KYTC

Microsimulation Guidelines

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1 Purpose and Background

1.1 Guidance Document Purpose

The primary purpose of this document is to provide guidance for those that scope, develop, apply, and review traffic microsimulation models in Kentucky. It offers practical tools and procedures as well as Kentucky specific parameters for creating and calibrating simulation models. The document also provides guidance to project teams as they decide if simulation modeling or some other approach is appropriate for a specific project.

The document should be used as a reference guide from scoping to project completion. It is not a complete how-to manual for simulation modeling. It is expected that staff creating simulation models in Kentucky have a basic understanding of the software and traffic simulation principles. The information in the manual provides guidance for how to implement simulation projects in Kentucky given that base knowledge.

1.2 What is Microsimulation?

Microsimulation is a traffic analysis tool that provides highly detailed vehicle interaction level data for analysis and visualization. Microsimulation modeling is hyper-customizable and can evaluate a variety of roadway configurations varying in complexity, roadway, and modal configurations. Microsimulation is the most detailed method for analyzing traffic operations as it can provide vehicle level details unavailable with other analysis tools. Microsimulation provides a tool that is highly impactful in traffic analysis and visualization using software that is very customizable and requires additional resources and training to implement properly. This guidance provides insight on how microsimulation should be applied for Kentucky-based projects.

1.3 Purpose of Microsimulation

Microsimulation is often utilized on projects where traffic operations are a key aspect of the project purpose and need. As microsimulation modeling is more involved than other traffic analysis methods (i.e., deterministic tools like HCS or Synchro), it is typically utilized when one of the following criteria are met:

- The project has complex configurations (existing or proposed) which other analysis methods cannot properly examine.
- The project has a combination of facility types (freeway, arterial, transit, pedestrian, etc.) which cannot be accurately analyzed with other available software packages.
- Areas or specific movements within the project area require more in-depth analysis than is possible via other analysis tools.
- The goals, performance measures, or proposed solutions require a very detailed or customized analysis.

1.4 Microsimulation in Kentucky

In Kentucky, microsimulation has become a popular tool to help in the decision-making process. As microsimulation models provide detailed outputs, they are useful for identifying project challenges and opportunities and comparing several competing improvement concepts. The results from microsimulation can be used to prioritize improvements, refine proposed concepts, and develop right-sized solutions, which are often not feasible with other analysis methods. As innovative transportation solutions incorporate new design concepts, operational strategies and mode choice, microsimulation modeling is emerging as a valuable tool for providing insights on current and future system performance.

1.5 Value of Kentucky Standards

Within microsimulation software, numerous variables control the operations and performance of the model. These variables define everything from the physical dimensions of the roadway network, to the performance attributes of vehicles, to the assumed behaviors of the individual drivers within the model. Many variables interact with each other, affecting performance in complex ways. Each of the software packages have been developed to allow a significant number of the variables to be modified by the user. This provides the ability to customize the model from the default settings assigned by the software developer. The default values in the models are representative of assumed typical driving conditions. Users have the ability to modify them and refine model performance to better represent local conditions. The ability to fine-tune the variables within a model allows microsimulation to be a more customized, representative tool than other analysis methods. A microsimulation model can yield unrealistic results if the model is based entirely on default parameters or if the parameters have been modified in unrealistic ways.

Without guidelines for model development, calibration, and modification, users are left without direction regarding the customization of models. This may result in models with only default values or with aggressively modified values, neither of which may provide results indicative of real-world conditions. In some cases, this could lead to the misevaluation of conditions and potentially the recommendation of unnecessary improvements. The lack of guidelines also creates inconsistencies across projects. Models generated for different projects are likely to be inconsistent due to different modeling methodologies for development and customization. This will yield results that are not comparable and are difficult to validate.

The development of microsimulation guidelines provides direction (as many other states and agencies have) for the development and customization of microsimulation models. This serves as a framework to assist modelers throughout the process. Guidelines also provide objective benchmarks for model development, performance, and review. This will yield microsimulation models that are more consistent, accurate, and representative of Kentucky drivers. Models that are more consistent will lead to trusted results and ultimately better outcomes in decision-making and project implementation.

This guide provides information to standardize microsimulation modeling in Kentucky. The guide will promote consistent model development and evaluation to make reliable investment decisions.

1.6 Existing Microsimulation Guidance by Other Agencies

Several other state agencies have developed similar guidance materials to provide insight, instruction, and recommendations to modelers and reviewers within their jurisdictions. The majority of these guidance materials serve as recommendations for model development and parameters as opposed to prescriptive instruction for model development. The contents of each guidance document vary, but each illustrates key items for potential inclusion from which this Kentucky guidance draws significant insight. A literature review was conducted on a majority of the known available guidance documents to provide supplemental information and background prior to the development of this manual. Several of these guidance documents include information regarding scoping, model development, calibration, and specific parameter values or ranges, which are considered in this guidance.

Table 1 details the materials reviewed for this guidance and provides links to the current versions of each for further investigation.

Table 1: Existing Microsimulation Guidance Content Summary

Agency	Date	Contents							Link to Document
		Traffic Analysis Scoping	Data Collection	Analysis Tool Selection	Traffic Forecasting	Calibration	Parameter Values	Reporting	
Colorado DOT	Jul 2018	✓	✓	✓	✓	✓		✓	CODOT Traffic Analysis and Forecasting Guidelines
Florida DOT	Mar 2014	✓	✓	✓	✓	✓	✓	✓	FDOT Traffic Analysis Handbook
Iowa DOT	Oct 2017	✓	✓			✓		✓	Iowa DOT Microsimulation Guidance
Maryland DOT	Aug 2017					✓	✓	✓	MDOT Vissim Modeling Guidance
Ohio DOT	July 2020	✓	✓	✓		✓		✓	OATS Manual
Oregon DOT	Jun 2011	✓	✓	✓	✓	✓	✓	✓	ODOT Protocol for Vissim Simulation
Virginia DOT	Nov 2015	✓	✓	✓	✓	✓	✓	✓	VDOT TOSAM
Washington DOT	Sep 2014	✓	✓	✓	✓	✓	✓	✓	WSDOT Protocol for Vissim Simulation
Wisconsin DOT	Jan 2018	✓	✓	✓	✓	✓		✓	WisDOT TEOpS - Chapter 16
FHWA	Aug 2019	✓	✓			✓		✓	FHWA Traffic Analysis Toolbox Vol. III

2 Pre-Model Development Materials

2.1 Analysis Scope and Tool Selection

The development of a thorough scope that outlines clear, measurable project objectives and the methodologies required to achieve them is requisite for a successful traffic analysis. The FHWA Traffic Analysis Toolbox (TAT) and the Highway Capacity Manual (HCM) provide a list of questions that should be answered at the outset of a traffic analysis. These questions help provide guidance and context to project scoping. The list of questions includes:

Five Questions for Traffic Analysis Scoping

1. What is the purpose and need of the study?
2. Are oversaturated conditions present or expected in the future? If so, are they relevant?
3. What are the spatial limits of the study network?
4. What are the temporal limits of the analysis?
5. What Analysis type(s) and tool(s) are relevant?

1. What is the purpose and need of the study?

Traffic analyses may be required at any stage within the life cycle of a transportation facility, from high-level planning to maintenance and operations. The results of these analyses may be used by agencies to accomplish several tasks:

- Evaluating and prioritizing project alternatives during the planning and design phases
- Reducing disruptions to traffic during maintenance and construction
- Maximizing existing roadway capacity by optimizing signal timing or reallocating right-of-way
- Presenting or marketing potential future projects to the public and other stakeholders

Since a number of traffic analysis tools and methods may be applicable to each of the scenarios listed, it is critical that the analyst understand what approach would best satisfy the project goals and objectives, while minimizing the time and resources required. Potential analysis tools and methods to accomplish this will be discussed later in this section.

2. Are oversaturated conditions present or expected in the future? If so, are they relevant?

Many projects are proposed to address existing or projected traffic congestion. The presence of heavy congestion or oversaturated conditions in the base or future analysis years can be a major factor in the selection of the most appropriate tools and methods. The 6th Edition of the HCM defines oversaturated conditions as:

> "Traffic flow during an analysis period is characterized as 'oversaturated' when any of the following conditions is satisfied: (a) the arrival flow rate exceeds the capacity of a point or segment, (b) a queue created from a prior breakdown of a facility has not yet dissipated, or (c) traffic flow is affected by downstream conditions."

Many deterministic, HCM-based tools, as well as various screening tools, are incapable of accurately assessing the impact of oversaturated conditions on traffic operations; therefore, microsimulation may be a required tool should this question be answered affirmatively.

3. What are the spatial limits of the study network?

Spatial limits define the geographic boundaries of a traffic analysis, and one should establish them only after existing traffic conditions are thoroughly understood. The extent of the study network and the types of system elements to be analyzed are key components of the scoping process, as many analysis tools are only applicable to a limited set of intersection and facility types. In general, the spatial limits of a traffic analysis should be determined through the following four-step process:

1. Include the *zone of influence*. This area includes the immediate study network plus the next adjacent interchange (for freeways) or signalized intersection (for arterials). Engineering judgement should be used to expand the zone of influence as necessary.
2. Extend beyond the zone of influence to include the outer limits of any recurring queues (i.e., from any downstream bottlenecks to the furthest back of queue) and to include any features that significantly influence driving behavior or the arrival of vehicle platoons (e.g., weaving areas or traffic signals).
3. Include both *existing* and *hidden* bottlenecks (i.e., those that do not yet exist but would if upstream demand was "released" due to the increased capacity provided by improvements).
4. Account for the expected extent of congestion in both the *existing* and *future* years.

4. What are the temporal limits of the analysis?

The temporal limits of a traffic analysis define the beginning and ending periods to be studied. Like the spatial limits of the study network, the temporal limits of an analysis should be defined based on project needs and a solid understanding of the study area. The following principles should also be considered:

- The number and length of analysis periods should be selected based on project-specific context.
- When oversaturated conditions exist, the first and last periods of the analysis should be uncongested at bottlenecks, critical to study outcomes. Future-year analyses should also capture the onset and dissipation of congestion so that all forecasted demand is served, allowing for the benefits and drawbacks of a given project alternative to be fully understood.
- When microsimulation is used, warm-up and cool-down periods should be utilized to establish realistic traffic conditions in the model prior to collecting outputs and to ensure that all demand is served by the model.

5. What Analysis type(s) and tool(s) are relevant?

Once study objectives, prevailing network traffic characteristics, and required spatial and temporal limits have been defined, relevant analysis types may be determined. The analysis types in **Table 2** are defined in FHWA's TAT, Volume II.

Table 2: Traffic Analysis Method Summary

Analysis Type	Description/ Application	Examples
Sketch Planning	High-level, "ballpark" estimates of travel demand and traffic operations under potential improvement scenarios. These tools are primarily used early in the planning process, and they may help focus subsequent analysis efforts.	• ITE Trip Generation Manual-based spreadsheets • Generalized Service Volume Tables
Travel Demand Modeling	Typically used at the onset of the planning process to forecast travel demand under various improvement scenarios for use in subsequent analyses or to validate the feasibility of a given design alternative. These tools may be integrated with microsimulation software packages during the later stages of a traffic analysis.	• TransCAD • Visum • Aimsun (some editions) • Cube
Deterministic (HCM-Based) Analysis	Typically perform the closed-form, macroscopic, static analytical procedures used in the HCM and produce a single answer from each set of user inputs. Associated tools are appropriate for analyzing the performance of isolated transportation facilities but often cannot capture interactions between facilities or individual facility elements. Deterministic tools may not be applicable to study areas that are exceedingly complex or exhibit significant congestion.	• Highway Capacity Software (HCS) • Synchro (HCM Module) • SIDRA • FREEVAL • Vistro
Traffic Signal Optimization	Apply the deterministic, HCM-based procedures described above but do so with the sole intent of optimizing signal timing and phasing for isolated intersections or corridors.	• Synchro • TransModeler[1] • Vistro
Macroscopic Simulation Tools	Replicate the movement of platoons of vehicles and are based on the deterministic relationships of traffic flow, speed, and density.	• TransModeler[2] • Aimsun (some editions)
Mesoscopic Simulation Tools	A hybrid of macro- and microscopic simulation tools, as they replicate the movement of platoons of vehicles but use equations to indicate how multiple platoons interact.	• TRANSYT-7F (built-in functionality in HCS) • TransModeler[2] • Aimsun (some editions)
Microscopic Simulation Tools	Track the movement of individual vehicles through a study network in brief time increments (typically one second or less) based on car-following and lane-changing theories. Since vehicles typically enter the network based on a statistical distribution of random arrivals (and are randomly assigned attributes), microsimulation tools are stochastic in nature, as each model run will produce a unique result.	• TransModeler[1] • Vissim • Aimsun • SimTraffic[3]

[1] *TransModeler and TransModeler SE*
[2] *TransModeler Only*
[3] *Synchro/SimTraffic has limited capabilities to modify and calibrate driving behavior and is not applicable for uninterrupted flow conditions*

2.1.1 Software Tool Selection

While these guidelines primarily serve to standardize the development and application of microsimulation models in the state of Kentucky, the full set of tools available to analysts should always be explored to ensure that project costs are minimized, and needs are properly met. This section summarizes various software packages commonly applied in practice, including a comparison of the strengths and limitations associated with each. It concludes with a description of the recommended methodology for selecting the appropriate tool.

The full set of tools available to analysts should always be explored to ensure that project costs are minimized, and needs are properly met.

Table 3 lists the most commonly used traffic analysis software packages, providing details for each including: type of analysis, typical uses, level of modeling effort, and the current version of the software.

Table 3: Traffic Analysis Tools

Analysis Tool	Type(s) of Analysis	Typical Uses/ Application	Level of Effort *(1-4 increasing)*	Current Version (as of January 2021)
Highway Capacity Software (HCS) KY	Deterministic	Traditional Freeway, Intersection, Segment Analysis	1 – 2	HCS7 (Version 7.9)
Synchro/SimTraffic KY	Deterministic, Optimization, Microsimulation	Intersection Analysis, Signal Optimization, Basic Arterial Simulation, Traffic Studies	2	Synchro 11/ SimTraffic 11
SIDRA KY	Deterministic	Intersection Analysis (Roundabout)	1	SIDRA Intersection 9
Vistro	Deterministic	Intersection Analysis, Traffic Studies,	2	Vistro 2021
FREEVAL KY	Deterministic	Traditional Freeway Analysis, Reliability Analysis	2	FREEVAL 2015e
Visum	Travel Demand Modeling	Travel Demand Forecasting, Volume Development	4	Visum 2021
TransCAD KY	Travel Demand Modeling	Travel Demand Forecasting, Volume Development	4	TransCAD 8.0
Vissim KY	Microsimulation	Microsimulation, Arterial and Freeway Analysis	3	Vissim 2021
TransModeler KY	Microsimulation, Optimization	Microsimulation, Arterial and Freeway Analysis, Mesoscopic Analysis, Signal Optimization, Traffic Studies	3	TransModeler 6.0 TransModeler SE*
Aimsun	Travel Demand Modeling, Microsimulation	Travel Demand Forecasting, Volume Development, Microsimulation, Arterial and Freeway Analysis	4	Aimsun Next
Cube KY	Travel Demand Modeling	Travel Demand Forecasting, Volume Development	4	Cube 6.4.4

**TransModeler SE is a light version of the TransModeler software in that it is limited by the network size (20 intersections/ 100 links) and some capabilities. Generally, it can accomplish a majority of the TransModeler capabilities if the network is maintained within the available geometric limits. TransModeler SE serves as an alternative to TransModeler on selected projects.*
KY Analysis software commonly used in Kentucky

To streamline the selection of an analysis tool, KYTC has adapted and updated the Virginia Department of Transportation (VDOT) Software Selection Tool (SST) for use in Kentucky. The SST is a Microsoft Excel-based tool that utilizes a series of macros to populate a summary table of planned project analyses and the tool(s) and measures of effectiveness (MOE(s)) applicable to each. The user provides answers to a series of questions about the analysis to be performed and is returned a spreadsheet that may be printed for reference and used to support the development of the analysis scope. The recommendations produced by the SST do not constitute a standard, nor should they serve as the sole justification for the use of a given analysis tool. Rather, the analyst should exercise engineering judgement and consult with members of the project team prior to selecting one or more analysis tools for use on a given project.

The KYTC Software Selection Tool can be found online here:

KYTC Traffic Analysis Software Selection Tool

Vissim and TransModeler are the preferred software packages for microsimulation for KYTC projects. Therefore, this guidance focuses primarily on those two software packages in subsequent chapters. TSIS-CORSIM is also accepted by KYTC but it is not frequently used in Kentucky and is not discussed in this guidance. Other microsimulation software packages may be approved by KYTC on a project-by-project basis. The list of currently accepted software packages can be found in the Traffic Engineering Software section on KYTC's Software and Support website.

Vissim and TransModeler are the currently preferred software packages for KYTC microsimulation projects

2.2 Data Collection and Traffic Forecasting

The quality of a traffic analysis is directly related to the quality of the input data. Since microsimulation is the most data-intensive of all available traffic analysis methods, it demands the greatest level of thought and attention to detail. Microsimulation data can generally be classified into three categories:

- Facility characteristics (physical aspects of the study network)
- Traffic characteristics (vehicular demand, routing, and operations)
- Model calibration and validation data (observed performance metrics for comparison to model outputs)

It is critical that the amount and types of data utilized are commensurate with the purpose, need, and scope of a given project and that all data is properly collected and processed

While facility characteristics are generally straightforward, obtainable through existing data sources, and subject to minimal error, traffic characteristics and model calibration and validation data are more cumbersome to collect and require substantial quality assurance. Consequently, it is critical that the amount and types of data utilized are commensurate with the purpose, need, and scope of a given project and that all data is properly collected and processed.

Table 4 outlines the data types required by commonly used traffic analysis software broken down by facility characteristics, traffic characteristics, and model calibration and validation data.

Table 4: Data Collection Summary

Data Type	Analysis Software				
	HCS7	FREEVAL	SIDRA	Synchro/ SimTraffic	TransModeler, Vissim, Aimsun
Facility Characteristics (physical aspects of the study network)					
Aerial Imagery[1]	○	○	○	●	●
Elevation Data	○	○	○	○	○
Roadway Cross Section (number of lanes, lane width, shoulder width, lane channelization, left- and right-turn bay storage length)	●	●	●	●	●
Intersection Control Type	●		●	●	●
Signs	○		○	○	●
Signals (timing, phasing, and detection)	●			●	●
Transit Signal Priority and Preemption				○	●
Parking	○			○	●
Ramp Metering		○			●
Multimodal Infrastructure (pedestrian, bicycle, and transit facilities)	○			○	○
Traffic Characteristics (vehicular demand, routing, and operations)					
Turning Movement and Link Counts	●	●	●	●	●
Fleet Composition (passenger cars, single-unit trucks, heavy trucks)	●	●	●	●	●
Capacity/Saturation Flow Rate	○	○		●	●
Travel Speed	○	○	○	●	●
Driving Behavior (e.g., lane utilization, driver response to traffic control, driver aggressiveness)				○[2]	●
Origin-Destination Data				○[3]	○
Model Calibration and Validation Data (evaluation measures of effectiveness)[4]					
Turning Movement Counts and/or Link Volumes				●	●
Travel Speed	●	●	○	●	●
Travel Time				●	●
Queue Lengths	●	●	○	●	●
Delay	○	○	○	○	○
Driving Behavior (e.g., lane utilization, driver response to traffic control, driver aggressiveness)	○			○[2]	●
Origin-Destination Data					○
Visual or Video Observations	○	○	○	●[2]	●

● Data required or typically utilized
○ Data not always required/utilized or only utilized in limited detail
[1] Built-in Bing Maps, OpenStreetMap, or Google Maps functionality exists but may be supplemented with higher-quality imagery
[2] Synchro/SimTraffic has limited ability to influence driving behavior
[3] Limited routing capabilities exist within Synchro/SimTraffic
[4] For deterministic tools, this data may be utilized to check software outputs for reasonableness

2.2.1 Facility Characteristics Data Collection

As shown in **Table 4**, facility characteristic data includes basic information about the physical layout features of the project area. It can likely be obtained from existing resources, and it does not require additional data collection. Occasionally, field observation or verification is required.

Table 5 highlights the common facility characteristic data types, purposes, and sources (with links if applicable).

Table 5: Facility Characteristics Data Summary

Data Type	Purpose of Data	Source	Publisher
Aerial Imagery	Coding of basic roadway geometry (e.g., number of lanes, lane width, shoulder width, intersection lane configuration and channelization)	KYFromAbove Natural Color Imagery	Kentucky Division of Geographic Information
		Built-in Mapping Services: Bing Maps, OpenStreetMap, or Google Maps	
		Free Online Mapping Resources: Google Earth, Bing Maps, etc.	
Street-level Imagery	Verification of existing traffic control devices (signal heads, signs, striping) and basic roadway geometry	KYTC Photolog Viewer	KYTC
		Free Online Mapping Resources: Google Earth, Bing Maps, etc.	
Roadway Inventory	Verification of existing traffic control devices and roadway characteristics such as speed limit and functional classification	KYTC DataMart	KYTC
		Other Local Agencies	-
Elevation Data	Coding of roadway grade throughout the simulation network	KYFromAbove DEM Data	Kentucky Division of Geographic Information
Traffic Signal Timing and Phasing Data	Coding of existing traffic signal timing and phasing data where applicable	Owning/Maintaining Agency	-

2.2.2 Traffic Characteristics Data Collection

Traffic characteristic data, outlined in **Table 4**, is very sensitive to the study area, context, and timing of the specified project. This data is less readily available and will need to be carefully defined and collected based on the objectives and goals of the analysis.

2.2.2.1 Existing Traffic Data

Existing traffic data is one of the most critical data collection items. It provides the foundation for accurate traffic analysis. There are several reasons why it is essential that existing traffic demand and operations are accurately quantified and documented. First, future-year traffic forecasts are often developed using the current-year traffic volumes as the starting point. Second, models are calibrated using the current-year volume and operations data. These calibrated models are used to evaluate the Build alternatives and compare them to the No-Build condition. Third, the existing data is used to validate the models and conduct reasonability checks of the final results. The following best practices are based on a synthesis of existing literature and project experiences:

- **Data collection period –** All traffic data should be collected on a typical weekday (Tuesday through Thursday is recommended) when school is in session, while avoiding holidays. Traffic data should be post-processed to check for the influence of weather, construction activity, or incidents. Atypical study areas and project emphases (e.g., study areas near schools or large employment centers or projects focused on special events) may warrant exceptions to these practices.
- **Data collection duration –** The required number and length of analysis periods will vary based on project needs and prevailing site characteristics, such as the presence of oversaturated conditions. The

duration of traffic counts and other data collection efforts should be determined based on a solid understanding of the study area and project purpose.

- **Data collection simultaneity –** Traffic counts (both turning movement counts and link counts) should be collected on the same day, if possible, so that the volume data is consistent. This will facilitate the volume balancing process. Ideally, model calibration and validation data would also be collected on or close to the same day as the traffic counts.
- **Data granularity –** Volume, speed, and origin-destination data should be collected in 15-minute intervals. Larger time increments (e.g., 1-hour intervals) may not provide an accurate assessment of predominant traffic conditions, while smaller time increments (e.g., 5-min intervals) may require substantially more data processing effort for minimal gain.
- **Statistical quality control –** Data should be examined for reasonableness. When discrepancies are observed, the dataset should be examined for errors and outliers removed using measures of central tendency and variance.
- **Data age –** Data should be collected as part of the current project when possible. If construction or other factors prevent the collection of existing data at a given location, archived data should be no more than three years old at the time of the study. Exceptions to this rule should be made with caution based on known growth in the study area and any changes to roadway geometry or traffic control.
- **Volume balancing –** Traffic volumes must be balanced for microsimulation models to function properly. Small imbalances can be reconciled using various methods, such as those contained in *NCHRP Report 765*. Large imbalances should be checked against known traffic volume sources and sinks between the count locations. Ultimately, engineering judgement should be used to establish the final volume balance.

2.2.2.2 Oversaturated Data

Commonly, traffic analysis projects are driven by areas that are currently or are anticipated to experience oversaturated traffic conditions. Oversaturated conditions occur when the traffic demand exceeds the traffic capacity. Demand is defined as the number of vehicles or other roadway users desiring to use a given system element during a specific period of time, typically 1 hour or 15 minutes. Capacity is defined as the maximum sustainable hourly flow rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, environmental, traffic demand, and traffic control conditions. It is important to understand the presence of, or potential for, oversaturated conditions when collecting project data.

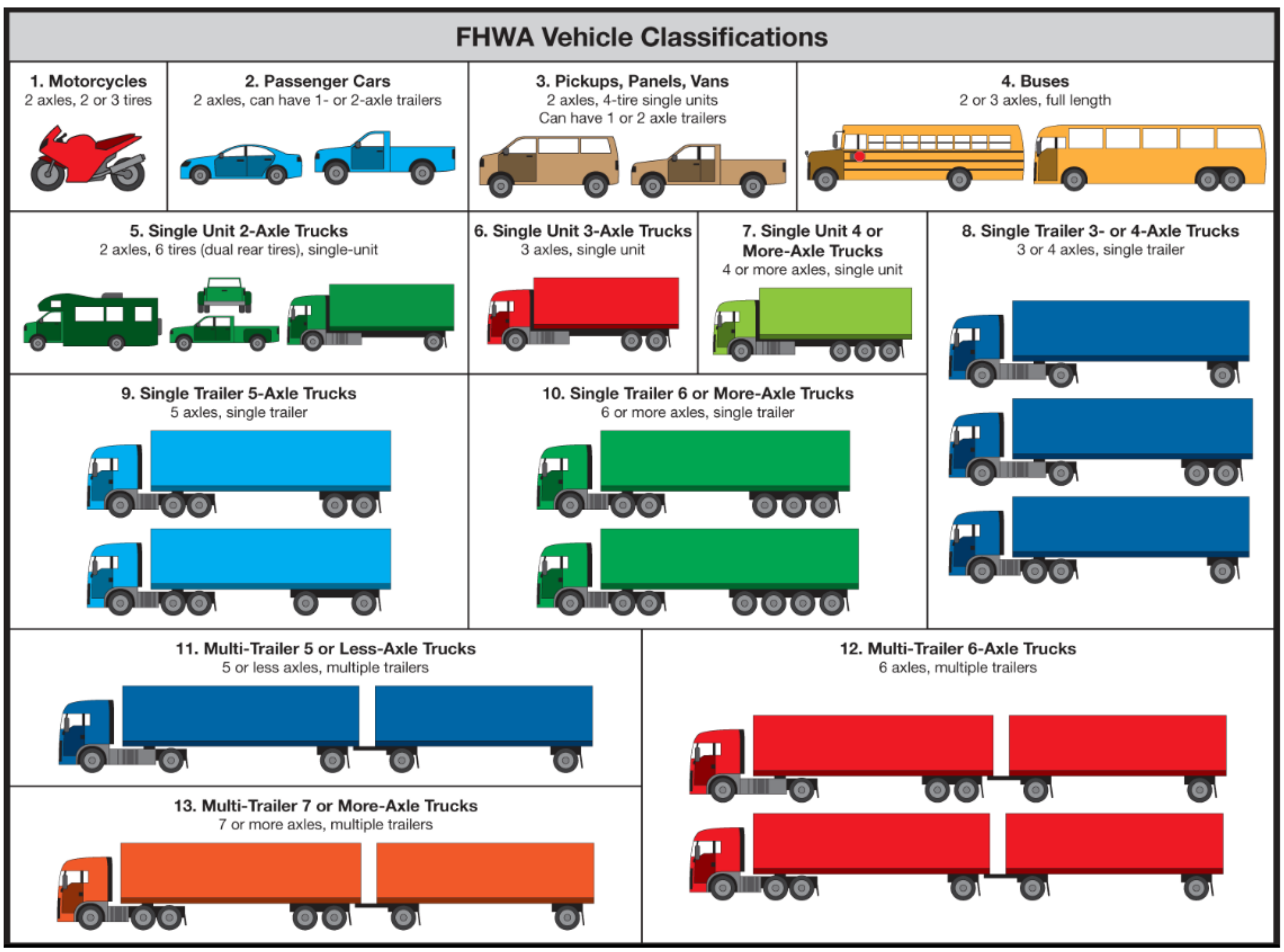
Observed traffic volumes measured at a bottleneck during oversaturated conditions will not accurately reflect demand for the movement in question. In such cases, volume data should be collected at an upstream location beyond the end of any queues that have formed, or residual queues should otherwise be accounted for at the end of the peak period(s). This is necessary to determine the actual demand volume which should be used as an input to the microsimulation model. In addition to the volume data, the queue data (length, duration, frequency, etc.) can provide key insights to the existing performance. Hence, it should be collected in applicable circumstances. Actual demand volumes should also be considered when developing peak-period traffic forecasts, as future-year volumes may otherwise be underestimated on capacity improvement projects.

2.2.2.3 Fleet Composition Data

Given the importance of highway-bound freight traffic in Kentucky, an emphasis should be placed on accurately estimating existing Annual Average Daily Truck Traffic (AADTT) and Truck Design Hourly Volumes (TDHV). These values may be calculated by multiplying the Annual Average Daily Traffic (AADT) and Design Hourly Volume (DHV) on a given link by the daily and peak-hour truck percentages, respectively. When available, historic vehicle classification data should be acquired from the KYTC Division of Planning to assist in developing accurate peak period truck volumes.

The Federal Highway Administration (FHWA) vehicle classification system is shown in **Figure 1.** Vehicle classes 1 through 3 comprise passenger cars and vehicle classes 4 through 13 comprise heavy vehicles. When reliable data is available, it can be advantageous to subdivide these classes further to capture differences in vehicle length and performance (e.g., motorcycles, passenger cars, and pick-up trucks/vans/SUVs within classes 1-3 and single-unit trucks/buses and tractor-trailers within classes 4-13). It is critical that microsimulation inputs reflect the study area's fleet composition, especially in areas with moderate to high truck percentages (i.e., ≥ 5% trucks).

Figure 1: FHWA Vehicle Classifications



Within microsimulation modeling, the vehicle classification is typically divided by vehicle type and performance and is not directly correlated with the FHWA classification count breakdown; however, the 13-class breakdown can be informative to differentiate or validate the available vehicle deviations within the software. **Table 6** shows the breakdown of vehicle classifications within a typical microsimulation and how that relates to the

FHWA classifications. If available, FHWA classification count data can help determine the split between motorcycles, passenger cars, pickups/vans/SUVs, buses, single-unit trucks, and trailer trucks.

Table 6: Microsimulation Vehicle Classifications and Corresponding FHWA Classifications

Typical Microsimulation Vehicle Fleet Categories								
Vehicle Type	**Motorcycles**	**Passenger Cars**			**Pickups/ Vans/ SUVs**	**Buses**	**Single Unit Trucks**	**Trailer Trucks**
		High Performance	**Middle Performance**	**Low Performance**				
FHWA Vehicle Classification	1	2			3	4	5 - 7	8 - 13

When possible, classification data should be collected at project-specific locations to increase the accuracy of the typical vehicle mix on the study network. As part of developing the parameter values in this guidance, vehicle classification data was examined. The software default values were compared against Kentucky vehicle registration data. From that effort, a recommended default Kentucky vehicle composition was developed to better illustrate Kentucky conditions; however, project specific data can provide a greater level of detail and supplement the recommended values. **Chapter 5** details the parameter development and results.

2.2.2.4 Network Routing Data

One major advantage of microsimulation is that it offers the ability to analyze a transportation facility holistically, rather than as a series of independent system elements. However, this type of analysis is most robust when origin-destination (O-D) data is used in conjunction with turning movement counts to code traffic volume inputs. O-D data describes travel patterns and predominant network flows by providing the starting and ending points of individual trips. It is highly valuable for analyzing complex transportation networks.

O-D data is becoming increasingly more accessible and can be obtained in a variety of formats. It can be obtained through field data collection (license plate surveys and Bluetooth device matching). It can also be obtained from companies which utilize GPS, cellular data, and location-based services (LBS) data (AirSage, Inc., Streetlight Data, Inc., etc.). These data sets can be queried for any project area with little lead-time required.

While desirable, O-D data may not always be required (e.g., for smaller-scale projects where multiple routes are not available between origins and destinations), and the acquisition of such data from the sources listed should be carefully considered based on project needs.

For projects where multiple routes are available between origin and destination points, it is important to consider the viability and popularity of the route options when obtaining the O-D data. The presence of multiple routes may influence the decision to obtain O-D data as well as how the data is gathered and processed. If it is important for the project to consider route choice or midpoint routing decisions between origins and destinations, the modeler should collect the data with pass-through points specified so that an additional layer of information can be discerned from the data. This will provide information about the overall O-D flows and the magnitude of specific route choices between the O-D pairs.

2.2.2.5 Traffic Forecasting

Microsimulation models are typically utilized to analyze multiple project alternatives in both a base year and one or more future years. Typically, traffic forecasts are developed for daily and peak traffic conditions for any anticipated analysis years for the specified project. On KYTC projects, traffic forecasts are typically developed by KYTC staff or by consultants on behalf of KYTC and provided for traffic analysis purposes. The existence and details of an available traffic forecast should be discussed between the consultant and KYTC during traffic analysis scoping.

2.2.3 Model Calibration and Validation Data

A microsimulation model is not useful for alternatives analysis until it can be shown that the base model (coded with existing roadway geometry and traffic volumes) reflects existing conditions to a reasonable degree. Recommended calibration parameter ranges and calibration targets will be presented in subsequent chapters. This section describes best practices for the collection of calibration data and provides a list of potential sources for each data type. As shown in **Table 5**, these data types typically include traffic volumes (turning movement counts, link counts, and origin-destination data), speed, travel time, and queue lengths and may also include intersection delay, driving behavior observations, and other visual or video observations.

A microsimulation model is not useful for alternatives analysis until it can be shown that the base model reflects existing conditions to a reasonable degree.

- **Traffic Volumes** – Turning movement/ link volumes collected as part of the traffic characteristics should suffice for calibration and validation purposes. If oversaturated conditions exist, demand volumes and queuing data should be obtained for calibration purposes.
- **Speed, Travel Time** – These data sets may be collected as part of the traffic characteristics data collection effort. They provide key metrics related to segments and routes to help calibrate models.
- **Queue Length, Delay** – These items sets may be gathered as either quantitative or qualitative data and provide performance metrics related to points and segments for model calibration.
- **Driving Behaviors, Visual Observations** – These observations are typically qualitative (commonly from field visits or video/ photos of the project site) and provide specialized project area information.

2.3 Scoping and Data Collection Meeting

At the outset of a traffic analysis project, the consultant should conduct a scoping and data collection meeting with KYTC staff. The project team (consultant, KYTC central office staff, and KYTC district staff) has the most knowledge about the project and should establish the initial assumptions to be utilized for the traffic analysis.

The main items to be determined during this meeting and through the project scoping process include:

- Project Goals (as they pertain to traffic analysis)
- Traffic Analysis Needs
  - Software Selection
  - Analysis Years and Scenarios
- Project Limits
- Project Context (Urban, Suburban, Rural)
- Data Collection
  - Available Data
  - Data Collection Plan
  - Traffic Forecasting
- Modeling Methodology including MOEs and Assumptions

3 Microsimulation Model Development

3.1 Software Versions

KYTC staff and project team members should agree upon an appropriate software version and model build number prior to model development, accounting for any recently released updates. The version used to develop and calibrate the base microsimulation model should be maintained throughout the life cycle of the project. To preserve the integrity of the results, software versions should only be changed during an analysis after consultation with KYTC staff. **Table 3** highlights the current recommended versions of Vissim and TransModeler (at the time of publication). Use of older software versions (prior to Vissim version 11 or TransModeler version 5) is not recommended as later versions have implemented features that improve the driving behavior and customization options. In addition, older software versions can create difficulty in support and review. If an older version needs to be used, that should be discussed with KYTC during scoping to determine the feasibility and potential impact on the modelling outcomes.

As noted previously, Vissim and TransModeler are the primary approved KYTC microsimulation software packages. This document focuses on the model development, parameters, and model settings for these two software packages specifically. If another simulation software is being considered, that should be discussed with KYTC staff during project scoping.

3.2 General Model Settings

Microsimulation models should be developed in English units (feet, miles per hour, etc.). To improve model accuracy, it is also recommended that the modeler use either orthorectified aerial imagery, built-in third-party map imagery, or CAD base files as a background for model development. While this process is straightforward in TransModeler, Vissim does not allow images to be imported to scale; consequently, it is critical that the modeler accurately scale and align the imagery. As an alternative, recent versions and select licenses of Vissim and all versions of TransModeler are equipped with built-in satellite or map imagery through third party vendors (e.g., Bing Maps, Google Maps, and Open Street Map). This method offers a simple but potentially less granular alternative for reference during network development. If the built-in map imagery is used, it is recommended that the modeler verify its accuracy, as it may not reflect recent changes. CAD roadway base files can also be imported as a reference in model development; however, the modeler should pay careful attention to the import process as the units and spatial references between the software may differ.

3.3 Model Development Best Practices

The next two sections present best practices for model development for Vissim (Section 3.4) and TransModeler (Section 3.5). The goal of these sections is to provide general guidance on model coding and set up, including how to code physical network attributes and traffic flow characteristics. Similar topics, including some common model development pitfalls, are addressed for each software package.

3.4 Vissim Model Development Best Practices

3.4.1 Physical Network Attributes

The physical network attributes are the model elements that represent physically observable features, primarily those associated with roadway geometry.

3.4.1.1 Network Geometry Coding

Regardless of software package, links should be coded to represent roadway segments and to match field-observed curvature and lane widths as closely as possible. Vissim uses connectors to connect links and introduce characteristics that affect driving behavior, especially lane changing. During model development, the number and length of connectors should be minimized, and links only split where necessary.

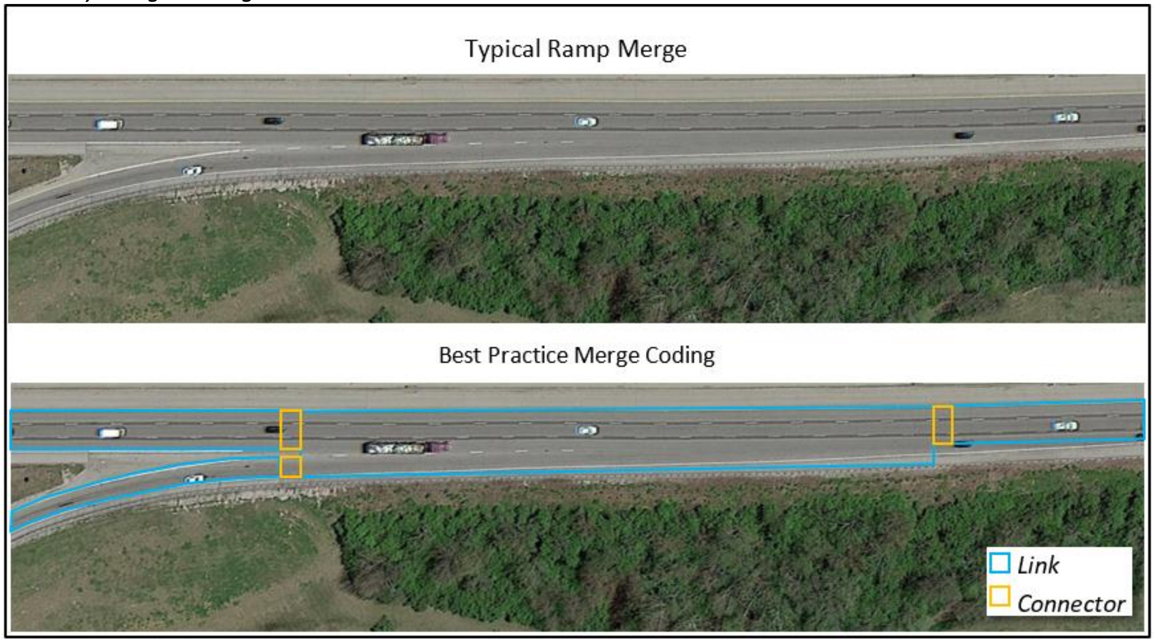
Each connector has "Lane Change" and "Emergency Stop" attributes that govern how upstream vehicles will interact while on the network. These parameters determine the distance upstream of the connector that vehicles will first attempt to change lanes (if needed) and the distance at which vehicles will come to a stop in the absence of an acceptable gap to make a required lane change. Traditionally, these attributes have been defined by singular values for each connector, but recent versions of Vissim allow distributions to define these attributes. Lane change distance is a critical model parameter and is discussed further in **Chapter 5**. Connectors also control the lane assignments between segments and prevent lane changes across them.

3.4.1.1.1 Merge, Diverge, and Weave Areas

The coding of merge, weave, and diverge areas on freeways is controlled by vehicle routing, lane changing parameters, and physical roadway geometry. Merge, diverge, and weaving areas should include the entirety of auxiliary lanes and capture the full length that is effectively used by vehicles (to the end of tapers if vehicles are observed to use the full length of the taper). In Vissim, merge links should be coded using a single continuous width all the way to the end of the effective taper (i.e., they should be rectangular and not narrow or taper over the length of the merge). Vehicles in the model will utilize the extra length when necessary.

The coding of a typical freeway merge section begins with two upstream links coded with the number of through lanes (**Figure 2**). Two connectors are then required to connect these links to the merge segment. The merge segment should be coded with the number of freeway lanes plus the additional merging lanes. The merge segment should extend to the end of the effective taper. A single connecter should be coded at the downstream end of the merge segment. This connecter should have the same number of lanes as the downstream freeway link and align with the downstream lanes. This configuration will force vehicles to make the merging lane change maneuver. This approach applies to parallel and taper merges. Proper merge coding in Vissim is illustrated in **Figure 2**.

Figure 2: Freeway Merge Coding Best Practices

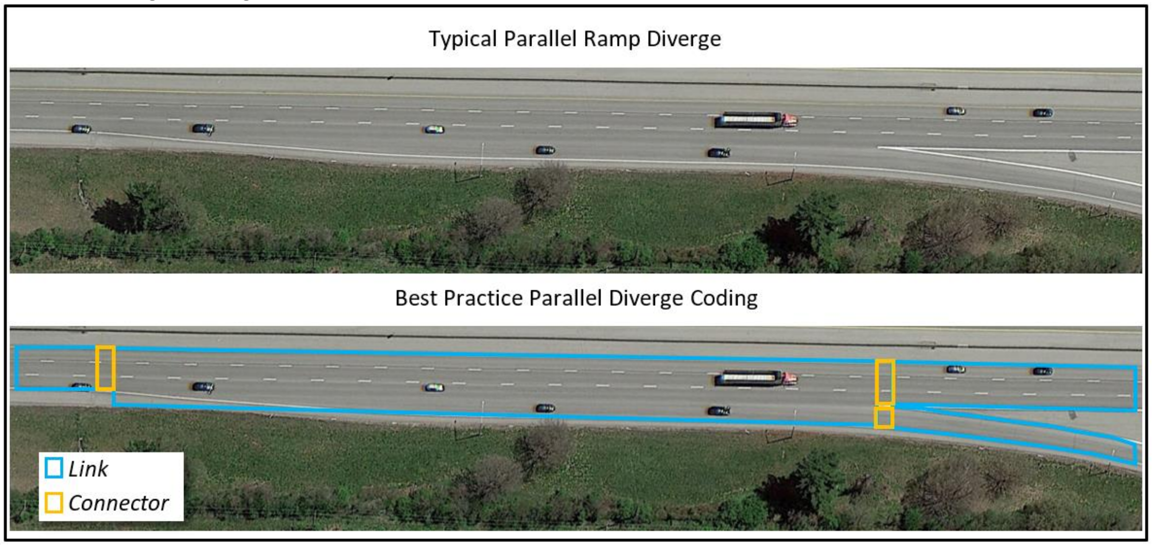


To properly code a diverge area, it must first be defined as either a parallel or taper diverge.

In Vissim, parallel diverges are coded like merges, only in the reverse order. At the upstream end, a single connector with the same number of lanes as the upstream freeway segment should connect the upstream freeway to the downstream diverge segment (**Figure 3**). At the downstream end, two connectors should be used to separate the mainline freeway lanes and diverging lanes. The diverge segment should include the entire auxiliary lane from the start of the taper to the painted gore and should consist of a single segment coded with the number of mainline freeway lanes plus the number of diverging lanes.

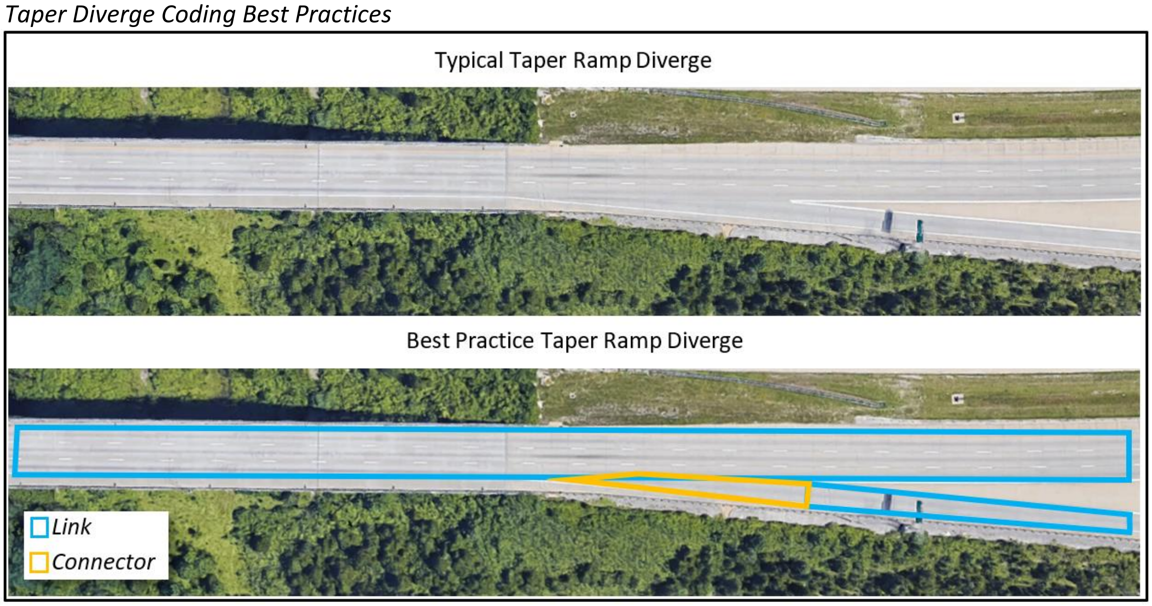
Modelers should use caution when coding a parallel diverge with a short (less than approximately 300 feet) deceleration length as this may adversely affect mainline operations. In these situations, a taper style diverge (discussed below) may better represent actual traffic operations. Additionally, when modeling freeways with significant congestion it is recommended that the modeler consider coding parallel ramps using the taper methodology. The taper ramp method may provide a more accurate way of modeling observed driving behavior in these situations. Proper parallel diverge coding in Vissim is shown in **Figure 3**.

Figure 3: Parallel Diverge Coding Best Practices



Taper diverges should be coded differently than parallel diverges. For taper diverges, no segmentation is required to model the diverge area. The mainline freeway segment should not be split; instead, a single ramp connector (with the number of lanes on the ramp) should be used to connect the freeway link to the ramp link. The connector should generally extend from near the start of the taper to the painted gore. However, in keeping with best model practice, connectors should be coded with as short of length as reasonable, while avoiding overlapping link segments that may generate conflict areas. As noted above, this approach can be used for parallel exit ramps in heavily congested areas. Proper taper diverge coding in Vissim is shown in **Figure 4**.

Figure 4: Taper Diverge Coding Best Practices



3.4.1.1.2 Arterials

The coding of arterial segments is governed by many of the same principles as freeway segments. For example, links should represent roadway segments that carry through movements and match field-observed curvature and lane widths as closely as possible. Also, the number and length of connectors should be minimized.

However, arterial coding does differ from freeway coding in several important ways due to intersection configurations and traffic control, which interrupts traffic flow.

3.4.1.1.3 Turn Bays

In Vissim, turn bays should be coded in two different ways. The parallel link method is preferred, but both methods are shown in **Figure 5**.

- Combined Link – This coding method is similar to the method used for parallel freeway diverges. It is typically applied in urban settings, where vehicles shift between through lanes and turn lanes as they approach an intersection, or when there is a mix of shared and dedicated turn lanes. With this method, the upstream link ends at the start of the tapers for the turn lanes(s). A connector extending across all lanes should be inserted at this point. The connector should continue for the length of any tapers and end at the point the turn lane(s) reach their full width. The modeler should then create a single downstream link that includes both the through lanes and the turn lanes(s). To avoid late lane changes, another connector and link can be coded approximately 50 feet upstream of the stop bar or junction point. The parameters associated with this final downstream link should be set to prevent lane changing. Additionally, to prevent late or unnecessary lane changing the "Emergency Stop" distance for the turn connectors attached to the final approach link should be coded to be slightly longer than the length of the 50-foot link to ensure vehicles are in the correct lane.

- Parallel Link – The second method for coding turn bays involves coding them as separate parallel links. This method is more commonly used and should be considered the default method unless driving behavior warrants use of the "Combined Link" method. This configuration only allows vehicles to enter the turn lane at the taper, preventing late lane changes. Separate links should be developed for each turn lane group. One link can be used to accommodate each turning movement (left or right) coded to include the proper number of lanes (one for single turn lanes, two for dual, etc.). Connectors should be coded to begin at the start of any taper and end where the turn lane is full width. They should connect the through lane segment to the turn lanes(s), similar to the way taper diverges are coded.

Figure 5: Turn Bay Coding Best Practices

3.4.1.2 Vehicle Interactions

Areas where vehicles on the network have the capability of interacting or conflicting outside of discretionary lane changing (i.e., due to overlapping links or connectors) should be coded with either conflict areas or priority rules in Vissim.

3.4.1.2.1 Conflict Areas

Conflict areas are auto generated by Vissim at any location where two links or connectors overlap, regardless of the direction of travel. The priority, or right-of-way, should then be coded by the modeler at the junction location. The options for conflict areas are:

a. yellow-yellow, or passive (default), where both approaching traffic flows continue without yielding and are granted no priority;
b. green-red, where the red movement yields to the green movement, or;
c. red-red, where both movements yield to the first vehicle to enter the conflict zone.

While conflict areas are recommended for intersection and arterial junctions (right-turns, left-turns, etc.), they are not typically used for freeway junctions, as they may cause unnatural behavior.

3.4.1.2.2 Priority Rules

Priority rules, like conflict areas, should be used at junction locations, but they provide a different level of control over vehicle interactions. For priority rules, the physical extent or length for which the rule applies can be defined by the modeler, whereas for conflict areas the extent of the overlapping segment defines the conflict point. Additionally, priority rules are based on user-defined gap times, and the rules are only evaluated by yielding vehicles. Therefore, depending on the context, priority rules may provide more granularity and specificity for recreating field-observed interactions. Priority rules are preferred for roundabouts, while conflict areas are typically used for traditional intersections and turning conflicts; however, decisions about which will work better in any given situation is often left to the modeler's discretion. Additionally, priority rules can be utilized at intersections in addition to conflict areas to model specific conditions (i.e., "don't block the box" intersection coding, yielding during permitted phases of a traffic signal, all-way-stop control intersections, etc.).

3.4.1.3 Intersection Coding

Intersection control should reflect existing or anticipated conditions as closely as possible from both an operational and physical standpoint. Traffic signal timing data should be field-collected or obtained from the owning and/or maintaining agency to program signal operations for the analysis period(s). Field observations should be utilized to facilitate the accurate representation of right-of-way/conflicts and driving behavior at both signalized and unsignalized intersections.

3.4.1.3.1 Signalized Intersections

The coding of signalized intersections consists of the creation of signal heads, detectors, and stop signs (for right turn on red (RTOR)) features in the model. Signal heads should be placed at the stop bar or at the location where vehicles are observed to stop and should be programmed to correspond to the correct controller, phase(s), and type of indicator (arrow or ball) for the operation. Detectors, where applicable, should be placed in the approach lane at the location of existing detection with proper length and controller and phase referencing. Stop signs for RTOR operations should be placed on the connectors of the right-turn movement and coded to correspond to the correct controller and phase(s) for RTOR operation. In these situations, the right-turn connector should slightly overlap the signal head for the through movement so that right-turning vehicles will bypass the signal in order to turn right on red.

For signal controllers in Vissim, the Ring-Barrier Controller (RBC) is the preferred type of signal control coding. This type of signal control coding includes most parameters associated with modern signal controllers, accurately models actuated-coordinated operation and includes detector, preemption, pedestrian, and transit priority settings. Additionally, the RBC data may be directly imported from Synchro or Vistro files. It is important to ensure that the data is coded accurately to match existing signal timing data, whether generated within the software or imported. The RBC controller frequency should also be set to a multiple of, or match, the Vissim simulation resolution.

3.4.1.3.2 Unsignalized Intersections

The physical and operational aspects of coding unsignalized intersections consists of the creation of stop bars and conflict areas/priority rules. Stop bars should be placed on each applicable approach at the location of the existing or proposed stop bar. Yield control, uncontrolled movements, and right-of-way priority should be controlled in the models via the usage of conflict areas or priority rules at the intersections. As mentioned previously, conflict areas are typically easier to code and preferred at unsignalized intersections. If conflict areas do not sufficiently replicate observed conditions, priority rules should be implemented.

At some unsignalized intersections, drivers frequently do not come to a complete stop. It can be difficult to accurately model this condition if stop bars are used, as they will cause all vehicles to stop completely. The WSDOT guidance provides a detailed approach for addressing this and similar situations. The WSDOT guidance suggests replicating a rolling stop by combining conflict areas or priority rules with reduced speed areas (described below).

3.4.1.3.3 Roundabouts

Key aspects of roundabout coding include the accurate representation of geometric elements and the placement of conflict areas or priority rules. As roundabouts are typically unsignalized and do not have stop control, there are no additional elements of control. The primary interactions are controlled by priority rules or conflict areas. Priority rules are the preferred conflict mitigation and control method for roundabouts (especially multi-lane roundabouts), as they allow for more control, are based on time spacing, and are only evaluated by the yielding (approaching) vehicles. With either method, priority should be given to the circulating traffic as they have the right-of-way. Accurately modeling roundabout operations can be difficult in Vissim, as it relies on using specifically defined priority rules. This is especially true for multi-lane roundabouts. Consult the ODOT Vissim Protocol (section 4.4.3)[1] or the WSDOT Vissim Protocol (section 4.4.3)[2] for detailed information regarding how to simulate a roundabout.

3.4.1.4 Speed Control Coding

Speed control coding is one of the most critical aspects of initial model development. The car following, lane changing, and gap acceptance characteristics of individual vehicles are directly related to their own speed and that of other vehicles. Parameters should be used to define the free-flow and geometric conditions of the roadway network and not implemented to mimic congested conditions. For example, for an arterial roadway with a posted and free-flow speed of 45 mph and an observed speed of 30 mph – the control speed should be coded at 45 mph. Additional microsimulation model components (vehicle demand, lane changing, traffic control, etc.) should be used to adjust vehicle speeds to mimic observed conditions instead of lowering the speed profile.

Vehicle speeds are controlled by desired speed distributions. These are initially assigned to vehicle types as they enter the network (via the vehicle input parameters), but they can be modified along a vehicle's route using *desired speed decisions* and *reduced speed areas*. Desired speed decisions are represented by a line feature placed across a travel lane. The desired speed decision applies a new speed distribution to vehicles as they approach the line and will remain in effect until the vehicles encounter another speed decision or reduced speed

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[1] *ODOT: Protocol for Vissim Simulation (June 2011)*
[2] *WSDOT: Protocol for Vissim Simulation (September 2014)*

area. These decision points are like speed limit signs and may be used when prevailing roadway geometry, functional class, or driving behavior changes. Reduced speed areas are represented by polygons and influence vehicle speeds as they approach and traverse the coverage area. Reduced speed areas are typically used to implement temporary speed reductions at locations such as intersections, ramps, or areas of extreme roadway curvature.

3.4.1.4.1 Desired Speed Distributions

The desired speed distributions (speed profiles) to be used on a specific project should consider several factors such as the study area speed limits, highway geometry, land-use context, and type of facility. Greater detail regarding the default speed distributions that should be used for Kentucky microsimulation models is provided in **Chapter 5**.

3.4.1.4.2 Reduced Speed Areas

Reduced speed areas should be applied to intersection turning movements to accurately replicate real world turning speeds and deceleration for right and left turns. Reduced speed areas should be placed along the turning link or connector, spanning the length of the turning movement and should have an appropriate speed distribution for the movement. Reduced speed areas may be used to model roadway or ramp curvature where drivers are observed to slow down to navigate the geometry or where there are posted advisory speed signs.

3.4.2 Traffic Attributes

3.4.2.1 Vehicle Routing

Within a microsimulation model, vehicle routing parameters describe how vehicles traverse the network from start-to-finish. Though the mechanics of vehicle routing inputs are slightly different within each software package, each supports three types of vehicle routing: static point-to-point, static end-to-end (O-D), and dynamic traffic assignment. Each method has separate data needs as well as advantages and disadvantages and should be evaluated for suitability during the project scoping and data collection process. In both static routing methods, volumes are represented by relative flows instead of absolute volumes. Relative flows provide a proportionate flow based on an input volume as opposed to representing the discrete volume amount. (For example, a vehicle input volume of 1,000 vehicles with 3 routes (A, B, and C) could have relative flows of A = 10, B = 100, and C = 500. These relative flows would result in the following route volumes: A = 16 vehicles, B = 164 vehicles, and C = 820 vehicles.) Coding the relative flows to match the absolute volume values helps to ensure model accuracy and is preferred; however, proportions can be used.

3.4.2.1.1 End-to-End Vehicle Routing (Origin-Destination Routing)

End-to-end routing is the preferred method of static routing, as it assigns vehicle paths from start-to-finish through the entire network, better replicating typical driving behavior and helping to eliminate unrealistic lane changing movements. With end-to-end routing, each origin and destination are linked with routes, allowing modeled vehicles to understand assigned route trajectory from entrance to exit of the network. However, more complexity is associated with route creation and volume development for end-to-end routing than point-to-point routing, as there may be many available routes for traversing the network, and volumes must be developed through the convergence of O-D data and the volume data. End-to-end routing development and volume assignment should be done in conjunction with the project specific

> **End-to-end routing is the preferred method of static routing under typical circumstances, as it assigns vehicle paths from start-to-finish through the entire network, better replicating typical driving behavior and helping to eliminate erratic movements.**

traffic count data and origin-destination data. Without both data components, it is often quite difficult to accurately estimate the volumes within the network due to the variety and complexity of the route options and trip patterns. For smaller networks, it is possible to manually assign volumes to O-D pairs, but this becomes increasingly complex as more entrance and exit locations are introduced.

The O-D data and the traffic count data should be processed together using an automated tool as opposed to manual calculation. For smaller networks, it is feasible that this can be handled using spreadsheet tools, but as the number of input and output locations increase, this becomes increasingly difficult. Both the ODOT Vissim Protocol (section 4.10.5)[3] and WSDOT Vissim Protocol (section 4.10.3.2)[4] provide detailed discussions on the matrix estimation process using the TFlowFuzzy process in the PTV software Visum. End-to-end routing is illustrated in **Figure 6**.

3.4.2.1.2 Point-to-Point Routing (Intersection Level Routing)

Point-to-point routing is simpler than end-to-end routing. It creates paths through the model by linking a series of short routes, with each route extending from one junction to the next (e.g., intersection-to intersection or ramp-to-ramp). Routes are assigned to vehicles as they traverse the network and destinations are unknown until the vehicle reaches the route assignment point. This method of routing can be suitable for small arterial networks depending on the travel patterns and complexity; however, it often yields additional lane changing and poor lane utilization. It also does not accurately capture details with regard to origin-destination patterns and merge-weave interactions as trips are randomly assigned at each junction. Therefore, point-to-point routing should only be used if the study network is very simple and/or no O-D data is available. If point-to-point routing is used, the simulation runs should be carefully reviewed by the analyst to verify the accuracy of modeled trip patterns. Routes should also be placed as far upstream as possible in order to maximize the weaving or lane change distances for approaching vehicles.

Point-to-point routing should only be used if the study network is simple and/or no O-D data is available, and simulation runs should be reviewed by the analyst to verify the accuracy of modeled trip patterns.

Additionally, for point-to-point routing there are several parameters which should be applied to provide vehicles with advanced routing knowledge. Modelers should enable the *"consider subsequent routing decisions"* option in the driving behaviors and the *"combine static routes"* option in the connector settings. These options provide vehicles with knowledge of the following two subsequent routes. This will make the lane change behavior and vehicle interactions more realistic. Point-to-point routing is illustrated in **Figure 6**.

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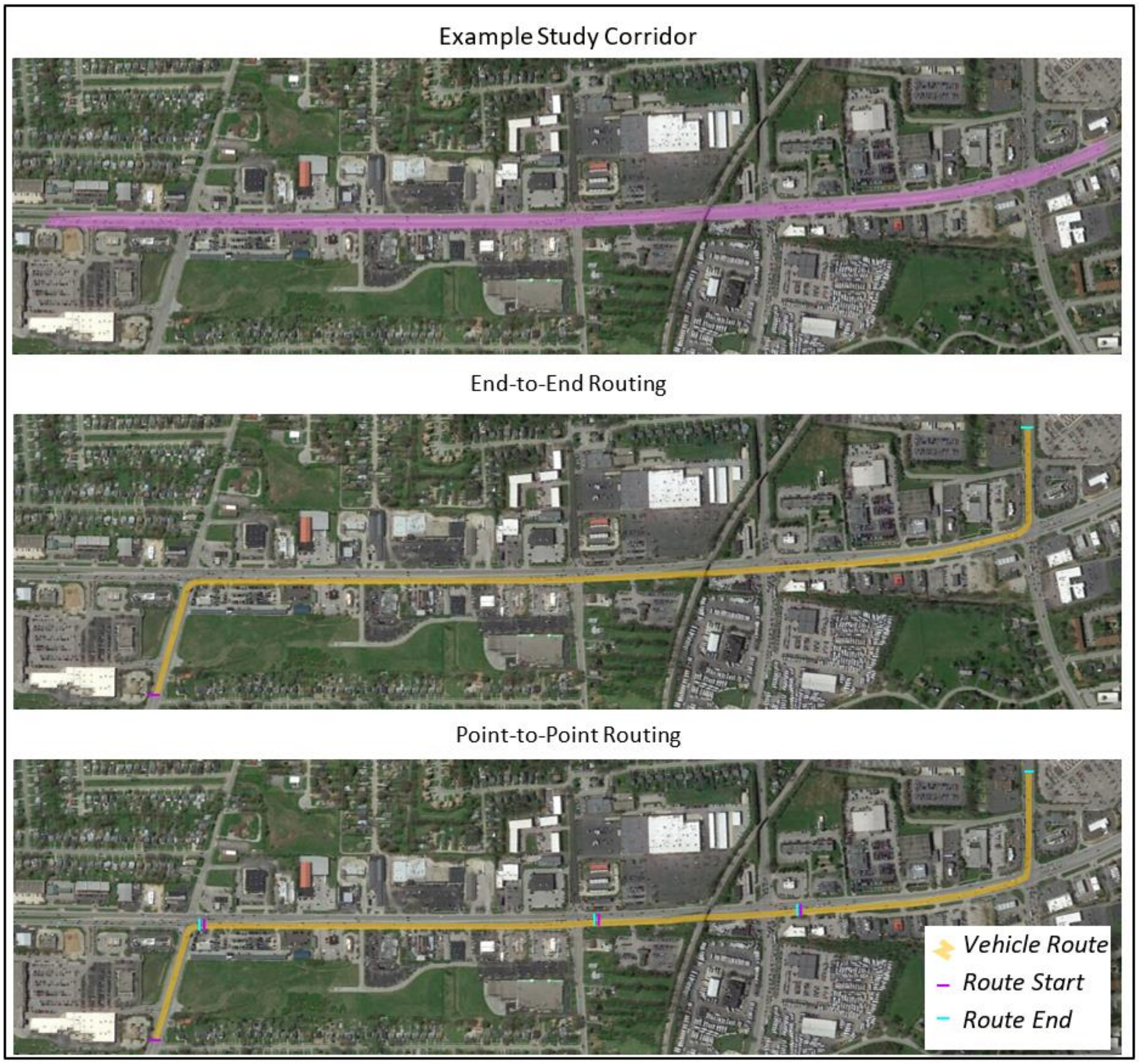
[3] *ODOT: Protocol for Vissim Simulation (June 2011)*
[4] *WSDOT: Protocol for Vissim Simulation (September 2014)*

Figure 6: Routing Methods Example



3.4.2.1.3 Dynamic Traffic Assignment

Dynamic traffic assignment is unlike the other routing methods in that it does not assign volume to specified routes and rather uses a routing methodology (commonly shortest travel time/ cost) to optimize the vehicle trajectories and paths throughout the network. This is a more complex and involved analysis process and is best suited for projects where there are multiple viable routes between network entrances and exits. The dynamic traffic assignment process consists of an iterative simulation process to converge on an equilibrium traffic assignment. This process can be time consuming and complex for larger networks. Dynamic traffic assignment is complex and is only appropriate in specific situations. Due to issues of complexity, cost, and applicability, this method should typically not be used unless approved by KYTC during the project scoping process.

> **Dynamic traffic assignment is more complex and is only appropriate in specific situations; therefore, dynamic traffic assignment should be discussed during the scoping process with KYTC and the project team to determine its need and applicability.**

3.4.2.2 Vehicle Inputs

In Vissim, vehicle inputs should be assigned to the network at all external entry nodes. The inputs dictate the volume, speed, and composition of vehicles entering the network. The entering vehicles will then be assigned routes and traverse the network as necessary. Typically, vehicle inputs are coded in 15-minute intervals to account for variations throughout the peak period, though other time intervals can be used. Time intervals larger than 15-minutes are not recommended, as they are likely to diminish the real impact peaking has on traffic operations. It is best if the field collected data (volumes, speeds, and O-D data) matches the 15-min time intervals. If smaller time intervals are used for data collection the values can be aggregated to 15-minute periods. If 15-minute field data is not available for the project area, it may be necessary to use surrogate data from another similar location to develop 15-minute volume distributions. The simulation time intervals and data needed to support the 15-minute analysis periods should be discussed during the project scoping process. In Vissim, time distributions for vehicle inputs can be added to account for the time periods and intervals of volumes used. Vehicle Inputs should be coded in terms of vehicles per hour as opposed to the observed 15-minute volume directly. While vehicle inputs may be applied as “stochastic” or “exact” inputs, the “exact” option is preferred, as microsimulation results will be based upon the averaging of multiple runs.

3.5 TransModeler Model Development Best Practices

3.5.1 Physical Network Attributes

The physical network attributes are the model elements that represent physically observable features, primarily those associated with roadway geometry. TransModeler provides several network development tools available through a series of dialogue boxes. The tools assist with coding roadway segments, intersections, and other model elements. This process creates a logical, streamlined approach to model coding and development.

3.5.1.1 Network Geometry Coding

Regardless of software package, links should be coded to represent roadway segments and to match field-observed curvature and lane widths as closely as possible. Connectors are utilized in TransModeler to connect lanes and they have an important influence on driving behavior, especially lane changing. Connectors are utilized along segments to accommodate lane additions, lane drops, etc. Nodes are used at intersections to connect links and accommodate movements. Therefore, the number and length of connectors should be minimized, and links only split where necessary.

Lane change behaviors are controlled by network-wide parameters instead of individual link-level parameters. However, several behaviors (including lane change distance) can be varied locally by using parameter markers in specific locations. Lane change distance is one of the key parameters investigated and discussed further in **Chapter 5**. If needed, lane change tendency, lane preference, and lane change distance settings can be edited at the individual connector level, but typically these parameters are handled globally.

3.5.1.1.1 Merge, Diverge, and Weave Areas

The coding of merge, weave, and diverge areas on freeways is controlled by vehicle routing, lane changing parameters, and physical roadway geometry. Merge, diverge, and weaving areas should include the entirety of any auxiliary lanes and capture the full length effectively used by vehicles (e.g., they should extend to the end of tapers if drivers are observed to use the full length of the taper).

For merge coding, the “Add Acceleration Lane” tool within the Roadway Editor toolbox will automatically generate an adjustable taper which can then be modified to match field conditions. Acceleration lane length should be coded to match field conditions as accurately as possible to optimize the available length for merging and accelerating to the roadway speed. Each upstream lane should be coded with its own lane connector, and the dropped lane should be connected to the adjacent downstream lane.

For diverge coding, the "Add Deceleration Lane" tool within the Roadway Editor will automatically generate an adjustable taper area for diverging. This area should be scaled to fit the roadway conditions similar to the merge coding procedures.

3.5.1.2 Arterials

The coding of arterial segments is governed by many of the same principles as freeway segments. For example, links should be coded to represent roadway segments that carry through movements and match field-observed curvature and lane widths as closely as possible. In addition, the number and length of connectors should be minimized. Even with these similarities, arterials do differ from freeways in important ways; traffic flow is interrupted, and intersection configurations and traffic control must be accounted for.

3.5.1.2.1 Turn Bays

In TransModeler, turn bays may be coded using the "Add Turn Bay" tool within the Roadway Editor, which automatically generates the turn bay and applicable lane connectors.

3.5.1.2.2 Vehicle Interactions

TransModeler automatically defines and manages conflict areas where vehicles interact based on the network geometry. Typically, these areas do not require additional coding; however, care should be taken to ensure that crossings and conflicts are coded properly, especially where there are unique conditions. This is especially true for roadways that cross each other at different elevations and therefore do not intersect (e.g., an overpass or underpass).

3.5.1.3 Intersection Coding

Intersection control should reflect existing or anticipated, operational and physical conditions as closely as possible. Traffic signal timing data should be field-collected or obtained from the appropriate agency to program signal operations. Field observations should be used to facilitate the accurate representation of right-of-way/conflicts and driving behavior at both signalized and unsignalized intersections. The "Intersection Control Editor" is the primary interface for developing and modifying intersection components, timings, and control.

3.5.1.3.1 Signalized Intersections

In TransModeler, signalized intersections may be defined using the "Intersection Control Editor", which includes most of the parameters associated with modern signal controllers. The "Add and Assign Detectors" button may be utilized to automatically generate stop bar and advance detection, after which detectors may be easily modified by the user. Stop bar locations and yield points should be field-verified and coded to match existing striping and driving behavior. By default, TransModeler assumes right-turn-on-red to be allowed at all signalized intersections. This setting can be turned off at specific locations by signal phase or globally under the traffic control defaults settings. Additionally, the TransModeler interface can import signal timing data and turning movement data from Synchro files. Modelers should check that the imported signal settings, phasing, and orientation are accurate, as this can be a common source of error.

3.5.1.3.2 Unsignalized Intersections

Unsignalized intersections may also be defined using the "Intersection Control Editor", which allows the user to specify applicable controls on each approach. As with signalized intersections, stop bar locations and yield points should be field-verified and coded to match existing striping and driving behavior.

3.5.1.3.3 Roundabouts

In TransModeler, roundabout geometry may be quickly generated at any node by using the “Add Roundabout” tool. After specifying roundabout and splitter island geometry, all circulating lanes, applicable lane connectors, and conflict areas are automatically calculated by the software. The modeler can modify driving behavior parameters locally or globally using parameter markers.

3.5.1.4 Speed Control Coding

Speed control coding is one of the most critical aspects of initial model development. The car following, lane changing, and gap acceptance characteristics of individual vehicles are directly related to their own speed and that of other vehicles. Parameters should be used to define the free-flow and geometric conditions of the roadway network and not implemented to mimic congested conditions. For example, for an arterial roadway with a posted and free-flow speed of 45 mph and an observed speed of 30 mph – the control speed should be coded at 45 mph. Additional microsimulation model components (vehicle demand, lane changing, traffic control, etc.) should be used to adjust vehicle speeds to mimic observed conditions instead of lowering the speed profile.

3.5.1.4.1 Desired Speed Distributions

The speed profiles associated with desired speed distributions are typically developed based on segment speed limits taking into account the type of facility. The TransModeler speed profiles are percentile-based additions and subtractions to the posted roadway speed. Desired speeds are assigned randomly to individual vehicles using a distribution of vehicle speeds for a particular speed limit. The distribution reflects the fact that for a given speed limit, speeds between vehicles can be variable. The desired speed distributions are assigned at the link attribute level, based on roadway classification and speed limit. The default distributions in TransModeler are based on a study conducted by the National Highway Traffic Safety Administration (NHTSA) in 2012. The default speed distributions that should be used for microsimulation models in Kentucky are discussed in **Chapter 5**. If necessary, the modeler should use field-collected data and engineering judgement to adjust the desired speed distribution associated with each vehicle class.

3.5.1.4.2 Reduced Speed Areas

TransModeler automatically assigns speed reductions due to roadway geometry including intersections and roadway curvature. While no additional coding may be required, the resulting speeds should still be reviewed. This is a key reason that geometric coding accuracy is important for TransModeler. The software calculates speed reductions based on geometric features unlike other microsimulation packages. This allows for fewer user inputs, but it does not preclude user-definition. Automatic speed reductions for curves are enabled by default, but the modeler can toggle them off if needed. The *smooth curvature* function in the roadway editor can help ensure that segments are coded correctly and that curves are properly recognized and calculated. The purpose of this feature is to decrease the number of inputs and edits required. However, users are still able to manually program reduced speed areas using reductions to the desired speeds, changes in speed limits for selected segments or areas, and the coding of speed humps. These features allow for additional customization when required.

3.5.2 Traffic Attributes

3.5.2.1 Vehicle Routing

Within a microsimulation model, vehicle routing describes how vehicles traverse the network from start-to-finish. In TransModeler, there are three primary route choice models: deterministic shortest path, stochastic shortest path, and probabilistic shortest path. Each model assigns vehicles to O-D routes based on a specific method. These methods are discussed in detail in the TransModeler documentation. Dynamic Traffic Assignment (DTA) can be used in combination with any of the route choice models. DTA adjusts the assignment of traffic throughout the model based on constantly changing travel times/costs. TransModeler automatically generates routing decisions based on the network conditions. The routes can later be modified by the modeler as needed to better align the volumes for select locations or paths.

Stochastic route choice is likely applicable for most modeling scenarios where there are multiple available paths between origin and destination points, but travel paths are generally maintained and are not influenced significantly by time of day or congestion.

TransModeler has a built-in Origin-Destination Matrix Estimation (ODME) process that allows the user to develop End-to-End O-D pairs within the software. The ODME process requires the user to select a traffic assignment method and volume delay function, develop a seed matrix (from a TDM subarea or cellular device tracking O-D data), and code observed link volumes into the simulation network. TransModeler also allows the user to weight link counts to rank their importance for hitting observed traffic volume targets. The ODME tool is not provided in TransModeler SE.

3.5.2.1.1 Route Choice

Within the routing tab, nested in the project settings, there is a selection for route choice. This selection governs the type of routing to be used in the model. There are three options: Deterministic shortest path, Stochastic shortest path, and Probabilistic shortest path. The route choice options vary in design and complexity, but all three calculate user costs for each possible route or path and then select routes for each trip. The calculated user costs for each trip can vary based on several factors (e.g., driver preferences, departure time, distance, travel time, number of occupants, and value of time). The stochastic option is enabled by default and is applicable to many modeling scenarios. This option seeks a shortest path for each vehicle but randomizes the path costs to account for variations in driver behavior, resulting in multiple potential shortest paths between O-D points.

Stochastic route choice is applicable for most modeling scenarios where route choice and detour paths are rarely utilized to navigate between origins and destinations. When using Stochastic routing, it is important to review the resulting volumes and paths to check for reasonability and to make sure that the volumes have been estimated accurately. Modifications may be necessary to align the model with field conditions.

3.5.2.1.2 Dynamic Traffic Assignment

DTA in TransModeler is similar to the process in Vissim, but the volumes and routing network are established based on the origins and destinations and a variety of potential shortest path routes. The dynamic assignment uses the selected route choice method to examine the available routes, travel times, and user costs. It runs an iterative process to converge on an

Dynamic traffic assignment is complex and is only appropriate in specific situations; therefore, dynamic traffic assignment should be discussed during the scoping process with KYTC and the project team to determine its need and applicability.

equilibrium traffic assignment consistent with selected assignment method. This convergence generates a series of historic travel time and turning delay matrices which can be loaded into the routing settings menu. This informs the model of new optimal routing decisions based on the observed shortest paths for vehicles moving through the model network.

The dynamic assignment process does not differ significantly between the two software packages. However, with TransModeler it is somewhat easier to implement DTA because the volumes are managed in an O-D matrix format and there are minimal network additions needed to enable the dynamic assignment. Dynamic traffic assignment is complex and is only appropriate in specific situations; therefore, DTA should be discussed during the scoping process with KYTC and the project team to determine its need and applicability.

3.5.2.2 Vehicle Inputs

In TransModeler, vehicle inputs are auto generated based on the network geometry. Routing through TransModeler is based on network Origin-Destination (O-D) pairs. Therefore, the user can directly define the O-D matrices to be used for volumes or generate volume O-D tables if turning movement or segments counts are used as the input data.

4 Model Calibration

4.1 Importance of Model Calibration

Calibration is the process by which a microsimulation model is developed and confirmed as an accurate representation of the study area network. Microsimulation models are highly customizable and able to analyze complex traffic conditions. For each project, it is important that the model be modified to match local driver behaviors and traffic flow characteristics to yield accurate and reliable results. A calibrated existing model, which can replicate the performance and visual acuteness of the existing traffic conditions will serve as the best starting point for modeling future traffic characteristics. The modifications made to calibrate an existing model, when carried forward, represents the most trusted method for developing future models and thus generating the most accurate future results.

4.2 Pre-Calibration Activities

Prior to calibration, it is important for the modeler to thoroughly check the model for errors. It is also important to determine the number of runs needed to achieve statistically valid results.

4.2.1 Error Checking

Prior to model calibration the analyst should check the model for errors. While there are numerous checks that should be done, two primary checks are discussed here. For more information on model checking please refer to FHWA's *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (2019 Update).

4.2.1.1 Visual/ Animation Checking

A key aspect of simulation modeling is the visualization of the traffic through the study network. Watching simulation runs helps the modeler to observe how traffic flows through the model network. This is a critical way to discover errors both before, and during, model calibration.

Once the model coding and input work is complete, the analyst should run the model and observe the animation for all time periods intended to be used in the analysis. This should include observing driver behavior throughout the network with a focus on congested areas. It should also include observations of all roadway segments, entry and exit points, flows between links and connectors, and all conflict and junction points. The goal of these observations is to identify model coding or parameter issues, which were difficult to notice without the active animation. Conducting visual observations for each analysis period is repetitive, but it can help identify issues with parameters, volumes, or signal timings which may only be present for one analysis period but should be modified for all periods.

Conducting visual observations and addressing any identified issues prior to calibration can help improve the calibration process, decreasing the time needed to achieve the expected, real-world conditions.

4.2.1.2 Error Files

After a simulation finishes, if any errors occurred during the simulation, an error file (Vissim) or simulation log (TransModeler) is produced. These files list the details of each error including error description, simulation time, and location. The error files can assist the modeler with finding and addressing coding errors which may have been difficult to detect any other way. A modeler should attempt to address all errors in the error file as they may have known and unknown impacts. For example, an error could limit vehicles from entering the network, cause vehicles to be removed from the network, change how vehicles navigate the network, or affect vehicle or driver behavior.

While minimizing and resolving errors is the goal, it may become unreasonable to resolve every model error. Some errors can be accepted as reasonable errors while others must be resolved prior to moving forward. Acceptable errors are those which are unique to individual model runs and/or vehicles and are singular and time limited in nature. These errors should not impact model performance at a larger scale, but may impact a vehicle, specific link, or specific route. Errors associated with lone vehicles have little to no impact on the overall model performance and a minimal number of these errors in various locations is typically not a cause for concern.

The errors which should be resolved prior to moving forward include those which are more impactful across the network, network section, or analysis period. These types of errors may impact the overall performance and can cause inaccurate and/or unreliable results. Errors like this include the inability of volumes (of any magnitude) to enter the network, traffic signal timing issues, large scale routing issues, network connectivity or continuity issues, and/or a significant number of concentrated or repeated acceptable errors (meaning singular vehicle errors which happen numerous times for the same location, route, input, etc. and are not associated with the randomness of simulation or model runs).

4.2.2 Number of Model Runs

4.2.2.1 Initial Number of Runs

To develop metrics and analyze results from a simulation model, multiple runs must be conducted in order to generate aggregate results and remove outliers which may occur in isolated, random conditions. The simulation runs should be conducted using a set of differing random seed values that are consistent between different model scenarios (i.e., set of runs). For the purposes of initial data gathering, it is suggested that 10 runs be completed to get initial model results. Once the required number of simulation runs is established, it should be followed, even if this number is fewer than 10.

4.2.2.2 Required Number of Simulation Runs

While 10 simulation runs is often sufficient to account for model variability, the minimum required number of runs should be calculated and implemented once the model is calibrated. This calculation will establish a 95 percent confidence level for the model results if the number of runs meets or exceeds the derived value. Once the minimum number of runs is established for the calibrated model, the model should be re-run to ensure the threshold is still met and all subsequent models (additional analysis years, build scenarios, etc.) should be run with the same random seeding and number of runs.

The equation for calculating the minimum number of required simulation runs is:

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

<u>Where:</u>
N = number of required simulation runs
$t_{0.025,N-1}$ = Student's statistic for two-sided error of 2.5% (5% total) with N-1 degrees of freedom (95% confidence level) *[t values can be found in statistics manuals or online]*
s = Standard deviation about the sample mean for selected measure
R = Confidence interval for the true mean

This calculation and the application are discussed in significant detail in several other guidance documents, including Washington DOT[5], Oregon DOT[6], and Iowa DOT[7].

[5] *WSDOT: Protocol for Vissim Simulation (September 2014)*
[6] *ODOT: Protocol for Vissim Simulation (June 2011)*
[7] *IOWADOT Microsimulation Guidance (October 2017)*

The purpose of using average data from a set of simulation runs is to generate a sample size that will provide enough data to determine if the model is providing representative, repeatable results. By using a large enough sample of runs, the analyst can achieve an appropriate level of confidence that the model results are valid for assessing existing and future network performance.

The process of determining the number of simulation runs is often conducted concurrently with the calibration effort, as it is dependent upon the variation in the model results. The variable "s" is the standard deviation of a selected output metric. If the standard deviation for the selected metric is large, then a large the number of simulation runs may be needed to have confidence that the average results accurately represent the real-world conditions. To simplify the process, it is typical practice to base the sample size equation on one calibration metric. However, multiple metrics can be used but "s" will be different for each metric examined. Since volume is a commonly used and critical measure in microsimulation, it is recommended that the standard deviation for volume be used to define "s" to determine the minimum number of simulation runs.

4.3 Model Calibration

Model calibration includes modifying parameters and driver behaviors to accurately model project area conditions. A successfully calibrated model will accurately replicate existing real-world conditions. This baseline accuracy establishes trust that the model can be used to evaluate future conditions including changes in traffic volumes, geometry, and traffic control or operations.

Model calibration makes modifications to parameters and behaviors to ensure that the model is representative of the project area conditions.

Model calibration should be conducted for all existing conditions models. It is important to take all model time periods into account during calibration, as each period is likely to have different volumes and congested locations, leading to different calibration modifications.

4.3.1 Calibration Procedures

The model calibration process is addressed in each of the existing reference guidance documents (see **Table 1**). Many of these documents outline a similar process with overlapping methods and calibration targets. Typically, the methods conveyed in these guidance materials are sufficient for the purposes of Kentucky models and thus this section draws from those documents to provide an overview of the calibration process and useful target criteria.

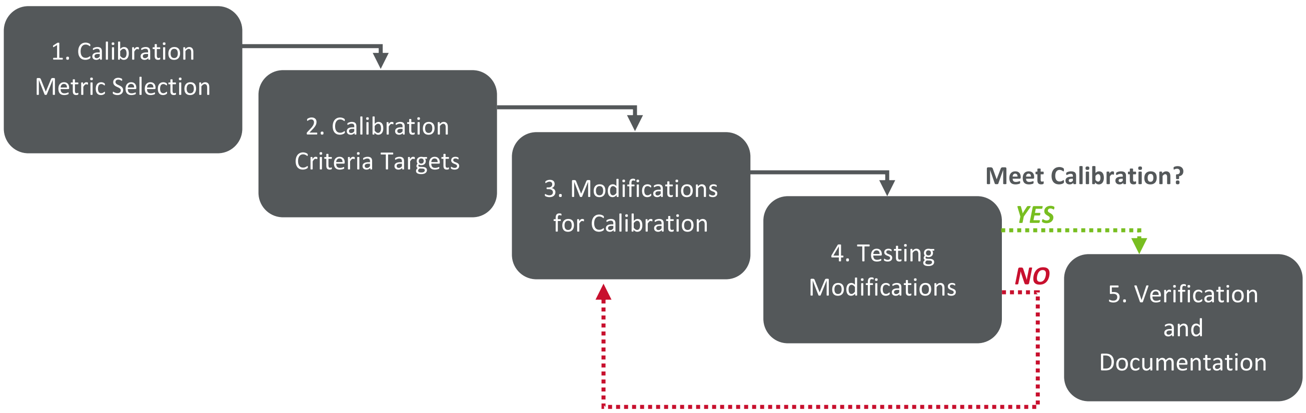
During project scoping it is important to determine the most appropriate methods for calibration based on the project area, overall project scope, and project goals. In 2019, FHWA revised the Traffic Analysis Toolbox Volume III (FHWA TAT III), which was previously published in 2004 (see link below). The 2019 version includes significant enhancements from previous editions, particularly in the calibration section. Implementation of the new calibration approach requires considerably more effort than the prior method. This includes a larger investment in both data collection and modeling. Projects using this new calibration guidance should be scoped accordingly to accurately capture the effort and cost required.

FHWA Traffic Analysis Toolbox Vol. III (2019 Update) – Chapter 5: Model Calibration

Many Kentucky projects do not require that level of effort to achieve the desired level of accuracy, so other calibration approaches may be sufficient. This guidance document outlines calibration measures and targets which are commonly referenced by other existing guidance documents. The project team (consultant staff, KYTC staff, and possibly FHWA staff) should determine the necessary calibration measures for the specific project during the scoping phase to account for data collection, modeling effort, and timeline.

Model calibration typically follows the five main process steps shown in **Figure 7** and explained below.

Figure 7: Model Calibration Process



1. Calibration Metric Selection

The first step in the calibration process is the selection of calibration metrics. This step establishes which model outputs are most important to ensure that the model is representative of the existing conditions. Typically, it is good practice to select several calibration metrics. This multifaceted approach limits the chances that adjustments made during calibration modify the model to accurately predict on metric, while making another key output less accurate. The selected metric(s) should be measurable, quantitative (if possible), and indicative of the purpose or goal of the modeling effort. Aligning the calibration metrics with the purpose and goals of the microsimulation modeling is very important. It helps make sure that the model is useful and able to support the project goals. For example, if the goal of a modeling effort is to examine and reduce queuing within a project area, but the calibration was completed using travel times and volumes, the resulting “calibrated” model may not accurately replicate existing queues. Therefore, the future models may not accurately predict future queuing.

Typical model calibration metrics include:

- Volume
- Travel Time
- Speed
- Congestion/ Delay
- Queue Lengths

2. Calibration Criteria Targets

Once the calibration metrics have been selected for a project, the criteria by which calibration is achieved should be established. This criterion will determine the allowable tolerance from the observed/expected result. **Appendix A** shows a comparison of calibration targets from other guidance documents.

The 2019 FHWA Traffic Analysis Toolbox III provides detailed procedures, metrics, targets, and an example for model calibration. This document should be consulted, and the calibration targets considered, considering the project context, data, budget, and schedule.

Table 7 provides standard calibration measures and targets that are referenced in several other guidance manuals (ODOT, FDOT, WSDOT, Iowa DOT, etc.). These were established as part of the previous version of the FHWA TAT III (2004 version). These targets for the specified metrics are typically easier to achieve than the requirements of the updated TAT III and commonly accomplish the calibration goals for most projects.

Table 7: Calibration Targets

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 15%, for 700 veh/h < Flow < 2,700 veh/h Within 100 veh/h, for Flow <700 veh/h Within 400 veh/h, for Flow >2,700 veh/h[1]	>85% of cases
	Sum of all Link Flows	Within 5% of sum of all link counts
	GEH Statistic < 5 for Individual Link Flows	>85% of cases
	GEH Statistic for Sum of All Link Flows	GEH <5 for sum of all link counts
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within 10% (or 10 mph, if higher)[2]	>85% of cases
Queues	(Qualitative) Queues in observed conditions	Observation of similar conditions within model (presence, magnitude, and duration)
	(Quantitative) Collected queue length data	Model queues within 20% of observed queue lengths
Visual Attributes	Matching Field Observed Conditions (Qualitative)	Reasonable replication of field observed conditions. Documentation/ photos preferable.

[1]For conditions with significantly higher volumes this metric may not be achievable.
[2]For oversaturated flow conditions that extend over several time periods, it may be difficult to achieve this speed calibration metric.

The calibration targets to be used should be established during project scoping if possible as that decision may influence the data collection effort (see the data collection chapter for more details).

When volume is used as a calibration metric, one of the key tools is use of the GEH statistic calculation. (The GEH formula gets its name from Geoffrey E. Havers and is used to compare two sets of traffic volumes.) The GEH comparison quantifies the variance between the modeled and observed volumes in a more effective manner than either magnitude or percent difference alone. The calculation for GEH, which should be used for all link flows through a network is represented by the following equation:

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

Where:
m = output traffic volume from simulation model
c = traffic volumes based on field data (expected)

GEH comparison values should meet the requirements shown in **Table 8** for calibration.

Table 8: GEH Guidelines

GEH Statistic	Guidance
< 3.0	Acceptable
3.0 to 5.0	Acceptable for local roadway facilities
> 5.0	Unacceptable

3. Modifications for Calibration

One of the key advantages to using microsimulation is the ability for customization; however, this can also be one of the pitfalls. Due to the number of possible modifications, modelers can lose track of the calibration changes they have made. They may also not understand the combined impact of their changes and how the changes are positively or negatively affecting the model results. Therefore, prior to making any model modifications, it is important to establish two parameter categories:

1. Parameters which the analyst is certain about and does not wish to adjust
2. Parameters which the analyst is less certain about and willing to adjust

This distinction will help to narrow down the number of possible modifications, remove a significant level of variability, and decrease the effort required for calibration. The number of parameters included in the modification category should be examined thoroughly and limited when possible.

As part of developing this guidance, nine key microsimulation parameters were identified and examined, and recommended default ranges have been generated for application on Kentucky models. The recommended values or ranges for each parameter were developed using Kentucky specific data and they are therefore generally representative of Kentucky conditions. These values are recommended for use as a starting point for calibration and can be modified or supplemented with additional data specific to each project. See **Chapter 5** for further details on these parameters and values.

4. Testing Modifications

This is the iterative stage of the calibration process with step 3. As shown in **Figure 7**, the results from this testing may not meet the calibration targets, at which point additional modifications are necessary and steps 3 and 4 will be repeated. Due to the iterative nature of this process, it is important to make small modifications, save versions of files, and document each iteration to gradually move closer to calibration. Making large parameter changes can lead to models which are ultimately more difficult to calibrate, because the results are likely to change significantly, and it can be difficult to clearly link the output changes to the model parameter changes in a way that leads to further beneficial modifications.

5. Verification and Documentation

Once the models meet the calibration targets, they should be run the appropriate number of times with proper network seeding and seeding increments. The resulting average values should then be compared against the calibration targets to confirm that they meet the criteria. Once the average results from the applicable number of simulation runs meets the calibration target criteria, the models are assumed to meet calibration.

The calibration process should be documented in a Model Calibration Technical Memorandum to be provided to KYTC for review.

4.4 Validation and Calibration Technical Memorandum

The purpose of this memo is to document the calibration process. The memo should outline the methodology, assumptions, modifications, results, and findings for calibrating the existing conditions models. Any parameter modifications from the default values should be noted. This includes changes to the Kentucky recommended parameters as well as changes to any other parameters. The document should serve to convey the process of calibration, so that another modeler could replicate the calibrated model if that was necessary in the future.

The calibration memo and documented results will serve as an interim checkpoint for review by KYTC in the analysis process. This will facilitate the development of models that meet the proper calibration metrics and will support the project goals. It will also provide an opportunity to make sure that the model parameters are within acceptable ranges prior to the development of the future conditions models.

5 Kentucky Microsimulation Parameter Development

5.1 Parameter Selection

5.1.1 Key Model Parameters

Within microsimulation, there are a myriad of parameters, inputs, and factors which influence model performance from the individual vehicle level to the entire network. The level of influence, accessibility, and customization varies between parameters which creates difficulty in determining which parameters to adjust and which to leave as the software default. Nine key parameters were selected and analyzed for the development of Kentucky specific recommended default values and/or ranges based primarily on satisfying one or more of the following criteria:

Nine key parameters were selected and analyzed for the development of Kentucky specific recommended default values and/or ranges.

- Parameters which are frequently changed in microsimulation models
- Parameters which can have a significant impact on microsimulation model results
- Parameters which have defaults that vary significantly from Kentucky values

These criteria yielded the selection of the following nine parameters for analysis:

1. **Time Headway**
2. **Minimum Headway**
3. **Acceleration Rates**
4. **Deceleration Rates**
5. **Standstill Distance**
6. **Vehicle Speed Ranges**
7. **Lane Change Distance**
8. **Vehicle Fleet Composition**
9. **Truck Weight-to-Power Ratio**

5.2 Parameter Analysis

The selected parameters were analyzed using local Kentucky data to evaluate the current software default values and to develop Kentucky recommended default values. One exception was the Truck Weight-to-Power Ratio as Kentucky data was not available. The data included vehicle trajectory data, speed data, vehicle identification number (VIN) data, aerial photography, and other sources. The analysis methods, data collection, and results are documented in **Appendix B**. This chapter provides a summary for each parameter including conclusions and applications for Kentucky based microsimulation models. **Appendix C** provides a summary table of the recommended parameter values from other guidance documents as well as the Kentucky values.

This is the first known set of guidelines to use local observed data to develop recommended parameter ranges. This approach provided considerable new insights into driver behavior and how that relates to key model parameters. As this is a new method, revisions to this document and the recommended parameter ranges are expected in the future as more information becomes available and the method matures over time.

5.3 Driving Behaviors and Car Following Models

Many of the parameters selected for analysis are related to driver behavior or car following models. Driving behaviors and car following models are critical pieces of microsimulation that differentiate it from other analysis methods, as they dictate the functions and actions of individual vehicles through the network. The availability and applicability of car-following models varies between Vissim and TransModeler and is important to understand prior to modifying or applying them. Within Vissim, there are two available car-following models: Wiedemann 99 (W99) and Wiedemann 74 (W74). These models are primarily aimed at freeway and arterial operations, respectively.

TransModeler (version 6.0) has eight car following models which can be selected. Most of these models are designed for specific applications and are not used in traditional microsimulation. The primary and default car following model is the Modified General Motors (MGM). Wiedemann 99 and Wiedemann 74 are within the other six available models for selection. The parameter analysis and results focus on the default values within the software as they pertain to the W99, W74, and MGM car following models as well as other global parameter settings.

5.4 Parameter Descriptions

5.4.1 Time Headway

Time headway is a main component of driving behavior in microsimulation models. It is commonly edited by modelers to reflect roadway conditions more accurately. In the 6th Edition of the *Highway Capacity Manual* (HCM6), headway is defined as *"the time between two successive vehicles on the roadway, measured from the same common feature of each vehicle".* As described by the definition, headway represents the time between the same feature of vehicles, typically front bumper to front bumper. Gap is commonly discussed alongside headway and defines the time spacing between vehicles, typically rear bumper to front bumper. This term does not take into consideration the length of one of the vehicles and is a lower value than headway.

It is important to be careful when using and applying these terms as they represent different measurements of driving behavior. Unfortunately, the models themselves do not always use the HCM6 definitions. The "time headway" values for the Wiedemann 99 car-following model are actually gap values, whereas the Modified General Motors model uses the traditional HCM6 time headway definition.

5.4.2 Minimum Headway

Minimum headway (Vissim) or Critical Headway (TransModeler) represents the absolute minimum spacing that that a driver will allow when they attempt to make a lane change maneuver. This value defines the tolerance for the minimum acceptable condition, likely only occurring during critical congested periods. Typically, drivers have enough advanced notice for lane changes that they are able to find gaps within the traffic stream to navigate properly without requiring tight maneuvers. However, there are times when emergency lane change maneuvers are required, and the minimum or critical headway defines the tolerance for how close drivers will come to other vehicles.

5.4.3 Standstill Distance

Standstill Distance in Vissim, referred to as Stopped Gap in TransModeler, defines the distance between vehicles while in a stopped condition. In general, stopped conditions are more applicable to arterials (interrupted flow) than freeways (uninterrupted flow); however, they can be experienced on either. This parameter affects overall model performance and several important outputs. It influences the capacity of a roadway by adjusting the spacing between vehicles and therefore vehicle density and queue length.

5.4.4 Acceleration Rates

Acceleration is a key part of microsimulation modeling. Vissim and TransModeler handle acceleration differently, but they both have multiple inputs or parameters that affect the acceleration of a vehicle. The inputs relate to vehicle type, vehicle operation, desired speed profile, reduced speed inputs, and others. The acceleration related inputs are found in different places (i.e., screens and dialogue boxes) throughout the software.

The most basic method for setting acceleration is through the attributes assigned to vehicle models. These define the characteristics for maximum, minimum, and desired (normal) acceleration. This approach is governed by vehicle capabilities and is the backbone for acceleration actions in models. In Vissim and TransModeler, acceleration rates are represented by a series of values based on vehicle speed and are assigned either based on vehicle type (Vissim) or mass-to-power ratio of the vehicles (TransModeler).

The next main method for setting acceleration is through the use of driving behaviors. In this case, vehicle acceleration is influenced by specific driver behaviors parameters that override the base vehicle acceleration characteristics if the new acceleration is within the ability of the vehicle. (For example: at 10 mph the base data has the following attributes: min = 2 ft./s^2, desired = 10 ft./s^2, max = 12 ft./s^2. If the driver behavior attribute is within 2 ft./s^2 and 12 ft./s^2, the vehicle will use that desired acceleration to replace the current 10 ft./s^2.) An important goal for these guidelines was to identify Kentucky driver behavior parameters for acceleration as opposed to global acceleration.

5.4.5 Deceleration Rates

Deceleration within microsimulation governs how vehicles will decelerate in response to curves, traffic control, congestion, other vehicles, etc. This attribute is expressed in several formats within a model (similar to acceleration) and has a hierarchy of governance. There are default deceleration curves or distributions which are attributed based upon vehicle type and are expressed typically as maximum, minimum, and desired (normal) deceleration values. These curves or distributions are based primarily on vehicle speed, as deceleration rates change depending on vehicle speed. In addition to this parameter, there are deceleration parameters within the Vissim driving behaviors that impact how vehicles change lanes and perform deceleration actions in car following. TransModeler has similar parameter sets for deceleration variance based on the driver behavior. If possible (meaning that it is within the min/ max bounds of the default curves), vehicles will follow the instructions for deceleration provided by these parameters, similar to the rules established by the acceleration driving behavior parameters.

A main goal of these guidelines was to set recommended Kentucky value ranges for the driver behavior and lane changing deceleration parameters, as they are the most commonly changed deceleration inputs and they override the default curves.

5.4.6 Lane Change Distance

Lane change distance in Vissim, referred to as critical distance in TransModeler, is a parameter which controls the lane changing behavior of vehicles prior to a necessary turn or exit to execute the assigned route. The values are expressed in terms of distance to indicate when the vehicle could first begin to make the lane change maneuver. The lane change could occur at any point along that distance with the actual location of the maneuver depending on congestion levels and various vehicle and driver behavior parameters.

Lane change distances can have a significant impact on the overall performance of a model. A common issue is lane change distances that are too short, which can cause unrealistic congestion because vehicles only begin to attempt lane changes near their destination. A less common issue is lane change distances that are too long, which can sometimes smooth out traffic flows that are in reality congested or even create unrealistic upstream bottlenecks.

5.4.7 Vehicle Speed Ranges

Vehicle speed ranges in micro-simulation define the distribution of speeds assigned to vehicles along a roadway link or segment based on properties or markers which vehicles pass during simulation. Typically, vehicle speed ranges are expressed as distributions which are based on the posted speed limit for the roadway segments.

5.4.8 Vehicle Classification

Vehicle Classification determines the makeup of the vehicle fleet in the micro-simulation model. The default fleet values for TransModeler and Vissim differ somewhat from the Kentucky average fleet, which is why this parameter was included in the guidelines. The vehicle fleet composition can have a significant impact on the analysis performance and results. The performance of vehicles differs based on their size and power capabilities. In modeling, like other traffic analysis, it is important to accurately capture the local project area distribution of heavy vehicles to accurately capture the operational conditions.

5.4.9 Truck Weight-to-Power Ratio

The weight-to-power ratio is the relationship between the two key heavy vehicles characteristics. This ratio has an impact on heavy vehicle performance throughout the model and is exceptionally impactful on acceleration and deceleration and the ability of heavy vehicles to operate on gradients and turns. This can impact the overall performance of a model depending on the configuration and percent trucks.

The subsequent sections discuss the results of the parameter analysis and the recommended values or ranges for each of the nine parameters. The material is divided by software package, with Section 5.5. addressing Vissim and Section 5.6 addressing TransModeler. Each section was written as a stand-alone reference section for the respective software packages. This resulted in much of the basic material being repeated in both sections, but it allowed for the sections to be written as references for specific software users. One additional note is that the Wiedemann driving behavior model parameters are included in both sections. They are the only models available in Vissim and they are optional models available for use in TransModeler.

5.5 Vissim Parameter Results Summary

5.5.1 Time Headway

The analysis resulted in a recommended range of headway values for use in the Wiedemann 99 model. The values can be applied as singular values in older version of Vissim or as a distribution of values in Vissim version 11 on onwards. **Figure 8** illustrates the headway findings and the relationship to the Wiedemann 99 default value (0.9 seconds). **Table 9** shows the recommended ranges for the Wiedemann 99 driving behavior in Vissim. The Wiedemann 99 car following model headway is the <u>time gap between vehicles</u> (back to front) and not the standard headway definition of <u>time between the front of subsequent vehicles</u> (front to front).

The recommended headway range includes values less than the default of 0.9 seconds (s), representing tighter headways than the default programming. Values below 0.9s should be used in specific conditions and are not anticipated to be applied often or in large areas of model networks, as this could increase the roadway capacity above what is typically observed.

Figure 8: Time Headway Observations and Recommended Range

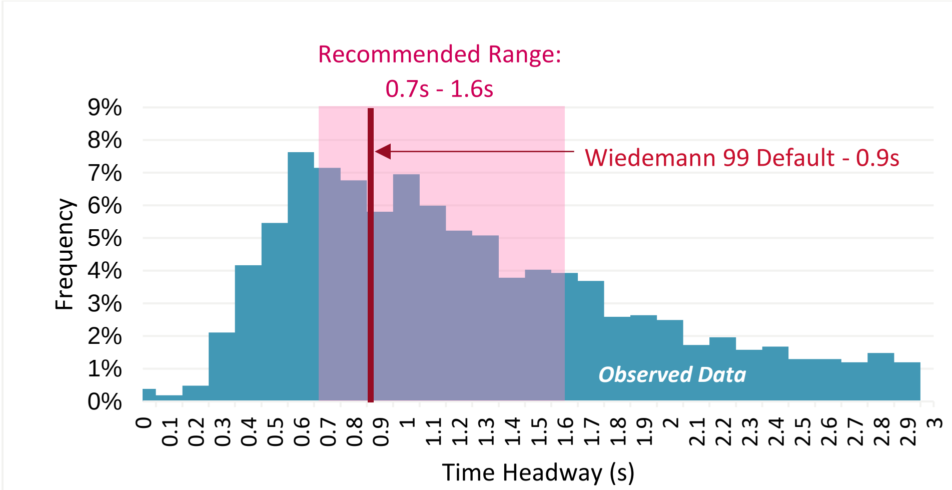


Table 9: Recommended Time Headway - Vissim

Vissim – Wiedemann 99* cc1 - Time Headway	
Default Value	0.9s
Recommended Range	0.7s – 1.6s

**Can be applied to TransModeler if Wiedemann 99 is selected as the driving behavior*

**Vissim version 11 and onward can implement time headway values as a distribution through the addition of a time distribution.*

5.5.2 Minimum Headway

The Vissim default value for minimum headway is expressed as a distance value of 1.64 ft. (0.5m). While this value is quite small for vehicle spacing it is important to recognize that it is the minimum allowable spacing between vehicles and is only engaged during heavy congestion and merge/weave operations. Based on the Kentucky trajectory data results, it is recommended that the current software default be used for Kentucky microsimulation models. The default value aligned with the minimum observed headways in the Kentucky data. **Table 10** shows the default value recommended for use in Kentucky.

Table 10: Minimum Headway Software Default and Recommended Value

Vissim Default Minimum Headway
Headway Distance (ft.)
1.64

5.5.3 Standstill Distance

Standstill distance is handled in the driving behaviors within Vissim. Standstill distance can be edited in both Wiedemann 99 and Wiedemann 74 but is most applicable in Wiedemann 74 as it is related to arterial conditions. For Wiedemann 74, the standstill distance is defined by a normal distribution where the user can define the average value, but the standard deviation and shape of the distribution are fixed. For Wiedemann 99 (applicable to freeways) the standstill distance is a fixed, definable value.

The analysis of the observed standstill data throughout Kentucky resulted in recommended values for urban and rural standstill distances that are different from the default Vissim values for Wiedemann 74. Due to the inability to change the shape of the distribution in Vissim, PTV staff recommended using multiple concurrent distributions to achieve a composite distribution with a larger standard deviation. This approach assigns different distributions to portions of the vehicle fleet, resulting in a new flatter overall distribution Refer to **Appendix B** for details. The resulting recommended urban and rural distributions are shown in **Table 11**. **Figure 9** illustrates the software default, observed, and recommended values for urban standstill distance for Vissim.

Table 11: Standstill Distances – Default and Recommended

Software Default Values

	Vissim – Wiedemann 74
Average (ft.)	6.56
Standard Deviation	0.98*
Minimum (ft.)	3.281
Maximum (ft.)	9.843

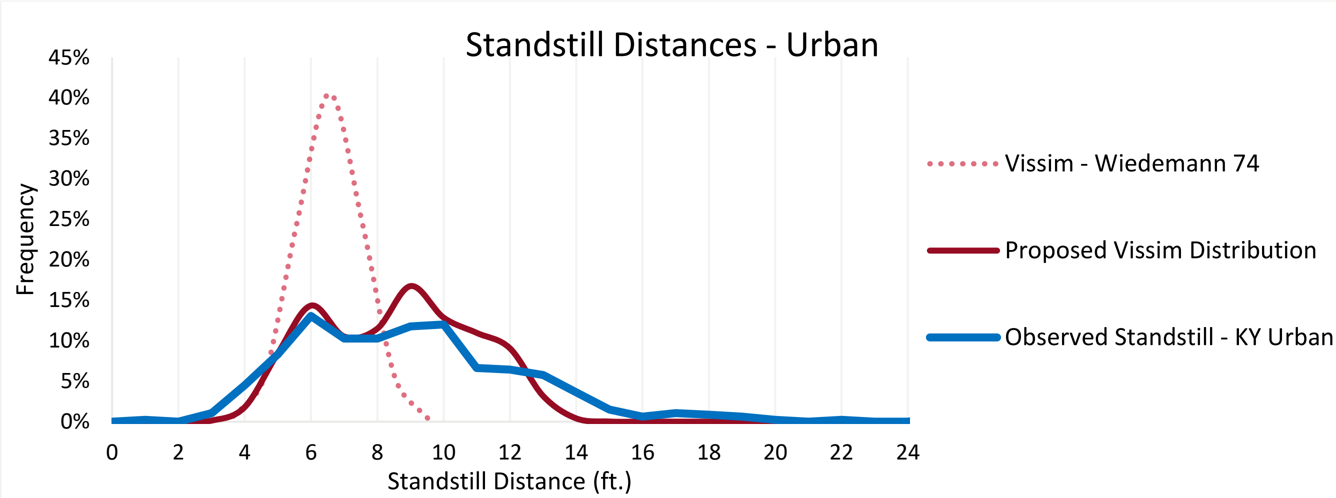
Recommended Values - Urban

	Vissim – Wiedemann 74 3 Distributions		
	Dist. 1 (35%)	Dist. 2 (40%)	Dist. 3 (25%)
Average (ft.)	6	9	11.5
Standard Deviation	0.98*		
Minimum (ft.)	2.719	5.719	8.219
Maximum (ft.)	9.281	12.281	14.781

Recommended Values – Rural

	Vissim – Wiedemann 74 3 Distributions		
	Dist. 1 (35%)	Dist. 2 (40%)	Dist. 3 (25%)
Average (ft.)	7	10	13.5
Standard Deviation	0.98*		
Minimum (ft.)	3.719	6.719	10.219
Maximum (ft.)	10.281	13.281	16.781
*Standard Deviation is a fixed value in Vissim for standstill distance			

Figure 9: Urban Standstill Distance – Observed, Default, and Recommended



**Vissim version 11 and onward can apply multiple distributions for standstill distance through the implementation of modifications to the W74 driving behavior and vehicle class compositions. Previous versions of Vissim are limited to singular average standstill distance values with the aforementioned set standard deviation.*

5.5.4 Acceleration Rates

The driver behavior acceleration rate parameters in Vissim are found in the Wiedemann 99 driving behavior inputs. The Wiedemann 99 model (freeway operations) defines acceleration using two primary driver behavior parameters: cc8 - Standstill Acceleration and cc9 - Acceleration at 50 mph.

The observed acceleration rates in Kentucky were more conservative than the Vissim default values for the Wiedemann 99 cc8 and cc9 parameters. The definitions for cc8 and cc9 represent the maximum desired acceleration of vehicles; therefore, the maximum observed values were compared against the default values. **Figure 10** and **Figure 11** illustrates the observed acceleration distributions as well as the default values. Based on the findings of the analysis, it is recommended cc8 be reduced from 11.98 ft./s^2 to 9.2 ft./s^2 and cc9 be reduced from 4.92 ft./s^2 to 4.5 ft./s^2 as shown in **Table 12**. While the KY default values are recommended, it is acceptable to adjust these values based on local observed conditions. It may be unrealistic to increase the acceleration values above the W99 defaults.

Figure 10: Standstill Acceleration – Observed, Default, and Recommended

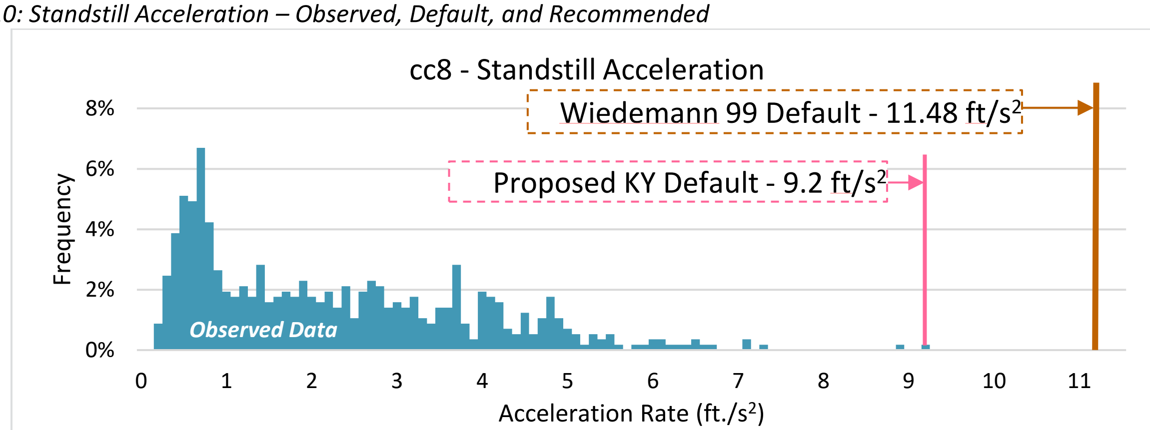


Figure 11: Acceleration from 50mph – Observed, Default, and Recommended

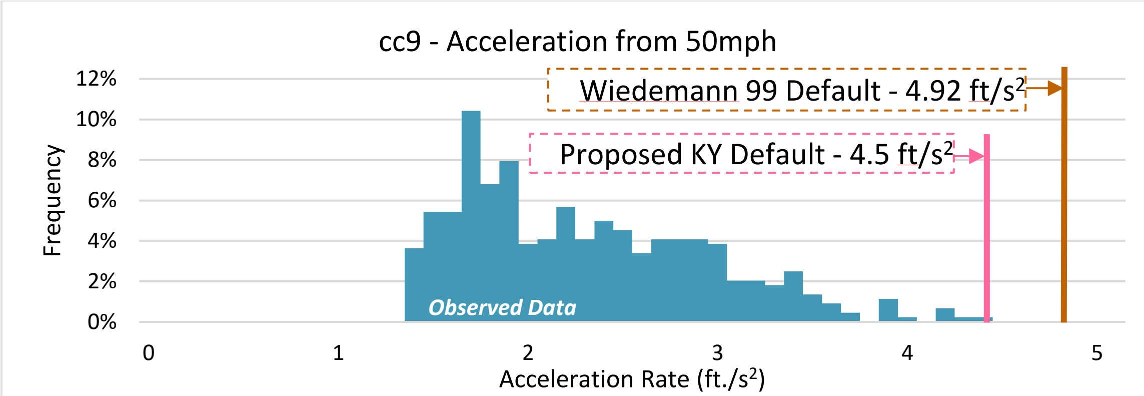


Table 12: Wiedemann 99 Default and Recommended Acceleration Parameters (cc8 and cc9)

	Default Values	Recommended Values
Acceleration from Standstill (cc8)	11.98 ft./s^2	**9.2 ft./s^2**
Acceleration from 50mph (cc9)	4.92 ft./s^2	**4.5 ft./s^2**

5.5.5 Deceleration Rates

The deceleration rate analysis indicated that the observed decelerations were similar to the software defaults. This resulted in a set of recommended values and ranges for the Vissim lane change decelerations for use in Kentucky microsimulation. **Table 13** shows the recommended Vissim values and ranges, while **Figure 12** shows the relationship between the default values and percentile curve.

Table 13: Vissim Lane Change Deceleration Values

Vissim Lane Change Deceleration Defaults

Default Values

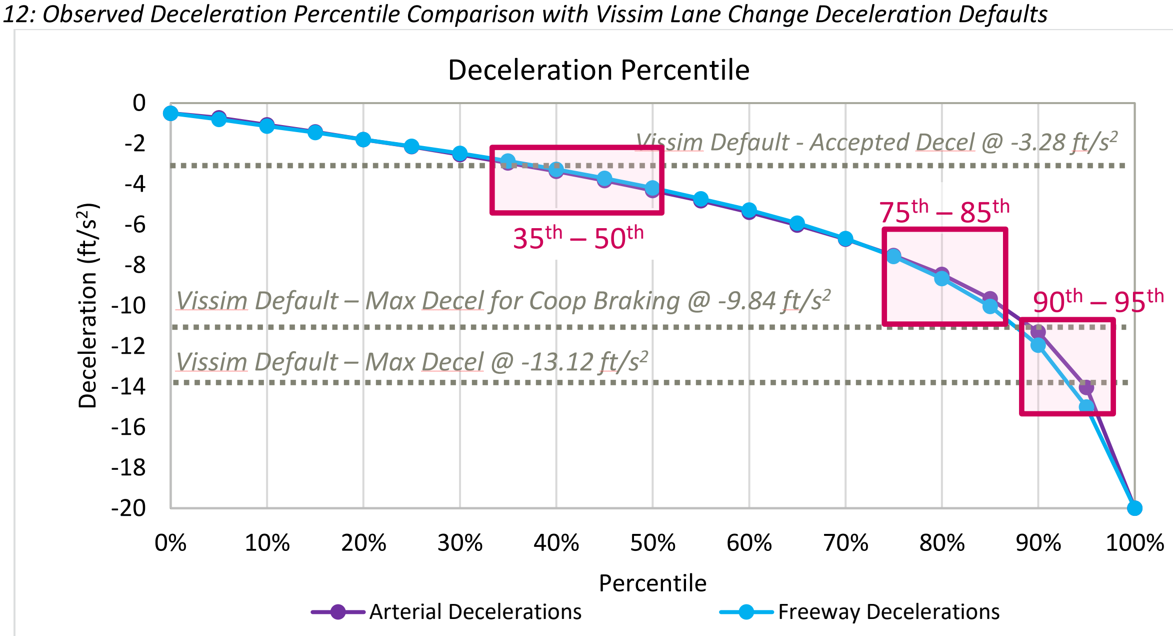
	W74			W99	
	Own	Trailing		Own	Trailing
Max Deceleration (*ft./s²*)	-13.12	-9.84		-13.12	-9.84
Accepted Deceleration (*ft./s²*)	-3.28	-3.28		-3.28	-1.64
Max Deceleration for Cooperative Braking (*ft./s²*)	-9.84			-9.84	

Recommended Values *(Accepted Ranges)*

	W74			W99	
	Own	Trailing		Own	Trailing
Max Deceleration (*ft./s²*)	-12.67 *(-11.30 to -14.03)*	-9.50 *(-8.48 to -10.52)*		-13.47 *(-11.95 to -15.00)*	-10.10 *(-8.96 to -11.25)*
Accepted Deceleration (*ft./s²*)	-3.61 *(-2.95 to -4.31)*	-3.61 *(-2.95 to -4.31)*		-3.51 *(-2.86 to -4.19)*	-1.76 *(-1.43 to -2.10)*
Max Deceleration for Cooperative Braking (*ft./s²*)	-8.54 *(-7.52 to -9.65)*			-8.76 *(-7.57 to -10.04)*	

All deceleration values are in ft./s²

Figure 12: Observed Deceleration Percentile Comparison with Vissim Lane Change Deceleration Defaults



5.5.6 Lane Change Distance

In Vissim, the lane change distance is a singular value of 656.6 ft. by default for all links. Based on the observed data, it is recommended that the TransModeler default distribution be used in both Vissim and TransModeler as a starting point for lane changing in all Kentucky models. While Vissim uses a default value, a distribution can be applied in newer versions of the software. * **Table 14** shows the default recommended lane change distances from TransModeler.

Table 14: Software Default and Recommended Lane Change Distances

Percentage of Drivers	Recommended Values: TransModeler Defaults – Streets	Recommended Values: TransModeler Defaults – Freeways	Vissim Defaults
2%	800’	1000’	656.6’
6%	850’	1100’	
10%	900’	1200’	
14%	950’	1300’	
18%	1000’	1500’	
16%	1050’	1750’	
10%	1100’	2000’	
8%	1150’	2250’	
5%	1200’	2500’	
3%	1250’	2750’	
2%	1300’	3000’	
2%	1350’	3250’	
2%	1400’	3500’	
1%	1450’	3750’	
1%	1500’	4000’	

It should be noted that these values are recommended, and local data and field observations should be used to modify the Kentucky recommended defaults to values that best reflect the project area.

**Vissim version 2020 and onward can implement lane change distance as a distribution through the addition and application of a distance distribution.*

5.5.7 Vehicle Speed Ranges

Vissim’s default speed profiles are centered around the posted/ objective speed, providing some variability in distribution of speeds above and below those speeds. However, the default distributions do not capture the full range of expected speeds and some distributions are not representative of observed driving speeds in Kentucky. In Vissim, speeds are represented by a cumulative distribution based on absolute speed values. These values are typically centered around the posted speed limit, but they are not always directly related. The results of the historic speed analysis resulted in a series of speed distributions based on speed limit, context, and roadway type. **Table 15** show the recommended speed distributions for common speed limits in Kentucky.

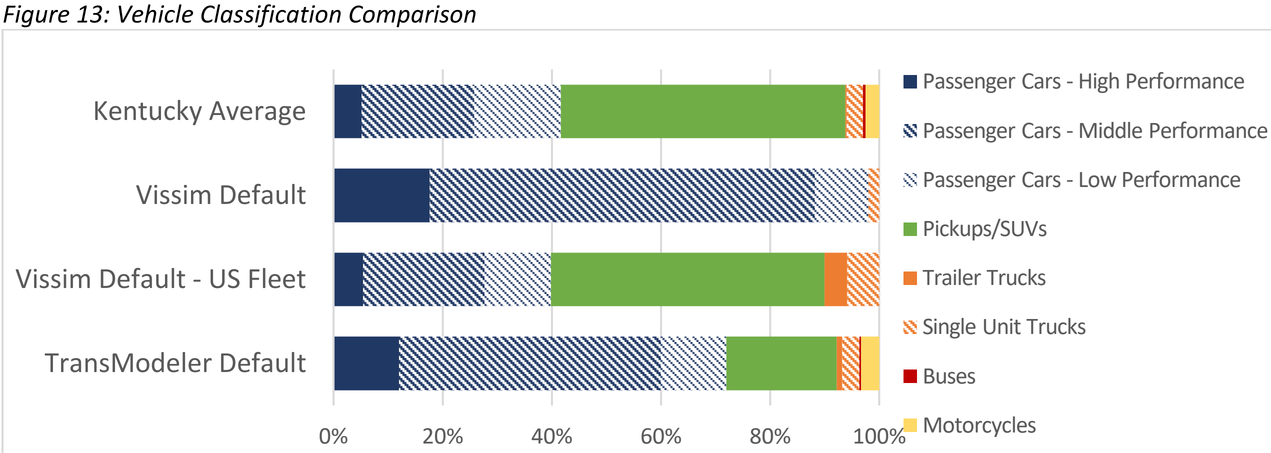
Table 15: Recommended Vehicle Speed Profiles - Vissim

Kentucky Recommended Speed Profiles – Absolute Speeds (Vissim)												
Speed Limit | Road Type		Percentile										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
25mph | Arterial	Urban	20.7	22.0	23.5	25.0	26.1	27.5	29.1	30.5	31.8	35.0	42.3
	Rural	22.6	24.0	25.6	27.3	28.5	30.0	31.7	33.3	34.7	38.2	46.1
35mph | Arterial	Urban	24.6	26.5	28.5	30.0	31.5	33.0	34.1	36.0	37.7	44.0	50.0
	Rural	33.4	35.0	36.4	37.0	39.0	41.0	42.4	43.5	45.2	50.0	54.4
40mph | Arterial	Urban	26.9	30.0	31.6	32.8	34.4	36.0	38.2	41.0	44.0	48.0	52.2
	Rural	29.3	32.7	34.5	35.8	37.5	39.2	41.6	44.7	48.0	52.3	56.9
45mph | Arterial	Urban	33.3	36.5	39.3	41.0	42.4	44.0	45.1	47.0	49.6	53.0	57.3
	Rural	41.1	42.0	43.4	45.0	46.5	47.5	48.7	49.5	50.7	54.0	61.0
55mph | Arterial	Urban	42.4	44.5	46.5	49.0	50.2	53.0	54.4	56.0	58.1	62.0	66.1
	Rural	49.8	51.0	52.4	54.0	55.0	56.0	57.2	58.5	60.1	64.0	67.7
65mph | Arterial	Urban	55.4	56.8	58.6	59.6	61.8	62.9	64.1	64.7	65.1	66.1	67.8
	Rural	59.5	61.0	62.9	64.0	66.3	67.5	68.8	69.5	69.9	71.0	72.8
55mph | Freeway	Urban	42.3	53.5	56.2	58.0	59.6	60.7	62.3	63.7	65.7	68.6	76.7
	Rural	43.1	54.6	57.3	59.2	60.8	61.9	63.5	65.0	67.0	70.0	78.2
65mph | Freeway	Urban	47.5	59.1	62.0	63.8	65.2	66.7	68.1	69.6	71.6	74.5	79.7
	Rural	48.0	59.7	62.6	64.4	65.9	67.4	68.8	70.3	72.3	75.2	80.5
70mph | Freeway	Urban	53.9	62.5	64.5	66.0	67.3	68.4	69.2	70.5	71.9	74.2	80.6
	Rural	51.8	61.6	64.0	65.4	66.9	68.1	69.3	70.7	72.3	74.7	80.5

5.5.8 Vehicle Classification

The default vehicle fleet mix in Vissim trends toward a smaller and higher performance fleet than is typically observed in most US settings. Vissim also provides a default US fleet which can be loaded from template files provided with the software. This vehicle mix is closer to a typical US fleet composition, but it is not loaded by default and may not be known by all modelers. **Figure 13** shows a comparison of the KY VIN data with the software defaults for vehicle classification. Note that the VIN data only shows vehicles registered in Kentucky. Most tractor-trailers and many single-unit trucks on major highways may be registered out of state but must be accounted for in the fleet mix.

Figure 13: Vehicle Classification Comparison



The KY VIN data analysis resulted in a base vehicle distribution that is representative of typical conditions throughout the state. From this distribution, a recommended vehicle composition and a range (providing variance in each direction) were developed. In microsimulation, vehicle composition is often categorized by separating passenger cars and heavy vehicles and applying distributions to them separately. They can be grouped into one distribution but are commonly separated. To assist in the process of establishing vehicle compositions for microsimulation, an interactive spreadsheet tool was developed. This tool factors the KY VIN data analysis results along with aggregated heavy vehicle percentage results for various roadway types and provides a vehicle fleet mix based on three user input criteria. The modeler can input the breakdown between passenger cars and heavy vehicles as well as the roadway type to generate a vehicle fleet mix which can be input directly into the microsimulation software. The results for an example roadway fleet mix are shown in **Table 16.** The interactive spreadsheet for editing vehicle composition can be found in the KYTC Microsimulation Parameters Quick Reference Spreadsheet which is available on the KYTC Microsimulation website and by using the link below.

KYTC Microsimulation Parameters Quick Reference Spreadsheet

Table 16: Sample Recommended Vehicle Composition - Vissim

Sample Vehicle Composition Output			
		INPUT↓	
	Passenger Cars	90%	**User Defined Attributes**
	Heavy Vehicles	10%	
	Project Area Roadway Type*	Interstate	
Vissim			
Initial %	**Description**	**Revised %**	
Passenger Cars			**Customized Vehicle Composition Results**
12.9%	1001: Car - Honda Accord	11.6%	
6.0%	1002: Car - Nissan Altima	5.4%	
6.4%	1003: Car - Nissan Quest	5.8%	
5.5%	1004: Car - Plymouth Voyager	5.0%	
13.5%	1005: Car - Toyota Avensis	12.2%	
10.6%	1006: SUV - Ford Explorer	9.5%	
5.0%	1007: SUV - GMC Yukon	4.5%	
5.8%	8: SUV - Jeep Grand Cherokee	5.2%	
19.2%	12: LtTruck - Ford F150	17.3%	
15.1%	11: LtTruck - Chevrolet Silverado	13.6%	
Heavy Vehicles			
10.5%	1021: HGV - US AASHTO WB-40	1.1%	
48.0%	22: HGV - US AASHTO WB-50	5.1%	
4.5%	23: HGV - US AASHTO WB-65	0.5%	
4.5%	24: HGV - US AASHTO WB-67	0.5%	
5.0%	25: HGV - Flatbed	0.4%	
27.5%	26: HGV - EU 04	2.4%	

**Project Area Roadway Type impacts the heavy vehicle breakdown based on the below lookup table.*

Roadway Type	*SU Trucks*	*Trailer Trucks*
KY Route	*62%*	*38%*
US Hwy	*59%*	*41%*
Interstate	*28%*	*72%*

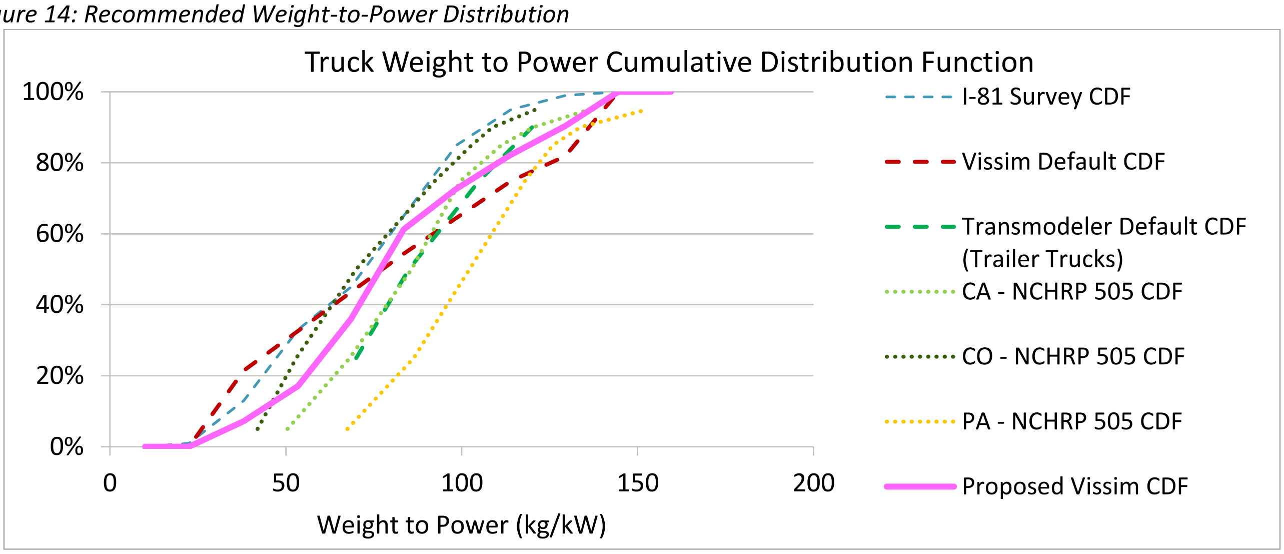
While this study developed recommended ranges for default microsimulation vehicle compositions, it should be noted that vehicle composition can vary significantly depending on the specific project location, context, and functional attributes. Therefore, local project specific vehicle classification data should almost always be used to update and modify the recommended Kentucky default values.

5.5.9 Truck Weight-to-Power Ratio

Based on available research, the default power, weight, and acceleration distributions for heavy trucks in Vissim do not appear to be representative of the U.S. truck fleet. Data from the previously conducted research was used to examine the vehicle mix and reported truck weight-to-power ratios. No Kentucky specific weight-to-power data was available; therefore, national research was used to provide insight on this parameter. One study for I-81 examined weigh station data to determine the weights, power, and distribution of trucks. The NCHRP 505 report summarizes percentile data for weight-to-power ratios in 3 states (California, Colorado, and Pennsylvania). These were used as reference points for the development of a proposed weight-to-power distribution via the implementation of revised weight and power distribution curves for heavy vehicles.

Based on the available literature, revised weight and power distributions were developed. The resulting weight-to-power distribution is shown in **Figure 14**.

Figure 14: Recommended Weight-to-Power Distribution



5.6 TransModeler Parameter Results Summary

5.6.1 Time Headway

Time headway is handled in the driving behaviors in TransModeler. As TransModeler provides the ability to select multiple driving behaviors which use time headway as a function, there are multiple options by which it can be edited. The driving behaviors examined in this analysis include the default Modified General Motors model and the Wiedemann 99 model. As Wiedemann 99 is the primary driving behavior in Vissim, the analysis conducted for that behavior can be used in TransModeler, should that model be enabled.

The results of the analysis provide a recommended range of headway values for use in the Wiedemann 99 model and a recommended range of values for the Alpha+ variable in the Modified General Motors Parameters within the driver behavior in TransModeler. The editable features impacting driver behavior for Modified General Motors include Alpha, Beta, Gamma, and Theta values for both positive (+) and negative (-). Based on conversations with the Caliper team, it was determined that the most impactful parameter for headway and headway distribution would be modifying the Alpha+ parameter. For the purposes of this study the other parameters were not modified in order to only impact the headway and headway distributions, while maintaining the other aspects of the driving behavior.

Figure 15 illustrates the headway findings and the relationship to the Wiedemann 99 default value. **Table 17** shows the recommended ranges for Wiedemann 99. **Table 18** shows the default and recommended Alpha+ values (as well as the other inputs) for the Modified General Motors model. **Figure 16** illustrates the default and recommended Alpha+ values in comparison with the observed data.

Figure 15: Time Headway Observations and Recommended Range

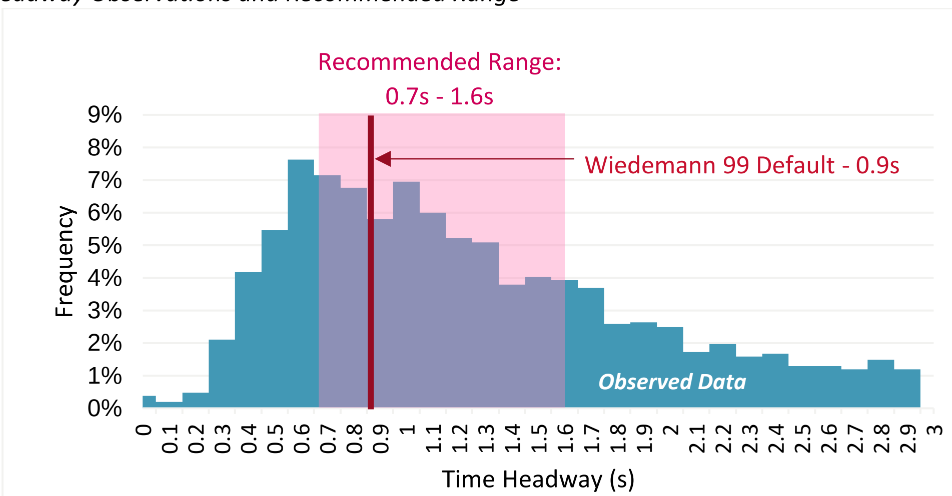


Table 17: Recommended Time Headway – Wiedemann 99

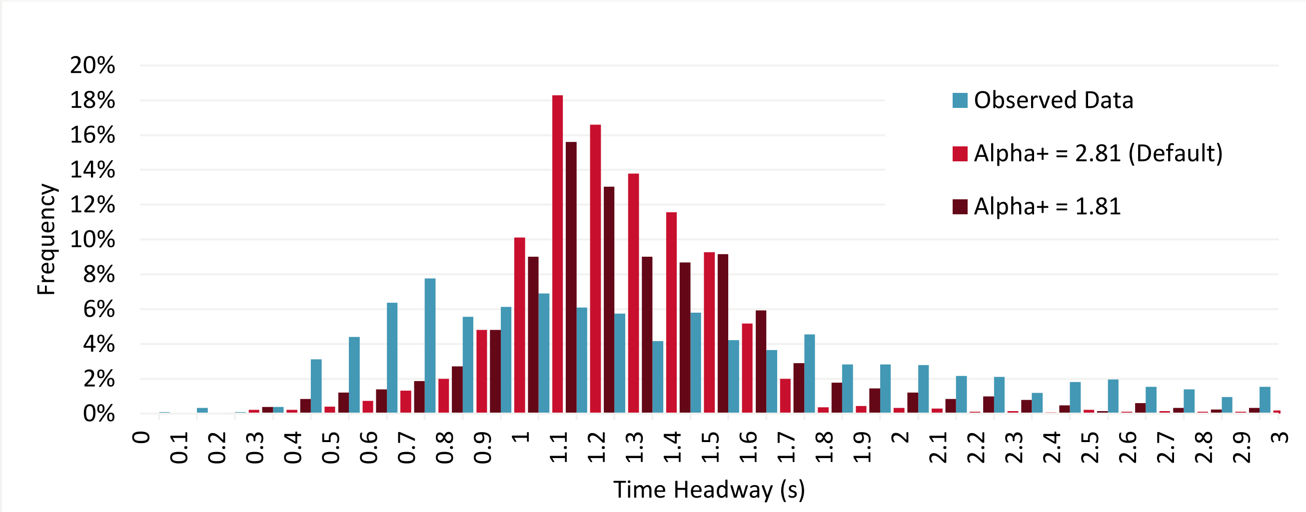
Wiedemann 99* cc1 - Time Headway	
Default Value	0.9s
Recommended Range	0.7s – 1.6s

**Can be applied to TransModeler if Wiedemann 99 is selected as the driving behavior*

Table 18: Recommended Alpha+ Values – TransModeler Modified General Motors

Modified General Motors Driving Behavior Parameters								
	Alpha+	Beta+	Gamma+	Theta+	Alpha-	Beta-	Gamma-	Theta-
Default	**2.81**	-1.67	-0.89	1.00	4.65	1.08	1.65	1.00
Recommended	**2.81- 1.81**	-1.67	-0.89	1.00	4.65	1.08	1.65	1.00

Figure 16: Recommended Modified General Motors Alpha+ Values



5.6.2 Critical Headway

The default critical headway is handled as a time-based distribution in TransModeler. The default distribution is 10% at 0.2s, 10% at 0.4s, 10% at 0.6s, 70% at 0.8s. As with Vissim, while these values are significantly lower than the typical headway, they are a representation of the minimum allowable threshold for headway and are only enabled during congested periods in merge/ weave conditions. Percentile data from the lowest observed headway values from the collected trajectory data align closely with the default TransModeler values, with the TransModeler values being slightly more conservative. Based on the analysis results, it is recommended that the TransModeler default values be used for Kentucky microsimulation models. **Table 19** shows the software default values recommended for us in Kentucky.

Table 19: Critical Headway Software Default and Recommended Values

TransModeler Default Critical Headway	
Headway Time (s)	Percent of Drivers
0.20	10%
0.40	10%
0.60	10%
0.80	70%

5.6.3 Standstill Distance (Stopped Gap in TransModeler)

In TransModeler the stopped gap distance in the general microscopic parameters menu allows for more definition as the user can define the average, standard deviation, minimum, and maximum distances. Additionally, the TransModeler distribution is developed for vehicles behind other passenger cars and behind heavy vehicles separately, allowing for greater distances to be left when heavy vehicles are involved.

The analysis of the observed standstill data throughout Kentucky resulted in recommended values for urban and rural standstill distances – modifying the default values in TransModeler. The resulting recommended distributions are shown in **Table 20**. **Figure 17** illustrates the software default values, observed, and recommended values for urban standstill distance.

Table 20: Standstill Distances – Default and Recommended

Software Default Values

	TransModeler	
	Passenger Veh	Heavy Veh
Average (ft.)	11.3	15.1
Standard Deviation	3.9	4.3
Minimum (ft.)	2	2
Maximum (ft.)	-	-

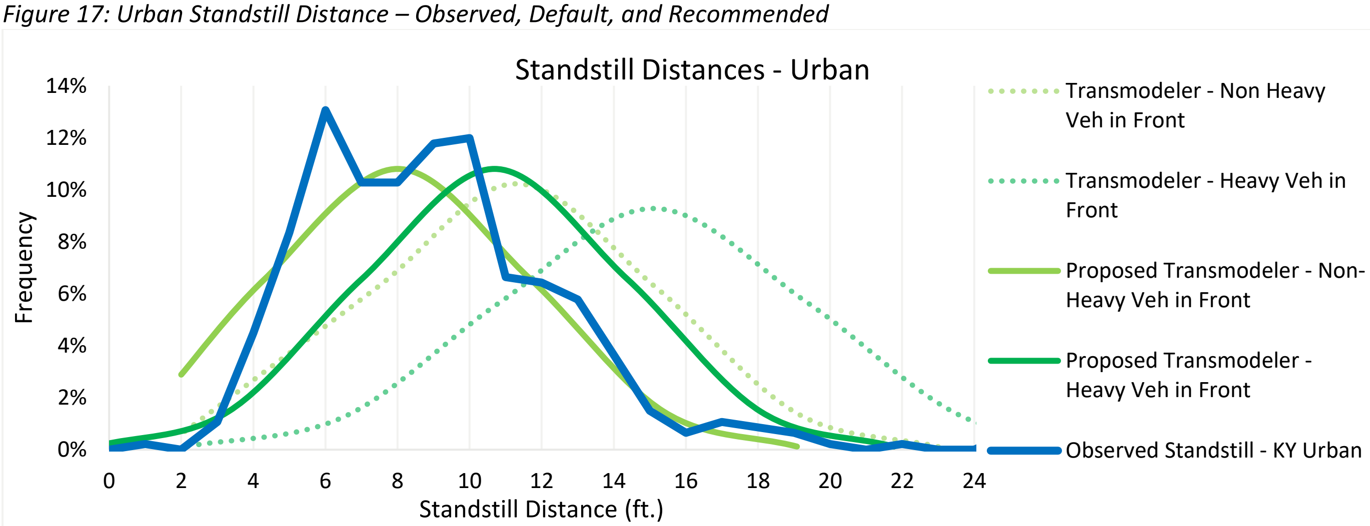
Recommended Values - Urban

	TransModeler	
	Passenger Veh	Heavy Veh
Average (ft.)	9	12
Standard Deviation	3.7	4
Minimum (ft.)	2	2
Maximum (ft.)	-	-

Recommended Values – Rural

	TransModeler	
	Passenger Veh	Heavy Veh
Average (ft.)	11	12
Standard Deviation	3.7	4
Minimum (ft.)	2	2
Maximum (ft.)	-	-
*Standard Deviation is a fixed value in Vissim for standstill distance		

Figure 17: Urban Standstill Distance – Observed, Default, and Recommended



5.6.4 Acceleration Rates

In the Modified General Motors driving behavior there are normal acceleration distributions which can be edited to modify the acceleration. The main goal of this study was to examine the default acceleration values within the driver parameters. In the Wiedemann 99 driver behavior (Vissim- freeway, TransModeler - as selected) acceleration can be defined in two parameters: cc8 - Standstill Acceleration or cc9 - Acceleration at 50mph.

The observed acceleration rates were more conservative than the default values in the Wiedemann 99 cc8 and cc9 parameters and the normal acceleration rates within TransModeler. The definitions for cc8 and cc9 are to represent the maximum desired acceleration of vehicles under these conditions; therefore, the maximum observed values were compared against the default values. **Figure 18** and **Figure 19** illustrate the observed acceleration distributions as well as the default values. Based on the findings of the analysis, it is recommended cc8 be reduced from 11.98 ft./s^2 to 9.2 ft./s^2 and cc9 be reduced from 4.92 ft./s^2 to 4.5 ft./s^2 as shown in **Table 21**. While the KY default values are recommended, it is acceptable to adjust these values based on local observed conditions. It may be unrealistic to increase the acceleration values above the W99 defaults.

Figure 18: Standstill Acceleration – Observed, Default, and Recommended

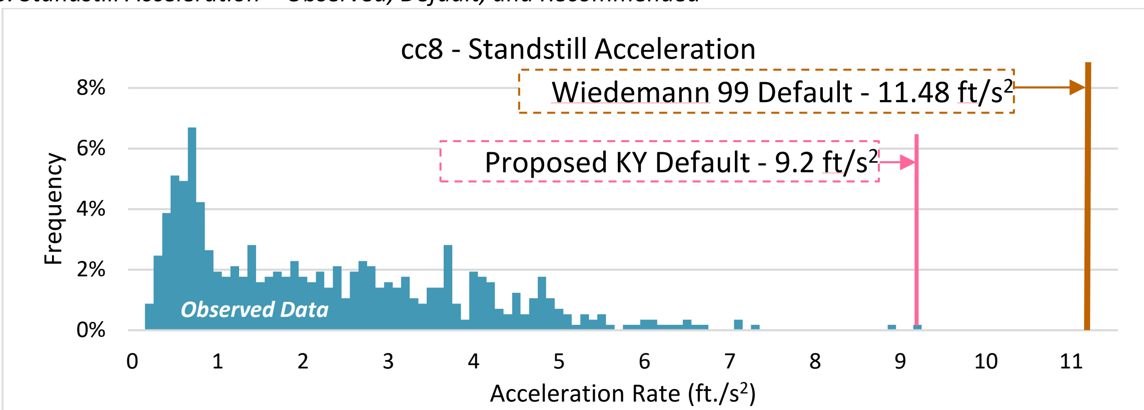


Figure 19: Acceleration from 50mph – Observed, Default, and Recommended

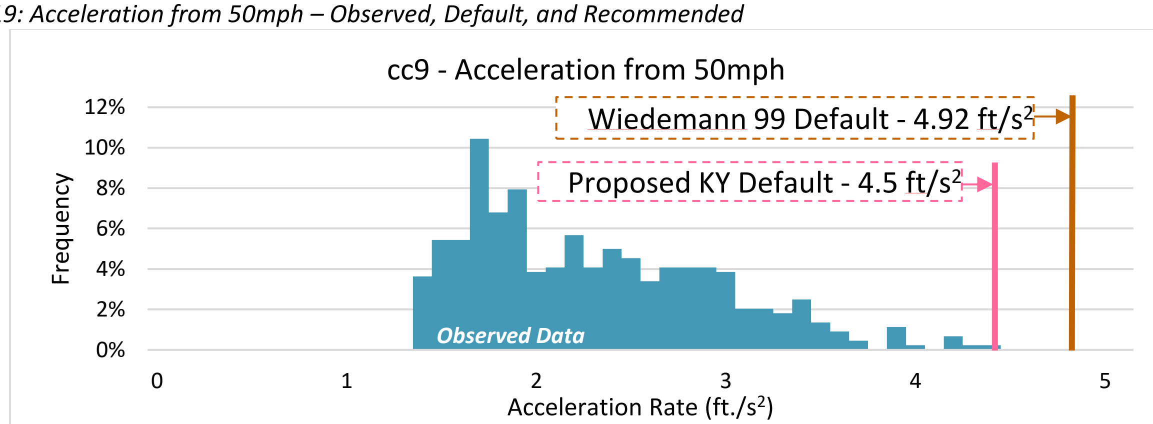


Table 21: Wiedemann 99 Default and Recommended Acceleration Parameters (cc8 and cc9)

	Default Values	Recommended Values
Acceleration from Standstill (cc8)	11.98 ft./s^2	**9.2 ft./s^2**
Acceleration from 50mph (cc9)	4.92 ft./s^2	**4.5 ft./s^2**

The TransModeler normal acceleration behavior is based on the application of the normal acceleration distribution against the vehicular attribute acceleration profile (minimum, maximum, desired) based on vehicle mass-to-power and speed. The observed acceleration data as compared with the desired acceleration profiles in TransModeler indicates that the maximum observed accelerations are more conservative than the default distributions. To account for this, it was recommended by the TransModeler team at Caliper to make modifications to the normal acceleration distributions. Based on this and the observed data, it is recommended that the default normal acceleration distribution be modified for Kentucky microsimulation as shown in **Table 22**.

Table 22: TransModeler Normal Acceleration Default and Recommended Values

Default Values				Recommended Values		
% of Vehicles	Alpha	Beta		% of Vehicles	Alpha	Beta
20%	0	1.1		10%	0	1.1
60%	0	1		30%	0	1
20%	0	0.95		20%	0	0.9
				20%	0	0.88
				20%	0	0.75

5.6.5 Deceleration Rates

The results of the analysis indicate that the observed decelerations are similar to the software defaults. This resulted in the validation of the TransModeler default values for use in Kentucky microsimulation. **Table 23** shows the default values for TransModeler. **Figure 20** shows the comparison of the normal deceleration with the 50th and 75th percentile observed deceleration curves.

Figure 20: Observed Deceleration Percentile Compared with TransModeler Normal Deceleration Default Profile

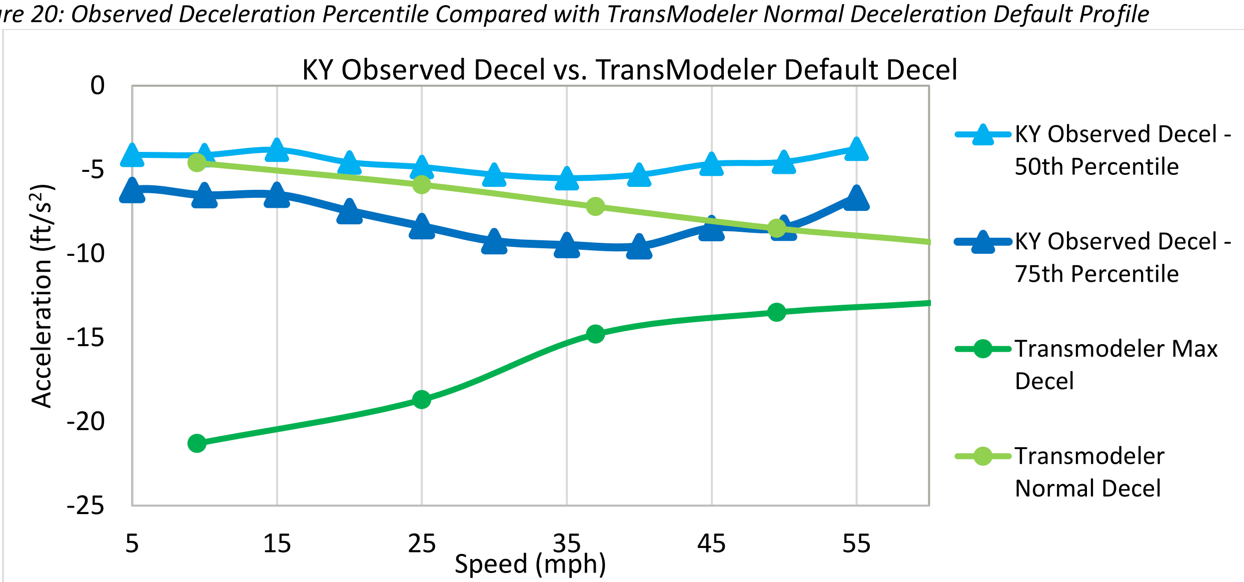


Table 23: TransModeler Default Deceleration Rates (Normal and Maximum)

TransModeler Default Normal and Maximum Deceleration						
Travel Speed (mph)			**Max Deceleration**		**Normal Deceleration**	
Lower Bound	Upper Bound	*Speed Midpoint*	Passenger Car	Heavy Vehicle	Passenger Car	Heavy Vehicle
0	19	*9.5*	-21.3	-21.3	-4.6	-4.6
19	31	*25*	-18.7	-18.7	-5.9	-5.9
31	43	*37*	-14.8	-14.8	-7.2	-7.2
43	56	*49.5*	-13.5	-13.5	-8.5	-8.5
56	68	*62*	-12.8	-12.8	-9.5	-9.5
68	80	*74*	-11.5	-11.5	-11.2	-11.2

All deceleration values are in ft/s²

5.6.6 Lane Change Distance

In TransModeler, the lane change distance is expressed as a distribution based on roadway type varying from 800-1,500 feet for streets, and 1,000-4,000 feet for freeways. Based on the observed data it is recommended for

Kentucky microsimulation modeling that the TransModeler default values be used as a starting point for lane changing. **Table 24** shows the default recommended lane change distances from TransModeler.

Table 24: Software Default and Recommended Lane Change Distances

Percentage of Drivers	Recommended Values: TransModeler Defaults	
	Streets	Freeways
2%	800’	1000’
6%	850’	1100’
10%	900’	1200’
14%	950’	1300’
18%	1000’	1500’
16%	1050’	1750’
10%	1100’	2000’
8%	1150’	2250’
5%	1200’	2500’
3%	1250’	2750’
2%	1300’	3000’
2%	1350’	3250’
2%	1400’	3500’
1%	1450’	3750’
1%	1500’	4000’

It should be noted that these values are recommended, and local data and field observations should be used to modify the Kentucky recommended defaults to values that best reflect the project area.

5.6.7 Vehicle Speed Ranges

TransModeler’s default speed profiles are centered around the posted/ objective speed, providing some variability in distribution of speeds above and below those speeds. However, the default distributions do not capture the full range of expected speeds and some distributions are not representative of observed driving speeds in Kentucky. The results of the historic speed analysis resulted in a series of speed distributions based on speed limit, context, and roadway type. TransModeler’s desired speed profiles are expressed as a distribution function of speed deviations from the posted speed limit and not as absolute values. **Table 25** shows the recommended speed distributions for common speed limits in Kentucky for TransModeler.

Table 25: Recommended Vehicle Speed Profiles - TransModeler

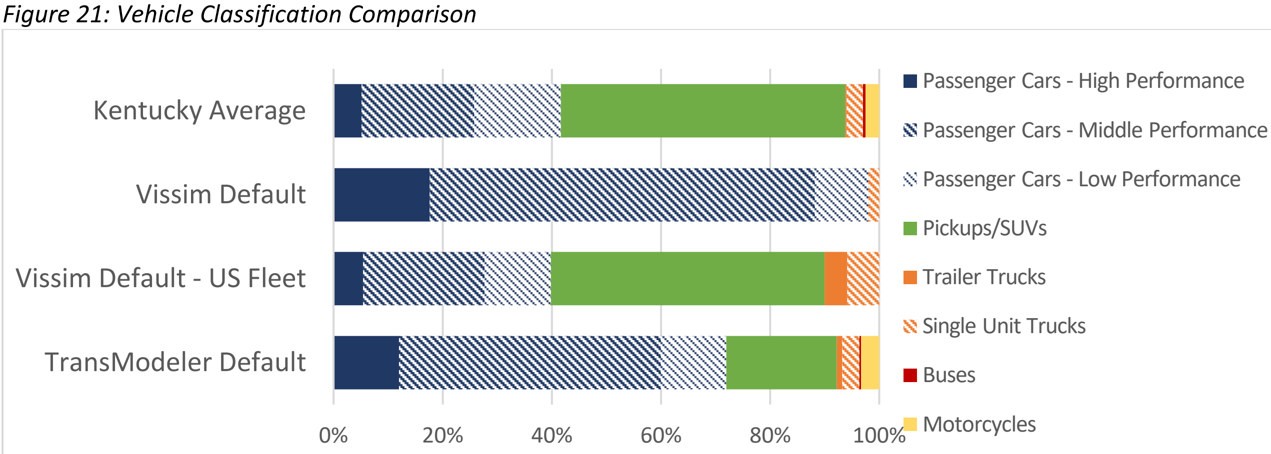
Kentucky Recommended Speed Profiles – Deviations from Speed Limit (TransModeler)*											
Speed Limit | Road Type		Percent of Drivers									
		10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
25mph | Arterial	Urban	-3.7	-2.3	-0.8	0.6	1.8	3.3	4.8	6.2	8.4	13.7
	Rural	-1.7	-0.2	1.5	2.9	4.3	5.9	7.5	9.0	11.5	17.2
35mph | Arterial	Urban	-9.5	-7.5	-5.8	-4.3	-2.8	-1.5	0.0	1.9	5.9	12.0
	Rural	-0.8	0.7	1.7	3.0	5.0	6.7	8.0	9.4	12.6	17.2
40mph | Arterial	Urban	-11.6	-9.2	-7.8	-6.4	-4.8	-2.9	-0.4	2.5	6.0	10.1
	Rural	-9.0	-6.4	-4.9	-3.4	-1.7	0.4	3.2	6.4	10.2	14.6
45mph | Arterial	Urban	-10.1	-7.1	-4.9	-3.3	-1.8	-0.5	1.1	3.3	6.3	10.2
	Rural	-3.5	-2.3	-0.8	0.8	2.0	3.1	4.1	5.1	7.4	12.5
55mph | Arterial	Urban	-11.6	-9.5	-7.3	-5.4	-3.4	-1.3	0.2	2.1	5.1	9.1
	Rural	-4.6	-3.3	-1.8	-0.5	0.5	1.6	2.9	4.3	7.1	10.9
65mph | Arterial	Urban	-8.9	-7.3	-5.9	-4.3	-2.7	-1.5	-0.6	-0.1	0.6	1.9
	Rural	-4.8	-3.1	-1.6	0.2	1.9	3.2	4.2	4.7	5.5	6.9
55mph | Freeway	Urban	-7.1	-0.1	2.1	3.8	5.2	6.5	8.0	9.7	12.2	17.7
	Rural	-6.2	1.0	3.3	5.0	6.3	7.7	9.3	11.0	13.5	19.1
65mph | Freeway	Urban	-11.7	-4.5	-2.1	-0.5	1.0	2.4	3.8	5.6	8.1	12.1
	Rural	-11.2	-3.8	-1.5	0.2	1.7	3.1	4.6	6.3	8.8	12.9
70mph | Freeway	Urban	-11.8	-6.5	-4.8	-3.3	-2.2	-1.2	-0.2	1.2	3.1	7.4
	Rural	-13.3	-7.2	-5.3	-3.8	-2.5	-1.3	0.0	1.5	3.5	7.6

**Speed values in table are representative deviations in speed from the posted speed in mph. These do not represent speed values.*

5.6.8 Vehicle Classification

The default vehicle fleet in TransModeler appears to be representative of a typical vehicle mix which could be observed throughout the United States. The main difference between the TransModeler default fleet and the Kentucky VIN data fleet is the makeup of pickups/SUVs and middle performance passenger cars. **Figure 21** shows a comparison of the KY VIN data with the software defaults for vehicle classification.

Figure 21: Vehicle Classification Comparison



The KY VIN data analysis resulted in a vehicle mix distribution that is representative of typical conditions throughout the state. From this distribution, a recommended vehicle composition as well as a range (providing variance in each direction) were developed. In microsimulation, vehicle composition is often categorized by separating passenger cars and heavy vehicles and applying distributions to them separately. They can be grouped into one distribution, but they are commonly separated. To accommodate this, the recommended values and ranges were developed for both methods. To assist in the process of establishing vehicle compositions for microsimulation, an interactive spreadsheet tool was developed. This tool factors the KY VIN data analysis results along with aggregated heavy vehicle percentage results for various roadway types and provides a vehicle fleet mix based on three user input criteria. The modeler can input the breakdown between passenger cars and heavy vehicles as well as the roadway type to generate a vehicle fleet mix which can be input directly into the microsimulation software. The results for an example roadway fleet mix are shown in **Table 26.** The interactive spreadsheet for editing vehicle composition can be found in the KYTC Microsimulation Parameters Quick Reference Spreadsheet which is available on the KYTC Microsimulation website and by using the link below.

KYTC Microsimulation Parameters Quick Reference Spreadsheet

Table 26: Sample Recommended Vehicle Composition – TransModeler

Sample Vehicle Composition Output			
		INPUT↓	
	Passenger Cars	90%	**User Defined Attributes**
	Heavy Vehicles	10%	
	Project Area Roadway Type*	Interstate	
TransModeler			
Initial %	**Description**	**Revised %**	
Passenger Cars			**Customized Vehicle Composition Results**
0.5%	Buses	0.5%	
0.0%	*Motorcycles*	0.0%	
5.5%	Passenger Cars - High Performance	4.9%	
21.9%	Passenger Cars - Middle Performance	19.7%	
16.8%	Passenger Cars - Low Performance	15.2%	
55.3%	Pickups/SUVs	49.8%	
Heavy Vehicles			
92.7%	Single Unit Trucks	2.8%	
7.3%	Trailer Trucks	7.2%	

**Project Area Roadway Type impacts the heavy vehicle breakdown based on the below lookup table.*

Roadway Type	*SU Trucks*	*Trailer Trucks*
KY Route	*62%*	*38%*
US Hwy	*59%*	*41%*
Interstate	*28%*	*72%*

While this study has developed recommended ranges for default microsimulation vehicle compositions, it should be noted that vehicle composition can vary significantly depending on specific project location, context, and functional attributes. Therefore, local project specific vehicle classification data should be used to modify the recommended Kentucky default values to match the local project area.

5.6.9 Truck Weight-to-Power Ratio

Data from previously conducted research documents was utilized to examine the vehicle mix and reported weight-to-power ratios of vehicles. No Kentucky specific data was available pertaining to vehicle power or truck power; therefore, national research was utilized to provide insight on this parameter. One study for I-81 examined weigh station data to determine the weights, power, and distribution of trucks. NCHRP 505 report summarizes percentile data for weight-to-power ratios in 3 states (California, Colorado, and Pennsylvania). These were used as reference points for the development of proposed weight-to-power distributions.

The weight-to-power ratios within TransModeler are based primarily on the same research used in this analysis and therefore are proposed to remain unchanged for use in Kentucky microsimulation models.

5.7 Parameter Results Quick Reference Spreadsheet

To provide a more streamlined and user-friendly version of the KY recommended default parameters an interactive summary excel spreadsheet was developed documenting the recommended values for each parameter for each software package. The spreadsheet provided an overview of each analyzed parameter noting which have recommended values which differ from the software defaults. For each parameter with a recommended value or range, a separate worksheet shows the default and recommended value and provides some supporting data from the parameter analysis. The vehicle composition worksheet provided an interactive table to help develop custom vehicle fleet compositions for specified truck percentages and roadway types. A link to the Kentucky Microsimulation Parameter Quick Reference is provided below, it can also be found on the KYTC Microsimulation website, and a printed version is included as **Appendix D**. The spreadsheet is also provided in the seed file packages for each software.

KYTC Microsimulation Parameters Quick Reference Spreadsheet

5.8 Kentucky Default Parameter Seed Files

To assist in the adoption and application of the default parameter values (or ranges) for Kentucky microsimulation modeling, seed files containing the parameter values have been developed for Vissim and TransModeler. It is recommended that these files be used as template files for starting new modeling projects as they have the Kentucky data preloaded. However, in both software packages it is also possible to manually edit or import the values into existing files. Links to the seed files are provided below.

Vissim KY Default Seed File

TransModeler KY Default Seed File

5.9 Pilot Projects

As part of the parameter analysis process, pilot projects for Vissim and TransModeler were conducted using the recommended parameter values. The purpose of the pilot projects was to test the proposed ranges and provide insight, feedback, and/or verification regarding their performance. The pilot projects were based on previously developed microsimulation models in Kentucky. Using the existing models and the calibration targets, the Kentucky parameters were applied to overwrite those values in the calibrated models to see how the models performed and whether the parameters would have assisted in the calibration effort. The results indicated that the new values would likely have been useful for both accelerating and improving the calibration efforts.

6 Alternatives Analysis

6.1 Future Model Development

After finishing the baseline model development, calibration, and validation, future models can be developed to examine the impacts of proposed changes throughout the project area. All future models should maintain the changes made during calibration. While geometry, volumes, traffic control, and other elements of the model may be impacted because of the future conditions, the calibration changes should remain consistent. The calibration changes are what makes the model representative of local conditions. Therefore, applying the same model settings to all future models will allow those models to accurately reflect local conditions as well.

6.1.1 No Build Models

Traffic analysis projects typically seek to examine short-term and/or long-term horizon year scenarios. The analysis years are typically established during project scoping. To properly analyze the impact of proposed improvement concepts, it is important to also provide comparison No-Build models for each analysis year. No-Build models should reflect the future conditions in the project area without the potential improvement project being studied. The future No-Build scenarios usually include traffic growth (possibly to the same degree as the Build scenarios) but may also include geometric and traffic control changes based on other already planned and funded projects in the area. These background projects should be defined during project scoping.

6.1.2 Alternative Model Development

Development of models to examine potential build alternatives or concepts should be done using the same methodology as the No-Build model development. A crucial aspect is the maintaining of the parameter and network changes made for existing model calibration. These changes should be incorporated into all future alternative concept models to ensure the local conditions are replicated as accurately as possible. Since the roadway network geometry and/or traffic volumes are likely to change from the existing or No-Build conditions, it is important to maintain or incorporate as much of the calibrated model attributes into the revised network as possible. Special attention should be given to physical changes such as new highway segments, weaves, ramps, intersections, etc. For these new elements it will be necessary to adjust the model coding to match the parameters developed during calibration. It is also important to consider other model coding aspects such as the locations of MOE data collection points, node layout, link numbering/naming, etc. Giving substantial attention to making sure the Build and No-Build models are based on the same or very similar input parameters and model coding methods is essential to producing a solid analysis that facilitates and “apples-to-apples” comparison of the No-Build and various Build scenarios.

It is important to maintain or incorporate as much of the model attributes into the revised network as possible.

7 Results and Documentation

The results and documentation stage is one of the final steps in the microsimulation traffic analysis process. It is important to understand the results of the modeling effort and how they can be conveyed to make assessments about existing and future conditions for the various scenarios.

7.1 Measures of Effectiveness

Model results used to evaluate the performance of a particular scenario or design concept are referred to as measures of effectiveness (MOEs). Common MOEs which can be drawn from microsimulation models and are typically applicable for Kentucky modeling scenarios include:

1) Volume
2) Speed
3) Travel Time
4) Queue Length
5) Level of Service (LOS)
    a) Density (Freeway)
    b) Delay (Arterial)

Modelers should select MOEs in coordination with KYTC and other agencies as appropriate for each project. Initial MOE selection is often done during the scoping phase of a project. For example, certain MOEs may be selected during scoping because they are important for achieving the goals of the overall project. The selection of MOEs early on is beneficial because it will allow for the field data collection of information related to those MOEs. This data can then be used for model calibration and/or validation. It is also common for additional MOEs to be considered during latter phases of a project when more information about the facility performance is known. These late addition MOEs often help clarify project needs or the benefits of a proposed concept. Model outputs used for MOEs should be developed through averaging from all simulation runs to prevent the use of outlier data for decision-making.

Model outputs used for MOEs should be developed through averaging from all simulation runs to prevent the use of outlier data for decision-making.

The five example MOEs listed above are discussed next, with their applications and limitations.

7.1.1 Volume

Volume is a major factor in nearly any traffic analysis project, and it is a common MOEs used for microsimulation. The volume output data provides an indication of a model's ability to serve observed or predicted volumes at specific locations. It can also be used to examine how much traffic can get into a model and how much can be processed through a model (throughput). In addition, the percent of demand that can be processed is often reported. This provides useful information for capacity constrained areas or models. It is important when using volume as an MOE to establish the time period and granularity of the data to be examined. Typically, hourly volume metrics are appropriate, but depending on the length of analysis multiple hours of volume reporting may be necessary and in select cases 15-minute volumes may be required.

7.1.2 Speed

Speed is another common MOE for microsimulation. Depending on the context and goals of the model, the speed output information may vary. The typical application of speed reporting is to include all of the segments throughout a model and report average speeds for the analysis period in either hourly, 15-minute, or 5-minute intervals. A more detailed application is the reporting of speeds by segment or even by lane at key interaction areas within a model (typically merge and weave areas). Speeds by lane can be used to examine speed differentials and provide possible indications of safety issues and lane level congestion.

7.1.3 Travel Time

Travel times in the model should be measured between logical points in the project area (between intersections, from one interchange to another along a freeway, etc.). The travel time segments should not overlap, but they should be contiguous, so that they can be summed together to provide travel times for a corridor. This method provides disaggregated data, so that parts of the system can be evaluated and compared, along with higher level corridor or system metrics. It is important to note that for most models only a portion of the traffic will traverse the entire project area, so the segment level data is very important. (The speed and travel time output data is directly related. The same segments and corridors can be used for both MOEs, which facilitates cross-checking the reported results.) Often, average travel times for the entire analysis period are sufficient, but sometimes smaller time periods are useful. The analysis intervals should be established with KYTC.

7.1.4 Queue Length

Depending on the goals of the project, this measure may provide important information about bottleneck locations within a model. If this MOE is selected, queue lengths should be reported at any location which experiences queuing to not overlook any areas. Typically reporting the maximum queue is sufficient but depending on the situation it may also be beneficial to report percentile-based queuing (50^{th}, 85^{th}, etc.) to illustrate the severity or duration of the events.

7.1.5 Level of Service (LOS)

LOS is a qualitative letter rating (A through F) which is commonly used to report the performance of a roadway segment or intersection based on the way HCM6 defines LOS for each facility type (often delay or density). In general, LOS A is associated with free-flow conditions and little or no delay, while LOS F indicates over capacity conditions with substantial congestion, delay, and queuing. LOS B through E indicate increasing levels of congestion, with the LOS E/F boundary serving as the capacity threshold.

While LOS is a commonly used performance metric for traffic operations, it is limited in its ability to accurately convey some important aspects of how intersections, segments, or models operate. Due to the operational complexity of many projects that require simulation modeling, LOS is often not the most applicable or accurate way to represent the results. In fact, the reason for using microsimulation is often because more detailed metrics are needed to properly assess and compare various alternatives. Based on its limitations, it is recommended that LOS not be the primary MOE for model performance.

While there are limitations with LOS, using it along with the delay or density can help provide a high level, easy to grasp, overview of how segments or intersections are performing. When used, LOS should be reported for all important segments and intersections for a model network. To determine the LOS from a microsimulation model, additional (sometimes complex) post-processing is required using the delay and density outputs. HCM6 has specific criteria defining LOS for freeways (basic, merge, diverge, weave) and arterials (segments and intersections). The LOS results should be cross-checked with other model outputs to confirm accuracy and validity. Critical considerations for defining LOS using simulation outputs include segment length, time duration, and units of measurement (passenger cars vs. vehicles). It is also important to consider the interrelationship between intersections and adjacent segments or intersections to make sure that delay is attributed to the correct location and traffic control. LOS calculation methodology should be explained alongside the results reporting.

7.2 Considerations for Alternatives Comparison

A key aspect to the microsimulation process is the development, evaluation, and comparison of various alternative concepts with one another as well as with the No-Build conditions. This evaluation between concepts can provide critical information to the decision-making process for a project. When conducting this evaluation, it is important for the metrics used to be equivalent and objectively based. The metrics should be pulled from comparable models (similar inputs and criteria) for the same analysis time periods and segmentation. If the two concepts are substantially different and therefore difficult to compare, this should be explained. For these situations it may be necessary to compare roll-up metrics such as delay or total queued vehicles for a corridor or even system level output metrics.

7.3 Microsimulation Summary Report

The analyst should prepare a summary report documenting the microsimulation analysis scope, methodology, results, and conclusions. The document should also explain how the analysis results relate to the overall planning or design project as applicable. The report should be as detailed as required to convey the information necessary to understand and replicate the analysis. To keep the report concise, appendices or electronic files should be used to communicate key details.

The guidelines provide a basic outline that can be used for the document. However, each project is unique, and it is understood that changes to this format may be needed. Even when changes are made, it is likely that most of the elements of the outline will be addressed in the report in some manner. Here are the basic elements to be included within the document:

1) Introduction and Context
   a) Project Goals
      i) Overall project goals (planning study or design project associated with microsimulation effort)
      ii) Microsimulation or traffic analysis specific goals
   b) Analysis Scope
   c) Data Collection Summary
2) Existing Model Development
   a) Methodology and Assumptions
   b) Model Calibration Summary
   c) Existing Condition Results
3) Future Model Development
   a) No-Build Conditions Summary
   b) Alternative Concepts Summary
   c) Comparison of Results
4) Findings and Conclusions
5) Digital Appendix holding the applicable model files and supporting data

8 Reviewing Checklists

To assist modelers, reviewers, and project team members in the model development and review processes, checklists for project scoping and model calibration have been developed. These checklists are intended to serve as supplementary tools to aide in the documentation, tracking, and discussion of scoping and calibration. Each checklist provides areas for modeler or reviewer input at various stages of the process. These checklists can help facilitate discussion with KYTC planning staff or other project team members. The checklists are provided as aides in the development, calibration, and review process but they do not replace the modeling team's responsibility to thoroughly detail check and review all models. Similar to other traffic analysis work, the checking and reviewing process at a minimum should examine all inputs and outputs and confirm the final results are reasonable and accurate.

The scoping checklist can be found in **Appendix E**. The calibration checklist can be found in **Appendix F**.

Both checklists are also hosted online as stand-alone documents and can be downloaded online at the following location.

KY Microsimulation Checklists (Scoping, Model Development, & Model Review)

9 Sources

This guidance document was developed based in part on information presented in previously developed microsimulation and traffic analysis guidance documents as well as other research materials. Several of these documents are referenced directly throughout the guidance, but information and concepts which are not explicitly referenced may have been drawn from these materials. The source documents used in the development of this document include:

- Colorado Department of Transportation (July 2018) – Traffic Analysis and Forecasting Guidelines
  https://www.codot.gov/library/traffic/traffic-manuals-guidelines/traffic_analysis_forecasting_guidelines/traffic_analysis_forecasting_guidelines
- Florida Department of Transportation (March 2014) – Traffic Analysis Handbook
  https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/planning/systems/systems-management/sm-old-files/traffic-analysis/traffic-analysis-handbook_march-2014.pdf?sfvrsn=51c88e22_0
- Iowa Department of Transportation (October 2017) – Microsimulation Guidance
  https://iowadot.gov/ijr/docs/MicrosimulationGuidance.pdf
- Maryland Department of Transportation (August 2017) – Vissim Modeling Guidance
  https://www.roads.maryland.gov/OPPEN/MDOT%20SHA%20TFAD%20VISSIM%20Modeling%20Guidance%2011-21-2016.pdf
- Ohio Department of Transportation (July 2020) – ODOT Analysis and Traffic Simulation Manual (OATS)
  https://www.transportation.ohio.gov/wps/wcm/connect/gov/4a5217b4-d590-41c0-923f-af08b93b26db/OATS+Manual+6-11-2020.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE.Z18_M1HGGIK0N0JO00QO9DDDDM3000-4a5217b4-d590-41c0-923f-af08b93b26db-nnnrydM
- Oregon Department of Transportation (June 2011) – Protocol for Vissim Simulation
  https://www.oregon.gov/ODOT/Planning/Documents/APMv2_Add15A.pdf
- Virginia Department of Transportation (November 2015) – Traffic Operations and Safety Analysis Manual
  Traffic Operations and Safety Analysis Manual (studylib.net)
- Washington Department of Transportation (September 2014) – Protocol for Vissim Simulation
  https://wsdot.wa.gov/sites/default/files/2010/05/10/VISSIM-Protocol.pdf
- Wisconsin Department of Transportation (January 2018) – Traffic Engineering, Operations, and Safety Manual
  Wisconsin Department of Transportation TEOpS Chapter 16 (wisconsindot.gov)
- Federal Highway Administration (FHWA) (August 2019) – Traffic Analysis Toolbox Volume III
  https://ops.fhwa.dot.gov/publications/fhwahop18036/fhwahop18036.pdf
- NCHRP 505 – Review of Truck Characteristics as Factors in Roadway Design
  https://nacto.org/docs/usdg/nchrprpt505_harwood.pdf
- NCHRP 765 – Analytical Travel Forecasting Approaches for Project-Level Planning and Design
  https://www.princeton.edu/~alaink/Orf467F14/AnalyticalTravelForecastingNCHRP765_091314.pdf
- Transportation Research Board (October 2016) – Highway Capacity Manual 6th Edition
  http://www.trb.org/Main/Blurbs/175169.aspx

10 Appendices

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Appendix A:
Calibration Target Comparison Chart

Appendix A: Calibration Comparison Table

Kentucky Microsimulation Guidance - Recommended Calibration Targets

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 15%, for 700 veh/h < Flow < 2,700 veh/h Within 100 veh/h, for Flow <700 veh/h Within 400 veh/h, for Flow >2,700 veh/h[1]	>85% of cases
	Sum of all Link Flows	Within 5% of sum of all link counts
	GEH Statistic < 5 for Individual Link Flows	>85% of cases
	GEH Statistic for Sum of All Link Flows	GEH <5 for sum of all link counts
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within 10% (or 10 mph, if higher)[2]	>85% of cases
Queues	(Qualitative) Queues in observed conditions	Observation of similar conditions within model (presence, magnitude, and duration)
	(Quantitative) Collected queue length data	Model queues within 20% of observed queue lengths
Visual Attributes	Matching Field Observed Conditions (Qualitative)	Reasonable replication of field observed conditions. Documentation/ photos preferable.

[1] For conditions with significantly higher volumes this metric may not be achievable.
[2] For oversaturated flow conditions that extend over several time periods, it may be difficult to achieve this speed calibration metric.

Colorado DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 15%, for 700 veh/h < Flow < 2,700 veh/h Within 100 veh/h, for Flow <700 veh/h Within 400 veh/h, for Flow >2,700 veh/h[1]	>85% of cases
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within ± 10 miles per hour (mph) of average observed speeds	>85% of cases
Queues	(Quantitative) Observed maximum queue length (ft) within: • ± 20% on arterials • (± 30% for movements ≤10 vph) • ± 35% on freeways	85% of Network Links, or additional critical links

Iowa DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 15%, for 700 veh/h < Flow < 2,700 veh/h Within 100 veh/h, for Flow <700 veh/h Within 400 veh/h, for Flow >2,700 veh/h[1]	>85% of cases
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within ± 10 mph of field data	>85% of cases
Queues	Queues formed in free flow areas Within 20% of field measured queue length	All Locations
Congestion	Duration of Congestion	Within 15 minutes from beginning and end of congestion

Mayland DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	10% of Count Traffic Volume and/or GEH<5	
Travel Time/ Speed	± 10% travel time or speed variation for small segments ± 5% travel time or speed variation for entire corridor	

Oregon DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 400 veh/h, for Flow >2,700 veh/h[1]	>85% of cases
	Sum of all Link Flows	Within 5% of sum of all link counts
	GEH Statistic < 5 for Individual Link Flows	>85% of freeway links within calibration area
	GEH Statistic < 5	All entry and exit locations within calibration area
	GEH Statistic < 5	All entrance and exit ramps within calibration area
	GEH Statistic < 5	All intersection turn movements greater than 100 vph
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within 10% (or 10 mph, if higher)[2]	>85% of cases
Queues	(Qualitative) Queues in observed conditions	Observation of similar conditions within model (presence, magnitude, and duration)
Visual Attributes	Matching Field Observed Conditions (Qualitative)	Reasonable replication of field observed conditions. Documentation/ photos preferable.

Washington DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Sum of all Link Flows	Within 5% of sum of all link counts
	GEH Statistic < 3	>85% of state facility segments within calibration area
	GEH Statistic < 3	All entry and exit locations within calibration area
	GEH Statistic < 3	All entrance and exit ramps within calibration area
	GEH Statistic < 5	>85% of applicable local roadway segments
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within 3 mph of observed real-world spot speed data	All freeway links where real-world data is available
	Within 10% of base free flow spot speed	Local roadways where observed real-world data is available
Queues	(Qualitative) Queues in observed conditions	Observation of similar conditions within model (presence, magnitude, and duration)
Visual Attributes	Matching Field Observed Conditions (Qualitative)	Reasonable replication of field observed conditions. Documentation/ photos preferable.

Appendix A: Calibration Comparison Table

Wisconsin DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Tier 1: RMSPE < 5.0% Tier 2: RNSE <3.0% for >85% of links	All Links > 100 vph (Mainline and Critical Arterials)
	Tier 1: Not Applicable Tier 2: RNSE <3.0% for >75% of links	All Turns
Travel Time	Tier 1: RMSPE < 10.0% Tier 2: Within ± 15% for >85% of routes	All Routes > 1.5 miles
Speed	Tier 1: RMSPE < 10.0% Tier 2: Within ± (Mainline Posted Speed x 20%) for >85% of locations	All Segments or Spot-Speed Locations
Queues	Tier 1: Not Applicable Tier 2: ± 150 feet for queues 300 to 750 feet long, Within ± 20% for queues > 750 feet long	All Critical Queue Locations
Lane Use	Tier 1: Not Applicable Tier 2: RNSE < 3.0% for > 85% of locations consistent with field conditions	All Critical Lane Utilization Locations

Florida DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 15%, for 700 veh/h < Flow < 2,700 veh/h Within 100 veh/h, for Flow <700 veh/h Within 400 veh/h, for Flow >2,700 veh/h[1]	>85% of cases
	Sum of all Link Flows	Within 5% of sum of all link counts
	GEH Statistic < 5 for Individual Link Flows	>85% of cases
	GEH Statistic for Sum of All Link Flows	GEH <5 for sum of all link counts
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Speed	Within 10 mph of field measured speeds	>85% of all network links
Queues	(Qualitative) Queues in observed conditions	Observation of similar conditions within model (presence, magnitude, and duration)
	(Quantitative) Collected queue length data	Model queues within 20% of observed queue lengths
Visual Attributes	Matching Field Observed Conditions (Qualitative)	Reasonable replication of field observed conditions. Documentation/ photos preferable.
Delay	Simulated and field delay times be within 15%	> 85% of cases

Virginia DOT

Calibration Metric	Calibration Measure	Calibration Target
Volume	Individual Link Flows: Within 20% for < 100 vph Within 15% for > 100 vph to < 300 vph Within 10% for > 300 vph to < 1,000 vph Within 5% for > 1,000 vph	>85% of cases, or a select number of critical links and/or movements
Travel Time	Within ± 30% for average observed travel times on arterials Within ± 20% for average observed travel times on freeways	>85% of the travel time routes, or a select number of critical routes
Speed	Within ± 5 mph of average observed speeds on arterials Within ± 7 mph of average observed speeds on freeways	>85% of network links, or a select number of critical links and/or movements
Queues	Undersaturated Conditions *Average queue length on arterials:* Within ± 30% for movements ≤ 10 vph Within ± 20% for movements > 10 vph *Maximum queue length on arterials:* Within ± 25%	Observation of similar conditions within model (presence, magnitude, and duration)
	Oversaturated Conditions *Average queue length:* Within ± 20% on arterials Within ± 30% on freeways *Maximum queue length:* Within ± 20% on arterials Within ± 35% on freeways	Top 85% of network links, or a select number of critical links and/or movements

Matches the Kentucky Proposed Calibration Targets

Appendix B:
Parameter Analysis Supplement

Parameter Analysis Methods

The below table outlines the methods of analysis and how they were applicable to each of the selected parameters.

Trajectory Analysis	Speed Data Analysis	VIN Data Analysis	Research Based Analysis
Time Headway	Vehicle Speed Ranges	Vehicle Fleet Compositions	Truck Weight-to-Power
Minimum Headway			
Acceleration			
Deceleration			
Standstill Distance			
Lane Change Distance			

Trajectory Analysis

Trajectory data continuously tracks the movement of vehicles along their route from start to finish. This data typically contains detailed information regarding a vehicle's speed, acceleration, deceleration, and position relative to other vehicles. This type of detailed information allows for in-depth analysis of the driving behavior parameters and vehicle characteristics that are the focus of this study.

Trajectory data has historically been difficult to collect due to the lack of technology available to monitor the spatial interactions of multiple cars within an area or roadway segment. For this analysis a newly developed method of trajectory data collection was utilized. This method included the collection of traffic video data via drones and the Data from Sky (DFS) analysis platform. The collected video data was uploaded to DFS and their machine learning algorithm is able to identify and track vehicles as they traverse through the video frame. This tracking data can then be geo-referenced to obtain location, speed, acceleration, deceleration, routing, and movement data for each vehicle.

The resulting trajectory files were then analyzed using the Data from Sky Viewer application. This is a proprietary app developed by DFS to analyze their trajectory data files. Within the software the trajectory points were geo-referenced to obtain real-world locations, speeds, and accelerations for each vehicle. The software provides a suite of analysis tools, views, and export options for the trajectory data.

This allowed for trajectory data to be obtained on-demand throughout Kentucky and provided a set of data to analyze six of the key parameters.

Speed Data Analysis

Speed data provides detailed granular level observed speed and historically averaged speed information along roadway segments rolled up into specified time stratifications (commonly 1-minute, 5-minute, 15-minute, or hourly intervals). KYTC provided historical HERE data for 43 roadway segments across the state. These segments varied in location, context, facility type, and posted speed limit providing a significant sample set of data to represent conditions throughout the state.

VIN Data Analysis

Vehicle Identification Number (VIN) data is catalogued and accessible for the entire state of Kentucky to examine the magnitude and proportion of registered vehicles by type across the state. This data will help to better understand the general distribution of vehicles to create a vehicle fleet mix that will be representative of the state. The VIN data is categorized by county, and thus more localized analysis can be conducted if required.

Research Based Analysis

The only parameter which is not able to be analyzed through the collection or obtaining of localized Kentucky data is the necessary data for Truck Weight-to-Power ratio. This analysis is more based on the capabilities of vehicles and driver behaviors throughout the U.S. and has little bearing on the local conditions compared with the other parameters. Heavy vehicle operations are not as localized as passenger car trips and the behaviors are less unique from that regard. Additionally, there is limited data that can be collected for this investigation. Therefore, a more research-based approach was utilized for this parameter.

Parameter Analysis

Time Headway

Data and Analysis

Time headway was evaluated using trajectory data collected along interstates throughout Kentucky. There were eight locations of video data collected, primarily centering around urban areas in (Northern Kentucky, Lexington, Louisville, and Paducah). Urban locations were necessary for the data collection as the headway value is meant to capture the desired headway in car-following regimes which is typically only achieved when there is enough congestion to instill car-following and platooning. Data collection was performed on the edges of the peak periods to capture some congestion and obtain more samples that were in a more typical car-following pattern.

The DFS platform was used to process and analyze the drone video data for time headway. The headway analysis consisted of preparing sets of gates across the travel lanes. This provided timestamp data for each vehicle as they traversed a known location. From this, headways between subsequent vehicles could be calculated based on the vehicle speeds, vehicle types, and timestamps of each vehicle.

The data provided a large sample of headway data between vehicles which was refined to account for the headways of assumed car-following patterns. The criteria to refine the data included:

- Headway values less than 3.0 seconds
- Platooning of multiple vehicles
- Successive vehicles traveling within the same lane

This helped to narrow the total samples into a more manageable, yet robust dataset. The criteria were established based on typical car-following assumptions. The final sample size for analysis resulted in over 2,000 applicable observed headway values.

The applicable data samples were then summarized in a series of distributions to compare against the software default values.

Results

Wiedemann 99 (W99)

For Wiedemann 99 (Vissim's uninterrupted flow car-following model), the cc1 parameter is the applicable time headway field. It should be noted that in W99 the cc1 parameter is expressed as gap as opposed to time headway, so all of the headway calculations were converted to gap by subtracting the vehicle length from the calculation. The cumulative distribution of observed values was then compared against the software default value of 0.9 seconds. This resulting comparison indicated that the observed data was similar to the default value but provided more variability. From this comparison a recommended range of cc1 values between 0.7 seconds to 1.6 seconds was recommended. Additionally, a distribution of this range corresponding to the frequency of observations was derived for use in modeling as well.

Modified General Motors (MGM)

The Modified General Motors car-following behavior is the default driving behavior in TransModeler. Based on discussions with the Caliper-TransModeler team, it was recommended that the Alpha+ parameter be modified to capture the impacts on time headway. There are several other parameters within the MGM car-following model, but to prevent additional modifications to the driving behaviors beyond time headway these were not modified from the default values. To determine the appropriate modifications to the Alpha+ parameters, a simple TransModeler network was developed specifically to test headways. This network consisted of several identical tangent freeway sections with on-ramps to provide additional volumes. Each freeway and on-ramp section had slightly different volumes to get a larger sample scenario. Different modifications to the default Alpha+ parameter was tested using this model. The headway exports were analyzed in excel and compared against the observed headway data.

Based on the analysis, a range of Alpha+ values were established for implementation as the recommended default values for Kentucky microsimulation. The top of this range was at the default value of 2.81 and extended to 1.81. This provided a set of data which matched closely with the observed data in both magnitude and range.

Minimum Headway

Data and Analysis

The trajectory data collected for time headway was used to analyze minimum (critical) headway as well. Like time headway, the minimum headway required some congestion in order to be able to capture values similar to the intent of the parameter within the software.

Minimum headway within Vissim is measured in distance as opposed to time, so the applicable samples were converted from time to distance utilizing the travel speeds of the vehicles. Using both the time (TransModeler – critical headway) and distance (Vissim – minimum headway) the smallest samples were examined to compare against the default values.

Results

The examination of the smallest set of observed headway data indicated a validation of the default values within both software packages. The Vissim default value is represented by a singular distance of 1.64 ft. (0.5 m). The TransModeler default is represented by a distribution of critical headways by time which corresponds to 10% at 0.2s, 10% at 0.4s, 10% at 0.6s, 70% at 0.8s in TransModeler 6 (20% at 0.2s, 50% at 0.4s, 20% at 0.6s, 10% at 0.8s in TransModeler 5). Unlike time headway, minimum headway examines the smallest spacing increment which vehicles will in order to perform necessary maneuvers, which should only occur in select conditions.

Based on how closely the observed data compares against the default values, there is not enough difference to recommend a change in these values for Kentucky microsimulation models. The observed data was similar to both the default datasets for Vissim and TransModeler. As this will only be enabled during significant congestion or oversaturated conditions, it was assumed that software default values capture the Kentucky behaviors accurately.

Standstill Distance

Data and Analysis

Standstill distance data was derived from two datasets – trajectory video data and aerial photography data via Google Earth. As standstill distance represents the spacing between vehicles in a stopped condition it could easily be observed at a variety of locations and conditions. Samples were obtained from measuring the rear bumper to front bumper distance on consecutive vehicles under stop conditions, which worked within both the trajectory data platform and Google Earth. In both observation conditions data was only used when it could be reasonably observed or assumed that vehicles were at a complete stop. In the arterial trajectory data this could be observed when vehicles were waiting at a traffic signal at an intersection. In the Google Earth aerials, it could be observed when other travel directions or turning vehicles were moving through the intersection, thus indicating a stop condition for opposing approaches. The combination of data collection methods resulted in approximately 500 standstill distance observations. This data was cataloged with respect to location context (urban or rural) to provide a further level of granularity in the analysis.

Results

The analysis of the observed standstill distances in Kentucky indicated that rural standstill distance was on average greater than urban standstill distances. As compared with the software defaults, the observed standstill was more conservative than both TransModeler and Vissim but more closely aligned with the TransModeler defaults. The average standstill distance from the observed data is 9 ft. for urban and 11 ft. for rural conditions. The software defaults are 8 ft and 6.56 ft for TransModeler and Vissim. As previously mentioned, while the average for the standstill distance is important, it is represented by a normal distribution in both software packages with a definable standard deviation in TransModeler and a fixed standard deviation in Vissim. The standard deviation of the observed standstill distances was 4 ft. which matched closely with the TransModeler standard deviation of 3.7 ft.

Based on the findings from the observed data, it is recommended that the default values be changed to match the observed data more accurately. As the standard deviation is fixed in Vissim, it is recommended that multiple distributions be used to account for the variability in the data.

Acceleration Rates

Data and Analysis

Trajectory data from interstate and arterial-intersection conditions was used to analyze the acceleration rates. Acceleration data was pulled from the trajectory files in two formats – instantaneous acceleration and acceleration between fixed points. The main source of analysis for acceleration was examining the acceleration between fixed points as this is more directly applicable to the W99 parameters of cc8 and cc9 which was the main goal of the parameter analysis process for acceleration. This analysis format was also instrumental for the analysis of the normal acceleration rates related to the TransModeler acceleration profiles.

The acceleration between fixed points analysis was conducted within the trajectory analysis platform to establish estimated accelerations from standstill conditions and from approximately 50mph. These directly relate to cc8 and cc9. Gates were used to establish a starting location and ending location from which speeds and timestamps were pulled allowing for the calculation of acceleration through the area as well as the filtering of non-compliant vehicles.

Results

The observed acceleration rates were more conservative than the default values in the W99 cc8 and cc9 parameters and the as it applies to the acceleration rates within TransModeler. The definitions for cc8 and cc9 are to represent the maximum desired acceleration of vehicles under these conditions; therefore, the maximum observed values were compared against the default values. The maximum observed standstill acceleration values was 9.2 ft./s^2 while the maximum observed acceleration from 50 mph was 4.5 ft./s^2. It is recommended that the W99 values of cc8 (standstill acceleration) and cc9 (acceleration from 50mph) be modified accordingly for defaults in KY microsimulation modeling.

The TransModeler acceleration behavior is defined based on the application of the normal acceleration distribution against the vehicular attribute acceleration profile (minimum, maximum, desired) based on vehicle mass-to-power and speed. The observed acceleration data as compared with the desired acceleration profiles in TransModeler indicates that the maximum observed accelerations are more conservative than the default distributions. To account for this is, it was recommended by TransModeler to make modifications to the normal acceleration distributions. The default normal acceleration in TransModeler is a simple distribution allowing for some variability in the experienced accelerations. For Kentucky it is recommended that the normal acceleration profile be modified to provide additional beta factors decreasing the rate of acceleration, to create more variability in acceleration between vehicles and better match the observed data.

Deceleration Rates

Data and Analysis

Similar to acceleration, trajectory data from interstate and arterial-intersection conditions was used to analyze the deceleration rates. Deceleration data was pulled from the instantaneous data as deceleration differs from acceleration in the way it is used while driving. Typically, deceleration is more reactionary to extraneous conditions on the roadway and less bound by the desirable conditions for the driver. The instantaneous deceleration data was downloaded from the trajectory data in one second intervals for each vehicle. This data was then filtered, sorted, and categorized based on vehicle speed and roadway type.

Results

The observed deceleration rates are similar to the default deceleration rates for Vissim and TransModeler.

For Vissim the deceleration rates that were studied were those within the driving behavior lane change parameters. These deceleration parameters pertain to the braking for the target and trailing vehicles when making and attempting lane change maneuvers. The resulting deceleration analysis indicated that the data was similar in the assumed percentiles for each type of deceleration action. Resulting recommended values and ranges were established for Maximum Deceleration (90th to 95th percentile), Accepted Deceleration (35th to 50th percentile), and Maximum Deceleration for cooperative braking (75th

to 85th percentile). The recommended values and ranges were developed for the target and trailing vehicles and are recommended as defaults for Kentucky microsimulation.

For TransModeler, deceleration is handled like acceleration in that it is controlled in common driving situations by the maximum and normal deceleration rates. The normal deceleration rates are that which vehicles will attempt to adhere. A comparison of the observed 50th and 75th percentile data with the default TransModeler normal deceleration profile indicates the similarities between the datasets. Based on this, it is recommended that the TransModeler deceleration parameters remain unchanged. There is not enough difference in the observed data and the TransModeler default data to recommend different values for use as defaults.

Lane Change Distance

Data and Analysis

Lane change distance is a more difficult parameter to examine due to the upstream length requirement needed prior to a turning location or ramp to determine the distance for which vehicles begin to change lanes. For this study anecdotal analysis was conducted using the trajectory video data and reference location distances along the roadway. These observations were used to categorize the relative distance when exiting or turning vehicles made lane changes.

Results

Based on the samples in the drone videos all vehicles are making lane changes in advance of the Vissim default measurement of 656.6 ft. (200m). It is likely that the majority are making lane changes greater than 2000 ft. upstream of the lane change location. While the data does not provide an exact value or distribution of values, it does provide insight that the Vissim defaults are not sufficient and helps provide indication that the TransModeler default values are likely more reasonable for base network development.

Based on the initial observations and conclusions, it is recommended that the TransModeler default values be used for both TransModeler and Vissim as a baseline scenario for lane change distance in microsimulation. Newer versions (Vissim 2020 and beyond) allow for lane change distance to be input as a distribution as opposed to a singular value. It is recommended that the lane change distance distributions be used in both software packages. If an earlier version of Vissim is being used, it is recommended that the lane change distances adhere to the TransModeler default curves as applicable for the scenario.

In addition to the difficulty to collect and examine data in this area, it is also thought that it is a very location dependent criteria and likely should be applied based on observations, traffic patterns, congestion, and other measures. The distance which drivers may make lane changes for one exit ramp or turning movement may be different than that at another interchange or intersection along even the same roadway and/or within the same context. Field observations should be utilized where available to provide more detailed examination of lane changing.

Vehicle Speed Ranges

Data and Analysis

Vehicle speed ranges were analyzed using historic HERE speed data was obtained from KYTC on 43 roadways throughout the state. These roadways varied in region of the state, context (rural, urban), facility type (arterial, freeway), and posted speed limit. The data obtained from two weeks in October of 2017 to depict typical traffic conditions for each of the corridors. Each of the corridors was analyzed to determine time periods when the corridor was operating in free-flow conditions. Based on information from microsimulation software, the speed profiles should be in concurrence with free-flow operation per the posted speed as opposed to peak or congested condition speeds as other aspects (lane change, volume, density, etc.) will cause traffic to operate at slower speeds as necessary. After establishing the time periods of free-flow operation, the data points were pulled out from total dataset for percentile analysis. Percentile information was calculated for the free-flow conditions to provide a subset of data points for each roadway.

Results

The percentile data for each roadway was compiled with the attribute information about context, facility, and posted speed. These percentiles were then averaged based on those metrics to develop calculated speed profiles for each posted speed, context, and applicable facility type. A relational factor between urban and rural speeds was developed using the data for facilities with the same posted speed limit of different contexts. This factor was applied to develop speed profiles when only one context was available from the initial data set.

The resulting recommended distributions are based on cumulative distributions with datapoints at each 10^{th} percentile. This provides a more detailed curve than is available in the default for either software. For Vissim, the distributions are based on absolute speed values, whereas for TransModeler they are based on speed deviations from the posted speed limit. Both sets of distributions represent the same overall speed values and are applied similarly in the software.

Vehicle Fleet Mix

Data and Analysis

Kentucky VIN data was analyzed to determine the average vehicle fleet mix by registered vehicles within the state. The VIN data is anonymous and is catalogued based on county and vehicle type, and can therefore be analyzed at a state, region, or county level. Several counties (with a focus on more urban areas) were selected to generate a more representative vehicle fleet mix to what is typically observed on roadways for microsimulation purposes. In addition, to better account for the mix of heavy vehicles, Kentucky classification count data across the state was examined. Since heavy vehicles are commonly used for commercial purposes and are not typically experiencing the same types of trips as passenger vehicles, it is likely that they are not being properly captured in the VIN data analysis. The summary of this data was used to generate recommended values and ranges for vehicle compositions.

Results

The summary of the VIN data resulted in a distribution of a vehicle mix that is representative of typical conditions throughout the state. This distribution established a recommended breakdown of passenger cars to be used for the majority of roadway and modeling conditions. The heavy vehicle mixture varies between roadway type, so three different roadway types were included in the analysis for heavy vehicle considerations (interstate, US route, KY highway). An interactive spreadsheet was developed using these distributions so that a modeler can input the breakdown between passenger cars, heavy vehicles, and the roadway type to generate a custom vehicle fleet composition which is tailored to a Kentucky vehicle fleet.

While this study has developed recommended ranges for default microsimulation vehicle compositions, it should be noted that vehicle composition can vary significantly depending on specific project location, context, and functional attributes. Therefore, localized project specific vehicle classification data is preferred and can be used to supplement the recommended Kentucky default values.

Truck Weight-to-Power Ratio

Data and Analysis

Data from previously conducted research documents was utilized to examine the vehicle mix and reported weight-to-power ratios of vehicles. There is little localized or Kentucky specific data pertaining to vehicle power and truck power; therefore, national research was utilized to provide insight on this parameter. One study for I-81 examines weigh station data to determine the weights, power, and distribution of trucks. The NCHRP 505 report summarizes percentile data for weight-to-power ratios in 3 states (California, Colorado, Pennsylvania). These were used as reference points for the development of proposed weight-to-power distributions.

Vissim randomly distributes the weight and power as separate functions to vehicles randomly (with equal probability of any value within the bounds being assigned) and therefore a vehicle may receive an unrealistic combination. Within the software these values are assigned in separate parameter windows and feature separate curves. Therefore, to compare the results against research documents and TransModeler results a series of matrices of the possible combinations and probabilities was developed to develop percentile distributions for the default curves.

In TransModeler the distributions are in tabular format based upon percentiles for each weight classification of vehicle.

Results

In review of the documentation in the TransModeler user guide and through discussions with Caliper, it was noted that the distribution curves were derived from the same research being used for this analysis. Due to this, it was not recommended that the TransModeler mass-to-power distributions be adjusted for use in Kentucky microsimulation.

For Vissim, a revised weight-to-power distribution was developed based on the results of the research. The revisions are in the form of separate weight and power distributions for heavy vehicles. As Vissim assigns the weight and power randomly for each heavy vehicle and has upper and lower limits, the distributions were developed to account for this and to create a more representative cumulative distribution to the available research. The recommended weight-to-power ratio for heavy vehicles should provide more consistent acceleration and performance for heavy vehicles similar to that in the US and Kentucky.

Appendix C:
Parameter Summary Table

Wiedemann 99 Car Following Parameters - Freeway														
		Default	Unit	Oregon DOT/ Washington DOT Parameters		Maryland DOT Parameters		Virginia DOT Parameters		Florida DOT Parameters		Iowa DOT Parameters		Kentucky Default Recommended Values
				Basic	Merging/ Weaving	Basic	Merging/ Weaving	Basic	Merging/ Weaving	Basic	Merging/ Weaving	Basic	Merge/ Diverge/ Weave	
CC0	Standstill Distance	**4.92**	ft	4.5 - 5.5	>4.92	4.5 - 5.5	>4.92	4.5 - 5.5	>4.92	>4.00	>4.92	>4.00	>4.92	**9**
CC1	Headway Time	**0.9**	s	0.85 - 1.05	0.90 - 1.50	0.85 - 1.05	0.8 - 1.50	0.85 - 1.05	0.90 - 1.50	0.70 - 3.0	0.9 - 3.0	0.7 - 3.0	0.9 - 3.0	**0.7-1.6**
CC2	Following' Variation	**13.12**	ft	6.56 - 22.97	13.12 - 39.37	6.56 - 22.97	13.12 - 39.27	6.56 - 22.97	13.12 - 39.37	6.56 - 22.97	13.12 - 39.37	6.56 - 22.97	13.12 - 39.37	Default
CC3	Threshold for Entering 'Following'	**-8**		Default		Default		Default		Default		Default		Default
CC4	Negative 'Following' Threshold	**-0.35**		Default		Default		Default		Default		Default		Default
CC5	Positive 'Following' Threshold	**0.35**		Default		Default		Default		Default		Default		Default
CC6	Speed Dependency of Oscillation	**11.44**		Default		Default		Default		Default		Default		Default
CC7	Oscillation Acceleration	**0.82**	ft/s^2	Default		Default		Default		Default		Default		Default
CC8	Standstill Acceleration	**11.48**	ft/s^2	Default		Default		Default		Default		Default		**9.2**
CC9	Acceleration at 50 mph	**4.92**	ft/s^2	Default		Default		Default		Default		Default		**4.5**
Wiedemann 74 Car Following Parameters														
Average Standstill Distance		**6.56**	ft	-		3.28 to 6.56		3.28 to 6.56		>3.28		>3.28		**9***
Additive Part of Safety Distance		**2**		-		2.0 to 2.2		2.0 to 2.2		1 to 3.5		1 to 3.5		Default
Multiplicative Part of Safety Distance		**3**		-		2.8 to 3.3		2.8 to 3.3		2.0 to 4.5		2.0 to 4.5		Default
Reference:				Table 4-2		Table 1 & 2		Appendix E		Table 7-9		Table 7-2		

**Due to the fixed distribution for standstill distance in Vissim, the KY default recommended value is a multi-distributional set of values with variable vehicle composition percentages. It is broken into 3 distribution sets of the following average values and vehicle composition distributions: Distribution 1 (35%) - Average = 6ft. | Distribution 2 (40%) - Average = 9ft. | Distribution 3 (25%) - Average = 11.5ft.*

Lane Change Parameters													
	Vissim Default		Unit	**Oregon DOT/ Washington DOT Parameters**		**Maryland DOT Parameters**		**Florida DOT Parameters**		**Iowa DOT Parameters**		**Kentucky Default Recommended Values**	
General Behavior	**Own**	**Trailing Vehicle**		Own	Trailing Vehicle	Own	Trailing Vehicle	Own	Trailing Vehicle	Own	Trailing Vehicle	Own	Trailing Vehicle
Maximum Deceleration	**-13.12**	**-9.84**	ft/s^2	-15 to -12	-12 to -8	-15 to -12	-15 to -8	< -12	< -8	< -12	< -8	**-11.95 to -15.00**	**-8.96 to -11.25**
$-1ft/s^2$ per distance	**200**	**200**	ft	150 to 250	150 to 250	100 to 250	100 to 250	>100	>50	>100	>50	Default	Default
Accepted deceleration	**-3.28**	**-1.64**	ft/s^2	-2.5 to -4	-1.5 to -2.5	-12 to -2.5	-12 to -1.5	< -2.5	< -1.5	<-2.5	<-0.5	**-2.86 to -4.19**	**-1.43 to -2.10**
Waiting time before diffusion	**60**		s	60		200		Default		Default		Default	
Minimum headway (front/rear)	**1.64**		ft	1.5 to 2		1.5 to 2		1.5 to 6		1.5 to 6		**Default**	
To slower lane if collision time above	**0**		s	0 to 0.5		0 to 0.5		-		-		-	
Safety distance reduction factor	**0.6**			0.25 to 1.00		0.1 to 1.0		0.1 to 0.9		0.1 to 0.9		Default	
Maximum deceleration for cooperative braking	**-9.84**		ft/s^2	-8 to -15		-8 to -20		-3 to -32.2		-3 to -32.2		**-7.57 to -10.04**	
Overtake reduced speed areas	**Unchecked**			Unchecked		Unchecked		Depends on Field Observations		Depends on Field Observations		Unchecked	
Cooperative Lane Change	**Unchecked**									Depends on Field Observations		**Checked**	
Maximum Speed Difference	**6.71**		mph							<20		Default	
Maximum Collision Time	**10**		s							<15		Default	
Reference:				Table 4-3		Table 3		Table 7-9		Table 7-2			

Appendix D:
Parameter Summary Table

Appendix D - Parameter Summary Quick Reference

	Vissim	TransModeler
1 Time Headway	✓	✓
2 Minimum Headway*	✗	✗
3 Standstill Distance	✓	✓
4 Acceleration	✓	✓
5 Deceleration*	✓	✗
6 Lane Change Distance*	✓	✗
7 Vehicle Speed Ranges	✓	✓
8 Vehicle Classification	✓	✓
9 Truck Weight: Power*	✓	✗

**Parameters without recommended change from software defaults do not have worksheets containing findings information*

Vissim W99: cc1 - Time Headway	
Default Value	0.9s
Recommended Range	0.7s - 1.6s

0.1

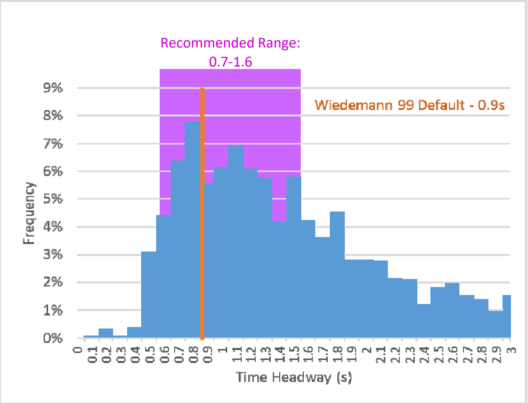
Interval	% of Headways	Cummulative %
0	0.4%	0.4%
0.1	0.2%	0.6%
0.2	0.5%	1.1%
0.3	2.1%	3.2%
0.4	4.2%	7.3%
0.5	5.5%	12.8%
0.6	7.6%	20.4%
0.7	7.1%	27.6%
0.8	6.8%	34.3%
0.9	5.8%	40.1%
1	7.0%	47.1%
1.1	6.0%	53.1%
1.2	5.2%	58.3%
1.3	5.1%	63.4%
1.4	3.8%	67.2%
1.5	4.0%	71.2%
1.6	3.9%	75.2%
1.7	3.7%	78.8%
1.8	2.6%	81.4%
1.9	2.6%	84.1%
2	2.5%	86.6%
2.1	1.7%	88.3%
2.2	2.0%	90.3%
2.3	1.6%	91.8%
2.4	1.7%	93.5%
2.5	1.3%	94.8%
2.6	1.3%	96.1%
2.7	1.2%	97.3%
2.8	1.5%	98.8%
2.9	1.2%	100.0%
3	0.0%	100.0%

Average Headway	
Time (s)	1.3
Distance (ft)	124.2

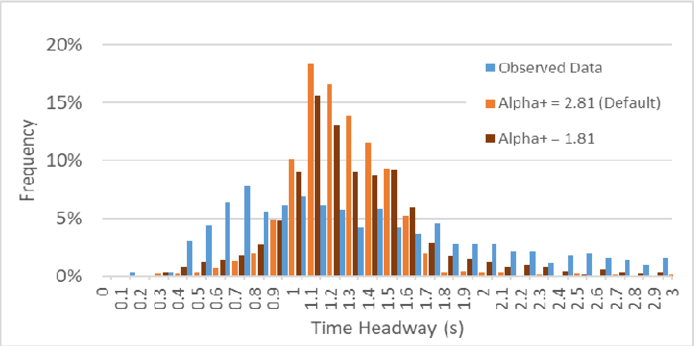
Mean	1.3
Median	1.15
Mode	0.60
Q1	0.70
Q3	1.60

Standard Deviation	0.66
+1 SD	1.81
-1 SD	0.49

Vissim Distribution	
Headway	%
0.80	0%
0.89	20%
1.00	40%
1.08	60%
1.18	80%
1.30	100%



Modified General Motors Driving Behavior Parameters								
	Alpha +	Beta +	Gamma +	Theta +	Alpha -	Beta -	Gamma -	Theta -
Default	**2.81**	-1.67	-0.89	1	4.65	1.08	1.65	1
Recommended	**2.81- 1.81**	-1.67	-0.89	1	4.65	1.08	1.65	1



Software Default Values

	Vissim – Wiedemann 74
Average (ft.)	6.56
Standard Deviation	0.98*
Minimum (ft.)	3.281
Maximum (ft.)	9.843

0.98

Recommended Values - Urban

	Vissim – Wiedemann 74 3 Distributions		
	Dist. 1 (35%)	Dist. 2 (40%)	Dist. 3 (25%)
Average (ft.)	6	9	11.5
Standard Deviation	0.98*		
Minimum (ft.)	2.719	5.719	8.219
Maximum (ft.)	9.281	12.281	14.781

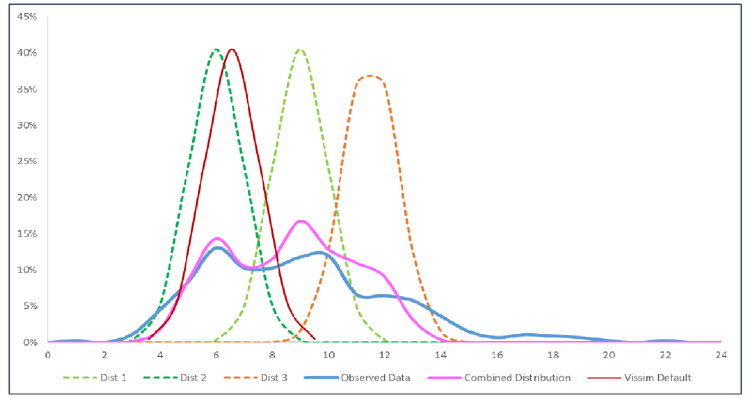
Recommended Values – Rural

	Vissim – Wiedemann 74 3 Distributions		
	Dist. 1 (35%)	Dist. 2 (40%)	Dist. 3 (25%)
Average (ft.)	7	10	13.5
Standard Deviation	0.98*		
Minimum (ft.)	3.719	6.719	10.219
Maximum (ft.)	10.281	13.281	16.781

*Standard Deviation is a fixed value in Vissim for standstill distance

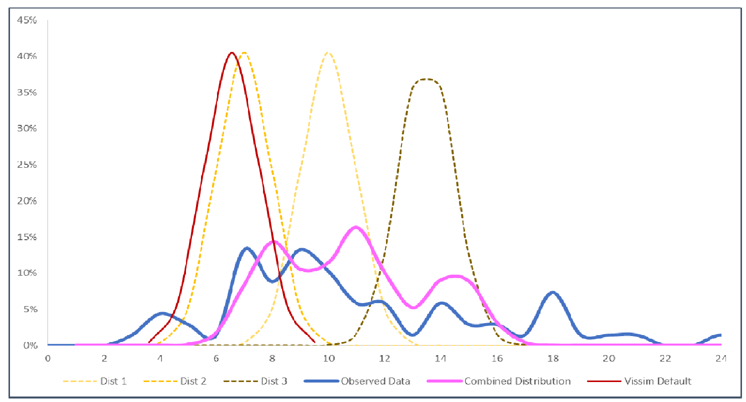
URBAN

Distance (ft)	Dist 1	Dist 2	Dist 3		Combined Dist
	40.0%	35.0%	25.0%	100%	
Avg	9	6	11.5		9.00
SD	0.98	0.98	0.98		
0	0.00	0.00	0.00		0.00
1	0.00	0.00	0.00		0.00
2	0.00	0.00	0.00		0.00
3	0.00	0.00	0.00		0.00
4	0.00	0.05	0.00		0.02
5	0.00	0.24	0.00		0.08
6	0.00	0.41	0.00		0.14
7	0.05	0.24	0.00		0.10
8	0.24	0.05	0.00		0.11
9	0.41	0.00	0.02		0.17
10	0.24	0.00	0.13		0.13
11	0.05	0.00	0.36		0.11
12	0.00	0.00	0.36		0.09
13	0.00	0.00	0.13		0.03
14	0.00	0.00	0.02		0.00
15	0.00	0.00	0.00		0.00
16	0.00	0.00	0.00		0.00
17	0.00	0.00	0.00		0.00
18	0.00	0.00	0.00		0.00
19	0.00	0.00	0.00		0.00
20	0.00	0.00	0.00		0.00
21	0.00	0.00	0.00		0.00
22	0.00	0.00	0.00		0.00
23	0.00	0.00	0.00		0.00
24	0.00	0.00	0.00		0.00
25	0.00	0.00	0.00		0.00



RURAL

Distance (ft)	Dist 1	Dist 2	Dist 3		Combined Dist
	40.0%	35.0%	25.0%	100%	
Avg	10	7	13.5		10.00
SD	0.98	0.98	0.98		
0	0.00	0.00	0.00		0.00
1	0.00	0.00	0.00		0.00
2	0.00	0.00	0.00		0.00
3	0.00	0.00	0.00		0.00
4	0.00	0.00	0.00		0.00
5	0.00	0.05	0.00		0.00
6	0.00	0.24	0.00		0.00
7	0.00	0.41	0.00		0.00
8	0.05	0.24	0.00		0.05
9	0.24	0.05	0.00		0.24
10	0.41	0.00	0.00		0.41
11	0.24	0.00	0.02		0.24
12	0.05	0.00	0.13		0.05
13	0.00	0.00	0.36		0.00
14	0.00	0.00	0.36		0.00
15	0.00	0.00	0.13		0.00
16	0.00	0.00	0.02		0.00
17	0.00	0.00	0.00		0.00
18	0.00	0.00	0.00		0.00
19	0.00	0.00	0.00		0.00
20	0.00	0.00	0.00		0.00
21	0.00	0.00	0.00		0.00
22	0.00	0.00	0.00		0.00
23	0.00	0.00	0.00		0.00
24	0.00	0.00	0.00		0.00
25	0.00	0.00	0.00		0.00



Software Default Values

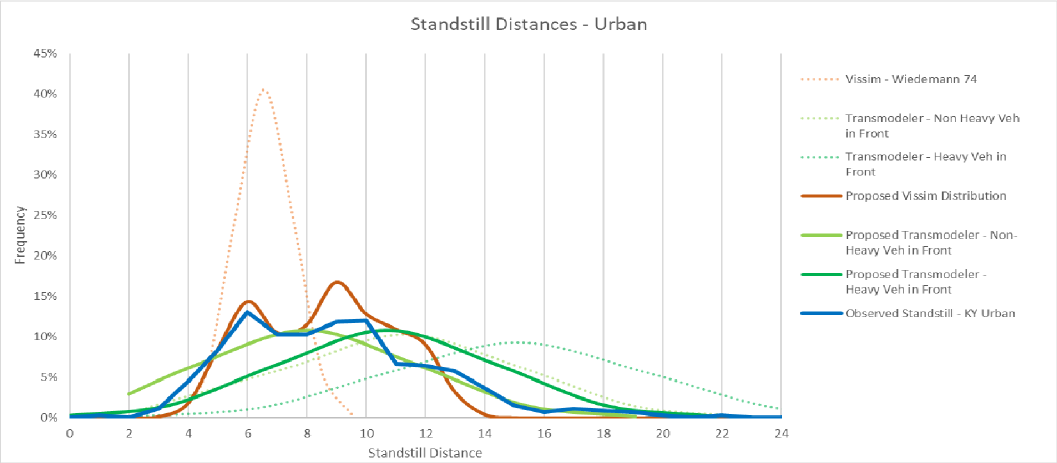
	TransModeler	
	Passenger Veh	Heavy Veh
Average (ft.)	11.3	15.1
Standard Deviation	3.9	4.3
Minimum (ft.)	2	2
Maximum (ft.)	-	-

Recommended Values - Urban

	TransModeler	
	Passenger Veh	Heavy Veh
Average (ft.)	9	12
Standard Deviation	3.7	4
Minimum (ft.)	2	2
Maximum (ft.)	-	-

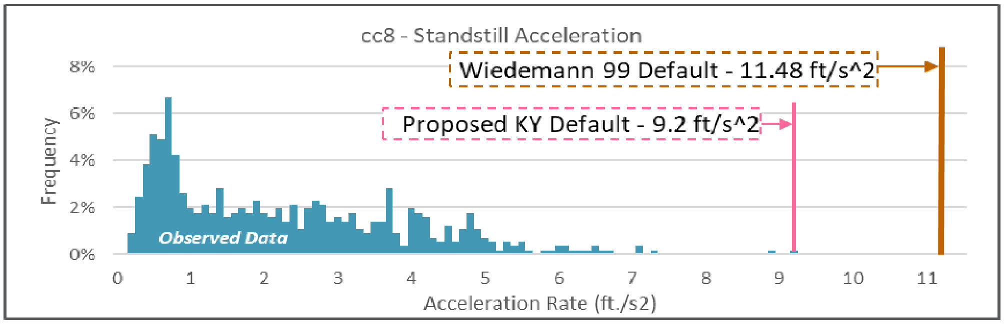
Recommended Values – Rural

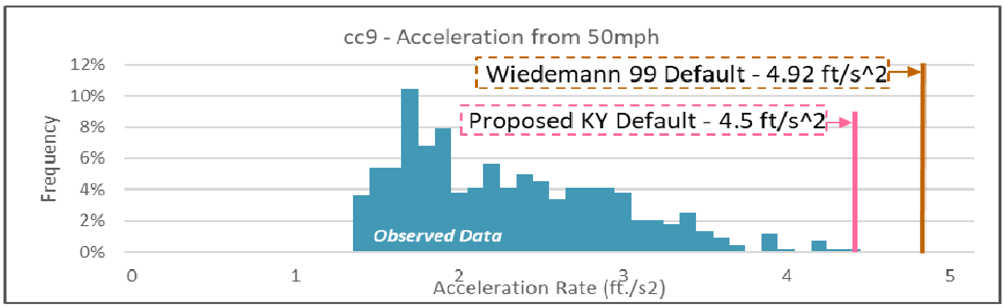
	TransModeler	
	Passenger Veh	Heavy Veh
Average (ft.)	11	12
Standard Deviation	3.7	4
Minimum (ft.)	2	2
Maximum (ft.)	-	-



Appendix D - Parameter Summary Quick Reference

	Default Values	Recommended Values
Acceleration from Standstill (cc8)	11.98 ft./s^2	**9.2 ft./s^2**
Acceleration from 50mph (cc9)	4.92 ft./s^2	**4.5 ft./s^2**





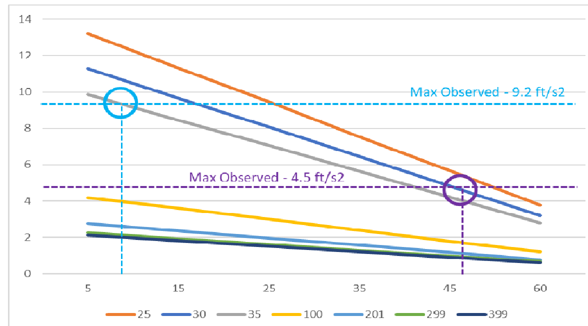
Normal Acceleration

Default Values				Recommended Values		
% of Vehicles	Alpha	Beta		% of Vehicles	Alpha	Beta
20%	0	1.1		10%	0	1.1
60%	0	1		30%	0	1
20%	0	0.95		20%	0	0.9
				20%	0	0.88
				20%	0	0.75

Max Acceleration

	MPR	<10	10-20	20-30	30-40	40-50	>50	
Car	25	13.22	11.32	9.45	7.55	5.68	3.77	*8.50*
Car	30	11.29	9.68	8.07	6.46	4.82	3.22	*7.26*
	35	9.88	8.46	7.05	5.64	4.23	2.82	*6.35*
SU	100	4.2	3.61	3.02	2.4	1.8	1.21	*2.71*
Semi	201	2.76	2.36	1.97	1.57	1.18	0.79	*1.77*
	299	2.26	1.94	1.61	1.28	0.98	0.66	*1.46*
	399	2.13	1.84	1.51	1.21	0.92	0.62	*1.37*

35/25 Ratio	0.75	0.75	0.75	0.75	0.74	0.75
35/30 Ratio	0.88	0.87	0.87	0.87	0.88	0.88
Avg	0.81	0.81	0.81	0.81	0.81	0.81



Based on the graph it seems that the MPR-35 class more closely aligns with the observed values - so as most passenger cars will be in the 25/30 categories it might be best to apply a Beta factor to recreate that type of behavior in the 25/30 classes.

Normal Acceleration [Proposed Modifications]

% of Vehicles	Alpha	Beta
10	0	1.1
30	0	1
20	0	0.9
20	0	0.88
20	0	0.75

Vissim Lane Change Deceleration Defaults

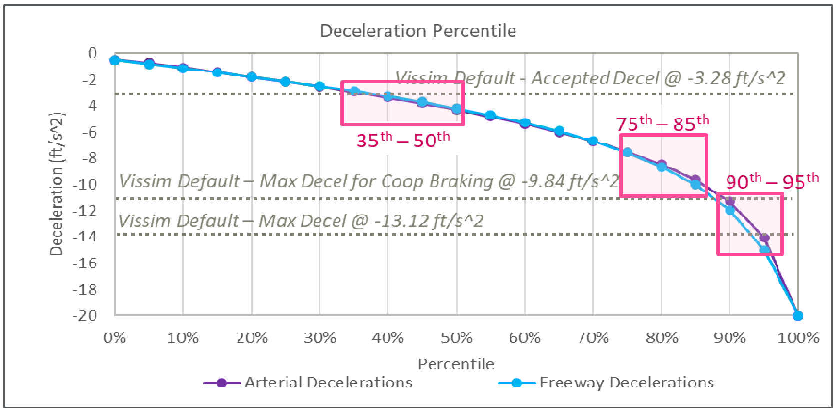
Default Values

	W74		W99	
	Own	Trailing	Own	Trailing
Max Deceleration (*ft./s* ^{2})	-13.12	-9.84	-13.12	-9.84
Accepted Deceleration (*ft./s* ^{2})	-3.28	-3.28	-3.28	-1.64
Max Deceleration for Cooperative Braking (*ft./s* ^{2})	-9.84		-9.84	

Recommended Values *(Accepted Ranges)*

	W74		W99	
	Own	Trailing	Own	Trailing
Max Deceleration (*ft./s* ^{2})	-12.67 *(-11.30 to -14.03)*	-9.5 *(-8.48 to -10.52)*	-13.47 *(-11.95 to -15.00)*	-10.1 *(-8.96 to -11.25)*
Accepted Deceleration (*ft./s* ^{2})	-3.61 *(-2.95 to -4.31)*	-3.61 *(-2.95 to -4.31)*	-3.51 *(-2.86 to -4.19)*	-1.76 *(-1.43 to -2.10)*
Max Deceleration for Cooperative Braking (*ft./s* ^{2})	-8.54 *(-7.52 to -9.65)*		-8.76 *(-7.57 to -10.04)*	

All deceleration values are in ft./s ^{2}



Appendix D - Parameter Summary Quick Reference

Percentage of Drivers	Recommended Values: TransModeler Defaults – Streets	Recommended Values: TransModeler Defaults – Freeways	Vissim Defaults
2%	800’	1000’	656.6’
6%	850’	1100’	
10%	900’	1200’	
14%	950’	1300’	
18%	1000’	1500’	
16%	1050’	1750’	
10%	1100’	2000’	
8%	1150’	2250’	
5%	1200’	2500’	
3%	1250’	2750’	
2%	1300’	3000’	
2%	1350’	3250’	
2%	1400’	3500’	
1%	1450’	3750’	
1%	1500’	4000’	

Appendix D - Parameter Summary Quick Reference

Kentucky Recommended Speed Profiles – Absolute Speeds (Vissim)												
Speed Limit | Road Type		Percentile										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
25mph | Arterial	Urban	20.7	22	23.5	25	26.1	27.5	29.1	30.5	31.8	35	42.3
	Rural	22.6	24	25.6	27.3	28.5	30	31.7	33.3	34.7	38.2	46.1
35mph | Arterial	Urban	24.6	26.5	28.5	30	31.5	33	34.1	36	37.7	44	50
	Rural	33.4	35	36.4	37	39	41	42.4	43.5	45.2	50	54.4
40mph | Arterial	Urban	26.9	30	31.6	32.8	34.4	36	38.2	41	44	48	52.2
	Rural	29.3	32.7	34.5	35.8	37.5	39.2	41.6	44.7	48	52.3	56.9
45mph | Arterial	Urban	33.3	36.5	39.3	41	42.4	44	45.1	47	49.6	53	57.3
	Rural	41.1	42	43.4	45	46.5	47.5	48.7	49.5	50.7	54	61
55mph | Arterial	Urban	42.4	44.5	46.5	49	50.2	53	54.4	56	58.1	62	66.1
	Rural	49.8	51	52.4	54	55	56	57.2	58.5	60.1	64	67.7
65mph | Arterial	Urban	55.4	56.8	58.6	59.6	61.8	62.9	64.1	64.7	65.1	66.1	67.8
	Rural	59.5	61	62.9	64	66.3	67.5	68.8	69.5	69.9	71	72.8
55mph | Freeway	Urban	42.3	53.5	56.2	58	59.6	60.7	62.3	63.7	65.7	68.6	76.7
	Rural	43.1	54.6	57.3	59.2	60.8	61.9	63.5	65	67	70	78.2
65mph | Freeway	Urban	47.5	59.1	62	63.8	65.2	66.7	68.1	69.6	71.6	74.5	79.7
	Rural	48	59.7	62.6	64.4	65.9	67.4	68.8	70.3	72.3	75.2	80.5
70mph | Freeway	Urban	53.9	62.5	64.5	66	67.3	68.4	69.2	70.5	71.9	74.2	80.6
	Rural	51.8	61.6	64	65.4	66.9	68.1	69.3	70.7	72.3	74.7	80.5

Appendix D - Parameter Summary Quick Reference

Kentucky Recommended Speed Profiles – Deviations from Speed Limit (TransModeler)*											
Speed Limit | Road Type		Percent of Drivers									
		10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
25mph - Arterial	Urban	-3.7	-2.3	-0.8	0.6	1.8	3.3	4.8	6.2	8.4	13.7
	Rural	-1.7	-0.2	1.5	2.9	4.3	5.9	7.5	9.0	11.5	17.2
35mph - Arterial	Urban	-9.5	-7.5	-5.8	-4.3	-2.8	-1.5	0.0	1.9	5.9	12.0
	Rural	-0.8	0.7	1.7	3.0	5.0	6.7	8.0	9.4	12.6	17.2
40mph - Arterial	Urban	-11.6	-9.2	-7.8	-6.4	-4.8	-2.9	-0.4	2.5	6.0	10.1
	Rural	-9.0	-6.4	-4.9	-3.4	-1.7	0.4	3.2	6.4	10.2	14.6
45mph - Arterial	Urban	-10.1	-7.1	-4.9	-3.3	-1.8	-0.5	1.1	3.3	6.3	10.2
	Rural	-3.5	-2.3	-0.8	0.8	2.0	3.1	4.1	5.1	7.4	12.5
55mph - Arterial	Urban	-11.6	-9.5	-7.3	-5.4	-3.4	-1.3	0.2	2.1	5.1	9.1
	Rural	-4.6	-3.3	-1.8	-0.5	0.5	1.6	2.9	4.3	7.1	10.9
65mph - Arterial	Urban	-8.9	-7.3	-5.9	-4.3	-2.7	-1.5	-0.6	-0.1	0.6	1.9
	Rural	-4.8	-3.1	-1.6	0.2	1.9	3.2	4.2	4.7	5.5	6.9
55mph - Freeway	Urban	-7.1	-0.1	2.1	3.8	5.2	6.5	8.0	9.7	12.2	17.7
	Rural	-6.2	1.0	3.3	5.0	6.3	7.7	9.3	11.0	13.5	19.1
65mph - Freeway	Urban	-11.7	-4.5	-2.1	-0.5	1.0	2.4	3.8	5.6	8.1	12.1
	Rural	-11.2	-3.8	-1.5	0.2	1.7	3.1	4.6	6.3	8.8	12.9
70mph - Freeway	Urban	-11.8	-6.5	-4.8	-3.3	-2.2	-1.2	-0.2	1.2	3.1	7.4
	Rural	-13.3	-7.2	-5.3	-3.8	-2.5	-1.3	0.0	1.5	3.5	7.6

Appendix D - Parameter Summary Quick Reference

	INPUT↓
Passenger Cars	98%
Heavy Vehicles	2%
Project Area Roadway Type	
Sum Check	100%

Use the orange cells to input the project specific traffic breakdown for more tailored vehicle composition percentages

Truck Percentage Lookup	SU	TT
KY Route	62%	38%
US Hwy	59%	41%
Interstate	28%	72%

Vissim

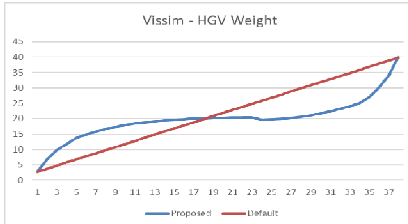
Initial %	Description	Revised %
Car		
12.9%	1001: Car - Honda Accord	12.6%
6.0%	1002: Car - Nissan Altima	5.9%
6.4%	1003: Car - Nissan Quest	6.3%
5.5%	1004: Car - Plymouth Voyager	5.4%
13.5%	1005: Car - Toyota Avensis	13.2%
10.6%	1006: SUV - Ford Explorer	10.4%
5.0%	1007: SUV - GMC Yukon	4.9%
5.8%	8: SUV - Jeep Grand Cherokee	5.7%
19.2%	12: LtTruck - Ford F150	18.8%
15.1%	11: LtTruck - Chevrolet Silverado	14.8%
100%		
HGV		
10.5%	1021: HGV - US AASHTO WB-40	0.2%
48.0%	22: HGV - US AASHTO WB-50	1.0%
4.5%	23: HGV - US AASHTO WB-65	0.1%
4.5%	24: HGV - US AASHTO WB-67	0.1%
5.0%	25: HGV - Flatbed	0.1%
27.5%	26: HGV - EU 04	0.6%
100%		
		100%

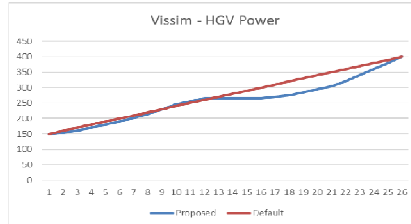
Transmodeler

	Initial %	Description	Revised %
Car			
0.005	*0.5%*	Buses	0.5%
0.000	*0.0%*	*Motorcycles*	0.0%
0.052	*5.5%*	Passenger Cars - High Performance	5.4%
0.206	*21.9%*	Passenger Cars - Middle Performance	21.4%
0.159	*16.8%*	Passenger Cars - Low Performance	16.5%
0.522	*55.3%*	Pickups/SUVs	54.2%
	100%		
HGV			
0.030	*92.7%*	Single Unit Trucks	1.9%
0.002	*7.3%*	Trailer Trucks	0.1%
	100%		
			100%

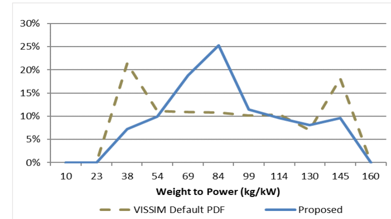
			Vissim	
Midpoint Low	*Midpoint High*	Weight to Power Ratio	Proposed Cumulative Distribution Function (CDF)	Proposed Percentile Distribution Function (PDF)
5	*15*	10	0%	0%
15	*30*	22.5	0%	0%
30	*46*	38	7%	7%
46	*61*	53.5	17%	10%
61	*76*	68.5	36%	19%
76	*91*	83.5	61%	25%
91	*106*	98.5	73%	11%
106	*122*	114	82%	10%
122	*137*	129.5	90%	8%
137	*152*	144.5	100%	10%
152	*167*	159.5	100%	0%

Default and Proposed Heavy Vehicle Weight and Power Distributions



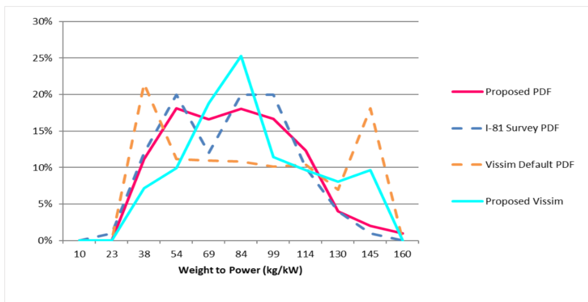


Default and Proposed Heavy Vehicle Weight-to-Power Probability Distribution Function

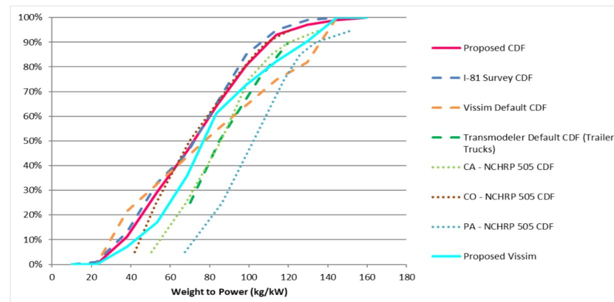


Default and Proposed Weight-to-Power Ratios as compared with TransModeler and other research studies.

Probability Distribution Functions



Cumulative Distribution Functions



Appendix E:
KY Microsimulation Scoping Checklist

Pre-Model Setup

Project Information

Project Name: ______________________________

Facility Type: ☐ Freeway ☐ Arterial ☐ Downtown Network ☐ Intersection/ Interchange

Project Extents: ______________________________

Analysis Extents: ______________________________

Analysis Tool: ______________ Why *(optional)* : ______________

Analysis Years: ☐ Existing: ______________ ☐ Base Year: ______________ ☐ Design Year: ______________

Data

		Provided by KYTC	Collected by Consultant	Notes
Volume Data	Existing Volumes	☐	☐	
	Volume Forecasts	☐	☐	
	Vehicle Classification	☐	☐	
Speed Data		☐	☐	
Travel Time Data		☐	☐	
Origin- Destination Data		☐	☐	
Crash Data/ Incident Data		☐	☐	

Notes:

Appendix F:
KY Microsimulation Calibration Checklist

Model Development

Geometry Coding

- ☐ Lane geometry correct along all segment/ intersections — Roadway Segments
- ☐ Lane add/ lane drops coded according to best practices
- ☐ Desired speed decision points coded at all entry segments to new facilities
- ☐ Lane change/ emergency stop distances were increased appropriately
- ☐ Intersection geometry segments coded correctly — Intersections
- ☐ Reduced speed areas coded for all turning movements
- ☐ Conflict areas and/or priority rules coded
- ☐ Intersection control elements (signal heads, stop signs, detectors) coded
- ☐ Traffic signal timing timing match field data

Vehicle Routing/ Inputs

- ☐ Dynamic Assignment neccesary?
- ☐ Vehicle routing is reflective of Origin-Destination patterns
- ☐ Vehicle Inputs correspond to routing decisions
- ☐ Vehicle Inputs/ Input Matrix demonstrate peaking patterns

Vehicle Composition

- ☐ KY default vehicle composition was used

  If not, why? ☐ Local data ____________________

  ☐ Other ____________________

Vehicle Speed Profiles

- ☐ KY default speed ranges were used

  If not, why? ☐ Local data ____________________

  ☐ Other ____________________

Driving Behaviors

- ☐ Transmodeler - Wiedemann 74 & 99 models used?
- ☐ Parameter values are within KY established ranges

Model Assumptions/ Notes:

Post- Model Development

Model Calibration

- ☐ Calculated Number of Simulation Runs: ____________
- ☐ Multiple Simulation Runs
  - Random Seeding ____________
  - Random Seeding Increment ____________

Calibration Metrics		Compliance with Calibration Metrics AM	PM
☐	Volume	☐	☐
☐	Speed	☐	☐
☐	Travel Time	☐	☐
☐	Delay	☐	☐
☐	Congestion (qualitative)	☐	☐

Unserved Demand (Average)	AM	PM
Unserved Vehicles		

Input Check

- ☐ Geometry matches existing conditions
- ☐ Signal timing matches exisiting conditions
- ☐ Routing decision
- ☐ Vehicle Composition matches KY default or project specific data
- ☐ Speed Profile's match KY default or project specific speed data
- ☐ Link Behaviors match roadway conditions
- ☐ Driving Behavior parameter ranges are within KY approved ranges

Results Metrics

- ☐ Volume/ Throughput
- ☐ LOS/ Delay
- ☐ Travel Time/ Speed
- ☐ Queue
- ☐ Other: ____________

Model Review Comments: