
6.0 Chapter 6 – Calibration Process

Calibration of a CORSIM model occurs only for the existing models. The model is calibrated when the volume, speed, and other operational observations are satisfactorily replicated. Calibration information from the existing model is carried forward to the alternatives analysis. If traffic does not get through an alternative model or if there is congestion in an alternative, then the alternative does not work, and either the geometry or signal timings should change, not the driver behavior or the calibration parameters.

The importance of calibration extends beyond the statistical tests. The changes made to achieve a valid statistical model need to reflect reality. Were car following parameters changed to unrealistic parameters to achieve calibration? Were artificial constraints put in the model to make congestion occur? It is very critical that an organized process be followed to achieve calibration. In example, changing multiple variables at one time can make it difficult to determine what caused the correct response. However, calibration cannot go on forever, and testing the effects of single changes in large models could take too long.

The approach and information provided in this chapter are a guide to calibration. Being successful and proficient at calibrating a model is based on experience. **Experience has proven that the number one step in calibrating a model is to have the base model set up properly and to have a good handle on conditions in the field. This means watching and understanding how the system really operates – knowing where the congestion occurs and why the congestion occurs along the system. Without a “good” model and a thorough understanding of the field conditions, calibration is a meaningless exercise with no end.**

6.1 Causes of Congestion

Congestion on roadways is caused by a number of different factors. Too much traffic, bottlenecks caused by changes in geometry, and incidents are some of the causes. Micro-simulation models including CORSIM require extensive inputs to reflect the real world. The first step is to get the basic information entered correctly: the number of lanes, storage lanes, balanced traffic volumes, and signal timings. Having this information entered correctly may not replicate the congestion that is observed. It may be necessary to adjust the operating characteristics of a link, such as the modeled desired speed, may need to be lowered or the headway spacing increased to reflect the localized congestion. The process to identify causes of congestion and adjusting the model to reflect these causes is iterative between field observations and running the model. The table below provides some insights into causes of congestion and potential model treatments. This list cannot cover every situation, and some the suggested model modifications may not be the complete answer (i.e., there may be other causes of congestion or other changes need to be made than what is suggested). Each model will be unique; however, the current project efforts on major portions of the metro freeway system have provided more refined insights into calibration. Please contact Mn/DOT to discuss calibration issues.

**Table 4
Causes of Congestion**

Observed Congestion Cause	Potential Model Modifications
<p>Inadequate sight distance caused by:</p> <ul style="list-style-type: none"> - Tight horizontal curvature - Lateral obstructions or lack of clear zone space - Short vertical curve 	<p>Curves and grades should already be reflected in the base model. However, it is possible for the desired modeled speed that is adjusted internally by the radius of curve and/or grade, to not go low enough to replicate the congestion. Drivers in the field may be responding differently, Adjust the desired free flow speed or headway spacing.</p> <p>Lateral obstructions may cause drivers to hesitate through that segment of freeway. Adjust the desired free flow speed or headway spacing.</p>
Poor or Inadequate Signing	<p>Drivers in the model using exit ramps begin to change lanes to position themselves for the exit at the warning sign location entered in RT 20. The default warning sign location is 2,500 feet. Adjust the warning sign location in RT 20 to reflect the observed condition.</p>
Poor Interchange Spacing	<p>Poor interchange spacing is reflected in the way the base model is constructed, (i.e., entrance and exit ramps are close together creating short weave sections). Usually when interchanges are spaced close together, there is very little ramp-to-ramp traffic creating more of a weave. To replicate congestion, make sure to incorporate an O-D matrix.</p>
Lane Continuity	<p>Lane continuity on a mainline freeway allows through vehicles to stay in the left hand lanes without any lane changing. Loss of lane continuity usually occurs through a systems interchange. The lane changing or shifts in these cases are caused by drivers given a choice of a destination. If the freeway splits at the systems interchange are not included in the model, traffic will operate in a free state not creating congestion. Expand the model to include a portion of the systems interchange and incorporate into the O-D matrix.</p>
Lane Drops	<p>Lane drops are coded directly in the CORSIM model. The important attributes to be observed and adjusted in the model are the warning sign location.</p>
Bad Weather	<p>Typically, design alternatives are not modeled for bad weather. FHWA is currently researching how to use CORSIM to test the effects of bad weather.</p>
Poor Signal Timings	<p>Identify the timings in the field and modify the timings in the model to reflect the field. When using Synchro to set up CORSIM, it is easy to incorrectly export optimal timings.</p>
Construction	<p>Testing the effects of construction can be done a number of different ways in CORSIM. The base model can be changed to reduce the number of lanes or long-term incidents can be used.</p>
Incidents or Crashes	<p>Modeling incidents or crashes is typically not part of the design process. However, if it is desired to examine this condition, CORSIM allows for modeling short and long-term incidents. Short-term incidents are randomly placed throughout the modeling period for the specified links. Long-term incidents are coded with a specified start and end time and for a specific location.</p>
Events	<p>Modeling events requires changing the volume inputs and signal timings to reflect the event condition.</p>

6.2 Calibration Approach

The approach to calibrating a model is to run the model and conduct statistical checks. If the statistics are acceptable, then the model is calibrated. If they are not, then modify the model until the statistics are acceptable. The approach to modifying the model for the purpose of calibration should be to change known global parameters and link level parameters first, and as a last resort, change unknown global parameters. Recent modeling experiences in the metro area have shown that it is possible to have different driver responses to the same circumstances depending on the location within the same model area. **Changing the car following sensitivity parameters without working through the link level conditions first will result in an unrealistic model.** If the modeler is trying to achieve a local change by using global parameters, then the results may never be achieved for the right reasons.

The following steps are given in an order and are intended only to provide a start point. At times, they may need to be done in conjunction or in a different sequence to determine the appropriate coding. In addition to these parameters, it may be necessary to change the physical geometry of the model to achieve results. For instance, if there is a downstream exit ramp that was not included in the model in the beginning, and yet it was determined in later review after the model was prepared that in order to get the vehicles to line up in the proper lanes that it should be added, then this is also part of calibration. **During the course of calibrating a model, the modeling limits may have to be adjusted to replicate existing conditions.**

6.2.1 Step 1: Modification of Known Global Parameters

Mn/DOT has identified two global parameters that must be incorporated into every mode. These two parameters are detailed below. At the start of the calibration process, this information should be coded directly into the input file.

6.2.1.1 Headway Distributions

There are three (3) stochastic *vehicle entry headway* choices: uniform distribution, normal distribution, and Erlang distribution. This is the method the program will use to generate vehicles at entry nodes. The default setting is a uniform distribution, but the preferred choice is a normal distribution for arterials and Erlang for freeways. For the Erlang distribution, the parameter “a” is set to 1.

6.2.1.2 Fleet Information

The main calibration parameters for the CORSIM model are the vehicle type characteristics found under the Network Properties menu. Up to nine (9) different types of vehicles can be simulated by the model. Four (4) different classes of vehicles can be modeled: auto, truck, transit, and carpool. For Mn/DOT modeling purposes, the following vehicles have been adopted:

1. 15-foot long auto
2. 30-foot long single unit truck (SUT)
3. 62-foot long semi-trailer
4. 40-foot long transit bus

The main variables for the vehicle types include:

1. Maximum non-emergency deceleration
2. Maximum emergency deceleration

To determine the headway between vehicles, the model uses the maximum deceleration rates. Altering these rates gives the user some control over the density of the system. The maximum deceleration rate of the program has been capped at 15 ft/s². For the vehicles listed above, the following deceleration rates have been selected as beginning points for calibration:

Vehicle Type	Max. Non-Emergency Deceleration	Max. Emergency Deceleration
	ft/sec ²	ft/sec ²
15-foot auto	13.1	15.0 (actual = 23.0)
30-foot SUT	9.8	15.0 (actual = 16.4)
62-foot semi	7.9	12.5
40-foot bus	9.8	15.0 (actual = 16.4)

The physical makeup of the traffic can also be entered. At entry links, the truck percentages can be entered. Within the vehicle type characteristics, the user can define the makeup of each vehicle class for either arterial or freeway systems. This is entered as a percentage, and the sum of the percentages must equal 100 for each vehicle class. For example, the truck class could be entered as 65 percent SUT and 35 percent semi-trailers.

Current fleet percentages shall be used in the model. This information is available by contacting the Mn/DOT Planning section.

It is important that the fleet information vehicle be coded for both the freeway and arterial models. There are some inconsistencies between the two submodels, so this vehicle information needs to be coded twice in a slightly different manner. This information is subject to change; the latest fleet information should be requested from Mn/DOT at the start of the modeling process.

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NETSIM global vehicle parameters
  5 15      100                25  0  0  0                130 58
  1 15      100                75  0  0  0                130 58
  2 30      120                0  60  0  0                120 58
  6 62      120                0  40  0  0                120 58
  3 19      100                0  0  0 100                250 58

FRESIM global vehicle parameters
20 15  1 30  5  4 130 130 100 80 35 80 100 80 70 100 15                70
  1 15  70 150 50  0  0  0  2 130                71
  2 15  70 150 50  0  0  0  2 130                71
  3 30  70 150  0 60  0  0  3 120                71
  4 62  70 150  0 40  0  0  5 120                71
  5 53  70 150  0  0  0  0  5 120                71
  6 64  70 150  0  0  0  0  6 120                71
  8 14  70 150  0  0  0  50 1 250                71
  9 19  70 150  0  0  0  50 2 250                71

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Figure 35 – CORSIM Model Fleet Information Codes

6.2.2 Step 2: Modification of Local or Link Length Parameters

Local conditions (link level) within the model are the anticipatory speed and warning sign location. These parameters apply to all on ramp locations and provide information to vehicles on the mainline upstream of the merge. The message is that if the entering vehicle speed drops below the specified value, the vehicles within the warning sign location on the mainline will change lanes to avoid the merging vehicle. Figure 36 illustrates this condition.

The default conditions in the model are 43 mph anticipating speed and the warning sign located 1,500 feet upstream of the merge. A recent crash statistic for the state of Minnesota indicated that Minnesota is twice the national average in accidents caused by failing to yield. Generally, during the peak conditions, very little cooperation is given at entrance ramps. However, some locations are better than others. Much of this has to do with the other ramp destinations and prevailing conditions so it needs to be addressed on a case-by-case basis. **If the failure to yield at an entrance ramp is very high, then the anticipatory speed should be very low, and the warning sign should be placed very close to the ramp.** If the yield conditions are very generous, which usually occurs in out-state areas under lower traffic flows, the default parameters are probably acceptable.

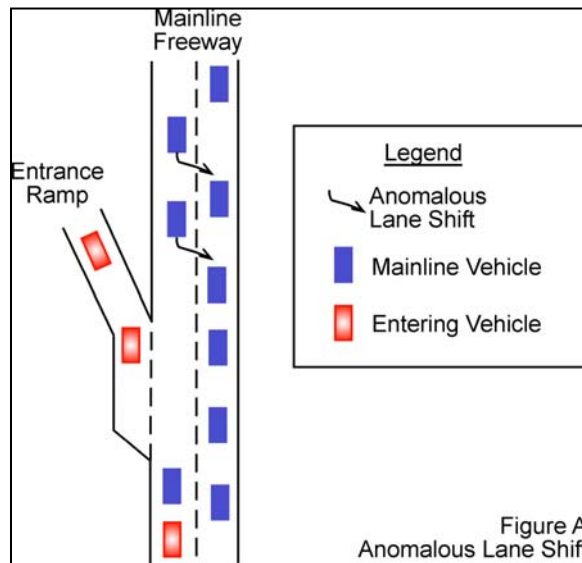


Figure 36 – Anticipatory Lane Change Parameter Illustration

6.2.2.1 Adjust Warning Sign Locations for Exit Ramps and Lane Drops

The default setting for where vehicles begin to change lanes to get to an exit ramp is 2,500 feet. In Minnesota, drivers tend to line up for exits beyond this limit. Field observations are important to make an estimate of when vehicles begin to line up for an exit. This occurs on westbound I-94 in Rogers at the TH 101 exit. At this location, the right lane of eastbound I-94 has a moving queue that is 5 miles long.

6.2.2.2 Adjust Free Flow Speeds/Headway Factors

Under certain circumstances, it may be necessary to lower the free flow speed and/or the headway factor on a link or a series of links. The modeler should correlate this change in the model to a geometric issue that may cause drivers to behave differently. In example, these parameters may require adjustment due to a sight distance constraint caused by a barrier or a bridge abutment. It is important to observe congestion in the field and try to identify the cause. If the congestion does not have something to do with warning signs or a ramp and only occurs at one location in the model, then adjusting the free flow speed or increasing the headway factor should be considered.

6.3 **Model Run Parameters**

The run parameters for the model include the minimum number of runs with different random number seeds required. There is a statistical test that should be applied to determine the sample size (number of runs). This involves picking a confidence level and percent error. For instance, 95th percentile confidence with a 5 percent error. When applying this test to a data set the number of runs required could be few or as many as 30. At this time, the required minimum number of runs with different random number seeds is 5.

6.4 Statistical Evaluation Process

6.4.1 Calibration Testing Process

1. Calculate the average volumes for ramp entry and exit points and mainline sections representing detector stations. This is done for each time interval.
2. For each detector location, graph the simulated volume and detector volumes against time. Visually inspect graphs for large differences in volumes and for simulation delays.
3. Calculate residual errors for each time interval at each ramp and detector station. Check for large residual errors occurring at entry ramps and exit ramps. These are indications of volume coding errors, particularly at entry links. When the residual errors are within 10 percent of the detector data, the simulated volumes are considered acceptable.
4. Review volume data in simulation files after the first run to check for possible coding errors suggested by the graphs and/or residuals.
5. Calculate the average speed for mainline sections representing detector stations. This is done for each time interval.
6. Compare mainline speeds at the detector stations to verify that the model is simulating the same congestion levels as the mainline detectors. When the simulated speeds are within 20 percent of the estimated detector station speeds, the speeds are considered acceptable.
7. Compare the actual ramp queue lengths with the simulated values to verify that ramps are servicing the same number of vehicles. When the residual errors are within 10 percent of the detector data, the simulated volumes are considered acceptable. Differences could be due to a coding error on ramp speed or value.

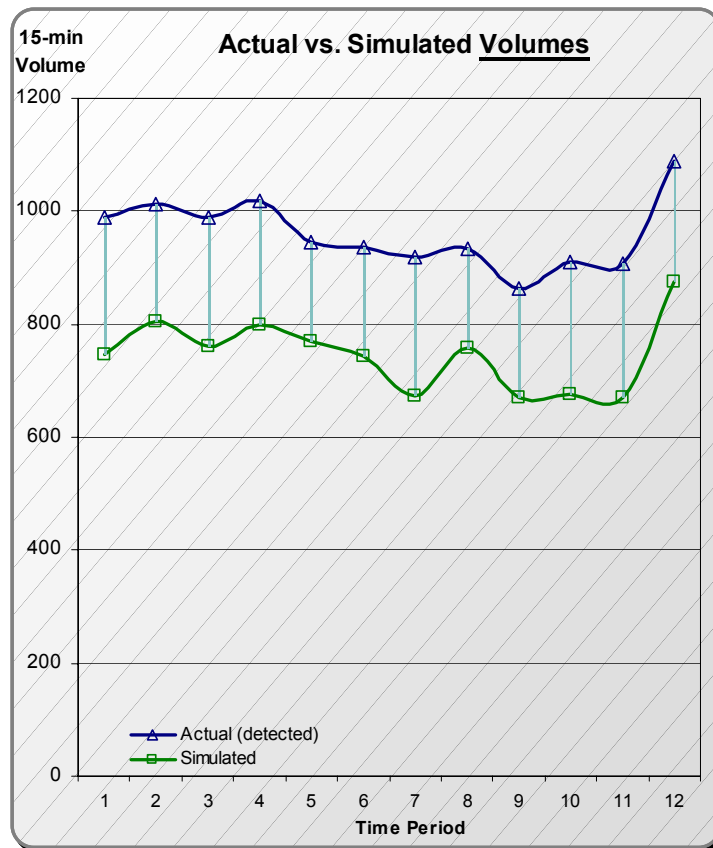


Figure 37 – Sample Statistical Calculations and Graph

6.5 Global Changes – Unknowns

As a last resort, global car following and basic vehicle response parameters should be modified and tested. Changing these parameters requires a more rigorous set of model runs to validate that the car following model should be modified.

Car Following Model

FRESIM parameters include driver behaviors, lane change parameters, and model parameters. These are best left in their default settings. The one model parameter that can be modified is the *minimum separation for generation of vehicles* parameter. This is the minimum time the model uses to produce vehicles at entry links and is the only parameter that controls freeway capacity. But, this is only true at the entry links and does not affect the other links in the modeled system. Entered in seconds, this parameter has a default value of 1.6 seconds that equals a capacity value of 2250 vplph.

To determine this parameter, the mainline entry point detector volumes, in vph, are plotted against their occupancy rates. From this graph, the maximum volume is determined and is divided into 3,600. Auxiliary lane detectors should not be included in this calculation.

There are a large number of parameters for NETSIM including several parameters for driver behaviors. All of these should be left in their default settings.