether the model has reached equilibrium. Once the number of vehicles present on the network stays constant or increases by an amount consistent with the applicable profile, the model has reached equilibrium and signifies the conclusion of the warm-up period. Figure 2.1 provides an illustration of how to verify that the warm-up period is adequate by reviewing the number of vehicles exiting the model.

Figure 2.1. Warm-Up Duration Verification Example



The cool-down period allows time for the dissipation of queues created during the analysis period which is typically necessary for the traffic model to replicate real-world conditions. Like the warm-up period, the cool-down period will vary depending on local field conditions but is typically in the range of 15 to 60 minutes. After completing one or more model runs, verify the adequacy of the cool-down period and extend as appropriate.

FHWA's TAT IV (3) provides additional guidance for determining the appropriate warm-up and cool-down periods for a traffic model. Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to confirm the warm-up and cool-down periods. Provide a brief discussion of the warm-up and cool-down periods within DT2290. Document all assumptions, methods, and exemptions regarding the warm-up and cool-down periods for the traffic model within the modeling methodology report and other project memoranda as appropriate.

2.2 Analysis Scenarios

It is generally advantageous to identify the anticipated analysis scenarios/alternatives prior to beginning development of the traffic models. Early identification of the analysis scenarios/alternatives aids in determining the level of effort requirements, resource needs, and budget implications. Additionally, by knowing the potential analysis scenarios in advance, the analyst can assess whether the spatial and temporal model limits sufficiently address all analysis scenarios up front, minimizing the chances of rework and model inconsistencies. When assessing the scenarios/alternatives to model, consider the potential impacts of any adjacent planned or pending projects, especially if the adjacent projects will influence the traffic demand in the study area. The analyst *should* coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the analysis scenarios/alternatives.

Although the specific details of the analysis scenarios are project dependent, there are four basic analysis categories: 1) Existing (EX) Model, 2) Design Year, No-Build (FEC) Model, 3) Design Year with Minor Improvements (FEC+) Model and 4) Design Year, Build Model. A brief description of each of these analysis scenario categories follows.

Existing (EX): The existing (or base) year traffic model replicates existing field conditions. Existing year traffic conditions *should* reflect the year that is as close to the original start of the traffic analysis as possible. Whenever possible, traffic data *should* be no more than three years old and ideally, all traffic data *should* be from the same year. Ongoing construction or other extraordinary circumstances may dictate the need to use older data or data from multiple years.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to select the existing year. Identify the existing year on the DT2290 form and document the rationale for selecting the existing conditions within the modeling methodology report and other project memoranda as appropriate. The analyst **shall** obtain approval of the existing year from the WisDOT regional traffic engineer prior to initiating development of the traffic model.

Design Year, No-Build (FEC): The design year, no-build traffic model reflects design year conditions absent of the proposed project. It will reflect design year traffic volumes and existing geometry or existing geometry with other planned and enumerated (or committed) improvement projects and may include signal timing modifications. As such, another name for this scenario is the future with existing plus committed (FEC) scenario. The inclusion of a planned improvement project in the FEC model is contingent on it occurring after the existing year but prior to the proposed project's design year. Note that the FEC conditions for a specific project may not match the no-build conditions reflected in a travel demand model (TDM) used in forecasting traffic. Therefore, coordination with the WisDOT traffic forecasting section (TFS) is essential to verify that the traffic forecasts reflect the FEC scenario assumed in the microsimulation model.

The roadway geometry of the FEC model often limits (or constrains) the volume of traffic entering, traveling through, or exiting the model. The FEC model, is thus a "constrained" model, and may not reflect the true demand on all segments within the model. Depending on the purpose and objectives of the project, full analysis of a true no-build or "constrained" traffic model may not be necessary.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the need for developing a design year, no-build model and to clarify the need to assess "constrained" conditions.

Document the rationale for including or not including the design year, no-build (FEC) model, or "constrained" conditions within the modeling methodology report and other project memoranda as appropriate. The analyst **shall** obtain approval from the WisDOT regional traffic engineer on how to address the design year, no-build (FEC) conditions prior to initiating development of the traffic model.

Design Year, FEC+:

For the traffic model to function with the design year traffic volumes, it may be necessary to include minor geometric improvements (e.g., the extension of an existing right or left turn lane or channelization optimizations such as the removal of shared lane movements within the FEC right-of-way, etc.) beyond the committed projects. In these cases, the traffic model represents future with existing plus committed plus minor improvements (FEC+) conditions. The project team *should* document these minor improvements within the modeling methodology report and other project memoranda as appropriate.

The driving factor for inclusion of a design year with minor improvements (or FEC+) model is frequently the need to eliminate the geometric constraints within or adjacent to the traffic model that prevent the realization of the true demand. Thus, the FEC+ model is typically (but not always) representative of an "unconstrained" model. The analyst may elect to apply other methodologies (such as removing traffic volumes that exit the roadway network prior to the study area) in addition to or instead of including minimum geometric improvements, to develop a design year "unconstrained" traffic model.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the need for developing a FEC+ model and to clarify the need to assess "unconstrained" conditions. Document the rationale for including or not including the FEC+ model or "unconstrained" conditions within the modeling methodology report and other project memoranda as appropriate. The analyst **shall** obtain approval from the WisDOT regional traffic engineer on how to address the FEC+ conditions prior to initiating development of the traffic model.

Design Year, Build (ALT):

The design year, build traffic models capture design year conditions with the proposed project improvements. The build traffic models may reflect "constrained" or "unconstrained" conditions. Typically, the analyst will need to develop a traffic model for more than one project alternative.

Due to the complexity and level of effort and resources required to develop microsimulation models, conduct a high-level review of potential alternatives using HCM-based deterministic analysis tools to narrow down the number of alternatives prior to developing the design year, build traffic model alternative using microsimulation.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the design year, build model alternatives and to clarify the need to assess "constrained" conditions, "unconstrained" conditions, or both. Document the rationale for including or not including the "constrained" or "unconstrained" conditions within the modeling methodology report and other project memoranda as appropriate. The analyst **shall** obtain approval from the WisDOT regional traffic engineer on the design year build alternatives prior to initiating development of the traffic model.

Depending on the specifics of the project, it may be beneficial to develop a model that represents the conditions that will exist the first year the proposed project improvements will be open to traffic (i.e., opening year conditions model). This scenario reflects the opening year traffic volumes and opening year geometry, which includes the existing geometry with the proposed project improvements and any other completed improvement projects. Discuss the need to develop an opening year model with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate.

To ensure consistency, avoid confusion, and aid in the model reviews, use the file naming convention spreadsheet.

2.3 Traffic Model Tree

Prior to development of the microsimulation traffic model, the analyst *should* coordinate with the project team and WisDOT regional traffic staff to develop the traffic model tree. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

The purpose of the model development tree is to show all the scenarios to include in the analysis, along with their relationships to one another and the existing conditions model. It formally illustrates the way the model will evolve as the work progresses and establishes the sequence of work activities. Developing the traffic model tree prior to development of the existing conditions model helps avoid unnecessary work. Whenever possible, the analyst *should* use the same transportation network structure for all temporal analysis periods (AM peak, PM peak, Friday peak, Sunday peak, etc.) within the same year. The fewer the number of model variations, the easier it is to maintain consistency between the different analysis scenarios. Figure 2.2 provides an illustration of a basic traffic model tree.

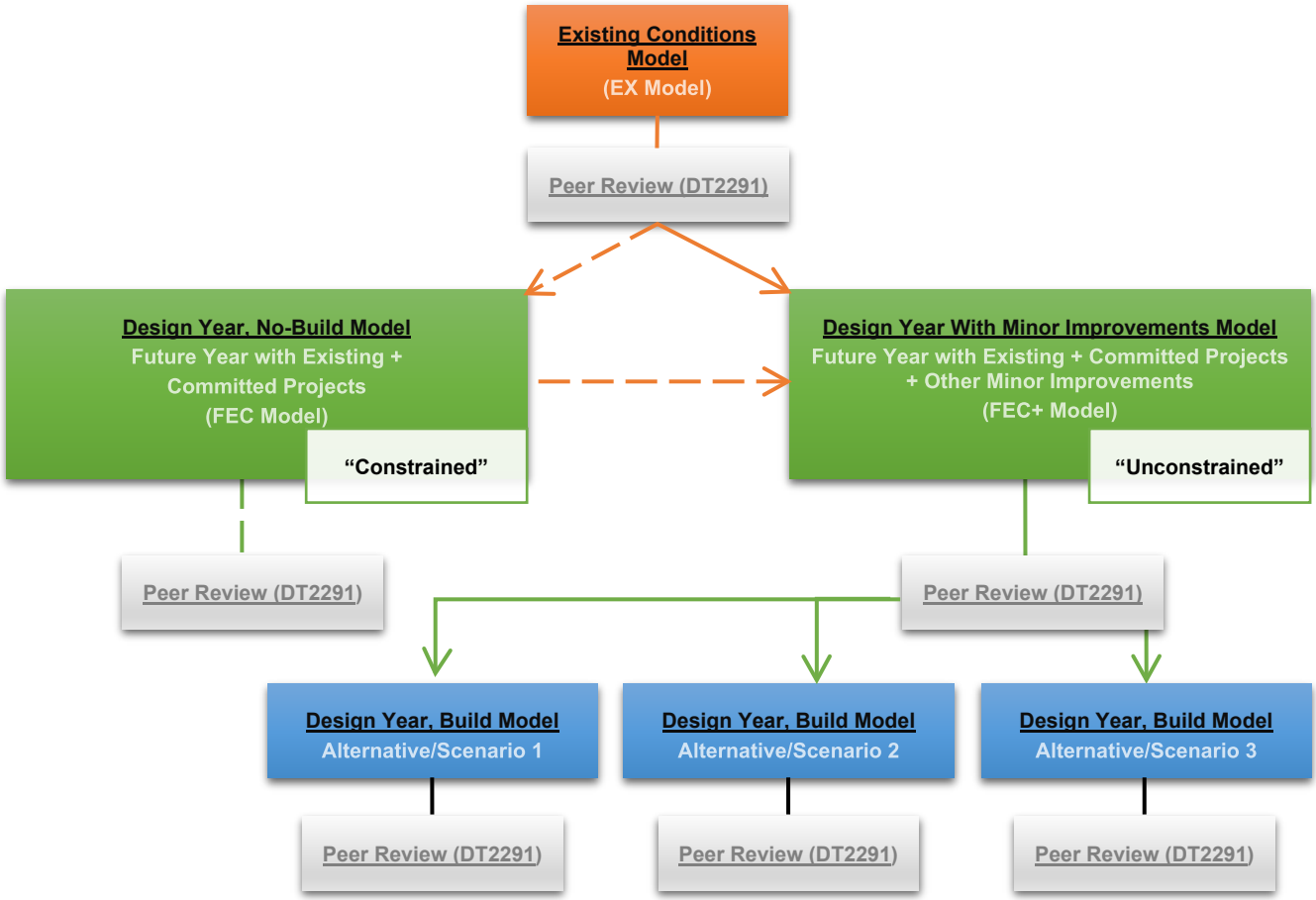
As illustrated in Figure 2.2, each version of the traffic model *should* undergo the peer review process prior to the development of the model for a new scenario. Refer to TEOpS 16-25 for additional details on the peer review process. When the project has a compressed schedule, there may be a temptation to begin development of the design year models prior to completion of the peer review process of the existing conditions model. This is often counterproductive, as the analyst needs to address any comments from the peer review of the existing conditions model in not only the existing (parent) model but also in any of the design year (child) models under development.

2.4 Constructing the Traffic Model

Construct and code the traffic model in accordance with the recommendations of the user guides/manuals for the applicable microsimulation software platform. When developing the model, the analyst *should* consider the following best practices:

- Use aerials or design plans as background images to aid in the review
- Minimize the amount of non-link space (connectors in Vissim) where practical
- Label major roadway segments
- Avoid the use of link-specific adjustment factors as much as possible. When their use is necessary, associate link-specific adjustment factors with roadway geometry or software limitations. This will make it easier to assess whether the adjustment factor is applicable for other modeling scenarios.
- Avoid introducing new driving behaviors in the design year, build (ALT) beyond those previously included in the existing models. When necessary, limit the use of new driving behaviors to locations where there have been significant changes in roadway geometry.

Figure 2.1 Example of a Typical Traffic Model Tree



2.5 Deliverables

It is generally advantageous to establish a list of deliverables prior to beginning development of the traffic models. This list will identify all the documents, videos, computer files, and other items that the project team will need to produce. Early identification of the list of deliverables can clarify project expectations and assist with defining resource needs. Typical deliverables include the following, among others:

- Traffic Forecasting Methodology Report, typically will include the following attachments
  - Design Hour/K-Factor Selection Methodology
  - Forecasting and O-D Development Methodology
  - Traffic Forecasts
  - Traffic Volume Balancing Methodology
- Traffic Analysis Tool Selection Memoranda
- Modeling Methodology Reports for each model, typically will include the following attachments
  - Existing Traffic Data (e.g., traffic volumes, speeds, queuing, etc.)
  - Exhibit Illustrating the Project Design Plans/Improvements
  - Tables Showing Validation Checks
- Microsimulation Software Files (provide for all temporal analysis periods and analysis scenarios/alternatives)
- DT2290
- DT2291 for each model

For sample formats or questions on any of the above deliverables, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

16-20-3 Measures of Effectiveness (MOEs) September 2019

3.1 Types of MOEs for Validation

The project's purpose, need, and objectives typically dictate which MOEs the analyst *should* use for reporting the performance measures of the traffic model. The MOEs chosen for validation of the traffic model; however, are dependent on several factors including, but not limited to, the availability and quality of data, the size of a model, the capability of the microsimulation software, the purpose of the model, and the project scope. The following focuses on the MOEs chosen for validation of the traffic model.

3.1.1 Traffic Volumes

It is critical to validate traffic volumes on the roadway link level and the turning-movement level for every microsimulation model, regardless of size or complexity. There are several data sources for traffic volumes with varying levels of availability and data quality. Some of these resources include manual counts and various detection methods (e.g., loop, microwave, radar, video, etc.). Sources available in Wisconsin include the following, among others:

- WisDOT interactive count map: WisDOT TCMap (Traffic Count Map) link
- Wisconsin Hourly Traffic Data: WisTransPortal, Wisconsin Hourly Traffic Data Web Access Portal
- V-SPOC detector database: WisTransPortal, V-SPOC: Volume, Speed and Occupancy Application Suite

The BTO-TASU Data Hub provides a list of additional data sources with a brief description of types of data available through each source, a hyperlink to the primary data source, and notes to consider when selecting a particular data source. Prior to conducting specialized counts, contact WisDOT regional traffic staff to determine whether there are other data sources available for the project study area. Review, verify, and document the validity of the volume data prior to developing the traffic model.

3.1.2 Traffic Speeds

Validation tests for traffic speeds may be representative of spot speeds or segment speeds. Common sources for spot speed data include, loop detectors, radar detection, or other resources. Common sources for segment speed data include, Bluetooth detectors, probe data, or floating car studies. Document the methodology used to collect and calculate the spot and segment speeds. Review, verify, and document the validity of the traffic speed data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

Larger-scale traffic models may rely on a combination of spot speed and segment speed validation, while models that are smaller in length may rely more on spot speed validation. Where possible, collect and report out spot or segment speed in 15-minute intervals.

Discuss the type of speed data required for model validation with WisDOT regional traffic staff during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

3.1.3 Travel Times

Travel time validation is a common MOE used for freeway models and arterial corridors. The availability and quality of travel time data has become better in recent years due to advancement in probe data and Bluetooth technologies. Common sources for travel time data include Bluetooth detectors, probe data, or floating car studies. Where possible, collect and report out travel times in 15-minute intervals. Review, verify, and document the validity of the travel time data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

If using both segment speeds and travel times for model validation, the roadway limits used for these comparisons *should* be of different lengths. It is desirable to have the travel time comparisons use longer lengths than the segment speed comparisons. The intent of the travel time validation test is to capture vehicle behavior at a larger scale while the intent of the speed validation test, whether spot or segment, is to capture the behavior at a more local level.

Discuss the limits, segmentation, and type of travel time data required for model validation with the regional traffic engineer during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

3.1.4 Intersection Queue Lengths

Intersection queue length is a common MOE used for arterial corridors or smaller freeway/interchange models where collection of other MOEs may not be possible or fiscally feasible. If there is significant congestion at an

intersection under existing conditions, the queue lengths may vary significantly day-to-day or even 15-minute period to 15-minute period. Video detection, loop detection, and field observations are common ways to collect intersection queue data. The methodology for the collection of intersection queues involves some subjectivity and requires sound judgment of vehicle speeds and the number of vehicles to include in the queue (e.g., *should* the vehicle queue include slow moving vehicles or just stopped vehicles?). Review, verify, and document the validity of the queue data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

If using queues for validation, the project team *should* consider the following questions prior to data collection and when performing comparisons to modeled data.

- If analyzing an interchange, do the exit ramp queues extend back to or close to the mainline?
- Do intersection queues spill back into the adjacent intersection(s)?
- Does data collection capture the average, 95th percentile, or maximum queue lengths? Is the desired type of queue length for model validation easily extractable from the selected microsimulation software?
- For multiple lanes, such as triple left-turn lanes, do the queue measurements and comparisons reflect the lane-by-lane queues or the worst-case lane queue?
- How, and at what frequency (every cycle, every 15 minutes, etc.), *should* field measurements of queues occur?

Discuss the locations of intersection queues required for model validation with WisDOT regional traffic staff during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

3.1.5 Lane Utilization

Lane utilization, or the volume/percentage of vehicles using a given lane relative to the other lanes in the same direction, is a common MOE used for freeway corridors or arterial corridors with complex intersection interaction. In Wisconsin, it may be possible to approximate lane utilization from lane-by-lane volume data available through the WisTransPortal, V-SPOC detector database ran by the Wisconsin Traffic Operations and Safety (TOPS) Lab (WisTransPortal, V-SPOC). The V-SPOC database has the most robust coverage in the Madison and Milwaukee metropolitan areas, with more sporadic coverage for other parts of the state. Other methods to collect lane utilization data include manual counts, time-lapse aerial photography, or video detection. Review, verify, and document the validity of the lane utilization data prior to developing the traffic model. When reviewing lane utilization data, be cognizant of the lane numbering scheme (i.e., lane numbering goes from inside/median lane to outside/shoulder lane or vice versa), as the lane number scheme can vary depending on the type of detector or software. Coordinate with WisDOT regional traffic staff as appropriate.

The analyst may use lane utilization as a validation metric for the traffic model; however, they *should* first carefully evaluate and document the quality and availability of the existing data. If used as a validation metric, perform lane utilization comparisons at critical locations within the corridor. Discuss the need for and locations of lane utilization comparisons with WisDOT regional traffic staff during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

3.1.6 Lane Density

Observed density is a less common metric used for model validation. Video detection or time-lapse aerial photography may allow for the collection of lane density information. Coordinate with WisDOT regional traffic staff prior to using lane density as a validation metric. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

3.1.7 Bottleneck Locations

Bottlenecks signify where recurring congestion occurs within a network. They have a direct relationship to travel times, traffic speeds, and intersection queue lengths. Validation of bottlenecks in a traffic model typically occurs through conducting visual observations or by creating spatiotemporal graphics displaying observed versus modeled MOEs. If observations indicate the presence of recurring congestion (a bottleneck) under existing conditions, the analyst *should* use this MOE as a validation metric.

3.1.8 Throughput

Throughput is a less common metric related to flow rates through an intersection or freeway segment. Potential ways to observe throughput include manual counts, video detection, or other methods. WisDOT *should* approve throughput as an acceptable MOE for model validation prior to its use.

3.1.9 Visual Observation

Visual observation is a good preliminary or secondary check for validating the model results to field or benchmark data, specifically for bottlenecks or queues, however, visual observations **shall not** be the sole MOE used for model validation. Instead, see the MOE descriptions for bottleneck or intersection queue validation.

3.1.10 Weaving Volumes

If existing O-D data is available, the analyst *should* evaluate weaving volumes. Common sources of O-D data included Bluetooth detection, video detection, time-lapse aerial photography, and field observations. In absence of field data, it may be possible to conduct a high-level evaluation of weaving percentages using data from travel demand models. Comparisons of weaving volumes are typically applicable to freeway weaving; however, it could also apply to arterials with complex intersection interactions.

If field data is the basis of the weaving volumes/patterns used for validation, the project team *should* document the conditions during field data collection. This may include construction activities, atypical congestion, weather, if school is in session, or other pertinent information.

If a travel demand model is the source of the weaving volumes/patterns used for validation, the project team *should* document general inputs and calibration notes about the travel demand model. These may include the version, socioeconomic data, base year, horizon year, anticipated developments in the project area, or other pertinent information.

If used as a validation metric, perform weaving volume comparisons at critical locations within the corridor. Discuss the need for and locations of weaving volume comparisons with WisDOT regional traffic staff during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

Review, verify, and document the validity of the weaving volume data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

3.1.11 Intersection Delay

Intersection delay dictates the intersection level of service (LOS), noting that if the volume-to-capacity ratio (v/c) exceeds 1.0 the LOS is F regardless of the delay value. Due to the difficulty of the data collection and the variance in day-to-day and minute-to-minute delays at congested intersections, it is not very common to obtain field data on intersection delay. Delay is typically more challenging to quantify than queue lengths, which also provide insight as to how the intersection operates at the approach level. WisDOT *should* approve intersection delay as an acceptable MOE for model validation prior to its use.

3.1.12 Capacity

Like throughput, capacity is a less common metric related to how much traffic an intersection, arterial segment, or freeway segment can handle. It may be possible to gather field capacity data during oversaturated conditions using manual counts, video detection, or other methods. Oftentimes, the analyst will indirectly adjust the capacity as part of the calibration process, therefore capacity may not be a suitable validation MOE. WisDOT *should* approve capacity as an acceptable MOE for model validation prior to its use.

3.1.13 Routing

Vehicle routing checks may be a qualitative exercise based on a project team's familiarity with a corridor, more of a quantitative exercise supported by O-D or demand modeling data, or a combination of both. Although a critical component of model calibration, vehicle routing checks *should not* be the primary model validation MOE.

3.2 Number of MOEs for Validation

3.2.1 Primary vs. Secondary MOEs

The project team *should* discuss, in detail, the type and number of MOEs to use for model validation with WisDOT regional traffic staff during the scoping of a project as they may have a significant effect on the project budget, schedule, and resource needs. Involve BTO-TASU, and other key stakeholders, in these discussions as appropriate.

The factors that influence the number of MOEs required for microsimulation model validation may include data availability and quality as well as project type, geometric conditions, traffic patterns, and levels of existing and anticipated congestion. The capabilities of the applicable microsimulation software may have implications on the MOEs. For example, SimTraffic has fewer capabilities when it comes to reporting weaving volumes and routing metrics than Vissim, thus these MOEs may not be appropriate for a SimTraffic model.

To assist in formulating recommendations on the type and number of MOEs to use for model validation from the least to most complex models, each MOE (see TEOpS 16-20-3.1) has either a "primary" or "secondary" designation. The validation checks for all models, regardless of the model complexity, **shall** always include a comparison of traffic volumes. Thus, traffic volumes do not have an associated primary or secondary designation.

The primary MOEs include spot speeds, segment speeds, and travel times. The secondary MOEs include lane utilization, weaving, and any other MOE that a project team may request for approval (such as intersection delay, throughput, etc.) based on available data. Depending on the purpose and objectives of a project, intersection queue lengths may be either a primary or a secondary MOE. Table 3.1 shows the primary and secondary MOE designations.

Table 3.1 Summary of MOEs for Model Validation

Metric (MOE)	MOE Designation	
Link and Turning Movement Volumes	Required for all projects	**Summary of MOEs for Model Validation** • 3 to 4 Primary • 2 to 3 Secondary • 6+ Upon WisDOT Approval
Segment Speeds	Primary	
Spot Speeds	Primary	
Travel Times	Primary	
Intersection Queues	Primary or Secondary	
Lane Utilization	Secondary	
Weaving Volumes	Secondary	
Density	Secondary Upon Approval	
Intersection Delay	Secondary Upon Approval	
Bottleneck Locations	Secondary Upon Approval	
Throughput	Secondary Upon Approval	
Capacity	Secondary Upon Approval	
Routing	Secondary Upon Approval	
Others?	Secondary Upon Approval	

3.2.2 Scoring System

The number of MOEs required for validation will vary depending on the complexity of the traffic model, which is dependent on the project type, project scope, corridor type, traffic control, roadway congestion level, and type of microsimulation tool used for analysis. To quantify the complexity of the traffic model (specifically a microsimulation traffic model), the department worked with a consultant to establish a scoring system. The same scoring system is applicable for determining the number of MOEs required for validation and defining the level of peer review required. Refer to TEOpS 16-25-2 for details on the model complexity scoring system.

Figure 3.1 provides an illustration of the traffic model level of complexity scoring system. Use Figure 3.1 in conjunction with the Traffic-Model Complexity Scoring Template (a Microsoft Office Excel based worksheet) provided in Attachment 3.1 to develop the overall complexity score for the traffic model. The project team's traffic lead or project manager, in coordination with WisDOT regional traffic staff, *should* complete the scoring template.

The overall traffic model complexity score defines the minimum number of MOEs required for model validation for the project. Depending on data availability, and the project objectives, it might be appropriate to use more than the minimum required MOEs for model validation. Ultimately, it is up to WisDOT regional traffic staff to define the type and number of MOEs to use for model validation. Refer to Table 3.2 for the complexity score associated with each MOE requirement level.

When assessing the complexity of the traffic model and number of MOEs needed for model validation, keep in mind that, due to modified roadway geometry, increased traffic volumes, reduced levels of congestion, etc., it is possible for the model complexity score to be different under future alternative scenarios than it is under existing conditions. Therefore, it is critical to consider both existing conditions and potential future alternatives (including levels of service) when defining the traffic model complexity score and the associated number of MOEs. The highest traffic model-complexity-score across all the scenarios (existing and future alternatives) dictates the number of primary and secondary MOEs required for base model validation.

Figure 3.1 Traffic Model Complexity Scoring Diagram

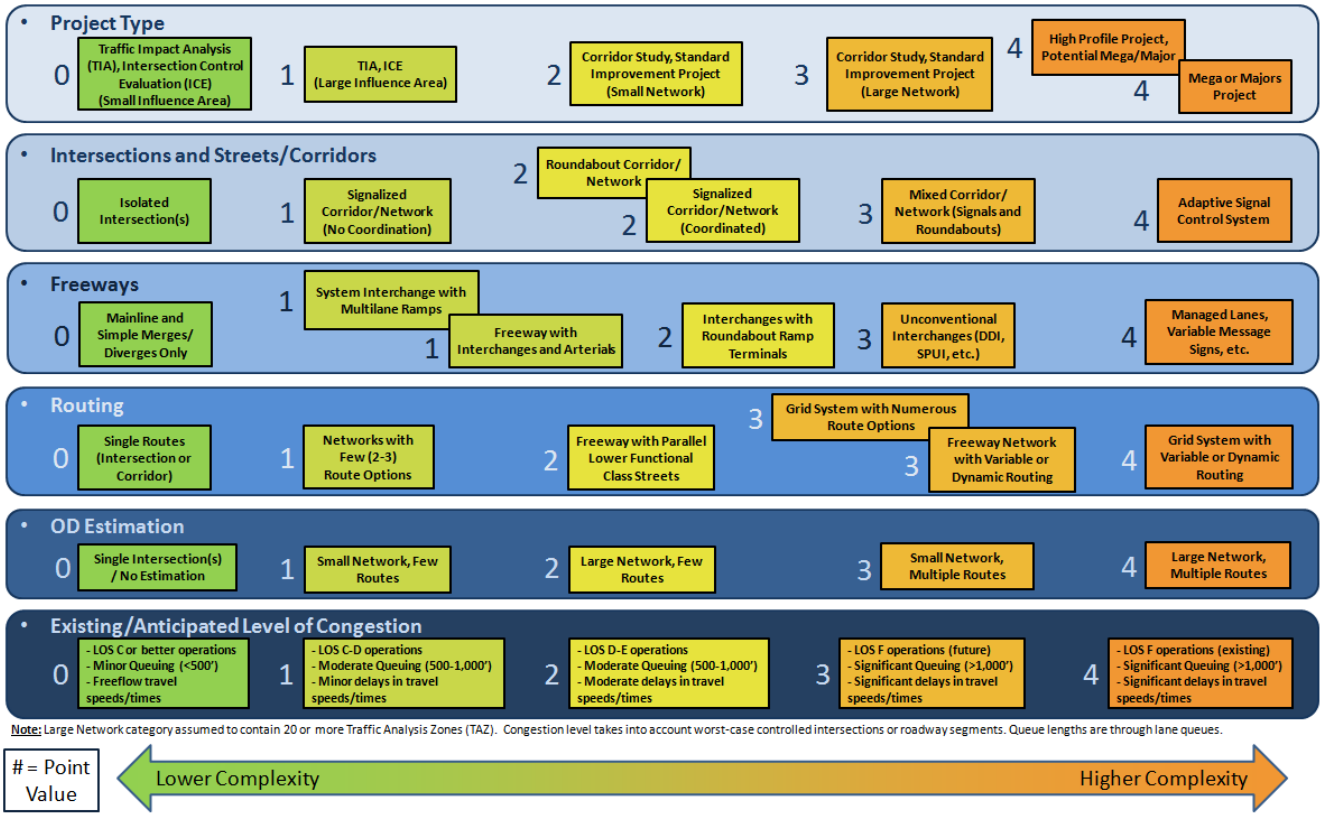


Table 3.2 Number of MOEs Required for Model Validation

Model Complexity Score (a)	Minimum # of MOEs Required for Model Validation (b)
0 – 3	1 to 2 Primary MOEs
4 – 7	1 to 2 Primary MOEs 1 Secondary MOE
8 – 10	2 to 3 Primary MOEs 1 Secondary MOE
11+	2 to 3 Primary MOEs 1 to 2 Secondary MOEs

(a) Model complexity score from the Traffic Model Complexity Scoring Template, Attachment 3.1
(b) Minimum MOEs are those in addition to link and turning movement traffic volumes

Use the scores and recommendations shown in Table 3.2 as a guide only. Professional judgment and coordination with WisDOT staff needs to factor into the decisions on the number and type of MOEs to use for validation of the traffic microsimulation model. Document all assumptions and decisions regarding the number and type of MOEs to use for model validation within the modeling methodology report and other project memoranda as appropriate.

LIST OF ATTACHMENTS

Attachment 3.1 Traffic Model Complexity Scoring Template

16-20-4 Microsimulation Analysis Software September 2019

4.1 WisDOT Supported Software

WisDOT currently supports the use of the following programs for microsimulation traffic analysis:

- SimTraffic, Trafficware
- Vissim, PTV Group

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and

build of the above software that WisDOT currently supports.

Prior to January 1, 2018, WisDOT supported the use of Paramics. As such, projects that initiated the microsimulation traffic analysis using Paramics prior to January 1, 2018 may continue to use Paramics for the duration of the project. However, if there is a need to make major revisions to the traffic models (e.g., use of different base year conditions), the analyst should consider switching the traffic models over to Vissim. Consult with the WisDOT regional traffic contact or BTO-TASU to determine whether it is appropriate to switch software programs.

Do not switch from one software platform to another without first consulting with BTO-TASU. TEOpS 16-20-11 provides additional information on when to consider upgrading the software for a microsimulation model that is either already complete or is in the development process.

4.2 SimTraffic Overview

Trafficware, a CUBIC company based out of Sugar Land, Texas, is the developer for both SimTraffic and its companion software Synchro. SimTraffic is the microsimulation platform and Synchro is the macroscopic (or deterministic) platform. Trafficware typically releases major updates to the Synchro/SimTraffic Studio every two to three years.

The Synchro platform is the primary mechanism for drawing the roadway network and coding in several of the parameters for roadway geometry and traffic control. The SimTraffic platform is where the analyst can code in various driver behavior and vehicle characteristics. Both SimTraffic and Synchro use a link-node structure. SimTraffic, tracks every vehicle in the traffic system on a 0.1-second interval. Typical MOEs available through SimTraffic include travel time, vehicle queues, and intersection delay.

WisDOT only accepts SimTraffic for arterial analysis and this software is best suited for signalized corridors. Oftentimes, the analyst will use SimTraffic to observe driver behavior and conduct a “reality check” on the Synchro outputs. SimTraffic may also be beneficial for reporting the vehicle queues, especially when vehicles spill-out of the turn lane and block through traffic. If the primary purpose of the SimTraffic model is to conduct “reality checks”, calibration and validation of the traffic model may not be necessary. However, prior to using the model outputs from SimTraffic (or any other microsimulation analysis tool) for project or study decisions, especially any related to critical aspects of the design, the analyst **shall** calibrate and validate the model in accordance with TEOpS 16-20-5 and TEOpS 16-20-8, respectively.

4.3 Vissim Overview

The PTV Group, a company based out of Karlsruhe, Germany (with U.S. offices in Oregon and Virginia), is the developer for the microsimulation software Vissim. The PTV Group typically releases major updates to the Vissim software once a year.

Vissim uses a link-connector structure. Vissim can model any facility, though it is especially known for being able to accurately represent complex arterial corridors. It provides great flexibility but can be time-consuming to use for modeling due to the many aspects of the software that enable that flexibility. Vissim has many parameters to adjust and ways to replicate real-world driver behaviors, leading to its applicability in almost any situation where deterministic tools and SimTraffic are not sufficient. Typical MOEs available through Vissim include travel time, speed, vehicle queues, intersection delay, and density, though Vissim provides ways to get data from the simulated vehicles at any granularity.

4.4 Other Microsimulation Software

Microsimulation analysis requiring the support, review, or input from BTO **shall** use one of the WisDOT supported microsimulation software packages. BTO-TASU conducts periodic reviews/evaluations of the microsimulation tools to assess the need to add or remove microsimulation tools to/from WisDOT’s traffic analysis toolbox. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) to request consideration of additional microsimulation software tools.

4.5 Selecting a Microsimulation Software

Consider the needs of the project along with the strengths and limitations of the software when selecting the most appropriate tool to use for developing the microsimulation model. In general, if you already have a Synchro model and you are looking at a relatively small scale/simple arterial network, consider the use of SimTraffic. All other scenarios, specifically freeway models, will typically require the use of Vissim for microsimulation analyses. As of January 1, 2018, do not initiate any new microsimulation analyses using Paramics. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

Document the rationale for choosing the selected microsimulation software tool in the Traffic Analysis Tool

Selection memoranda and submit to the WisDOT regional traffic staff for approval.

16-20-5 Microsimulation Model Calibration May 2021

5.1 Introduction

Calibrating a traffic model requires the analyst to review and potentially adjust various model parameters (e.g., global and local headway and reaction times, driver aggressiveness, etc.) to get the traffic model to reproduce conditions observed in the field. Failure to calibrate a microsimulation model properly can produce unrealistic or misleading results. Therefore, prior to using the microsimulation model outputs for critical design decisions, the analyst **shall** calibrate the traffic model.

5.2 Calibration Process

The model calibration process is often very complex, labor intensive, and resource intensive and may take more time to complete than the initial development of the traffic model. Modifications to the input parameters in one component of the traffic model may have unexpected impacts in other areas of the traffic model. Skipping the model calibration process is not permissible and there is no shortcut to completing model calibration. However, applying the following principles will provide structure and efficiency to the calibration process.

When developing the model, the analyst *should* strive to balance model perfection with practicality. To help achieve this balance, BTO-TASU developed both quantitative and qualitative validation thresholds for microsimulation models that are dependent on the purpose and need of the traffic model. See TEOpS 16-20-8 for additional details on the WisDOT microsimulation validation thresholds.

5.2.1 Global, Categorical and Local Calibration Factors

The analyst can apply and modify the input parameters within a microsimulation model on a global, categorical, or localized level. For the purposes of WisDOT policy, global, categorical, and localized calibration factors have the following definitions:

Global Factors: Global factors are those factors/parameters that affect the entire model.

Categorical Factors: Categorical factors are those factors/parameters that affect a category of the links within the model (e.g., every off-ramp, all weaving segments, major street signalized intersection approaches, etc.).

Localized Factors: Localized (or link-specific) factors are those factors/parameters that only influence vehicles while they are driving on a link, a short series of connected links, or through a specific intersection within the model.

When calibrating a traffic model, the analyst *should* adjust the global and categorical parameters first and *should* use localized/link-specific factors sparingly and only for the final fine-tuning of the model. Document and justify the use of any localized/link-specific factors by associating them to limitations of the microsimulation software or specific geometric conditions that may influence driving behavior (e.g., a short weaving segment). Relating the localized adjustment factors to geometric conditions or software limitations makes it easier to assess whether to carry the adjustments forward from existing year to alternative scenarios.

5.2.2 Unreleased, Blocked, Stuck/Stalled Vehicles

For purposes of WisDOT policy, unreleased, blocked, and stuck/stalled vehicles have the following definitions:

Unreleased Vehicles: Unreleased vehicles represent those vehicles that were able to enter the network but were unsuccessful in traveling through the model and were thus not able to exit the network. Typically, the presence of unreleased vehicles results in a downstream traffic volume undercount and gives the false impression that downstream operations are better than actuality.

Blocked Vehicles: Blocked vehicles are those vehicles that are unable to enter the network at their desired time due to downstream vehicle queues. When vehicle blockage occurs, the traffic model will not be able to capture the true demand on the system and will thus not be able to accurately report out MOEs such as delay and vehicle queues. If the vehicle blockage in the model matches field conditions, it may be necessary to extend the link or temporal limits of the model to accommodate the entire queue (i.e., congestion). See TEOpS 16-20-2 for additional details on the spatial and temporal model limits.

Stuck/Stalled Vehicles: Stuck or stalled vehicles are vehicles that unexpectedly slow or stop partway through their route. They can cause backups that do not exist in the field.

The presence of unreleased, blocked, or stuck/stalled vehicles within the traffic model is an indicator of congestion within the model but may also be a sign of a serious model calibration problem. When calibrating the traffic model, the analyst *should* consider the magnitude and location of the blocking that occurs. If the blocking occurring in the traffic model does not reflect field conditions, or does not meet expectations, reevaluate the spatial and temporal model boundaries, warm-up/cool-down factors, and demand profiles (see TEOpS 16-20-2.1) as they may have a direct effect on issues related to blocked vehicles. It may not be necessary, or realistic, to prevent blocking of all vehicles, specifically for the design year, no-build, or FEC constrained scenario.

Vissim contains a feature, referred to as "diffusion", that allow the analyst to specify a maximum allowable time a vehicle can remain in the same position before removing the stuck/stalled vehicle from the model as if it never existed. Using this feature leads to undercounting vehicles and is not realistic. The use of "diffusion" in the pre-calibration model building can be helpful, but it is not acceptable for a final calibrated model.

5.2.3 O-D Matrix Estimation

Oftentimes the analyst may use a separate O-D matrix estimating software (e.g., Cube by CITILABS, TransCAD by Caliper, Visum by PTV Group, etc.) to develop the O-D matrices for the microsimulation models. Use of a O-D matrix estimating software that is separate from the microsimulation model may be useful, as it will allow the O-D matrix to reflect true demand without influence from network coding problems. However, intersection or other network coding errors within the microsimulation model may affect throughput such that the microsimulation model outputs may not reflect the same volumes as those developed by the O-D matrix estimation tool. Therefore, for preparing the model validation checks, the analyst **shall** run the volumes through the network using the primary modeling software. It is not acceptable to prepare the model validation checks using statistics from the O-D matrix estimation software. Refer to TEOpS 16-5-20 for additional details on the development and use of O-D matrices in microsimulation models.

5.3 Traffic Volume Balancing

Usually the available traffic data for a microsimulation study area is unbalanced. For example, starting at an Automatic Traffic Recorder (ATR) station on a freeway mainline and proceeding in the direction of travel, adding the raw on-ramp volumes, and subtracting the raw off-ramp volumes, the result will rarely match the volume measured at the next downstream ATR. This happens for three main reasons:

- Often, due to limited resources, it may be necessary to collect intersection or ramp traffic counts for multiple locations along the corridor at various times/days.
- There are inherent imperfections in the data collection process. For example, if a vehicle is changing lanes as it drives over a detection loop, the detector loop could count the vehicle twice (or not count it at all) or, with respect to microwave detectors, a larger vehicle could occlude a smaller vehicle making the smaller vehicle undetectable.
- Data collected manually (such as intersection turning counts) is subject to human error.

Microsimulation models cannot account for these imperfections, so the analyst *should* balance the data to create a mathematically consistent volume set. In general, the analyst *should* use balanced volumes as the traffic volume targets for the existing conditions model. The use of balanced volumes usually removes statistical outliers from the target volume set, making it easier to achieve validation targets. Refer to TEOpS 16-5-15 for details on volume balancing methodologies.

5.4 Vehicle Characteristics and Classification

When coding and calibrating the traffic model it is important to verify that the vehicle composition (vehicle type, classification, operating characteristics, etc.) included in the model accurately represents that which is present in the project study area.

When available, the analyst *should* use field data to determine the appropriate vehicle mix or classifications, specifically as it pertains to the volume or percentage of heavy vehicles, buses, high-occupancy vehicles (HOVs), pedestrians/bicycles, and other vehicle types included in the analysis. Oftentimes the microsimulation model will use separate demand profiles or O-D matrices for heavy trucks and passenger vehicles. However, depending on the project purpose, it may be necessary to have additional demand profiles or O-D matrices for other travel modes as well.

The format for entering in the specifics on vehicle characteristics and classifications varies depending on the microsimulation software package. However, most software packages have predefined default values that

specify various vehicle characteristics including, but not limited to, vehicle length, vehicle acceleration/deceleration rates, and vehicle occupancy. The default values are a good starting point; however, the analyst *should* adjust the default values as appropriate to reflect local conditions.

SimTraffic automatically includes the default values as part of the initial model set-up. Vissim, however, requires the analyst to load in the vehicle characteristics files. BTO-TASU worked with a consultant team to develop Wisconsin-specific fleet default values for Vissim. Analysts *should* use the Wisconsin-specific fleet default values for the initial input values into Vissim and adjust them based on project-specific field data as appropriate.

Details on the Vissim WisDOT vehicle fleet settings and the "WisDOT Defaults inpx" Vissim input files are available for download on the BTO Traffic Analysis, Modeling and Data Management Program area webpage.

5.5 Route Assignment

The analyst *should* develop the route assignment in coordination with WisDOT regional traffic staff, as well as BTO-TASU and other key stakeholders as appropriate.

16-20-6 Calibration Parameters and Simulation Settings April 2025

6.1 Overview

Microsimulation models contain many adjustable parameters, and the relevant adjustments vary for each software package. If a model fails to satisfy the validation thresholds, it is essential for the analyst to adjust the appropriate parameters to correct the situation. For example, adjusting driver aggressiveness or link cost factors will not successfully compensate for a flawed O-D matrix. The user manuals and technical support service for each software product provide some guidance on calibration parameters, but these sources may not be privy to the local or specific characteristics for the project study area. Local peer/user groups such as the ITE Simulation and Capacity (SimCap) user group or other independent experts with experience in the relevant software may also provide valuable insight with respect to which model calibration parameters to adjust during the calibration process.

The following text provides details on the key parameters of the traffic model that the analyst *should* consider during the model calibration process. The guidance below is specific for SimTraffic and Vissim; however, the general principles are applicable for all microsimulation software packages. This list is not all-inclusive and *should* only serve as a guide to the project team.

6.1.1 Network Coding

Network coding establishes the horizontal and vertical geometry of the roadway network, including intersection spacing and roadway curvature. Network coding also includes appropriate use of settings such as link free-flow speed and turning speeds.

6.1.2 Intersection Traffic Control and Ramp Metering

Intersection controls are devices that regulate traffic flow at intersections (e.g., signals, roundabouts, stop control, and ramp meters). Elements of the signals/ramp meters may include the controller type, detector placement, signal heads, signal groups, coordination between signals, signal phasing, and signal/ramp meter-timing plans.

6.1.3 Closures, Restrictions, and Incidents

Closures represent temporary or permanent roadway segment, link, or lane closures (i.e., no traffic can use that particular roadway segment, link, or lane). Restrictions represent links or lanes that limit travel, either temporarily or permanently, to specific vehicle types (e.g., lanes designated for HOV or lanes restricting truck use). Incidents include simulated vehicle breakdowns, crashes, etc.

6.1.4 Entrance Ramps

Entrance ramps or freeway merge areas typically require careful coding in microsimulation. This is typically applicable to parallel freeway entrance ramps, although there are instances where this feature is appropriate for arterials as well. The reviewer *should* review the lane utilization upstream of the entrance ramp, the aggressiveness of the merging vehicles (e.g., minimum time on entrance ramp, driver headway factors), and the length of the acceleration lane and taper parallel to the entrance ramp.

6.1.5 Lane Use Parameters

Lane use parameters control the amount and destination of the traffic using each lane. A typical application of these parameters is to pre-position vehicles in advance of a fork in the road.

6.1.6 Zone Structure/Vehicle Inputs

Zone structure and vehicle inputs define where and how traffic loads into the network.

6.1.7 O-D Matrices, Demand Profiles & Time Periods

O-D matrices contain the network demand patterns (number of trips traveling between each pair of zones). Time periods and demand profiles control the timing for the release of vehicles into the network (e.g., are the vehicles released at a steady rate or at a gradually increasing/decreasing rate). In some cases, it is necessary to use multiple O-D matrices or demand profiles (e.g., there may be one matrix for cars and a second matrix for trucks).

6.1.8 Core Simulation Parameters

Core simulation parameters affect fundamental aspects of vehicle behavior in the network, such as driver aggressiveness and the willingness to merge into small gaps. Default values are acceptable for some parameters, but other parameters require project- or area-specific values.

6.1.9 Routing Parameters/Vehicle Routes

Routing parameters influence the way vehicles travel through the network. If coded improperly, these controls can cause unrealistic or erratic routing.

6.1.10 Vehicle Types and Proportions

The proportion and types of vehicles (such as trucks, buses, and HOVs) influence the overall performance of each part of the network.

6.1.11 Stuck/Stalled Vehicles

Stuck or stalled vehicles are vehicles that unexpectedly slow or stop partway through their route. They can cause backups that do not exist in the field.

6.1.12 Special Features

Special features include site or study-specific items such as the use of detectors, car parks, variable message signs, special purpose lanes, speed harmonization, public transit routes, toll lanes, toll plazas, pedestrian modeling, special graphics, plugins, or scripts, among others.

6.2 SimTraffic Calibration Parameters

6.2.1 Interval Settings

A critical component of performing a SimTraffic simulation is to set up appropriate simulation intervals. The default settings for the simulation interval include a 3-minute seeding period and a 10-minute analysis period. To be more compliant with HCM analysis methodologies and common microsimulation practices, the modeler *should* extend the seeding period and analysis period beyond these default values. WisDOT recommends using the interval settings setup shown in Table 6.1 for SimTraffic simulation models if SimTraffic is one of the project's official traffic analysis tools (i.e., the project will rely on SimTraffic volume and operation reports to make critical decisions).

The interval setting shown in Table 6.1 are not necessary for applications such as conducting reality checks on Synchro outputs, creating videos for public involvement, or performing high-level screening of alternatives. For high-level applications, a seeding period and one 15-minute analysis interval may be appropriate.

Table 6.1 Recommended Interval Settings for SimTraffic

Interval	Seeding	Recording	Recording	Recording (Peak)*	Recording
Duration	7 mins**	15 mins	15 mins	15 mins	15 mins
PHF Adjust	No	No	No	Yes	No
Anti-PHF Adjust	No	Yes	Yes	No	Yes
Random Seed	Non-zero for repeatable results; Zero for random seeding				

*Recommendation is to have the peak 15-minute interval be the 2nd or 3rd interval in the simulation.
**Seeding interval *should* be long enough for one vehicle to travel through the network or longer than the maximum cycle length in the network, whichever is greater

6.2.2 Parameter Discussion

Attachment 6.1 provides a list of the parameters, along with recommended ranges, that the modeler will typically adjust while calibrating a SimTraffic model. This list provides a good starting point for the parameter value adjustment. Unless field data or experience supports doing otherwise, modify only those parameters

recommended as settings to adjust. Obtain WisDOT staff approval prior to modifying non-recommended adjustment parameters.

Refer to the *Synchro Studio 12User Guide* (4), for some tips on calibrating a SimTraffic model. Departing from the Synchro/SimTraffic defaults may not be necessary to validate modeled traffic volumes at moderately congested locations. However, at highly congested locations, it may be necessary to modify the Synchro/SimTraffic defaults to calibrate and validate the traffic model. If validating to intersection queue data, the analyst may need to make minor adjustments to settings such as turning speeds (based on geometry of the intersection) or local headway factors (change in small increments only) to improve the locations with long queues.

6.2.3 Common Errors and Warnings

Chapter 25 of the *Synchro Studio 12 User Guide* (4) provides a list of common errors and warning messages along with potential causes and tips for resolving the issues. This list of common errors and warnings may serve as a beneficial resource during the calibration process.

6.3 Paramics Calibration Parameters

As noted in TEOpS 16-20-4.3, prior to January 1, 2018, WisDOT supported the use of Paramics. As such, projects that initiated the microsimulation traffic analysis using Paramics prior to January 1, 2018 may continue to use Paramics for the duration of the project. Thus, it is possible that Paramics will still be in use in Wisconsin for several more years necessitating the need to provide some guidance on calibrating Paramics models, specifically for the alternative model development.

Attachment 6.2 provides a list of the parameters, along with recommended ranges, that the modeler will typically adjust while calibrating a Paramics model. This list provides a good starting point for the parameter value adjustment. Unless field data or experience supports doing otherwise, modify only those parameters recommended as settings to adjust. Obtain WisDOT staff approval prior to modifying non-recommended adjustment parameters.

6.4 Vissim Calibration Parameters

Given the complex and iterative nature of model calibration and the vast number of calibration parameters provided in Vissim, it is a good practice to start calibration using parameters that a modeler is certain about based on field data or experience. If additional calibration is still necessary, the analyst may move to parameters that they are less certain about but willing to experiment with using different values. Attachment 6.3 provides a list of the parameters, along with recommended ranges, that the modeler will typically adjust while calibrating the Vissim model. This list provides a good starting point for the parameter value adjustment.

The following typically-used parameters all have direct impacts on model performance. Since different methods with multiple parameter combinations may exist to calibrate a specific modeling condition in Vissim, the analyst *should* first adjust the global parameters and then, only if necessary, adjust the local parameters.

6.4.1 Vehicle Fleet

Use the “WisDOT Defaults inpx” vehicle compositions for the initial input values. Based on local project conditions and road types included in the model, it may be necessary to refine or adjust the vehicle classifications or speed distributions. Direct any specific questions on adjusting the vehicle fleet in Vissim to BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

6.4.2 Simulation Step

In most cases, use 10 seconds per simulation second.

6.4.3 Car Following Model for Freeways

For freeway segments, apply the Wiedmann 99 car following model. Standstill distances (CC0), headway time (CC1), and following variation (CC2) have significant impacts on the car following behaviors. Higher values represent more cautious driving behaviors and lower roadway capacity.

6.4.4 Car Following Model for Urban Arterials

For urban arterials, apply the Wiedmann 74 car following model. Higher values of average standstill distance, additive part of safety distance, and multiplicative part of safety distance means more distance between vehicles and therefore lower roadway capacity.

6.4.5 Lane Change Parameters

Lane change parameters are the same for both freeway and arterial segments and the analyst *should* adjust

them to match field conditions, especially at merging, diverging, and weaving areas.

6.4.6 Local Car Following and Lane Change Parameters

The analyst can define additional car-following and lane-change parameter sets separately as global settings and then only apply them to local links and connectors where driving behaviors are different from global definitions.

6.4.7 Connector Lane Change Distance

The default lane change distance for all connectors is 656 feet and is typically representative of arterials. The analyst can and *should* adjust the default lane change distance higher or lower as needed, especially for freeways and closely-spaced intersections. Additionally, there is an option to have this lane change distance increase for each lane that a vehicle must cross to travel via the connector. The analyst *should* adjust the lane-change distance parameters to avoid unrealistic prepositioning and last-minute lane-changing behavior that may arise.

6.4.8 Other Adjustable Parameters

Unless field data or experience supports doing otherwise, modify only those parameters recommended as settings to adjust. Obtain WisDOT staff approval, prior to modifying non-recommended adjustment parameters.

LIST OF ATTACHMENTS

Attachment 6.1	SimTraffic Calibration Parameters
Attachment 6.2	Paramics Calibration Parameters
Attachment 6.3	Vissim Calibration Parameters

16-20-7 Simulation Runs April 2025

7.1 Need for Multiple Simulation Runs

Real-world traffic varies considerably from day to day, and even from minute to minute. Microsimulation models attempt to mimic this effect by using stochastic (randomized) variables to account for variations in driver behavior and departure time. The source of this stochasticity is an algorithm within the microsimulation software package known as a pseudo-random number generator. Since purely random generation of numbers is mathematically problematic, pseudo-random number generators require a seed that initiates the underlying algorithm. This algorithm then generates a stream of millions or more apparently random numbers, which determine the release pattern of vehicles (i.e., how many and when) and the distribution of driver characteristics such as speed, among others, for each microsimulation model run. If the microsimulation software is functioning correctly, two model runs with the same seed will produce identical results.

If the analyst were to conduct only one run of the simulation model, there would be no way to assess whether the model was a good representation of reality as, depending on the seed value and the validity of the model, the results could represent a typical day, an abnormal day, or they could mispresent reality altogether. Running multiple runs of the model with different seed values allows the analyst to get a better sense as to whether the model results accurately reflects the range of traffic conditions encountered in the real world. Thus, during the calibration and validation process, the analyst **shall** complete multiple simulation runs.

7.2 Simulation Seeds

Microsimulation software packages use several types of pseudo-random number generating algorithms, potentially including multiple options within each package, but due to their pseudo-random nature, every type of algorithm will eventually begin to repeat if left running continuously. At the point of repetition, the algorithm will start generating the same stream of numbers in the same order. With certain types of pseudo-random number generators, the seed type can dictate the length of the resulting stream of numbers; zero and even numbers can cause some algorithms to repeat quickly or have other undesirable effects. Out of an abundance of caution, WisDOT has historically and will continue to require the use of prime numbers as seeds.

The purpose of this policy is to assure the uniform use of prime numbers as seeds, provide transparency, and allow for the reproducibility of results. It has long been good modeling practice to record the seed number associated with each model run, but this has never been a formal requirement. With adoption of the formal peer review policy (see TEOpS 16-25), it has become necessary to document how the results recorded can be replicated. To ease this process and ensure consistency statewide, WisDOT is specifying the use of the seed values listed in Table 7.1 for all traffic model scenarios. Typically, a calibrated model will not require more than

30 simulation runs. If there is a desire to conduct additional runs, the analyst *should* carefully weigh the potential benefits of conducting additional runs against the additional resource requirements. If warranted, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) to receive seed values for additional runs.

Table 7.1 Seed Values

Run Number	Seed Value	Run Number	Seed Value	Run Number	Seed Value
1	**199**	11	**7**	21	**23**
2	**409**	12	**157**	22	**29**
3	**619**	13	**307**	23	**13**
4	**829**	14	**457**	24	**103**
5	**1039**	15	**607**	25	**193**
6	**1249**	16	**757**	26	**283**
7	**1459**	17	**907**	27	**373**
8	**1669**	18	**5**	28	**463**
9	**1879**	19	**11**	29	**28657**
10	**2089**	20	**17**	30	**514229**

Notes:

1. To simplify the process of running the models using the specified seed numbers (especially for Vissim), the seed numbers above represent prime numbers. The first ten runs are prime numbers that have an increment of 210 between each seed value (runs 11-17 have an increment of 150, runs 18-22 have an increment of 6, and runs 23-28 have an increment of 90). To run the first ten runs in Vissim, enter the first seed (199) in the "Random Seed" box under Simulation>Parameters. Set the "Number of runs" to the desired number (up to 10), and then enter 210 as the "Random seed increment". This allows Vissim to complete runs 1-10 with the seed values shown above.
2. The SimTraffic simulation engine generates sequential seeds for multiple runs, the seed values shown above are **not** applicable

7.3 Number of Simulation Runs - Background

The purpose of this policy is to provide transparency and consistency with the determination of the number of simulation runs. Multiple forms of federal guidance exist on the number of simulation runs. After reviewing the national guidance, BTO-TASU chose to use the methodology outlined in the *Guidance on the Level of Effort Required to Conduct Traffic Analysis Using Microsimulation* (7), published by FHWA in March 2014 as the basis for WisDOT's policy on determining the number of simulation runs. The FHWA 2014 Guidance (7) methodology uses field data to calculate the error tolerance. After completing several (5-10) initial model runs, the analyst can evaluate the number of required runs, and then, if necessary continue conducting additional model runs until the required number of runs is satisfied. The following details WisDOT's policy regarding the number of simulation runs.

7.4 Number of Simulation Runs - Process

7.4.1 Selecting Test Location Sites

To complete the required number of runs calculations, the analyst **shall** select at least one representative location within the model study area for each peak period of analysis. A location is representative if it meets all the following criteria:

- Lies within the area of interest associated with the purpose of the model
- Is on a facility of the highest or second-highest functional class
- Experiences higher-than-average traffic demand during the peak period

Given the data requirements spelled out below, the location(s) selected *should* have enough field data available to complete the required number of runs calculations.

The analyst may use the same location for more than one peak period provided it is representative of the peak period conditions. A location may be directional – that is, the location may reflect only the eastbound direction of a two-way facility. In fact, directional locations that match up with the peak traffic flows may be more representative than a location that reflects both directions of travel.

Although the minimum number of locations is one per peak period, for larger models, the analyst *should* include more than one location. A general rule would be to have one location per five miles of freeway or other principal arterial included in the model, with a practical upper limit of four locations per peak period.

7.4.2 Selecting the MOEs to Test

Volume has historically been the MOE used for calculating the required number of simulation runs. The national

publications providing guidance on determining the number of runs cited in the simulation background (TEOpS 16-20-7-3) use volume in their examples. This may be because volume, in the past, has been the most data-rich MOE. Given advances in technology and data collection methodologies, WisDOT has other MOEs (such as travel time and speed) with sufficient field data that may be available for calculating the number of runs. Refer to TEOpS 16-20-3 for details on other potential MOEs.

In general, the analyst has latitude in selecting the MOE to use for determining the number of runs. The analyst *should* use the same MOE for every location and peak period included in the number of runs evaluation. Volume remains a good starting point, though data availability, the nature of the facility, and the model purpose *should* play a role in the MOE selection.

7.4.3 Use of Field Data

Rather than determining *a priori* what level of error is acceptable when calculating the required number of runs, the analyst *should* compute the error tolerance based on the variability observed in field data. To assist with determining the error tolerance using field data and calculating the number of required runs, BTO-TASU developed a Microsoft Excel based workbook.

The number of runs workbook requires the use of between 3 and 365 field data points, which the analyst would enter into the "Variability Analysis of Field Data" area of the workbook. To preserve the integrity of the test, the data entered **shall** be representative of the operating conditions that align with the purpose of the modeling effort. In other words, filter out data points with atypical conditions such as incidents or inclement weather when modeling normal operating conditions. Likewise, use only comparable situations when analyzing a special condition, such as an event at a stadium. Selecting field data for entry in such a way as to unduly influence the resulting calculations, is not permissible.

The field data generates a margin of error, from which the spreadsheet then computes an error tolerance percentage. The workbook then uses this tolerance in combination with the initial model run results to calculate a required number of runs. Through thorough testing of the workbook, to account for the stochasticity inherent in the modeling processing, BTO-TASU set a minimum tolerance of one percent, even if the calculated tolerance from field data is lower. There is no upper limit to the tolerance.

7.4.4 Initial Simulation Runs

After entering the field data into the number of runs worksheet, the analyst must perform a series of initial model runs to allow for comparisons between the field data and model result variability. Historically, seven runs have proven to be a sufficient number of runs to capture the variation observed in the field. It provides enough samples to run summary statistics on and falls within the 5 to 10 initial runs recommended in the most recent national guidance. Accordingly, the analyst **shall** complete seven initial model runs.

To facilitate the consistent use of prime seeds, discussed above in TEOpS 16-20-7.2, the "Initial Runs" portion of the number of runs workbook contains the seeds to use for each simulation run. Using prime number seeds in arithmetic sequence, or primes that are evenly spaced, simplifies the process of running the models using the specified seed numbers, at least in Vissim. To run the initial seven runs in Vissim, enter the first seed, 199, in the "Random Seed" box under Simulation>Parameters. Set the "Number of runs" to 7, and then enter 210 as the "Random seed increment." This allows Vissim to complete seven successive runs with the appropriate seed values.

After the model runs are complete, enter the results from the first location for the selected MOE for the peak hour of the first peak period into the number of runs workbook. The workbook will automatically eliminate any statistical outliers (at the 95% confidence level) and will update the number of valid (non-outlier) runs accordingly. For additional information on how to address outliers, see TEOpS 16-20-7.4.7.

Using the tolerance from the field data, the workbook will compute an estimated number of runs. If the number of valid runs is greater than or equal to the estimated number of runs, the test is complete for that location. Continue for other locations and other peak periods. If the number of valid runs is less than the estimated number of runs, more runs will be necessary (see the following section, TEOpS 16-20-7.4.5).

7.4.5 Additional Simulation Runs

If additional runs are required, enter the additional results data in the "Additional Runs" part of the number of runs workbook. The results from the first seven runs will automatically transfer over. The workbook will update the required number of runs calculations as appropriate to reflect the additional run data. The analyst *should* continue with additional runs, adding one at a time, until either the number of runs completed exceeds the number of runs required, or they have completed 30 runs. If the analysis indicates a need for more than 30 runs, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

7.4.6 Number of Runs to Use for Reporting Results

It is likely that the number of runs will vary for each location and peak period of analysis; it may be higher than the seven initial runs for one or more locations and lower for others. The analyst *should* use the highest required number of runs value from any location for reporting model results. This will ensure meeting (and often exceeding) the required number of runs everywhere. If the highest required number of runs is less than seven, use the seeds for the initial seven runs to report results.

Typically, a calibrated model will not require more than 30 simulation runs. However, if the number of runs calculations find that more than 30 runs are necessary, coordinate with WisDOT regional traffic staff to assess whether to conduct additional model runs, as it may be necessary to perform additional model calibration. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed and to request the seed values to use for any additional runs beyond 30.

Unless the results of the model run are determined to be a statistical outlier (see TEOpS 16-20-7.4.5), the analyst **shall** use the results for the appropriate number of runs for the corresponding seed number shown in Table 7.1. See the following section (TEOpS 16-20-7.4.7) for additional information on how to address outliers in both the number of runs calculations and runs used to report model results.

7.4.7 Model Run Outliers

In a non-technical sense, a model run is a statistical outlier if its value is significantly higher or lower than expected given the other model runs. For the purposes of WisDOT microsimulation analyses, WisDOT defines an outlier as anything outside of the 95% confidence interval, or more than 1.96 standard deviations away from the average value assuming a two-tailed normal distribution. Normally, a t-statistic-based test would be most appropriate for data sets with less than 30 samples; however, this would add complexity to the process. More importantly, assuming a normal distribution is consistent with the FHWA 2014 Guidance (7) which serves as the basis for the number of run calculations (TEOpS 16-20-7.3).

Identify model run outliers in both the initial seven runs and in any additional required runs. It is possible for there to be more than one outlier, though this is highly unlikely in the initial seven runs given the significant effect of the outliers themselves on the standard deviation of the sample.

The analyst **shall** remove the statistical outliers from calculations related to the number of runs required, as they overstate the dispersion of results observed in the model and would unnecessarily require a higher number of runs. Identifying outliers in an objective manner eliminates questions surrounding the analyst manually selecting runs to eliminate and will introduce greater consistency across projects.

7.4.8 Model Runs for Future Year Scenarios

The above policy applies to the existing conditions models, as they are the only scenarios with field data. For future scenarios, or for those without any applicable field data, use the same seed numbers associated with the required number of runs from the existing conditions (see Table 7.1 for the seed numbers to use). This includes using the highest required number of runs when reporting results for all other scenarios.

7.4.9 Recommended Process with Limited Field Data

When insufficient field data is available for representative locations, the analyst **shall** use the methodology laid out in Chapter 7 of HCM7 (6). Use volume as the MOE and seven initial runs. For the E_T, the maximum tolerable error, BTO-TASU recommends the use of 2 percent of the average volume at the representative location. If using an alternate maximum tolerable error, document the rationale for using the selected percent tolerable error within the modeling methodology report. Complete this calculation at each location for each peak period. Comply with the “Number of Runs to Use for Reporting Results” section above (TEOpS 16-20-7.4.6).

7.5 Software Considerations

The above policy is applicable for all Vissim models. For SimTraffic models, conduct a minimum of seven runs. The SimTraffic simulation engine generates sequential seeds for multiple runs, the seed values shown in Table 7.1 are not applicable. To ensure the use of the same seed values for all model scenarios, make sure to start the multiple run recording with the same value.

16-20-8 Model Validation September 2019

8.1 Introduction

This section describes the validation metrics and acceptance thresholds required for the MOEs discussed in TEOpS 16-20-3. This policy addresses the validation process for microsimulation traffic models and replaces

the 2014 WisDOT Draft Microsimulation Guidelines previously housed on the www.wisdot.info website. **The policy provided within this document is effective as of January 1, 2018.**

As of January 1, 2018, use of the 2014 WisDOT Draft Microsimulation Guidelines will continue to be acceptable only for those projects that satisfy all the following conditions:

- The completion date of the existing conditions traffic model is prior to January 1, 2018
- The existing conditions traffic model has undergone the peer review process
- The WisDOT regional traffic engineer or BTO-TASU determined that the model was sufficiently calibrated and validated
- No major revisions to the existing conditions model are necessary

If the project satisfies all the above conditions, the 2014 WisDOT Draft Microsimulation Guidelines may be applicable for all traffic modeling scenarios. However, WisDOT strongly encourages the analyst to assess whether the traffic model would satisfy the new validation thresholds as outlined below. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) to request a copy of the 2014 WisDOT Draft Microsimulation Guidelines.

8.2 Validation Process

To validate that the traffic model reflects real world conditions, the analyst **shall** conduct both quantitative and qualitative checks on the model outputs for the analysis period. The analyst **shall** conduct validation checks of the existing conditions model using field-measured data, including but not limited to, traffic volumes, travel speeds, travel times, intersection queuing, and trip-making patterns (e.g., weaving volumes). The analyst **shall** conduct the validation checks of the alternative models using traffic forecast and other data that is available for the alternative scenario. See TEOpS 16-20-8.3, 16-20-8.4, and 16-20-8.5 for details on the quantitative and qualitative validation thresholds.

During validation, it is also important to confirm that the model meets the purpose and need of the project (e.g., if the purpose of the project is to assess the feasibility of managed lanes, during validation it is important to confirm that the model can capture managed-lane alternatives, etc.).

If the model outputs satisfy the validation thresholds (see TEOpS 16-20-8.3, 16-20-8.4, and 16-20-8.5), and the model meets the purpose and need of the project, the analyst can consider the model to be valid and can use the model to assess various performance measures and MOEs. If the model outputs fail to satisfy the validation thresholds or the model does not meet the purpose and need of the project, additional calibration of the model will be necessary.

8.2.1 Historical Validation Process (pre-January 1, 2018)

The 2014 WisDOT Draft Microsimulation Guidelines validation process consisted of three realism tests, where realism test 1 looked at traffic volumes, realism test 2 assessed travel times and speeds, and realism test 3 considered travel patterns. Realism tests 1 and 2 were quantitative/mathematical tests that used GEH (Geoffrey E. Haver's volume tolerance formula) and absolute or percent differences to assess the differences between observed (field) and modeled data. Realism test 3 was a qualitative test that relied on professional judgement to determine if the modeled travel patterns were a good representation of field conditions. The 2014 WisDOT Draft Microsimulation Guidelines required the traffic model to satisfy all criteria in all three realism tests.

Although the realism tests generally provided a good assessment as to whether a traffic model accurately represented real world conditions, there were some concerns with the methodology. Specifically, WisDOT had the following concerns with the 2014 realism tests:

- Considering that the acceptance targets for GEH were initially developed for travel demand models, are they appropriate for microsimulation models?
- Since the original intent of the GEH formula was to evaluate daily or hourly volumes, was it appropriate to apply the GEH formula to 15-minute volumes?
- Depending on whether the modeled value was higher or lower than the target value, the same incremental difference could result in different GEH values. For example, if the target value was 250, a modeled volume of 325 (75 higher than the target) would yield a GEH of 4 while a modeled volume of 175 (75 lower than the target) would yield a GEH of 5. In this example, it appears that a modeled volume that is 75 vehicles higher than the target volume is a closer match to reality than a modeled volume that is 75 vehicles lower than the target volume. Does this make sense?

- Did it make sense to apply travel time realism tests to short routes, especially if performing travel speed realism tests on the same segment?
- How could BTO-TASU ensure that travel times did not blend in with travel speeds (i.e., the calculation of travel speeds was simply the inverse of travel time)?
- How *should* project teams handle situations where there is no data available for a MOE included in one of the realism tests? Data is not always available for both travel time and travel speeds, making it impossible to conduct all three realism tests.
- Was it appropriate to apply the same validation tests for all types of microsimulation models?

Considering the concerns WisDOT had with the 2014 realism tests, BTO-TASU worked with a consultant team to assess whether there were other Goodness of Fit (GoF) metrics and validation thresholds that would be better suited for assessing whether a traffic model provided a good representation of reality. As part of the assessment, BTO-TASU and the consultant team conducted literature reviews, surveys of other state DOT practices, and evaluation testing. To evaluate the GoF metrics, the consultant team used output from previously developed models, most of which were previously calibrated and validated in accordance with the 2014 realism tests. The evaluation included models from the three WisDOT supported software tools (SimTraffic, Paramics, and Vissim). The SimTraffic models were the only models that did not previously go through the calibration and validation process.

Since most of the models used in the evaluation testing had already undergone the calibration and validation process, the consultant team performed sensitivity testing by modifying model inputs to broaden the sample size of the data sets. After completing the sensitivity testing, the consultant team assigned a ranking system (with 1 being the best and 7 being the worst) for each MOE to determine the quality of validation for each model. This ranking system helped evaluate both the feasibility and acceptance levels for each of the GoF validation tests.

Through the literature reviews, surveys, and evaluation testing; WisDOT determined that an overhaul of the 2014 realism tests were necessary. Although the new validation tests use different GoF metrics, models previously calibrated and validated using the 2014 realism tests *should* still be able to pass the new validation process. The following sections describe the new validation thresholds.

8.2.2 Tiered Validation Process (post January 1, 2018)

Effective January 1, 2018, WisDOT will require the use of a tiered validation approach. In this tiered approach, the Tier 1 test would be a global validation test for a metric and the Tier 2 test would be a local test for that same metric. If a model passes the Tier 1 (global) test, the modeling team would not need to perform the Tier 2 (local) test and a detailed summary of the Tier 2 test would not be necessary. BTO-TASU established the validation acceptance criteria to allow only well calibrated and validated models to pass the Tier 1 (global) test.

Table 8.1 summarizes the tiered validation tests. Refer to TEOpS 16-20-3 to identify the number and type of MOEs on which to perform validation tests, noting that the volume validation tests are required for all traffic models. The analyst *should* satisfy the validation thresholds shown in Table 8.1 for the selected MOEs to the best extent that is practically feasible. If the model is unable to satisfy the validation thresholds outlined in Table 8.1, the analyst **shall** consult with WisDOT regional traffic staff prior to finalizing the modeling methodology report or proceeding with the development of additional modeling scenarios. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

8.3 Tier 1 (Global) Validation Tests

The Root Mean Squared Percent Error (RMSPE) is the primary validation metric for the global tests. This metric was based on the results of literature reviews, surveys of other state DOT practices with respect to GoF metrics to apply to microsimulation models and evaluation testing. The equation for RMSPE is as follows:

$$\textbf{RMSPE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{M_i - O_i}{O_i}\right)^2}$$

Where:
M = Modeled Data
O = Observed Data
N = Number of Data Points
i = Observation Point

The Tier 1 (global) validation tests are applicable for link/segment volumes, travel times, and travel speeds. Table 8.2 summarizes the Tier 1 (global) validation tests. Refer to TEOpS 16-20-3 to identify the number and

type of MOEs on which to perform the Tier 1 (global) validation tests, noting that the Tier 1 volume validation tests are required for all microsimulation traffic models.

Table 8.1 Validation Tests

MOE	Criteria	Validation Acceptance Threshold	
Volume[a]	All Links > 100 vph (Mainline and Critical[b] Arterials)	Tier 1:	RMSPE <5.0%
		Tier 2:	RNSE <3.0% for >85% of links
	All Turns	Tier 1:	Not Applicable
		Tier 2:	RNSE <3.0% for >75% of turns
Speeds	All Segments or Spot-Speed Locations	Tier 1:	RMSPE <10.0%
		Tier 2:	Within ± (Mainline Posted Speed X 20%) for >85% of locations
Travel Times	All Routes > 1.5 Miles	Tier 1:	RMSPE <10.0%
		Tier 2:	Within ± 15% for >85% of routes
Queues	All Critical[b] Queue Locations	Tier 1:	Not Applicable
		Tier 2:	± 150 feet for queues 300 to 750 long, Within ±20% for queues >750 feet long
Lane Use	All Critical[b] Lane Utilization Locations	Tier 1:	Not Applicable
		Tier 2:	RNSE <3.0% for >85% of locations Consistent with field conditions

[a] All traffic models **shall** undergo volume validation (Tier 1) tests
[b] Critical locations are those locations likely to have an impact on operations to the project study area (e.g., locations with higher traffic volumes, existing or projected level of service is at or approaching unstable flow, queues block or impede travel, weaving areas, merge/diverge locations, etc.)
vph = vehicles per hour
RMSPE = Root Mean Squared Percent Error, See TEOpS 16-20-8.4 for equation
RNSE = Root Normalized Squared Error, See TEOpS 16-20-8-5.1 for equation

Table 8.2 Tier 1 (Global) Validation Tests

MOE	Criteria	Validation Acceptance Threshold	
Volume[a]	All Links > 100 vph (Mainline and Critical[b] Arterials)	Tier 1:	RMSPE <5.0%
Speeds	All Segments or Spot-Speed Locations	Tier 1:	RMSPE <10.0%
Travel Times	All Routes > 1.5 Miles	Tier 1:	RMSPE <10.0%

[a] All traffic models **shall** undergo volume validation (Tier 1) tests
[b] Critical locations are those locations likely to have an impact on operations to the project study area (e.g., locations with higher traffic volumes, existing or projected level of service is at or approaching unstable flow, queues block or impede travel, weaving areas, merge/diverge locations, etc.)
vph = vehicles per hour
RMSPE = Root Mean Squared Percent Error, See TEOpS 16-20-8.4 for equation

8.3.1 Traffic Volumes

All microsimulation traffic models **shall** undergo the Tier 1 volume validation test, see Table 8.2. This test requires a global evaluation of the modeled versus observed (field) traffic volumes for all roadway links/segments for which traffic volume data is available. The volume validation tests evaluate the volumes during the peak period analysis times (does not include the warm-up or cool-down periods) included in the model (see TEOpS 16-20-2.1.2 for additional direction on determining the temporal analysis periods).

The traffic model will often be broken into smaller links than what exists in the field, so use the roadway segmentation that exists, or is planned to exist, in the field to identify locations where volume data comparisons are justified. Focus on the mainline segment and other critical arterials and ramps included in the study area, where critical locations are those locations likely to have an impact on traffic operations.

A benefit of the RMSPE is that it considers relative error, so the results will be the same whether the modeled volume is higher or lower than the observed volume. Sensitivity testing, however, found that the RMSPE was

somewhat unstable when volumes were less than 100 vehicles per hour (vph). Thus, the Tier 1 volume validation threshold is only applicable for those roadway links with a minimum volume of 100 vph during the analysis period. Values that may be under 100 vph likely include ramps or arterial roadways that have minimal to no effect on the operations of the facility under study.

The acceptance criteria for the global link volume test is a RMSPE of 5 percent (i.e., to pass the Tier 1 volume validation test, the RMSPE for all links must be less than 5 percent). This acceptance criterion was based on the results of the evaluation testing on previously developed, calibrated, and validated models. Only well validated models will pass the 5 percent acceptance criteria. If the model does not pass the 5 percent acceptance criteria, the analyst **shall** proceed onto the Tier 2 volume validation to pinpoint where any issues in the model may exist.

Conduct the Tier 1 volume validation tests by direction for every model run. The analyst *should* conduct the volume validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the volume validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the volume validation test at the sub-hourly level.

Summarize and document the results of the volume validation tests. Include a copy of the volume validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the volume validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.3.2 Travel Speeds

See TEOpS 16-20-3 to identify whether to apply the Tier 1 travel speed validation test. As shown in Table 8.2, the Tier 1 travel speed validation test requires a global evaluation of the modeled versus observed (field) travel speeds during the analysis period (does not include the warm-up or cool-down period) for all segments where travel speeds are available (either average segment travel speeds or spot speeds). To ensure that the travel speed validation test is independent from the travel time validation test, take care not to use the inverse of travel times to derive the segment travel speeds for the travel speed validation.

The acceptance criteria for the global travel speed test is a RMSPE of 10 percent (i.e., to pass the Tier 1 travel speed test, the RMSPE for all segment/spot speed locations must be less than 10 percent). This acceptance criterion was based on the results of the evaluation testing on previously developed, calibrated, and validated models. Only well validated models will pass the 10 percent acceptance criteria. If the model does not pass the 10 percent acceptance criteria, the analyst **shall** proceed onto the Tier 2 travel speed validation to pinpoint where any issues in the model may exist.

Conduct the Tier 1 travel speed validation tests by direction for every model run. The analyst *should* conduct the speed validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the speed validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the speed validation test at the sub-hourly level.

Summarize and document the results of the travel speed validation tests. Include a copy of the travel speed validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel speed validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.3.3 Travel Times

See TEOpS 16-20-3 to identify whether to apply the Tier 1 travel time validation test. As shown in Table 8.2, the Tier 1 travel time validation test requires a global evaluation of the modeled versus observed (field) travel times during the analysis period (does not include the warm-up or cool-down period) for all study routes greater than 1.5 miles in length. To ensure that the travel time validation test is independent from the travel speed validation test, take care not to use the inverse of the segment travel speeds to derive the travel times for the travel time validation.

It is easier for drivers to relate travel time to longer routes versus shorter routes (i.e., a driver may say they drove ½ mile at an average of 60 miles per hour but typically will not say they took 30 seconds to drive the ½ mile). Further, on shorter segments, travel times and travel speeds tend to blend together (i.e., the travel time is the inverse of travel speed). WisDOT experience with previous projects has shown that it is easiest to make a distinction between travel time and travel speeds when the travel route is at least 1.5 miles long. For these reasons, the Tier 1 validation test for travel times is only applicable to travel routes greater than 1.5 miles long.

Unless the use of shorter segments is logical, the analyst *should* combine short travel time segments (those less than 1.5 miles) together to make one longer travel time segment to use for the Tier 1 travel time validation test. If unsure whether to combine segments for the travel time validation test, contact WisDOT regional traffic staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed. Document the rationale for using the shorter travel time routes or combining routes into one longer segment in the modeling methodology report.

The acceptance criteria for the global travel time test is a RMSPE of 10 percent (i.e., to pass the Tier 1 travel time test, the RMSPE for all routes greater than 1.5 miles must be less than 10 percent). This acceptance criterion was based on the results of the evaluation testing on previously developed, calibrated, and validated models. Only well validated models will pass the 10 percent acceptance criteria. If the model does not pass the 10 percent acceptance criteria, the analyst **shall** proceed onto the Tier 2 travel time validation to pinpoint where any issues in the model may exist.

Conduct the Tier 1 travel time validation tests by direction for every model run. The analyst *should* conduct the travel time validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the travel time validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the travel time validation test at the sub-hourly level.

Summarize and document the results of the travel time validation tests. Include a copy of the travel time validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel time validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4 Tier 2 (Local) Validation Tests

If the model fails to pass the Tier 1 (global) validation tests, the analyst **shall** perform the Tier 2 (local) test for the applicable MOEs. The purpose of the Tier 2 validation test is to pinpoint where potential problems in the model may exist. Since the Tier 2 validation test is a localized test, the GoF metric varies depending on the MOE. The Tier 2 (local) validation tests are applicable for link/segment volumes, turning movement volumes, travel speeds, travel times, queues, and lane use. Table 8.3 summarizes the Tier 2 (local) validation tests. Refer to TEOpS 16-20-3 to identify the number and type of MOEs on which to perform validation tests, noting that if a model passes the Tier 1 (global) tests for a specific MOE, it is not necessary to perform the Tier 2 (local) tests for that same MOE. Document the rationale for excluding the Tier 2 validation tests (e.g., the MOE in question successfully passed the Tier 1 validation test) in the modeling methodology report. The analyst, however, *should* always perform the Tier 2 turning movement volume test for projects that include intersections.

Table 8.3 Tier 2 (Local) Validation Tests

MOE	Criteria	Validation Acceptance Threshold	
Volume[a]	All Links > 100 vph (Mainline and Critical[b] Arterials)	Tier 2:	RNSE <3.0% for >85% of links
	All Turns	Tier 2:	RNSE <3.0% for >75% of turns
Speeds	All Segments or Spot-Speed Locations	Tier 2:	Within ± (Mainline Posted Speed X 20%) for >85% of locations
Travel Times	All Routes > 1.5 Miles	Tier 2:	Within ± 15% for >85% of routes
Queues	All Critical[b] Queue Locations	Tier 2:	± 150 feet for queues 300 to 750 long, Within ±20% for queues >750 feet long
Lane Use	All Critical[b] Lane Utilization Locations	Tier 2:	RNSE <3.0% for >85% of locations Consistent with field conditions

[a] All traffic models that do not pass the Tier 1 validation test **shall** undergo the Link/Segment Volume Tier 2 validation tests. All traffic models that include intersections **shall** undergo the Turning Volume Tier 2 validation tests.
[b] Critical locations are those locations likely to have an impact on operations to the project study area (e.g., locations with higher traffic volumes, existing or projected level of service is at or approaching unstable flow, queues block or impede travel, weaving areas, merge/diverge locations, etc.)
vph = vehicles per hour
RNSE = Root Normalized Squared Error, See TEOpS 16-20-8-5.1 for equation

8.4.1 Traffic Volumes

All microsimulation traffic models **shall** undergo the volume validation test, however, only those models that fail

to pass the Tier 1 volume validation test require the completion of the Tier 2 volume validation test for links/segments. Conversely, the analyst **shall** always perform the Tier 2 turning movement volume test for projects that include intersections. A metric named root normalized squared error (RNSE), which is a variation of the GEH (Geoffrey E. Havers) tolerance formula is the validation metric for local volume tests. The RNSE removes the modeled volume from the basis of normalizing error. Literature reviews and evaluation testing informed the development of the RNSE metric. The equations for GEH and RNSE are below.

$$GEH = \sqrt{2\frac{(M-O)^2}{(M+O)}} \qquad RNSE = \sqrt{\frac{(M-O)^2}{O}}$$

Where:

M = Modeled Data

O = Observed Data

The RNSE shares the same general form as the global RMSPE test that is the basis for the global volume test. Additionally, RNSE provides a consistent value above and below a target volume, whereas GEH does not, eliminating some of the concerns BTO-TASU has with the GEH.

Sensitivity testing found that volumes less than 100 vph may erroneously influence the statistics by potentially reducing the impact of critical links with higher volumes not meeting the threshold. Thus, the Tier 2 (local) volume validation threshold is only applicable for those roadway links with a minimum volume of 100 vph during the analysis period. Values that may be under 100 vph likely include ramps or arterial roadways that have minimal to no effect on the operations of the facility under study. The RNSE, however, is applicable to all turning movements (i.e., there is no minimum volume threshold for turning movements).

The local link volume test requires a RNSE of less than 3.0 for greater than 85 percent of links over 100 vehicles per hour. The local turning movement volume test requires a RNSE of less than 3.0 for greater than 75 percent of turns. These acceptance criteria are based on the results of the evaluation testing on previously developed, calibrated, and validated models. Though the RNSE test value is more robust than the WisDOT 2014 local volume criteria (realism test 1.1, 1.2, and 1.3), its use did not result in well-validated models becoming invalid. Other agencies including the Washington Department of Transportation and London Department for Transport use a similarly strict criterion (GEH criteria of 3.0).

Conduct the Tier 2 volume validation tests by direction for every model run. The analyst *should* conduct the volume validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the volume validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the volume validation test at the sub-hourly level.

Summarize and document the results of the volume validation tests. Include a copy of the volume validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the volume validation test, BTO-TASU(DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.2 Travel Speeds

See TEOpS 16-20-3 to identify whether to apply the Tier 2 travel speed validation test (note Tier 2 is only required if the model fails to pass the Tier 1 validation test). A combination of absolute error and percent error related to the posted speed limit of a roadway segment is the validation metric for local travel speeds (see Table 8.3). These validation metrics are based on the results of literature reviews, surveys of other state DOT practices, and evaluation testing. The range of acceptance for this test is determined by using a threshold of plus or minus 20 percent of the posted speed limit (i.e., a posted speed of 40 mph would have a range of acceptance of plus or minus 8 mph). For the validation testing, the analyst would apply this range of acceptance (plus or minus 20 percent of the posted speed limit) to the observed speed. For example, an observed speed of 31 mph would have a range of acceptance between 23 and 39 mph (31 +/- 8 MPH) if the posted speed were 40 mph.

Since the 2014 realism tests had an acceptance criterion of plus or minus 10 mph regardless of the speed, it was possible for models to pass the realism test even if portions of the study corridor had modeled speeds that were 50% or more higher or lower than the observed speeds. This was most noticeable on arterials. The new local speed test tightens up the travel speed criteria for arterials and provides more flexibility for freeways experiencing congestion as compared to the 2014 realism tests.

Conduct the Tier 2 travel speed validation tests by direction for every model run. The analyst *should* conduct the travel speed validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the travel speed validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the travel speed validation test at the sub-hourly level.

Summarize and document the results of the travel speed validation tests. Include a copy of the travel speed validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel speed validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.3 Travel Times

See TEOpS 16-20-3 to identify whether to apply the Tier 2 travel time validation test (note Tier 2 is only required if the model fails to pass the Tier 1 validation test). The 2014 realism test for travel times had separate acceptance thresholds for routes less than seven minutes and routes equal to or greater than seven minutes, where routes less than seven minutes had an acceptance criterion of plus or minus one minute. The one-minute acceptance criterion for short routes was very easy to meet, especially if considering routes with observed travel times of less than one minute. For this reason, BTO-TASU and the consultant team considered several local testing options for travel times to develop a validation threshold that would address the issues the 2014 realism test had concerning short segments.

Percent error is the metric for the local travel time validation test. Literature reviews, surveys of other state DOT practices, and evaluation testing informed the development of this validation metric. The selected travel time criterion requires modeled travel times to be within plus or minus 15 percent of observed travel times (see Table 8.3). WisDOT experience with previous projects has shown that it is easiest to make a distinction between travel time and travel speeds when the travel route is at least 1.5 miles long. Further, a driver is more likely to start noticing slight changes in travel times on routes 1.5 miles long or longer (e.g., at 45 mph, the driver would take 2 minutes to travel 1.5 miles, any changes in travel time less than 2 minutes will likely be unnoticeable), For these reasons, the local travel time test is only applicable for routes over 1.5 miles in length. Unless the use of shorter segments is logical, the analyst *should* combine short travel time segments (those less than 1.5 miles) together to make one longer travel time segment to use for the Tier 2 travel time validation test. If unsure whether to combine segments for the travel time validation test, contact WisDOT regional traffic staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed. Document the rationale for using the shorter travel time routes or combining routes into one longer segment in the modeling methodology report.

Conduct the Tier 2 travel time validation tests by direction for every model run. The analyst *should* conduct the travel time validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the travel time validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the travel time validation test at the sub-hourly level.

Summarize and document the results of the travel time validation tests. Include a copy of the travel time validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel time validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.4 Queue Lengths

Refer to TEOpS 16-20-3 to identify whether to apply the Tier 2 (local) queue validation test, noting that queues can be either a primary or a secondary validation MOE. Typically, if intersection queuing is critical to the design decisions (e.g., the project is assessing the storage length requirements for a left turn lane), queue lengths will be one of the primary validation MOEs for the arterials. Intersection queue lengths are often the primary MOE for validation of a SimTraffic model. The quantitative metrics for queues shown in Table 8.3 are applicable for all models where queue lengths are a primary validation MOE (typically applicable for arterial segments). The qualitative measures discussed in TEOpS 16-20-8.5 are applicable for models that use queue length as a secondary validation MOE (typically applicable for freeway segments).

The validation metric for intersection queue length is a combination of absolute error and percent error. Literature reviews, surveys of other state DOT practices, and evaluation testing informed the development of this validation metric. The acceptance criterion for the intersection queue validation test is an absolute error of plus or minus 150 feet for all observed queues between 300 and 750 feet and a percent error of plus or minus

20 percent for all observed queues greater than or equal to 750 feet. As with other tests, this metric requires 85 percent of the locations to pass the intersection queue validation criteria.

Although the analyst *should* perform the queue length validation test for all models where queue lengths are a primary validation MOE, BTO-TASU realizes there are potential issues with using queue length as a validation metric including, but not limited to:

- Queue lengths are generally unstable and can fluctuate significantly from one moment to the next, thus the queues observed in the field may not reflect the queues that were present during the time of the turning movement count.
- There is no standard procedure for measuring the length of queue. Queues could include only stopped vehicles or they could include stopped and slow moving (less than 5 mph) vehicles.
- Each microsimulation analysis tool has its own proprietary methodology for reporting on queue lengths, so there is a lack of consistency.

As such, the Tier 2 (local) queue validation test is non-binding, in that failure to meet the queue validation thresholds alone will not necessarily require further calibration and validation of the model. If the model is unable to satisfy the queue validation thresholds outlined in Table 8.3, the analyst **shall** consult with WisDOT regional traffic staff to assess the need for further model calibration. This coordination **shall** occur prior to finalizing the modeling methodology report or proceeding with the development of additional modeling scenarios. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

Conduct the Tier 2 queue validation tests by direction for every model run. The analyst *should* conduct the queue validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the queue validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the queue validation test at the sub-hourly level.

Summarize and document the results of the queue validation tests. Include a copy of the queue validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the queue validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.5 Lane Utilization

Refer to TEOpS 16-20-3 to identify whether to apply the Tier 2 (local) lane utilization validation test. Other agencies (such as Oregon DOT, Minnesota DOT, and Washington DOT) use their traffic volume validation criteria and a comparison of modeled and observed lane utilization percentages. Comparable to the criteria used by Oregon DOT, Minnesota DOT, and Washington DOT, the acceptance criterion for lane utilization is a RNSE of less than 3.0 for greater than 85 percent of data points (see Table 8.3). The data points chosen for the lane utilization validation *should* represent those locations where lane usage is critical for the operations of the facility (e.g., weaving areas, upstream of lane drops, etc.).

Although BTO-TASU encourages the analyst to perform the quantitative lane utilization validation test for areas where lane usage has a considerable influence on operations, BTO-TASU acknowledges that data may not always be available to conduct mathematical checks on lane utilization. As such, it may be acceptable to do more of a qualitative assessment to assess that the model reasonably reflects the lane utilization observed in the field. Justify and document the use of any qualitative assessments in the modeling methodology report.

Conduct the lane utilization validation tests by direction for every model run. The analyst *should* conduct the lane utilization validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the lane utilization validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the lane utilization validation test at the sub-hourly level.

Summarize and document the results of the lane utilization validation tests. Include a copy of the lane utilization validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the lane utilization validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.6 Density

Acceptance of quantitative validation testing for density may be acceptable. To use density as a validation check

for microsimulation models; the analyst **shall** obtain approval from WisDOT regional traffic staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

8.5 Qualitative Validation Tests

The goal of the model validation process is to assure that the model is a good representation of the actual traffic conditions. This means that the model must not only meet the mathematical targets related to traffic volumes, speeds, and travel times, but must also be reasonable in terms of overall traffic patterns such as lane choice and routing. Table 8.4 provides a summary of the qualitative validation checks. The analyst **shall** perform the qualitative validation tests for all models, even those that pass the Tier 1 (global) mathematical validation thresholds. Document and justify the decisions made as they pertain to the qualitative validation tests and summarize the findings of the tests in the modeling methodology report.

Table 8.4 Qualitative Validation Tests

MOE	Criteria	Validation Acceptance Threshold
Queues	All Critical Queue Locations	Visually realistic for intersection queues. Quantitative checks required if queues are a primary validation MOE.
Bottlenecks	Replication of Real-World Bottlenecks	Visually realistic for intersection queues and freeway bottlenecks
Routing	All Routes	Represents field conditions and driver behavior. Acceptance of quantitative results require WisDOT approval.
Lane Use	All Critical Lane Utilization Locations	Visually realistic. Quantitative checks encouraged for areas where lane usage has a considerable influence on operations.
Freeway Merging	All Merge Locations	Visually realistic
Vehicle Types and Truck Percentages	All Locations	Represents field conditions.

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9.1 Recommended Process

Only after calibrating and validating the existing conditions and only after completing the peer review process of the existing conditions model, *should* the analyst proceed with the development of other modeling scenarios. If the analyst chooses to develop the alternatives model prior to calibrating and validating the existing conditions model and prior to having the model go through the peer review process, they take the risk that they must go back and revise not only the alternatives model but the existing conditions model as well. This can lead to potential inconsistencies in the modeling scenarios and could result in the need for additional time to calibrate and perform the peer review(s) of the alternatives model. Although it may be tempting, especially when the project has a compressed schedule, to skip or delay the calibration, validation, or peer review process of the existing conditions model, it may end up being counterproductive and is strongly discouraged.

Refer to TEOpS 16-20-2 for additional details on the model development process, analysis scenarios, and traffic model tree.

9.1.1 Carrying Parameters Forward into Model Scenarios

Unless changes to roadway geometry or traffic conditions are expected to alter the driving behavior, the analyst *should* carry the parameters from the calibrated existing conditions model forward, without any changes, to each subsequent scenario. For example, if it is necessary to use a headway of 0.85 to reproduce the level of congestion in the existing real-world network during the AM peak hour, then the analyst *should* use the same 0.85 headway value for the AM peak hour model in the design year.

Document and justify the rationale for modifying any of the existing conditions parameters. Where possible, associate any modification to the existing conditions parameters to changes in geometric conditions that may influence driving behavior (e.g., the design year build alternative lengthens the weaving area resulting in the need for drivers to be less aggressive thus increasing the headway).

9.1.2 Validation of Design Year Models

The only mathematical validation test that is applicable for design year models is the volume validation (both Tier 1 and Tier 2) tests. When conducting the volume validation tests (see Table 8.1) for the design year

models, the analyst *should* compare the modeled volumes (i.e., output from the microsimulation model) to the appropriate design year traffic forecasts. Due to future congestion, the microsimulation model may not be able to sufficiently capture the true design year traffic demand within the analysis period, specifically for the no-build or FEC conditions. Under this scenario, the analyst *should* run the model with only the traffic demand for the analysis period (e.g., do not include the demand from the warm-up or cool-down periods) until all vehicles have exited the network, thereby capturing the full demand reflected in the design year traffic forecasts. Apply the volume validation tests (typically for each one-hour period) to both the seed matrix (full demand, no warm-up or cool-down) and analysis period matrix (includes warm-up, analysis period, and cool-down periods) runs. Running the model with the seed matrix allows the analyst to validate that the peak period demand matrix, when isolated, is sound.

Given the context within which quantitative checks on MOEs (specifically travel speeds, travel times, queue lengths, and lane utilization) are conducted for the design year models, the validation tests for the MOEs for design year models consist of a visual check of the traffic model for reasonableness. Additionally, the analyst *should* perform the qualitative validation tests as summarized in Table 8.4 as appropriate.

In addition to the visual and qualitative tests, the analyst *should* compare the travel times, travel speeds, and queue results from the design year model to existing conditions data to assess whether the relative increase/decrease in each MOE between the scenarios is reasonable.

Conduct the quantitative volume validation tests and qualitative/visual checks by direction for each 15-minute analysis period for every model run. Summarize and document the results of the quantitative volume validation tests and qualitative/visual checks for the average of all (valid) runs. Include a copy the volume validations tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the design year volume validation test, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

9.2 Traffic Volume Development

Work with the WisDOT regional traffic staff and WisDOT-TFS to develop the forecasts for the design year. Chapter 9 of the WisDOT *Transportation Planning Manual* provides details on the process for obtaining and developing traffic forecasts.

The forecasts developed by WisDOT-TFS typically provide forecasts for the annual average daily traffic (AADT) and peak-hour intersection turning movement volumes (if requested). The microsimulation models, however, often require the use of O-D matrix tables in addition to or instead of turning movement volumes and typically need to capture 15-minute profiles for the warm-up, analysis, and cool-down periods. Further, microsimulation models require the use of a balanced volume data set, and oftentimes the traffic forecasts will reflect unbalanced volumes. Thus, in most cases, it will not be possible to enter the forecasts into the microsimulation model directly as provided by WisDOT-TFS.

Document the methodology used to develop and modify the forecasts for use in the microsimulation models in the Traffic Forecasting Methodology Report and submit to the regional office and WisDOT-TFS for approval. WisDOT-TFS will typically provide any comments on their review of the forecasting methodology report in DT2340. The regional office will involve BTO-TASU in the review as appropriate.

9.2.1 Design Hour Volumes for Microsimulation Models

The analyst **shall** coordinate with WisDOT regional traffic staff, as well as WisDOT-Bureau of State Highway Programs (BSHP), WisDOT-TFS, BTO-TASU, and other stakeholders as appropriate, to develop design-hour volumes (DHV) for microsimulation models.

9.2.2 Origin-Destination Matrix Development for Microsimulation Models

The analyst **shall** coordinate with WisDOT regional traffic staff, as well as WisDOT-TFS, BTO-TASU, and other stakeholders as appropriate, to develop the O-D matrices for microsimulation models.

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10.1 Modeling Methodology Report

Prior to submitting the traffic model to the WisDOT regional office and other members of the peer review team (see TEOpS 16-25), document the methodology and assumptions used to develop, calibrate, and validate the traffic model. Prepare a separate modeling methodology report for each model scenario. The exact format of the modeling methodology report will vary depending on the specifics of the project; however, the content of the report *should* always include the following:

- Project background – What is the goal/purpose of the project and what is the justification for the use of microsimulation?
- Methodology/assumptions – Identify the methodology used to develop the model, being sure to note any assumptions.
- Calibration parameters – Identify and describe any user-defined parameters (i.e., note where the model includes changes to default parameters). Provide justification for the use of any localized (link-specific) calibration parameters.
- Validation summary – Summarize the findings of the validation tests. Provide the detailed validation testing results as an attachment to the report. Additionally, submit an electronic copy (preferably in Excel format) of the validation tests to the peer review team members.

Reference other reports such as the Traffic Analysis Tool Selection memo or Traffic Forecasting Methodology Report as appropriate, being sure to provide copies of any referenced documents as an attachment to the modeling methodology report.

For sample formats or questions on what to include in the modeling methodology report, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

10.2 Presentation or Results

It is critical to format the presentation of microsimulation results to the audience because the expectation is that managers, technical staff, public officials, and the traveling public will each have varying levels of comprehension. For example, the average transportation user may understand the impacts on roadway performance through travel times, delay, or congestion levels. If the average commute on a corridor increases from 20 minutes in a current year to 40 minutes in the future, the average user may understand how this is going to affect them. Whereas this same audience may have more difficulty understanding how future traffic conditions are going to affect them if density increases by 100%.

Typically, most audiences can understand pictures, graphical presentations, simulation videos, or screen shots that describe the results. Presentations at public meetings *should* begin by orienting the audience around the modeled scenario. Point out the basic elements of the simulation display and identify traffic conditions that will help to gain the audience's confidence in the model. Animation videos or screen shots are very powerful to display a traffic flow concept that is difficult to grasp using numerical output. For example, depending on the type of data, it may be difficult to identify the start of a freeway bottleneck using numerical output alone. It may be obvious to the analyst where the bottleneck begins but a 30-second video or series of screen shots can convey this message clearly to an audience that is unfamiliar with the model.

10.2.1 Animation Output

Use animation videos or static screen shots exclusively for qualitative assessment. The analyst *should* review the simulation model and focus on the key points of a particular scenario. Before showing the animation videos to an audience outside of the modeling development and review team, verify that the driver behavior is realistic. Most microsimulation tools now provide the option to show a 3D visualization of the model, complete with roadway infrastructure and other architectural features. While these features may help to orient the audience to the project study area, take care not to let the presentation graphics overshadow the fundamental engineering objectives of the model. Discuss the requirements for the needs and emphasis of animation output of the traffic model with the WisDOT project team during the project scoping process.

Choosing an appropriate segment of the model to display during presentations requires professional judgment and an understanding of the project's objectives. Typically, the analyst *should* consider the average condition unless the worst case is realistic and the result causes system failure.

Recording animation output minimizes the chance for software and technology issues during presentations. It is usually best to keep the recorded animation videos relatively short (a run time of 2 to 3 minutes). Overlay text on the simulation videos as appropriate to orient the audience and provide information on the model outputs.

10.2.2 Graphical and Numerical Output

Most microsimulation models can output a seemingly endless amount of data. The importance of such outputs is dependent upon the purpose of the project, operational analysis, and microsimulation model. The objective of the analyst is to focus on a few key performance measures that tell the story of how the transportation facility is operating. The analyst *should* carefully choose numerical output that best addresses the objectives of the simulation model and overall project.

Understanding the strengths of microsimulation software and knowing how the software calculates different performance measures are important aspects of the analysis process. The methods and effectiveness of each software to measure performance may require analysts to use multiple tools to provide a comprehensive evaluation of the traffic operations.

Display graphical or tabular data in a clear and concise format so the intended audience can draw conclusions without becoming overwhelmed with the amount of data. Analysts *should* consider supplementary visual cues to draw the audience's attention to the most important pieces of data. Bolding, indenting, or highlighting text with distinct colors can help to increase discrimination between the various levels of data.

Colored shading typically represents the following conditions:

Color	Performance Level
Green / Blue	Good
Yellow	Acceptable
Orange	Poor
Red	Failing or Severe

Analysts *should* be cognizant of common vision deficiencies when presenting results with colors. Consider using redundant visual cues instead of relying on color alone (e.g., use colors along with letters or shapes).

16-20-11 Upgrading Simulation Models September 2019

Keeping a model relevant and useful often requires upgrading it to the latest release of the simulation software. As noted in TEOpS 16-20-4, the PTV Group typically releases major updates to the Vissim software once a year and Trafficware typically releases major updates to the Synchro/SimTraffic Studio software every two to three years. The software vendor may release minor updates, to address software bugs/errors, as often as once a month.

These releases may or may not affect a specific simulation model, but it is important to understand that no matter how small a change, any change could influence the results and validity of a model. This section will go over the questions to ask and the steps to follow when upgrading a model. The purpose of these steps is to give the analyst the information they need to assess the potential impact of upgrading the traffic model and to identify the additional work that may be necessary to re-calibrate and re-validate the traffic model. Before upgrading to a new model version, the analyst **shall** consult with the WisDOT project team and WisDOT regional traffic engineering staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed. When determining whether to upgrade, be cognizant of the version of the software that the peer review team has available to them to review the models (it may not be possible to open/use one version of the software in another version).

11.1 Software Upgrades

The general goals of large-scale projects involving microsimulation models usually involve multiple project stages/phases and may take 12 months or longer to complete. During this extended timeline, a software package may go through one or more updates. These updates usually occur for one or more of the following reasons:

- Software bug or error fix
- Feature addition
- Major version release

These updates can play a critical role in the application of the software to a project and may require the need to update the model. For example, if the software vendor discovers a bug within the latest version of the software, they may release an update to address/fix the bug. Typically, the analyst *should* update the model to apply the bug fix as soon as possible. If the software update includes new or enhanced features, the modeling team may decide that the new features would benefit the project. If the benefit of adding the additional feature outweighs any potential implications (e.g., additional time/resources needed to revise the model), it may be possible to justify updating the model to apply the new features. Since major version releases of the software typically involve larger changes to the analysis methodologies, upgrading the traffic model to the latest version release may introduce problems that did not exist previously. As such, BTO-TASU encourages the analyst to hold off on upgrading the model to a later date.

11.2 When to Upgrade

In most cases, when establishing the project scope and budget, the project team assumes/expects the use of a

specific version of the traffic modeling software. Thus, the project scope and budget may not be able to absorb the additional time/costs needed to upgrade the traffic model to a new release of the software.

The stage/phase of the model is the most important thing to consider when evaluating whether it is the correct time to upgrade the model to a new release of the software. The best time to upgrade a model is usually between major stages of a project.

The following list highlights scenarios when the analyst and project team may want to consider upgrading a model:

- A new project is using an older model
- There is a major break in a project schedule
- The latest update feature(s) to the software addresses a geometric element or other concern of the project that the older version of the software could not accurately capture
- The latest version update to the software addresses/fixes major bugs/errors

The following list highlights scenarios when upgrading a model might introduce problems that did not previously exist:

- Current project is almost complete
- Analyst is still using the current model to run test scenarios
- Model is very large and complex
- Newer version if not available to the peer review team

Under the above scenarios, the analyst and project team may decide to upgrade the model later or not at all. Ultimately, before upgrading the model to a new software version, the analyst **shall** consult with the WisDOT project team and WisDOT regional traffic engineering staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

11.3 Verify Model Calibration and Validation

If the WisDOT project team, WisDOT regional traffic engineering staff, and BTO-TASU all agree that there is enough reason to convert the model to a new release/version of the software, it is often advisable for the analyst to compare the outputs/results of the key MOEs from the upgraded model to those of the original calibrated/validated model. This check *should* give the analyst an idea of how much work is necessary to get the model to the same level of validity as the previous model. A model that does not require an extensive amount of modifications following an upgrade *should* be able to provide results that are similar and close to the original model.

Depending on the software package and the extent of the software modifications, upgrading the traffic model to the newest software version/release may cause a previously calibrated/validated model to fall out of validation. Therefore, the analyst *should* verify that the model still meets the validation thresholds. The analyst *should* first conduct a high-level, qualitative, assessment of the model, focusing on the components most significantly impacted by the software upgrade, to identify where revisions to the model may be necessary. Upon completing any necessary revisions to the model, the analyst *should* verify the validity of the model by performing the quantitative and qualitative validation tests summarized in TEOpS 16-20-8.

Document the results of the validation tests, either as part of the modeling methodology report or as a separate addendum and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate.

16-20-12 References April 2025

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2. **Federal Highway Administration.** *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software.* 2004. FHWA-HRT-04-040.

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4. **Cubic Transportation Systems.** *Synchro Studio 12 User Guide.* 2023. Published November 24, 2023.

5. **Transportation Research Board.** *Highway Capacity Manual 2010.* Washington D.C. National Academy of

Sciences, 2010. ISBN 978-0-309-16077-3.

6. **Transportation Research Board.** *Highway Capacity Manual, 7th Edition: A Guide For Multimodal Mobility Analysis.* Washington, D.C. National Academy of Sciences, 2022. ISBN 978-0-309-08766-7.

7. **Federal Highway Administration.** *Guidance on the Level of Effort Required to Conduct Traffic Analysis Using Microsimulation.* McLean, VA. Research, Development, and Technology Turner-Fairbank Highway Research Center, 2014. FHWA-HRT-13-026.

SimTraffic Calibration Settings

Last Updated: 11-27-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per SimTraffic v. 10.1.1.1)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
GLOBAL SETTINGS (Adjusted within SimTraffic)	***Driver Parameters***	Yellow Deceleration (ft/s^2)	7.0 - 12.0	8 to 10	Yes	Increase to make drivers less prone to running red lights.
		Speed Factor (%)	0.85 - 1.15	No range specified	Yes	Can be changed to increase or decrease the range of driver speeds (e.g. for a link speed of 50 mph and a speed factor of 1.1, the driver will attempt to maintain a speed of 55 mph).
		Courtesy Deceleration (ft/s^2)	3.0 - 10.0	7 to 9	Yes	Amount of deceleration a vehicle will accept in order to allow a vehicle ahead to make a mandatory lane change. Higher value = more courteous driver.
		Yellow Reaction Time (s)	0.7 - 1.7	No range specified	No	Amount of time it takes a driver to respond to a signal changing to yellow. More aggressive drivers will have a longer reaction time to yellow lights. Longer reaction times tends to reduce red light running for higher speed approaches and vehicles slowing to make a turn, however, may increase red light running for low speed approaches.
		Green Reaction Time (s)	0.2 - 0.8	0.5 to 2.0	Yes	Amount of time it takes the driver to respond to a signal changing green. More aggressive drivers will have a shorter reaction time to green lights.
		Headway at 0 mph (s)	0.35 - 0.65	No range specified	Yes, typically modify last	Interpolation used between these factors. May be necessary to change to match local driver parameters. The default headways provide an Saturation Flow Rate similar to the HCM (1900 vphpl) from 25 to 50 mph.
		Headway at 20 mph (s)	0.80 - 1.80	2 to 2.5		
		Headway at 50 mph (s)	1.00 - 2.20	1.7 to 2.0		
		Headway at 80 mph (s)	1.00 - 2.20	2.0 to 2.5		
		Gap Acceptance Factor	0.85 - 1.15	No range specified	Yes	Gap vehicles will accept at unsignalized intersections, for permitted left-turns, and for right turns on red. Higher values represent more conservative drivers.
		Positioning Advantage (veh)	1.2 - 15.0	Use defaults	No	Drivers will make a positioning lane change when there is >x vehicles ahead in the target lane than in the current lane. Higher values are associated with more conservative drivers and cause drivers to line up in correct lane. Lowe values are associated with aggressive drivers and cause drivers to avoid lining up in the correct lane until reaching the mandatory lane change point.
		Optional Advantage (veh)	0.5 - 2.3	Use defaults	No	Drivers will make a desired lane change when <x vehicles are ahead in the target lane than in the current lane. Higher values are associated with more conservative drivers and cause drivers to have unbalanced lane use. Lower values are associated with aggressive drivers and cause drivers to use lanes evenly.
		Mandatory Distance Adjustment (%)	50 - 200	No range specified	Yes	Global multiplier for local lane change settings.
		Positioning Distance Adjustment (%)	60 - 150	No range specified	Yes	Global multiplier for local lane change settings.
		Average Lane Change Time (s)	10 - 55	No range specified	No	Average time between lane change maneuvers. Applies only to optional lane changes, which are made to choose a lane with less congestion. Less time applies to more aggressive drivers.
		Lane Change Variance +/- (%)	10 - 30	No range specified	No	Adjustment similar to Average Lane Change Time, but base on driver type. Applies only to optional lane changes, which are made to choose a lane with less congestion. Higher percentage leads to increased awareness of lane change.
	Vehicle Parameters	Vehicle parameters (Occurrence, acceleration, dimensions, etc.)	See Synchro Studio 10 User Guide, Chapter 26 (page 26-7)	Defaults typically acceptable Modify vehicle fleet based on field classification counts if needed	Yes	Modify vehicle percentages based on nearest classification count. Fleet mix should add up to 100% for all truck types and 100% for all car types.

SimTraffic Calibration Settings

Last Updated: 11-27-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per SimTraffic v. 10.1.1.1)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
LOCAL SETTINGS (Adjusted within Synchro)	***Synchro Settings***	Link Speed (Lane Settings)	30	Start with posted. Adjust to reflect free flow speed (typically posted + 5 mph), if needed.	Yes	May be adjusted to match field speeds if data is available and speeds are not being used for validation
		Ideal Saturation Flow Rate (Lane Settings)	1,900	Adjust to match field if field data is available	Yes	Refer to TEOpS 16-15-5 for additional guidance on saturation flow rates for through lanes
		Growth Factor (Volume Settings)	1.0	Use for sensitivity testing or future year scenarios. Do not use for RTOR	No	
		Headway Factor (Simulation Settings)	1.0	0.8 to 1.2	Yes	Can be set on a per-movement basis. Can be used to calibrate the Saturated Flow Rates.
		Turning Speed (Simulation Settings)	9 mph (right-turns) 15 mph (left-turns)	Right turns = 12 to 15 mph	Yes	Default speeds are set for small radius urban intersections. With large suburban intersections, turning speeds may be significantly higher. Right-turns speeds need to be adjusted to or near the freeway speeds when simulating entrance ramps. At low speeds, the Saturated Flow Rate is highly sensitive to small changes in speed. Right-turns: SimTraffic = 9 mph (1545 vph). HCM for protected rights = 1615 vphpl Left-turns: SimTraffic = 15 mph (1883 vph). HCM for protected left-turns = 1805 vph.
		Mandatory Distance (Simulation Settings)	333	Base on field conditions	Yes	Distance ahead vehicle is forced to make lane change. Measured from Stop bar. Increase to allow vehicles to shift into correct lane earlier. Decrease to allow vehicles to shift into lane at the last possible moment. Large cities: Shorter mandatory distances Small towns: Longer mandatory distances. Useful to adjust with congested signals or lane drops after signals. With long turn bays consider setting this to less than the storage distance to allow for some late lane changes.
		Positioning Distance (Simulation Settings)	1320	Base on field conditions	Yes	Distance ahead vehicle starts to attempt lane change. Measured from Stop bar.
		Mandatory Distance2 (Simulation Settings)	880	Base on field conditions	Yes	Additional mandatory distance to make 2 lane changes. Measured from Stop bar. Typically used more for high-speed facilities. See Synchro Studio 10 User Guide, Chapter 28 (pages 28-5 to 28-18)
		Positioning Distance2 (Simulation Settings)	1760	Base on field conditions	Yes	Additional positioning distance to make 2 lane changes. Measured from Stop bar. Typically used more for high-speed facilities. See Synchro Studio 10 User Guide, Chapter 28 (pages 28-5 to 28-18)
		Lane Alignment (Simulation Settings)	Right for right-turns Left for left-turns and thru movements Right-NA for U-turns	Base on field conditions	Yes	
		Enter Blocked Intersection (Simulation Settings)	"No" for intersections	Code 1 vehicle if used Yes for driveways No for high speed movements	Yes	Enter "No" for high speed approaches and movements. "Yes" can help capacity of driveways. In general, controls gridlock avoidance.
		Taper Length (Simulation Settings)	25	Code as part of storage based on field conditions	Yes	Impacts when vehicles can start entering the storage.

Paramics Calibration Settings

Last Updated: 08-31-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Paramics v. 6.9.3)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
GLOBAL SETTINGS	*Core Settings*	Time steps	2	2 to 4, Typically 4 for models with freeway merging	Yes	Higher Time Step allows vehicles to make decisions based on the car following and lane change logic at a higher frequency.
		Queue gap distance (ft)	32.81	Typically not modified	No	Maximum distance between queuing vehicles.
		Queuing speed (mph)	4.47	Typically not modified	No	Maximum speed of queuing vehicles.
		Heavy vehicles weight (ton)	2.95	Typically not modified	No	Minimum weight of a heavy vehicle.
		Mean target headway (s)	1.00	Urban areas: 0.85 to 0.90 Small Cities: 0.90 to 0.95 Rural areas: 0.95 to 1.00	Yes	Raise to increase distance between vehicles and represent more passive drivers. Lower to decrease distance between vehicles and represent more aggressive drivers.
		Mean driver reaction time (s)	1.00	Urban areas: 0.85 to 0.90 Small Cities: 0.90 to 0.95 Rural areas: 0.95 to 1.00	Yes	Value is associated with the lag in time between a change in speed of the preceding vehicle and the following vehicle's reaction to this change. Raise for more passive drivers. Lower for more aggressive drivers.
		Speed memory	3	1.5x the Time steps value	Yes, if time step value is changed.	Speed Memory is used to store previous vehicle speeds at each Time Step. Speed Memory x time step should be > than the global Driver Reaction Time.
		Minimum gap (ft)	6.56	Typically not modified	No	Minimum gap between stationary vehicles in a queue.
		Loop length (ft)	6.56	Typically not modified on global level	No	Default distance between upstream and downstream edges of a loop detector (2 meters). Detector lengths may be modified locally as well.
		Amber time (s)	3	Typically not modified on global level	No	Default yellow time included in traffic signal phases. This setting should be modified locally based on field signal timing and phasing settings.
		Red time (s)	5	Typically not modified on global level	No	Default red time included in traffic signal phases. This setting should be modified locally based on field signal timing and phasing settings.
		Default curve speed factor	1	Typically not modified	No	Allows vehicles to make turns at a safe speed. Typically not modified.
		Speed drift unit	5	Typically not modified	No	Specifies minimum number of units that the link speed can be altered by in the Link Editor. Typically not modified.
		Wrong lane diversion time (s)	300	Typically not modified	No	Additional cost a vehicle would tolerate in order to reach its destination by choosing an alternative route. Only applies to links that have the "re-route stuck vehicles" flag enabled.
	Assignment Settings	Assignment settings-Time Cost Coefficient	1.000	0.667	Yes, change from default in initial network setup.	Coefficient that defines how travel time affects routing for all vehicles in the network.
		Assignment settings-Distance Cost Coefficient	0.000	0.333	Yes, change from default in initial network setup.	Coefficient that defines how distance affects routing for all vehicles in the network.
		Assignment settings-Toll Price Cost Coefficient	0.000	0	Only if tolling applies. Should be based on prevailing wage rate in the study area.	Coefficient that defines how toll pricing affects routing for all vehicles in the network.
		Assignment settings-Dynamic Assignment: Feedback Period	0	Start with 5 minute feedback period	Yes, change in small increments	Sets period at which link times are fed back into the routing calculations. At the beginning of each feedback period route cost tables are calculated for each viable network node to each destination zone.
		Assignment settings-Dynamic Assignment: Feedback Smoothing	0.500	Adjust to reflect field conditions	Yes, change in small increments	Determines the percentage of historical data to be included in the routing table calculations. The lower the value the more emphasis is placed on historic data.
		Assignment settings-Dynamic Assignment: Feedback Decay	0.995	0.3 to 0.5	Yes, change in small increments	Reduces dynamic feedback costs over time if there is no new data to make new calculations with. This avoids having a rapid oscillation in costs.
		Assignment settings-Dynamic Assignment: Feedback Envelope	0	Adjust to reflect field conditions	Yes, change in small increments	Defines how delay at a distance from a vehicle affects routing decisions. The further away a delay value is from the driver's position, the less weight the driver applies to their route choice decision.
		Assignment settings-Matrix Tuning Level	None	Typically not modified	No	Modifies the demand distribution during simulation. For large networks there is a performance penalty with selection this option.
	Other Parameters	Other parameters-Vehicle types (proportion, familiarity, kinematics, dimensions, etc.)	-	Use Wisconsin-tailored vehicles file. Adjust vehicle type proportions to represent field conditions if possible.	Yes	Adjust to reflect vehicle proportions observed in the field.
		Other parameters-Other global parameters (options menu, etc.)	-	1) Check "Heavies Use All Lanes" 2) TWOPAS HGV climbing model 3) Gap reduction for stopped buses	1) Always check "Heavies Use All Lanes" 2) TWOPAS HGV climbing model use is project specific. 3) Gap reduction for stopped buses use is project specific	1) Allows heavy vehicles (i.e. trucks) to drive in all lanes. WI does not require trucks to stay in right lane. 2) TWOPAS HGV climbing model allows for grades coded in model to affect truck kinematics. Additional effort in coding grades accurately and correctly is needed. 3) Gap reduction for stopped buses should only be used in special-case scenarios where pick ups and drop offs are being modeled.

Paramics Calibration Settings

Last Updated: 08-31-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Paramics v. 6.9.3)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
LOCAL SETTINGS	*Link Parameters*	Link Speed	Varies, set by link category	Use field data to code links speeds. If field data is not available, code link speed as posted speed	Yes, changes that stray from posted speed limit should be based on field data.	Drivers typically drive 10% over the posted speed limit in uncongested conditions. Link speed may need to be adjusted to reflect observed travel speeds.
		Link Signpost and Signrange	Varies, set by link category	Base on field conditions. Allow signpost to enter zone on freeways.	Yes	Controls how and when vehicles move to the correct lane upstream of a hazard. Propagation of signposting can be used for widening hazards.
		Link Force Merge	unchecked	Lower priority use	Yes, use sparingly	For links with priority other than major, drivers that have exceeded their patience threshold will force their way into the flow of traffic as long as a conflicting vehicle is not in the driver's path.
		Link Force Across	unchecked	Lower priority use	Yes, use sparingly	For links with priority other than major, drivers that have exceeded their patience threshold will force their way across traffic to join any desired traffic stream as long as a conflicting vehicle is not in the driver's path.
		Link Force Vehicle Aware	unchecked	Could be adjusted if applicable	Yes, if applicable	Used in shared-space pedestrian applications. Can be used to improve the quality of vehicle/pedestrian interaction logic by forcing all vehicles to be aware of pedestrians.
		Link Reaction factor	1.00	Lower priority use, small adjustments only	Yes, use sparingly	Value is associated with the lag in time between a change in speed of the preceding vehicle and the following vehicle's reaction to this change. Raise for more passive drivers. Lower for more aggressive drivers.
		Link Headway factor	1.00	Lower priority use, small adjustments only	Yes, use sparingly	Raise to increase distance between vehicles and represent more passive drivers. Lower to decrease distance between vehicles and represent more aggressive drivers.
		Link Approach Visibility	Normal Link = 0 Roundabout approach = 32.8	Important for roundabouts. Can be used with other unsignalized control.	Yes, typically adjusted with roundabouts.	Aids in vehicles identifying gaps at an unsignalized intersection approach. Important for roundabout calibration.
		Link Stimulus Time	5	Typically not modified based on survey results	No	Lower value results in faster decision time for lane change
		Link Transition Time	5	Typically not modified based on survey results	No	Lower value results in faster lane changing maneuver
		Category Cost Factors	0.8 to 1.0	Typically not modified from defaults	No	Aids in routing control for unfamiliar drivers
		Link Cost Factor	1.00	Adjust as needed to correct local routing issues.	Yes	Aids in routing control for all drivers
	Node Parameters	Node parameters-Allow sneaking	Unchecked	Could be used at congested intersections	Yes	Applies only when multiple vehicles are waiting to transfer to the same outbound link. Allows blocked vehicles to perform their movement before other vehicles of a higher priority. Could be used to reduce queue lengths and simulate more aggressive driving behavior.
		Node parameters-Anticipate gaps	Unchecked	Could be used at congested intersections	Yes	By default vehicles wait for crossing vehicles to complete clear a node before completing their turning movement. This option allows vehicles to complete turning movement once the driver's path across the node is cleared. Could be used to reduce queue lengths and simulate more aggressive driving behavior.
		Turning Penalties	1.00	No range specified	No	Aids in routing control for all drivers
	Entrance Ramp Parameters	Entrance ramp settings-Minimum Ramp Time (s)	2	0 to 2 Typically 1	Yes	Specifies amount of time vehicles must spend on the ramp prior to considering merging maneuver. Use 0 seconds as last resort after modifying headway, ramp aware, or other parameters to calibrate entrance ramp. Use of 0 seconds may be necessary with high volume merges and/or freeway segments.
		Entrance ramp settings-Headway Factor	1.00	0.80 to 1.00	Yes	Target headway for all vehicles on the entrance ramp. Raise to increase distance between vehicles and represent more passive drivers. Lower to decrease distance between vehicles and represent more aggressive drivers.
		Entrance ramp settings-Ramp Aware Distance (ft)	656.2	Modify on case-by-case basis depending on field conditions (topography, visibility of onramp, signing, etc.) and driver behavior or courtesy in study area	Yes	Defines point at which vehicles on the mainline become aware of the entrance ramp. Mainline drivers will only change lanes to allow for merging gaps and will not decelerate or accelerate to create gaps.
	Other Parameters	Other parameters-Gap Acceptance Rules	-	Lower priority use	Yes	Estimation of the minimum time required to clear the theoretical collision point with oncoming vehicles. If time is less than estimation, the driver will complete their movement. Typically used to calibrate queues at unsignalized intersections.
		Other parameters-Variable Speed Limit Rules	-	Typically not modified	No	Controls the speed limit on a route over a set timeframe. Transition times can be specified to avoid abrupt changes.
		Other parameters-Dynamic Tolling Rules	-	Typically not modified	No	May be used in HOT analysis.
		Other parameters-Spatial Test Transfer Rules (Merge or Crossing)	-	Could be used	Yes, typically with roundabouts or short links	Aids in gap acceptance. Generally used with roundabouts or areas with short links.
		Other parameters-Spatial Test Movement Rules	-	Could be used	Yes, typically with roundabouts or short links	Aids in gap acceptance. Generally used with roundabouts or areas with short links.

VISSIM Calibration Settings

Last Updated: 03-30-21
Source: PTV Vissim 2020 User Manual

Type of Setting	Parameter Grouping	Parameter Name		Default Settings (per Vissim v. 2020.00-11)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description
GLOBAL	*Simulation Settings*	Simulation resolution; Time steps (seconds)/Simulation second		10.00	5 to 10	Yes	The simulation resolution has an impact on the behavior of vehicles, pedestrians, and the way they interact. A higher simulation resolution allows vehicles to make decisions based on the car following and lane change logic at a higher frequency.
		Simulation Speed, Simulation second/second		10	Value 1.0: the simulation is run in real-time Value 2.0: The simulation is run at double real-time speed, etc. Maximum option: Runs the simulation at the maximum speed	No	Corresponds to a time lapse factor. It indicates simulation seconds per real-time second. The simulation speed does not affect the simulation results. The simulation speed can be changed during the simulation run.
	Traffic Settings	Vehicle Composition (Veh Type; DesSpeedDistr; RelFlow)		100: Car, 50:50 km/h, 0.980 200: Car, 50:50 km/h, 0.020	Adjust to represent field conditions	Yes	Adjust relativeflows to represent field conditions
		Pedestrian Composition (Ped Type; DesSpeedDistr; RelFlow)		100: Man, 1022:IMO-M 30-50, 1.000 Woman 1023:IMO-F 30-50, 1.000	Adjust to represent field conditions	Yes	Adjust relative flows to represent field conditions
	Base Settings	Vehicle Fleet			Use "WisDOT Defaults inpx" as default	Yes	Adjust to represent field conditions
		Vehicle/Pedestrian Types		Car, HGV, Bus, Tram, Pedestrian, Bike	Adjust to represent field conditions	Yes	Vehicle/pedestrian type allows you to form a group of vehicles/pedestrians with the same technical driving/walking characteristics
		Vehicle/Pedestrian Classes		Car, HGV, Bus, Tram, Bike Man, Bike Woman, Man, Woman, Woman & Child, Wheelchair	Typically separate into passenger cars and heavy trucks, but may use any of the FHWA 13 vehicle classes	Yes	By default, the data for all vehicle and pedestrian classes is entered together, but you can show the data for certain vehicle classes and/or pedestrian classes separately in the evaluation.
		Functions (Maximum and Desired Acceleration/Deceleration)		-	Use "WisDOT Defaults inpx" as default	No	Impacts how fast or slow a vehicle will accelerate/decelerate. Generally more critical on steeper grades.
		Distributions (vehicle characteristics, function and distribution)		-	2D/3D Model - Use "WIsDOT Defaults inpx" as default, adjust to match field conditions as appropriate	Yes	Allows you to define the specific vehicles (Volkswagen Golf, Audi A4, etc.) that are included in the vehicle fleet.
		Vehicle Characteristics function and distribution			Speed Distribution: left turn 12.4 to 18.6 mph; right-turn 7.5 to 15.5 mph		Adjust to represent field conditions
LOCAL	*Car Following*	Look ahead distance min. (feet)		0.00	Typically not modified	No	Minimum distance that a vehicle can see forward in order to react to other vehicles either in front or to the side of it (within the same link). The minimum look-ahead distance is important when modeling lateral vehicle behavior. If several vehicle can overtake within a lane, this value needs to be greater than 0.00. If several vehicles can overtake within a lane, you can enter a greater look ahead distance to prevent any vehicle from running a red light (when doing so, do not change the number or **Observed vehicles** as this can lead to unrealistic simulation).
		Look ahead distance max. (feet)		820.21	Typically not modified	No	Maximum distance that a vehicle can see forward in order to react to other vehicles either in front or to the side of it (within the same link). May want to extend if modeling rail traffic with block signals.
		Look ahead distance. Observed vehicles		Arterial: 4 Freeway: 2	4	Yes	The number of observed vehicles or number of certain network objects affects how well vehicles in the link can predict other vehicles' movements and react accordingly. Higher value means vehicles can better react to multiple network objects in the network
		Look back distance min. (feet)		0.00	Typically not modified	No	Defines the minimum distance that a vehicle can see backwards in order to react to other vehicles behind (within the same link). The minimum look-back distance is important when modeling lateral vehicle behavior. If several vehicles can overtake with a lane, this value needs to be greater than 0.00. This way you make sure the cars drive in an orderly fashion when two or more vehicles, than specified in the **Observed vehicles** attribute, on the same route want to position themselves at a stop line. This applies in particular to bicycles.
		Look back distance max. (feet)		492.13	Typically not modified	No	Defines the maximum distance that a vehicle can see backwards in order to react to other vehicles behind (within the same link). You can reduce the maximum look-back distance in close-meshed networks (e.g., many connectors over a short distance). This may positively affect the simulation speed.
		Temporary lack of attention duration (s)		0.00	0.00 to 1.00	No	The period of time when vehicles may not react to a preceding vehicle (they do react, however, to emergency braking). With increasing values, the capacity of the affected links decreases.
		Temporary lack of attention probability		0%	0 to 5%	No	Frequency of the lack of attention. With increasing values, the capacity of the affected links decreases.
		Smooth closeup behavior		Selected	Typically not modified	No	If this option **is** checked, vehicles slow down more evenly when approaching a stationary obstacle. If this option **is not** selected, the following vehicle uses the normal following behavior until the speed of the preceding vehicle drops to less than 3.28 feet/second and it comes almost to a halt. The later approach behavior can include a temporary acceleration.
		Standstill distance for static obstacles		Not Selected, 1.64 ft if selected	Typically not modified	No	Standstill distance upstream of static obstacles such as signal heads, stop signs PT stops, priority rules, conflict areas. Not valid for stop signs in parking lots. The attribute **Smooth closeup behavior** must be selected. If this option is not selected, the vehicles us a normally distributed random value [0.5;0.15]. If this option is selected, the vehicles will use the given value.
		Wiedemann 74 Car following model (applicable for arterials)	Wiedemann 74-Average standstill distance (feet)	6.56 ft	3.28 to 9.84 ft.	Yes	Defines the average desired distance between two cars. Higher value means larger standstill distance and lower capacity
			Wiedemann 74-Additive part of safety distance	2.00	1 to 3.75 ft	Yes	Value used for the computation of the desired safety distance. Higher value means larger standstill distance and lower capacity
			Wiedemann 74-Multiplic. Part of safety distance	3.00	2 to 4.75 ft	Yes	Value used for the computation of the desired safety distance. Greater value equals greater distribution (standard deviation) of safety distance. Higher value means larger standstill distance and lower capacity

VISSIM Calibration Settings

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Source: PTV Vissim 2020 User Manual

Type of Setting	Parameter Grouping	Parameter Name		Default Settings (per Vissim v. 2020.00-11)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description
LOCAL (CONT)	*Car Following (Cont)*	*Wiedemann 99 Car following model (applicable for freeway/highway)*	Wiedemann 99-CC0 (Standstill Distance) (feet)	4.92 ft	Basic segment: 4.0 to 5.5 Weaving/Merge/Diverge: >4.92	Yes	The average desired standstill distance between two vehicles, it has no variation. Higher value means larger standstill distance and lower capacity
			Wiedemann 99-CC1 (Headway Time) (s)	0.90	Basic segment: 0.7 to 3.0 Weaving/Merge/Diverge: 0.9 to 3.0	Yes	Time distribution of speed-dependent part of desired safety distance. Higher value means more cautious driver and lower capacity
			Wiedemann 99-CC2 ('Following' Variation) (feet)	13.12 ft	Basic segment: 6.56 to 22.97 Weaving/Merge/Diverge: 13.12 to 39.37	Yes	Restricts the distance difference (longitudinal oscillation) or how much more distance than the desired safety distance a driver allows before he intentionally moves closer to the car in front. Higher value means more cautious driver and lower capacity
			Wiedemann 99-CC3 (Threshold for Entering 'Following')	-8.00	Typically not modified	No	It controls the start of the deceleration process (i.e., the number of seconds before reaching the safety distance.) At this stage the driver recognizes a preceding slower vehicle.
			Wiedemann 99-CC4 (Negative 'Following' Threshold)	-0.35	Typically not modified	No	Defines negative speed difference during the following process. Low values result in a more sensitive driver reaction to the acceleration or deceleration of the preceding vehicle.
			Wiedemann 99-CC5 (Positive 'Following' Threshold)	0.35	Typically not modified	No	Defines positive speed difference during the following process. Low values result in a more sensitive driver reaction to the acceleration or deceleration of the preceding vehicle.
			Wiedemann 99-CC6 (Speed dependency of Oscillation)	11.44	Typically not modified	No	Influence of distance on speed oscillation while in the following process. If the value is 0, the speed oscillation is independent of the distance. Larger values lead to a greater speed oscillation with increasing distance.
			Wiedemann 99-CC7 (Oscillation Acceleration) (ft/s^2)	0.82 ft/s^2	Typically not modified	No	Oscillation during acceleration
			Wiedemann 99-CC8 (Standstill Acceleration) (ft/s^2)	11.48 ft/s2	Typically not modified	No	Desired acceleration when starting from standstill (limited by maximum acceleration defined within the acceleration curves).
			Wiedemann 99-CC9 (Acceleration with 50 mph) (ft/s^2)	4.92 ft/s2	Typically not modified	No	Desired acceleration when starting at 80 km/h, approximately 50 mph, (limited by maximum acceleration defined within the acceleration curves).
	Lane Change	General behavior		Free lane selection	Free lane selection or Slow lane rule	No	Free lane selection: vehicles may overtake on each lane Slow lane rule: allows overtaking on freeways or similar links according to the rules in road traffic Regardless of option selected, you can model the general behavior more realistically using the settings under Cooperative lane change
		Maximum deceleration - Own (ft/s^2)		-13.12 ft/s2	-15 to -12	Yes	Upper bound of deceleration for own vehicle. Higher absolute value means more aggressive lane changing behaviors
		-1 ft/s2 per distance - Own (feet)		Arterial: 100 Freeway: 200	100 to 250	No	This reduces the **Maximum deceleration** with increasing distance from the emergency stop distance linearly by this value down to the **Accepted deceleration**.
		Accepted deceleration - Own (ft/s^2)		-3.28	-2.5 to -4	No	Lower bound of deceleration for own vehicle for a lane change
		Maximum deceleration - Trailing (ft/s^2)		-9.84 ft/s2	-12 to -8	No	Upper bound of deceleration for trailing vehicle. Higher absolute value means more aggressive lane changing behaviors
		-1 ft/s2 per distance - Trailing (feet)		Arterial: 100 Freeway: 200	50 to 250	No	This reduces the **Maximum deceleration** with increasing distance from the emergency stop distance linearly by this value down to the **Accepted deceleration**.
		Accepted deceleration -Trailing (ft/s^2)		Arterial: -3.28 Freeway: -1.64	-1.5 to -2.5	No	Lower bound of deceleration for trailing vehicle for a lane change
		Waiting time before diffusion (s)		60.00	99999.00	Yes	The maximum amount of time a vehicle can wait at the emergency stop distance for a necessary change of lanes. When this time is reached, the vehicle is removed from the network. Higher value means more tolerance on vehicles waiting at the emergency stop distance for necessary lane changes.
		Min. headway (front/rear), (ft)		1.64	1.5 to 6	No	The minimum distance between two vehicles that must be available after a lane change, so that the change can take place. A lane change during normal traffic flow might require a greater minimum distance between vehicles in order to maintain the speed-dependent safety distance.
		To slower lane if collision time is above (s)		11.00	0 to 0.5	No	Defines the minimum distance to a vehicle in front, in seconds, which must be present on the slower lane, so that an overtaking vehicle switches to the slower lane. Only applicable for **Slow lane rule** or **Fast lane rule**.
		Safety distance reduction factor		0.60	0.1 to 1.0	No	This factor is taken into account for each lane change. During the lane change, Vissim reduces the safety distance to the value that results from the following multiplication: **Original safety distance * safety distance reduction factor.** The default value of 0.6 reduces the safety distance by 40%. Once a lane change is completed, the original safety distance is taken into account again.
		Maximum deceleration for cooperative braking (ft/s^2)		-9.84	-32.3 to -3	No	Specifies to what extent the trailing vehicle is braking cooperatively, so as to allow a preceding vehicle to change lanes into the same lane they are traveling in. The higher the value, the stronger the braking and the greater the probability of changing lanes.
		Overtake reduced speed areas		Not Selected	Typically not modified	No	If this option is selected, vehicles immediately upstream of a reduced speed area may perform a free lane change. The vehicle will acknowledge any reduced speed area of the lane they changed into and adjust their speed accordingly. If the option is not selected (default), vehicles never start a free lane change directly upstream of a reduced speed area and they completely ignore the reduced speed areas on the new lane.
		Advanced merging		Selected	Adjust to match field conditions	Yes	If this option is selected, more vehicles can change lanes earlier, therefore capacity increases
		Vehicle routing decisions look ahead		Selected	Typically not modified	No	If this option is selected, vehicles leaving the route identify new routing decisions on the same link in advance and take them into account when choosing the lane. For routing decisions further downstream that vehicles should identify in advance, the option **Combine static routing decisions** (under "Attributes of static vehicle routing decisions) must be selected.

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Type of Setting	Parameter Grouping	Parameter Name		Default Settings (per Vissim v. 2020.00-11)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description
LOCAL (CONT)	*Lane Change (Cont)*	Cooperative lane change		Not Selected	Adjust to match field conditions	Yes	If this option is selected, trailing vehicles will make necessary lane change to facilitate the lane change of a leading vehicle
		> Maximum speed difference (mph)		6.71	Typically not modified	No	Applicable only if **Cooperative lane change** has been selected. Identifies the maximum possible speed difference.
		> Maximum collision time (s)		10.00	Typically not modified	No	Applicable only if **Cooperative lane change** has been selected. Identifies the maximum collision time (time a vehicle can travel before reaching a preceding vehicle or network object that has an impact on its desired speed)
		Rear correction of lateral position		Not Selected	Typically not modified	No	This causes the vehicle to be aligned to the middle of the lane at the end of the lane change, instead of at an angle in the original lane. This can affect the capacity. Only performed if the **Keep lateral distance to vehicles on next lane(s)** option is selected under "Lateral" behavior.
		> Maximum speed (mph)		1.86	Typically not modified	No	Speed up to which the correction of the rear end position should take place. Lateral correction of the rear end position is not performed for faster vehicles.
		> Active during time period from "x sec" until "x sec" after lane change start		1.00 until 10.00	Typically not modified	No	Time after the start of the lane change at which the lateral movement of the rear end position should start **until** time after the start of the lane change at which the lateral movement of the rear end position should end.
	Lateral	Desired position at free flow		Middle of lane	Typically not modified	No	Lateral orientation of a vehicle within its lane while it is in free traffic flow
		Keep lateral distance to vehicles on next lane(s)		Not Selected	Typically not modified	No	If this option is selected, the vehicles consider the position and therefore the lateral orientation of vehicles on adjacent lanes and keep the **Lateral min. distance**. For this purpose, vehicles even adjust their lateral orientation on their own lane and swerve out of the way. If this option is not selected, vehicles on adjacent lanes are ignored even if they are wider than their lanes, except when they perform a lane change. **Note: using this option can reduce the simulation speed significantly**.
		Diamond shaped queuing		Not Selected	Typically not modified	No	If this option is selected, queues take into account a realistic shape of vehicles with vehicles positioned offset, such as bikes. Vehicles are internally represented not as a rectangle, but as a rhombus.
		Consider next turning direction		Not Selected	Typically not modified	No	Enables more intelligent lateral behavior in case of non-lane-bound traffic. If the option has been selected, a vehicle with this driving behavior does not pass another vehicle on the same lane if this might cause a collision at the next turning connector. To achieve this, attributes that enable passing on the same lane **must** be selected. Note the option **Consider next turning direction** has precedence over option **Desired position at free flow**.
		Collision time gain (s);		2.00	Typically not modified	No	Minimum value of the collision time gain for the next vehicle or signal head, which must be reached so that a change of the lateral position on the lane is worthwhile and will be performed. Calculated based on the desired speed of the vehicle. Smaller values lead to a livelier lateral behavior, since vehicles also have to dodge sideways for minor improvements.
		Minimum longitudinal speed (mph):		2.24	Typically not modified	No	Minimum longitudinal speed which still allows for lateral movements. The default value (2.24 mph) ensures that vehicles can also move laterally if they have almost come to a halt already.
		Time between direction changes (s):		0.00	Typically not modified	No	Defines the minimum simulation time which must pass between the start of a lateral movement in one direction and the start of a lateral movement in the reverse direction. The higher this value, the smaller the lateral movements of vehicles. These lateral movements only take place if overtaking on the same lane is permitted. (Does not affect the lateral movement for a lane change.)
		Default behavior when overtaking vehicles on the same lane or on adjacent lanes	Overtake on same lane	Overtake left (default) - Not Selected Overtake right (default) - Not Selected	Typically not modified	No	When modeling traffic that is not lane-bound, you can allow vehicles to overtake within a lane. **Left:** vehicles are allowed to overtake on a lane to the left; **Right**: vehicles are allowed to overtake on a lane to the right.
			Minimum lateral distance (ft)	Distance standing at 0 mph: 0.66 ft Distance driving at 30 mph: 3.28 ft	Typically not modified	No	Minimum distance between vehicles when overtaking within the lane and keeping the distance to vehicles in the adjacent lanes. **Distance Standing at 0 mph** is the lateral distance of the passing vehicle; **Distance driving at 30 mph** is the lateral distance of the passing vehicles.
		Exceptions for overtaking vehicles of the following vehicle classes		No exceptions listed	Typically not modified	No	Behavior for specific vehicle classes that deviates from the default behavior when overtaking vehicles on the same lane. When modeling traffic that is not lane-bound, you can select vehicle classes which may be overtaken within a lane by vehicles of the defined driving behavior set.
	Signal Control	Reaction after end of green	Behavior at amber signal	Continuous Check	Not typically modified	No	Defines the behavior of vehicles when they approach an amber light. **Continuous check:** driver of vehicle continuously decides whether to continue driving or whether to stop. Vehicles assume that the amber light will only be visible for another two seconds. They then decide continuously, with each time step, whether they will continue to drive or stop. A vehicle will not brake, if its maximum deceleration does not allow it to stop at the stop line, or if it would have to brake for more than 15 ft/s^2. The vehicle will brake, if at its current speed, it cannot drive past the signal head with two seconds. Both braking and stoping are possible for cases that lie in between these two scenarios. **One decision:** The decision made is maintained until the vehicle crosses the stop line. Calculated using the probability factors.
			Probability Factors	Alpha: 1.59 Beta 1: -0.26 Beta 2: 0.27	Only applicable is **One decision model** is selected, Not typically modified	No	Used to calculate the probability (i.e., whether a driver stops at an amber light or not). $p = \frac{1}{1+e^{-\alpha-\beta_1 v-\beta_2 dx}}$ The following settings make a vehicle continue driving for longer when there is an amber light and occasionally even make it run a red light: The **One decision** option is selected, **Alpha** is greater than the default value 1.59; **Beta1** is greater than the default value 0.27; and **Beta2** is greater than the default -0.26 but less than 0.00.
		Reaction after end of red	Behavior at red/amber signal	Go (same as green)	Not typically modified	No	Used to define country-specific or regional behavior at red/amber signal. Options are **Stop (same as red)** or **Go (same as green);** where **Stop (same as red)** means the Go signal is green (the response time is effective from the time step the signal changes to green) and the **Go (same as green)** means the **Go** signal is red-amber (the response time is effective from the time step the signal changes to red-amber).
			Reaction time distribution	Blank	Typically not modified	No	Reaction time of a vehicle to the **Go** signal. It causes a time delay between the time step when the signal switches to **Go** and the time step when the first vehicle upstream of the corresponding stop line starts to move. If no time distribution is selected, the default time is 0 seconds.
		Reduced safety distance close to a stop line	Factor	0.60	0.60	Yes	Higher value reduces the safety distance between vehicles close to the signal stop bar
			Start upstream of stop line (ft)	328.08	Not typically modified	No	Distance upstream of the signal head
			End downstream of stop line (ft)	328.08	Not typically modified	No	Distance downstream of the signal head

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LOCAL (CONT)	*Connector-level*	Emergency Stop (feet)	16.4 ft per lane	Adjust to match field conditions	Yes	Distance before the downstream connector where vehicles can make last chance lane changes
		Lane change (feet)	656.20	>656.20	Yes	Distance before the downstream connector where vehicles begin to make lane changes
		Lane change per lane	Not Selected	Adjust to match field conditions	Yes	If this option is selected, the entered lane change attribute value is multiplied by the number of lane changes which a vehicle requires to reach the connector
	Point-level	Speed distributions (mph)	Linear distributions	Adjust to represent the field conditions	Yes	The distribution function of desired speeds is a particularly important parameter, as it has an impact on link capacity and achievable travel times. If not hindered by other vehicles or network objects (e.g., signal controls), a driver will travel at his desired speed. Desired speed distributions are defined independently of vehicle or pedestrian type.
		Time distributions (mph)	Linear distributions	Not typically modified	No	You can use dwell time distributions for: 1) standstill time on parking lots 2) waiting times at toll counters through stop signs or 3) for PT stops to allow adequate time for passengers to board and alight the bus/transit vehicle.