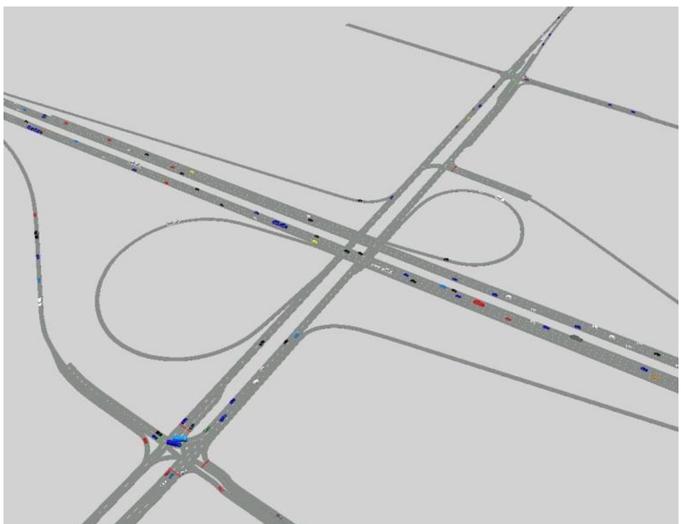

Iowa DOT Microsimulation Guidance

Version 1.0
October 18, 2017

Contents

Tables

Figures

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1 Introduction

This document provides guidance on conducting microscopic simulation (microsimulation) analysis on projects for the Iowa Department of Transportation (DOT). Microsimulation is a powerful tool that provides detailed analysis and offers visualization of traffic conditions under hypothetical conditions. It allows for evaluation of complex conditions that less sophisticated tools often cannot.

This microsimulation guide aims to communicate consistent expectations among practitioners across geographic boundaries and between analysts and project leadership staff of varying technical backgrounds. The resulting reduction in the potential for misunderstanding will help to improve the efficiency and quality of microsimulation modeling that will lead towards successful project delivery. The guidelines and resources presented in this document shall be used when conducting microsimulation analysis for Iowa DOT.

Resources are referenced throughout this guidance that are useful for developing a microsimulation model. Additionally, a comprehensive list of resources that are referenced throughout this document with links to those resources online is located in Chapter 11.

DISCLAIMER: An important note regarding resources presented in this guidance: Resources and policies continue to be updated. The user of this guidance document should review the resources and policies referenced in this guidance for updated materials that may be relevant to conducting microsimulation analysis.

1.1 Application of this Guidance

The primary focus of this guidance is presenting requirements and methods for calibration of microsimulation models and reporting their results, specifically for Iowa DOT projects. Model calibration shall be completed on all microsimulation projects for Iowa DOT unless Iowa DOT provides direction that model calibration is not needed (as may be the case for models used as "proof-of-concept" analysis or as public information using the visualization capabilities of simulation). This guidance does not lead the analyst step by step through the full simulation process; although, the major steps to conducting microsimulation analysis are discussed. It is assumed that analysts are familiar with data collection, model coding, error checking, and other basic tasks associated with microsimulation modeling, or will utilize other resources to support these tasks. References to (and excerpts from) other microsimulation guidance resources are provided as appropriate. The analyst is encouraged to use materials referenced throughout this document as supplemental information when not in contradiction to this guidance document.

The primary focus of this guidance is presenting requirements and methods for calibration of microsimulation models and reporting their results

Although there are several high-quality microsimulation tools available, this guide generally refers to the use of Vissim, a product of PTV. Vissim is microsimulation software familiar to most operations analysts on projects undertaken by Iowa DOT. The expectations for calibration and reporting documented in this guidance are to be applied to any microsimulation software. If software other than Vissim is proposed to be used, additional dialogue with Iowa DOT and the Federal Highway Administration (FHWA) will be necessary to approve the use of the software and define methods and assumptions specific to that software.

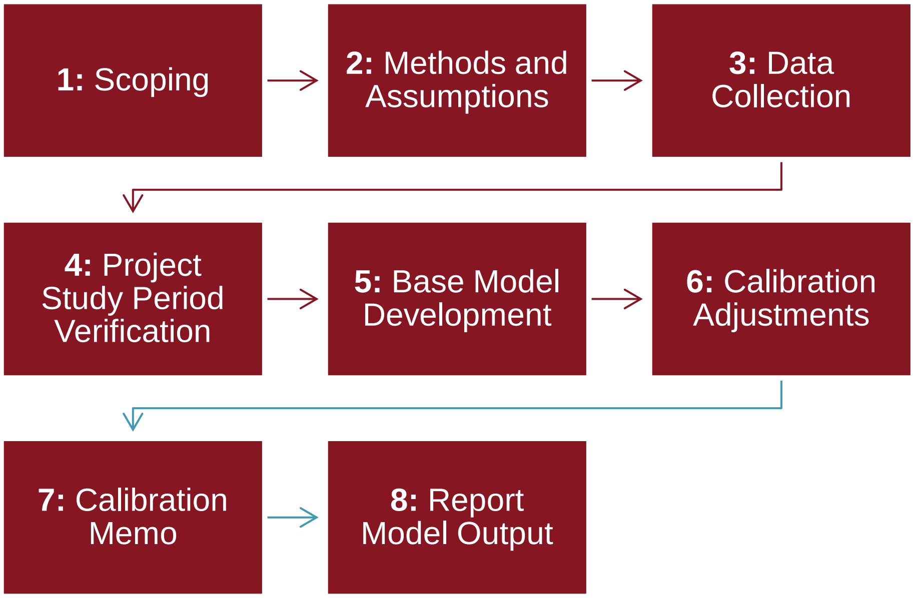
1.2 Audience for this Guidance

This guidance has been developed for technical analysts who perform microsimulation modeling and are familiar with the specific software that will be used on a project. Iowa DOT and FHWA expect simulation modeling efforts to follow applicable guidance, and they will use this document to help assess the suitability of such efforts for use in project analysis. The requirements described and referenced here should be taken into account when establishing the scope and budget for analysis of Iowa DOT projects.

1.3 Microsimulation Process

The main steps to develop a calibrated microsimulation base (existing conditions) model consist of the steps outlined in **Figure 1-1**.

Figure 1-1. Process to Develop a Calibrated Microsimulation Model



Each of these is discussed in more detail in the following chapters. Once these steps have been completed and the model has been approved, it is ready for use in identifying and quantifying the impacts of alternative conditions.

2 Scoping

Within a project scope, the scope for microsimulation tasks should be well-defined for the efficient and effective execution of the microsimulation tasks. Well-defined scope includes detail on the purpose of the simulation, what will be simulated and how it will be simulated. A scope that is prepared with up-to-date information, proper foresight, and well-defined expectations for microsimulation can contribute valuable information and insight to the overall analysis effort.

2.1 Resources for Scope Development

Multiple guides have been developed to provide support in developing scope for microsimulation analysis. Users of this guide are encouraged to use supplemental resources to develop appropriate scope for microsimulation analysis. Some guides that provide discussion on microsimulation scoping include:

- Scoping and Conducting Data-Driven 21st Century Transportation System Analyses – https://ops.fhwa.dot.gov/publications/fhwahop16072/index.htm
- Oregon DOT Protocol for Vissim Simulation – http://www.oregon.gov/ODOT/TD/TP/APM/Add15A.pdf
- Washington State DOT Protocol for Vissim Simulation – http://www.wsdot.wa.gov/Design/Traffic/Analysis/VISSIMProtocol.htm

2.2 Scope Items

Within a project scope, specifics of the microsimulation analysis should, at a minimum, include:

- Microsimulation software to be used
- Modeling limits (typically includes greater coverage than the project area or area of influence)
- Study periods (month of year, day of week and time of day)
- Model duration (e.g., one hour, two hour, etc.)
  - Including duration for model seeding
- Scenarios (e.g., Existing AM, Existing PM, Year 20XX No-Build AM, Year 20XX No-Build PM, Year 20XX Alternative 1 AM, Year 20XX Alternative 1 PM, etc.)
- Data collection plan (including a list of data supplied by Iowa DOT)
- Calibration measures and targets
- Model output to be reported

** Specifics of scope items should be confirmed by Iowa DOT and other stakeholders*

Additionally, scope should include effort to develop a Methods and Assumptions Document for the traffic analysis (including microsimulation methodologies) and a

Calibration Memo. The Methods and Assumptions Document and Calibration Memo are discussed in more detail later in this guidance document.

An integral piece to developing scope to complete microsimulation analysis on Iowa DOT projects is having an understanding of data available from Iowa DOT, and calibration and results reporting requirements (guidance for calibration and reporting results is provided later in this document). Having this understanding will improve the accuracy of the necessary effort for data collection, staff time, and schedule to complete the microsimulation effort for Iowa DOT projects.

It is important to discuss scope items for completing microsimulation analysis with Iowa DOT early in the scoping phase. This is useful to understand availability of data to be supplied by Iowa DOT and project specific expectations for modeling limits, study periods, scenarios, calibration and results. In many instances, Iowa DOT can organize collection of data (including video) using its availability of equipment if they are notified early enough. Having discussions of data needs with Iowa DOT during the scoping phase can provide sufficient notice to the DOT to collect data in coordination with other data collection activities for the project.

Discuss scope items with Iowa DOT early in the scoping phase to coordinate data to be provided by DOT

Model duration should be determined during the scoping phase using readily available INRIX data available from Iowa DOT. Additionally, effort to incorporate microsimulation methods into a Methods and Assumptions document during the project should be considered when scoping the microsimulation effort. The following sections further detail these considerations.

2.3 Model Limits

Model limits often extend beyond the project area (area for improvement) and analysis area suggested by FHWA for access change projects[1]. The analysis area suggested by FHWA to be used on access change projects includes[2]:

- At least the first adjacent existing or proposed interchange on either side of the proposed change in access.
- On the crossroads and local street network, to at least the first major intersection on either side of the proposed change in access.

At a minimum, microsimulation model limits should include the areas listed above and, in many instances, limits beyond these areas. The Oregon DOT and Washington State DOT Protocol for Vissim Simulation documents that were referenced in the scope development resources section (2.1) provide a detailed summary for model limits when using Vissim simulation, and the limits described in those documents can be applicable to other microsimulation platforms.

[1] FHWA, Policy on Access to the Interstate System, May 22, 2017.

[2] Code of Federal Regulations: 23 CFR 625.2(a), 655.603(d) and 771.111(f).

An important model limit consideration that is documented in the Vissim protocol references is the potential need to extend model limits at model entry locations to prevent vehicle queues from spilling back off the network and to provide adequate distance for vehicles to make lane changes for downstream turn decisions. This also provides a benefit to analyzing future year conditions when traffic volumes are likely higher and may result in a greater need to have long entry links.

Model limits at model entry points may need to be extended further upstream to prevent vehicle queues from spilling back off the network and provide adequate distance for turn decisions

When discussing the model area, it may be helpful to include a graphic. An example graphic for model area is provided in the Appendix.

2.4 Model Duration for Scope

The duration of the study periods to be modeled should be estimated during the scoping process. For projects where a freeway is the focus of the project, model duration is most easily determined by reviewing speed data in the study area for congestion (sustained drop in travel speed: below 60% of the 85th percentile speed for locations with free flow speeds greater than or equal to 75 mph, or below 45 mph for locations with free flow speeds less than 75 mph). Speed data should be reviewed from the previous year during the identified study periods. Model duration should include time leading up to a drop in travel speed and time after speeds have recovered near free flow speed. This review should use data from times of the year that reflect typical demand (March through May; September through November) unless the project aims to evaluate conditions during a specific time of year, condition or event.

Model duration should include time leading up to a drop in travel speed and time after speeds have recovered near free flow speed and freeway queues have dissolved

For support in determining model duration, analysts should use INRIX data purchased by Iowa DOT to review speed data. When reviewing speed data for locations of congestion, it is suggested to look at INRIX Analytics of how bottlenecks are tracked as a means to support model duration. This includes identifying when the average travel speed is sustained at or below 60% of the reference speed for more than five minutes. The reference speed is the 85th percentile speed for all times of the day. For model duration, the analyst should identify a duration that begins before the average travel speed declines below 60% of the 85th percentile speed, ends after the average travel speed is above 60% of the percentile speed, and includes a sufficient duration before and after the slowdown of traffic that includes the buildup to congestion and recovery from congestion. *Note: for locations with 85th percentile speed below 75 mph, the user should use 45 mph as the threshold for beginning of a bottleneck rather than 60% of the 85th percentile speed.* For locations where speeds do not drop below 60% of the 85th percentile speed (or 45 mph depending on the 85th percentile

Analysts should use INRIX data through Iowa DOT to determine model duration listed in the scope

speed just mentioned) or the drop in speeds is for a short duration, model duration of one hour may be sufficient. A minimum of one hour should be used for model duration (not inclusive of the model seeding period).

For determination of model duration on projects where arterial roadways with signalized intersections is the focus, INRIX data is less readily available. Determination of model duration on arterial projects is most easily determined by reviewing field data and observations collected as part of the project. During scoping, in advance of collecting field data and observations for the project, count data and local knowledge of duration of congestion should be used to estimate model duration on arterial projects during scoping.

The model duration determined during scoping should be used to determine the duration of data collection during the study periods. The model duration should be reviewed during the project when more data and field observations are available and adjusted as needed.

3 Methods and Assumptions Document

Some projects include development of a project-specific Methods and Assumptions (M&A) document that details forecasting and analysis methods and assumptions to be used on the project. Development of an M&A document occurs during a project after a contract has been initiated, and it is used as a tool to discuss with Iowa DOT and other project stakeholders how analysis tasks will be carried out on the project. M&A documents may be created for any type of change in access project or other large planning/analysis studies. To the extent possible, microsimulation methods and assumptions should be incorporated into the overall M&A document. This instrument is even more important for projects of longer duration where the staff performing or reviewing the work may change over time. If a project M&A document is not developed for the project as a whole, such a document that is specific to the microsimulation effort should be considered and discussed with Iowa DOT during project scoping for applicability on a project for multi-party agreement and for reference throughout the project. Much like the items included in the scope, microsimulation information in an M&A document should include the following information:

An M&A document should be developed that documents the methodology and assumptions for microsimulation analysis on a project

- Microsimulation software to be used
- Modeling limits (typically includes greater coverage than the project area or area of influence)
- Study periods (day of week and time of day)
- Model duration (e.g., one hour, two hour, etc.)
    - Including duration for model seeding
- Model intervals and type of routing to be used (static vs. dynamic; end-to-end vs. point-to-point)
- Scenarios (e.g., Existing AM, Existing PM, Year 20XX No-Build AM, Year 20XX No-Build PM, Year 20XX Alternative 1 AM, Year 20XX Alternative 1 PM, etc.)
- Data collection plan (including a list of data supplied by Iowa DOT)
- Calibration measures and targets
- Model parameters and allowable ranges for use in calibration
- Model output to be reported

Though much of the information in the M&A document is provided in a project scope, the M&A document provides additional detail on how the analysis will be performed. This is beneficial for stakeholders to fully understand the analysis process and provide input early in the project to minimize the need for rework later in the project and identify any potential changes to scope.

4 Data Collection

Data needs to be collected for use in developing and calibrating a model that matches field conditions, such as: geometry, intersection control, travel speeds (or travel times), local driver behavior and general driver gap acceptance. Collecting the right amount and type of existing field data is crucial in model development and calibration. Project purpose and need should be used to determine what performance data should be captured for model development and calibration, and when the data should be collected. The duration of data collection during study periods should be based on the model duration determined during scoping or that which is further defined within an M&A document.

Data may come from third party sources (parties other than Iowa DOT or the entity performing the analysis). This data should be validated for quality to the extent possible. Validation includes using all data collected by Iowa DOT or directly obtained by the entity conducting the analysis to validate third party data. An example of third party data is INRIX speed data. This data should be validated using speed data from Iowa DOT ATRs or speed data obtained by the entity conducting the analysis.

4.1 Resources for Data Collection Needs

Similar to the availability of reference materials discussed in the Scoping chapter of this guidance, resources are available that provide discussion on data collection needs for microsimulation projects, and users of this guide are encouraged to use supplemental resources to understand data collection needs for microsimulation analysis. Some guides that provide discussion on microsimulation data collection include:

- Scoping and Conducting Data-Driven 21st Century Transportation System Analyses – https://ops.fhwa.dot.gov/publications/fhwahop16072/index.htm
- Oregon DOT Protocol for Vissim Simulation – http://www.oregon.gov/ODOT/TD/TP/APM/Add15A.pdf
- Washington State DOT Protocol for Vissim Simulation – http://www.wsdot.wa.gov/Design/Traffic/Analysis/VISSIMProtocol.htm
- Florida DOT Traffic Analysis Handbook – http://www.fdot.gov/planning/systems/programs/SM/intjus/pdfs/Traffic%20Analysis%20Handbook_March%202014.pdf

4.2 Data for Model Development

The bulk of the model development effort consists of coding the model to match field conditions prior to model calibration. To that end, the most important data to collect when developing the base model include geometry, traffic control, volume and speed. Additional data on demand, system performance and operational conditions may also be needed for model calibration, discussed in the following section. The data elements for model development and potential sources for the analyst to obtain them are listed in **Table 4-1**. Additional guidance on vehicle types for a car fleet is provided in **Table 4-2** based on a breakdown of registered vehicle types in Iowa. The vehicle percent distribution for the car fleet in **Table 4-2** is applicable for both freeways and arterials in Iowa unless field data indicates otherwise. For the percent distribution of vehicles for other fleets, such as heavy vehicles, the analyst should use classification count data.

Table 4-1. Data Collection for Model Development

Data Element	Source
Geometry	
Basic lanes/layout	Publicly available online imagery; field observation
Lane and shoulder widths	As-built plans from constructing agency; field measurement
Lengths of acceleration lanes, deceleration lanes and turn lanes	Publicly available online imagery; as-built plans from constructing agency
Substantial grades (≥ 3%)	As-built plans from constructing agency; topographic mapping
Traffic Control	
Control type	Publicly available online imagery; field observation
Signal phasing/timing	Local jurisdiction (City or County)
Signal detection	As-build plans from constructing agency; field observation
Traffic Volumes	
Intersection turn movements and pedestrian crossing volume	Iowa DOT Office of Systems Planning (https://iowadot.gov/maps/digital-maps/traffic/turn) / Office of Systems Planning Traffic Processing/Analyst Coordinator ; local jurisdiction (City or County); project-specific field counts
Automatic Traffic Recorder (ATR) counts	Iowa DOT Office of Systems Planning (https://iowadot.gov/maps/data/automatic-traffic-recorder-reports) / Forecasting and Modeling Team
Origin-destination data	Iowa DOT Office of Systems Planning (https://iowadot.gov/systems_planning/modeling-forecasting-and-telemetrics) / Forecasting and Modeling Team; local Metropolitan Planning Organization or Regional Planning Agency; other third party (e.g., StreetLight Data)
Classification/fleet composition	ATR data (Iowa DOT Office of Systems Planning); project-specific field counts; Iowa Motor Vehicle Division (https://iowadot.gov/mvd/factsandstats#vehiclestats)
Transit data*	Local transit agency
Railway crossing details**	At-grade rail crossing owner (railroad); Federal Railroad Administration (FRA) (http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/crossing.aspx)
Travel Speeds	
Freeway mainline speed	INRIX data (via access from Iowa DOT Office of Traffic Operations ITS Administrator); ATR speed data (via Iowa DOT Office of Systems Planning); field measured (spot speed data)
Ramp speed	Posted advisory speed; design speed from plans; field measured (spot speed data; pilot car)
Arterial	Posted speed

* If applicable; headway/schedule, dwell time, vehicle performance characteristics

** If applicable; frequency and duration of crossing events that affect traffic

Table 4-2. Vehicle Types for Car Fleet

Vehicle Type	Percentage of Car Fleet (%)
Motorcycle	6%
Passenger Car	39%
Sport Utility Vehicle (SUV) and Minivan	30%
Pickup Truck	25%

Source: HDR Engineering, Inc., 2017. Based on 2016 Iowa Vehicle Registrations Summary.

Note: Percent distribution of vehicles for other fleets, such as heavy vehicles, should be based on classification count data.

When using INRIX data to develop speed profiles, the analyst should review INRIX Traffic Message Channel (TMC) data and INRIX XD data. INRIX TMC data provides average speed for a TMC segment over a user specified interval of time. INRIX XD data provides speeds for various percentiles of flow (generally in percentiles of 5 and 10) throughout a day. The XD data is useful for determination of free flow speed, as the 85th percentile speed is commonly used for freeway free flow speed. The XD data that is purchased by Iowa DOT is historical; therefore, the TMC data needs to be used to match days of field observations. The analyst should compare the TMC speeds with the mean speeds in the XD data for a common location and adjust the XD data so that the mean speeds match the TMC speeds. This may include increasing/decreasing all XD percentile speed values by an absolute value. The analyst should then use the adjusted 85th percentile speed for the free flow speed.

4.3 Data for Model Calibration

A model's calibration to field conditions requires careful comparison of model conditions to data collected in the field. Field observations should coincide with field traffic data to remove discrepancy in travel patterns that likely exist from day-to-day variations. Therefore, field observations and collection of traffic data should occur on the same days, unless otherwise approved by Iowa DOT (and FHWA when involving Interstates). It is also important that the existing model represent conditions for which the proposed project is being designed. For many projects (specifically, those not including a reliability analysis), conditions often include the following:

Field observations and collection of traffic data should occur on the same days

- Local schools, institutions, and businesses are operating normally.
- No construction projects that restrict capacity or alter traffic demand are underway in the project area or on adjacent routes.
- Weather does not affect operations or individuals' travel choices.
- Crashes do not occur that affect operations or individuals' travel choices.
- Local events do not affect demand, operations or individuals' travel choices.

It is important to note that variations in items listed above should be considered when performing a reliability analysis. Reliability analysis is further discussed in Chapter 10. Additionally, depending on the project, varying the operational conditions may be desired to test the elasticity of proposed design alternatives. The application of analyses that consider items like reliability, construction and variations in demand should be determined on a project-by-project basis.

The time of year and specific days for data collection should be based on the specific project goals. In Iowa, seasonal traffic variability for the conditions listed above is generally lowest in March through May and September through November. Even during these months, it is important that disruptions to normal traffic demand and routing patterns be avoided to the maximum extent possible when selecting data collection dates.

The data needed for model calibration represent targets for the model's measurements of traffic operations (model output), and they can provide potential cues for reasons model output can vary from what is expected. Data to calibrate a model includes much of the same data that is used in model development. Additional data for model calibration primarily involves that which is collected via field studies and observations. Data and other information to be considered for use in model calibration along with potential sources for that data are presented in **Table 4-3**. Selection of data to be used for model calibration should be based on the project goals (e.g., when a primary goal of project is reduced queue length, queue lengths are a critical piece of data for calibration, whereas speed data may not be as critical).

Table 4-3. Data Collection for Model Calibration

Data Element	Source
Traffic volumes	*See data collection for model development*
Travel speeds	*See data collection for model development*
Travel times	Calculated from INRIX speed data based on the INRIX TMC segment length; field measurement (pilot car); other third party
Duration of congestion	INRIX data; field observation
Spot speeds	Field measurement, ATRs
Delay	Field measurement
Capacity (freeways)	Field measurement; traffic volume throughput at locations experiencing congestion
Saturation flow rate (arterials)	Field measurement
Queue extents	Field measurement/observation
Lane utilization	Field observation
Lane changing	Field observation
Signal cycle/split failures and associated queuing	Field measurement/observation
Atypical driving behavior	Field observation
Impact or approximate count at minor driveways	Field observation
Videos	Field observation

An important resource for field observations is the collection of video footage at key calibration locations. Video allows for independent verification by those not present during field observation and provides an opportunity for review in case additional information is desired after initial, direct field observations are made. Video of field conditions can be a source for many of the data elements listed in **Table 4-3**. In many cases, Iowa DOT can gather video information. The level of video data collection to be employed on the project should be discussed and agreed to during the scoping process.

For collection of travel time data, INRIX TMC data is some of the most accessible and abundant data through coordination with Iowa DOT. Since TMC data is broken into TMC segments, the data most likely will not encompass an entire study area. It may be beneficial to obtain travel time data that encompasses segments longer than the limits of individual TMCs (e.g., travel times to traverse from one end of a study area to another). Travel times calculated from TMC data cannot simply be added together to obtain travel times across multiple TMC segments since traffic demands likely change across different TMC segments. To obtain travel time data for segments longer than TMC segments, pilot car data or other third party data should be collected.

4.4 Data Request from Iowa DOT

To the extent possible, pieces of data to be provided by Iowa DOT for a project should be made with a single request to avoid any overlap in requests or duplication of effort. Data elements for which DOT may provide the data and specific sources within the DOT are outlined in **Table 4-1**. When requesting data, the following information shall be included:

- Official project description
- Full project number
- Microsimulation model limits
- Traffic data request (e.g., 15-minute traffic counts, truck %, traffic forecasts, etc.)
- Facility identifiers and mileposts specific to each type of data requested
- Dates, as appropriate, whether past (for archived data) or future (for counts or traffic projections)
- Analysis team contact (where to send results)

When requesting that new field counts be conducted, the requester should indicate that field observations are planned to coincide with collection of count data. If the specified dates for data collection do not work for Iowa DOT, additional coordination will be needed to ensure that appropriate field observations are conducted at the same time as count data collection.

5 Project Model Duration Verification

The estimate for model duration that is determined during project scoping needs to be verified or refined once additional data is available during the project. This verification is accomplished through field observation of congestion symptoms and/or review of INRIX data that could indicate prolonged drops in speed. INRIX Analytics definition of bottleneck conditions for determining duration of congestion is the length of time the average speed is sustained below 60% of the reference speed (85th percentile speed for all times of the day). For locations with 85th percentile speed below 75 mph, the user should use 45 mph as the threshold for beginning of a bottleneck rather than 60% of the 85th percentile speed. The analyst should also review count data to identify the duration of sustained peak flow rates. If any congestion is observed outside the period during which counts were taken, additional data collection for a longer study period could be warranted.

The analyst should present the findings of the project model duration review with Iowa DOT (and FHWA when involving Interstates) for concurrence.

6 Base Model Development

A base microsimulation model provides the foundation for developing a calibrated model. As mentioned previously, it is assumed that the analyst is familiar with tasks for base model development or will seek out resources to support base model development. A list of resources for model development is provided in the following section. This chapter then calls special attention to select items within base model development that are specific to Iowa, not well documented in the references listed below or are provided for reinforcement.

6.1 Resources for Base Model Development

As mentioned earlier, this microsimulation guidance document is not intended to provide users detailed direction on developing a base model. Analysts who are not well-versed in model development are encouraged to consult the following resources for detailed information:

- Software manual for the chosen microsimulation package
- FHWA Guidelines:
  - Traffic Analysis Toolbox, Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software – https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol3/vol3_guidelines.pdf
  - Update to FHWA Traffic Analysis Toolbox Volume III (release pending)
  - Traffic Analysis Toolbox, Volume IV: Guidelines for Applying CORSIM Microsimulation Modeling Software – https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol4/vol4_guidelines.pdf
- For Vissim simulation:
  - Oregon DOT Protocol for Vissim Simulation – http://www.oregon.gov/ODOT/TD/TP/APM/Add15A.pdf
  - Washington State DOT Protocol for Vissim Simulation – http://www.wsdot.wa.gov/Design/Traffic/Analysis/VISSIMProtocol.htm
- Other State DOTs with microsimulation guidance. Some examples include:
  - Minnesota DOT Advanced CORSIM Training Manual – http://www.dot.state.mn.us/trafficeng/modeling/resources/CORSIMmanual/final%20corsim%20manual%209-19-09.pdf
  - Nevada DOT CORSIM Modeling Guidelines – https://www.nevadadot.com/home/showdocument?id=4520
  - Florida DOT Traffic Analysis Handbook – http://www.fdot.gov/planning/systems/programs/SM/intjus/pdfs/Traffic%20Analysis%20Handbook_March%202014.pdf

Users should consult the most recent guidance available.

6.2 Vehicle Input Time Increments

The project area travel characteristics, purpose and need will drive the duration of model intervals. Vehicle inputs should generally be coded in 15-minute increments to best replicate fluctuations in traffic patterns and support finer reporting of output statistics as needed. The analyst should coordinate with Iowa DOT regarding the characteristics of travel patterns in the model area to determine if smaller increments are more appropriate. Iowa DOT typically collects data in 15-minute increments, although other durations of time increment can be specified prior to data collection. The time increments used in the model should be documented in an M&A document.

6.3 Vehicle Routing

Some microsimulation platforms have capabilities for static and dynamic routing methods that allow for modeling of vehicle routing either statically or dynamically. Dynamic routing within a microsimulation environment only comes into play when there are multiple routes between two endpoints. When there is only a single route between two endpoints in a model, vehicles traveling between two endpoints are forced to use the only route available, and static routing is applicable. For many projects in Iowa, microsimulation models will only have one route to travel between each pair of model endpoints, and static routing should be used. For models that have multiple routing options between endpoints, the decision to use static or dynamic routing should be based on the operating conditions within the area and project objectives. The decision on which routing method to be used on a project should be discussed with Iowa DOT and other project stakeholders and documented in an M&A document.

There are also varying techniques to set up routes within the model. Routing can also be set up to route vehicles through an entire model (from model entry to model exit; referred to as “end-to-end” routing) or between two specific points within the model area (e.g., from a location just downstream of an intersection to a specific leg of the next downstream intersection; referred to as “point-to-point” routing). The routing technique, whether end-to-end or point-to-point, should be based on the operating conditions within the project area and project objectives. The routing technique should be documented in an M&A document.

6.4 Travel Time Segments

Travel time segments should be set up in the microsimulation model to match the upstream and downstream endpoints of field collected travel time data. This includes the limits of INRIX TMC segments, as previously sourced in the Data Collection chapter, and limits of longer segments to capture travel time through an entire study area or subset of the study area. When setting up travel time segments to match the limits of the TMC segments, the analyst should identify locations of INRIX TMC segment endpoints and match the endpoints in the model as close as possible.

6.5 Vissim Link Connector Parameters

In most cases, the default Vissim values for Link Connector Emergency Stop and Lane Change distances are low compared to Iowa field conditions. The analyst should set initial values for Emergency Stop and Lane Change for each type of facility (freeway and arterial) and apply them globally. These values should be revisited during model calibration. Suggestions for initial coding of Connector Emergency Stop and Lane Change distanced include:

- Emergency Stop distance (arterial) ≥ 50 ft.
- Emergency Stop distance (freeway) ≥ 100 ft
- Lane Change distance for freeway Connectors ≥ 4,000 ft.
- Lane Change distance for arterial Connectors ≥ 1,500 ft.

6.6 Model Error Checking

After the initial coding of the base model, the model should be checked for errors prior to calibration. The purpose of error checking is to identify software errors, input errors, or other issues that might misconstrue the model's representation of field conditions. Since this step is performed after the initial coding of the base model, existing peak period demand should be used during the model error checking. Good error-checking should reduce the number and magnitude of calibration adjustments and allow the model to be more useful in testing a broader range of potential facility changes. The model error checking process should be a combination of reviewing model coding, visual inspection of the model animation and reviewing model output.

A review of the base model for errors prior to model calibration is a critical step to avoid rework during model calibration

Microsimulation models contain a number of elements and inputs. It is unlikely that the initial coding of the base model is without errors. All network elements and inputs should be double-checked during model error checking, preferably by a modeler not responsible for the majority of the network coding.

Errors become more apparent when the simulation is running. Model animation at all key calibration locations should be examined for indications of potential inaccurate modeled vehicle behavior, especially where yielding relationships and gap acceptance could affect capacity over the course of the project study period. Specifically, visual inspection is useful to identify locations where the model has slow-downs or queuing, where field observations did not, as a result of the way the model was initially coded.

Reviewing model output can be useful to identify locations where field-measured demand is not served in the model or other performance measures (density, delay, speed, travel time, etc.) seem very different than what was observed in the field. Identifying these locations from the model output can then help to key-in on those locations during visual inspection of the animation.

For more information on error-checking procedures, analysts are encouraged to consult the Oregon and Washington State DOT Protocol for Vissim Simulation resources.

7 Model Calibration

Microsimulation model calibration is the process of making model adjustments to replicate local, field-measured traffic conditions. The process is iterative whereby the model parameters are adjusted until simulation output reasonably matches the field-measured data. A microsimulation model cannot be depended upon to provide reliable information regarding hypothetical transportation facility performance unless it is properly calibrated. Potential pitfalls of poor model development or poor calibration include, but are not limited to:

A properly calibrated microsimulation model is necessary to provide reliable information to make decisions on facility improvements

- Discrepancies between field geometry and traffic control, and those modeled.
- Unrealistic driving behavior.
- Discrepancies between field measured traffic volumes and the amount of traffic served in the microsimulation model.
- Creation of false bottlenecks.
- Inaccurate measurements of traffic operations quality.
- Unreasonable routings of vehicles through the network during dynamic assignment.
- Improper accounting of the effects of (and on) non-motorized travelers.
- Too much or too little sensitivity of traffic operations measures to proposed transportation facility changes.

This chapter focuses on the model output that should be examined against field measures for model calibration, targets for those measures, and guidelines for making adjustments to calibrate a microsimulation model. This chapter also presents the methodology for determining the number of microsimulation runs that should be completed for statistical confidence of the reported results.

7.1 Calibration Measures and their Targets

Microsimulation models can output a variety of results for use in model calibration. FHWA, Oregon DOT, Washington State DOT and Florida DOT guidance documents (referenced previously in this guidance document) present model output measures that should be considered for examination during model calibration and suggested thresholds for constituting the model to be calibrated. As noted previously, an update to the FHWA Traffic Analysis Toolbox, Volume III is pending and it will update the process for model calibration.

The measures selected for calibration and their targets for model calibration should be established based on the purpose and need of the project. At a minimum, it is suggested that volume throughput and speeds (or travel times) are used as metrics during model calibration. The following list provides common microsimulation output/metrics that should be used as a guide for metrics to consider for comparison against field measures when determining whether a model is calibrated to local conditions. Note that some projects may benefit from using other metrics for calibration to meet project objectives.

Measures selected for model calibration and their targets for model calibration should be based on the purpose and need of the project

- Volume throughput
- Speed
- Travel time
- Queues
- Duration of congestion (length of time with sustained drop in travel speed)
  - Either observed in the field or calculated from speed data (duration of time that the average travel speed is sustained at or below 60% of the 85th percentile speed for locations with free flow speed greater than or equal to 75 mph or below 45 mph for locations with free flow speed less than 75 mph).
- Capacity

When gathering results from a microsimulation model for use in calibration, the location within the model area for results needs to be consistent with the location of field data.

Based on guidance available at the time of development of this guidance and current best practices, suggested calibration items and their targets are summarized in **Table 7-1**. The calibration items and targets listed in **Table 7-1** should be a starting point for the discussion with Iowa DOT and other project stakeholders for which items and their targets should be used on a project. As mentioned previously, project purpose and need should be used to further define calibration items and their calibration targets.

Table 7-1. Suggested Calibration Items and Targets

Calibration Item	Calibration Target
Volume Throughput	
Individual movement flows ≤ 700 veh/hr	Within 100 vehicles of field data for more than 85% of movements in model area
Individual movement flows between 700 and 2,700 veh/hr	Within 15% of field data for more than 85% of movements in model area
Individual movement flows > 2,700 veh/hr	Within 400 vehicles of field data for more than 85% of movements in model area
Capacity	Within 10% of field data at locations experiencing congestion
Speed	
Link speed	Within 10 mph of field data for more than 85% of network links
Travel Time	
Field travel times ≤ 7 minutes	Within 1 minute of field data for more than 85% of travel time segments
Field travel times > 7 minutes	Within 15% of field data for more than 85% of travel time segments
Queues	
Queues formed in free flow areas	All locations with formed queues are modeled
Queue length	Within 20% of field measured queue length
Congestion	
Duration of congestion	Within 15 minutes from the beginning and end of congestion

Source: HDR Engineering, Inc., 2017. Based on guidance in FHWA Traffic Analysis Toolbox Volume III, Oregon DOT Protocol for Vissim Simulation, Washington State DOT Protocol for Vissim Simulation and Florida DOT Traffic Analysis Handbook.

The interval durations for which models are calibrated should be based on the operating conditions within the model area and the project objectives. For many projects, it may be appropriate to calibrate models at intervals of 15 minutes or less throughout the model period. This entails comparing model output for each 15-minute or finer interval to field measurements for the calibration items established on the project. An example of when calibrating a model for intervals of 15 minutes or finer may be needed is when trying to replicate build up and recovery of congestion within the model area. For model calibration on projects with little or no measured/observed congestion in the model area, it may be appropriate to compare the model output as an hourly aggregate to the hourly aggregate of field measurements. Demand and operations will fluctuate throughout the hour; however, models that have little or no congestion may have little benefit from calibrating to finer increments since they would not show build up and recovery of congestion. Again, field observations and data should be used to determine what is most appropriate on a project for the interval duration of model calibration.

The analyst should document the calibration targets and intervals of model output for use in calibration in an M&A document. These may need to be refined after field observations and data are gathered.

7.2 Calibration Adjustments

Model calibration adjustments should be undertaken with the goal of making only the incremental changes necessary to produce a calibrated model, rather than trying to customize the entire model for perfect replication of field conditions. This section primarily focuses on calibration adjustments made in Vissim. If software other than Vissim is proposed, the analyst must coordinate closely with Iowa DOT (and FHWA when involving Interstates) to establish consensus on appropriate default values prior to modifying any calibration settings and is encouraged to use research and guidelines specific to that software, in addition to following the software-neutral parts of this guidance document, when making calibration adjustments.

For Vissim microsimulation analysis, PTV has developed North American Default Settings (available from PTV upon request) that should be reviewed and considered as a starting point for model calibration. The North American Default Settings include updates to fleet composition and units from those in the out-of-the-box Vissim default file. The analyst should use the fleet composition in the North American Default Settings only for assignment of vehicles into the model; fleet composition specific for the model area needs to be based on obtained data. For additional information on freeway simulation projects, the analysis should consult "Vissim Calibration for Urban Freeways, CTRE, December 2015" (http://www.intrans.iastate.edu/research/documents/research-reports/VISSIM_calibration_for_urban_freeways_w_cvr.pdf) with attention to the applicability of its guidelines to the project.

Calibration adjustments consist of global and/or local adjustments

The parameters to be adjusted for model calibration depend on the scope of the target discrepancy between modeled and observed conditions. Parameter adjustments may need to be made on a global and/or local level. Changes to global parameters should be considered when a change is desired to affect all elements in an area of the model or network-wide. Changes to global parameters are generally made at the network level and may impact sub-areas or groupings of similar network features (e.g., all links with the same assigned driving behavior). Changes to local parameters should be considered when a change is needed at an isolated location to match field conditions for this location and adjacent locations that may be impacted by the model operations at this location. Changes to local parameters are generally made at the link level.

The analyst should generally address global calibration adjustments prior to making local calibration adjustments, as global adjustments may resolve the need to make some local adjustments. However, the process can be iterative, and the analyst may need to make some local adjustments before global changes or revisit global adjustments after making local adjustments. Suggestions for global and local model parameters to focus on during model calibration and ranges to be used for these parameter values are provided in the following sections.

The analyst should provide a summary of potential calibration parameters to be used during calibration and their allowable ranges in an M&A document. Additionally, model adjustments made during calibration should be documented throughout the calibration process. Documenting calibration adjustments can aid the analyst in knowing what values have already been modeled during earlier calibration tests. Documenting calibration adjustments is also needed for a calibration memo (discussed in the following chapter).

7.2.1 Global Adjustments

Global model calibration adjustments should be used to best match operations of the typical road sections. In Vissim, the car-following logic is the primary influence of saturation flow rate, or the functional capacity on any given link. Saturation flow rate is not a direct input, so changes in global capacity must be made by adjusting car-following parameters that govern driver behavior in the model. Prior to adjusting driving behavior parameters, it is recommended that separate driving behaviors be created and assigned for merge/diverge and weave areas, as these areas typically have operational characteristics in the field that vary from basic freeway sections. Vissim driving behavior parameters the analyst may consider adjusting during calibration and the suggested ranges for their values are presented in **Table 7-2**. Driving behavior parameters and the ranges that will be allowed on a project should be established on a project-by-project basis through coordination with Iowa DOT and other project stakeholders.

Global adjustments in Vissim are primarily to car following and lane changing driving behavior

Table 7-2. Vissim Global Calibration Parameters and Suggested Ranges

Calibration Parameter*	Default	Suggested Range	
		Basic Segment	Merge/Diverge/ Weave
Freeway Car Following (Wiedemann 99)			
CC0 Standstill Distance	4.92 ft	>4.00 ft	>4.92 ft
CC1 Headway Time	0.9 s	0.7 to 3.0 s	0.9 to 3.0 s
CC2 ‘Following’ Variation	13.12 ft	6.56 to 22.97 ft	13.12 to 39.37 ft
Arterial Car Following (Wiedemann 74)			
Average Standstill Distance	6.56 ft	>3.28 ft	
Additive Part of Safety Distance	2.00	1 to 3.5**	
Multiplicative Part of Safety Distance	3.00	2 to 4.5**	
Lane Change			
Maximum Deceleration	-13.12 ft/s² (Own) -9.84 ft/s² (Trailing)	< -12 ft/s² (Own) < -8 ft/s² (Trailing)	
-1 ft/s² per Distance	200 ft (Freeway) 100 ft (Urban)	>100 ft (Freeway) >50 ft (Urban)	
Accepted Deceleration	-3.28 ft/s² (Own) -1.64 ft/s² (Trailing)	< -2.5 ft/s² (Own) < -0.5 ft/s² (Trailing)	
Min. Headway (Front/Rear)	1.64 ft	1.5 to 6 ft	
Safety Distance Reduction Factor	0.6	0.1 to 0.9	
Max. Deceleration for Cooperative Breaking	-9.84 ft/s²	-32.2 to -3 ft/s²	
Overtake Reduced Speed Areas	Not checked	Depends on field observations	
Cooperative Lane Change	Not checked	Depends on field observations (should be checked in most freeway merge/diverge/ weave areas)	
Maximum Speed Difference	6.71 mph	<20 mph	
Maximum Collision Time	10.00 s	<15 s	
Link Connector			
Emergency Stop	16.4 ft	≥16.4 ft (Depends on field observations)	
Lane Change	656.2 ft	≥656.2 ft (Depends on field observations)	
per lane	Not checked	Depends on field observations	

Source: HDR Engineering, Inc., 2017. Based on guidance in Florida DOT Traffic Analysis Handbook and suggestions provided by PTV.
* Parameters available in Vissim that are not listed are suggested to remain at the default values.
** The relationship should be based on the Vissim User Manual (Multiplicative = Additive + 1).

For calibration of freeway elements, it is suggested to begin by making adjustments to the CC1 Headway Time, Safety Distance Reduction Factor and Cooperative Lane Change parameters, as they tend to have a large impact on freeway operations and may limit the need for further global calibration adjustments. As discussed in the Base Model Development chapter, the default Vissim values for Connector Emergency Stop and Lane Change distances are often low compared to Iowa field conditions. Calibration with global parameters may include adjustment to the initial values for Emergency Stop and Lane Change that were assigned for each facility type during base model development.

For parameters that the analyst desires to adjust that are not listed in **Table 7-2** or values that are outside of the allowable ranges listed in **Table 7-2**, the analyst should provide justification to Iowa DOT (and FHWA when involving Interstates) and gain concurrence.

7.2.2 Local Adjustments

Local model calibration adjustments should be used to best match operations at isolated locations. There are a number of local adjustments that the analyst might determine are needed or appropriate to support model calibration. Some common examples of local adjustments to address discrepancies between model output and field measures are shown in **Table 7-3** along with some example situations for making these types of adjustments. There are no specific parameter thresholds for local model features; rather, the analyst should visually inspect model animations for realistic driving behavior resulting from local adjustments.

Table 7-3. Local Calibration Strategies

Local Adjustment to Address Model Discrepancy to Field Conditions	Examples of Applied Strategy
Modify model geometry	• Extend link onto a shoulder area for locations where traffic is observed to use that pavement.
Adjust Conflict Area or Priority Rule parameter values	• Increase/decrease Conflict Area Front Gap or Rear Gap time to mimic less/more aggressive driving behavior for gap acceptance of conflicting traffic at junctions. • Increase/decrease Priority Rule Min. Gap Time to mimic less/more aggressive driving behavior for gap acceptance of conflicting traffic at junctions. • Add Priority Rule conflict markers to lanes adjacent to a destination lane to mimic less aggressive driving behavior for gap acceptance of conflicting traffic at junctions.
Adjust Connector parameter values	• Increase Connector lane change distance to reduce or eliminate slowing or stopping of vehicles near a junction. • Decrease Connector lane change distance at a lane drop location to increase utilization of the drop lane at upstream locations.
Modify traffic control	• Replace a stop sign in the model with a Reduced Speed Area with a low speed (i.e., 1-3 mph) to mimic location that is treated by most drivers as a “rolling stop”. • Modify detection area size and/or signal controller vehicle extension/gap times to better match field observations of signal phase gap-out conditions and the resulting intersection queues.
Modify desired speed	• Increase speeds for a desired speed profile assigned to an arterial link to reduce travel time between intersections to match field observed platooning and intersection queuing.
Modify vehicle input demand flows	• Modify demand flows at select model entry locations to better match field observations of congestion effects and the flow counted as volume throughput within the model area. If demand volume at input areas is overcapacity, and counted volumes are lower than demand, adjustments to input flow rates may be needed to achieve congestion levels necessary.

Source: HDR Engineering, Inc., 2017.

7.3 Model Confidence Determination (Number of Simulation Runs Necessary)

Microsimulation models are stochastic, which incorporate random variability into the models. Models need to be run multiple times with different random number seeds to minimize the impact of the stochastic nature of the model on the results. For many project models, 10 runs with different random numbers are adequate. However, the formula below should be used to ensure that the average output values reported are true statistical representations of the average at a 95% confidence level. The determination for minimum number of runs should be made after the model is calibrated. Once the number of runs is determined from the calibrated base models, this number of runs should be performed for subsequent scenarios. The user is encouraged to review resources mentioned throughout this guidance document for additional guidance on determination of the minimum number of simulation runs.

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

N =	Number of required simulation runs
$t_{0.025,N-1}$ =	Student t-statistic for two-sided error of 2.5 percent (5 percent total) with N-1 degrees of freedom (95% confidence level)
s =	Standard Deviation about the sample mean for selected measure
R =	Confidence interval for the true mean

8 Calibration Memo

The calibration memo documents how the model was calibrated and shows model results compared to field measures. To some degree it will repeat the information in an M&A document, but its intent is to present the model adjustments made to calibrate the model and demonstrate that the model replicates the traffic operating conditions resulting from field data collection and observations in accordance with the agreed-upon microsimulation methods and assumptions. Content in the calibration memo should include the following:

- Model limits.
- Model duration determination.
  - Document data sources used for determination.
  - Present analysis and rationale for determination.
- Description of calibration measures and their targets (this should match those listed in an M&A document).
- Summary of model parameters and allowable ranges used for calibration (this should match those listed in an M&A document and include any additional concurrence by Iowa DOT (and FHWA when involving Interstates) to modify the allowable ranges listed in the M&A document).
- Details and rationale regarding calibration adjustments.
- Model confidence determination (minimum number of runs necessary) for key calibration measures.
- Final model comparison of results to field data and observations showing the model meets calibration targets. Discuss locations where the model results do not match calibration targets and coordination with Iowa DOT (and FHWA when involving Interstates) that was used to gain acceptance for these results not matching the project identified targets.

An example calibration memo is provided in the Appendix.

9 Reporting of Model Output

MOEs reported from microsimulation results should be defined to meet the specific goals of a project through coordination with Iowa DOT and other project stakeholders

Microsimulation models can report a variety of output and that output can be post-processed in a variety of ways. Through development of the project scope and M&A document, coordination with Iowa DOT and other project stakeholders should be used to confirm the measures of effectiveness (MOEs) to be summarized from the microsimulation output and the format the output is reported. These MOEs may be above and beyond those which were used for model calibration. Output from all model runs should be averaged before calculating/reporting MOEs.

9.1 Reporting MOEs

The analyst should identify MOEs that are most critical to their project with concurrence from Iowa DOT (and FHWA when involving Interstates) via an M&A document. The following list provides a summary of common MOEs that should be considered for reporting on a project in Iowa, many of which are also suggested to be used as model calibration measures:

- Volume throughput and percentage of demand served
- Speed
- Travel time
- Queue length
- Duration of congestion
- Density/Level of Service (LOS)
- Delay/LOS

Reporting LOS from a microsimulation model requires careful consideration since this is not an output in many microsimulation platforms or, at best, is not reported with consistency to the Highway Capacity Manual (HCM). Additional detail on reporting LOS is provided in a sub-section below.

The interval duration for reporting MOEs, whether MOEs are reported every 15 minutes, hour or other duration, should be established on a project basis based on the project objectives. For models with durations longer than one hour or have peaking within an hour that has a discernable impact to operations, it may be desirable to report MOEs at finer increments than one hour.

The following sections provide direction for reporting the MOEs listed above. MOEs should be reported using a combination of tabular and graphical format. Example tables and figures for reporting MOEs are provided in the Appendix.

9.1.1 Volume Throughput

Volume throughput and percent of demand served during the peak periods should be reported by movement for key freeway and arterial movements. It can also be useful to report volume throughput and percent served for the entire network during the peak periods to compare the ability of various alternatives to serve the demand. For most projects in Iowa, volume throughput and percentage of demand served reported as an hourly aggregate is appropriate. Some projects may necessitate reporting volume throughput and percent served at finer increments than one hour to evaluate the variation in throughput throughout the period.

Vissim output to capture volume throughput can be obtained using evaluations from Links, Nodes or Data Collection Points. Volume throughput for freeway movements should be obtained from Links and Data Collection Points. Volume throughput for arterial movements should be obtained from Nodes and Data Collection Points.

9.1.2 Speed

If speed is selected as a reporting measure, the analyst should report speed for all freeway mainline segments between ramp junctions. For some projects in Iowa, speed reported at an hourly aggregate is appropriate. Other projects may necessitate reporting speed at finer increments than one hour to evaluate the change in speed throughout the period.

Vissim output to capture speed can be obtained using evaluations from Links, Data Collection Points or Vehicle Travel Time segments.

9.1.3 Travel Time

If travel time is selected as a reporting measure, the analyst should report travel time for freeway mainline segments to capture travel time between ramp junctions and through the entire network (if appropriate). For very large networks, the number of vehicles traveling from one end of the network the other may be limited and it may be more appropriate to look at a travel time segment that combines multiple freeway segments with logical breakpoints (such as a systems interchange). Travel time segments through a sub-area (i.e., travel time segment that traverses through multiple interchanges, or through turning decisions at an interchange) should be considered for locations where alternatives are being considered. For some projects in Iowa, travel time reported at an hourly aggregate is appropriate. Other projects may necessitate reporting travel time at finer increments than one hour to evaluate the variation in travel time throughout the period.

Vissim output to capture travel time is obtained using evaluations from Vehicle Travel Time segments.

9.1.4 Queue Length

If queue length is selected as a reporting measure, the analyst should report queue length for all freeway mainline segments where queues form and at intersection approaches. Queue length can be reported or calculated for various percentiles of peak flow. Typically, reporting the maximum queue length is appropriate as it provides worse-case conditions that can be used to identify locations with queue spillback concerns. For some projects in Iowa, reporting the queue lengths at an hourly level is appropriate. Other projects may benefit from reporting queue length at finer increments than one hour to determine the change in queue length throughout the period.

Vissim output to capture queue length is obtained using evaluations from Nodes or Queue Counters.

9.1.5 Duration of Congestion

If duration of congestion is selected as a reporting measure, the analyst should report the duration of congestion for all freeway locations that meet criteria established for congestion. As mentioned previously, it is suggested to look at INRIX Analytics of how bottlenecks are tracked for measuring congestion. This includes identifying when the average travel speed is sustained at or below 60% of the 85th percentile speed for more than five minutes. For locations with free flow speed below 75 mph, the analyst should look for sustained speeds below 45 mph to identify congestion. Duration of congestion should be reported at increments of 15 minutes or less.

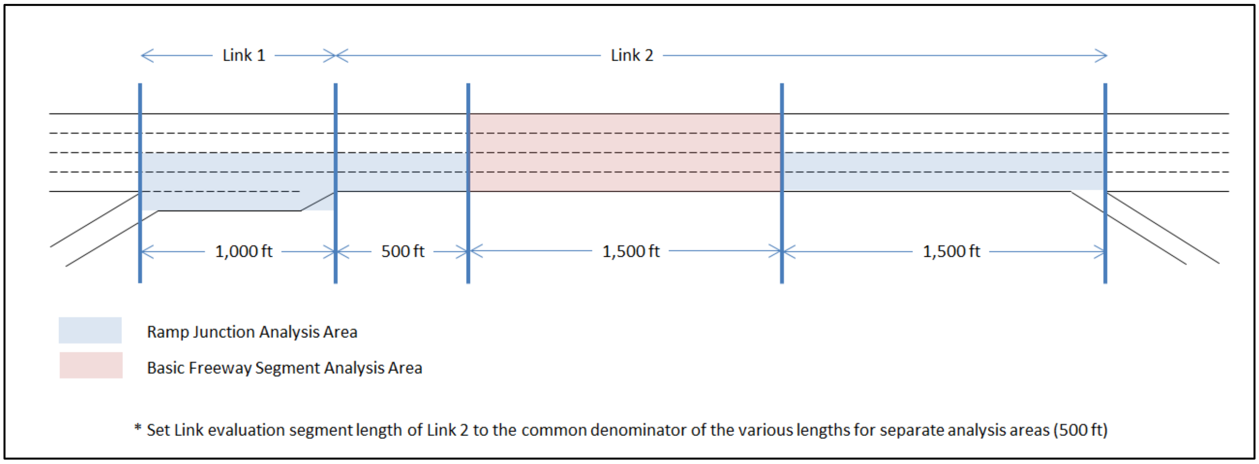
Vissim output to capture duration of congestion can be obtained from speed data using evaluations from Links, Data Collection Points or Vehicle Travel Time segments.

9.1.6 Density/LOS

If density and LOS are selected as reporting measures, the analyst should consider reporting them for all basic freeway segments, ramp junction areas and weave segments. Depending on the project, it may only be necessary to report density and LOS for select locations within the model area. If density and LOS are selected as reporting measures and it is proposed that these measures are only reported for a subset of the model area, the decision on the reporting area limits should be discussed with Iowa DOT and other project stakeholders and documented in an M&A document. For most projects in Iowa, it is appropriate to report density and LOS for the peak 15 minutes of demand during the model periods. This is consistent with the methodology for reporting these MOEs in the 6th edition of the HCM (HCM 6).

Vissim output to capture density can be obtained using evaluations from Links and LOS is determined through further computation of captured density. For reporting LOS consistent with HCM 6 segment definitions, link evaluation segment length values in Vissim should be set up to report results consistent with the definitions of basic freeway segments, ramp junction areas and weave segments in the HCM 6. As an example, the link evaluation segment length for a Link between two interchanges should be set up such that there is separate output from the portion of the Link that meets the definition of a basic freeway segment and from the portion of the Link that meets the definition of a ramp influence area. Evaluations from Links should be also reported by lane to allow for aggregation of specific lane data that is needed for calculating density in a ramp influence area. An example of determining segment length for Link evaluation is shown in **Figure 9-1**. Lane results for each segment should be aggregated as needed to calculate an overall density within a basic freeway segment, ramp junction area or weave segment.

Figure 9-1. Link Evaluation Segment Length Example



Additionally, Vissim reports density in units of vehicles/mile/lane. The HCM uses density in passenger cars/mile/lane for reporting LOS. When using density to report LOS, Vissim density needs to be converted to passenger car equivalents using equations from the HCM 6. This provides an estimate of density as a passenger car equivalent that can be used to look up LOS. The HCM 6 provides discussion on the comparison of microsimulation density and HCM density. The HCM 6 provides density thresholds for each LOS for basic freeway segments, ramp junction areas and weave segments.

9.1.7 Delay/LOS

Delay and LOS should be reported for all intersections as an overall intersection MOE. For most projects in Iowa, it is appropriate to report delay and LOS for the peak 15 minutes of demand during the model periods. This is consistent with the methodology for reporting these MOEs in the HCM 6.

Vissim output to capture delay can be obtained using evaluations from Nodes. The HCM 6 provides delay thresholds for each LOS for signalized and unsignalized intersections.

10 Other Project Considerations

Though the focus of this guidance is on model calibration and reporting for traffic demand and geometric conditions that largely do not fluctuate within an alternative, there are a number of other project considerations for which microsimulation analysis may be needed. This chapter highlights some of those considerations with respect to microsimulation analysis.

10.1 Reliability Analysis

The reliability of travel has become a heightened focus for agencies and practitioners as they plan for new or improved transportation infrastructure. Recognizing that roadway operating conditions can fluctuate from day to day as a result of variations in demand, weather or incidents, the transportation industry has started to place an increasing priority of evaluating roadway reliability.

The pending update to FHWA Traffic Analysis Toolbox Volume III, referenced throughout this guidance document, will include a focus on reliability analysis to be included on microsimulation projects. The pending guidance for inclusion of reliability analysis builds off of the Strategic Highway Research Program 2 (SHRP 2) and SHRP 2 L04 research. The analyst should use the guidance from the update to FHWA Traffic Analysis Toolbox Volume III and SHRP 2 when determining model adjustments to accommodate reliability analysis.

The need for reliability analysis on a project should be determined on a project by project basis and should be used to support the project objectives. Inclusion of reliability analysis should be discussed during project scoping with Iowa DOT and other project stakeholders.

10.2 Construction Analysis

Evaluating operations of traffic during construction conditions can be useful when trying to understand the impacts during those conditions and make decisions about how improvements should be constructed or staged. Depending on the geometric and anticipated operating conditions during construction, it may be necessary to use a sophisticated tool like microsimulation to appropriately evaluate these conditions. Modeling traffic during construction with microsimulation may include any or all of the following alterations to a calibrated base model:

- Geometry to match the construction conditions.
- Modifications to traffic control.
- Speeds based on design, advisory or measured speeds on roadways throughout the construction area.
- Driving behavior that reflects operating conditions within the construction area (this may be different from what was in a calibrated model).

- Revision to traffic demand through the model based on the change in operating conditions within the construction area.

The need to evaluate conditions during construction should be determined on a project by project basis and should be used to support the project objectives. Inclusion of construction analysis should be discussed during project scoping with Iowa DOT and other project stakeholders.

10.3 Transportation System Management and Operations (TSMO)

Iowa DOT has taken steps to make Transportation System Management and Operations (TSMO) a core business practice. TSMO optimizes the existing infrastructure through the implementation of multimodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve the security, safety, and reliability of the transportation system. Iowa DOT has developed guidance for performance measures that are included within TSMO, including reliability, which was mentioned above. Iowa DOT has developed a TSMO Plan that identifies sources for evaluating these performance measures. Depending on the project, TSMO evaluations may need to be incorporated into the project to support decisions on system improvements. The need to include TSMO in addition to microsimulation modeling should be discussed during project scoping with Iowa DOT and project stakeholders.

11 Resources

The following is a summary of resources listed throughout this guidance:

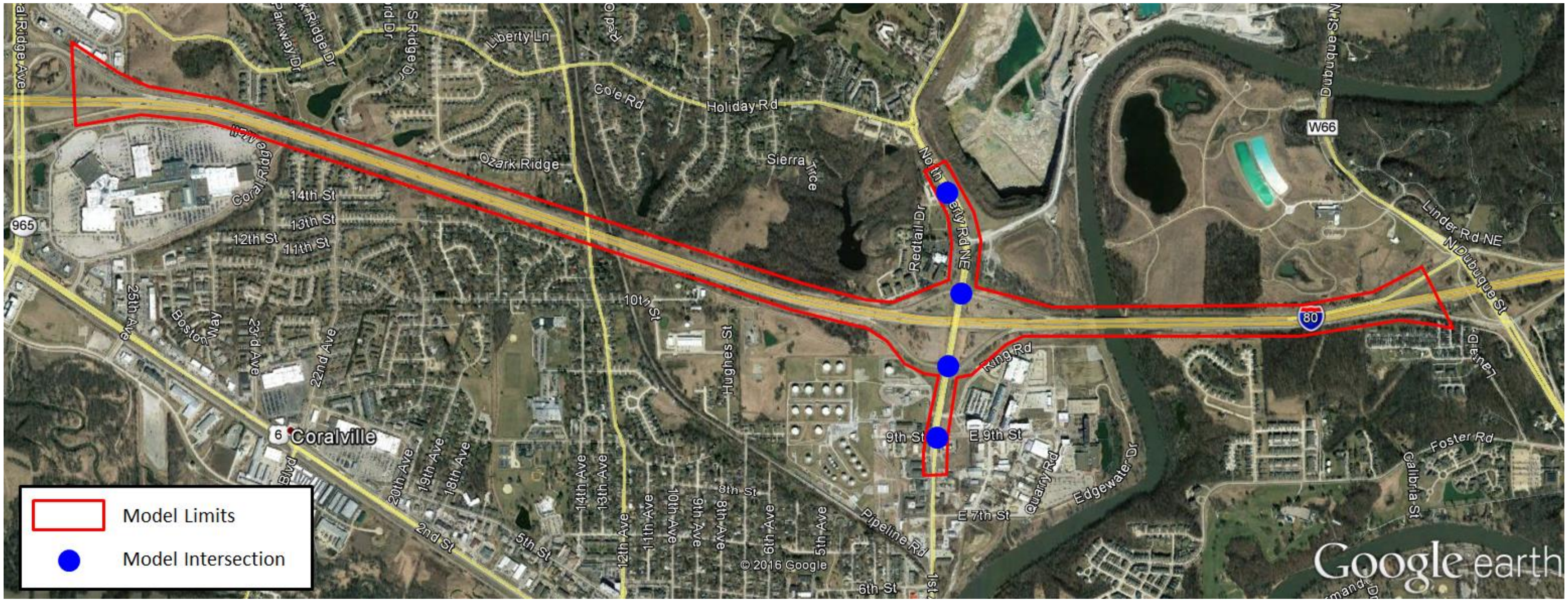
- Scoping and Conducting Data-Driven 21st Century Transportation System Analyses, FHWA – https://ops.fhwa.dot.gov/publications/fhwahop16072/index.htm
- Traffic Analysis Toolbox, Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software, FHWA – https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol3/vol3_guidelines.pdf
- Update to FHWA Traffic Analysis Toolbox Volume III (release pending)
- Traffic Analysis Toolbox, Volume IV: Guidelines for Applying CORSIM Microsimulation Modeling Software, FHWA – https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol4/vol4_guidelines.pdf
- Oregon DOT Protocol for Vissim Simulation – http://www.oregon.gov/ODOT/TD/TP/APM/Add15A.pdf
- Washington State DOT Protocol for Vissim Simulation – http://www.wsdot.wa.gov/Design/Traffic/Analysis/VISSIMProtocol.htm
- Florida DOT Traffic Analysis Handbook – http://www.fdot.gov/planning/systems/programs/SM/intjus/pdfs/Traffic%20Analysis%20Handbook_March%202014.pdf
- Minnesota DOT Advanced CORSIM Training Manual – http://www.dot.state.mn.us/trafficeng/modeling/resources/CORSIMmanual/final%20corsim%20manual%209-19-09.pdf
- Nevada DOT CORSIM Modeling Guidelines – https://www.nevadadot.com/home/showdocument?id=4520
- Vissim Calibration for Urban Freeways, CTRE – http://www.intrans.iastate.edu/research/documents/research-reports/VISSIM_calibration_for_urban_freeways_w_cvr.pdf

12 Appendix

- Example Model Limits Figure
- Example Calibration Memo
- MOE Reporting Examples
  - Volume Throughput
  - Speed
  - Travel Time
  - Queue Length
  - Density/LOS
  - Delay/LOS

Example Model Limits Figure

Figure. Model Limits



<u>Freeway Analysis Included:</u>
I-80 from east side of Coral Ridge Ave interchange to west side of Dubuque Street interchange

<u>Intersection Analysis Included:</u>
1st Ave / Russell Slade Drive (stop-controlled)
1st Ave / I-80 WB Ramp Terminal (signalized)
1st Ave / I-80 EB Ramp Terminal (signalized)
1st Ave / 9th Street (Signalized)

Example Calibration Memo

Memo

Date:	Date
Project:	I-80/35/235 Northeast Mixmaster – Proposed Interchange Improvements Project Number IMN-035-4(159)87–0E-77
To:	Iowa DOT and FHWA Project Management Team
From:	Consultant
Subject:	Existing Conditions Vissim Calibration

Introduction

This memorandum summarizes the calibration efforts of the Vissim microscopic simulation models used to assess traffic operations within the defined area of influence for the I-80/35/235 Northeast Mixmaster (NEMM) – Proposed Interchange Improvements project. Model calibration included:

- Determining peak period duration.
- Adjusting model parameters to match local driving conditions.
- Determining the number of model runs to reach statistical significance.
- Comparing model output to field collected data to check model calibration.

Model Limits

Model limits included the following:

- I-80 from NW 2nd Street on west end to U.S. 65 on the east end
- I-35/235 from Euclid Avenue on the south end to Corporate Woods Drive on the north end.
- Intersections:
    - Broadway Avenue/NE 14th Street (Signalized)
    - Eastbound I-80/NE 14th Street (Signalized)
    - Westbound I-80/NE 14th Street (Signalized)
    - 51st Avenue/NE 14th Street (Signalized)
    - 25th Street/Euclid Avenue (Signalized)
    - Northbound I-235/Euclid Avenue (Signalized)
    - Southbound I-235/Euclid Avenue (Signalized)
    - Delaware Avenue/Euclid Avenue (Signalized)
    - Northbound I-35/Corporate Woods Drive (Unsignalized; will be signalized in 2015)
    - Southbound I-35/Corporate Woods Drive (Unsignalized; will need to be signalized before 2050 based on completed IOR)
    - 22nd Street/Corporate Woods Drive (Signalized)

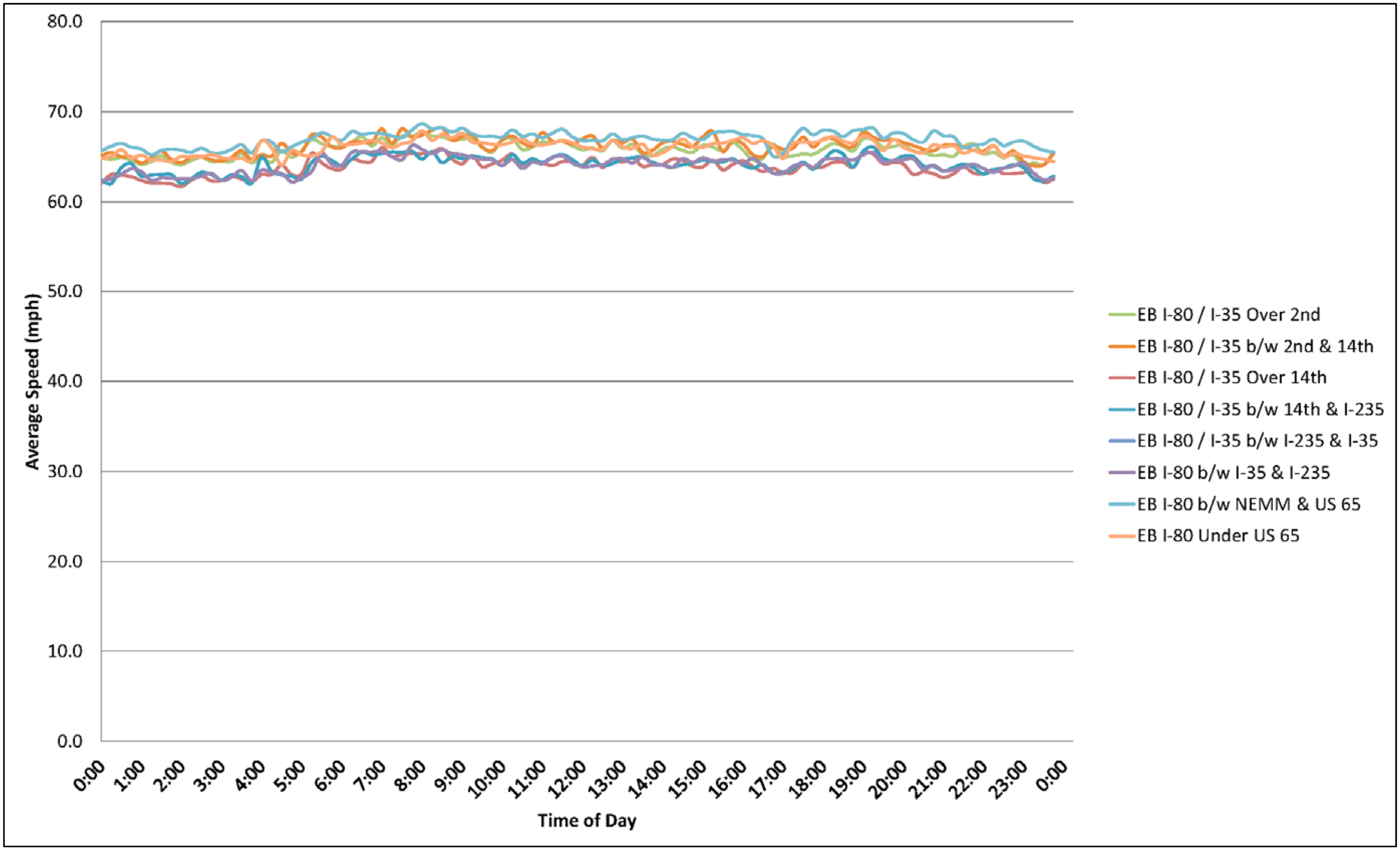
Model Duration

A review of the 2010 Highway Capacity Manual (HCM) traffic analysis results and INRIX speed data was performed to determine the model duration that would be needed for the analysis. HCM analysis of 2012 conditions identified three locations that operate at LOS 'D' during the AM peak hour and one location that operates at LOS 'D' during the PM peak hour (all other locations operate at LOS 'C' or better). The locations reporting LOS 'D' operations in 2012 are:

- AM Peak Hour – Westbound I-80 diverge to northbound I-35.
- AM Peak Hour – Southbound I-235 merge from eastbound I-80.
- AM Peak Hour – Southbound I-235 between the NEMM and Euclid Avenue.
- PM Peak Hour – Eastbound I-80 diverge to southbound US 65.

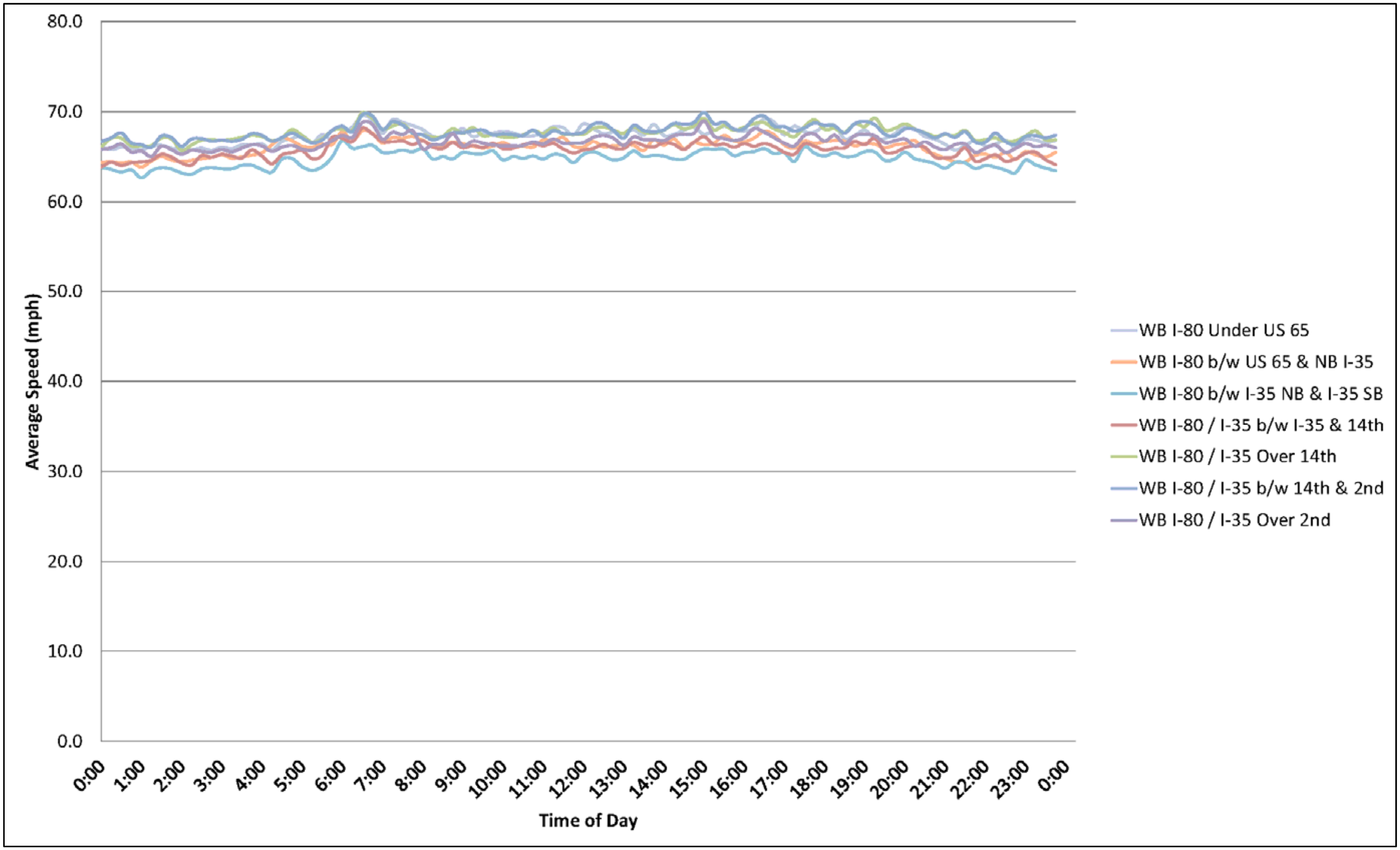
To assess any operational deficiencies that may exist in these areas for periods longer than a single hour, a review of the 2012 INRIX speeds was performed. Plots of the speed data at locations within the study area are provided in **Figures 1 through 4**. The review of speed data found that there are no noticeable impacts to speed at study area locations during the peak hours that would conclude the need to analyze a period longer than one hour in the morning and afternoon. Therefore, a one-hour model analysis period was determined to be sufficient for the AM and PM peak periods. This determination was presented to Iowa DOT and FHWA on Tuesday, February 3rd, 2015, and concurrence was received by FHWA on Wednesday, February 4th, 2015.

Figure 1. Average Speed by Time of Day along Eastbound I-80 near NEMM – July 2012



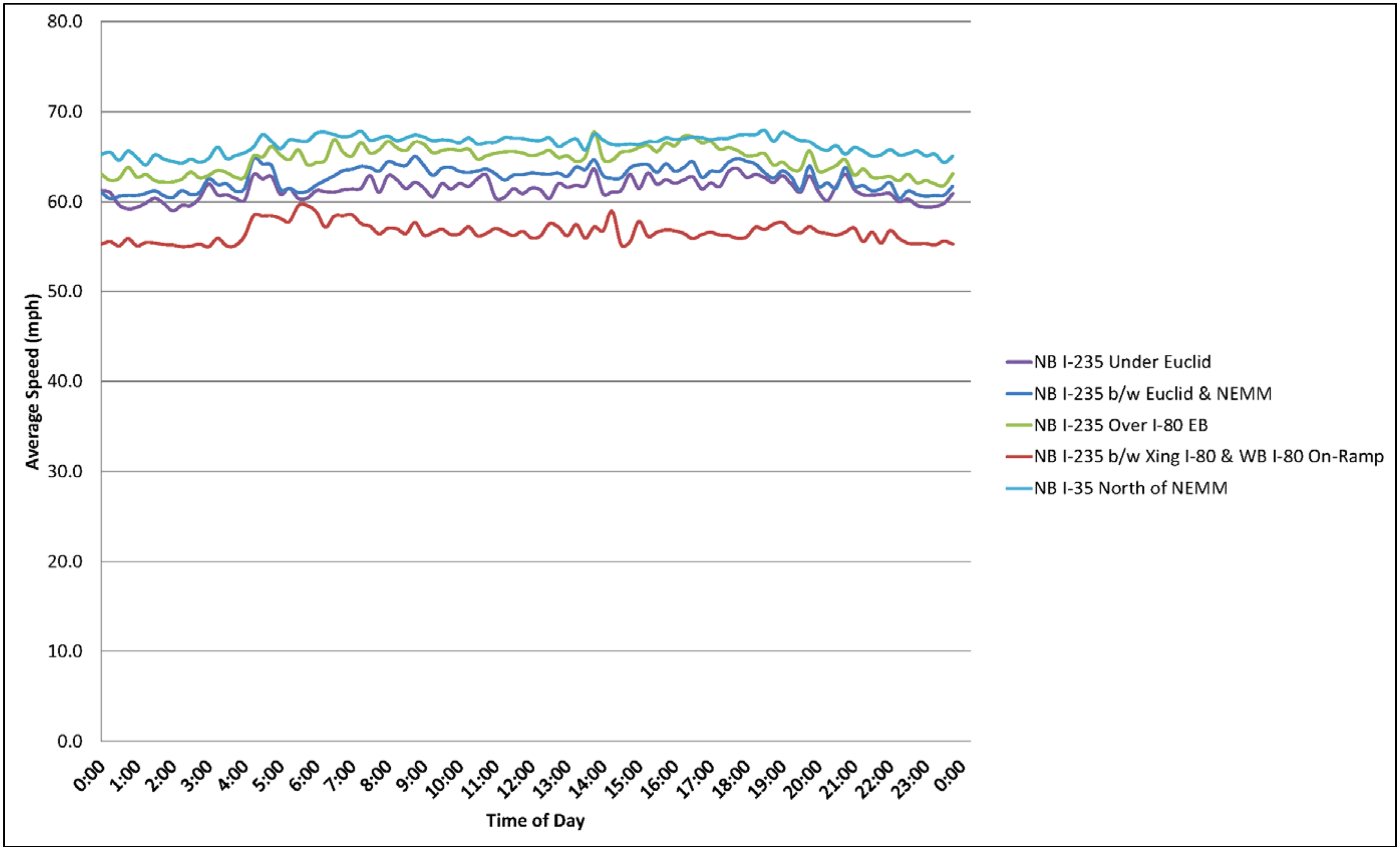
Source: INRIX Analytics, Accessed by Consultant December 2014.

Figure 2. Average Speed by Time of Day along Westbound I-80 near NEMM – July 2012



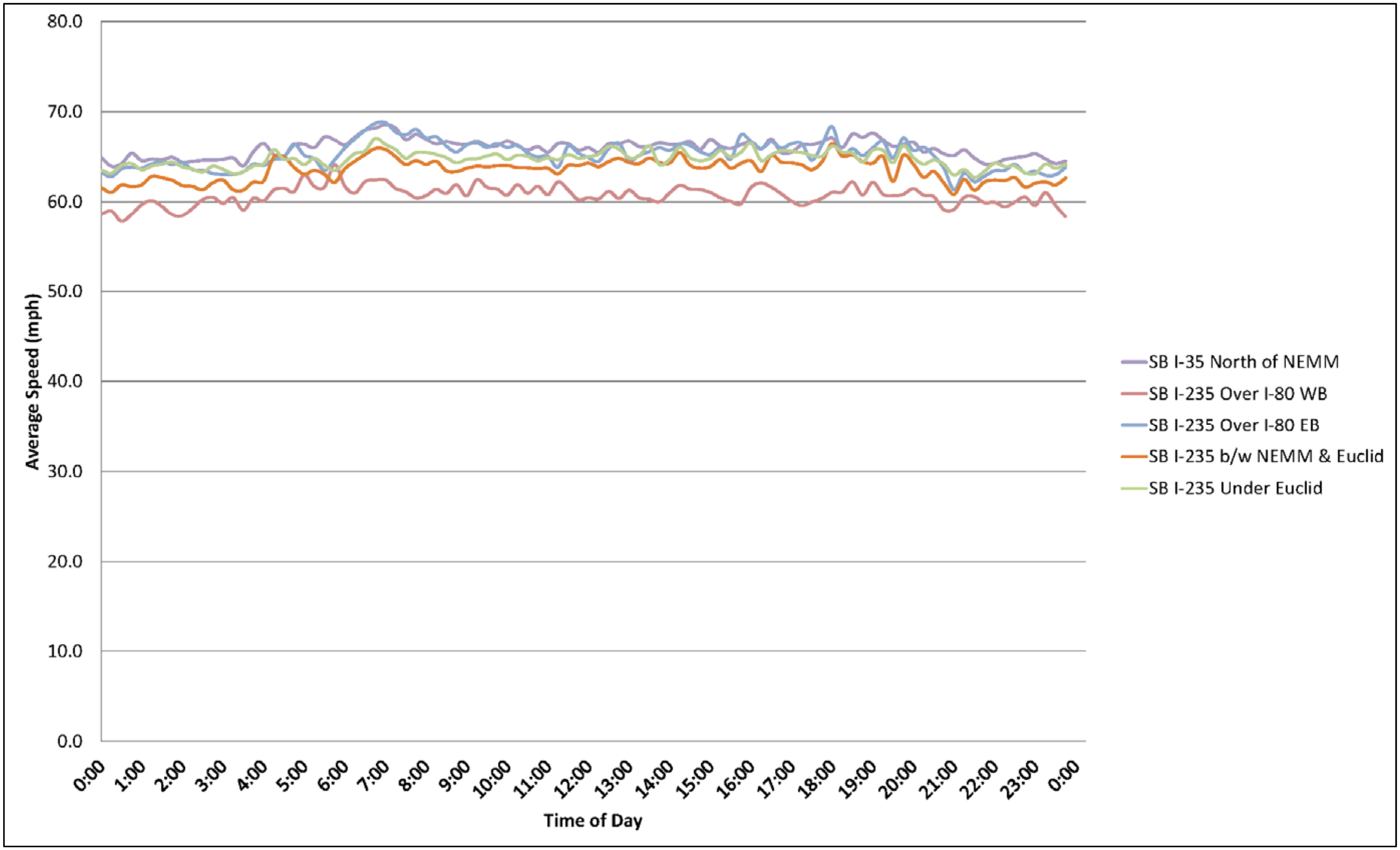
Source: INRIX Analytics, Accessed by Consultant December 2014.

Figure 3. Average Speed by Time of Day along Northbound I-235/35 near NEMM – July 2012



Source: INRIX Analytics, Accessed by Consultant December 2014.

Figure 4. Average Speed by Time of Day along Southbound I-35/235 near NEMM – July 2012



Source: INRIX Analytics, Accessed by Consultant December 2014.

Calibration Measures and Targets

Calibration will be identified when the conditions in **Table 1** are met.

Table 1. Calibration Measures and Targets

Calibration Item	Calibration Target
Volume Throughput	
Individual movement flows ≤ 700 veh/hr	Within 100 vehicles of field data for more than 85% of movements in model area
Individual movement flows between 700 and 2,700 veh/hr	Within 15% of field data for more than 85% of movements in model area
Individual movement flows > 2,700 veh/hr	Within 400 vehicles of field data for more than 85% of movements in model area
Speed	
Link speed	Within 10 mph of field data for more than 85% of network links
Travel Time	
Field travel times ≤ 7 minutes	Within 1 minute of field data for more than 85% of travel time segments
Field travel times > 7 minutes	Within 15% of field data for more than 85% of travel time segments
Queues	
Queues formed in free flow areas	All locations with formed queues are modeled
Queue length	Within 20% of field measured queue length
Congestion	
Duration of congestion	Within 15 minutes from the beginning and end of congestion

Allowable Calibration Adjustments

Model adjustments that will be considered during the calibration effort are presented in **Table 2**.

Table 2. Allowable Calibration Adjustments

Calibration Parameter	Default	Allowable Range	
		Basic Segment	Merge/Diverge/ Weave
Freeway Car Following (Wiedemann 99)			
CC0 Standstill Distance	4.92 ft	>4.00 ft	>4.92 ft
CC1 Headway Time	0.9 s	0.7 to 3.0 s	0.9 to 3.0 s
CC2 'Following' Variation	13.12 ft	6.56 to 22.97 ft	13.12 to 39.37 ft
Arterial Car Following (Wiedemann 74)			
Average Standstill Distance	6.56 ft	>3.28 ft	
Additive Part of Safety Distance	2.00	1 to 3.5[i]	
Multiplicative Part of Safety Distance	3.00	2 to 4.5[i]	
Lane Change			
Maximum Deceleration	-13.12 ft/s^2 (Own) -9.84 ft/s^2 (Trailing)	< -12 ft/s^2 (Own) < -8 ft/s^2 (Trailing)	
-1 ft/s^2 per Distance	200 ft (Freeway) 100 ft (Urban)	>100 ft (Freeway) >50 ft (Urban)	
Accepted Deceleration	-3.28 ft/s^2 (Own) -1.64 ft/s^2 (Trailing)	< -2.5 ft/s^2 (Own) < -0.5 ft/s^2 (Trailing)	
Min. Headway (Front/Rear)	1.64 ft	1.5 to 6 ft	
Safety Distance Reduction Factor	0.6	0.1 to 0.9	
Max. Deceleration for Cooperative Breaking	-9.84 ft/s^2	-32.2 to -3 ft/s^2	
Overtake Reduced Speed Areas	Not checked	Depends on field observations	
Cooperative Lane Change	Not checked	Depends on field observations (should be checked in most freeway merge/diverge/ weave areas)	
Maximum Speed Difference	6.71 mph	<20 mph	
Maximum Collision Time	10.00 s	<15 s	
Link Connector			
Emergency Stop	16.4 ft	≥16.4 ft (Depends on field observations)	
Lane Change	656.2 ft	≥656.2 ft (Depends on field observations)	
per lane	Not checked	Depends on field observations	

Additionally, the local adjustments listed in **Table 3** will be considered during model calibration.

Table 3. Local Calibration Strategies

Local Adjustment to Address Model Discrepancy to Field Conditions	Examples of Applied Strategy
Modify model geometry	• Extend link onto a shoulder area for locations where traffic is observed to use that pavement.
Adjust Conflict Area or Priority Rule parameter values	• Increase Conflict Area Front Gap or Rear Gap time to mimic less aggressive driving behavior for gap acceptance of conflicting traffic at junctions. • Reduce Priority Rule Min. Gap Time to mimic more aggressive driving behavior for gap acceptance of conflicting traffic at junctions. • Add Priority Rule conflict markers to lanes adjacent to a destination lane to mimic less aggressive driving behavior for gap acceptance of conflicting traffic at junctions.
Adjust Connector parameter values	• Increase Connector lane change distance to reduce or eliminate slowing or stopping of vehicles near a junction. • Decrease Connector lane change distance at a lane drop location to increase utilization of the drop lane at upstream locations.
Modify traffic control	• Replace a stop sign in the model with a Reduced Speed Area with a low speed (i.e., 1-3 mph) to mimic location that is treated by most drivers as a “rolling stop”. • Modify detection area size and/or signal controller vehicle extension/gap times to better match field observations of signal phase gap-out conditions and the resulting intersection queues.
Modify desired speed	• Increase speeds for a desired speed profile assigned to an arterial link to reduce travel time between intersections to match field observed platooning and intersection queuing.

Calibration Adjustments

The following sections present the calibration adjustments made within the Vissim models. Calibration adjustments were identical between the AM and PM models. Each section below discusses a specific item used during calibration. It should be noted that these items were modified simultaneously to provide for a well calibrated model, and the order that they are presented does not reflect an order in which these items were adjusted.

Driving Behavior Parameters

Separate Driving Behavior Parameter Sets were developed for arterials, basic freeway areas, ramp merge areas and short weave segments. The software default “Urban (motorized)” parameter set was applied to all arterial links. The software default “Freeway (free lane selection)” was copied to create parameter sets for the weave segments, ramp merge areas and ramp lane drop areas (ramp links that either have a lane drop or have a diverge without lane balance). The software default values for the “Urban (motorized)” parameter set were used for all arterial links. Select parameters of the “Freeway (free lane selection)” parameter set were modified for freeway links. The acceptable limits of parameters through adjustment were listed in the Methodology Letter of Understanding for this project and are based on the Oregon DOT Vissim Protocol. Parameters for each of the parameter sets applied to freeway links were based on comparisons of model throughput to coded demand (based on traffic counts), comparisons of model travel times to INRIX data, observations of lane changing maneuvers, and observations of merging behavior at ramp junctions. The modified parameters for each of the Driving Behavior Parameter Sets are provided in **Table 4**.

Table 4. Modified Driving Behavior Parameters

Parameter	Default "Freeway (free lane selection)"	Modified Parameter Sets Applied to Freeway Links			
		"Freeway (free lane selection)"	"Freeway Weaving Section"	"Freeway Ramp Area"	"Ramp Lane Drop Area"
Following Behavior					
CC1 (Headway Time)	0.90 sec	1.05 sec	0.95 sec	0.90 sec	0.95
CC2 ('Following' Variation)	13.12 ft	22.97 ft	15.00 ft	13.12 ft	15.00
Maximum deceleration (Own)	-13.12 ft/s^2	-13.12 ft/s^2	-14.00 ft/s^2	-15.00 ft/s^2	-14.00 ft/s^2
Maximum deceleration (Trailing)	-9.84 ft/s^2	-10.50 ft/s^2	-12.00 ft/s^2	-12.00 ft/s^2	-12.00 ft/s^2
Deceleration rate (- 1 ft/s^2 per distance) (Own)	200.00 ft	190.00 ft	160.00 ft	150.00 ft	165.00 ft
Deceleration rate (- 1 ft/s^2 per distance) (Trailing)	200.00 ft	190.00 ft	160.00 ft	150.00 ft	165.00 ft
Accepted deceleration (Own)	-3.28 ft/s^2	-3.28 ft/s^2	-3.28 ft/s^2	-4.00 ft/s^2	-3.28 ft/s^2
Accepted deceleration (Trailing)	-1.64 ft/s^2	-2.00 ft/s^2	-2.36 ft/s^2	-2.50 ft/s^2	-2.36 ft/s^2
Min. headway (front/rear)	1.64 ft	1.64 ft	1.50 ft	1.50 ft	1.50 ft
Safety distance reduction factor	0.60	0.50	0.45	0.30	0.45
Maximum deceleration for cooperative braking	-9.84 ft/s^2	-10.50 ft/s^2	-13.50 ft/s^2	-15.00 ft/s^2	-13.50 ft/s^2

Lane Change Parameter of Model Connectors

The Lane Change parameter defines the location at which vehicles begin to make necessary lane changes in order to continue along their assigned route. The base Lane Change values assigned in the models were 2,600 feet for freeway connectors and 1,300 feet for arterial connectors on a distance per lane basis (lane change locations at the distance multiplied by the number of lane changes needed to continue on a desired path). Lane Change values were modified for select connectors at locations where routes diverged. The modified Lane Change values were based on comparisons of model throughput to coded demand (based on traffic counts), comparisons of model travel times to INRIX data, observations of lane changing maneuvers, and observations of queuing. These modifications included several locations that were adjusted from the base lane change per distance feature to an absolute lane change distance regardless of number of lane changes. The locations and Lane Change distances of connectors with modified Lane Change values are provided in **Table 5**.

Table 5. Modified Lane Change Distances

Location	Calibrated Distance (ft)
Arterial	
NB NE 14th Street lane drop north of NE 51st Avenue	1,500
NB NE 14th Street lane add south of EB I-80 Ramp Terminal	1,600
SB NE 14th Street left-turn lane at Broadway	1,900
SB NE 14th Street right-turn at Broadway	2,100
WB Euclid Avenue left-turn lane at Delaware Avenue	1,600
WB Euclid Avenue right-turn at Delaware Avenue	1,600
EB Euclid Avenue right-turn at SB I-235	2,200
EB Euclid Avenue right-turn lane at NB I-235 loop	2,500
WB Euclid Avenue right-turn lane at SB I-235 loop	1,800
NB Turns at NB I-35/Corporate Woods Ramp Terminal	3,500*
Freeway	
EB I-80 exit to NE 14th Street	6,000* (Exit) 3,500* (Continue on mainline)
EB I-80 exit to SB I-235	9,000* (Exit) 5,000* (Continue on mainline)
EB I-80 exit to NB I-35	7,000* (Exit) 5,000* (Continue on mainline)
EB I-80 exit to SB US 65	9,000* (Exit) 5,000* (Continue on mainline)
WB I-80 exit to NB I-35	9,200* (Exit) 5,000* (Continue on mainline)
WB I-80 exit to SB I-235	8,550* (Exit) 5,000* (Continue on mainline)
WB I-80 exit to NE 14th Street	6,000* (Exit) 3,500* (Continue on mainline)
WB I-80 exit to NW 2nd Avenue	6,000* (Exit) 3,500* (Continue on mainline)
NB I-235 exit to I-80	7,000* (Exit) 6,000* (Continue on mainline)
NB I-235 to I-80 ramps at I-80 east/west split	4,500*
NB I-35 exit to Corporate Woods Drive	8,500* (Exit) 6,000* (Continue on mainline)
SB I-35 exit to I-235	8,500* (Exit) 5,000* (Continue on mainline)
SB I-35 to I-80 ramps at I-80 east/west split	8,500*
SB I-235 exit to Euclid Avenue	7,000* (Exit) 3,500* (Continue on mainline)

* Lane Change distance does not include the per lane feature

Vehicle Pre-Positioning

A review of lane changing behavior and output travel times from initial runs indicated the need to pre-position vehicles at the freeway model entries. Pre-positioning was used because of the study area limits and the inability to simply extend model links without the influence of areas adjacent to the study area. Pre-positioning was accomplished by using separate links for each lane at freeway model entry locations and applying even distribution amongst those lanes. Pre-positioning included aligning vehicles in the outer most lanes upon network entry that would be diverting from mainline at the NEMM or locations between model entry and the NEMM. This generally resulted in fewer lane changes, which more closely matched observations and decreased travel times to more closely match INRIX data.

Speed Decision Locations

Desired speeds along the mainline were defined using INRIX data. Initially, data for only the off-peak time (20:00-6:00) were used to determine free-flow speeds. However, through the review of the INRIX data it was determined that speeds generally increase during daytime hours for all segments. This was confirmed through a comparison of speed data between the off-peak and daytime periods. Therefore, speeds during daytime hours (6:00-18:00) were used to set desired speeds. Separate Desired Speed Decisions were used to set varying speeds for each leg adjacent to the NEMM. Ramp speeds were defined using field data of ramp speeds at various points along each ramp. Desired Speed Decisions and Reduced Speed Areas were used to assign speeds profiles at various points along ramps to match the field data.

Conflict Areas and Priority Rules

Yielding behavior and intersections was controlled using a combination of Conflict Areas and Priority Rules. Parameters of these model elements were defined using observations of gap acceptance in the field and by matching model queues with those observed in the field.

Number of Runs Determination

Once preliminary calibration adjustments were made, a set of 5 runs was performed to gather model output to be used in determining the number of simulation runs needed to produce 95% confidence of achieving results within the maximum tolerable error. Maximum tolerable error was set to 10% of the average for a given measure of effectiveness (MOE). After this initial set of 5 runs it was determined that more runs would be required. A set of 10 runs were then performed and the output was evaluated to determine if the results produced 95% confidence of achieving a maximum tolerable error. It was determined that 10 runs were sufficient to produce 95% confidence of achieving a maximum tolerable error. A summary of the model output and statistical results used to determine the number of runs is provided below.

AM Peak Hour

- With 10 runs, the number of required runs needed to produce 95% confidence of achieving results within the maximum tolerable error for each of the following variable are:
    - Network-wide number of vehicles that left the network – N < 10.
    - Network-wide total travel time – N < 10.
    - Network-wide average speed – N < 10.
    - Network-wide delay time per vehicle – N < 10.
    - Peak hour volume throughput on freeway ramps and mainline segments – N < 10 for 89.5% of freeway ramps and mainline segments within the study area.
    - Travel time through segments and overall corridors – N < 10 for 100% of travel time segments and corridors.

PM Peak Hour

- With 10 runs, the number of required runs needed to produce 95% confidence of achieving results within the maximum tolerable error for each of the following variable are:
    - Network-wide number of vehicles that left the network – N < 10.
    - Network-wide total travel time – N < 10.
    - Network-wide average speed – N < 10.

- Network-wide delay time per vehicle – N < 10.
- Peak hour volume throughput on freeway ramps and mainline segments – N < 10 for 94.7% of freeway ramps and mainline segments within the study area.
- Travel time through segments and overall corridors – N < 10 for 100% of travel time segments and corridors.

Calibration Results

Calibration was determined by matching model volume throughput to coded demand (based on traffic counts), model travel times to INRIX data and model queues to observed queues. The following conditions related to these comparisons were outlined in the project Methodology Letter of Understanding as the criteria for calibrated conditions.

- The hourly simulated volumes for freeway segments and ramps match the hourly demand volumes for freeway segments and ramps. This will be determined by the following rules:
  - For a demand flow less than 700 veh/hr, the simulated volume must be within 100 veh/hr of the demand flow for more than 85% of all cases.
  - For a demand flow between 700 veh/hr and 2,700 veh/hr, the simulated volume must be within 15% of the demand flow for more than 85% of all cases.
  - For a demand flow greater than 2,700 veh/hr, the simulated volume must be within 400 veh/hr of the demand flow for more than 85% of all cases.
  - GEH statistic value less than 5 for individual link flows for more than 85% of all cases.
  - GEH statistic value less than 4 for the sum of all link flows.
- Output travel times for all segments defined by the INRIX data match the INRIX travel times. Output travel times will need to be within 15% of INRIX data for 85% of all INRIX segments. Output travel times for mainline through segments that span the entire study area will also be compared to the INRIX data (the travel time comparison for these segments will be within 15% since all individual segments will be within 15%). ATR speed data from days of counts in 2012 will also be compared with the calculated speeds from the Vissim output.
- Model queue locations and lengths are representative to those observed in the field.

Comparisons of the model volume throughput to the coded demand and key statistics used in the comparisons are provided in **Tables 6 through 11**.

Comparisons of the model travel times to the INRIX data and key statistics used in the comparisons are provided in **Tables 12 and 13**.

Comparisons of the model queues at ramp terminal intersections and at approaches downstream of ramp terminal intersections (approaches that could impact ramp terminal operations) are provided in **Tables 14 and 15**.

A summary of the calibration results is provided following the information provided in the tables.

Table 6. Freeway Volume Comparison – AM Peak Hour

Location	Coded Demand[1]	Volume Throughput[2]	Volume Differential			GEH
			V<700	700≤V≤2,700	V>2,700	
Freeway Ramps						
I-80 EB Entry from NW 2nd	456	454	-2			0.080
I-80 EB Exit to NE 14th	621	618	-3			0.129
I-80 EB Entry from SB NE 14th	111	110	-1			0.076
I-80 EB Entry from NB NE 14th	131	129	-2			0.149
I-80 EB Exit to I-235 SB	739	724		-2.1%		0.569
I-80 EB Exit to I-35 NB	984	986		0.2%		0.073
I-35 SB Exit to I-80 EB	423	407	-16			0.771
I-235 NB Exit to I-80 EB	343	331	-12			0.632
I-80 EB Exit to US 65 SB	623	611	-12			0.483
US 65 NB Exit to I-80 WB	1136	1131		-0.4%		0.146
I-80 WB Exit to I-35 NB	639	639	0			0.012
I-80 WB Exit to I-235 SB	1474	1456		-1.2%		0.465
I-235 NB Exit to I-80 WB	482	481	-2			0.046
I-35 SB Exit to I-80 WB	1379	1365		-1.0%		0.383
I-80 WB Exit to NE 14th	360	361	1			0.042
I-80 WB Entry from NB NE 14th	242	240	-3			0.161
I-80 WB Entry from SB NE 14th	234	229	-5			0.355
I-80 WB Exit to NW 2nd	333	325	-8			0.424
I-235 NB Entry from Euclid	257	254	-3			0.169
I-235 NB Exit to I-80 EB/WB	825	816		-1.1%		0.321
I-35 NB Exit to Corp Woods	345	343	-2			0.119
I-35 SB Entry from Corp Woods	298	296	-2			0.110
I-35 SB Exit to I-80 EB/WB	1802	1773		-1.6%		0.686
I-235 SB Exit to Euclid	345	338	-8			0.406
Mainline Freeway						
I-80 EB over NW 2nd	2677	2666		-0.4%		0.209
I-80 EB b/w NW 2nd and NE 14th	3133	3120			-13	0.225
I-80 EB b/w NE 14th Exit and Loop	2512	2500		-0.5%		0.246
I-80 EB b/w NE 14th Entries	2623	2605		-0.7%		0.346
I-80 EB b/w NE 14th and NEMM	2754	2729			-25	0.477
I-80 EB b/w 235 Exit and 35 Exit	2015	2001		-0.7%		0.310
I-80 EB b/w 35 Entry and 235 Entry	1454	1420		-2.4%		0.902
I-80 EB b/w NEMM and US 65	1797	1749		-2.8%		1.152
I-80 EB under US 65	1174	1133		-3.6%		1.195
I-80 WB under US 65	3164	3156			-8	0.135
I-80 WB b/w US 65 and NEMM	4300	4275			-25	0.386
I-80 WB b/w 35 Exit and 235 Exit	3661	3625			-36	0.600
I-80 WB b/w 235 Entry and 35 Entry	2669	2648		-0.8%		0.405
I-80 WB b/w NEMM and NE 14th	4048	4007			-42	0.654
I-80 WB b/w NE 14th Exit and Loop	3688	3643			-45	0.743
I-80 WB b/w NE 14th Entries	3930	3880			-50	0.797
I-80 WB b/w NE 14th and NW 2nd	4164	4108			-57	0.879
I-80 WB over NW 2nd	3831	3779			-53	0.851
I-235 NB under Euclid	1560	1553		-0.5%		0.177
I-235 NB b/w Euclid and NEMM	1817	1805		-0.7%		0.291
I-235 NB Exit to I-35 NB	992	985		-0.7%		0.219
I-35 NB b/w I-80 Entries	1976	1971		-0.3%		0.119
I-35 NB b/w NEMM and Corp Woods	2615	2609		-0.2%		0.117
I-35 NB under Corp Woods	2270	2262		-0.4%		0.172
I-35 SB under Corp Woods	4318	4303			-15	0.227
I-35 SB b/w Corp Woods and NEMM	4616	4592			-24	0.357
I-35 SB Exit to I-235 SB	2814	2808			-7	0.123
I-235 SB b/w I-80 Entries	4288	4262			-26	0.392
I-235 SB b/w NEMM and Euclid	5027	4977			-50	0.701
I-235 SB under Euclid	4682	4637			-45	0.664

[1] Source: Iowa DOT Systems Planning, December 2014.
[2] Average of 10 simulation runs, Consultant, April 2015.

Table 7. Intersection Volume Comparison – AM Peak Hour (1 of 2)

Turning Movement	Coded Demand[1]	Volume Throughput[2]	Volume Differential			GEH
			V<700	700≤V≤2,700	V>2,700	
NE 14th Street/NE 51st Avenue						
NB Left	44	44	0			0.000
NB Through	503	503	0			0.004
NB Right	170	168	-3			0.192
SB Left	20	19	-1			0.272
SB Through	527	524	-3			0.118
SB Right	14	16	2			0.541
EB Left	33	33	0			0.017
EB Through	23	24	1			0.145
EB Right	49	47	-2			0.245
WB Left	74	72	-2			0.222
WB Through	10	9	-1			0.358
WB Right	9	9	0			0.132
NE 14th Street/I-80 WB Ramp Terminal						
NB Through	523	520	-4			0.153
SB Through	650	643	-7			0.291
WB Left	166	167	1			0.047
WB Right	194	195	1			0.072
NE 14th Street/I-80 EB Ramp Terminal						
NB Through	474	477	3			0.124
NB Right	68	66	-2			0.207
SB Left	76	75	-1			0.104
SB Through	395	394	-2			0.076
EB Left	266	261	-5			0.302
EB Through	60	60	0			0.052
EB Right	295	295	0			0.023
WB Left	48	50	2			0.272
WB Right	156	152	-4			0.306
NE 14th Street/Broadway Avenue						
NB Left	65	65	0			0.000
NB Through	393	393	0			0.020
NB Right	64	64	-1			0.063
SB Left	180	183	3			0.200
SB Through	511	507	-4			0.195
SB Right	46	46	0			0.030
EB Left	52	54	2			0.207
EB Through	99	98	-1			0.121
EB Right	63	60	-3			0.383
WB Left	66	68	2			0.232
WB Through	78	76	-2			0.216
WB Right	97	97	0			0.041
Euclid Avenue/Delaware Avenue						
NB Left	70	66	-4			0.522
NB Through	69	71	2			0.275
NB Right	47	46	-1			0.206
SB Left	123	120	-3			0.300
SB Through	63	63	0			0.013
SB Right	56	56	0			0.000
EB Left	56	57	1			0.133
EB Through	292	292	0			0.012
EB Right	49	47	-2			0.230
WB Left	100	97	-3			0.282
WB Through	552	544	-8			0.350
WB Right	218	209	-9			0.609

1 Source: Iowa DOT Systems Planning, December 2014.
2 Average of 10 simulation runs, Consultant, April 2015.

Table 8. Intersection Volume Comparison – AM Peak Hour (2 of 2)

Turning Movement	Coded Demand[1]	Volume Throughput[2]	Volume Differential			GEH
			V<700	700≤V≤2,700	V>2,700	
Euclid Avenue/I-235 SB Ramp Terminal						
SB Left	110	112	2			0.180
SB Right	235	226	-9			0.619
EB Through	311	305	-6			0.365
EB Right	151	152	1			0.114
WB Through	635	625	-10			0.406
Euclid Avenue/I-235 NB Ramp Terminal						
NB Left	247	246	-1			0.038
NB Right	102	102	0			0.020
EB Through	297	293	-4			0.245
WB Through	945	942		-0.3%		0.101
WB Right	257	253	-4			0.238
Euclid Avenue/25th Street						
NB Left	90	90	0			0.042
NB Through	17	16	-1			0.322
NB Right	12	11	-1			0.265
SB Left	4	3	-1			0.312
SB Through	4	3	-1			0.312
SB Right	7	6	-1			0.311
EB Left	40	43	3			0.481
EB Through	318	311	-7			0.406
EB Right	41	41	0			0.047
WB Left	18	19	1			0.117
WB Through	1105	1103		-0.2%		0.057
WB Right	6	6	0			0.166
Corporate Woods Drive/Delaware Avenue						
NB Left	30	31	1			0.145
NB Through	121	118	-3			0.238
NB Right	72	70	-2			0.249
SB Left	177	173	-4			0.302
SB Through	150	151	1			0.098
SB Right	40	40	0			0.032
EB Left	50	46	-4			0.622
EB Through	182	183	1			0.074
EB Right	35	35	0			0.034
WB Left	128	125	-3			0.285
WB Through	207	205	-2			0.160
WB Right	209	212	3			0.193
Corporate Woods Drive/I-35 SB Ramp Terminal						
SB Left	28	27	-2			0.287
SB Right	124	123	-1			0.081
EB Through	198	192	-6			0.444
EB Right	233	234	1			0.033
WB Left	65	64	-1			0.175
WB Through	420	420	-1			0.024
Corporate Woods Drive/I-35 NB Ramp Terminal						
NB Left	290	289	-1			0.065
NB Right	55	50	-5			0.690
EB Left	102	95	-7			0.726
EB Through	124	124	0			0.036
WB Through	195	195	0			0.014
WB Right	42	39	-3			0.471

[1] Source: Iowa DOT Systems Planning, December 2014.
[2] Average of 10 simulation runs, Consultant, April 2015.

Table 9. Freeway Volume Comparison – PM Peak Hour

Location	Coded Demand[1]	Volume Throughput[2]	Volume Differential			GEH
			V<700	700≤V≤2,700	V>2,700	
Freeway Ramps						
I-80 EB Entry from NW 2nd	502	499	-3			0.116
I-80 EB Exit to NE 14th	437	433	-4			0.206
I-80 EB Entry from SB NE 14th	211	209	-2			0.131
I-80 EB Entry from NB NE 14th	230	226	-4			0.252
I-80 EB Exit to I-235 SB	485	480	-5			0.214
I-80 EB Exit to I-35 NB	1272	1258		-1.1%		0.394
I-35 SB Exit to I-80 EB	723	717		-0.8%		0.209
I-235 NB Exit to I-80 EB	1753	1713		-2.3%		0.963
I-80 EB Exit to US 65 SB	1088	1065		-2.2%		0.704
US 65 NB Exit to I-80 WB	861	858		-0.4%		0.109
I-80 WB Exit to I-35 NB	567	561	-6			0.244
I-80 WB Exit to I-235 SB	524	512	-12			0.518
I-235 NB Exit to I-80 WB	687	697	10			0.376
I-35 SB Exit to I-80 WB	1226	1219		-0.5%		0.192
I-80 WB Exit to NE 14th	230	232	2			0.138
I-80 WB Entry from NB NE 14th	358	352	-6			0.318
I-80 WB Entry from SB NE 14th	351	346	-6			0.295
I-80 WB Exit to NW 2nd	369	360	-10			0.498
I-235 NB Entry from Euclid	239	240	1			0.090
I-235 NB Exit to I-80 EB/WB	2440	2412		-1.2%		0.573
I-35 NB Exit to Corp Woods	439	432	-7			0.345
I-35 SB Entry from Corp Woods	383	372	-11			0.545
I-35 SB Exit to I-80 EB/WB	1949	1937		-0.6%		0.270
I-235 SB Exit to Euclid	384	375	-9			0.472
Mainline Freeway						
I-80 EB over NW 2nd	2875	2866			-9	0.174
I-80 EB b/w NW 2nd and NE 14th	3377	3363			-14	0.246
I-80 EB b/w NE 14th Exit and Loop	2940	2926			-14	0.251
I-80 EB b/w NE 14th Entries	3151	3131			-20	0.351
I-80 EB b/w NE 14th and NEMM	3381	3353			-28	0.477
I-80 EB b/w 235 Exit and 35 Exit	2896	2870			-26	0.480
I-80 EB b/w 35 Entry and 235 Entry	2347	2329		-0.8%		0.378
I-80 EB b/w NEMM and US 65	4100	4034			-66	1.033
I-80 EB under US 65	3012	2948			-65	1.182
I-80 WB under US 65	1646	1644		-0.1%		0.057
I-80 WB b/w US 65 and NEMM	2507	2496		-0.5%		0.230
I-80 WB b/w 35 Exit and 235 Exit	1940	1930		-0.5%		0.239
I-80 WB b/w 235 Entry and 35 Entry	2103	2118		0.7%		0.329
I-80 WB b/w NEMM and NE 14th	3329	3329			0	0.007
I-80 WB b/w NE 14th Exit and Loop	3099	3092			-8	0.135
I-80 WB b/w NE 14th Entries	3457	3445			-13	0.213
I-80 WB b/w NE 14th and NW 2nd	3808	3781			-27	0.434
I-80 WB over NW 2nd	3439	3420			-19	0.318
I-235 NB under Euclid	4222	4212			-10	0.148
I-235 NB b/w Euclid and NEMM	4461	4446			-15	0.225
I-235 NB Exit to I-35 NB	2021	2014		-0.4%		0.160
I-35 NB b/w I-80 Entries	3293	3267			-26	0.456
I-35 NB b/w NEMM and Corp Woods	3860	3824			-36	0.587
I-35 NB under Corp Woods	3421	3386			-35	0.607
I-35 SB under Corp Woods	2904	2899			-6	0.102
I-35 SB b/w Corp Woods and NEMM	3287	3271			-16	0.281
I-35 SB Exit to I-235 SB	1338	1324		-1.1%		0.395
I-235 SB b/w I-80 Entries	1862	1834		-1.6%		0.663
I-235 SB b/w NEMM and Euclid	2347	2311		-1.6%		0.754
I-235 SB under Euclid	1963	1932		-1.6%		0.698

1 Source: Iowa DOT Systems Planning, December 2014.
2 Average of 10 simulation runs, Consultant, April 2015.

Table 10. Intersection Volume Comparison – PM Peak Hour (1 of 2)

Turning Movement	Coded Demand[1]	Volume Throughput[2]	Volume Differential			GEH
			V<700	700≤V≤2,700	V>2,700	
NE 14th Street/NE 51st Avenue						
NB Left	33	33	0			0.052
NB Through	582	578	-4			0.154
NB Right	61	59	-2			0.219
SB Left	19	18	-1			0.139
SB Through	678	675	-3			0.100
SB Right	16	17	1			0.295
EB Left	29	28	-1			0.206
EB Through	12	12	0			0.116
EB Right	52	51	-1			0.153
WB Left	187	184	-3			0.213
WB Through	22	20	-2			0.370
WB Right	30	32	2			0.288
NE 14th Street/I-80 WB Ramp Terminal						
NB Through	575	569	-6			0.247
SB Through	917	908		-0.9%		0.285
WB Left	129	130	1			0.105
WB Right	101	102	1			0.099
NE 14th Street/I-80 EB Ramp Terminal						
NB Through	785	780		-0.6%		0.172
NB Right	90	91	1			0.105
SB Left	76	74	-2			0.219
SB Through	408	408	0			0.015
EB Left	221	214	-7			0.447
EB Through	39	42	3			0.487
EB Right	177	174	-3			0.219
WB Left	43	47	4			0.567
WB Right	157	152	-5			0.410
NE 14th Street/Broadway Avenue						
NB Left	80	76	-5			0.510
NB Through	606	607	1			0.037
NB Right	96	96	0			0.041
SB Left	105	109	4			0.348
SB Through	481	479	-2			0.096
SB Right	42	39	-3			0.455
EB Left	59	59	0			0.026
EB Through	138	138	0			0.009
EB Right	83	81	-2			0.210
WB Left	117	123	6			0.548
WB Through	149	143	-6			0.488
WB Right	210	207	-3			0.194
Euclid Avenue/Delaware Avenue						
NB Left	74	71	-3			0.352
NB Through	102	102	0			0.040
NB Right	121	122	1			0.127
SB Left	241	248	7			0.416
SB Through	129	122	-7			0.616
SB Right	45	43	-2			0.241
EB Left	67	63	-4			0.534
EB Through	800	801		0.2%		0.046
EB Right	75	73	-2			0.268
WB Left	71	64	-7			0.827
WB Through	576	570	-7			0.272
WB Right	124	119	-5			0.454

1 Source: Iowa DOT Systems Planning, December 2014.
2 Average of 10 simulation runs, Consultant, April 2015.

Table 11. Intersection Volume Comparison – PM Peak Hour (2 of 2)

Turning Movement	Coded Demand[1]	Volume Throughput[2]	Volume Differential			GEH
			V<700	700≤V≤2,700	V>2,700	
Euclid Avenue/I-235 SB Ramp Terminal						
SB Left	236	224	-12			0.765
SB Right	148	149	1			0.057
EB Through	877	893		1.7%		0.524
EB Right	285	282	-3			0.202
WB Through	623	608	-15			0.617
Euclid Avenue/I-235 NB Ramp Terminal						
NB Left	262	254	-8			0.517
NB Right	626	632	6			0.219
EB Through	819	818		-0.1%		0.031
WB Through	633	625	-9			0.339
WB Right	239	241	2			0.129
Euclid Avenue/25th Street						
NB Left	120	116	-4			0.359
NB Through	37	36	-1			0.182
NB Right	49	51	2			0.241
SB Left	37	35	-3			0.418
SB Through	14	13	-1			0.189
SB Right	20	21	1			0.221
EB Left	149	145	-4			0.297
EB Through	1185	1189		0.3%		0.116
EB Right	111	113	2			0.198
WB Left	40	39	-1			0.095
WB Through	732	727		-0.6%		0.170
WB Right	17	18	1			0.192
Corporate Woods Drive/Delaware Avenue						
NB Left	60	57	-3			0.405
NB Through	280	283	3			0.173
NB Right	111	106	-5			0.490
SB Left	248	244	-4			0.236
SB Through	162	164	2			0.118
SB Right	70	70	0			0.036
EB Left	70	66	-4			0.522
EB Through	195	197	2			0.121
EB Right	20	20	-1			0.113
WB Left	81	84	3			0.308
WB Through	205	194	-11			0.757
WB Right	256	252	-4			0.251
Corporate Woods Drive/I-35 SB Ramp Terminal						
SB Left	36	34	-2			0.338
SB Right	90	89	-1			0.095
EB Through	294	292	-2			0.093
EB Right	260	254	-6			0.381
WB Left	123	120	-4			0.318
WB Through	452	440	-12			0.568
Corporate Woods Drive/I-35 NB Ramp Terminal						
NB Left	349	338	-11			0.577
NB Right	90	86	-5			0.480
EB Left	118	114	-5			0.418
EB Through	212	213	1			0.041
WB Through	226	221	-5			0.308
WB Right	52	54	2			0.288

[1] Source: Iowa DOT Systems Planning, December 2014.
[2] Average of 10 simulation runs, Consultant, April 2015.

Table 12. Freeway Travel Time Comparison – AM Peak Hour

Travel Time Segment	INRIX Travel Time (sec)[1]	Vissim Output Travel Time (sec)[2]	% Difference
Eastbound I-80			
EB I-80/35 b/w NW 2nd Ave and NE 14th St (TMC 118+04626)	13.4	14.2	6%
EB I-80/35 over NE 14th St (TMC 118P04626)	44.7	47.0	5%
EB I-80/35 b/w NE 14th St and SB I-235 Exit (TMC 118+04627)	30.4	34.2	13%
EB I-80/35 b/w SB I-235 Exit and SB I-35 Entry (TMC 118P04627)	14.2	14.4	2%
EB I-80 b/w SB I-35 Entry and NB I-235 Entry (TMC 118P04612)	19.9	21.1	6%
EB I-80 b/w NB I-235 Entry and US 65 (TMC 118+04613)	119.3	124.2	4%
EB I-80 Through Study Area (b/w NW 2nd Ave and US 65)[3]	**241.8**	**250.7**	**4%**
Westbound I-80			
WB I-80 b/w US 65 and NB I-35 Exit (TMC 118-04612)	98.9	111.9	13%
WB I-80 b/w NB I-35 Exit and SB I-35 Entry (TMC 118N04612)	34.8	37.0	6%
WB I-80 under Delaware Ave (TMC 118N04627)	8.6	9.6	11%
WB I-80 b/w Delaware Ave and NE 14th St (TMC 118-04626)	32.9	35.9	9%
WB I-80 over NE 14th St (TMC 118N04626)	40.4	44.6	10%
WB I-80 b/w NE 14th St and NW 2nd Ave (TMC 118-04625)	10.4	11.4	10%
WB I-80 Through Study Area (b/w US 65 and NW 2nd Ave)[3]	**226.0**	**247.9**	**10%**
Northbound I-235/35			
NB I-235 b/w Euclid Ave and I-80 Exit (TMC 118+04644)	55.7	62.4	12%
NB I-235 through NEMM Core (TMC 118P04644)	26.3	27.2	3%
NB I-235/35 b/w NEMM Core and WB I-80 Entry (TMC 118P04636)	19.3	17.2	-11%
NB I-35 b/w WB I-80 Entry and Corporate Woods Dr (TMC 118+04636)[4]	63.3	66.9	6%
NB I-235/35 Through Study Area (b/w Euclid Ave and Corporate Woods Dr)[3]	**164.6**	**173.5**	**5%**
Southbound I-35/235			
SB I-35 b/w Corporate Woods Dr Entry and I-80 (TMC 118-04636)	60.1	69.4	15%
SB I-235 b/w I-80 Exit and NEMM Core (TMC 118N04636)	21.3	21.4	0%
SB I-235 b/w NEMM Core and EB I-80 Entry (TMC 118N04644)	21.8	24.5	12%
SB I-235 b/w EB I-80 Entry and Euclid Ave (TMC 118-04643)	58.8	67.0	14%
SB I-35/235 Through Study Area (b/w Corporate Woods Dr and Euclid Ave)[3]	**162.1**	**178.6**	**10%**

1 Source: INRIX, July 2012 data, accessed December 2014.
2 Average of 10 simulation runs, Consultant, April 2015.
3 INRIX travel times for overall corridor is based on summation of individual TMC segments because data for vehicles traveling across a selection of TMCs is not available through INRIX. Vissim travel times for overall corridor is based on vehicles traveling from beginning to end of the study area corridor.
4 INRIX data not available for this segment. TMC number based on TMC number of opposing direction. Comparable INRIX data based on adjusted INRIX XD data for north leg to match TMC data.

Table 13. Freeway Travel Time Comparison – PM Peak Hour

Travel Time Segment	INRIX Travel Time (sec)[1]	Vissim Output Travel Time (sec)[2]	% Difference
Eastbound I-80			
EB I-80/35 b/w NW 2nd Ave and NE 14th St (TMC 118+04626)	13.6	14.2	4%
EB I-80/35 over NE 14th St (TMC 118P04626)	46.0	47.2	3%
EB I-80/35 b/w NE 14th St and SB I-235 Exit (TMC 118+04627)	31.2	34.3	10%
EB I-80/35 b/w SB I-235 Exit and SB I-35 Entry (TMC 118P04627)	14.5	14.7	1%
EB I-80 b/w SB I-35 Entry and NB I-235 Entry (TMC 118P04612)	20.4	22.3	9%
EB I-80 b/w NB I-235 Entry and US 65 (TMC 118+04613)	122.4	129.8	6%
EB I-80 Through Study Area (b/w NW 2nd Ave and US 65)[3]	**248.1**	**259.3**	**4%**
Westbound I-80			
WB I-80 b/w US 65 and NB I-35 Exit (TMC 118-04612)	99.8	104.7	5%
WB I-80 b/w NB I-35 Exit and SB I-35 Entry (TMC 118N04612)	34.9	36.2	4%
WB I-80 under Delaware Ave (TMC 118N04627)	8.6	9.2	7%
WB I-80 b/w Delaware Ave and NE 14th St (TMC 118-04626)	33.3	35.3	6%
WB I-80 over NE 14th St (TMC 118N04626)	40.5	44.0	9%
WB I-80 b/w NE 14th St and NW 2nd Ave (TMC 118-04625)	10.4	11.3	8%
WB I-80 Through Study Area (b/w US 65 and NW 2nd Ave)[3]	**227.5**	**240.1**	**6%**
Northbound I-235/35			
NB I-235 b/w Euclid Ave and I-80 Exit (TMC 118+04644)	55.4	61.4	11%
NB I-235 through NEMM Core (TMC 118P04644)	26.2	28.1	7%
NB I-235/35 b/w NEMM Core and WB I-80 Entry (TMC 118P04636)	20.1	17.9	-11%
NB I-35 b/w WB I-80 Entry and Corporate Woods Dr (TMC 118+04636)[4]	63.6	68.8	8%
NB I-235/35 Through Study Area (b/w Euclid Ave and Corporate Woods Dr)[3]	**165.3**	**175.9**	**6%**
Southbound I-35/235			
SB I-35 b/w Corporate Woods Dr Entry and I-80 (TMC 118-04636)	61.6	67.2	9%
SB I-235 b/w I-80 Exit and NEMM Core (TMC 118N04636)	21.8	20.4	-6%
SB I-235 b/w NEMM Core and EB I-80 Entry (TMC 118N04644)	22.5	23.4	4%
SB I-235 b/w EB I-80 Entry and Euclid Ave (TMC 118-04643)	59.5	62.6	5%
SB I-35/235 Through Study Area (b/w Corporate Woods Dr and Euclid Ave)[3]	**165.4**	**169.7**	**3%**

1 Source: INRIX, July 2012 data, accessed December 2014.
2 Average of 10 simulation runs, Consultant, April 2015.
3 INRIX travel times for overall corridor is based on summation of individual TMC segments because data for vehicles traveling across a selection of TMCs is not available through INRIX. Vissim travel times for overall corridor is based on vehicles traveling from beginning to end of the study area corridor.
4 INRIX data not available for this segment. TMC number based on TMC number of opposing direction. Comparable INRIX data based on adjusted INRIX XD data for north leg to match TMC data.

Table 14. Intersection Queue Comparison – AM Peak Hour

Turning Movement	Approximate Observed Max Queue Length (ft)[1]	Model Max Queue Length (ft)[2]	Absolute Difference	% Difference
NE 14th Street/NE 51st Avenue				
NB Left	50	61	11	22%
NB Through	400	306	-94	-24%
NB Right	100	61	-39	-39%
NE 14th Street/I-80 WB Ramp Terminal				
NB Through	200	235	35	18%
SB Through	250	266	16	6%
WB Left/Right	100	130	30	30%
NE 14th Street/I-80 EB Ramp Terminal				
NB Through/Right	200	180	-20	-10%
SB Left	100	137	37	37%
SB Through	150	138	-12	-8%
EB Left/Through	250	238	-12	-5%
EB Right	175	184	9	5%
WB Left	150	133	-17	-11%
WB Right	150	126	-24	-16%
NE 14th Street/Broadway Avenue				
SB Left	250	288	38	15%
SB Through/Right	150	183	33	22%
Euclid Avenue/Delaware Avenue				
WB Left	100	96	-4	-4%
WB Through/Right	250	306	56	22%
Euclid Avenue/I-235 SB Ramp Terminal				
SB Left	100	100	0	0%
SB Right	250	165	-85	-34%
EB Through	300	241	-59	-20%
WB Through	150	159	9	6%
Euclid Avenue/I-235 NB Ramp Terminal				
NB Left	150	218	68	45%
NB Right	0	0	0	0%
EB Through	100	89	-11	-11%
WB Through	300	338	38	13%
Euclid Avenue/25th Street				
EB Left	75	71	-4	-5%
EB Through/Right	125	105	-20	-16%
Corporate Woods Drive/Delaware Avenue				
WB Left	125	138	13	10%
WB Through	200	175	-25	-13%
WB Right	75	71	-4	-5%
Corporate Woods Drive/I-35 SB Ramp Terminal				
SB Left	50	52	2	4%
SB Right	100	45	-55	-55%
WB Left	25	52	27	108%
Corporate Woods Drive/I-35 NB Ramp Terminal				
NB Left	350	444	94	27%
NB Right	50	0	-50	-100%
EB Left	50	73	23	46%

[1] Source: Consultant, observations in October 2014.
[2] Average of 10 simulation runs, Consultant, April 2015.

Table 15. Intersection Queue Comparison – PM Peak Hour

Turning Movement	Approximate Observed Max Queue Length (ft)[1]	Model Max Queue Length (ft)[2]	Absolute Difference	% Difference
NE 14th Street/NE 51st Avenue				
NB Left	50	54	4	8%
NB Through	450	380	-70	-16%
NB Right	75	58	-17	-23%
NE 14th Street/I-80 WB Ramp Terminal				
NB Through	200	231	31	16%
SB Through	200	268	68	34%
WB Left/Right	100	106	6	6%
NE 14th Street/I-80 EB Ramp Terminal				
NB Through/Right	250	208	-42	-17%
SB Left	125	120	-5	-4%
SB Through	175	145	-30	-17%
EB Left/Through	250	239	-11	-4%
EB Right	125	156	31	25%
WB Left	150	129	-21	-14%
WB Right	175	153	-22	-13%
NE 14th Street/Broadway Avenue				
SB Left	250	223	-27	-11%
SB Through/Right	200	205	5	3%
Euclid Avenue/Delaware Avenue				
WB Left	100	124	24	24%
WB Through/Right	300	307	7	2%
Euclid Avenue/I-235 SB Ramp Terminal				
SB Left	175	188	13	7%
SB Right	150	148	-2	-1%
EB Through	450	429	-21	-5%
WB Through	175	154	-21	-12%
Euclid Avenue/I-235 NB Ramp Terminal				
NB Left	200	200	0	0%
NB Right	0	0	0	0%
EB Through	200	189	-11	-6%
WB Through	200	210	10	5%
Euclid Avenue/25th Street				
EB Left	125	107	-18	-14%
EB Through/Right	250	293	43	17%
Corporate Woods Drive/Delaware Avenue				
WB Left	150	112	-38	-25%
WB Through	200	213	13	7%
WB Right	100	111	11	11%
Corporate Woods Drive/I-35 SB Ramp Terminal				
SB Left	50	61	11	22%
SB Right	100	56	-44	-44%
WB Left	50	73	23	46%
Corporate Woods Drive/I-35 NB Ramp Terminal				
NB Left	600	690	90	15%
NB Right	150	42	-108	-72%
EB Left	50	63	13	26%

[1] Source: Consultant, observations in October 2014.
[2] Average of 10 simulation runs, Consultant, April 2015.

Calibration Results Summary

Below is a summary of the calibration results that indicate the models were calibrated to existing (2012) baseline conditions.

Volume Throughput

The average results from the model runs (10 runs) show that freeway volume throughput for all freeway model mainline segments and ramps, and the intersection turning movements for all turning movements are within the criteria established for calibration. These results are highlighted below.

- AM Peak Hour – Freeway Throughput
    - All freeway mainline segments and ramps with less than 700 veh/hr demand have a modeled flow within 16 vehicles of the demand (criteria is to be within 100).
    - All freeway mainline segments and ramps with demand between 700 veh/hr and 2,700 veh/hr have a modeled flow within 3.6% of the demand (criteria is to be within 15%).
    - All freeway mainline segments and ramps with demand greater than 2,700 veh/hr have a modeled flow within 57 vehicles of the demand (criteria is to be within 400).
    - The calculated GEH statistic for volume throughput on all freeway mainline segments and ramps is less than 1.195 (criteria is to be less than 5).
- AM Peak Hour – Intersection Turning Movement Throughput
    - All intersection turning movements with less than 700 veh/hr demand have a modeled flow within 10 vehicles of the demand (criteria is to be within 100).
    - All intersection turning movements with demand between 700 veh/hr and 2,700 veh/hr have a modeled flow within 0.3% of the demand (criteria is to be within 15%).
    - There are no intersection turning movements with demand greater than 2,700 veh/hr.
    - The calculated GEH statistic for volume throughput at all intersection turning movements is less than 0.726 (criteria is to be less than 5).
- PM Peak Hour – Freeway Throughput
    - All freeway mainline segments and ramps with less than 700 veh/hr demand have a modeled flow within 12 vehicles of the demand (criteria is to be within 100).
    - All freeway mainline segments and ramps with demand between 700 veh/hr and 2,700 veh/hr have a modeled flow within 2.3% of the demand (criteria is to be within 15%).
    - All freeway mainline segments and ramps with demand greater than 2,700 veh/hr have a modeled flow within 66 vehicles of the demand (criteria is to be within 400).
    - The calculated GEH statistic for volume throughput on all freeway mainline segments and ramps is less than 1.182 (criteria is to be less than 5).
- PM Peak Hour – Intersection Turning Movement Throughput
    - All intersection turning movements with less than 700 veh/hr demand have a modeled flow within 15 vehicles of the demand (criteria is to be within 100).
    - All intersection turning movements with demand between 700 veh/hr and 2,700 veh/hr have a modeled flow within 1.7% of the demand (criteria is to be within 15%).
    - There are no intersection turning movements with demand greater than 2,700 veh/hr.
    - The calculated GEH statistic for volume throughput at all intersection turning movements is less than 0.827 (criteria is to be less than 5).

Travel Times

The average results from the model runs (10 runs) show that travel times for all but one freeway INRIX TMC segment are within 15% of the INRIX travel time data. The one segment that is not within 15% was different by 16%. These results are highlighted below.

- AM Peak Hour – Freeway Travel Times
    - The modeled travel times for 96% of the INRIX TMC segments within the study area are within 14% of the INRIX data.
    - One of the model segments has a modeled travel time that is 15.4% different from the INRIX data. This is the segment on southbound I-35 between the Corporate Woods Drive and the NEMM.
    - The modeled travel time along the length of the study area corridors was within 10% of the INRIX data.
- PM Peak Hour – Freeway Travel Times
    - The modeled travel times for all of the INRIX TMC segments within the study area are within 11% of the INRIX data.
    - The modeled travel time along the length of the study area corridors was within 6% of the INRIX data.

Queue Lengths

The average results from the model runs (10 runs) show that the maximum queue lengths at intersections are representative of those observed in the field. No queues were observed to impact upstream intersections or the freeway during field observations. This is reflected in the models, and the magnitudes of queues are similar to those observed in the field.

MOE Reporting Examples

Example Table. Simulated Freeway Segment Volume Throughput – AM Peak Hour

Location	Demand		Modeled Vehicles[1]		Abs Diff		% Diff		Total Volume Diff			Truck Volume Diff		
	Total	Trucks	Total	Trucks	Total	Trucks	Total	Trucks	V<700	700≤V≤2700	V>2700	V<700	700≤V≤2700	V>2700
I-80 EB Over NW 2nd	2875	518	2866	518	-9	0	-0.3%	0.0%			-9	0		
I-80 EB b/w NW 2nd and NE 14th	3377	543	3363	544	-14	1	-0.4%	0.1%			-14	1		
I-80 EB b/w NE 14th Exit and Loop	2940	464	2926	465	-14	1	-0.5%	0.2%			-14	1		
I-80 EB b/w NE 14th Entries	3151	475	3131	475	-20	0	-0.6%	-0.1%			-20	0		
I-80 EB b/w NE 14th and NEMM	3381	507	3353	506	-28	-1	-0.8%	-0.1%			-28	-1		
I-80 EB b/w 235 Exit and 35 Exit	2896	445	2870	446	-26	1	-0.9%	0.3%			-26	1		
I-80 EB - Core	2347	482	2329	481	-18	-1	-0.8%	-0.3%		-0.8%		-1		
I-80 EB b/w NEMM and US 65	4100	574	4034	572	-66	-3	-1.6%	-0.4%			-66	-3		
I-80 EB under US 65	3012	422	2948	421	-65	-1	-2.2%	-0.2%			-65	-1		
I-80 WB under US 65	1646	263	1644	256	-2	-7	-0.1%	-2.7%		-0.1%		-7		
I-80 WB b/w US 65 and NEMM	2507	401	2496	396	-12	-5	-0.5%	-1.4%		-0.5%		-5		
I-80 WB b/w 35 Exit and 235 Exit	1940	247	1930	245	-11	-2	-0.5%	-0.8%		-0.5%		-2		
I-80 WB - Core	2103	266	2118	264	15	-2	0.7%	-0.7%		0.7%		-2		
I-80 WB b/w NEMM and NE 14th	3329	434	3329	432	0	-2	0.0%	-0.4%			0	-2		
I-80 WB b/w NE 14th Exit and Loop	3099	388	3092	388	-8	0	-0.2%	-0.1%			-8	0		
I-80 WB b/w NE 14th Entries	3457	426	3445	423	-13	-4	-0.4%	-0.8%			-13	-4		
I-80 WB b/w NE 14th and NW 2nd	3808	445	3781	440	-27	-5	-0.7%	-1.2%			-27	-5		
I-80 WB Over NW 2nd	3439	423	3420	419	-19	-5	-0.5%	-1.1%			-19	-5		
I-235 NB b/w Euclid Off-Ramp & On-Loop	3928	191	3922	183	-6	-8	-0.2%	-4.5%			-6	-8		
I-235 NB Under Euclid	4222	221	4212	216	-10	-5	-0.2%	-2.5%			-10	-5		
I-235 NB b/w Euclid and NEMM	4461	223	4446	218	-15	-5	-0.3%	-2.5%			-15	-5		
I-235 NB to I-35 NB	2021	58	2014	53	-7	-5	-0.4%	-9.4%		-0.4%		-5		
I-35 NB b/w I-80 Entries	3293	232	3267	222	-26	-10	-0.8%	-4.6%			-26	-10		
I-35 NB b/w NEMM and Corp Woods	3860	386	3824	370	-36	-16	-1.0%	-4.3%			-36	-16		
I-35 NB Under Corp Woods	3421	360	3386	343	-35	-17	-1.0%	-5.0%			-35	-17		
I-35 SB Under Corp Woods	2904	410	2899	403	-6	-7	-0.2%	-1.7%			-6	-7		
I-35 SB b/w Corp Woods and NEMM	3287	427	3271	419	-16	-8	-0.5%	-1.9%			-16	-8		
I-35 SB to I-235 SB	1338	48	1324	46	-14	-2	-1.1%	-3.4%		-1.1%		-2		
I-235 SB b/w I-80 Entries	1862	102	1834	101	-29	-1	-1.6%	-1.1%		-1.6%		-1		
I-235 SB b/w NEMM and Euclid	2347	164	2311	162	-36	-2	-1.6%	-1.3%		-1.6%		-2		
I-235 SB Under Euclid	1963	116	1932	111	-31	-5	-1.6%	-4.9%		-1.6%		-5		

[1] Vissim simulation results, average of 10 runs, December 2014.

Example Table. Simulated Freeway Segment Mean Speeds (AM Peak Hour)

Location	Mean Vehicle Speed (mph)[1]
I-80 EB Over NW 2nd	64.4
I-80 EB b/w NW 2nd and NE 14th	64.4
I-80 EB b/w NE 14th Exit and Loop	63.0
I-80 EB b/w NE 14th Entries	62.3
I-80 EB b/w NE 14th and NEMM	57.5
I-80 EB b/w 235 Exit and 35 Exit	61.7
I-80 EB - Coe	59.6
I-80 EB b/w NEMM and US 65	61.5
I-80 EB under US 65	64.1
I-80 WB under US 65	65.8
I-80 WB b/w US 65 and NEMM	62.7
I-80 WB b/w 35 Exit and 235 Exit	63.7
I-80 WB - Core	61.7
I-80 WB b/w NEMM and NE 14th	62.6
I-80 WB b/w NE 14th Exit and Loop	62.9
I-80 WB b/w NE 14th Entries	62.9
I-80 WB b/w NE 14th and NW 2nd	63.8
I-80 WB Over NW 2nd	63.2
I-235 NB b/w Euclid Off-Ramp & On-Loop	59.9
I-235 NB Under Euclid	60.2
I-235 NB b/w Euclid and NEMM	57.3
I-235 NB to I-35 NB	61.9
I-35 NB b/w I-80 Entries	60.6
I-35 NB b/w NEMM and Corp Woods	62.3
I-35 NB Under Corp Woods	62.3
I-35 SB Under Corp Woods	63.9
I-35 SB b/w Corp Woods and NEMM	61.2
I-35 SB to I-235 SB	64.5
I-235 SB b/w I-80 Entries	60.7
I-235 SB b/w NEMM and Euclid	60.9
I-235 SB Under Euclid	61.9

1 Vissim simulation results, average of 10 runs, December 2014.

Note: Table shown for reporting results after calibration. When reporting results for calibration, additional columns to compare model results to field data are necessary (see Example Calibration Memo).

Example Table. Simulated Freeway Segment Mean Speeds (AM Peak Period; 15-Minute Breakdown)

Time	Eastbound West Dodge Road Freeway Speeds (mph)[1]												
	Cross Street												
		168th		156th	150th		144th		137th		132nd		Expressway
615-630	65.8	63.7	60.1	55.4	50.7	53.4	57.2	55.8	57.3	57.1	57.4	54.9	51.0
630-645	65.6	62.3	57.4	52.7	46.2	49.6	56.7	54.2	57.1	56.7	57.3	54.5	50.9
645-700	64.4	49.4	45.7	37.6	36.2	43.7	55.8	52.8	56.2	55.5	56.4	53.6	50.2
700-715	63.2	21.2	26.7	19.0	25.4	39.9	55.5	50.6	55.3	55.7	56.3	53.2	50.1
715-730	15.2	9.1	20.3	16.6	23.5	39.2	55.3	51.8	55.8	55.8	56.7	53.5	50.1
730-745	10.2	9.4	20.8	17.0	24.3	41.1	55.6	52.6	56.0	55.7	56.6	54.1	50.3
745-800	10.7	9.9	22.5	19.2	27.0	43.1	56.0	53.4	56.0	55.8	56.8	54.1	50.5
800-815	11.0	10.6	25.1	22.0	30.1	45.3	56.1	54.0	56.0	56.1	56.9	54.2	50.3
815-830	12.8	11.2	30.0	26.3	34.5	46.3	56.1	54.2	56.5	56.3	56.8	54.6	50.5
830-845	65.5	29.3	45.0	35.2	39.5	49.5	56.8	55.6	57.1	56.6	57.1	54.8	50.8
845-900	66.5	65.5	62.2	57.3	54.4	55.7	57.8	56.4	58.1	58.0	57.9	56.0	51.7
900-915	67.3	66.1	63.6	58.5	56.0	56.5	58.2	57.7	58.9	58.8	58.8	57.0	52.7

[1] TransModeler simulation results, average of 10 runs, September 2016.

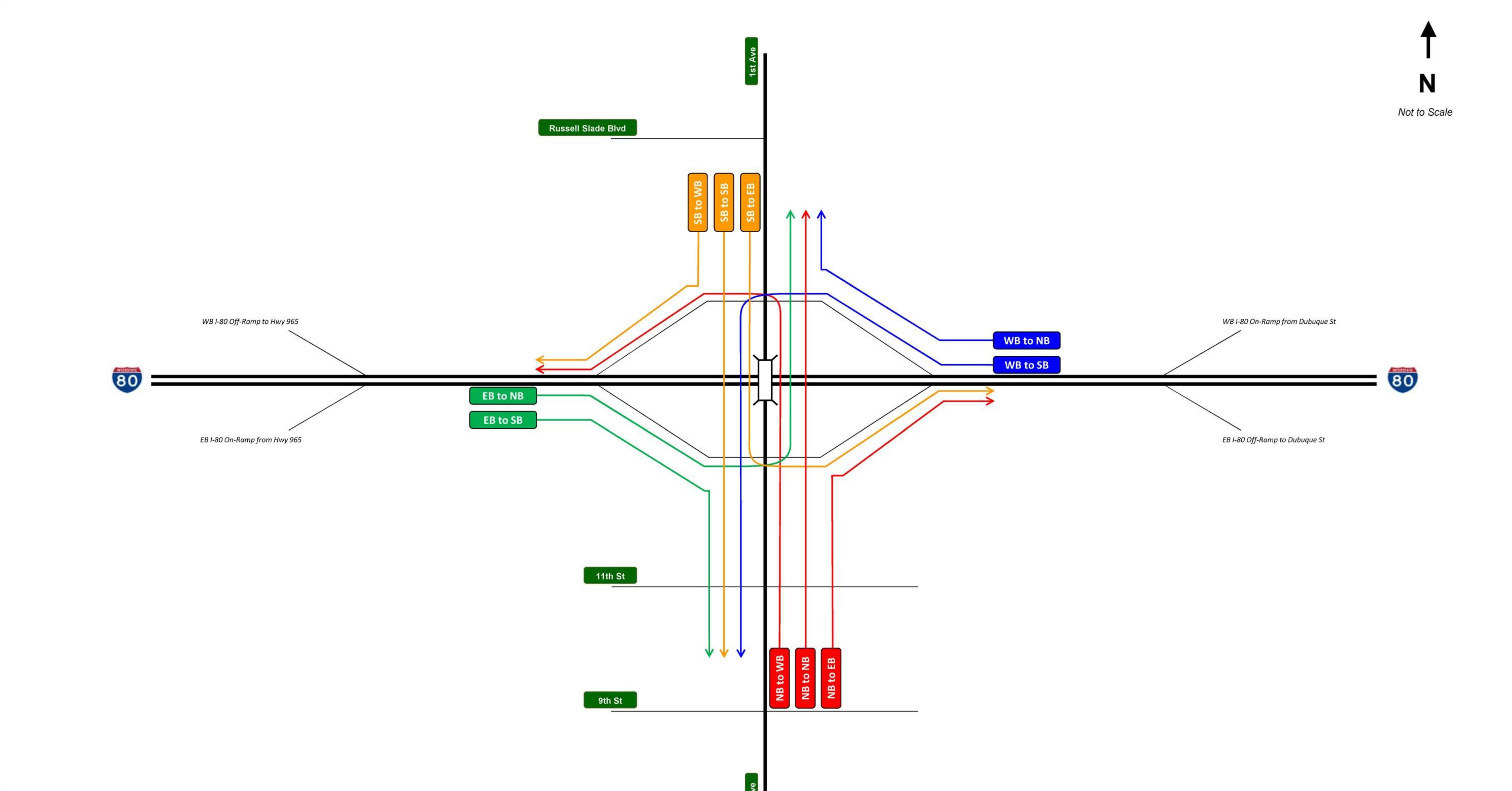
Example Table. Simulated Freeway Travel Time – AM Peak Hour

Travel Time Segment	Travel Time (sec)[1]
Eastbound I-80	
EB I-80/35 b/w NW 2nd Ave and NE 14th St	14.2
EB I-80/35 over NE 14th St	47.0
EB I-80/35 b/w NE 14th St and SB I-235 Exit	34.2
EB I-80/35 b/w SB I-235 Exit and SB I-35 Entry	14.4
EB I-80 b/w SB I-35 Entry and NB I-235 Entry	21.1
EB I-80 b/w NB I-235 Entry and US 65	124.2
EB I-80 Through Study Area (b/w NW 2nd Ave and US 65)	**250.7**
Westbound I-80	
WB I-80 b/w US 65 and NB I-35 Exit	111.9
WB I-80 b/w NB I-35 Exit and SB I-35 Entry	37.0
WB I-80 under Delaware Ave	9.6
WB I-80 b/w Delaware Ave and NE 14th St	35.9
WB I-80 over NE 14th St	44.6
WB I-80 b/w NE 14th St and NW 2nd Ave	11.4
WB I-80 Through Study Area (b/w US 65 and NW 2nd Ave)	**247.9**
Northbound I-235/35	
NB I-235 b/w Euclid Ave and I-80 Exit	62.4
NB I-235 through NEMM Core	27.2
NB I-235/35 b/w NEMM Core and WB I-80 Entry	17.2
NB I-35 b/w WB I-80 Entry and Corporate Woods Dr	66.9
NB I-235/35 Through Study Area (b/w Euclid Ave and Corporate Woods Dr)	**173.5**
Southbound I-35/235	
SB I-35 b/w Corporate Woods Dr Entry and I-80	69.4
SB I-235 b/w I-80 Exit and NEMM Core	21.4
SB I-235 b/w NEMM Core and EB I-80 Entry	24.5
SB I-235 b/w EB I-80 Entry and Euclid Ave	67.0
SB I-35/235 Through Study Area (b/w Corporate Woods Dr and Euclid Ave)	**178.6**

[1] Vissim simulation results, average of 10 runs, December 2014.

Note: Table shown for reporting results after calibration. When reporting results for calibration, additional columns to compare model results to field data are necessary (see Example Calibration Memo).

Example Figure. Simulated Interchange Travel Time



Interchange Option/ Time Period	Movement/Travel Times (Min:Sec)									
	EB to NB	EB to SB	WB to NB	WB to SB	NB to WB	NB to EB	NB to NB	SB to WB	SB to EB	SB to SB
DDI – AM	1:44	1:24	0:47	1:45	1:51	0:57	1:19	0:39	1:12	1:11
ParClo – AM	1:47	1:28	0:44	1:36	1:35	1:03	0:56	0:47	1:18	0:51
Difference	-0:03	-0:04	0:03	0:09	0:16	-0:06	0:23	-0:08	-0:06	0:20
DDI – PM	1:49	1:21	0:57	1:49	2:12	1:09	1:38	0:39	1:11	1:18
ParClo – PM	2:19	1:44	1:05	1:20	1:43	1:11	1:02	0:47	1:24	1:03
Difference	-0:30	-0:23	-0:08	0:29	0:29	-0:02	0:36	-0:08	-0:13	0:15

IOWADOT

Travel Time Segments in VISSIM Traffic Analysis

I-80 / 1st Avenue Interchange Peer Review
Coralville, Iowa

Date: May 2014

Figure: 8

Example Table. Simulated Intersection Queue Lengths – AM Peak Hour

Turning Movement	Max Queue Length (ft)[1]
NE 14th Street/NE 51st Avenue	
NB Left	54
NB Through	380
NB Right	58
SB Left	78
SB Through/Right	279
EB Left/Through/Right	89
WB Left	74
WB Through/Right	49
NE 14th Street/I-80 WB Ramp Terminal	
NB Through	231
SB Through	268
WB Left/Right	106
NE 14th Street/I-80 EB Ramp Terminal	
NB Through/Right	208
SB Left	120
SB Through	145
EB Left/Through	239
EB Right	156
WB Left	129
WB Right	153
NE 14th Street/Broadway Avenue	
NB Left	79
NB Through/Right	449
SB Left	223
SB Through/Right	205
EB Left	119
EB Through/Right	221
WB Left	154
WB Through/Right	387

[1] Vissim simulation results, average of 10 runs, December 2014.

Note: Table shown for reporting results after calibration. When reporting results for calibration, additional columns to compare model results to field data are necessary (see Example Calibration Memo).

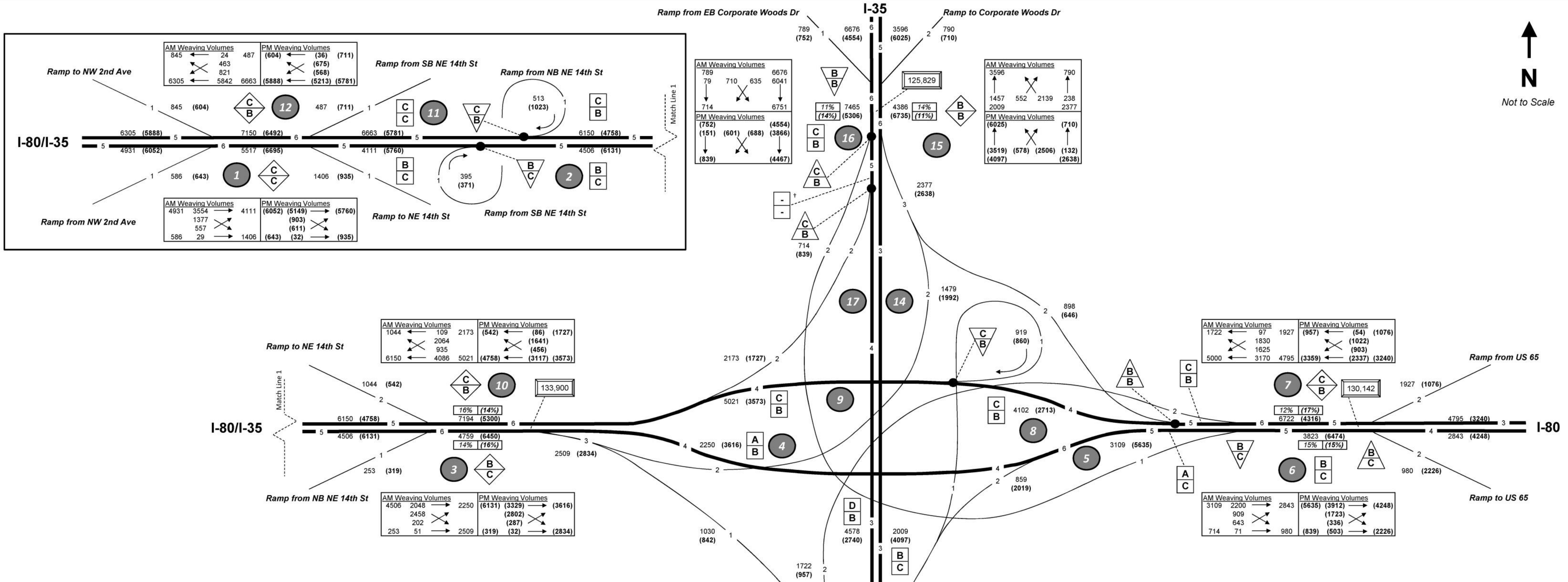
Example Table. Simulated Freeway Density/LOS

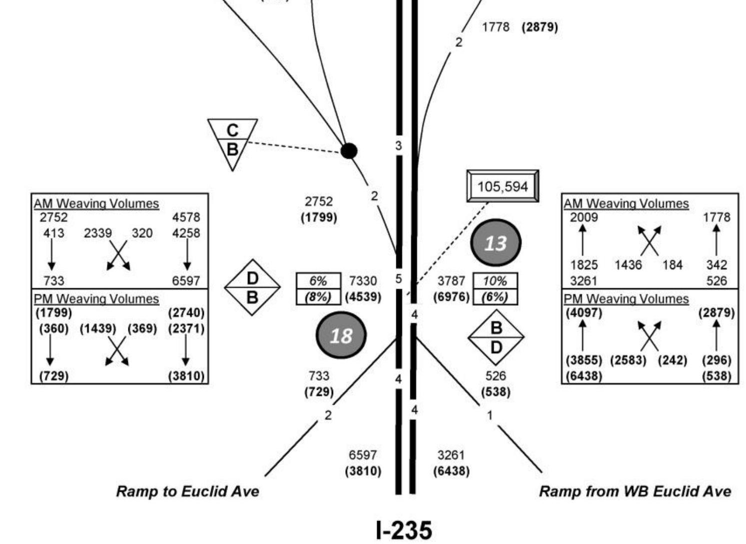
Location	Segment Type	Density (pc/mi/ln) / LOS [1]	
		AM Peak Hour	PM Peak Hour
I-80 Eastbound			
B/W NW 2nd Ave Entry and NE 14th St Exit	Weave	**85.5 / F**	**34.1 / D**
B/W NE 14th St Exit and SB NE 14th St Entry	Basic Freeway	25.3 / C	**31.0 / D**
At SB NE 14th St Loop Entry	Ramp Junction	15.1 / B	19.5 / B
B/W SB NE 14th St Entry and NB NE 14th St Entry	Basic Freeway	25.0 / C	**35.9 / E**
At NB NE 14th St Entry	Ramp Junction	22.7 / C	**35.3 / E**
At SB I-235 Exit	Ramp Junction	25.9 / C	**35.4 / E**
B/W SB I-235 Exit and NB I-35 Exit	Basic Freeway	18.2 / C	**35.1 / E**
At SB I-35 Loop Entry	Ramp Junction	14.6 / B	**50.8 / F**
B/W SB I-35 Entry and NB I-235 Entry	Basic Freeway	20.9 / C	**57.9 / F**
B/W NB I-235 Entry and SB US 65 Exit	Basic Freeway	17.3 / B	**47.1 / F [2]**
At SB US 65 Exit	Ramp Junction	19.8 / B	**33.8 / D [2]**
I-80 Westbound			
At NB US 65 Entry	Ramp Junction	**35.1 / E**	22.1 / C
B/W NB US 65 Entry and NB I-35 Exit	Basic Freeway	**40.0 / E**	24.2 / C
At NB I-35 Exit	Ramp Junction	**36.4 / E**	**29.2 / D**
B/W NB I-35 Exit and SB I-235 Exit	Basic Freeway	25.9 / C	19.3 / C
At NB I-235 Loop Entry	Ramp Junction	27.9 / C	21.7 / C
B/W NB I-235 Entry and SB I-35 Entry	Basic Freeway	**38.1 / E**	**30.2 / D**
B/W SB I-35 Entry and NE 14th St Exit	Weave	**30.1 / D [2]**	25.4 / C
B/W NE 14th St Exit and NB NE 14th St Entry	Basic Freeway	**26.2 / D [2]**	23.6 / C
At NB NE 14th St Loop Entry	Ramp Junction	23.1 / C [2]	21.9 / C
B/W NB NE 14th St Entry and SB NE 14th St Entry	Basic Freeway	**32.4 / D [2]**	**30.6 / D**
B/W SB NE 14th St Entry and NW 2nd Ave Exit	Weave	26.4 / C [2]	24.4 / C
I-235/35 Northbound			
B/W WB Euclid Ave Entry and I-80 Exit	Weave	20.9 / C	**61.5 / F [2]**
B/W I-80 Exit and I-35 (EB I-80) Entry	Basic Freeway	13.1 / B	**32.4 / D**
B/W I-35 (EB I-80) Entry and WB I-80 Entry	Basic Freeway	16.4 / B	**31.2 / D**
B/W WB I-80 Entry and Corporate Woods Dr Exit	Basic Freeway	15.5 / B	**26.1 / D**
At Corporate Woods Dr Exit	Ramp Junction	14.7 / B	24.4 / C
I-35/235 Southbound			
At EB Corporate Woods Dr Entry	Ramp Junction	**84.7 / F [2]**	-
B/W Corporate Woods Dr Entry and I-80/35 Exit	Basic Freeway	**28.2 / D [2]**	-
B/W Corporate Woods Dr Entry and I-80/35 Exit	Weave	-	26.6 / C
B/W I-80/35 Exit and WB I-80 Entry	Basic Freeway	**31.5 / D [2]**	19.1 / C
B/W WB I-80 Entry and EB I-80 Entry	Basic Freeway	**35.3 / E [2]**	19.0 / C
At EB I-80 Entry	Ramp Junction	**52.2 / F [2]**	19.2 / B
B/W EB I-80 Entry and Euclid Ave Exit	Basic Freeway	**38.4 / E [2]**	23.0 / C
At Euclid Ave Exit	Ramp Junction	**37.5 / E [2]**	23.5 / C

Source: Vissim - Consultant, April 2015.

1. Results are the average from 10 simulation runs. Results are based on the demand during the peak 15 minutes within the hour. Locations without a value are based on the HCM weave criteria methodology; these locations are either analyzed as a weaving segment or a combination of basic freeway and ramp junctions. Highlighted cells indicate operations at LOS 'D' or worse.
2. Simulation volume throughput less than 85% of forecasted demand.

Example Figure. Simulated Freeway LOS, Travel Times and Speeds





Notes:

1. Results are the average from 10 simulation runs.
2. Level of service (LOS) results are based on the average density per lane of passenger car equivalent vehicles for the peak 15-minute period within each peak hour.
3. Weaving volumes are provided for the four legs adjacent to the Northeast Mixmaster for both directions. However, some of these locations do not meet HCM weave criteria based on a combination of geometry, weaving volumes and distance between ramps. For these locations, weave segment operations are reported during the periods weave segment criteria are met; otherwise, basic freeway operations are reported. Note that the locations reported as weaves are based on the HCM weave segment criteria.

† No basic freeway analysis reported because of overlapping ramp junction influence areas.

LEGEND

- ### (###) — AM and **(PM)** Peak Hour Volumes
- #% (#%) — AM and **(PM)** Peak Hour Truck Percentages
- —#— Number of Lanes
- AM Peak Hour Basic Freeway Level of Service / PM Peak Hour Basic Freeway Level of Service
- AM Peak Hour Ramp Merge Level of Service / PM Peak Hour Ramp Merge Level of Service
- AM Peak Hour Ramp Diverge Level of Service / PM Peak Hour Ramp Diverge Level of Service
- AM Peak Hour Weaving Section Level of Service / PM Peak Hour Weaving Section Level of Service
- #,### Average Daily Traffic (ADT)
- # Travel Time Segment Number

VISSIM Travel Time Results

Segment	Description	Average Travel Time (sec) AM	Average Travel Time (sec) (PM)	Average Segment Speed (mph) AM	Average Segment Speed (mph) (PM)
1	EB I-80/35 b/w NW 2nd Ave and NE 14th St	16.6	15.9	60.5	63.0
2	EB I-80/35 over NE 14th St	44.2	44.2	60.2	60.3
3	EB I-80/35 b/w NE 14th St and I-35/235 Exit	19.3	19.7	61.8	60.7
4	EB I-80/35 b/w I-35/235 Exit and NB I-235 Entry	52.7	53.5	64.3	63.3
5	EB I-80 b/w NB I-235 Entry and SB I-35 Entry	20.6	21.2	64.9	63.1
6	EB I-80 b/w SB I-35 Entry and US 65	98.2	100.8	64.7	63.0
	EB I-80 Through Study Area	**246.4**	**251.8**	**64.7**	**63.3**
7	WB I-80 b/w US 65 and SB I-235 Exit	72.5	70.7	62.6	64.3
8	WB I-80 b/w SB I-235 Exit and NB I-235 Entry	51.9	50.7	61.9	63.3
9	WB I-80 b/w NB I-235 Entry and SB I-35 Entry	27.9	26.9	60.1	62.4
10	WB I-80 b/w SB I-35 Entry and NE 14th St	31.8	30.6	60.5	62.9
11	WB I-80 over NE 14th St	44.1	43.2	62.0	63.2
12	WB I-80 b/w NE 14th St and NW 2nd Ave	16.1	15.9	62.6	63.4
	WB I-80 Through Study Area	**240.8**	**235.6**	**62.7**	**64.1**
13	NB I-235 b/w Euclid Ave and I-80 Exit	57.6	62.3	59.7	55.1
14	NB I-235 b/w I-80 Exit and I-80 Entry	76.6	79.8	63.4	60.9
15	NB I-35 b/w I-80 Entry and Corporate Woods Dr	33.3	34.0	63.2	61.8
	NB I-235/35 Through Study Area	**166.4**	**175.7**	**62.5**	**59.2**
16	SB I-35 b/w Corporate Woods Dr Entry and EB I-80 Exit	45.7	44.2	60.5	62.5
17	SB I-235 b/w EB I-80 Exit and I-80 Entry	89.5	85.8	60.1	62.7
18	SB I-235 b/w I-80 Entry and Euclid Ave	35.9	33.6	56.3	60.1
	SB I-35/235 Through Study Area	**169.4**	**162.2**	**60.0**	**62.6**

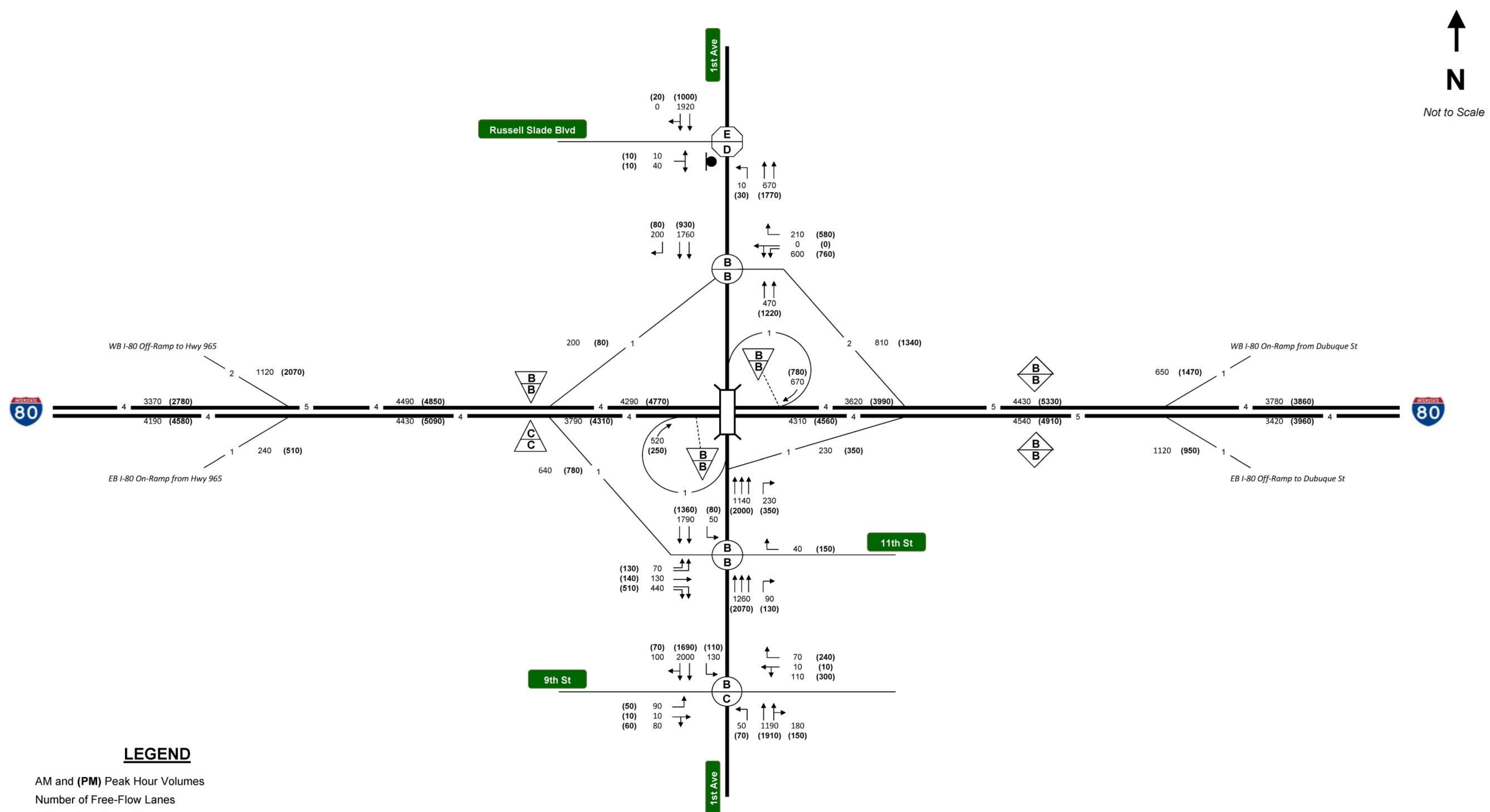
* Travel Times and Speeds are averages over the course of the entire AM and PM peak hours.

Sources:
1. Traffic Volumes - Iowa DOT, February 2015.
2. Traffic Capacity Analysis (VISSIM Micro-Simulation, version 5.4) - HDR, March 2015.

80 35 235 NORTHEAST MIXMASTER
Alternative 2 - Year 2050 Build Dual Exit Conditions - VISSIM Traffic Analysis
IJR / Preliminary Design
Polk County, Iowa

Date Nov 2015
Figure 2.3-3

Example Figure. Simulated Interchange Intersection and Freeway LOS



LEGEND

XXX **(XXX)**	AM and **(PM)** Peak Hour Volumes
—#—	Number of Free-Flow Lanes
→	Intersection Geometrics
	Stop Sign
X / X (circle)	AM Peak Hour Signalized Intersection Level of Service PM Peak Hour Signalized Intersection Level of Service
X / X (octagon)	AM Peak Hour Worst Case Stop-Controled Approach Level of Service PM Peak Hour Worst Case Stop-Controled Approach Level of Service
X / X (inverted triangle)	AM Peak Hour Freeway Merge Level of Service PM Peak Hour Freeway Merge Level of Service
X / X (triangle)	AM Peak Hour Freeway Diverge Level of Service PM Peak Hour Freeway Diverge Level of Service
X / X (diamond)	AM Peak Hour Freeway Weave Level of Service PM Peak Hour Freeway Weave Level of Service

Sources:
1. Traffic Volumes - HDR, December 2013, Based on Volumes in November 2010 IJR.
2. Traffic Capacity Analysis (VISSIM) - HDR, May 2014.

Note:
Analysis was based on third northbound lane on 1st Avenue added approximately 400 feet south of 9th Street. This was to accommodate projected peak hour demand and serve a higher percentage of the demand at the ramp terminal intersections.

Year 2035 Build ParClo Volumes, Geometrics and Levels of Service

I-80 / 1st Avenue Interchange Peer Review
Coralville, Iowa

Date: May 2014

Figure: 7