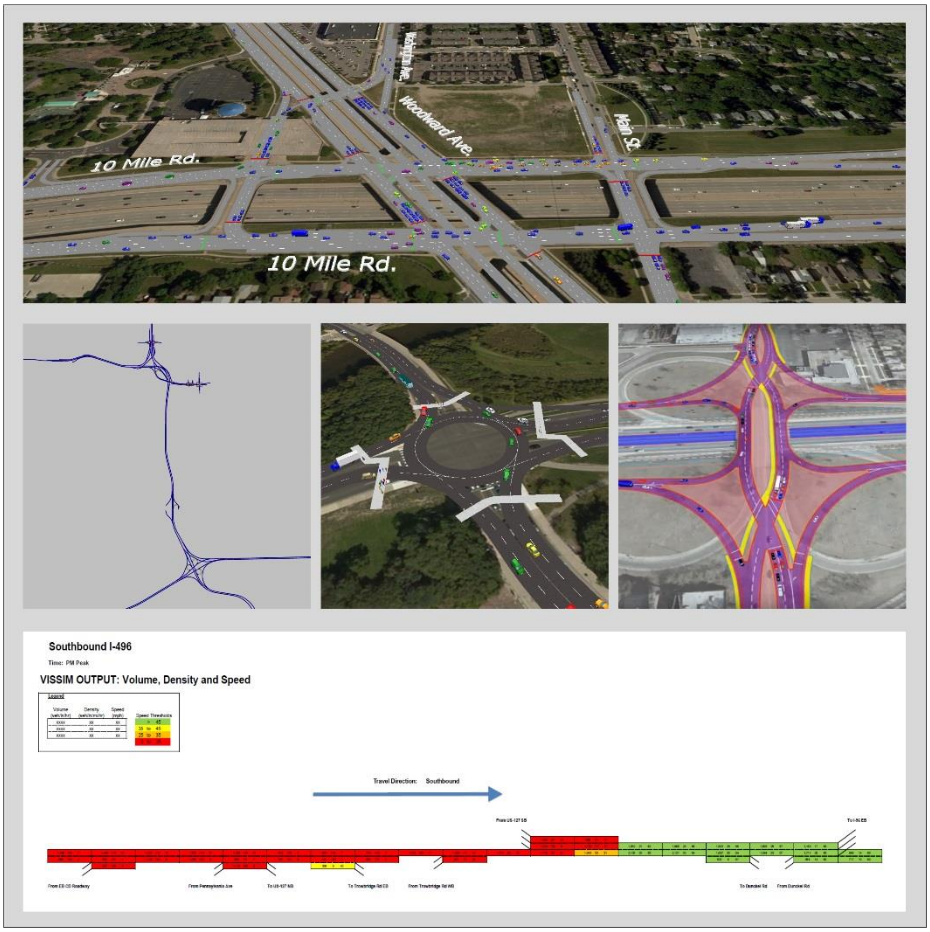
VISSIM Protocol Manual



Michigan Department of Transportation

Distribution, Updates and Contact

This document is Version 1.1 and available online. The most recent version of the manual will always be found online and it is recommended that users frequently check back for updates prior to the start of a project. Manual users can submit comments, questions and proposed revisions to the MDOT Congestion and Reliability Unit at the below contact.

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List of Abbreviations

ANM	Abstract Network Model
ATM	Active Traffic Management
CV/AV	Connected Vehicle/Autonomous Vehicle
DMS	Dynamic Message Sign
DTA	Dynamic Traffic Assignment
FHWA	Federal Highway Administration
GEH	A Statistic formula
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
HGV	Heavy Gross Vehicle
HOV	High Occupancy Vehicle
MDOT	Michigan Department of Transportation
MOE	Measure of Effectiveness
MPO	Metropolitan Planning Organization
N/A	Not Applicable
O-D	Origin - Destination
PTV	Planung Transport Verkehr AG
QA	Quality Assurance
QC	Quality Control
RBC	Ring Barrier Controller
RITIS	Regional Integrated Transportation Information System
RTOR	Right Turn on Red
SEMCOG	South Eastern Michigan Council of Governors
SUV	Sport Utility Vehicle
Synchro	Macroscopic Analysis and optimization Software
TDMS	Transportation Data Management System
TSP	Transit Signal Priority
VAP	Vehicle Actuated Programing

VISSIM	A microscopic multi-modal traffic flow simulation software package
VISTRO	Macroscopic Analysis and optimization Software
VISUM	A macroscopic multi-modal traffic flow simulation software package
.err	VISSIM simulation error name extension
.inpx	VISSIM file name extension
3D	Three Dimensional

1 VISSIM PROTOCOL OVERVIEW

VISSIM is the microsimulation software developed and maintained by PTV. VISSIM modeling is generally a labor-intensive effort to develop a calibrated and validated model which accurately reports measures of effectiveness (MOEs). With any microsimulation software, there are many points in the model development process where assumptions need to be made and agreed upon between the modeler and the reviewing agency to ensure final deliverables meet Michigan Department of Transportation (MDOT) expectations. This document will serve as standard protocol for VISSIM model development and deliverables for the MDOT. The goal is to provide clear modeling guidance and expectations for VISSIM model development in Michigan.

This protocol was developed from the MDOT Research Project OR18-011, that conducted a literature review of other protocol documents from around the United States. Best practices from this literature review were incorporated into this MDOT VISSIM Protocol Manual.

1.1 PURPOSE OF THIS MANUAL

The purpose of the *VISSIM Protocol Manual* is to provide guidelines and recommendations for VISSIM modeling on projects in the State of Michigan. This manual provides guidance to administrative, engineering, and technical staff. This manual provides general guidelines; however, it is understood that adaptation, adjustments, and deviations are sometimes necessary. Innovation is a key foundational element to advance the state of engineering practice and develop more effective and efficient engineering solutions and materials.

It is expected when making significant or impactful deviations from the technical information within this manual, consultation with MDOT will occur. MDOT leadership is committed to a culture of innovation to optimize engineering solutions.

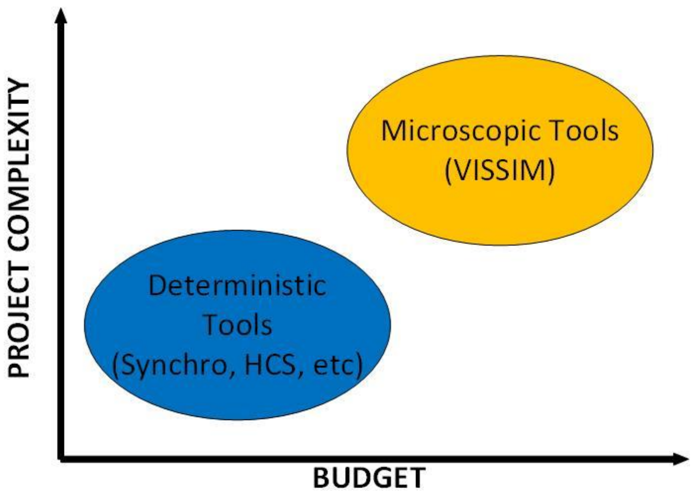
The VISSIM Protocol Manual is to provide clear modeling guidance and expectations for VISSIM model development in Michigan.

1.2 WHEN TO USE MICROSIMULATION

Microsimulation models, such as VISSIM, explicitly model traffic movements based on geometric parameters, traffic volumes, vehicle types, intersection control, and driver behavior. VISSIM assesses the roadway network in a dynamic fashion, instead of analyzing each intersection or each roadway segment in isolation. VISSIM can provide MOEs such as vehicle delay, density, travel time, average speed, number of stops, queuing, and fuel consumption on a networkwide basis, so that the effects of improvements at a single location may be measured throughout the network. VISSIM also can generate 3-D visualizations, which are a powerful tool for public meetings and generating stakeholder consensus. The data from VISSIM can also be exported to a third-party visualization software when higher end graphics are desired.

It is important to pick the right analysis tool for the project analysis needs, and due to the complexity and data/labor intensity typical of a microsimulation analysis, it is not always the most efficient or cost-effective tool. Simpler deterministic software packages such as the *Highway Capacity Software* (HCS) may provide analysis capabilities and the level of detail to meet the project analysis needs.

Figure 1: Analysis Tool vs. Project Budget and Complexity



In addition to microsimulation (microscopic simulation), there are macroscopic simulation models and mesoscopic simulation models. Macroscopic models are based on deterministic relationships between traffic flow, speed, and density. The simulation in a macroscopic model takes place on a section-by-section basis rather than by tracking individual vehicles like a microscopic simulation. Macroscopic models are typically used as a high-level regional planning tool. Mesoscopic simulation models combine the properties of both microscopic and macroscopic simulation models. Mesoscopic models provide less fidelity than microsimulation models, but more than macroscopic tools and are typically used for more detailed regional or corridor planning analysis compared to a macroscopic modeling tool. Microscopic simulation models, like VISSIM, are data-intensive and simulates individual vehicles providing a greater level of detail compared to macro and mesoscopic modeling tools. Microscopic simulation models can be time consuming, costly, and difficult to calibrate.

Many agencies default to the Federal Highway Administration's guidance on appropriate analysis tool selection. The FHWA Traffic Analysis Toolbox Volume II recommends the first step in selection of a traffic analysis tool is the identification of the analytical context of the project. The project can fall into one of three phases, which include: planning, design, or operations/construction.

FHWA outlined the following criteria to help identify the analytical tools that are most appropriate for a project:

1. Ability to analyze the geographic scope or study area. Including isolated intersection, single roadway, corridor, or network.

2. Capability of modeling various facility types, such as freeways, high-occupancy lanes, ramps, arterials, etc.

3. Ability to analyze various travel modes, such as single-occupancy vehicles, bus, train, and non-motorized traffic.

4. Ability to analyze various traffic management strategies and applications, such as ramp metering, signal coordination, incident management, etc.

5. Capability of estimating traveler responses to traffic management strategies, including route diversion, mode shift, and induced demand.

6. Ability to produce and output performance measures, such as safety measures, efficiency, mobility, productivity, and environmental measures.

7. Tool/cost-effectiveness for the task from an operational perspective. Parameters that influence cost-effectiveness include tool capital cost, level of effort, ease of use, hardware requirements, data requirements, animation, etc.

Reviewing these seven criteria will help identify the analysis tool or tools that meet the needs for the project. In the case where multiple tools will meet the needs, the project team should confirm the most efficient and cost-effective tool to move forward with for analysis. In some instances, multiple analysis tools may be necessary.

VISSIM is an ideal tool for testing and comparing alternatives to determine the most effective combination of elements in facilitating traffic flow. In addition, the sensitivity of the VISSIM model allows the user to test more subtle changes to the roadway system, such as adjustments in traffic signalization, addition or removal of driveways and access points, changes in transit operations, complex geometrics, and others. VISSIM is best applied for high-resolution operational analysis, where the nuances of the scenario to be tested fall outside of the capabilities of other software packages. This may include:

- Complex signal timing/operations (transit signal priority and pre-emption strategies, e.g.)
- Complex geometrics
- Traffic flow and interaction through closely-spaced intersections
- Managed lane operations
- Transit operations
- Ramp metering and ATM strategies

- Roundabouts
- Curbside operations
- CV/AV operations
- Interactions between non-motorized and motorized modes of travel

MOEs from VISSIM often require post-processing by the modeler to create reports/tables/figures. Project Managers should contact the MDOT Congestion and Reliability Unit if guidance is needed as to whether VISSIM modeling is appropriate.

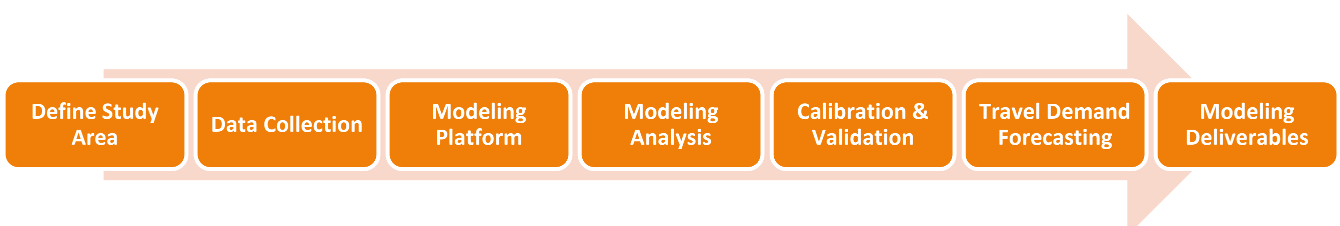
1.3 MODEL SCOPE DEVELOPMENT

Successful delivery of a VISSIM modeling analysis requires a clear and defined project scope. Some key questions to answer during the scoping process are as follows:

- ***WHY*** – Why is the analysis needed?
- ***WHAT*** – What questions should the analysis answer?
- ***WHO*** – Who are the intended reviewers and recipients of the results?
- ***HOW*** – How should results be presented?

It is important that the work tasks be clearly defined and that the parties responsible for completing them are identified. The following sections highlight the critical elements in developing a VISSIM modeling scope of work. Questions to be considered when developing the scope associated with each of these elements follows. Detailed descriptions and considerations for developing each of these elements are found in Chapter 2.

Figure 2: Scope of Work Critical Elements



Define Study Area

- What should be the geographic limits of the modeled area? *There are differences between project limits and modeling limits. It is important that the appropriate modeling limits are chosen to encompass as much of the congestion as is feasible.*
- What time periods should be represented in the models? *VISSIM modeling differs from other microscopic modeling in that larger time periods are often utilized in the model.*

Data Collection

- What data is needed (traffic volumes, speeds, vehicle classifications, travel times, signal timings, etc.)? *It is important to notify the consultant what data is necessary so proper cost estimations can be made for data collection.*
- Who is collecting/providing the data? *This is a key part of the analysis contract.*
- How will data be screened and validated? *It is important to make sure the data used is valid and meets the needs of the eventual model.*

Modeling Platform

- What version of VISSIM will be used? *Contact the MDOT Congestion and Reliability Unit to know which version should be used, and be sure to notify the consultant in advance of the project.*

Modeling Analysis

- What scenarios are to be modeled? *It is important to establish early on how many different scenarios will eventually be modeled. This also impacts the contract cost.*
- How are volume/routing information to be modeled? *VISSIM models can be static or dynamic.*
- What modes are to be included? *Pedestrian, Transit, and Other Modes can be modeled in great detail using VISSIM.*
- What traffic control is present in the study area? *Signal timing permits may be needed.*

Calibration & Validation

- What criteria will be used to consider a model validated? *It is important to know if there exists good probe data or speed data for calibration.*

Travel Demand Forecasting

- What information is needed from the forecasting model? *Sometimes data from external partners is necessary in order to build a proper VISSIM model.*
- Who is responsible for providing the travel demand forecasts? *If coordination with the local MPO is needed for the model, it is important to establish that need early on.*
- How many future year scenarios? *An appropriate target year is also necessary to model future conditions.*

Modeling Deliverables

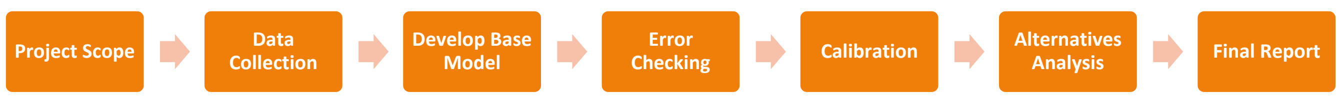
- What MOEs will be required to evaluate/differentiate alternatives? *Establishing MOEs guides the consultant in developing a VISSIM model that properly answers the questions being asked.*
- What format will MOEs be presented in? *It is important that the consultant knows to include those metrics in the model that are needed in the final report. Formatting is also key.*

- What level of visualization/animations will be needed? *It helps to know early on if a 3D simulation will be needed for presenting to external stakeholders.*

1.4 PROJECT MANAGEMENT

Project management of a VISSIM analysis requires establishing clear objectives, defining a solid scope of work and schedule, monitoring milestones, and reviewing deliverables. The general workflow is as follows:

Figure 3: VISSIM Analysis Workflow



A prototypical schedule as presented in FHWA'S *Traffic Analysis Toolbox Volume III* is presented below. MDOT key milestones and deliverables are presented on the following page. For questions about or during this workflow, please contact the MDOT Congestion & Reliability Unit. Developing VISSIM models can be a lengthy process and the Project Manager should account for the longer analysis duration in the project schedule for microsimulation..

Figure 4: Typical VISSIM Schedule (source: *FHWA Traffic Analysis Toolbox Volume III)*

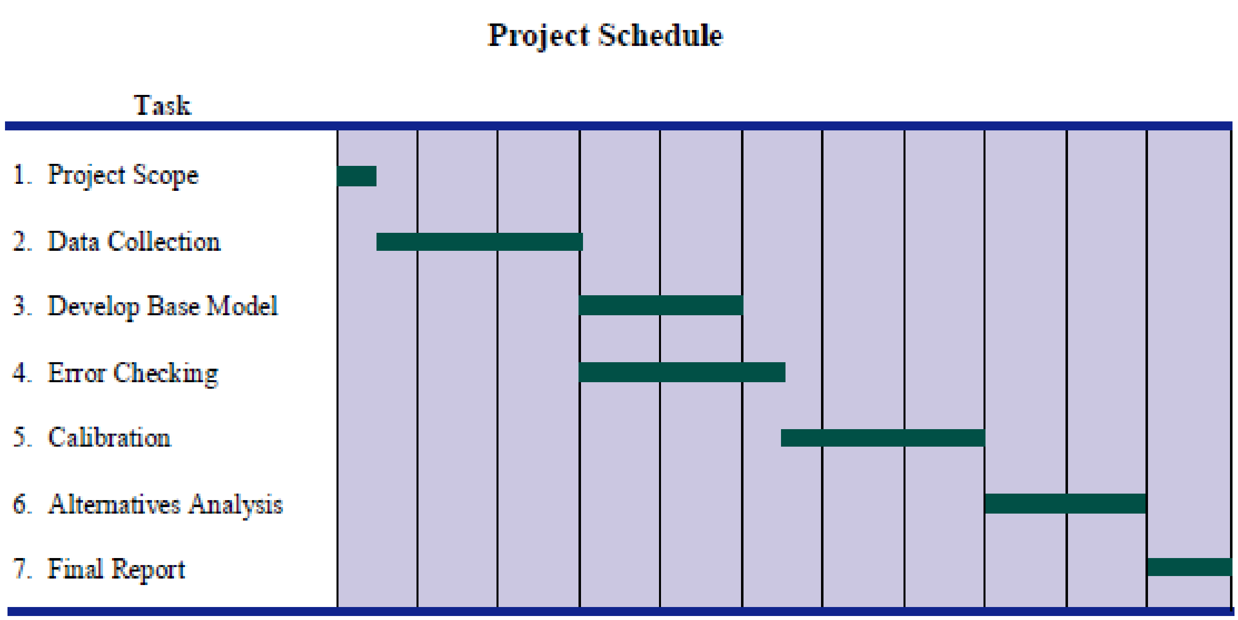
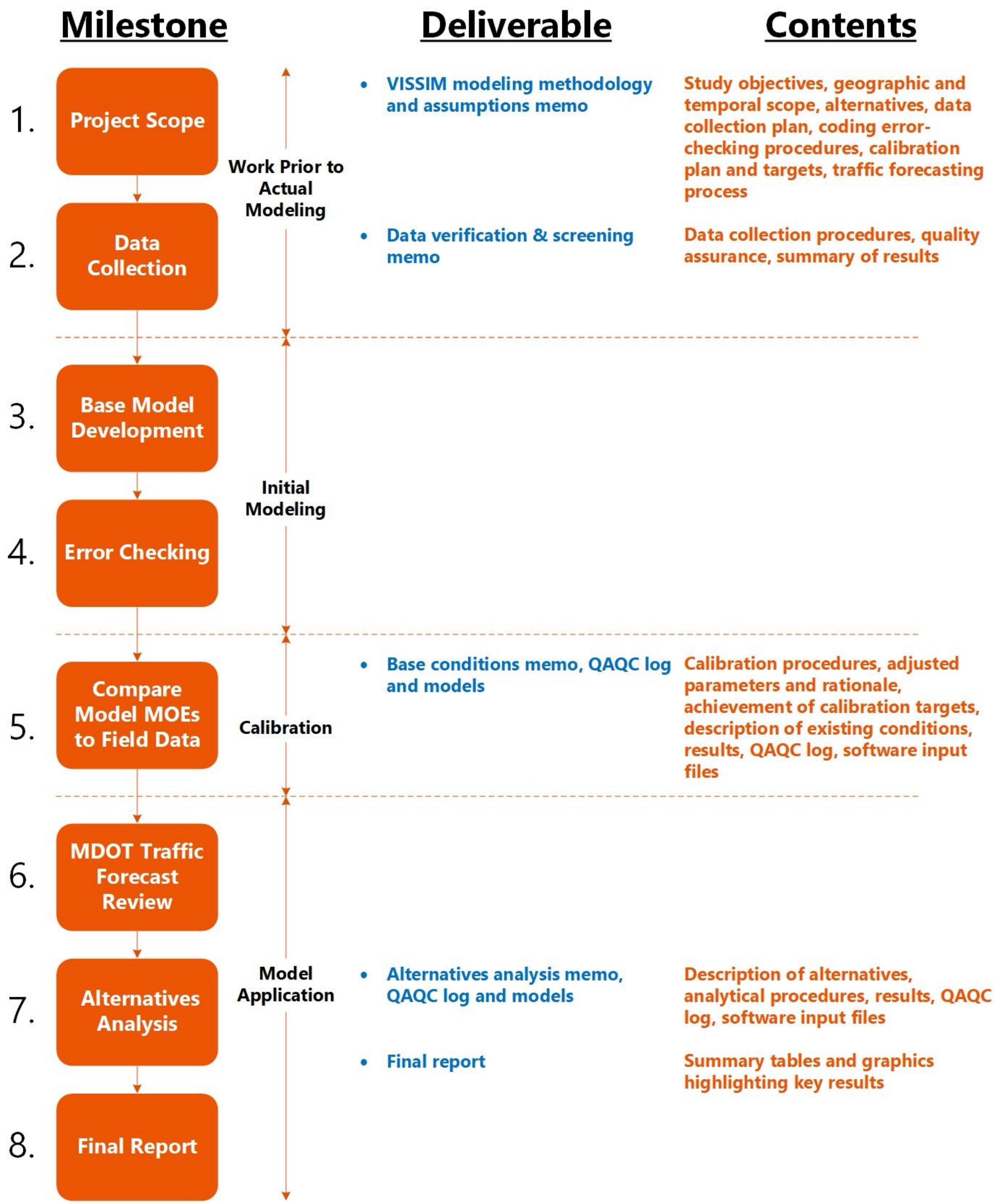


Figure 5: MDOT VISSIM Analysis Milestones and Deliverables



1.5 REVIEWING DELIVERABLES

There are primarily two types of deliverables that will require MDOT review on VISSIM modeling projects:

1. Documentation (memos and report)
2. Model Software files and supporting electronic files

Documentation

The various memos and reports that are generated as part of the project should at a minimum be reviewed by the MDOT Project Manager and representatives within MDOT's Congestion & Reliability Unit. The MDOT Project Manager may choose to incorporate additional key stakeholders to review these documents as appropriate.

A consolidated set of comments will be prepared by the MDOT Project Manager and distributed back to the model development team. Project managers should allow the MDOT Congestion and Reliability Unit (and others) at least two weeks of review time to evaluate VISSIM models, and other associated memos and reports.

Model Software Files

In traditional design project delivery methods, comments can be made directly on plan sheets or by tracking revisions/comments within a document, however making comments within a VISSIM model directly is not possible. A separate comment tracker needs to be prepared, and the MDOT preferred template is provided in Appendix A.

Prompt lists/checklists are excellent tools that provide a structured review and uniform review process that is consistent and comprehensive.

Quality control (QC) and quality assurance (QA) of models needs to occur internally within the model development team prior to submission to MDOT. Prompt lists/checklists can be very useful in providing a structured and uniform review process that is consistent and comprehensive. A sample VISSIM model review prompt sheet for reference and use is provided in Appendix A. The model development team is not obligated to use this checklist; however, a document providing proof of QA/QC procedures is to be submitted with each modeling deliverable.

The model software files and associated input files should be reviewed by the MDOT Congestion & Reliability Unit. The Congestion & Reliability Unit will prepare comments in a comment tracker sheet and provide a consolidated set of review comments to the MDOT Project Manager for distribution to the model development team.

2 VISSIM PROTOCOL PROCESS

This chapter of the *MDOT VISSIM Protocol Manual* provides guidance on preparing VISSIM models within the State of Michigan. MDOT's VISSIM model development expectations are described in detail and it is the intent for model developers to follow these guidelines which will provide consistency with approved coding techniques and for a more efficient review dialogue between modelers and the MDOT review team. The sections that follow provide guidance for preparing individual elements of model development, data collection, MOEs, and documentation.

2.1 VISSIM VERSION SELECTION

A decision should be made at the start of the project as to which version of VISSIM should be used and documented in the scope. PTV Group typically releases major updates to the VISSIM software once a year in addition to minor updates to address feature updates and software bugs/errors more frequently.

Project managers should consult with MDOT Congestion and Reliability Unit to identify current VISSIM version used.

Some projects may take over one year to complete and as such a software package may go through one or more updates. Typically, the model should remain in the VISSIM version originally identified in the project scope, but there may be exceptions to where an upgrade during the project duration makes sense. Before upgrading to a new release or version of VISSIM, the modeler shall consult with the MDOT Project Manager and identify the reason(s) to justify the upgrade. Below is a list of the types of updates and general actions to take:

- ***SOFTWARE BUG/ERROR FIX*** – should be updated as soon as possible.
- ***FEATURE ADDITION*** – may be updated during the project duration. If the benefit of adding the additional feature outweighs any potential issues (e.g., additional time/resources needed to revise the model and re-validate), updating the model to apply the new features may be justified. MDOT concurrence is necessary before proceeding with the update.
- ***MAJOR VERSION RELEASE*** – update only as necessary. Since major version releases of the software typically involve larger changes to the analysis methodologies, upgrading the traffic model to a new version is not recommended during the course of a project unless advised by the MDOT Project Manager.

CAUTION: In the case where a previously calibrated and validated model is being used as the base model for a new project, upgrading the traffic model to the newest software version/release may cause the previously calibrated model to fall out of validation due to new software features and/or new default parameters. Care should be taken to verify the model still validates after upgrading to the agreed upon version if an upgrade is required. Additional calibration may be necessary to get the model to validate in the upgraded VISSIM version and should be planned for accordingly in the labor effort when setting up the initial modeling scope.

2.2 GEOGRAPHIC AND TEMPORAL MODEL SCOPE

FHWA's *Traffic Analysis Toolbox Volume III* states, "The geographic and temporal scopes of a microsimulation model should be sufficient to completely encompass all of the traffic congestion present in the primary influence area of the project during the target analysis period (current or future)."

First, it is necessary to understand some key terms when defining a VISSIM model's geographic scope. The primary study area is typically defined as the principal area of concern that was identified as having operational deficiencies. The primary study area is often where mitigations are applied in the model and MOE's are collected. For example, a freeway bottleneck and resulting queue. The influence area is defined after the primary study area is established. The influence area is larger in geographic scope than the primary study area to ensure the impacts to and from adjacent facilities are accounted for in the analysis.

It is common for a VISSIM analysis to have broader geographic limits than the discrete boundaries of a roadway design project due to accounting for the larger influence area.

The following are general guidelines for determining both geographic and temporal scopes.

GEOGRAPHIC SCOPE - FREEWAY AND RAMP TERMINALS

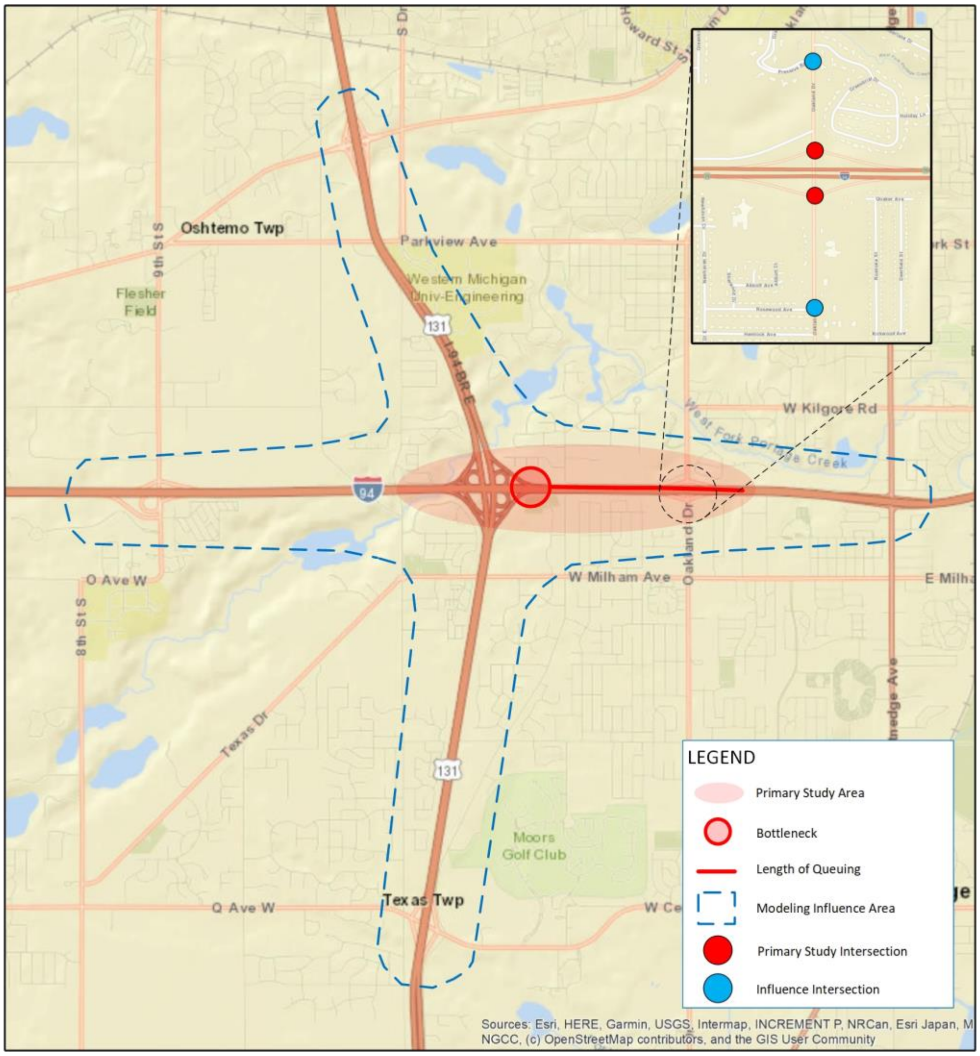
Mainline: The VISSIM network should at a minimum generally extend through at least one interchange on either side of the primary study area. This is done to properly capture any metering of traffic from this "influence area" into the project's primary study area. In cases with large interchange spacing, two miles on either side is a good rule of thumb. Keep in mind that in closely spaced areas, additional interchanges may need to be included to capture their influence. Caution should be given when modeling system interchanges and areas with significant weaving. The distance required to capture correct weaving behavior depends greatly on the surrounding interchanges' configuration and the level of congestion. The network limits should extend far enough to capture the full extent of mainline queues without spilling out of the network. Also, any upstream and downstream bottlenecks that meter traffic entering and exiting the primary study area should be included.

Interchange Ramp Terminals: Within the primary study area, the VISSIM network should include ramp terminal intersections as part of the project. At a minimum, the nearest adjacent intersections in all directions of a ramp terminal are generally included as part of the "influence area" to properly meter traffic into the primary study area. All intersections that have significant influence on the arrival pattern or lane choice of vehicles entering the network shall be modeled, including unsignalized intersections. The surface street network limits should extend far enough to capture the full extent of queues within the primary study area without spilling out of the network.

Figure 6 illustrates the typical geographic scope of a model taking into account congestion spillback from the primary study area. All network boundaries should be segments with free flow traffic conditions and be long enough to prevent queues from spilling out of the network. It should be confirmed with the MDOT Project Manager whether interchanges in the influence area need to have the full ramp terminals and surface street coded, or if just the ramps without ramp terminals are sufficient.

NOTE: *The influence area does not typically need to have MOE's summarized as the purpose of this additional network is to accurately meter traffic into the primary study area. It is, however, recommended that validation reporting should include both the primary study area and the entire influence area. The influence area and the primary study area both should be coded.*

Figure 6: Sample Freeway Geographic Scope



GEOGRAPHIC SCOPE - ARTERIALS

VISSIM networks that include arterial surface streets will have similar requirements to those described for ramp terminals. The VISSIM model should extend, at a minimum, one intersection beyond the primary study area if within half-mile spacing. If the next intersection is beyond a half-mile, the project team should determine if it should be included based on its known influence of metering traffic into/out of the primary study area. All intersections including unsignalized intersections influencing the arrival patterns or the lane choice should be included in the model.

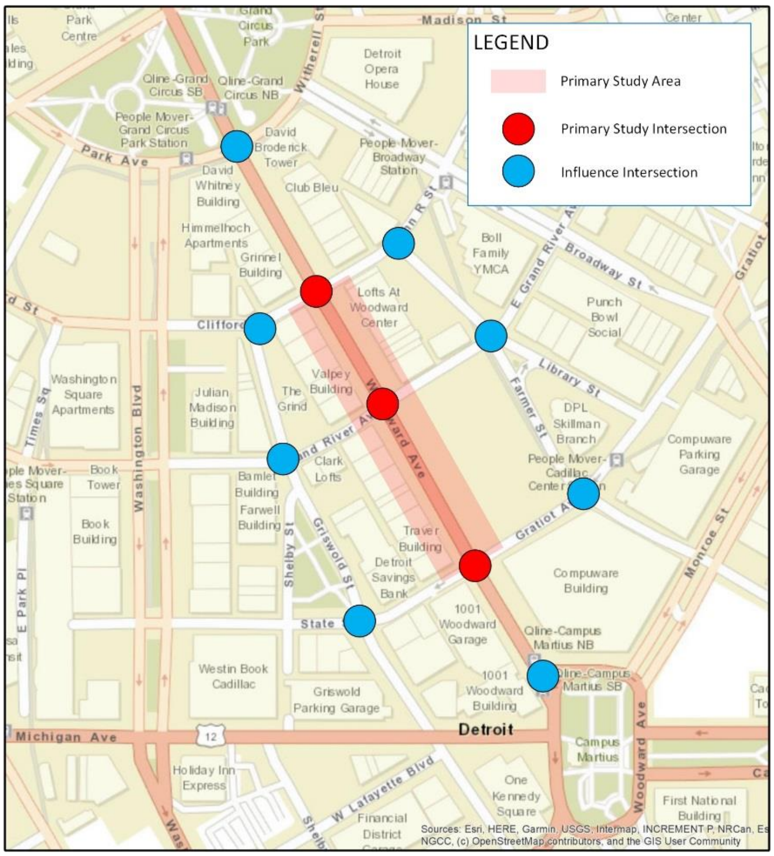
All intersections including unsignalized intersections influencing the arrival patterns or the lane choice should be included in the model.

Bottlenecks causing queue spillback into study intersections and upstream bottlenecks that meter traffic into the study area should be included.

Figure 7 illustrates the typical geographic scope of a model including both the primary study area and influence area. All network boundaries should be segments with free flow traffic conditions and be long enough to prevent queues from spilling out of the network.

NOTE: *The influence area does not typically need to have MOE's summarized as the purpose of this additional network is to accurately meter traffic into the primary study area. It is, however, recommended that validation reporting should include both the primary study area and the entire influence area. The influence area and the primary study area both should be coded.*

Figure 7: Sample Arterial Geographic Scope



TEMPORAL SCOPE

The typical temporal scope for freeway and arterial VISSIM modeling projects should include the time when operations change from free flow to when congestion starts to form (pre-peak), the peak period of congestion, and time congestion dissipates back to free flow conditions (post-peak). In situations where there is not regular congestion, temporal limits may only be the peak hour(s) of interest based on traffic volumes or a special event and should be confirmed with the MDOT Project Manager.

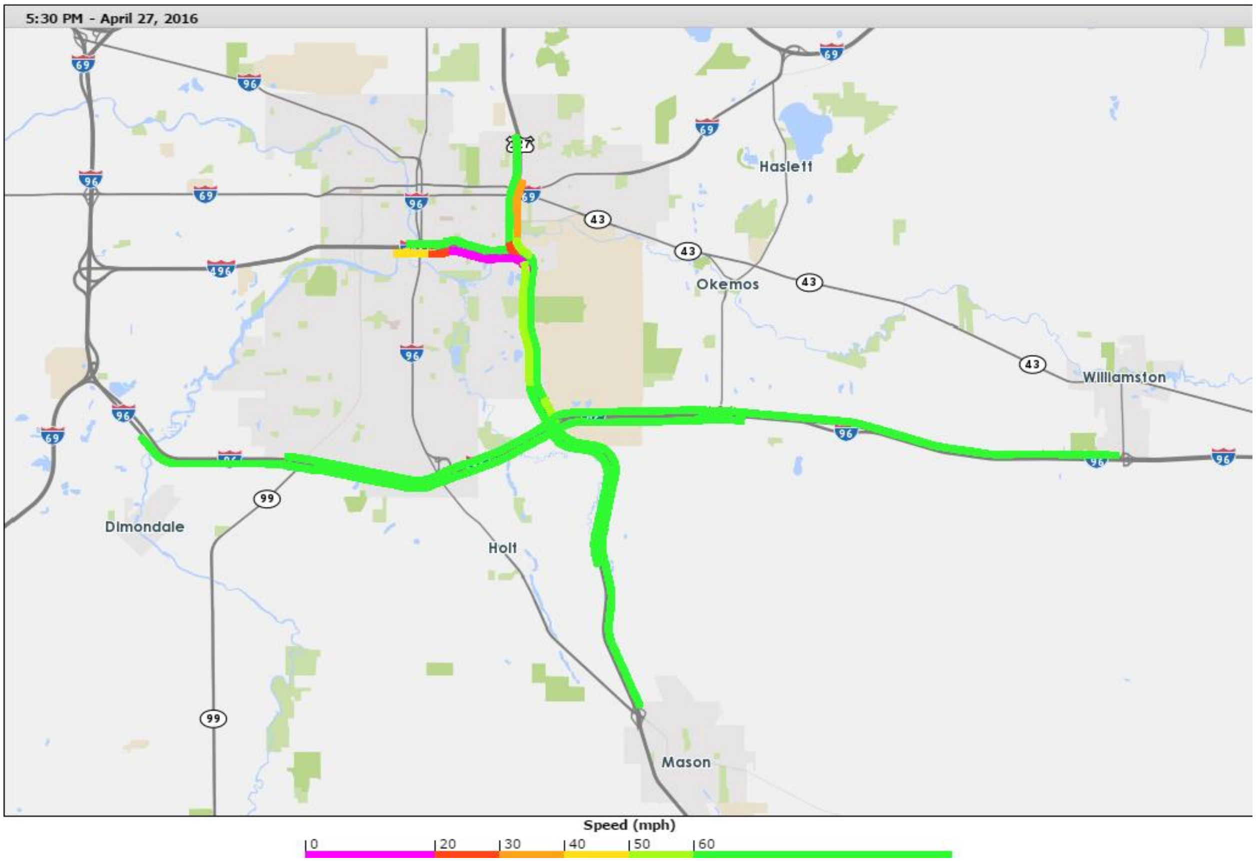
Temporal limits may be for only one time period of the day (PM peak only), multiple time periods (AM and PM commuter rush), a special event scenario, or incident/inclement weather scenario depending on the project description and purpose.

USEFUL TOOLS FOR DETERMINING GEOGRAPHIC AND TEMPORAL SCOPE

When determining the geographic and temporal scope of a study, it is often helpful to review historical data that illustrates the typical operational trends within a study area. MDOT has access to vehicle probe data through the **Regional Integrated Traveler Information System (RITIS)**, which provides real-time and historical vehicle probe data for speeds on all of Michigan's interstate system and M-routes. This data illustrates both the geographic extents of congestion and the time duration of the congestion. The RITIS data is also useful for speed validation data when calibrating base models. All model development teams working on an MDOT project can be granted access to RITIS by submitting a request to the MDOT Congestion and Reliability Unit.

Where RITIS data is not available, other vehicle probe datasets may be used with the approval of the MDOT Project Manager (Google Maps, TomTom, HERE, etc.). Travel time runs and field observations may also be necessary for calibration purposes.

Figure 8: Example RITIS Congestion Map



2.3 DATA COLLECTION AND DEVELOPMENT

This section provides guidance on the typical data needs required for VISSIM model development. The data needs and how that data is collected is often driven by the model's purpose.

GEOMETRIC DATA

Detailed geometric data must be collected within the modeling limits. Typical resources of geometric data are aerial photographs and construction drawings. A field visit often is required to verify this data. It is MDOT's preference, unless otherwise directed by the MDOT Project Manager, to defer to the scaled Bing aerial imagery that is included in several PTV standard license packages as the base for geometric data with a field review conducted to verify this data.

Geometric data to be collected must include:

- Number and width of lanes

- Significant grades that could affect flow rates (>3%, <-3%)
- Lengths of roadway segments
- Lengths of storage bays and tapers

Additional geometric data that may need to be collected depending on the project may include:

- Locations and dimensions of freeway ramp tapers
- Details of user specific lanes (e.g., High Occupancy Vehicles [HOV], Truck, Bus, Bikes)
- Pedestrian and bicycle facilities and widths
- Crosswalk locations, widths, and lengths, raised median, pedestrian refuges, and parking island locations and dimensions
- Transit facility locations
- Roundabout inscribed diameter, circulating lane width, entry angles
- Freight rail crossing locations and number and duration of crossing events
- Acceleration and deceleration lengths for ramps and turn lanes
- Curve (e.g., sharp curves that may affect vehicle speed)
- Radii at intersections for turning vehicles
- Sight distance at conflict points, for example: how far upstream a driver stopped at a stop sign can see on the cross street to make a gap acceptance decision

TRAFFIC CONTROL DATA

Traffic control data must be collected for all locations within the modeling limits. These will all be used as input to the model and are checkpoints that control the flow and movement of vehicles. Data to be collected should include:

- Posted speed limits and free flow speeds
- Intersection controls
- Traffic signal characteristics
- Signal timing / time of day plans (time of day plans should be obtained from either the region or local agencies when available, otherwise timings may be collected in the field during the relevant time periods with approval from the MDOT Project Manager)

- Movement permissions/restrictions (right turn on red, no turn on red, U-turn permitted, protected/permitted phasing, overlaps, etc.)
- Stop bar locations
- Detection zones

Some models may require that the following control/operational data be collected:

- Rail crossing control and usage
- Ramp meter timing
- Freeway guide sign locations
- Emergency signal preemption parameters
- Transit signal priority parameters
- Toll plaza information (e.g. capacity, number of booths, etc.)

TRAFFIC VOLUME DATA

The project purpose will determine when traffic volume data should be collected and under what travel conditions. The majority of studies looking to capture normal commuter rush conditions for a typical work day, should have volumes collected during the peak month and day of the week (typically Tuesday – Thursday) excluding weeks that contain holidays. Where project schedules dictate data collection outside of the peak month, a seasonal adjustment factor may be applied if necessary with permission from the MDOT Project Manager. **All traffic data should be no more than three years old**, unless agreed upon with MDOT staff. The use of data over three years old requires a sensitivity analysis to determine the regional or local growth rates that have occurred over the period of time in question. If it is determined that little to no growth has taken place, volumes older than three years may be used with permission from the MDOT Project Manager.

Traffic volumes shall be collected in 15-minute increments for the entire study period. If feasible, traffic volumes should be collected on the same day at all locations throughout the entire study area and coincide with other data collection and field observations. In addition to manual traffic count collection, potential count resources include MDOT's permanent traffic recorders (PTR), microwave vehicle detection sensors, MDOT's and SEMCOG's Transportation Data Management System (TDMS).

Unmet demand is typically referred to as the number of vehicles that are destined to travel through a network at a specific time period but cannot do so due to capacity constraints. When collecting data in congested networks, data collection and observation locations must consider how to capture the unmet demand. Upstream data collection of any major bottlenecks may be necessary to capture true demand. Traffic counts should be collected at the less congested entry points into the network to capture the vehicle arrival/demand profile. Care should be taken to avoid balancing traffic counts collected on either side of a known bottleneck location.

Vehicle classification counts should be collected at a minimum of one location in the study area. Vehicle classification counts may need to be collected at more locations depending on the purpose and geographic limits of the model.

Pedestrian and bicycle count data should be collected for all surface street networks to be modeled in VISSIM. This data must be collected in 15-minute increments for the entire study period.

ORIGIN-DESTINATION DATA

Origin-Destination data (O-D) may be important for correctly coding lane-changing, weaving, and related types of driver behavior in a VISSIM model. O-D data is often difficult to collect and subsequently historically expensive. The following sources may be utilized:

- Travel Demand Models
- WiFi/Bluetooth surveys
- License Plate Surveys
- 3rd Party O-D data (INRIX, HERE, TomTom, Streetlight, e.g.)

O-D data collection should be carefully considered and coordinated with MDOT staff due to the varying methods and cost. Detailed O-D data collection is only recommended for locations where O-D data is critical to understanding network operations. The local MPO's macroscopic and dynamic traffic assignment (DTA) models may be a key resource for the project, and should be considered if necessary.

TRAVEL TIME DATA

In the absence of reliable RITIS speed and congestion data or other probe-vehicle data, field collected travel time data is useful validation data. Even if there is RITIS data available, it still may be useful to field collect travel time data if there is lane specific congestion that is not reflected in the aggregated speed data in RITIS. Floating car runs are the most common method for collecting travel time data. Data is collected by either a GPS unit record location and time or by having a passenger record data with a stop watch. It is recommended a minimum of 10 travel time runs be collected in each direction during the peak hour of each time period to be simulated. Although, under free flow conditions, as few as three runs can establish a reliable mean travel time.

For complex corridors with long travel times, a statistical calculation outlined in the FHWA's *Traffic Analysis Toolbox Volume III* to determine the required number of travel time runs to reach a certain confidence interval may be required.

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

NOTE:

- R = 95-Percent confidence interval for the true mean
- $T_{0.025,N-1}$ = Student's t-statistics for 95-percent confidence – two-sided error of 2.5 percent with N-1 degrees of freedom
- S = Standard deviation of floating car runs
- N = Number of required floating car runs

SPOT SPEED DATA

Spot speed data is key for model validation as well as determining typical free flow speed ranges for entry in the VISSIM model. Generally, speed data should be collected when there is no influence from weather, incidents and/or other factors unless requested otherwise by the MDOT Project Manager. MDOT prefers to use RITIS speed data for this purpose where available. Spot speeds are generally not collected on arterial corridors due to closer intersection spacing and the delay impacts from traffic control.

QUEUING DATA

Queue observations should be collected during field review. Queuing data is not required but should always be used as a visual comparison to verify that the VISSIM model is replicating field conditions. Whenever possible, queueing data should be collected at the same time as other data, such as traffic volumes. For freeway projects, MDOT prefers the use of RITIS data when available for documenting queue lengths and duration. On arterial roadways, visual inspection from a field review is MDOT's preferred method to capture queue information.

LANE UTILIZATION DATA

The need for lane utilization data must be determined through field inspection of traffic operations during the scoping process. If lane imbalances could affect the calibration and validation of the VISSIM model, lane utilization data should be collected during the study period. Areas where lane utilization data may also be collected are:

- Lane drop locations
- Multiple turn lanes
- Truck climbing lanes
- Weaving sections
- Managed lanes

- Closely spaced intersections
- Lanes where certain vehicle types are prohibited.

TRANSIT DATA

Transit data collection and detail is dependent on the project purpose. For all arterial models where transit currently exists or is proposed to be implemented, the location of the transit stops in the study area and transit headways must be compiled. For freeway models, transit headways and park and ride locations may be required.

If an arterial VISSIM model is being built to focus on the evaluation of transit operations, further transit data may be required including:

- Transit vehicle acceleration and deceleration
- Headway data
- Number of boarding and alighting passengers
- Boarding and alighting time per passenger
- Dwell time at transit stop
- Number of passengers on transit entering the network
- Boarding and alighting location on transit vehicle
- Transit signal priority
- Schedule variability
- Transit gate-crossing time:
    - Vehicle clearance time
    - Gate closing time
    - Transit crossing time
    - Gate opening time

TRAVEL DEMAND FORECASTS

Forecasts of future travel demand are best obtained from the local regional transportation planning agency. In cases where the study area is not captured in a regional travel demand model, MDOT Planning may provide the forecasted growth for future year scenarios. The MDOT Project Manager will confirm the source of the travel demand forecasts. Care must be taken when determining future year demand. Traffic volumes may need to be adjusted to spread traffic volumes from over-capacity time periods to adjacent time periods (peak spreading). Consideration should be given for peak period travel demand spreading in order to create reasonable volume inputs for microsimulation.

In some instances, the no-build condition can have known capacity constraints that prohibit the forecasted demand from being modeled. It is possible, under these circumstances, that a no-build future demand could differ from a build future demand (with capacity constraints removed). Estimating the excess demand at inbound bottlenecks and reducing demand inbound at gateways can assist in producing reasonable future demand.

DATA VERIFICATION & SCREENING ASSESSMENT

Once data collection is completed, the modeler must review the data for errors. The documentation of the data review shall be summarized in a Data Verification & Screening Assessment memo. Good data is required for a successful analysis and poor data will confuse the analysis and make it difficult to achieve meaningful analysis results. Verification should include checking that weather, incidents or construction did not influence the data collected (unless that is the project's purpose). Checking data discrepancies or missing data to determine any abnormalities or outliers (based on historical data, local knowledge or experience) and determining their probable causes is necessary to understand the accuracy of the data collected.

MDOT's Congestion & Reliability Unit must review the Data Verification & Screening Assessment memo and approve the data before the model development begins.

2.4 MODEL DEVELOPMENT

GENERAL NETWORK PARAMETERS

Units: The network shall be created in English units. The use of scaled aerial imagery (VISSIM supported Bing Maps) or as-build files should be used to code links.

Simulation Resolution: A simulation resolution of 10 steps per second is preferred. It is recommended that the simulation resolution not be changed once the model has been calibrated to prevent differing model results. Increasing the model resolution increases the computation load of the model and can increase the simulation duration. Approval from MDOT is required for a simulation resolution under 10 steps per second.

SEEDING PERIOD

The time period used to load vehicles into a microsimulation until the model reaches equilibrium and MOEs can be recorded is called the "seeding" period. Following FHWA guidelines, the seeding period should be the **longest** of following three criteria to allow for full vehicle saturation of the network.

1. A minimum of 10 minutes.

2. Equal to or greater than twice the estimated free flow travel time from one end of the network to the other.

3. Vehicle queue lengths in the model at the end of the seeding period replicate real-world observations at that time of day.

Larger networks may require a larger seeding period to ensure that vehicles have reached equilibrium within the model.

NOTE: *Typically the hourly flow rates of the first 15 minute time interval of your temporal scope is used for the seed interval as well.*

TRAFFIC COMPOSITION AND VEHICLE FLEET

Traffic Composition: A vehicle classification count is highly recommended to determine the traffic composition inputs for all entry links in the VISSIM model. The traffic composition is typically the percent passenger cars vs. large trucks. General rule of thumb is to enter one traffic composition for the entire time period being analyzed on each entry link vs individual traffic compositions every 15 minutes of the time period unless otherwise indicated by the MDOT Project Manager.

Vehicle Fleet: The "Car" and "HGV" (heavy goods vehicle) distribution fleet found in the PTV provided NorthAmericanDefault.inpx is MDOT's preferred vehicle fleet information to be used on MDOT projects unless otherwise directed by the MDOT Project Manager. The NorthAmericanDefault.inpx includes a range of ten vehicle models under the car distribution and six types of trucks under HGV. The car models range from midsize cars to pickups and SUVs, while the HGV models include box trucks, flatbed trailers, and various sizes of tractor-trailers. These vehicle fleets were specifically developed for the North American market. Failure to update the vehicle fleet from the default will result in a European based vehicle fleet, which are typically smaller vehicles than the North American fleet and can lead to higher than actual roadway capacities within the model when modeling North American roadway networks.

Other vehicle/roadway user fleets may be created based on the model needs, such as pedestrians, bicycles, managed lane vehicles, shuttle/taxi vehicles, transit vehicles, AV/CV, etc. with review and approval by the MDOT Congestion & Reliability Unit.

NETWORK CODING

The following provides suggested coding techniques and preferences for network coding of links and connectors.

Freeway Merge, Diverge, and Weave Coding

Connector lengths should be minimized for freeway coding. To properly code merging and weaving sections, these points should be followed:

- The effective merging area should include the entire acceleration lane to the farthest extent of the acceleration lane taper and capture the full effective length utilized by vehicles. Vehicles in VISSIM will utilize the extra link length when necessary, which more accurately models the utilization of the taper area.
- The merge or weaving section should be one link with the number of lanes equal to the number of lanes on the main freeway plus the number of lanes merging onto the freeway.
- There should only be one connector downstream of the merge link or at the end of a lane drop section.
- There should be two connectors upstream of the merge link, one for the ramp link and one for the main freeway link.
- One of two options should be implemented to avoid unrealistic lane changes on mainline into the acceleration lane or auxiliary lane:
    - Ensure that the “Lane Change” distance, in the downstream connector is longer than the length of the merge/weave area.
    - Indicate “no lane change” for the appropriate lane, using the link dialog box

Figure 9: Suggested Coding of a Freeway Merge Area

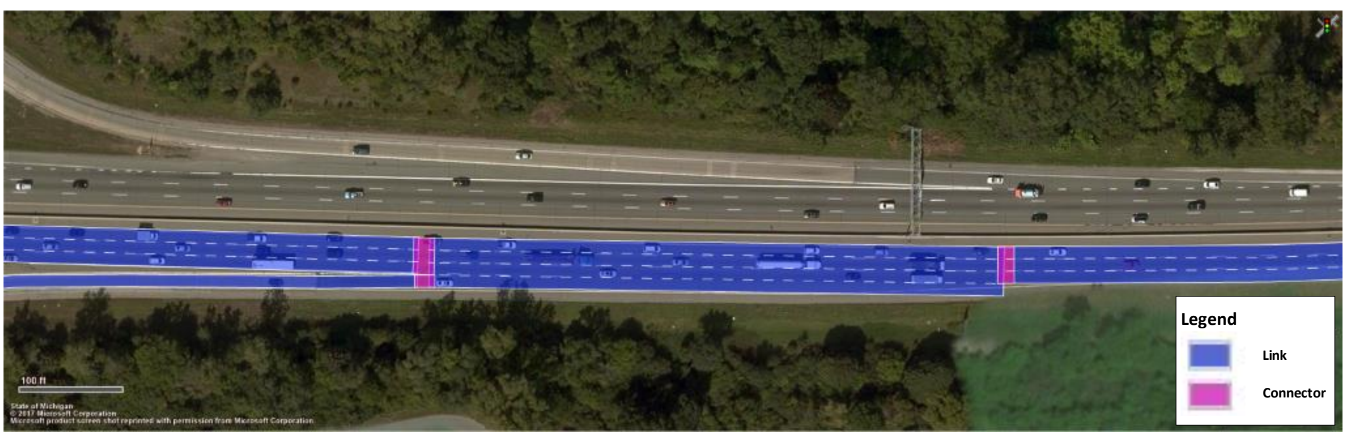


Figure 10: Suggested Coding of a Freeway Weave Area

In order to code diverging sections, first identify whether the diverge section is functioning as a parallel or taper ramp. To function as a parallel ramp diverge area in VISSIM, the deceleration lane typically extends 700 ft or more.

For coding a parallel Freeway Exit Ramp diverge area, these points should be followed:

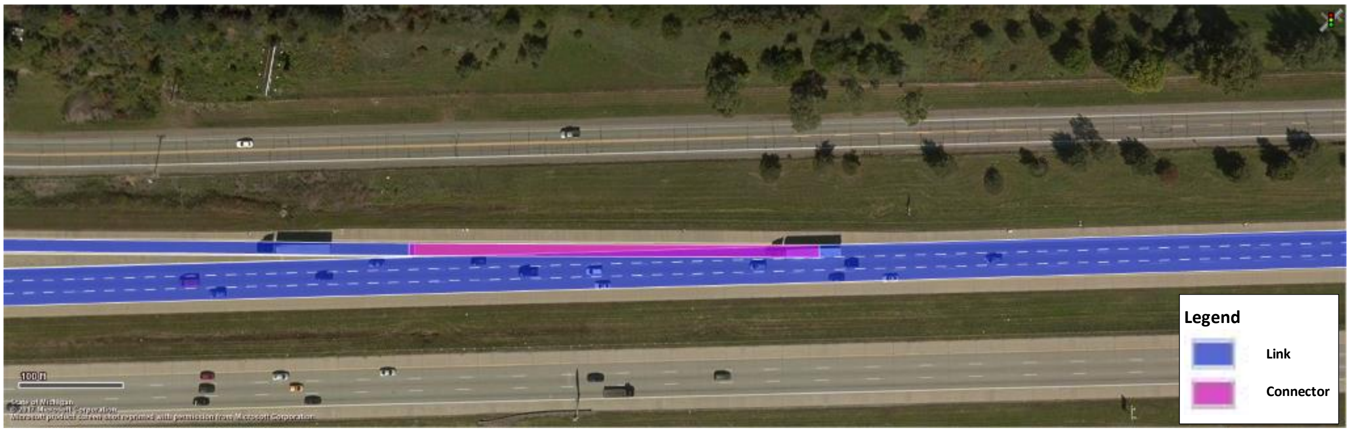
- The effective diverging area should include the entire deceleration lane starting at the taper and continuing to the painted gore point.
- The diverge section will be one link with the number of lanes equal to the number of lanes on the main freeway plus the number of lanes diverging from the freeway.
- There should only be one connector upstream of the diverge link
- There should be two connectors downstream of the diverge link, one for the ramp link and one for the main freeway link.

Figure 11: Suggested Coding of Freeway Diverge Area (parallel)

For coding a taper Freeway Exit Ramp diverge area, these points should be followed:

- There is no need to break the main freeway link with a connector.
- There should be one connector placed at the painted gore point connecting the main freeway link to the ramp link.

Figure 12: Suggested Coding of Freeway Diverge Area (taper)



NOTE: *Freeway links may need to be split based on HCM Freeway Facilities definition of analysis segments if MOEs are to be summarized in this format per request of the MDOT Project Manager. For example, the links may need to be split to represent the 1500 ft influence area typical of a ramp merge or diverge area, but again, this should only be done at the request of the MDOT Project Manager.*

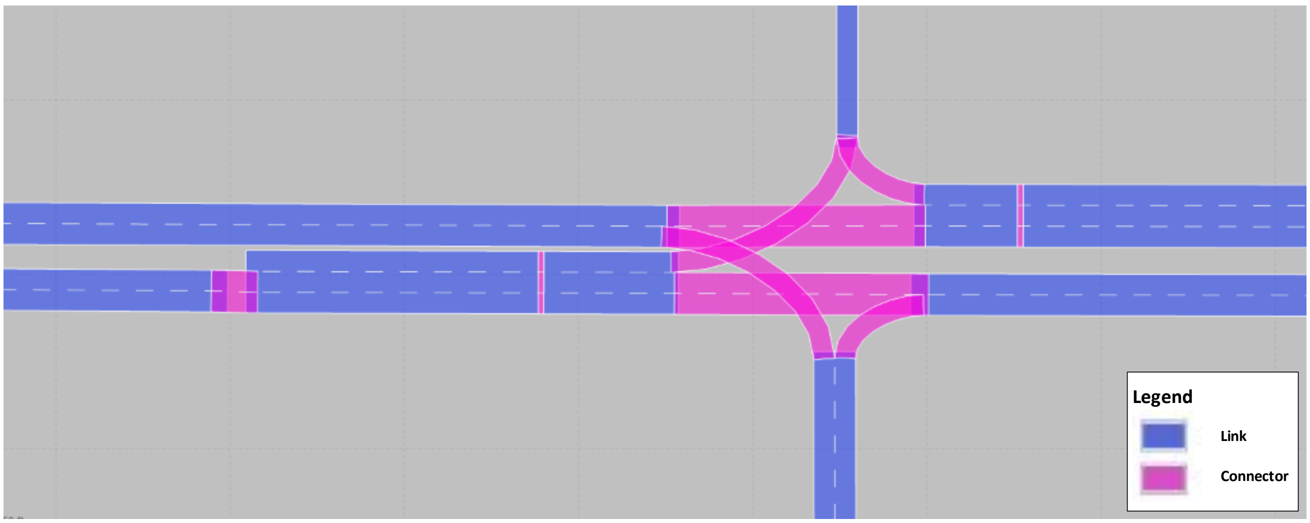
Surface Streets

There are two options for coding turn bays at intersections. The first option is coding a turning bay similar to the merging and weaving areas. In this option connectors start at the beginning of the taper and end at the point the bay reaches its full width. The section of roadway adjacent to the turn bay should be one link with the number of lanes equal to the number of lanes on the mainline plus the number of turn lanes. To ensure no unrealistic lane changes between the through and turning vehicles, these points should be followed:

- Break link with turn bay about 50 ft from the stop bar
- In the link with the turn bay closest to the intersection code, “no lane change” both in and out of the turn bay, in the Link Data dialog box.
- In the link with the turn bay farther from the intersection, code “no lane change” only out of the turn bay, in the Link Data dialog box.

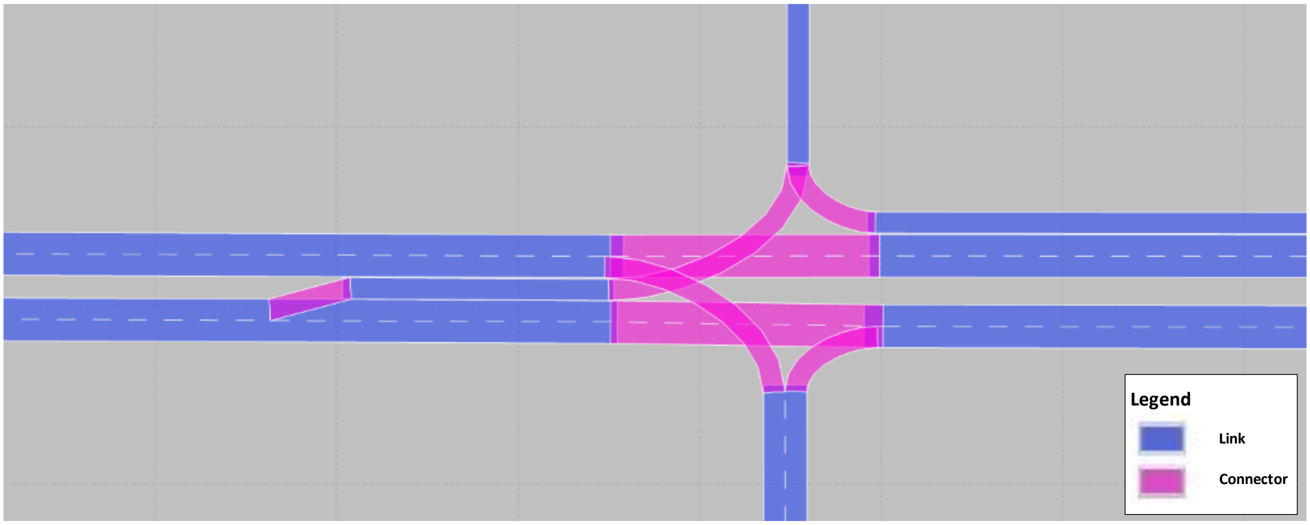
- In the Connector dialog box for the connector attached to the end of the turn bay, enter an emergency stop to be about the length of the turn bay minus 35 ft. In the same dialog box enter the lane change to be well beyond the length of the turn bay, this should point back to the location that it would be logical for a vehicle to consider turning left (ex: location of a directional sign).

Figure 13: Suggested Coding of a Turning Bay (Option 1)



The second option is coding a turning bay as a separate parallel links where vehicles enter the turn bay at the beginning of the bay, which helps ensure that no unrealistic lane changing occurs between the through and turning vehicles. In this option connectors should also start at the beginning of the taper and end at the point the bay reaches its full width (not necessarily where the striping begins). This is the preferred option by MDOT when models are being built from scratch and not imported from another source.

Figure 14: Suggested Coding of a Turning Bay (Option2)



When importing an Abstract Network Model (ANM) from VISUM, VISTRO, or Synchro, turn bays are coded as an additional lane of the through link (option 1). The desired lane change behavior is replicated by the import automatically adjusting the turning connector's emergency stop distance equal to the turn bay length minus 32.8 feet.

TRAFFIC CONTROL

VISSIM traffic control measures such as signals, stop signs, and yield conditions should be modeled as closely to real-world conditions as possible. Traffic signal timing from field or local agency time of day plans should be used to code signals in VISSIM. Conflict areas or priority rules should be used at all intersections to correctly replicate vehicle interactions. Adjustments to gap times and other conflict area and priority rules parameters may be required. It is MDOT's preference to use conflict areas over priority rules whenever possible; however, priority rules may be used for more complex control of yielding behavior if necessary, such as at dual-lane roundabouts.

Traffic Signal Controller Settings

The Ring Barrier Controller (RBC) module is the preferred method for coding traffic signals. It includes parameters to replicate a real-world signal controller and accurately models actuated-coordinated signal operations. It also includes advanced features such as detector settings and signal priority/preemption. Submissions of all base conditions models must include source documentation for all signal timings, typically in the form of timing permits.

It is important to note that the frequency of the RBC file must be a factor of the simulation resolution otherwise an incompatible error will be generated. The modeler should provide any .rbc file(s) with the applicable model files, and they should be submitted to MDOT in such a way that the reviewer does not need to re-reference the proper .rbc file in the VISSIM model.

The preferred method for coding future signal timing is to optimize signal timing using a third-party optimization software such as Synchro, HCS, or another optimization package and manually code the signal timing into the RBC.

Ramp Meters

Ramp meters can be coded using Vehicle Actuated Programing (VAP) which is written to replicate the speed/density logic. If field data indicates that the ramp meter operates at a fixed rate during the study period, or if approximation of ramp meter operations is sufficient, a fixed time signal controller can be used to approximate operations using the RBC module.

Unsignalized Intersections

At intersections operating with stop control, code stop signs at the same location as the stop bars in the field in addition to the conflict areas at the actual vehicle conflict zone. For intersections with yield control, vehicle interactions should be controlled with just conflict areas and/or priority rules. A conflict area and priority rule should not be used for the same conflict or movement.

Coding of unsignalized intersections should start with conflict areas and if it necessary to replicate real-world conditions, priority rules can be used instead. In some cases, coding a stop sign in the model does not actually replicate field conditions. An alternative to coding a stop sign is to use a lower than typical reduced speed area in combination with conflict areas/priority rules to replicate a rolling stop.

SPEEDS

To control the speed of vehicles in VISSIM, a “desired speed decision” or “reduced speed area” on the network link or connector is utilized. Desired speed decisions change the desired speed of vehicles that cross it until crossing another desired speed decision and should be used when significant free-flow speed changes due to posted speed limits, geometric changes, topography, or facility changes. Reduced speed areas are temporary zones with a reduced speed and should be used to code small sections where vehicles have a significant change in speed. Typically, reduced speed areas are used due to vertical or horizontal curvature of the roadway (left and right-turn movements as well as freeway loop ramps, e.g).

The use of desired speed decisions and/or reduced speeds areas to mimic congestion when calibrating a model should generally be avoided.

Freeways

Spot speed data (free flow) or archived speed data, such as RITIS speed data can be used to code the desired speed decisions. In the absence of observed speed data, a speed profile based off the posted speed limit can be used. In either case, separate desired speed decisions should be coded for cars and HGV’s.

Arterials

Due to lack of true free flow condition on most arterial networks, detailed speed profiles are generally not necessary. A speed profile that is linearly plus and minus five mph of the posted speed is sufficient.

For turn movements at intersections, reduced speed areas should be used for both left and right turn movements. Suggested values for the reduced speed distributions for cars are 15 mph for left turns and 9 mph for right turns, the reduced speed distribution for HGV is slightly less, at 10 mph for left and 5 mph for right turns. The location and length of a reduced speed area is typically localized to the apex of the curve for the movement. Reduced speed areas should cover the full distance where a vehicle must traverse at that reduced speed.

VEHICLE INPUTS

It is MDOT's preference that vehicle inputs should be coded in 15-minute demand intervals. However, hour increments may be acceptable if volumes arrival rates are fairly uniform throughout the hour with little or no peaking. Each input location should have specific truck percentages. Traffic compositions will also need to be assigned with the volume input. It is MDOT's preference that **input volumes be set to "exact" instead of a stochastic distribution.**

If a project is transit oriented, bus volumes should not be included in the vehicle input; rather, bus volumes will be input as public transit lines with defined frequencies and headways.

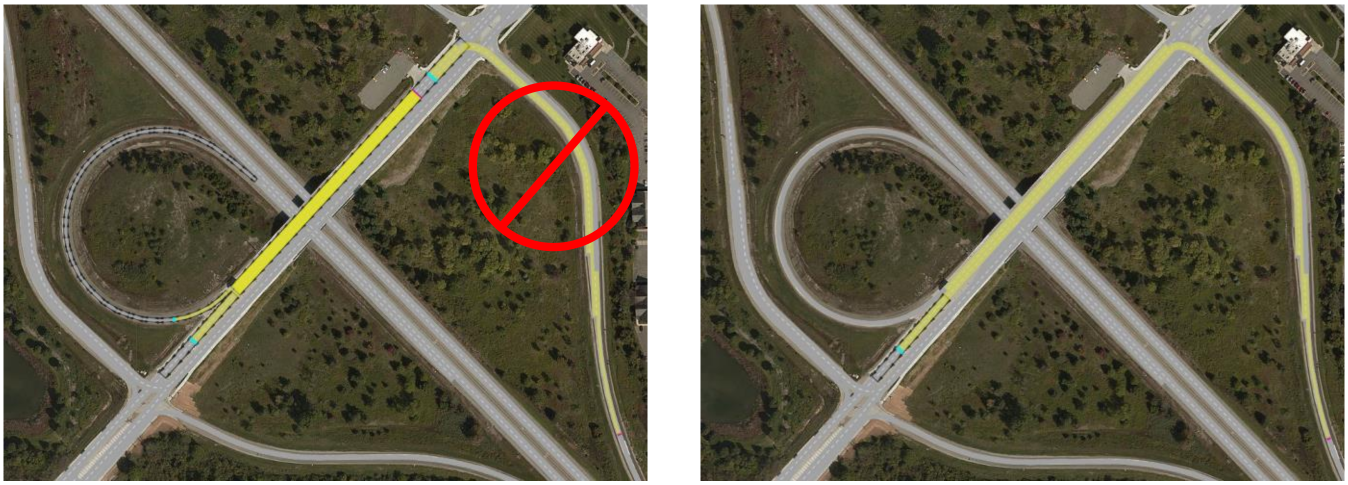
VEHICLE ROUTING DECISIONS

Vehicle routes should also be coded in 15-minute demand increments. Again, hour increments may be acceptable if volume arrival rates are fairly uniform throughout the hour. There are three different methods for coding vehicle routing typically used by MDOT: static, dynamic, and origin-destination. **Static routes are the expected coding method by MDOT** unless other methods are more appropriate based on recommendation of the modeling team and MDOT Congestion and Reliability Unit. The routing decisions to use on a specific project should be confirmed with the MDOT Project Manager prior to actual coding.

Static Routes: Traffic volumes in smaller networks with adequate intersection/ramp spacing can be coded with static routing decisions. Static routing decisions should be placed as far upstream on a link as possible to allow for maximum lane positioning distance.

It may be necessary to route vehicles through multiple intersections or closely spaced freeway ramps with a single routing decision to eliminate unrealistic lane changing or turning-movements. For example, the static routing decision for the ramp approach at a freeway ramp terminal should take the exit ramp traffic completely through the interchange to avoid this traffic from being assigned to re-enter the freeway at the other ramp terminal (see Figure 16).

Figure 15: Example Static Routing Through Interchange



Dynamic Routes: Dynamic routes are used to reroute traffic if a certain condition occurs, such as a parking lot becomes full or a gated crossing is blocked. Vehicles can be reassigned using a VAP script. Dynamic routing requires the coding of static routes with the relative flows being changed during the simulation based on events within the simulation. Dynamic routing should only be used if the project purpose specifically calls for this type of conditional analysis where the route can change between an origin and destination pair within the model, such as the analysis of the impacts of a drawbridge, at-grade rail crossing, or impacts of an ITS treatment like real-time travel time information on a DMS sign for multiple routes.

Origin-Destination Matrix: The static routing option becomes less effective for both multi-lane arterial networks with many closely spaced intersections and freeway networks with closely spaced interchanges. In both situations, vehicles may not have enough warning to make proper lane changes, which can lead to inaccurate weaving behavior and lane utilization in the simulation model.

A vehicle should be assigned one complete route upon entering the network that continues until the vehicles leave the network. It is acceptable to have separate O-D matrices for each roadway type for example both arterial and freeway links. For example, one matrix routes traffic to and from each freeway ramp, while the freeway matrix routes vehicles from entrance ramp to exit ramp.

It is possible to create manual static routes that extend from each entrance ramp to all downstream exit ramps although this is typical only possible with smaller networks. However, in most cases a more automated process to develop O-D routing is recommended. There are two options for automated O-D routing in VISSIM. Option 1 uses VISUM to macroscopically assign the O-D matrix to the network and then uses the ANM data transfer to export all generated O-D paths as fixed routes into VISSIM. Option 2 uses VISSIM's Dynamic Traffic Assignment to generate O-D routes.

DRIVER BEHAVIORS

Driving behavior in VISSIM consists of two behavior models:

- Vehicle following model
- Lane change model

Parameters within these models can be adjusted during the initial coding process or the calibration process. The following sections provide guidance on which parameters are most commonly changed and typical ranges for those values. The ranges of parameters outlined here have been found to reflect typical traffic conditions, but there may be conditions that require adjustment of parameters outside of the ranges provided to adequately calibrate a model. Parameters can be adjusted to have values outside the suggested ranges when necessary, however any adjustments outside of suggested ranges must be approved by the MDOT Congestion & Reliability Unit.

Vehicle Following - Wiedemann 99 model – Freeway Traffic: For freeway links and connectors, the Wiedemann 99 model should be selected as the vehicle following model. The default vehicle following parameter set is a good starting point, but it may need to be adjusted to better match real-world conditions. Any proposed values for these parameters that are outside the suggested ranges should be documented with its reason and application in the Calibration and Validation memo.

Changes to parameters may require creating a new link type that will apply only to a specific portion of the model and/or specific vehicle classes. Typical areas that may require unique driver behaviors are merge and weave areas. Care should be taken to minimize the creation of unique behavior parameter sets for specific links within a model. Table 1 depicts the suggested range of Wiedemann 99 vehicle following parameters for most typical freeway models.

Table 1: Wiedemann 99 Vehicle Following Parameters

Parameter		Default	Unit	Suggested Range	
				Basic Segment	Merging/Diverging
CC0	Standstill Distance	4.92	ft	4.5 – 5.5	> 4.92
CC1	Headway Time	0.9	s	0.85 – 1.05	0.90 – 1.50
CC2	Following Variation	13.12	ft	6.56 – 22.97	13.12 – 39.37
CC3	Threshold for Entering Following	-8	-	Use Default	
CC4	Negative Following Threshold	-0.35	-	Use Default	
CC5	Positive Following Threshold	0.35	-	Use Default	
CC6	Speed Dependency of Oscillation	11.44	-	Use Default	
CC7	Oscillation Acceleration	0.82	ft/s^2	Use Default	
CC8	Standstill Acceleration	11.48	ft/s^2	Use Default	
CC9	Acceleration at 50 mph	4.92	ft/s^2	Use Default	

CCO, CC1, and CC2 have the greatest influence on car following behavior in VISSIM. They are the most intuitive in terms of their impact on the vehicle following behavior because those are key parameters used to determine desired safety distance.

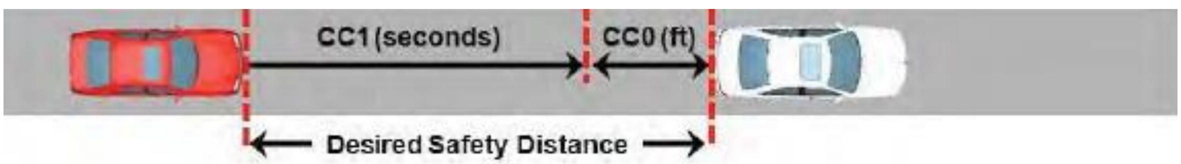
CCO (Standstill Distance): Desired rear-bumper to front-bumper distance between stopped cars. This parameter has greater impact to desired safety distance when traffic is in jam condition.

Figure 16: Standstill Distance Parameter (CCO) (Source: *WSDOT VISSIM PROTOCOL)*

CC1 (Headway Time): The distance (in seconds) that the following driver wishes to keep. The desired safety distance shown below is determined every time step based on the following equation:

Desired Safety Distance = CC0 + (CC1 x speed)

Figure 17: Headway Time Parameter (CC1) (Source: *WSDOT VISSIM PROTOCOL)*



CC2 (Following Variation): The longitudinal oscillation during following condition. It defines how much more distance than the desired safety distance before the driver intentionally moves closer to the lead vehicle.

Figure 18: Following Variation Parameter (CC2) (Source: *WSDOT VISSIM PROTOCOL)*

Vehicle Following – Wiedemann 74 model – Surface Street Traffic: For most surface street links and connectors, the Wiedemann 74 vehicle following model should be applied. There are three parameters available for this model: average standstill distance, additive part of safety distance, and the multiplicative part of safety distance.

As with the freeway vehicle following model, the default parameters are a good starting point. The first parameter, "Average Standstill Distance," corresponds to the CC0 parameter in the freeway Wiedemann 99 behavior model. The other two Wiedemann 74 parameters work together to determine the target desired safety distance (which has a direct relationship with saturation flow rate).

A greater parameter value will result in a greater desired safety distance, thus reducing the saturation flow rate. Any proposed values for these parameters that are outside the suggested ranges should be documented with its reason and application in the Calibration and Validation memo.

The suggested ranges for Wiedemann 74 vehicle following parameters are illustrated in Table 2.

Table 2: Wiedemann 74 Vehicle Following Parameters

Surface Street Car Following Model Parameters Suggested Range			
Parameter	**Default Value**	**Unit**	**Suggested Range**
Average Standstill Distance	6.56	ft	3.28 – 6.56
Additive part of safety distance	2.00	-	2.0 – 2.2
Multiplicative part of safety distance	3.00	-	2.8 – 3.3

Lane Changing Parameters: The available lane changing parameters are the same for both freeway and surface streets and are applied on the same link type basis as the vehicle following model. The default parameters are a good starting point, just like the vehicle following parameters. However, some parameters may need to be changed in the calibration process to match real-world driving behavior, specifically when modeling merging, diverging, and weaving areas.

Any changes from the default parameters should be documented with the reason and justification in the Calibration and Validation memo. Tables 3 and 4 illustrate the default parameters and MDOT's suggested range for the parameters, respectively.

Table 3: Default Lane Change Parameters

General Behavior	**Free Lane Selection**			
Necessary Lane Change (route)	**Own**	**Unit**	**Trailing Vehicle**	**Unit**
Maximum deceleration	-13.12	ft/s^2	-9.84	ft/s^2
-1 ft/s2 per distance	200 (Freeway) 100 (Arterial)	ft	200 (Freeway) 100 (Arterial)	ft
Accepted deceleration	-3.28	ft/s^2	-1.64	ft/s^2
Waiting time before diffusion			60	s
Min. headway (front/rear)			1.64	ft
To slower lane if collision time above			0	s
Safety distance reduction factor			0.6	-
Maximum deceleration for cooperative braking			-9.84	ft/s^2
Overtake reduced speed area			Unchecked	-

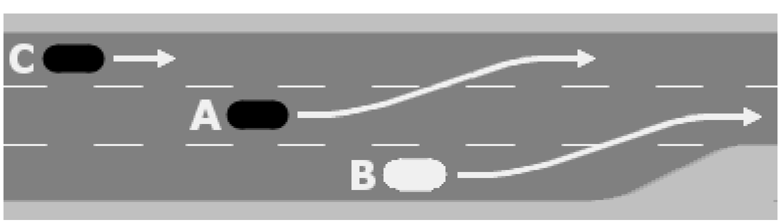
Table 4: Suggested Lane Change Parameters

General Behavior	Free Lane Selection			
Necessary Lane Change (route)	**Own**	**Unit**	**Trailing Vehicle**	**Unit**
Maximum deceleration	-15 to -12	ft/s^2	-12 to -8	ft/s^2
-1 ft/s2 per distance	150 - 250	ft	150 - 250	ft
Accepted deceleration	-2.5 to -4	ft/s^2	-1.5 to -2.5	ft/s^2
Waiting time before diffusion			200	s
Min. headway (front/rear)			1.5 - 2	ft
To slower lane if collision time above			0.0 – 0.5	s
Safety distance reduction factor			0.25 – 1.00	-
Maximum deceleration for cooperative braking			-8.0 to -15	ft/s^2
Overtake reduced speed area			Unchecked	-

Other Parameters: Additional driver behavior parameters that can be useful during calibration are advanced merging, vehicle routing decisions look ahead, and cooperative lane change found in the lane change tab when editing a driver behavior.

- Advanced merging: Selecting this option allows more vehicles to change lanes earlier, thus increasing capacity and reducing the likelihood of stopped vehicles waiting for a gap.
- Vehicle routing decisions look ahead: Selecting this option allows vehicles to identify and consider the next downstream routing decision.
- Cooperative lane change: If this option is selected, a vehicle upstream of a merging vehicle will change lanes itself to the next lane in order to facilitate the downstream vehicle.

Figure 19: Cooperative Lane Change (Source: *PTV VISSIM USER MANUAL)*



Connector Lane Change Distance: The distance at which a vehicle decides to make a lane change to position for a downstream maneuver is controlled by the connector "lane change distance." A good starting point is to set back the distance so that it concurs with the guide sign locations or based on field observations. The lane change distance can also be defined "per lane" to stagger lane change decisions on multi-lane facilities. In order for connector lane change distance to be effective, the routing decision needs to be set at a distance upstream that is greater than the connector lane change distance.

Driving Behavior Summary: The driving behaviors can be sorted based on their application to different facility types and the basis of conservative or aggressive driving conditions.

The following table provides guidance to modelers for setting up and naming the driving behavior types during model development and calibration that MDOT prefers to use. The driver behaviors outlined in Table 5 are a framework to develop behaviors needed to achieve calibration targets. All driver behaviors developed are to be reviewed and approved by the MDOT Congestion & Reliability Unit.

Table 5: Driver Behavior Application Summary

FREEWAY						
Conservative				**Aggressive**		
Description	**Name**	**#**	**Link Type**	**#**	**Name**	**Description**
Can be used at segments where reduction in throughput is required. Significant factors include increased CC1 and CC2 values.	Freeway Basic Conservative	101	Basic	103	Freeway Basic Aggressive	**Throughput is higher than default and simulates aggressive behavior. Significant factors include reduction of SDRF, higher lane change parameters and increased maximum deceleration for cooperative braking.**
Can be used at segments where reduced throughput is desired at merge/diverge/weave segments. Lane change parameters are reduced along with higher SDRF.	Freeway Lane Change Conservative	102	Merge/ Diverge/ Weave	104	Freeway Lane Change Aggressive	**Model is suitable for simulating aggressive lane changing links. Significant parameters are lower CC1, higher accepted deceleration, lower SDRF, and higher maximum deceleration for cooperative braking.**
ARTERIAL						
Conservative				**Aggressive**		
Description	**Name**	**#**	**Link Type**	**#**	**Name**	**Description**
Model is used for simulating conservative driving on arterial segments. The lane change parameters are kept low and SDRF is default.	Arterial Basic Conservative	201	Basic	202	Arterial Basic Aggressive	**Model can be used for simulation aggressive arterial segments. Significant factors include lower SDRF and higher maximum cooperative braking value.**

2.5 ERROR CHECKING

All models should go through the process of error checking once the base model has been fully coded. The process is to, double check inputs, run the model, and review the VISSIM error file that is generated.

VERIFY MODELING INPUTS

A thorough quality control review should occur during development of the base model. General practice is for this review to be performed by someone independent of the original model development. Prompt lists/checklists can be very useful during this review process and aid in ensuring a comprehensive and consistent review. MDOT uses the checklist provided in Appendix A. Not all items in the checklist may apply to the particular model, and a “Not Applicable (N/A)” is noted. The following are some of the key inputs to be verified to ensure the accuracy of the coded data:

1. Geometry, speed and control checks
    - Check basic network connectivity (link and connector coding)
    - Check link geometry
    - Check free-flow speed coding
    - Check desired speed distributions
    - Check reduced speed areas
    - Check coding and placement of intersection controls to ensure vehicles are reacting as intended
    - Check for prohibited turns, right turn on red restrictions, lane closures, and lane use restrictions
    - Check conflict area settings
2. Vehicular demand checks
    - Check vehicle compositions at each entry link
    - Verify VISSIM freeway link demand volumes against traffic counts
    - Verify “exact” volumes were entered for volume inputs vs “stochastic”
    - Verify VISSIM arterial routing decisions match turning movement input data
    - Check vehicle occupancy distribution

- Check O-D zone lot coding and placement
- Check content of O-D trip matrices

3. Vehicle type and behavior
    - Check traffic compositions
    - Check model distributions
    - Check vehicle types and vehicle classes
    - Check link types for appropriate behavior model

MDOT will use the more detailed checklist in Appendix A when reviewing the first submittal of the network, and it is encouraged that the model development team also review this checklist to understand the quality control expectations. The modeler should provide documentation to the Project Manager that someone on the modeling team has performed a review of the models in accordance with the items on the checklist.

ANIMATION CHECKING

Many errors become apparent when the simulation model is running. The model should be observed for full seeding and simulation time at key congestion points to determine realism. If observed behavior appears unrealistic, then the following issues should be explored as potential causes:

- Error in Expectations
    - First, vehicle behavior should be verified for the location and time period being simulated before deciding that the animation is showing unrealistic vehicle behavior. Often, expectations of realistic vehicle behavior are not matched by actual behavior in the field. Field inspection may reveal causes of vehicle behavior that are not apparent when coding the network from plans and aerial photographs. These causes need to be coded into the model if the model is expected to produce realistic behavior.
- Data Coding Errors
    - The modeler should check for data coding errors that may be causing the simulation model to represent travel behavior incorrectly.
- Route Assignment Errors
    - A review of the animation may show a higher number of vehicles taking a roadway than what would be expected in the field.

VISSIM ERROR FILES

At the end of the simulation, VISSIM provides an error file (.err) in text format that details the exact location of the error. The modeler should review each entry in the .err file and ensure that the error condition is not impacting the model results. Three error messages that signify significant issues in the model are:

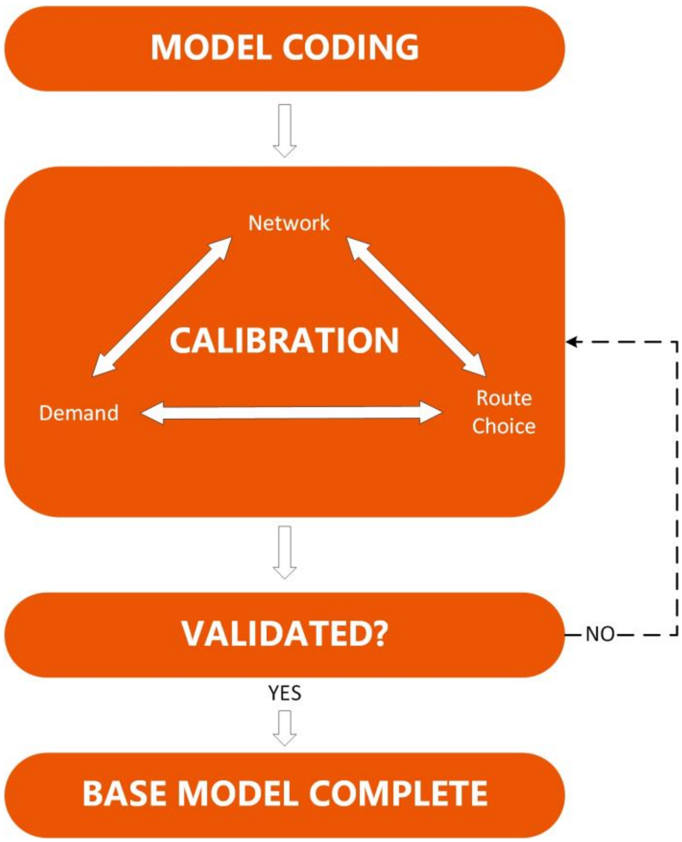
- An entry link that did not generate all vehicles (congestion spillback out of the network)
- A vehicle left its route because the distance between the routing decision and the first connector on its path was too short
- A vehicle was removed from the network because it had reached the maximum lane change waiting time (time before diffusion)

NOTE: *Not all errors necessarily need to be corrected. There may be a specific reason the modeler coded something the way they did to accurately capture operations that may trigger an error note from VISSIM. Leaving reported errors in a model will need to be documented and justified to MDOT.*

2.6 MODEL CALIBRATION AND VALIDATION

Calibration and validation are part of an iterative cycle. If, after the initial round of calibration, the model results do not satisfy the validation criteria, the modeler must conduct additional model calibration and recheck the updated model results against the validation targets. This process continues until the model results meet the validation targets to a level that is acceptable to both the model development team and MDOT. The following discusses the general process MDOT follows for calibration and validation.

Figure 20: Model Validation and Calibration Process



SIMULATION RUNS

Prior to reviewing outputs from a model against validation criteria, the modeler must first determine if the outputs are stable from any individual run of the simulation model. As microsimulation models are stochastic in nature, there will be variations in MOEs with different random number seeds. Because there is variation, multiple runs are generally conducted with the results averaged to determine representative MOE's. Depending on the amount of variation between individual runs will determine how many runs should be conducted to arrive at a statistically significant average. Volatile networks with excessive congestion typically require more runs than more stable networks that operate at near free flow speeds and produce more consistent results between model runs. To determine the number of runs that should be conducted, an initial sampling of the model outputs is required consisting of several simulation runs. Typically, 10 runs generate a large enough sample size but must be verified by calculation.

A statistical calculation based on a 95% confidence level is typical but can be altered if necessary. The chosen confidence level along with the selected confidence interval will be used to determine the number of required runs to ensure the results reported are representative of the true mean of the model.

The confidence interval is the range of values within which the true mean value may lie. The length of the interval is at the discretion of the analyst and may vary according to the purpose of the results. For example, if the analyst is testing alternatives that are very similar, then a small confidence interval will be desirable to distinguish between alternatives. If the analyst is testing alternatives with greater differences, then a larger confidence interval can be tolerated. Both the confidence level and interval need to be documented in the VISSIM Modeling Methodology and Assumptions Memo.

In order to ensure that the results reported are representative of the true mean of the model, the following formula for a 95 percent confidence level shall be applied:

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

NOTE:

- R = 95-Percent confidence interval for the true mean
- $T_{0.025,N-1}$ = Student's t-statistics for 95-percent confidence – two-sided error of 2.5 percent with N-1 degrees of freedom
- S = Standard deviation of selected MOE sample
- N = Number of required simulation runs

The goal of this effort is to determine if the number of runs conducted is sufficient enough to produce an average result that falls within a certain range of values in which the unknown true mean of the model lies.

It is not practical to test the statistical significance of the average of every data output. This calculation should only be conducted for the measures of effectiveness (MOEs) that are deemed most important to the outcome of the project. Typical MOEs selected to determine the required number of simulation runs include throughput volume or corridor travel times.

CALIBRATION STRATEGY

Calibration is the process used to achieve adequate reliability or validity of the model by establishing suitable parameter values so that the model replicates local traffic conditions as closely as possible. The calibration process is often a time-consuming process, but one that cannot be overlooked.

Since the calibration process requires real world data to be performed, it is typically only conducted for the base conditions models.

Calibration parameters should be divided into two basic categories:

1. Parameters that the modeler is reasonably certain about and does not wish to adjust.
2. Parameters that the modeler are less certain and willing to adjust.

The modeler should make all efforts to keep the set of adjustable parameters to as small a set as possible to minimize the effort required to calibrate. The set of adjustable parameters are divided into those that directly impact capacity (vehicle following and lane changing) and those that directly impact demand (route choice).

These parameters can be further subdivided into those that affect the simulation on a global basis and those that affect the simulation on a more localized basis. The global parameters are calibrated first followed by the link-specific parameters for fine tuning.

VALIDATION

Best practice is to have validation criteria for at least two different MOEs. It is strongly recommended that the following MOEs be used for validation criteria for all traffic models.

- Traffic Volumes
- Speed/Travel Times

These MOEs are suggested to be prioritized given their influence on the many other operational characteristics of the transportation network, such as density and delay. Field data for these MOEs are also relatively quick to obtain.

The goal is to get the best match possible between model estimates and field measurements. However, there is a point of diminishing return to the amount of time and effort that can be put into eliminating error in the model.

Traffic Volumes: The first measure of proof of validation is how closely throughput volumes from the field match simulation output volumes. A simple percentage difference is not a fair comparison of the wide range of mainline segment or turning movement throughput volumes possible in the model. A universal measure to compare field data is the GEH formula.

GEH statistics shall be calculated for all mainline segments and ramps identified in the modeling limits. The GEH statistic must also be calculated for all throughput volumes at all entry and exit locations in the the model. Parameters may need to be adjusted in the calibration process to match the throughput volume criteria. Any changes must be documented in the Calibration & Validation memo.

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

NOTE:

- m = output traffic throughput volumes from the simulation model (veh/h/ln)
- c = traffic throughput volumes based on field data (veh/h/ln)

Table 6 provides the throughput traffic volume calibration criteria.

Table 6: Throughput Traffic Volume Calibration Criteria

Criteria	Acceptable Targets
GEH < 3.0	All MDOT facility segments within the calibration area
GEH < 3.0	All entry and exit location within the calibration area
GEH < 3.0	All entrance and exit ramps within calibration area
GEH < 5.0	At least 85% of applicable local roadway segments
Sum of all segment flows within the calibration area	Within 5%

Meeting the calibration criteria outlined above may prove to be difficult and time consuming depending on the modeling effort. If the locations that fail the criteria are demonstrated to only have minor influence on the desired model outputs and overall operations, then the model may still be considered calibrated to throughput volumes with MDOT's approval.

Increasing the GEH threshold from 3.0 to 5.0 may be acceptable for certain projects. A higher GEH could be acceptable on facilities where a higher variation in volumes is expected. Any revisions to the validation criteria will require approval from MDOT and documentation in the Calibration and Validation memo.

Facility Speed: Speed data is a very useful second proof of validation metric. This usually pertains to freeway segments because it is difficult to measure speed data on arterials.

Speed and congestion information can be visualized in a speed "heat map" format. This graphical display of speeds is useful in comparing simulation vehicle speeds against probe vehicle speed data (e.g., RITIS). In the absence of this data, field collected speeds or segment space mean speed determined from travel time runs may be collected and used for validation. Speed heat maps should have distance along the corridor on one axis and simulation time on the other axis in 15-minute increments. Speed and congestion validation should apply to freeway or limited access facilities only. Speed should be collected from models at segments or spots that align with probe data segmentation. Figure colors should be varied at 10 mph increments (<25 mph is dark red, > 65 mph dark green).

The goal of validating to the speed heat maps is to match the spatial extent and duration of congestion resulting from bottlenecks. Models are deemed acceptable based on the visual acceptance between the simulated speeds heat map and observed speeds heat map. Final approved of simulated model speeds will be conducted by MDOT. All speed heat maps will be documented in the Calibration and Validation memo. Facility Speed is the preferred method of calibration verification by MDOT.

Figure 21: Example of a Speed Heat Map

Route (Dir.)	Mainline / Ramp		RITIS Speed (mph)														
			900-1800	1800-270	2700-360	3600-450	4500-540	5400-630	6300-720	7200-810	8100-900	9000-990	9900-108	10800-11	11700-12	12600-13	Average
I-94 (EB)	BEGIN EB 94	Mainline	65	67	68	63	66	66	67	66	66	65	65	64	65	64	65
	EB 94 (AA-Saline)	Mainline	66	68	71	67	64	68	67	66	68	68	66	64	65	63	66
	EB 94	Mainline	66	68	71	67	64	68	67	66	68	68	66	64	65	63	66
	EB 94	Mainline	66	68	71	68	64	66	64	66	64	67	66	65	66	61	66
	EB 94 (State St)	Mainline	66	68	68	70	65	56	61	62	68	65	68	66	66	62	65
	EB 94	Mainline	66	68	68	70	65	56	61	62	68	65	68	66	66	62	65
	EB 94	Mainline	65	65	66	65	66	57	63	64	65	65	67	65	64	66	64
	EB 94 (US-23)	Mainline	64	67	65	66	66	65	64	72	65	68	67	66	65	67	66
	EB 94	Mainline	66	65	64	65	63	59	59	62	65	64	63	63	64	65	63
	EB 94 (Michigan Ave)	Mainline	73	65	74	65	69	68	62	62	65	67	67	66	67	67	67
	EB 94	Mainline	73	65	74	65	69	68	62	62	65	67	67	66	67	67	67
	EB 94 (Huron St)	Mainline	68	69	64	69	68	67	64	67	67	67	67	66	68	64	67
	EB 94	Mainline	68	69	64	69	68	67	64	67	67	67	67	66	68	64	67
	EB 94	Mainline	64	67	65	67	67	66	63	63	64	64	65	65	65	63	65
	END EB 94 (US-12)	Mainline	67	69	65	67	68	67	66	65	65	66	67	66	66	66	66
I-94 (WB)	BEGIN WB 94	Mainline	65	66	67	53	32	29	65	65	64	66	65	65	66	66	59
	WB 94 (US-12)	Mainline	64	64	63	41	27	36	49	63	61	59	67	65	66	65	56
	WB 94 (Huron St)	Mainline	64	64	63	44	19	51	30	52	49	48	64	67	65	64	53
	WB 94	Mainline	64	64	63	44	19	51	30	52	49	48	64	67	65	64	53
	WS 94	Mainline	64	65	64	36	25	44	23	35	32	33	64	67	64	63	48
	WB 94 (Michigan Ave)	Mainline	63	65	64	24	25	19	15	17	17	31	61	67	65	63	42
	WB 94	Mainline	63	65	64	24	25	19	15	17	17	31	61	67	65	63	42
	WB 94	Mainline	61	64	62	18	24	15	15	16	16	27	52	63	60	61	40
	WB 94 (US-23)	Mainline	56	50	59	20	28	20	23	22	21	34	35	42	40	56	36
	WB 94	Mainline	56	50	59	20	28	20	23	22	21	34	35	42	40	56	36
	WB 94 SB US-23 On	Mainline	56	50	59	20	28	20	23	22	21	34	35	42	40	56	36
	WB 94	Mainline	63	62	59	44	53	45	44	48	49	51	30	33	31	56	48
	WB 94 (State St)	Mainline	61	63	62	57	62	54	61	57	58	59	55	47	56	60	58
	WB 94	Mainline	61	63	62	57	62	54	61	57	58	59	55	47	56	60	58
	WB 94	Mainline	61	64	63	62	64	59	63	61	61	62	62	62	61	61	62
	WB 94 (AA-Saline)	Mainline	62	65	65	64	65	61	67	60	65	63	65	65	63	63	64
	END WB 94	Mainline	62	65	67	64	67	65	68	62	64	63	67	67	63	65	65

Route (Dir.)	Mainline / Ramp		VISSIM Speed (mph)														
			900-1800	1800-270	2700-360	3600-450	4500-540	5400-630	6300-720	7200-810	8100-900	9000-990	9900-108	10800-11	11700-12	12600-13	Average
I-94 (EB)	BEGIN EB 94	Mainline	69	68	68	68	68	67	68	68	68	68	69	69	69	69	68
	EB 94 (AA-Saline)	Mainline	69	68	68	68	67	66	67	67	67	68	68	69	69	68	68
	EB 94	Mainline	68	68	67	67	65	60	67	66	67	68	68	68	69	68	67
	EB 94	Mainline	68	67	66	66	61	59	63	64	64	66	67	68	68	68	65
	EB 94 (State St)	Mainline	68	68	67	68	65	66	66	66	66	67	68	68	69	68	67
	EB 94	Mainline	68	68	67	67	63	54	66	66	66	67	68	68	68	68	66
	EB 94	Mainline	68	68	67	66	63	62	67	66	66	67	68	68	68	68	67
	EB 94 (US-23)	Mainline	68	68	67	66	65	64	66	66	65	67	68	68	68	68	67
	EB 94	Mainline	68	68	68	68	67	67	68	68	68	68	69	69	69	69	68
	EB 94 (Michigan Ave)	Mainline	68	68	68	68	68	68	68	68	68	68	69	69	69	69	68
	EB 94	Mainline	68	68	68	68	68	67	68	68	68	68	69	69	69	69	68
	EB 94 (Huron St)	Mainline	68	68	68	67	67	67	67	67	67	68	68	69	69	69	68
	EB 94	Mainline	68	68	68	67	67	66	67	67	67	68	68	69	69	69	68
	EB 94	Mainline	68	68	68	67	67	66	68	67	68	68	69	69	69	69	68
	END EB 94 (US-12)	Mainline	68	68	68	67	68	67	68	68	68	68	69	69	69	69	68
I-94 (WB)	BEGIN WB 94	Mainline	69	68	68	69	68	69	64	52	59	64	65	69	69	68	66
	WB 94 (US-12)	Mainline	69	67	67	67	67	57	24	18	31	40	53	67	68	68	55
	WB 94 (Huron St)	Mainline	69	67	67	66	63	18	9	12	15	21	36	59	68	67	45
	WB 94	Mainline	69	67	66	66	42	8	9	13	15	19	26	52	68	67	42
	WS 94	Mainline	69	68	67	66	15	9	11	17	18	22	27	46	68	68	41
	WB 94 (Michigan Ave)	Mainline	68	66	65	35	8	7	8	13	14	15	18	41	68	67	35
	WB 94	Mainline	68	67	66	12	6	6	7	10	11	11	13	28	60	68	31
	WB 94	Mainline	66	60	25	9	7	6	8	12	13	13	16	23	46	61	26
	WB 94 (US-23)	Mainline	66	63	57	57	59	60	57	51	36	28	39	34	47	58	51
	WB 94	Mainline	54	42	42	54	57	57	48	39	22	19	27	23	28	40	39
	WB 94 SB US-23 On	Mainline	64	59	57	62	64	64	59	49	25	21	29	26	28	49	47
	WB 94	Mainline	68	67	65	66	67	67	66	63	58	53	39	28	27	36	55
	WB 94 (State St)	Mainline	66	64	60	65	65	66	63	60	60	57	57	57	57	59	61
	WB 94	Mainline	69	68	67	68	67	68	67	65	65	65	65	65	64	65	66
	WB 94	Mainline	67	67	65	66	66	66	66	64	64	64	65	64	64	64	65
	WB 94 (AA-Saline)	Mainline	69	68	68	68	68	68	68	67	67	67	67	67	67	67	68
	END WB 94	Mainline	69	68	68	68	68	68	68	67	67	67	67	67	67	67	68

Travel Time: The travel time criteria are separated into two facility types: uninterrupted flow and interrupted flow.

Travel time routes that span a long distance, such as through multiple freeway interchanges, should be broken into multiple segments for validation purposes. The overall travel time route of the corridor should also be validated.

Modelers should ensure an adequate sample size of travel time data is available for comparison with average model outputs. When available, probe vehicle data sources should be used to provide a large sample size over multiple days. Alternatively, field travel time runs may be conducted, though project budgets may limit the number of runs below that which would be considered a statistically significant sample size. The travel time data should align with the period of travel time validation (peak hour or peak period).

The travel time validation criteria is as follows:

- 85% of the travel time routes and segments, or a select number of critical routes and segments shall be within the following thresholds:
    - ± 30% for average observed travel times on arterials
    - ± 20% for average observed travel times on freeways

2.7 FUTURE YEAR MODELS

Volume forecasting and methodology should be documented and approved before the development of the future year models via a meeting with the MDOT PM, MDOT Congestion & Reliability Unit, and other parties as appropriate to the project. The future year demand forecasts is a critical element to the accuracy of the alternatives analysis. The new traffic volume data can be submitted in graphical format for approval.

A copy of the calibrated base conditions model shall be used to create the future year models. Future No-Build models should only change the traffic demand inputs and routing, signal timing, and any planned improvements. Once completed, the No-Build model can be used to develop all additional alternative models. The No-Build model represents a benchmark for comparison against all improvement alternatives.

Changes to driver behavior and parameters in future year models normally are not altered unless major changes to the network or volumes are included. Additional documentation of changes and assumptions should be compiled and submitted with each model for MDOT review if they deviate from the already approved calibrated parameters of the base models.

2.8 REPORTED MEASURES OF EFFECTIVENESS (MOE'S)

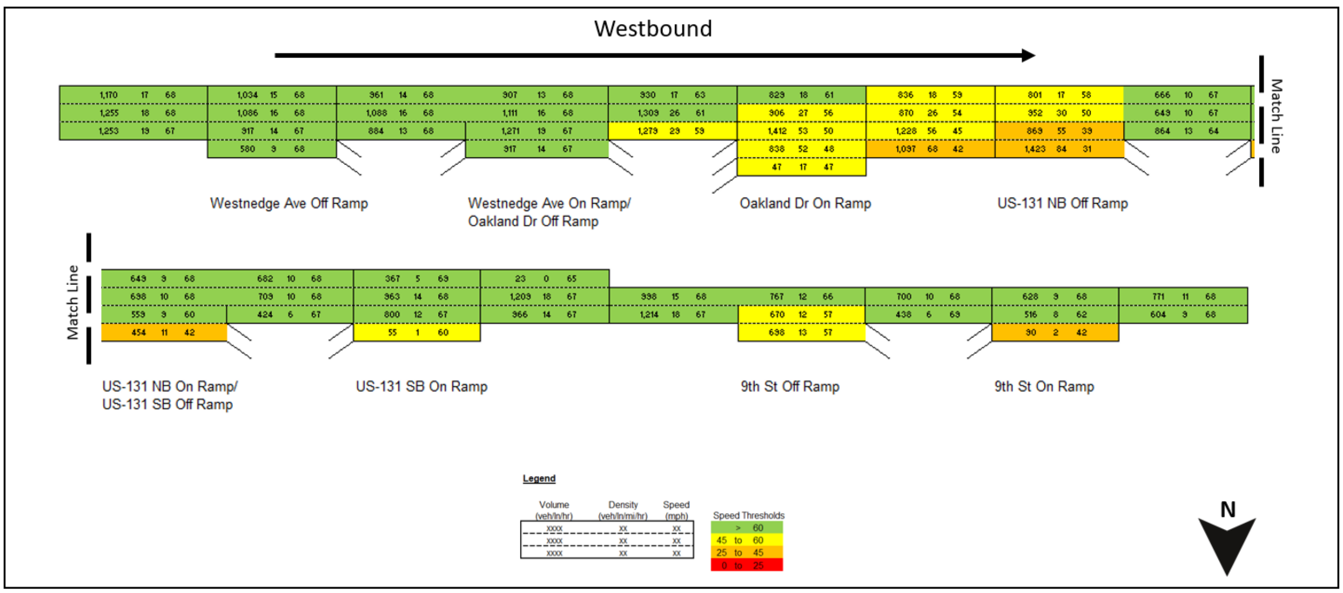
Graphical and tabular presentation of MOE's should be carefully created to help convey the results. Presentation and format of reported outputs should target a non-technical audience while allowing a technical reviewer the ability to verify the results of the analysis.

FREEWAY MOE'S

For reporting freeway MOE's, it is MDOT's preference to display color-coded lane schematics of the ramps and mainline (see sample in Figure 22). Freeway MOE's generally include:

- Volume throughput
- Travel speeds
- Density
- Travel time

Figure 22: Sample Freeway MOE Lane Schematic Summary



In addition to the lane schematic, there may be cases where the project calls for freeway MOE's to be reported as levels of service in a comparable fashion to the methodologies of the *Highway Capacity Manual* (HCM), i.e. levels of service reported for Basic, Merge/Diverge, and Weaving segments of the freeway corridor. In this case, proper segmentation of the corridor is required by the modeler to represent proper HCM influence areas and data outputs need to be collected by lane with weighted averages of the lane data used to determine the level of service based on the calculated density from the model output. It should be noted that this is a method to provide LOS data comparable to the

HCM methodology, but is not in fact the calculation of LOS to true HCM methodologies, since that is a deterministic calculation.

Figure 23: Sample Freeway MOE Summary

I-94 Eastbound		Type	AM				PM			
ID	Segment		Total Volume	Weighted Density	LOS	Weighted Speed	Total Volume	Weighted Density	LOS	Weighted Speed
E1	I-94 EB	basic	2,943	21.7	C	67.7	2,239	16.3	B	68.6
E2	Ann Arbor-Saline Rd Off Ramp	diverge	2,909	20.9	C	63.5	2,233	15.2	B	65.5
E3	I-94 EB	basic	2,553	19.2	C	66.9	1,823	13.5	B	68.3
E4	Ann Arbor-Saline Rd SB On Ramp	merge	2,755	20.7	C	65.4	2,066	15.7	B	67.0
E5	I-94 EB	basic	2,769	23.2	C	60.5	2,071	19.1	C	64.2
E6	Ann Arbor-Saline Rd NB On Ramp	merge	3,256	28.1	D	54.3	2,325	26.5	C	58.5
E7	I-94 EB	basic	3,368	27.2	D	62.7	2,358	43.7	E	48.7
E8	State St Off Ramp	diverge	3,346	24.2	C	60.4	2,306	55.4	F	37.7
E9	I-94 EB	basic	2,505	19.1	C	66.3	1,818	93.0	F	15.4
E10	State St SB On Ramp	merge	2,839	22.1	C	62.6	2,920	108.7	F	12.3
E11	I-94 EB	basic	2,898	26.2	D	56.1	2,969	97.8	F	16.5
E12	State St NB On Ramp	merge	3,308	33.1	D	49.5	3,975	72.0	F	31.4
E13	I-94 EB	basic	3,423	26.6	D	64.3	4,135	32.5	D	63.7
E14	US-23 Off Ramp	diverge	3,393	33.1	D	45.1	4,116	42.7	F	43.1
E15	I-94 EB	basic	2,399	18.5	C	65.4	3,056	23.5	C	65.3
E16	US-23 On Ramp	merge	4,054	21.8	C	62.4	4,827	25.6	C	62.8
E17	I-94 EB	basic	4,093	20.2	C	67.6	4,882	24.2	C	67.2
E18	US-12 (Michigan Ave) Off Ramp	diverge	4,077	19.4	B	66.7	4,864	22.7	C	66.8
E19	I-94 EB	basic	3,791	18.8	C	68.0	4,512	22.4	C	68.1
E20	US-12 (Michigan Ave) SB On Ramp	merge	4,131	20.2	C	67.6	5,083	24.9	C	66.9
E21	I-94 EB	basic	4,114	20.4	C	67.6	5,061	25.3	C	66.9
E22	US-12 (Michigan Ave) NB On Ramp	merge	4,758	24.2	C	65.2	5,716	29.0	D	66.1
E23	I-94 EB	basic	4,839	24.2	C	67.3	5,815	29.7	D	65.8
E24	Huron St Off Ramp	diverge	4,825	23.6	C	64.8	5,802	31.2	D	57.0
E25	I-94 EB	basic	4,223	21.2	C	66.8	4,670	24.7	C	63.9
E26	Huron St SB On Ramp	merge	4,487	22.3	C	66.6	5,197	25.8	C	64.7
E27	I-94 EB	basic	4,439	22.2	C	67.2	5,136	26.0	C	66.5
E28	Huron St NB On Ramp	merge	4,915	25.3	C	62.0	5,513	27.1	C	66.0
E29	I-94 EB	basic	4,954	24.7	C	67.1	5,550	27.7	D	67.0
E30	US-12 (Michigan Ave) Off Ramp	diverge	4,926	25.1	C	62.7	5,521	29.2	D	60.0
E31	I-94 EB	basic	4,391	21.8	C	67.4	4,806	23.8	C	67.4

ARTERIAL MOE'S

For reporting arterial MOE's, it is MDOT's preference to display color-coded level of service graphics (see sample in Figure 16). MOE's for arterials may generally include:

- Delay/LOS
- Travel time
- Queue lengths

Figure 24: Sample Intersection Level of Service Summary – Color-Coded by LOS

Intersection	AM Peak Hour																
	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
	Left	Thru	Right	Appr.	Left	Thru	Right	Appr.	Left	Thru	Right	Appr.	Left	Thru	Right	Appr.	
M-1 & Cambourne	-	A	A	A	-	A	A	A	-	C	A	C	-	C	A	C	A
M-1 & Sylvan	-	A	A	A	-	C	A	C	-	D	B	B	-	C	B	B	C
NB M-1 & EB I-696 SD	-	B	A	B	-	-	-	-	A	A	-	A	-	-	-	-	A
NB M-1 & WB I-696 SD	-	C	-	C	-	-	-	-	-	-	-	-	-	C	E	D	D
SB M-1 & EB I-696 SD	-	-	-	-	-	B	-	B	-	C	B	C	-	-	-	-	B
SB M-1 & WB I-696 SD	-	-	-	-	-	B	A	B	-	-	-	-	A	A	-	A	A
NB M-1 & Washington	A	A	A	A	-	-	-	-	-	-	-	-	-	C	B	C	B
SB M-1 & Washington	-	-	-	-	-	B	C	C	-	-	-	-	A	A	-	A	B
M-1 & Lincoln	-	A	A	A	-	A	A	A	-	C	B	C	-	C	A	B	A
M-1 & 11 Mile	-	A	A	A	-	A	A	A	-	C	B	C	-	C	B	B	A
EB I-696 SD & Coolidge	-	B	A	B	-	A	-	A	-	C	C	C	-	-	-	-	C
WB I-696 SD & Coolidge	-	A	-	A	-	B	B	B	-	-	-	-	-	C	C	C	B
EB I-696 SD & Scotia	-	C	B	C	C	B	-	B	A	A	A	A	-	-	-	-	B
WB I-696 SD & Scotia	A	A	-	A	-	C	B	B	-	-	-	-	B	B	B	B	B
EB I-696 SD & SB M-1 Slip	-	-	-	-	C	-	-	C	-	D	-	D	-	-	-	-	D
WB I-696 SD & SB M-1 Slip	-	-	-	-	-	C	A	B	-	-	-	-	A	A	-	A	A
EB I-696 SD & Main	-	C	C	C	-	-	-	-	A	A	-	A	-	-	-	-	B
WB I-696 SD & Main	E	B	-	D	-	-	E	E	-	-	-	-	-	F	F	F	F
EB I-696 SD & Bermuda	-	C	A	B	B	B	-	B	A	A	A	A	-	-	-	-	A
WB I-696 SD & Mohawk	A	A	-	A	-	C	A	B	-	-	-	-	C	C	B	C	C

Figure 25: Sample Intersection Queuing Statistics

INTERSECTION	PM PEAK HOUR QUEUE (FT)							
	Northbound		Southbound		Eastbound		Westbound	
	Avg.	Max	Avg.	Max	Avg.	Max	Avg.	Max
Fuller/Maiden Ln/EMCD	163	334	1055	1915	1026	1744	3400	4748
EMCD/West Medical Center	45	196	-	-	162	393	-	-
EMCD/Cancer Center	168	464	28	113	26	99	-	-
EMCD/Nichols	61	300	75	119	25	81	36	114
EMCD/Psychiatric Emerg.	0	21	-	-	26	107	-	-
EMCD/Taubman Entrance	0	38	-	-	-	-	-	-
EMCD/Taubman Exit	-	-	-	-	38	149	-	-
EMCD/P2 Entrance	0	28	-	-	24	81	-	-

Additional MOE's may be requested by the MDOT Project Manager depending on the specific purpose of the project. For example, if the impact of transit signal priority (TSP) is being evaluated on a corridor, the delay and/or queue lengths just during the TSP actuations at an intersection could be requested as well as the corridor travel time impacts for both general passenger car traffic and transit vehicles.

NETWORK PERFORMANCE EVALUATION

The Network Performance Evaluation is an overall snapshot of network-wide MOE's and is useful for quickly comparing alternatives. This evaluation is an aggregation of all vehicles on the network independent of any node or travel time segment definitions. The MOEs provide from this evaluation are vehicle delay and stops, vehicle-hours traveled, mean system speed, emissions, latent demand and several others.

ANIMATION VIDEOS

Animation videos can be used as a tool to convey information to project stakeholders and members of the public. Before showing the animation videos to an audience outside of the modeling development and/or review team, verify that the driver behavior is realistic. Most microsimulation tools now provide the option to show a 3D visualization of the model, complete with roadway infrastructure and other architectural features. While these features may help to orient the audience to the project study area, take care not to let the presentation graphics overshadow the fundamental engineering objective of the model, which is to accurately represent operations.

2.9 DELIVERABLES

The deliverables throughout the lifecycle of a VISSIM project include electronic modeling files, interim technical memorandums and a final report. Technical memorandums in this process are interim reports that document technical issues relevant to the analysis process. Each submitted memorandum will allow MDOT and other stakeholders the opportunity to review and understand analysis methodologies and results prior to a final report. The interim memorandums allow for verification and correction of the model development at key points in the process. MDOT and additional reviewing agencies should review and concur with the content of the technical memorandums before the model development team proceeds to the next deliverable. The sections below detail expected technical memorandums and their content. Some technical memorandums outlined below may be omitted based on project scope.

VISSIM MODELING METHODOLOGY AND ASSUMPTIONS MEMO

For each model a VISSIM Modeling Methodology and Assumptions created a document will be prepared detailing the following information:

- Purpose
- Study Area
    - Documented congestion and Influence area
    - Geographic limits
    - Temporal Limits
- Data Sources
- VISSIM Version and Build
- Speed and Geometrics
- Traffic Volume Input
- Seed Interval
- Driver Behavior Input
- Validation Criteria
- Travel Demand Forecasting Process
- MOEs

- Other Assumptions

DATA VERIFICATION AND SCREENING ASSESSMENT MEMO

A data verification and screening memorandum will be submitted to MDOT detailing how the data set collected compares to a "typical" day of operations within the study area (or typical for what is being evaluated if a special event). The assessment should include:

- Traffic volume data
    - A review of how the counts collected compare to other counts within the study area (if available)
- Speed data (assumes RITIS speed data)
    - Dates - a minimum of three months of data should be used for comparison. Any holidays should be excluded from the dataset.
    - Days of comparison - Tuesdays, Wednesdays, and Thursdays are the preferred days of comparison.
    - Time of comparison – detail peak hours
    - How do the typical speeds and congestion compare to the speeds and congestion on the day(s) traffic counts were collected
- Field review summary
    - Do field review observations on days of data collection align with what is generally known about operations within the project study area
- Validity of data
    - Collected data is verified and is representative of the target traffic conditions.

BASE CONDITIONS MEMO

The base conditions technical memorandum provides an overview of the existing transportation network under study. Its contents are derived from field observations, data collection from various sources, and existing data analysis. This memo specifically presents the base conditions modeled calibration and validation data, and MOE's.

The calibration and validation summary should include the following:

- Basic processes and procedures followed during calibration and validation
- Assumptions made
- Problems encountered
- Solutions devised during the study effort
- Confidence in model results

- Comparison of model results to real world data
- Identify validation targets that were not met and why the results are still valuable

Any and all calibration parameters changed from default settings should be clearly documented with reasons justifying these adjustments.

ALTERNATIVES ANALYSIS MEMO

This technical memorandum summarizes the results of the alternatives analysis and should include:

- Design year forecasts and methodology
- No-Build methodology and projections
- Alternative descriptions
- MOE summary (No-Build and alternatives)
- Recommended alternative selection

FINAL REPORT

The final report is developed in detail to document and support assumptions, findings, recommendations and decisions that were made from the analysis. The final report will incorporate all previous work completed under each interim technical memorandum. The technical memorandums should be attached in the final report as appendices.

The size and complexity of the project will dictate the length of the final report. The final report should follow the outline presented in Figure 26. This outline divides the report into sequential sections that will aid in the review process. All graphical and tabular displays presented in the report should be supported by text. This deliverable will include submittal of a draft report to present the findings of the analysis and a second submittal of the final report that incorporates comments obtained through the review process.

Figure 26: Typical Final Report Outline

1. Title Page
2. Executive Summary
3. Table of Contents
- A. List of Figures
- B. List of Tables

4. Introduction
- A. Project Description and Study Area
- B. Project Purpose and Objective

6. Data Collection
- A. Data Collected and Sources
- B. Data Collection Methodology
- C. Summary of Data Collection and Field Observations

7. Base Conditions
- A. Base Model Development
- B. Model Verification/Error Checking
- C. Model Calibration and Validation
- D. MOE's

8. Alternatives Analysis
- A. No-Build Alternative
  - i. Future Year Demand Forecasts
  - ii. No-Build Analysis MOE's
- B. Preliminary Alternatives
  - i. Development and Screening of Concepts
- C. Build Alternatives
  - i. Alternatives Evaluated
  - ii. Traffic Volume Forecasts (trip pattern/circulation routes & assumptions)
  - iii. Design Considerations
  - iv. VISSIM Model Development
  - v. Alternatives Analysis MOE's
- D. Alternatives Evaluation Matrix of Pros/Cons

9. Conclusions and Recommendations
10. Appendices

VISSIM ELECTRONIC MODELING FILES

Throughout the project, VISSIM model files should be provided to MDOT for review. In particular, the initial base model(s) should be provided for review once calibration is complete. The VISSIM models for the various alternatives should also be provided to MDOT for a potential review prior to the completion of the final report. At the end of the project the VISSIM model(s) and accompanying files should be provided to MDOT via ProjectWise. Files include:

- VISSIM file (.inpx)
- Signal Controllers (.rbc)
- Balanced volumes (electronic)

The following naming conventions are suggested for the VISSIM .inpx files and .rbc files

- Vissim file (.inpx)
    - Scenario-TimePeriod.inpx
        - Examples:
            - BASE-PM.inpx
            - FNB-AM.inpx
            - ALT_1-PM.inpx
- Signal Controllers (.rbc)
    - Scenario-MajorStreet&MinorStreet-TimePeriod.rbc
        - Examples:
            - BASE-Woodward&Warren-AM.rbc
            - ALT_1-Woodward&Warren-OP.rbc

APPENDIX A.1: VISSIM Scoping Checklist

VISSIM Scoping Checklist

Project Name: ____________________

Staffing Plan

- ☐ Names of modelers: ____________________
- ☐ Location of modelers: ____________________
- ☐ Names of people that will be reviewing the models: ____________________

Project Schedule

Includes:

- ☐ Milestones
- ☐ Check-in points
- ☐ Review time for agency

Project Study Period Definition

Period to Study	Weekday	Saturday	Simulation Length
AM			
PM			
Midday			
Other			

Alternatives

- ☐ Alternative Study Years: ____________________
- ☐ Proposed Alternative #1: ____________________
- ☐ Proposed Alternative #2: ____________________
- ☐ Proposed Alternative #3: ____________________
- ☐ Proposed Alternative #4: ____________________

Field Review (MDOT and Consultant Together)

- ☐ Locate any upstream or downstream bottlenecks
  List: ____________________
- ☐ Locate any significant lane imbalances
  List: ____________________
- ☐ Locate any spots with significantly high truck use
  List: ____________________

Project Boundary Definition

Figure with:

- ☐ Project study area
- ☐ Model area
- ☐ Calibration area (s)

Data Collection

Geometric Data:

- ☐ Number of Lanes
- ☐ Lane Widths
- ☐ Taper Locations and Lengths
- ☐ Lengths of Raodway Segments

- ☐ Sidewalk Locations
- ☐ Parking Locations
- ☐ Length of Roadway Segments

Control/Operational Data

- ☐ Speed Limits
- ☐ Intersection Controls
- ☐ Signal Characteristics
- ☐ Rail Crossing Lcoations
- ☐ Signal Timing
- ☐ Right Turn on Red Locations

Traffic Volume Data

- ☐ Turn Movement Counts
- ☐ Vehicle Classifications
- ☐ Bike and Pedestrian Counts

Other

- ☐ Origin Destination Data
- ☐ Travel Time Data
- ☐ Spot Speed Data
- ☐ Queuing Data
- ☐ Transit Data
- ☐ Saturation Flow Data
- ☐ Lane Utilization Data
- ☐ Aerials

Definition of Calibration Targets

- ☐ Traffic Volumes Within: ________________________
- ☐ Spot Speed Within: ________________________
- ☐ Travel Time Within: ________________________

Queue Comparison

- ☐ Visual
- ☐ Numerical Results

- ☐ Freeway Capacity
- ☐ Other: ________________________

Selection of Measure of Effectiveness (MOEs)

Delay

- ☐ Vehicles
- ☐ Transit
- ☐ Pedestrians
- ☐ Bicycles

Travel Time

- ☐ Vehicles
- ☐ Transit
- ☐ Pedestrians
- ☐ Bicycles

Other

- ☐ Traffic Volume Throughput
- ☐ Queuing
- ☐ Other: ________________________

APPENDIX A.2: VISSIM Modelers Prompt List (Available electronically with ScreenTips)

Project Name: ____________________

Scenario: ____________________

Reviewed By: ____________________

Date: ____________________

	Addressed	Notes:
VISSIM Version		
Background		
Image		
Scale		
Coordinate System		
Links/Connectors		
# Lanes		
Lane widths		
Connection points		
Lane change restrictions		
Vehicle restrictions/closures		
Behavior Type		
Display Type		
Numbering protocal		
Link evaluation segment length		
Link evaluation active		
Gradient		
Visualization		
3d settings		
Link Breaks/lengths appropriate for MOE summary		
Lane change distances		
Emergency stop distances		
Visual alignment		
Link names		
Signals		
3d signals		
Source timing file		
Timing parameters		
Detectors		
TSP		
Preempt		
VAP		
Signal heads		
Controller names		
Vehicle fleet		
2d/3d model distributions		
Vehicle classes		
Traffic compositions		
Parking Lots		
Numbering protocal		

Size		
Attraction		
Fees		
Blocking time distribution		
Open hours		
Priority Rules		
Appropriate		
Conflict Areas		
Parameters		
Overlapping		
Stop Signs		
RTOR		
Dwell Distribution		
Placement		
Vehicle inputs		
Hourly Flow Rates		
Time Intervals		
Traffic Compositions		
Exact or Stochastic		
Routing Decisions		
Types		
Start/End		
Relative flows		
Vehicle Classes		
Reduced Speed Areas		
Location		
Speeds		
Vehicle classes		
Speed Decisions		
Location		
Speed Distribution		
Vehicle classes		
Pavement markings		
Location		
Public Transit		
Routes		
Vehicle		
Headways		
Stations		
Dwell Distribution		
Pedestrians/Bicyclists		
Ped module used?		
Vehicle model		
Speed distribution		
Overtaking		
Nodes		
Numbering protocal		

Evaluations		
Configuration		
Driving Behavior		
Parameters		
Dynamic Assignment		
Matrices		
Parking Lots		
Nodes		
Surcharges		
Route Closures		
Edge Closures		
Path search		
Convergence		
Simulation Parameters		
Seed Interval		
Simulation resolution		
AVI		
Simulation resolution		
CODEC		
Story		
Error Log		
MOEs		
Data collection points		
Queue counters		
Travel time sections		
Node Evaluations		
Link Evaluations		

Existing Conditions Only

Validation		
Source data		
Thresholds		
# of Runs		
Calibration		
Adjusted parameter documentation		
Unresolvable differences		

APPENDIX A.3: VISSIM Comment Log

Project Name: I-94/US-131 System Interchange Analysis
Project Number: 194403A
Project Manager: Lauren Warren
Initials: MJH = Matthew John Hill, PE, PTOE / TJK = Trevor J Kirsch, MS, EIT

Comment #	Document Name	Stage	Page/Section/File Name	Comment	Comment By	Date of Comment	Action Taken/Response	Response By	Date of Response	Final Status	Approved By	Date Approved
1			Existing VISSIM Model	Modeling limits need to be extended to the west to include the WB I-94 exit and entrance ramps to/from 9th Street.	MJH	10/3/2019	Model limits extended to include 9th St on and of ramps	TJK	10/4/2019	Complete	MJH	10/8/2019
2			Existing VISSIM Model	Extend WB 94 entry link further to the east (east of Portage Road interchange) to allow for entering traffic to position adequately for exiting at Westnedge without artificially creating congestion from last second lane changes.	MJH	10/3/2019	Extended I-94 WB entry link	TJK	10/4/2019	Complete	MJH	10/8/2019
3			Existing VISSIM Model	Behavior type for freeway links should be set to a freeway free lane selection behavior type.	MJH	10/3/2019	Behavior type adjusted for all freeway links	JMP	10/4/2019	Complete	MJH	10/8/2019
4			Existing VISSIM Model	Extend link 2 all the way back to where the decel lane taper begins per modeling best practices and adjust connector accordingly (seek to keep connectors as short as possible in general but still visible for reviewing/adjusting).	MJH	10/3/2019	Extended Link 2 to the decel lane taper and adjusted the connector	TJK	10/4/2019	Complete	MJH	10/8/2019
5			Existing VISSIM Model	Extend link 2 all the way to the gore where the striping splits (it's close, but lets capture every inch of allowable lane changing space for general modeling practice). Connectors should be adjusted so that they start right at the end of Link 2 and do not overlap link 2 much. Keep short.	MJH	10/3/2019	Extended Link 2 to the striping split and adjusted the connectors	TJK	10/4/2019	Complete	MJH	10/8/2019

APPENDIX A.4: Reviewing Agency Checklist

Milestone	Items to Check	
Scoping		
Project Problem Statement	☐	The goals of the project are clearly stated
	☐	Proposed MOEs provide the necessary information to answer the Project Problem Statement
	☐	Field visit has been conducted
Comments:		
Data Collection Plan	☐	Summary of a field visit to determine data collection needs has been provided in a graphical format
	☐	Summary of real-world observations (and historical data if available) showing congestion locations have been provided
	☐	Time periods for data collection have been determined and documented
	☐	Type of data to be collected and locations that they will be collected are documented in tabular and graphical format
Comments:		
Project Methods and Assumptions	☐	Project understanding, including the problem statement, is described
	☐	Software tools to be used for this project and their use have been outlined
	☐	Model area, calibration area, and study area have been defined
	☐	Project study period and years for analysis have been defined
	☐	The types of data to be collected, location of collection, and the time increment and period that they will be collected are provided
	☐	Documentation of if the data collected will be used for model development and/or calibration purposes
	☐	A complete list of MOEs that will be collected from the model is included
	☐	Calibration targets have been outlined for this project.
	☐	Any known assumptions associated with this project have been outlined
	☐	Any known deviations from the protocol guidelines are documented with justification
	☐	A project schedule demonstrating a linear sequence of milestones is provided
	☐	VISSIM experience of the staff that will be working on the project are described
Comments:		

Data Collection		
Data Collection Summary	☐	Development of input volume data sets have been documented
	☐	Sink and source locations are identified in graphical format
	☐	Lane schematics in graphical format
	☐	Documentation of any errors found in data and the assumptions that were made in accordance with the errors
	☐	Traffic volumes to be used in analysis of all existing conditions are provided in graphical format
	☐	Posted speeds and any localized segments of adjusted desired speeds are provided in graphical format
	☐	Any lane imbalance locations that require special coding are documented and described graphically
	☐	Summary of travel time and speed data
Comments:		
Model Coding		
Base VISSIM Model	☐	Lane geometry correct at all intersections
	☐	Locations of freeway lane drops/adds correct
	☐	Merge/diverge locations coded correctly
	☐	Desired Speed Decisions coded at all locations of change in posted speed
	☐	Reduced Speed Areas at all turns and areas of temporary speed reductions
	☐	Conflict Areas/Priority Rules coded at all intersections and other conflict points
	☐	Stop Signs coded at proper locations
	☐	Traffic signals coded at correct intersections
	☐	Traffic signal stop bars and detectors coded at proper locations
	☐	Traffic signal timing matches field timing
	☐	Nodes coded at all study intersections with Node Evaluation toggled on
	☐	Queue Counters coded for all movements at all intersections in the List of Key Calibration Locations
	☐	Max Queue Value increased from default value to include longest possible queue

	☐	Data Collection Points coded on all entry and exit links
	☐	Travel Time Segments coded for all sections identified in the Data Collection Plan
	☐	Transit routes, headways, and dwell time parameters match real-world conditions
Comments:		
Calibration and Validation	☐	Calibration Methodology and Results Report submitted Model animations match expected driver behavior and conditions observed in the field
	☐	Model output volumes satisfy GEH statistic requirements
	☐	Model link speeds meet speed calibration requirements
	☐	Model travel time results meet calibration requirements
	☐	Model queuing replicates real-world conditions
	☐	Calibration results are based on the average of the minimum number of simulation runs calculated
Comments:		
Additional Base Year Scenarios		
Additional Base Year Models	☐	Calibration Methodology and Results report has been expanded to provide proof of calibration for additional base year models
	☐	Model animations match expected driver behavior and conditions observed in the field
	☐	Model output volumes satisfy GEH statistic requirements
	☐	Model link speeds meet speed calibration requirements
	☐	Model travel time results meet calibration requirements
	☐	Model queuing replicates real-world conditions
	☐	Calibration results are based on the average of the minimum number of simulation runs calculated
Comments:		
Alternatives		
No-Build Forecasted Volumes	☐	Methodology for developing traffic volumes has been provided
	☐	Any assumptions made during volume development have been outlined
	☐	Traffic volumes to be used in analysis are provided in graphical format

No-Build Models and Documentation	☐	Summary of input and output vs. demand is documented with any reasons for variation
	☐	Any preliminary findings from the models are documented
	☐	Signal timing matches agency guidelines
	☐	Assumptions and parameter changes are documented
	☐	All proposed network changes coded correctly
	☐	Animation of the network looks feasible
Comments:		
Alternatives Input Traffic Volumes	☐	Methodology for developing traffic volumes has been provided
	☐	Any assumptions made during volume development have been outlined
	☐	Traffic volumes to be used in analysis are provided in graphical format
Comments:		
Alternative Models and Corresponding Documentation	☐	Summary of input and output vs. demand is documented with any reasons for variation
	☐	Any preliminary findings from the models are documented
	☐	Signal timing matches agency guidelines
	☐	Assumptions and parameter changes are documented
	☐	All proposed network changes coded correctly
	☐	Animation of the network looks feasible
Comments:		
Reporting		
Final Report	☐	Project description is provided
	☐	Scope of work is outlined
	☐	Alternatives are adequately described
	☐	Bottlenecks and other problem areas have been clearly documented
	☐	Opportunities and recommendations are included

APPENDIX B.1: Simulation Run Confidence Report

WSP VISSIM TT Confidence Report
Model Results Confidence Test

Project: I-94/US-131 Interchange
Scenario: Existing Conditions
Prepared: TJK
Date: 10/18/2019

Number of Sample Runs	10
Select Confidence Level	85%
Number of sites Failing to meet Target	0

Confidence Interval Target	Uninterrupted Flow	$\Delta = \frac{1}{\frac{1}{t} - \frac{4.4}{L}} - t$
Acceptable Variation in Results Based on Facility Type	Interrupted Flow	$\Delta = \frac{1}{\frac{1}{t} - \frac{0.1 * 5280\, S}{3600\, L}} - t$

Notes:
Δ = Allowable TT Variation (+/- seconds)
t = Travel Time (seconds)
L = length (feet)
S = Free Flow Speed (mph)

Analysis Interval	
Start Time	900
End Time	15300

Location Description								Model Results				Confidence Interval Target		Confidence Test	
ID	Route	Start Location	End Location	Distance	Additional Notes	Facility Type	FFS	Average Model TT	Standard Deviation	Confidence Interval based on 85% Confidence Level(s)	Confidence Interval based on 85% Confidence Level (%)	Confidence Interval based on Facility Type (s)	Confidence Interval based on Facility Type (%)	Test	# of Runs Required
900-4500	1	I-94 WB	I-94 WB	41427.55		Uninterrupted Flow	68	415.030227	0.678453	0.308845253	0.1%	19.08268957	5%	PASS	0.002621111
900-4500	2	US-131 NB	US-131 NB	21219.8		Uninterrupted Flow	68	216.571423	0.664806	0.302632868	0.1%	9.774434477	5%	PASS	0.009592495
900-4500	3	I-94 WB	US-131 NB	40856.45		Uninterrupted Flow	68	434.459934	5.722543	2.605015001	0.6%	18.81962508	4%	PASS	0.191726074
4500-8100	1	I-94 WB	I-94 WB	41427.55		Uninterrupted Flow	68	416.795213	1.242832	0.565761761	0.1%	19.08268957	5%	PASS	0.008795705
4500-8100	2	US-131 NB	US-131 NB	21219.8		Uninterrupted Flow	68	216.064	0.88743	0.403975726	0.2%	9.774434477	5%	PASS	0.01709267
4500-8100	3	I-94 WB	US-131 NB	40856.45		Uninterrupted Flow	68	449.130124	23.192137	10.55752046	2.4%	18.81962508	4%	PASS	3.149086466
8100-11700	1	I-94 WB	I-94 WB	41427.55		Uninterrupted Flow	68	423.670733	5.787374	2.634527357	0.6%	19.08268957	5%	PASS	0.190725565
8100-11700	2	US-131 NB	US-131 NB	21219.8		Uninterrupted Flow	68	216.818437	0.241798	0.110071242	0.1%	9.774434477	5%	PASS	0.001268958
8100-11700	3	I-94 WB	US-131 NB	40856.45		Uninterrupted Flow	68	540.524039	37.726526	17.17386242	3.2%	18.81962508	3%	PASS	8.332909804
11700-15300	1	I-94 WB	I-94 WB	41427.55		Uninterrupted Flow	68	417.942516	9.954124	4.531314547	1.1%	19.08268957	5%	PASS	0.564224456
11700-15300	2	US-131 NB	US-131 NB	21219.8		Uninterrupted Flow	68	213.356892	0.67254	0.306153539	0.1%	9.774434477	5%	PASS	0.009816981
11700-15300	3	I-94 WB	US-131 NB	40856.45		Uninterrupted Flow	68	491.924218	28.233599	12.85249389	2.6%	18.81962508	4%	PASS	4.666975642

APPENDIX B.2: GEH-Link Volumes Template

Route	Segment	Laneage	Vissim ID	Input 3:00 PM-4:00 PM	Input 4:00 PM-5:00 PM	Input 5:00 PM-6:00 PM	Input 6:00 PM-7:00 PM	Input Total	Output 3:00 PM-4:00 PM	Output 4:00 PM-5:00 PM	Output 5:00 PM-6:00 PM	Output 6:00 PM-7:00 PM	Output Total	GEH 3:00 PM-4:00 PM	GEH 4:00 PM-5:00 PM	GEH 5:00 PM-6:00 PM	GEH 6:00 PM-7:00 PM	GEH Total
				900-4500	4500-8100	8100-11700	11700-15300	900-15300	900-4500	4500-8100	8100-11700	11700-15300	900-15300	900-4500	4500-8100	8100-11700	11700-15300	900-15300
I-94 Westbound	I-94 WB	Basic	1	3276	3637	3463	1960	12336	3259	3631	3473	1984	12347	0.3	0.1	0.2	0.5	0.1
	Westnedge Ave Off Ramp	Diverge	24	492	612	743	531	2378	466	590	723	529	2308	1.2	0.9	0.7	0.1	1.4
	I-94 WB	Basic	3	2784	3025	2720	1429	9958	2746	3007	2738	1472	9963	0.7	0.3	0.3	1.1	0.0
	Westnedge Ave On Ramp	Merge	40	879	1102	1287	780	4048	863	1070	1254	771	3958	0.5	1.0	0.9	0.3	1.4
	I-94 WB	Basic	4	3663	4127	4007	2209	14006	3595	4076	3999	2256	13926	1.1	0.8	0.1	1.0	0.7
	Oakland Dr Off Ramp	Diverge	53	472	537	693	387	2089	454	507	667	397	2025	0.8	1.3	1.0	0.5	1.4
	I-94 WB	Basic	5	3191	3590	3314	1822	11917	3135	3558	3322	1890	11905	1.0	0.5	0.1	1.6	0.1
	Oakland Dr On Ramp	Merge	55	536	609	670	433	2248	526	600	657	430	2214	0.4	0.4	0.5	0.1	0.7
	I-94 WB	Basic	56	3727	4199	3984	2255	14165	3603	4068	3862	2363	13896	2.1	2.0	1.9	2.2	2.3
	US-131 NB Off Ramp	Diverge	10069	1763	1904	1960	1212	6839	1747	1886	1897	1350	6879	0.4	0.4	1.4	3.9	0.5
	I-94 WB	Basic	65	1964	2295	2024	1043	7326	1934	2256	2020	1138	7348	0.7	0.8	0.1	2.9	0.3
	US-131 NB On Ramp	Merge	18	156	174	224	100	654	148	168	214	109	640	0.6	0.4	0.6	0.9	0.5
	I-94 WB	Weave	8	2120	2469	2248	1143	7980	2051	2387	2205	1236	7879	1.5	1.7	0.9	2.7	1.1
	US-131 SB Off Ramp	Diverge	58	435	553	573	277	1838	426	553	557	310	1847	0.4	0.0	0.7	1.9	0.2
	I-94 WB	Basic	9	1685	1916	1675	866	6142	1638	1849	1663	941	6092	1.2	1.5	0.3	2.5	0.6
	US-131 SB On Ramp	Merge	59	317	288	414	254	1273	316	287	412	253	1267	0.1	0.1	0.1	0.0	0.2
	I-94 WB	Basic	11	2002	2204	2089	1120	7415	1954	2138	2081	1203	7376	1.1	1.4	0.2	2.4	0.5
	9th St Off Ramp	Diverge	47	691	839	1095	504	3129	676	816	1101	563	3156	0.6	0.8	0.2	2.5	0.5
	I-94 WB	Basic	37	1311	1365	994	616	4286	1283	1330	1006	664	4282	0.8	1.0	0.4	1.9	0.1
	9th St On Ramp	Merge	70	184	188	240	70	682	182	186	238	70	676	0.1	0.1	0.1	0.0	0.2
	I-94 WB	Basic	67	1495	1553	1234	686	4968	1466	1515	1250	741	4972	0.8	1.0	0.5	2.1	0.1
US-131 Northbound	US-131 NB	Basic	13	1307	952	1384	910	4553	1303	951	1378	909	4541	0.1	0.0	0.2	0.0	0.2
	I-94 EB Off Ramp	Diverge	60	421	429	446	344	1640	418	420	445	340	1624	0.1	0.4	0.0	0.2	0.4
	US-131 NB	Basic	15	886	523	938	566	2913	880	530	923	571	2905	0.2	0.3	0.5	0.2	0.2
	I-94 EB On Ramp	Merge	61	380	480	397	277	1534	380	479	398	278	1535	0.0	0.1	0.0	0.1	0.0
	US-131 NB	Weave	16	1266	1003	1335	843	4447	1232	984	1290	830	4337	1.0	0.6	1.2	0.4	1.7
	I-94 WB Off Ramp	Diverge	18	156	174	224	100	654	148	168	214	109	640	0.6	0.4	0.6	0.9	0.5
	US-131 NB	Basic	17	1110	829	1111	743	3793	1111	837	1102	740	3789	0.0	0.3	0.3	0.1	0.1
	I-94 WB On Ramp	Merge	10069	1763	1904	1960	1212	6839	1747	1886	1897	1350	6879	0.4	0.4	1.4	3.9	0.5
	US-131 NB	Basic	81	2873	2733	3071	1955	10632	2813	2688	2959	2083	10543	1.1	0.9	2.0	2.8	0.9
	Stadium Dr Off Ramp	Diverge	62	866	1046	1117	713	3742	820	998	1048	750	3617	1.6	1.5	2.1	1.4	2.1
	US-131 NB	Basic	21	2007	1687	1954	1242	6890	1978	1697	1891	1352	6918	0.6	0.2	1.4	3.1	0.3
	Stadium Dr On Ramp	Merge	69	437	581	574	415	2007	435	578	571	413	1996	0.1	0.1	0.1	0.1	0.2
	US-131 NB	Basic	22	2444	2268	2528	1657	8897	2411	2277	2461	1770	8918	0.7	0.2	1.3	2.7	0.2

APPENDIX B.3: Speed Validation Template

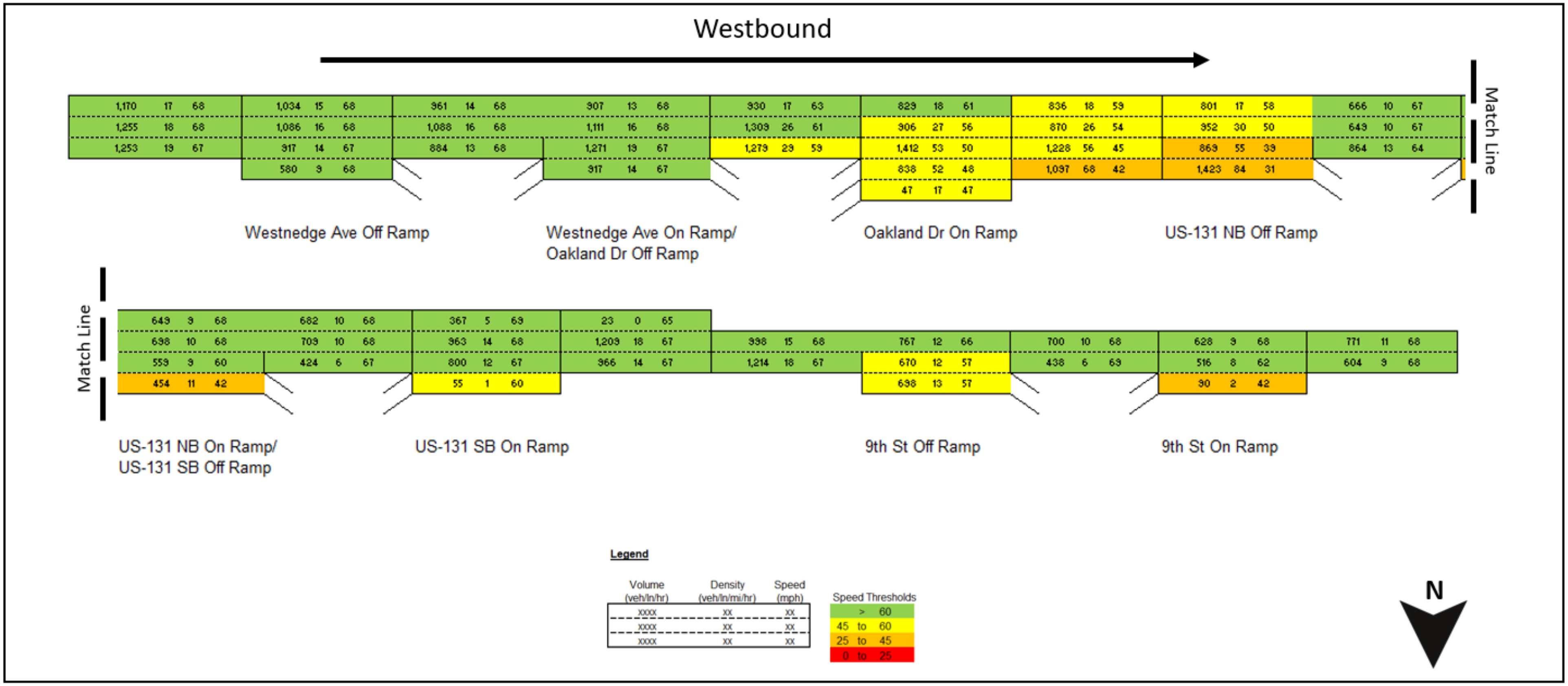
Route (Dir.)	Mainline / Ramp		RITIS Speed (mph)														
			900-1800	1800-270	2700-360	3600-450	4500-540	5400-630	6300-720	7200-810	8100-900	9000-990	9900-108	10800-11	11700-12	12600-13	Average
I-94 (EB)	BEGIN EB 94	Mainline	65	67	68	63	66	66	67	66	66	65	65	64	65	64	65
	EB 94 (AA-Saline)	Mainline	66	68	71	67	64	68	67	66	68	68	66	64	65	63	66
	EB 94	Mainline	66	68	71	67	64	68	67	66	68	68	66	64	65	63	66
	EB 94	Mainline	66	68	71	68	64	66	64	66	64	67	66	65	66	61	66
	EB 94 (State St)	Mainline	66	68	68	70	65	56	61	62	68	65	68	66	66	62	65
	EB 94	Mainline	66	68	68	70	65	56	61	62	68	65	68	66	66	62	65
	EB 94	Mainline	65	65	66	65	66	57	63	64	65	65	67	65	64	66	64
	EB 94 (US-23)	Mainline	64	67	65	66	66	65	64	72	65	68	67	66	65	67	66
	EB 94	Mainline	66	65	64	65	63	59	59	62	65	64	63	63	64	65	63
	EB 94 (Michigan Ave)	Mainline	73	65	74	65	69	68	62	62	65	67	67	66	67	67	67
	EB 94	Mainline	73	65	74	65	69	68	62	62	65	67	67	66	67	67	67
	EB 94 (Huron St)	Mainline	68	69	64	69	68	67	64	67	67	67	67	66	68	64	67
	EB 94	Mainline	68	69	64	69	68	67	64	67	67	67	67	66	68	64	67
	EB 94	Mainline	64	67	65	67	67	66	63	63	64	64	65	65	65	63	65
	END EB 94 (US-12)	Mainline	67	69	65	67	68	67	66	65	65	66	67	66	66	66	66
I-94 (WB)	BEGIN WB 94	Mainline	65	66	67	53	32	29	65	65	64	66	65	65	66	66	59
	WB 94 (US-12)	Mainline	64	64	63	41	27	36	49	63	61	59	67	65	66	65	56
	WB 94 (Huron St)	Mainline	64	64	63	44	19	51	30	52	49	48	64	67	65	64	53
	WB 94	Mainline	64	64	63	44	19	51	30	52	49	48	64	67	65	64	53
	WS 94	Mainline	64	65	64	36	25	44	23	35	32	33	64	67	64	63	48
	WB 94 (Michigan Ave)	Mainline	63	65	64	24	25	19	15	17	17	31	61	67	65	63	42
	WB 94	Mainline	63	65	64	24	25	19	15	17	17	31	61	67	65	63	42
	WB 94	Mainline	61	64	62	18	24	15	15	16	16	27	52	63	60	61	40
	WB 94 (US-23)	Mainline	56	50	59	20	28	20	23	22	21	34	35	42	40	56	36
	WB 94	Mainline	56	50	59	20	28	20	23	22	21	34	35	42	40	56	36
	WB 94 SB US-23 On	Mainline	56	50	59	20	28	20	23	22	21	34	35	42	40	56	36
	WB 94	Mainline	63	62	59	44	53	45	44	48	49	51	30	33	31	56	48
	WB 94 (State St)	Mainline	61	63	62	57	62	54	61	57	58	59	55	47	56	60	58
	WB 94	Mainline	61	63	62	57	62	54	61	57	58	59	55	47	56	60	58
	WB 94	Mainline	61	64	63	62	64	59	63	61	61	62	62	62	61	61	62
	WB 94 (AA-Saline)	Mainline	62	65	65	64	65	61	67	60	65	63	65	65	63	63	64
	END WB 94	Mainline	62	65	67	64	67	65	68	62	64	63	67	67	63	65	65
Route (Dir.)	**Mainline / Ramp**		**VISSIM Speed (mph)**														
			900-1800	**1800-270**	**2700-360**	**3600-450**	**4500-540**	**5400-630**	**6300-720**	**7200-810**	**8100-900**	**9000-990**	**9900-108**	**10800-11**	**11700-12**	**12600-13**	**Average**
I-94 (EB)	BEGIN EB 94	Mainline	69	68	68	68	68	67	68	68	68	68	69	69	69	69	68
	EB 94 (AA-Saline)	Mainline	69	68	68	68	67	66	67	67	67	68	68	69	69	68	68
	EB 94	Mainline	68	68	67	67	65	60	67	66	67	68	68	68	69	68	67
	EB 94	Mainline	68	67	66	66	61	59	63	64	64	66	67	68	68	68	65
	EB 94 (State St)	Mainline	68	68	67	68	65	66	66	66	66	67	68	68	69	68	67
	EB 94	Mainline	68	68	67	67	63	54	66	66	66	67	68	68	68	68	66
	EB 94	Mainline	68	68	67	66	63	62	67	66	66	67	68	68	68	68	67
	EB 94 (US-23)	Mainline	68	68	67	66	65	64	66	66	65	67	68	68	68	68	67
	EB 94	Mainline	68	68	68	68	67	67	68	68	68	68	69	69	69	69	68
	EB 94 (Michigan Ave)	Mainline	68	68	68	68	68	68	68	68	68	68	69	69	69	69	68
	EB 94	Mainline	68	68	68	68	68	67	68	68	68	68	69	69	69	69	68
	EB 94 (Huron St)	Mainline	68	68	68	67	67	67	67	67	67	68	68	69	69	69	68
	EB 94	Mainline	68	68	68	67	67	66	67	67	67	68	68	69	69	69	68
	EB 94	Mainline	68	68	68	67	67	66	68	67	68	68	69	69	69	69	68
	END EB 94 (US-12)	Mainline	68	68	68	67	68	67	68	68	68	68	69	69	69	69	68
I-94 (WB)	BEGIN WB 94	Mainline	69	68	68	69	68	69	64	52	59	64	65	69	69	68	66
	WB 94 (US-12)	Mainline	69	67	67	67	67	57	24	18	31	40	53	67	68	68	55
	WB 94 (Huron St)	Mainline	69	67	67	66	63	18	9	12	15	21	36	59	68	67	45
	WB 94	Mainline	69	67	66	66	42	8	9	13	15	19	26	52	68	67	42
	WS 94	Mainline	69	68	67	66	15	9	11	17	18	22	27	46	68	68	41
	WB 94 (Michigan Ave)	Mainline	68	66	65	35	8	7	8	13	14	15	18	41	68	67	35
	WB 94	Mainline	68	67	66	12	6	6	7	10	11	11	13	28	60	68	31
	WB 94	Mainline	66	60	25	9	7	6	8	12	13	13	16	23	46	61	26
	WB 94 (US-23)	Mainline	66	63	57	57	59	60	57	51	36	28	39	34	47	58	51
	WB 94	Mainline	54	42	42	54	57	57	48	39	22	19	27	23	28	40	39
	WB 94 SB US-23 On	Mainline	64	59	57	62	64	64	59	49	25	21	29	26	28	49	47
	WB 94	Mainline	68	67	65	66	67	67	66	63	58	53	39	28	27	36	55
	WB 94 (State St)	Mainline	66	64	60	65	65	66	63	60	60	57	57	57	57	59	61
	WB 94	Mainline	69	68	67	68	67	68	67	65	65	65	65	65	64	65	66
	WB 94	Mainline	67	67	65	66	66	66	66	64	64	64	65	64	64	64	65
	WB 94 (AA-Saline)	Mainline	69	68	68	68	68	68	68	67	67	67	67	67	67	67	68
	END WB 94	Mainline	69	68	68	68	68	68	68	67	67	67	67	67	67	67	68

APPENDIX C: VISSIM Model MOE Sample (Surface Street Intersection)

Intersection		NB								SB								EB								WB								Total	
Major	Minor	UT/LT		TH		RT		Approach		UT/LT		TH		RT		Approach		UT/LT		TH		RT		Approach		UT/LT		TH		RT		Approach			
Niagara Falls Blvd	Longmeadow Rd	NA	NA	4.4	A	4.3	A	4.4	A	19.5	B	3.5	A	NA	NA	4.6	A	NA	NA	NA	NA	NA	NA	NA	NA	21.1	C	NA	NA	5.0	A	15.4	B	5.6	A
Niagara Falls Blvd*	Highland Ave/Ruth Dr*	5.3	A	NA	NA	NA	NA	NA	NA	4.1	A	NA	NA	NA	NA	NA	NA	11.6	B	19.5	C	6.7	A	10.8	B	11.0	B	12.3	B	4.9	A	6.6	A	NA	NA
Niagara Falls Blvd	Eggert Rd	60.5	E	8.9	A	5.8	A	13.9	B	50.0	D	3.4	A	1.3	A	7.5	A	NA	NA	54.1	D	10.9	B	39.7	D	56.0	E	48.5	D	31.8	C	46.4	D	20.2	C
Eggert Rd	Alberta Dr	6.0	A	6.5	A	2.4	A	4.3	A	6.3	A	3.2	A	2.3	A	3.5	A	47.2	D	37.9	D	24.3	C	38.1	D	45.9	D	33.5	C	37.0	D	33.8	C	34.7	C
Niagara Falls Blvd	Sheridan Dr	NA	NA	21.4	C	10.1	B	18.9	B	60.1	E	23.3	C	8.6	A	24.1	C	54.3	D	38.8	D	0.0	A	42.0	D	48.6	D	36.7	D	4.7	A	35.3	D	31.1	C
Niagara Falls Blvd*	Franklin Ave/Rochelle Pl*	4.5	A	NA	NA	NA	NA	NA	NA	3.7	A	NA	NA	NA	NA	NA	NA	0.0	A	0.0	A	0.0	A	NA	NA	9.1	A	NA	NA	6.6	A	7.3	A	NA	NA
Niagara Falls Blvd	Treadwell Rd	34.9	C	10.5	B	9.4	A	10.8	B	39.1	D	8.2	A	6.8	A	8.5	A	54.8	D	54.3	D	16.5	B	31.6	C	56.6	E	54.5	D	7.5	A	39.1	D	10.3	B
Niagara Falls Blvd	Boulevard Mall	28.9	C	9.1	A	8.8	A	9.1	A	34.4	C	3.9	A	3.7	A	4.6	A	0.0	A	0.0	A	0.0	A	NA	NA	81.5	F	0.0	A	8.0	A	18.5	B	6.8	A
Niagara Falls Blvd	Brighton Rd/Maple Rd	61.6	E	28.1	C	15.9	B	25.2	C	51.8	D	27.1	C	22.6	C	32.0	C	32.6	C	42.5	D	28.2	C	38.9	D	36.2	D	37.6	D	7.0	A	30.0	C	31.2	C
Maple Rd	Alberta Dr	14.2	B	14.3	B	5.9	A	10.4	B	16.8	B	28.3	C	9.0	A	16.7	B	4.6	A	6.1	A	3.0	A	5.6	A	7.1	A	5.3	A	2.7	A	5.5	A	6.3	A
Maple Rd	N Bailey Ave	19.1	B	27.7	C	5.6	A	20.4	C	19.9	B	16.8	B	3.7	A	18.2	B	15.8	B	21.0	C	4.3	A	20.0	B	15.4	B	15.7	B	8.4	A	13.7	B	17.7	B
Maple Rd	Hillcrest Dr	19.5	B	NA	NA	5.5	A	7.9	A	24.2	C	30.3	C	12.5	B	24.4	C	NA	NA	4.7	A	5.2	A	4.7	A	11.8	B	5.2	A	NA	NA	5.5	A	5.9	A
Maple Rd	Sweet Home Rd	35.1	D	43.5	D	12.5	B	34.3	C	30.6	C	29.8	C	8.7	A	23.4	C	27.1	C	32.4	C	7.2	A	29.8	C	23.9	C	34.6	C	4.1	A	28.6	C	28.8	C
Sweet Home Rd	Rensch Rd	46.8	D	28.8	C	7.8	A	21.8	C	25.7	C	17.0	B	14.4	B	20.0	B	43.6	D	44.0	D	20.9	C	41.1	D	37.9	D	38.5	D	5.8	A	22.4	C	22.2	C
John James Audubon Pkwy	Rensch Rd	24.8	C	24.0	C	5.2	A	23.2	C	27.6	C	22.6	C	8.9	A	20.4	C	27.7	C	10.0	B	6.4	A	14.5	B	25.9	C	15.6	B	5.2	A	17.1	B	17.4	B
John James Audubon Pkwy*	Core Rd/Lee Rd*	2.2	A	0.4	A	2.4	A	2.3	A	4.5	A	3.4	A	3.8	A	3.7	A	8.3	A	9.4	A	8.2	A	9.0	A	5.1	A	3.8	A	3.9	A	3.9	A	5.2	A
John James Audubon Pkwy	Forest Rd	14.7	B	14.8	B	5.5	A	10.4	B	12.9	B	12.4	B	5.7	A	11.9	B	7.8	A	7.8	A	4.2	A	7.2	A	16.0	B	17.4	B	11.6	B	15.1	B	12.6	B
John James Audubon Pkwy	Gordon R Yaeger Dr	3.2	A	0.6	A	1.1	A	0.9	A	1.6	A	0.7	A	NA	NA	0.8	A	NA	NA	NA	NA	NA	NA	NA	NA	11.0	B	NA	NA	4.6	A	9.0	A	1.0	A
Maple Rd	Bowmart Pkwy	NA	NA	NA	NA	NA	NA	NA	NA	17.8	B	NA	NA	0.0	A	17.8	B	0.0	A	3.8	A	NA	NA	3.8	A	NA	NA	2.9	A	2.7	A	2.9	A	4.0	A
Eggert Rd	Sheridan Dr	44.3	D	40.2	D	20.9	C	41.9	D	40.1	D	40.9	D	10.0	A	39.9	D	22.9	C	21.4	C	5.1	A	19.2	B	NA	NA	19.5	B	16.2	B	19.2	B	25.2	C

* = Unsignalized Intersection

APPENDIX D: VISSIM Model MOE Sample (Freeway)



APPENDIX E.1: VISSIM Modeling Methodology And Assumptions Memo Sample

wsp

MEMO

TO: Michelle O'Neill, PE

FROM: Lauren Warren, PE, PTOE; Trevor J. Kirsch, MS, EIT; Matt Hill, PE, PTOE

SUBJECT: Vissim Modeling Methodology and Assumptions Memo

DATE: October 1, 2019

PURPOSE

The intent of this memorandum is to summarize the microsimulation methodology and assumptions utilized for the I-94 and US-131 Interchange Study (MDOT JN 205492) for MDOT review and comment prior to starting the actual modeling effort. Figure 1 provides a general overview of the modeling workflow with a detailed description of each step provided in the following sections.

Figure 1. Proposed I-94/US-131 Operations Study Modeling Workflow

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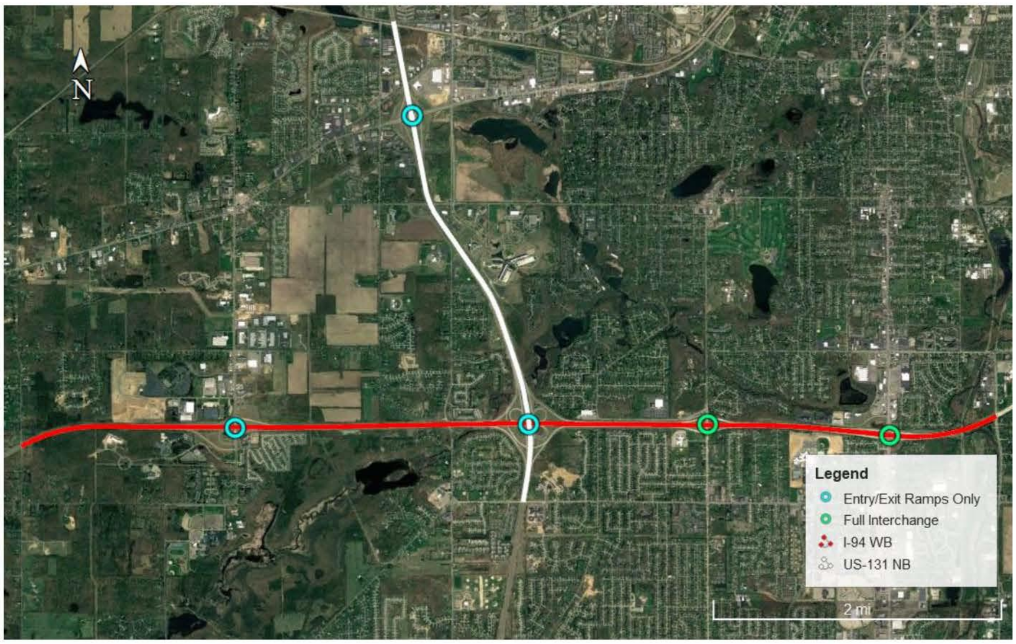
DEFINE STUDY AREA

Spatial Limits

- The focused area of interest for this analysis is the interchange ramp between I-94 WB and US-131 NB. Typical best practices for microsimulation modeling include extending at least one interchange past the area of interest per FHWA's *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software.* When coding service interchanges, it is recommended that the surface roadway also be coded at least one signalized intersection past the ramp terminals to meter traffic into the interchange accurately.
- It is important to consider the frequency and spatial length of congestion experienced under real-world conditions. Typical best practices include ensuring that the modeled study area spatially represents the extent to which any bottlenecks queue, even if it is outside of the immediate area of interest. This ensures that the full impact of these bottlenecks is represented in the modeling effort.
- For this analysis, the typical spatial length of congestion was identified through three methods: (1) field review, (2) MDOT feedback, and (3) video observation. Based on discussions with MDOT, the congestion is typically focused around the interchange ramp between I-94 westbound (WB) and US-131 northbound (NB) during the PM peak period. MDOT also noted that the congestion is frequent but volatile, as the typical queue length in this area can range from localized slowing to extreme backups which persist along the mainline. From video observations, a standard queue length was discovered that is consistent with MDOT expectations and representative of typical traffic patterns.
- Considering these congestion patterns and best practices, the proposed modeled study area is described below and pictured in Figure 2.
  - I-94 WB from Lovers Ln to 6th St
  - US-131 NB from Milham Ave to KL Ave
  - Full interchange coding at the following interchanges
    - I-94 and Westnedge Ave
    - I-94 and Oakland Dr
  - Entry/Exit ramps of interest only at the following interchanges
    - I-94 WB and US-131 NB
    - I-94 WB and 9th St
    - US-131 NB and Stadium Dr

Figure 2. Proposed Study Area



Temporal Limits

- The analysis period should include the buildup of congestion within the influence area, the peak congested period, and the recovery period. In this analysis, only the PM peak period is considered per the scope of work. The temporal limits of the PM peak period are from 3:00 PM to 7:00 PM. This 4-hour period is proposed based on field review and confirmation from local MDOT staff.
- A seed interval is the amount of time the microsimulation model is run in advance of summarizing the MOEs. This ensures that the appropriate amount of traffic is on the network when the program begins to calculate the desired MOE metrics. Best practices suggest including a seed interval that is equivalent to the time it would take one simulation vehicle to travel from one end of the network to the other end under free flow conditions. Using this logic, a 15-minute seed interval is proposed for the microsimulation model to ensure that the network is appropriately seeded at the beginning of MOE development.

DATA COLLECTION

- **Traffic Counts**: A variety of traffic counts were collected by the MDOT on March 20, 2018. This information included 15-minute ramp and surface street counts conducted at the following locations:
  - I-94 Ramps and Westnedge Ave
  - I-94 EB Ramps and Oakland Dr
  - I-94 WB Ramps and Oakland Dr
  - I-94 at US-131 Ramps

- **Traffic Counts**: WSP also collected additional traffic counts on September 18 and September 19, 2019. This information included 15-minute mainline and ramp counts with vehicle classification at the following locations:
  - I-94 WB (mainline underneath Oakland Avenue bridge)
  - US-131 NB (mainline just north of Milham Avenue bridge)
  - WB I-94 at US-131 Ramps
  - I-94 WB Ramps at 9th St
  - US-131 NB Ramps at Stadium Dr
- **Traffic Signal Timings**: Signal timing permits were provided by MDOT to ensure that existing signal timings could be included in the models. The following are the signalized intersections to be included in the models:
  - I-94 Ramps at Westnedge Ave
  - I-94 EB Ramps at Oakland Dr
  - I-94 WB Ramps at Oakland Dr
- **Speed Data**: Average free flow speed data was obtained by WSP from the Regional Integrated Transportation Information System (RITIS) which provided speed and congestion information from probe vehicle data.

VISSIM VERSION AND BUILD

- VISSIM 10.00-16 is proposed as the microsimulation tool for the modeling effort. VISSIM is a microsimulation analysis software in which traffic movements are explicitly modeled based on geometric parameters, traffic volumes, vehicle types, intersection control, and driver behavior. VISSIM assesses the roadway network in a dynamic fashion, instead of analyzing each intersection or each roadway segment in isolation. VISSIM can provide measures of effectiveness (MOEs) such as vehicle delay, travel time, and queuing metrics on a network-wide basis, so that the effects of improvements at a single location may be measured throughout the network. This ability makes VISSIM an ideal tool for testing and comparing alternatives to determine the most effective combination of elements in facilitating traffic flow. In addition, the sensitivity of the VISSIM model allows the user to test more subtle changes to the roadway system, such as adjustments in traffic signalization, different interchange configurations, ATM strategies such as ramp metering, and others.

SPEED & GEOMETRICS

- Speed distributions for the simulation vehicles will be based on the posted speed limit of the modeled roadways, with independent speed limits established per vehicle type. For this network, passenger vehicles and heavy vehicles have unique speed distributions on the interstate roadways as the posted speed limit is different per vehicle class. On the surface streets, the speed distributions are the same regardless of vehicle type, as the posted speed limit is the same for all vehicles. A review of the RITIS free flow speed data for this area will also be conducted to confirm the speed distributions are appropriate.
- Network geometrics (i.e. laneage and curvature) will be modeled using scaled aerial imagery from Bing Maps (inherent within the VISSIM license used). The geometry of the microsimulation model will be constructed by drawing the appropriate laneage on top of the aerial imagery and matching the edgeline of the simulated roadways with the edgeline of the real-world roadways; thereby creating a reasonable replica of the existing geometry.

TRAFFIC VOLUME INPUT

- VISSIM requires that all traffic is balanced within the model before a simulation can be completed. A balanced volume workbook will be developed where the ramp entry and exit counts will be used as anchor points for the balancing of the subsequent mainline volumes. Volumes will be balanced for all 16 of the 15 minute time intervals (4 hours total) in the PM peak period.
- The vehicle composition (i.e. the percentage of passenger vehicles vs heavy vehicles) for each volume input in the model will be determined based on the previously collected classification data by WSP. The unique percentage of heavy vehicles and passenger vehicles at each volume input will be entered for the entire PM peak period (4 hours) based on the peak hour vehicle classification, i.e., the percentage of heavy vehicles and passenger vehicles during the peak hour will be used for the entirety of the PM peak period at each individual volume input.
- The makeup of the vehicle fleet for both the simulated passenger vehicles and the simulated heavy vehicles was set to the default North American vehicle models and distributions as issued by VISSIM software vendor PTV. This fleet makeup was established by PTV in January 2010.

DRIVER BEHAVIOR INPUT

Freeway and Entrance Ramps

- Default driver behavior parameters (Wiedemann 99) were assumed for all freeway segments and entry ramp segments within the modeled study area. Adjustments will be made as necessary during the calibration process to more appropriately match real-world conditions. Lane change distances will also be adjusted to ensure that congestion is formed as expected based on the previously mentioned observations.

Surface Streets and Exit Ramps

- Default driver behavior parameters (Wiedemann 74) were assumed for all surface street segments and interstate exit ramp segments within the modeled influence area. Adjustments will be made as necessary during the calibration process to more appropriately match real-world conditions. Lane change distances will also be adjusted to ensure that congestion is formed as expected based on the previously mentioned observations.

CALIBRATION & VALIDATION

- A validation process is necessary to ensure that the microsimulation model is as representative of real-world traffic conditions as possible. This is achieved through a rigorous process of calibration and validation to ensure adequate model reliability and validity of calculated MOEs. Best practice for microsimulation modeling is to have two separate validation criteria to ensure the existing condition microsimulation model is representative of the provided data. For this analysis, the two metrics of interest were (1) vehicle volumes within the network and (2) queue patterns.
- The first measure of validity is how closely the microsimulation traffic volumes match the real-world traffic volumes within the study area. A simple percentage difference is not a fair comparison of the wide range of mainline segment or turning movement volumes possible in the model. Thus, a universal measure to compare the microsimulation data with the real-world data is the GEH formula. The GEH formula is displayed below:

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

where *m* (vehicles/hour) is the traffic volume on the desired segment from the microsimulation model and *c* (vehicles/hour) is the traffic volume on the desired segment from the real-world data. Acceptable criteria for GEH statistics are shown in Table 1.

Table 1. GEH Statistic Criteria

Facility Type	Criteria
Mainline Segments	GEH<3.0
Network Entry and Exit Segments	GEH<3.0
Entry and Exit Ramp Segments	GEH<3.0
Other Roadway Segments	GEH<5.0 (for at least 85% of all segments)

Lastly, the sum of the microsimulation traffic volume on all segments should be within 5% of the real-world traffic volume within the study area.

- The second measure of validity is how closely the microsimulation model queue patterns match the real-world queue patterns. As mentioned previously, the queue patterns for the influence area were established from field review, MDOT feedback, and video observations.
- In order to obtain accurate results from the VISSIM traffic simulation model, the driver behavior parameters may need to be adjusted in order to calibrate the model to real-world conditions as previously described. Driver behavior varies based on location, weather, roadway condition, geometry, and other factors. Another typical calibration step is the adjustment of the default VISSIM parameters for lane change distances at exit ramp locations and creating separate behavior types for specific areas, such as heavy merge or heavy weave areas. Any adjustments made to behavior types beyond the default values for the purpose of calibration will be documented for MDOT review.

TRAVEL DEMAND FORECASTING

- A 2039 future year was selected by MDOT to evaluate operations within the study area. The growth factors from current traffic volumes were provided by MDOT's Planning Department for use in this study.

MOE SUMMARY

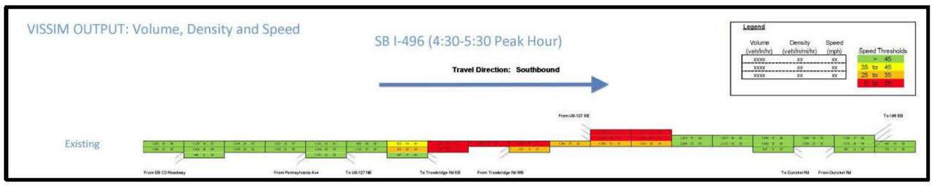
Freeway MOEs

- VISSIM can report several measures of effectiveness (MOEs). For the purposes of this analysis, volume, density and speed will be recorded for each freeway segment, weave segment and ramp merge/diverge point. Total network delay will also be collected as one of the MOEs. Each time the model is run, these MOEs are summarized and can vary based on a random number seed. Since the MOEs vary slightly with different random number seeds, much like how traffic can vary day by day, the VISSIM models will be ran multiple times with multiple different random number seeds and then the MOEs averaged. This information will be plotted graphically for each model link similar to the example shown in Figure 3. The total number of runs will be determined based on statistical significance for a 85% confidence interval.

Surface Street MOEs

- Intersection level of service will be reported for all surface street intersections, including ramp terminals. In addition to delay/LOS, the average and maximum queues on each intersection approach will also be summarized similar to examples in Figure 3.

Figure 3. Sample Freeway and Surface Street MOE Summaries



Sample freeway MOE summary by link (speed/volume/density) and color-coded by speed.

Intersection	AM Peak Hour																
	Northbound				Southbound				Eastbound				Westbound				Overall
	Left	Thru	Right	Appr.	Left	Thru	Right	Appr.	Left	Thru	Right	Appr.	Left	Thru	Right	Appr.	Intersection
M-1 & Cambourne	-	A	A	A	-	A	A	A	-	C	A	C	-	C	A	C	A
M-1 & Sylvan	-	A	A	A	-	C	A	C	-	D	B	B	-	C	B	B	C
NB M-1 & EB I-696 SD	-	B	A	B	-	-	-	-	A	A	-	A	-	-	-	-	A
NB M-1 & WB I-696 SD	-	C	-	C	-	-	-	-	-	-	-	-	-	C	E	D	D
SB M-1 & EB I-696 SD	-	-	-	-	-	B	-	B	-	C	B	C	-	-	-	-	B
SB M-1 & WB I-696 SD	-	-	-	-	-	B	A	B	-	-	-	-	A	A	-	A	A
NB M-1 & Washington	A	A	A	A	-	-	-	-	-	-	-	-	-	C	B	C	B
SB M-1 & Washington	-	-	-	-	-	B	C	C	-	-	-	-	A	A	-	A	B
M-1 & Lincoln	-	A	A	A	-	A	A	A	-	C	B	C	-	C	A	B	A
M-1 & 11 Mile	-	A	A	A	-	A	A	A	-	C	B	C	-	C	B	B	A
EB I-696 SD & Coolidge	-	B	A	B	-	A	-	A	-	C	C	C	-	-	-	-	C
WB I-696 SD & Coolidge	-	A	-	A	-	B	B	B	-	-	-	-	-	C	C	C	B
EB I-696 SD & Scotia	-	C	B	C	C	B	-	B	A	A	A	A	-	-	-	-	B
WB I-696 SD & Scotia	A	A	-	A	-	C	B	B	-	-	-	-	B	B	B	B	B
EB I-696 SD & SB M-1 Slip	-	-	-	-	C	-	-	C	-	D	-	D	-	-	-	-	D
WB I-696 SD & SB M-1 Slip	-	-	-	-	-	C	A	B	-	-	-	-	A	A	-	A	A
EB I-696 SD & Main	-	C	C	C	-	-	-	-	A	A	-	A	-	-	-	-	B
WB I-696 SD & Main	E	B	-	D	-	-	E	E	-	-	-	-	-	F	F	F	F
EB I-696 SD & Bermuda	-	C	A	B	B	B	-	B	A	A	A	A	-	-	-	-	A
WB I-696 SD & Mohawk	A	A	-	A	-	C	A	B	-	-	-	-	C	C	B	C	C

Sample intersection level of service color-coded by LOS

INTERSECTION	PM PEAK HOUR QUEUE (FT)							
	NORTHBOUND		SOUTHBOUND		EASTBOUND		WESTBOUND	
	AVG.	MAX	AVG.	MAX	AVG.	MAX	AVG.	MAX
FULLER/MAIDEN LN/EMCD*	171	357	40	235	57	344	172	534
EMCD/WEST MEDICAL CENTER	44	197	-	-	453	584	-	-
EMCD/CANCER CENTER*	86	414	22	210	3	75	-	-
EMCD/NICHOLS	5	304	0	0	1	38	3	86
EMCD/PSYCHIATRIC EMERG.	0	31	-	-	7	112	-	-
EMCD/TAUBMAN ENTRANCE	1	44	-	-	-	-	-	-
EMCD/TAUBMAN EXIT	-	-	-	-	14	127	-	-
EMCD/P2 ENTRANCE	0	34	-	-	7	76	-	-
**FULLER RD/FULLER ST/GLEN*	-	-	156	752	69	362	39	295
XO E. OF EMCD*	71	405	-	-	-	-	378	831
AA STATION W. DRIVE	1	44	1	60	-	-	-	-
AA STATION E. DRIVE	11	105	-	-	-	-	-	-
XO E. OF AA STATION DRIVE	11	118	-	-	-	-	-	-

**Signalized Intersection*

Sample intersection queue metrics

APPENDIX E.2: VISSIM Modeling Data Verification and Screening Memo Sample

MDOT JN 202162

MEMO

TO: Lynne Kirby, PE (MDOT)

FROM: Matthew Hill, PE, PTOE (WSP)

SUBJECT: **I-94 Operational Study – Volume Data Screening**

DATE: **February 11, 2019**

The Michigan Department of Transportation (MDOT) provided WSP with traffic volume data for segments of I-94 between Ann Arbor-Saline Rd and the US-23 interchange, collected on September 11th, 2018. To ascertain the validity of the volume dataset as being representative of a "typical" day operationally for the corridor, corresponding speed data was obtained through the Regional Integrated Transportation Information System (RITIS). The speed data was collected for all Tuesdays, Wednesdays, and Thursdays between September 1st, 2018 through November 30th, 2018, excluding holidays, along the segments identified in Figure 1. This dataset was considered the "**baseline**", with the geographic extent selected to ensure the full extent of queueing and related congestion would be captured in the results.

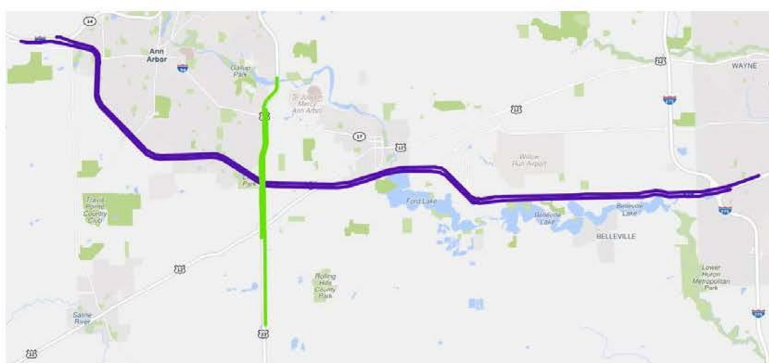


Figure 1 - Speed Data Collection Segments

Speed data collected through RITIS was organized into fifteen minute increments between 7:00 – 9:00AM and 4:00 – 6:00PM, which corresponded with peak periods of congestion along the corridor. The **baseline** was scanned by segment and fifteen-minute time periods to determine the minimum, median, and maximum speeds experienced over the three-month study period to provide a typical range of speeds along the corridors during the morning and afternoon periods.

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wsp.com

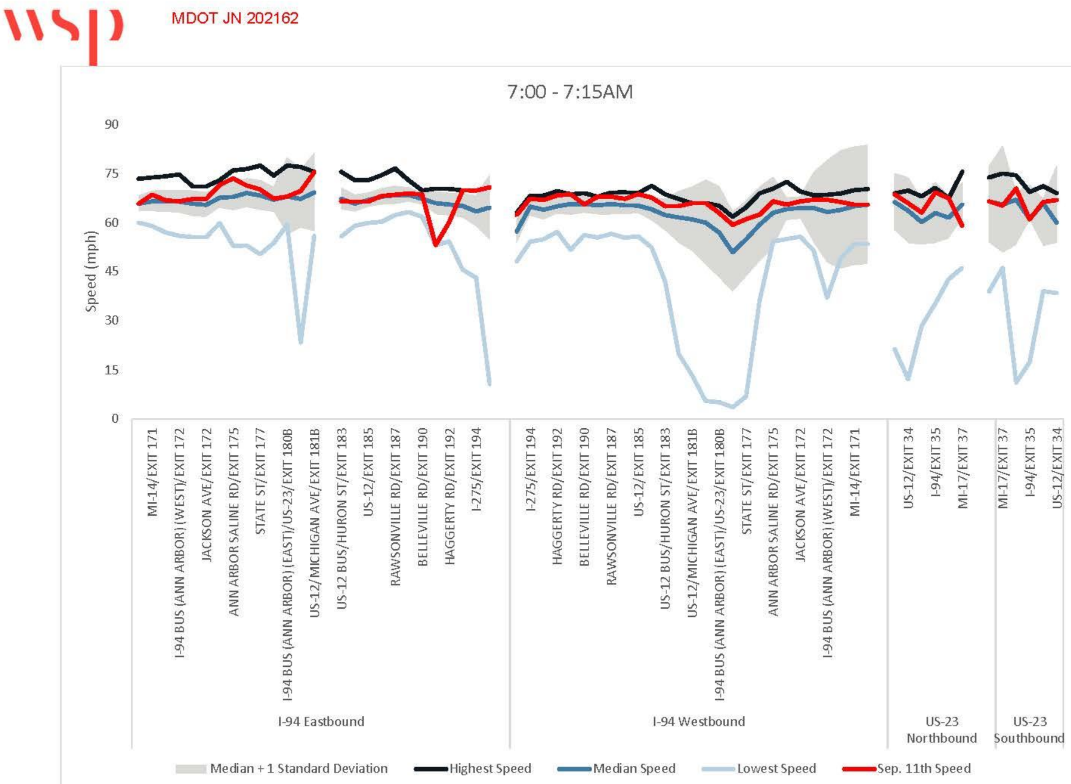
The speed data for September 11th was extracted from the baseline dataset and plotted on the following graphs. This provided a comparison of speeds experienced along the corridor for the day the traffic volumes were collected against "typical" speeds experienced in the study area for each fifteen-minute period[1].

While there is variation by time period and segment along the corridor, travel speeds recorded on September 11th, 2018 generally appear to align within one standard deviation of the median travel speeds as recorded over the three-month period, suggesting operations were relatively typical.

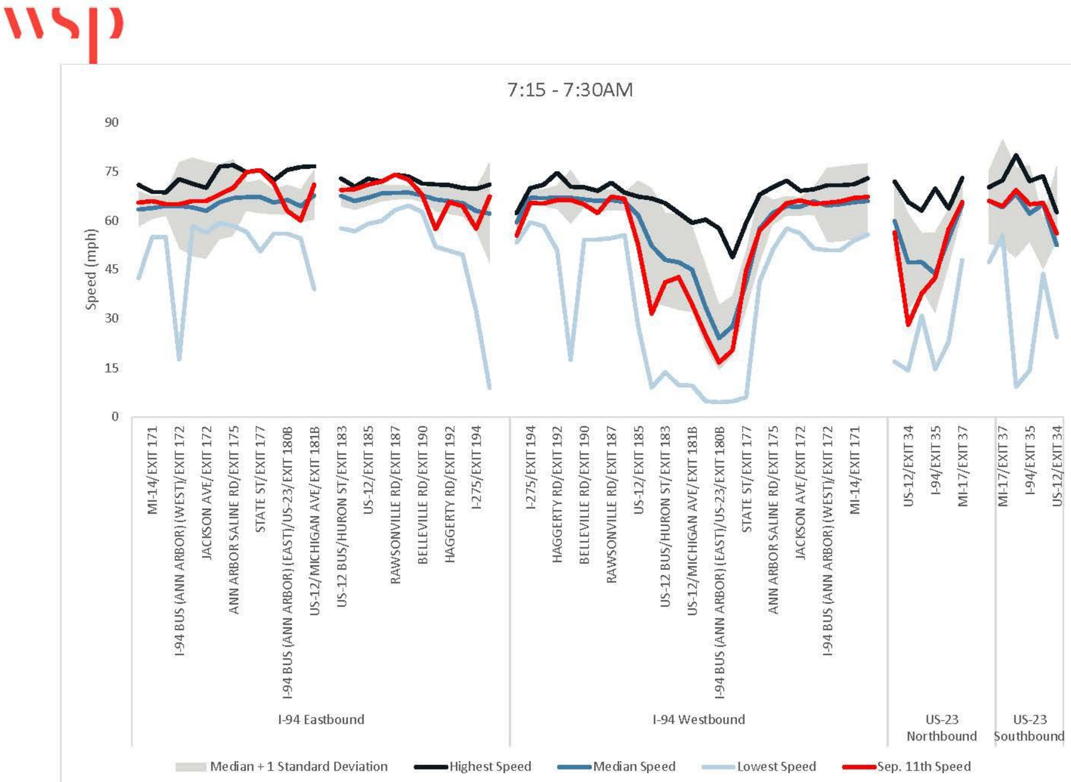
Additional data screening can be conducted if MDOT would like to provide incident data that would have occurred September 2018 through November 2018 to further refine the "typical" weekday operations.

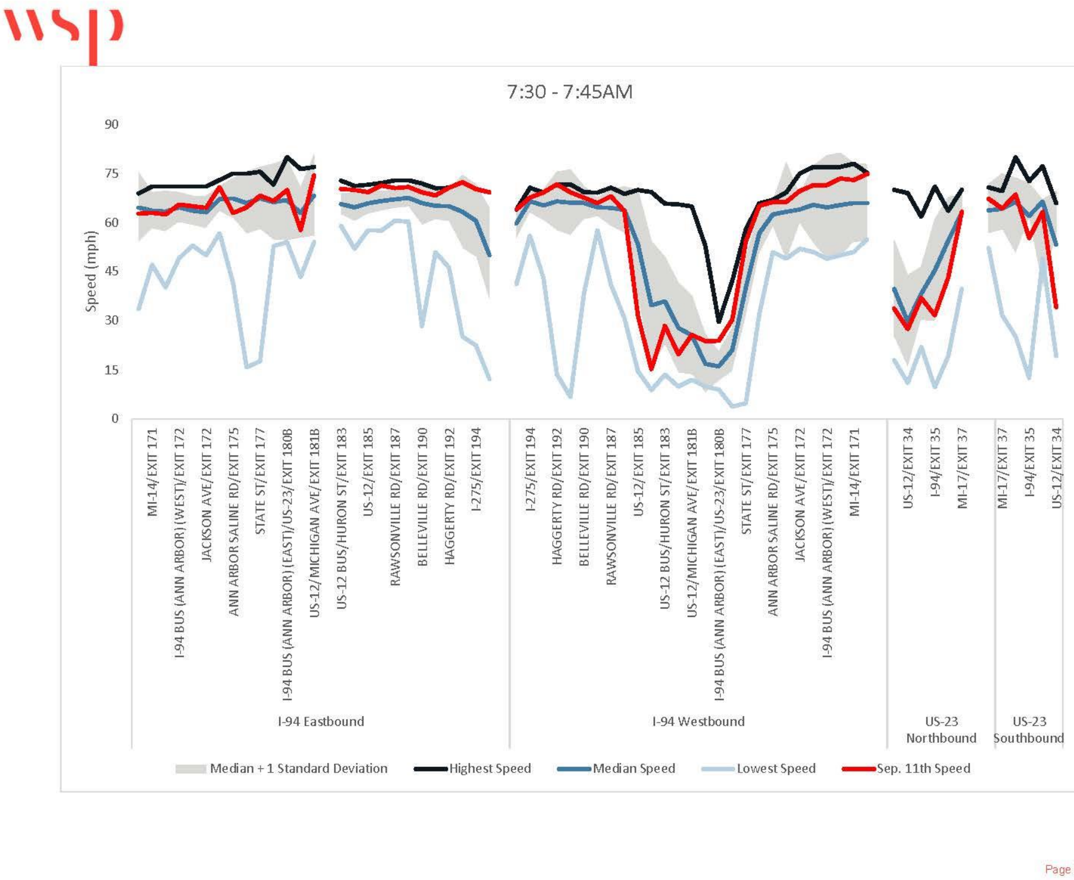
Matthew Hill, PE, PTOE
WSP Project Manager

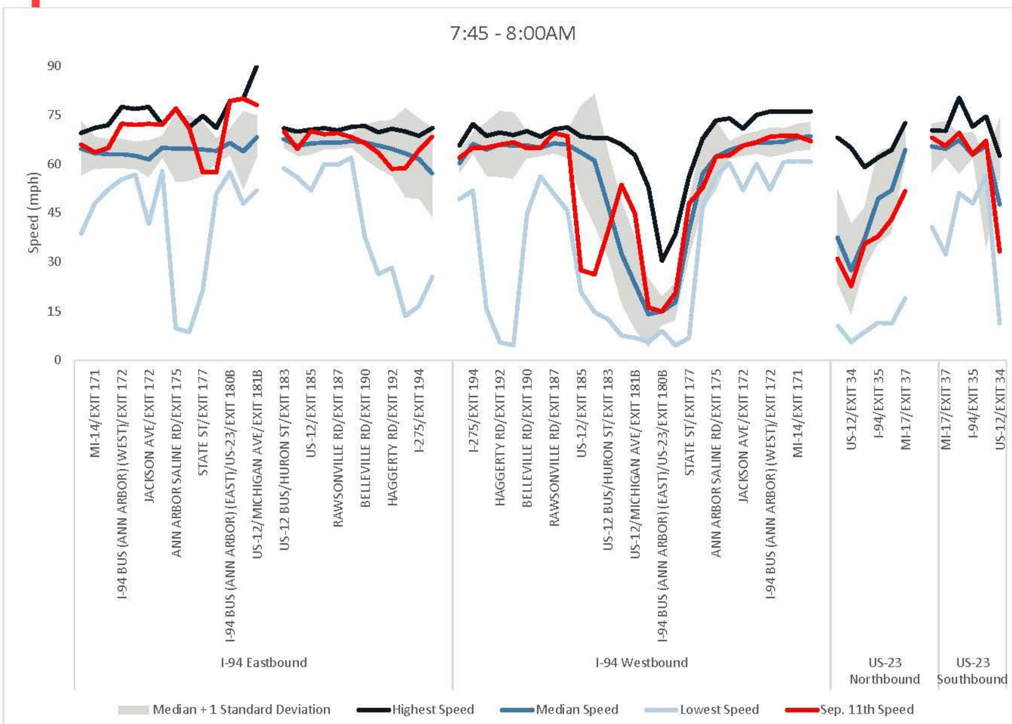
[1] One segment lacked speed data for all time periods. This was omitted to improve legibility. Additionally, any instances showing 0mph speed measurements were as reposted by RITIS.



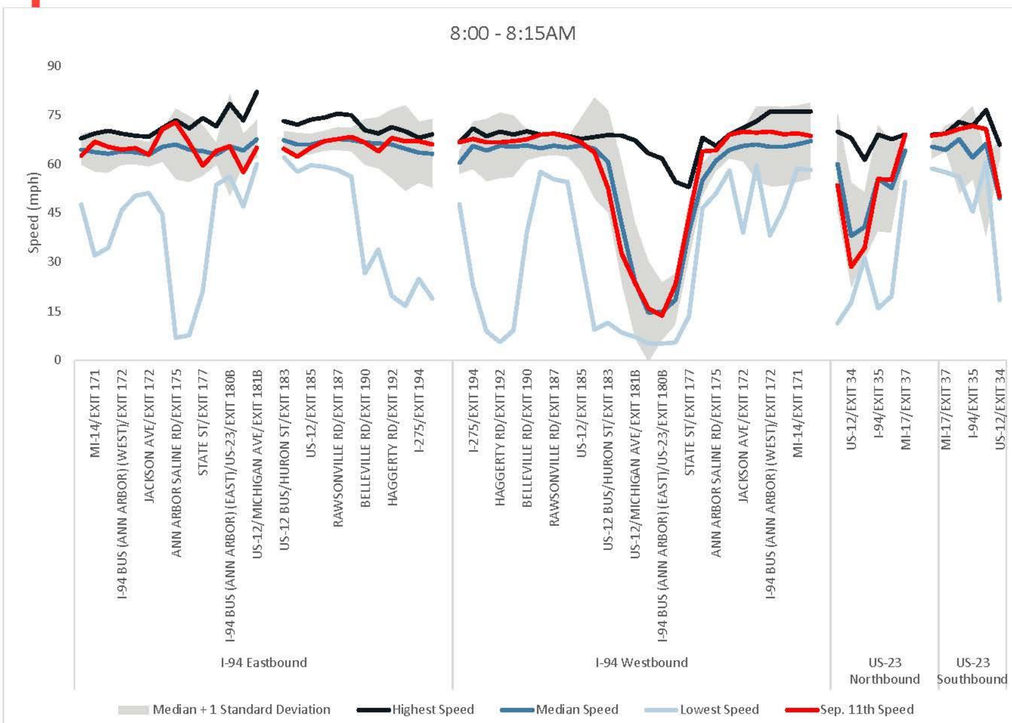
wsp
MDOT JN 202162
7:00 - 7:15AM
Speed (mph)
90
75
60
45
30
15
0
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
STATE ST/EXIT 177
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
US-12/MICHIGAN AVE/EXIT 181B
US-12 BUS/HURON ST/EXIT 183
US-12/EXIT 185
RAWSONVILLE RD/EXIT 187
BELLEVILLE RD/EXIT 190
HAGGERTY RD/EXIT 192
I-275/EXIT 194
I-275/EXIT 194
HAGGERTY RD/EXIT 192
BELLEVILLE RD/EXIT 190
RAWSONVILLE RD/EXIT 187
US-12/EXIT 185
US-12 BUS/HURON ST/EXIT 183
US-12/MICHIGAN AVE/EXIT 181B
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
STATE ST/EXIT 177
ANN ARBOR SALINE RD/EXIT 175
JACKSON AVE/EXIT 172
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
MI-14/EXIT 171
US-12/EXIT 34
I-94/EXIT 35
MI-17/EXIT 37
MI-17/EXIT 37
I-94/EXIT 35
US-12/EXIT 34
I-94 Eastbound
I-94 Westbound
US-23 Northbound
US-23 Southbound
Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed


wsp
7:15 - 7:30AM
Speed (mph)
90
75
60
45
30
15
0
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
STATE ST/EXIT 177
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
US-12/MICHIGAN AVE/EXIT 181B
US-12 BUS/HURON ST/EXIT 183
US-12/EXIT 185
RAWSONVILLE RD/EXIT 187
BELLEVILLE RD/EXIT 190
HAGGERTY RD/EXIT 192
I-275/EXIT 194
I-94 Eastbound
I-94 Westbound
US-23 Northbound
US-12/EXIT 34
I-94/EXIT 35
MI-17/EXIT 37
US-23 Southbound
Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed

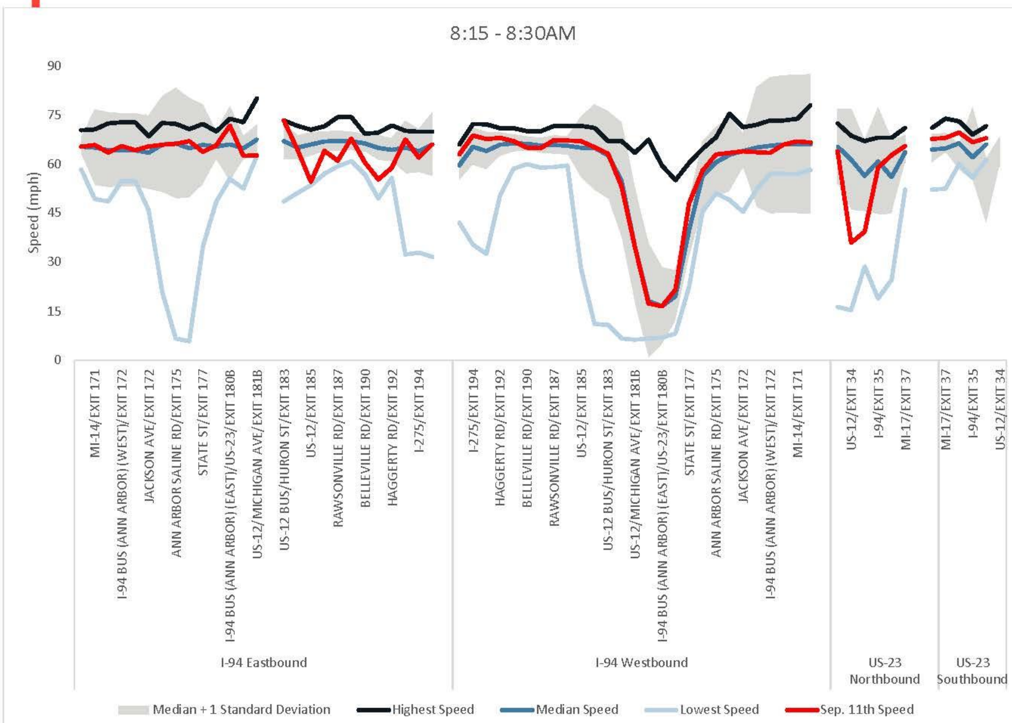

7:30 - 7:45AM
Speed (mph)
90
75
60
45
30
15
0
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
STATE ST/EXIT 177
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
US-12/MICHIGAN AVE/EXIT 181B
US-12 BUS/HURON ST/EXIT 183
US-12/EXIT 185
RAWSONVILLE RD/EXIT 187
BELLEVILLE RD/EXIT 190
HAGGERTY RD/EXIT 192
I-275/EXIT 194
I-94 Eastbound
I-94 Westbound
US-23 Northbound
US-23 Southbound
US-12/EXIT 34
I-94/EXIT 35
MI-17/EXIT 37
Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed
Page 5



7:45 - 8:00AM
Speed (mph)
0
15
30
45
60
75
90
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
STATE ST/EXIT 177
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
US-12/MICHIGAN AVE/EXIT 181B
US-12 BUS/HURON ST/EXIT 183
US-12/EXIT 185
RAWSONVILLE RD/EXIT 187
BELLEVILLE RD/EXIT 190
HAGGERTY RD/EXIT 192
I-275/EXIT 194
I-275/EXIT 194
HAGGERTY RD/EXIT 192
BELLEVILLE RD/EXIT 190
RAWSONVILLE RD/EXIT 187
US-12/EXIT 185
US-12 BUS/HURON ST/EXIT 183
US-12/MICHIGAN AVE/EXIT 181B
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
STATE ST/EXIT 177
ANN ARBOR SALINE RD/EXIT 175
JACKSON AVE/EXIT 172
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
MI-14/EXIT 171
US-12/EXIT 34
I-94/EXIT 35
MI-17/EXIT 37
MI-17/EXIT 37
I-94/EXIT 35
US-12/EXIT 34
I-94 Eastbound
I-94 Westbound
US-23 Northbound
US-23 Southbound
Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed



8:00 - 8:15AM
Speed (mph)
90
75
60
45
30
15
0
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
STATE ST/EXIT 177
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
US-12/MICHIGAN AVE/EXIT 181B
US-12 BUS/HURON ST/EXIT 183
US-12/EXIT 185
RAWSONVILLE RD/EXIT 187
BELLEVILLE RD/EXIT 190
HAGGERTY RD/EXIT 192
I-275/EXIT 194
I-275/EXIT 194
HAGGERTY RD/EXIT 192
BELLEVILLE RD/EXIT 190
RAWSONVILLE RD/EXIT 187
US-12/EXIT 185
US-12 BUS/HURON ST/EXIT 183
US-12/MICHIGAN AVE/EXIT 181B
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
STATE ST/EXIT 177
ANN ARBOR SALINE RD/EXIT 175
JACKSON AVE/EXIT 172
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
MI-14/EXIT 171
US-12/EXIT 34
I-94/EXIT 35
MI-17/EXIT 37
MI-17/EXIT 37
I-94/EXIT 35
US-12/EXIT 34
I-94 Eastbound
I-94 Westbound
US-23 Northbound
US-23 Southbound
Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed
Page 7


8:15 - 8:30AM
Speed (mph)
90
75
60
45
30
15
0
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
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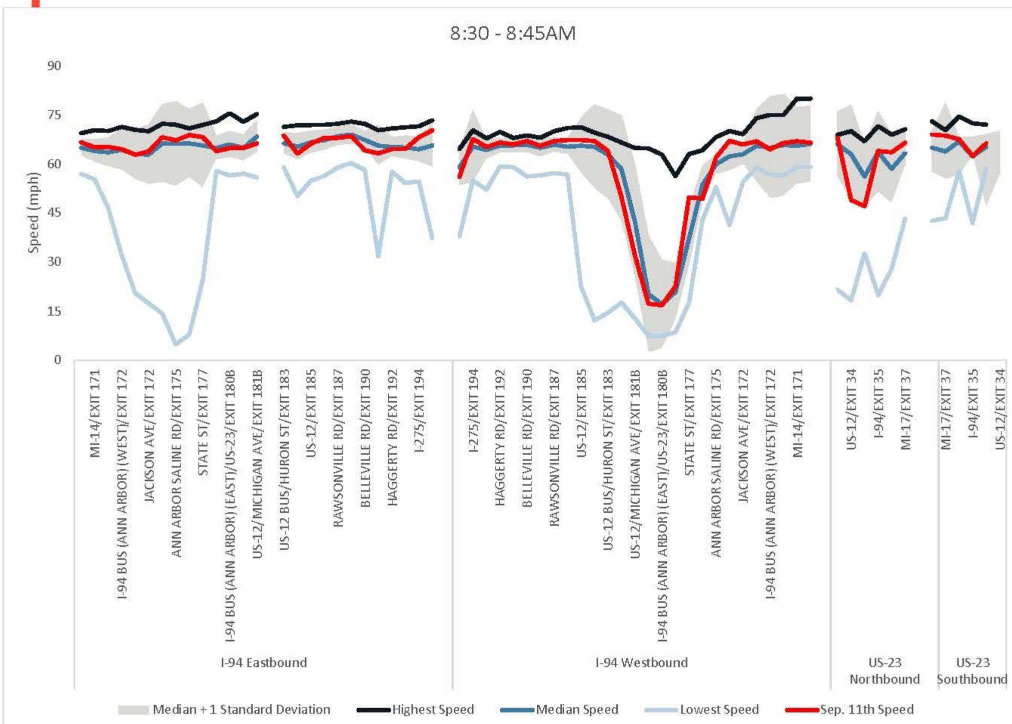
BELLEVILLE RD/EXIT 190
HAGGERTY RD/EXIT 192
I-275/EXIT 194
I-94 Eastbound
I-275/EXIT 194
HAGGERTY RD/EXIT 192
BELLEVILLE RD/EXIT 190
RAWSONVILLE RD/EXIT 187
US-12/EXIT 185
US-12 BUS/HURON ST/EXIT 183
US-12/MICHIGAN AVE/EXIT 181B
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
STATE ST/EXIT 177
ANN ARBOR SALINE RD/EXIT 175
JACKSON AVE/EXIT 172
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
MI-14/EXIT 171
I-94 Westbound
US-12/EXIT 34
I-94/EXIT 35
MI-17/EXIT 37
US-23 Northbound
MI-17/EXIT 37
I-94/EXIT 35
US-12/EXIT 34
US-23 Southbound
Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed


8:30 - 8:45AM
Speed (mph)
90
75
60
45
30
15
0
MI-14/EXIT 171
I-94 BUS (ANN ARBOR) (WEST)/EXIT 172
JACKSON AVE/EXIT 172
ANN ARBOR SALINE RD/EXIT 175
STATE ST/EXIT 177
I-94 BUS (ANN ARBOR) (EAST)/US-23/EXIT 180B
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Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed

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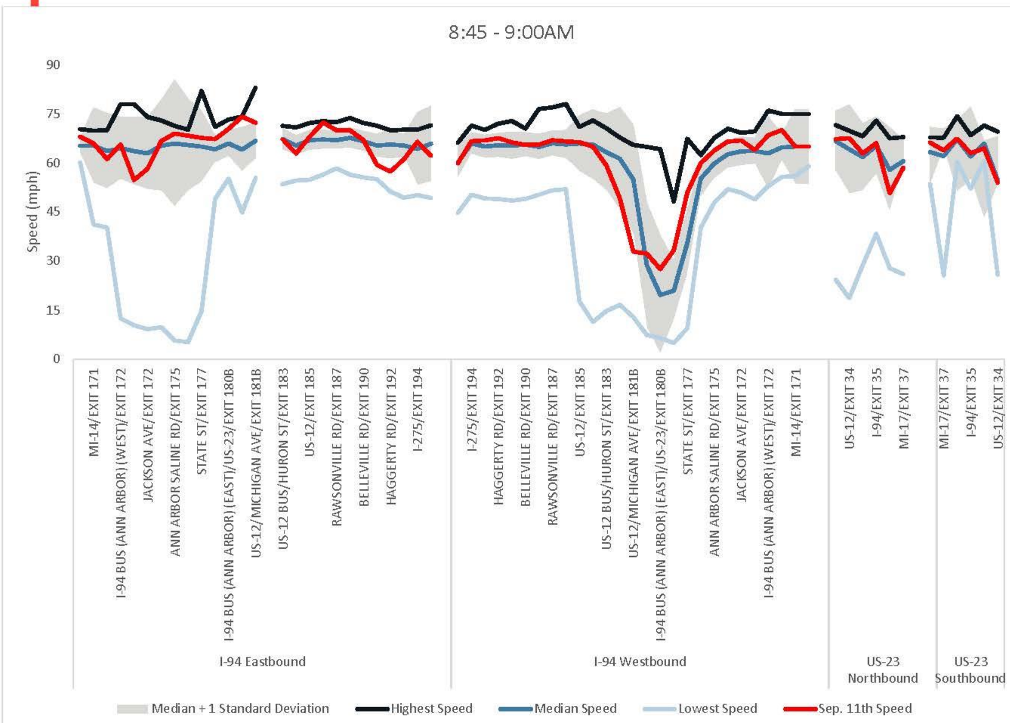
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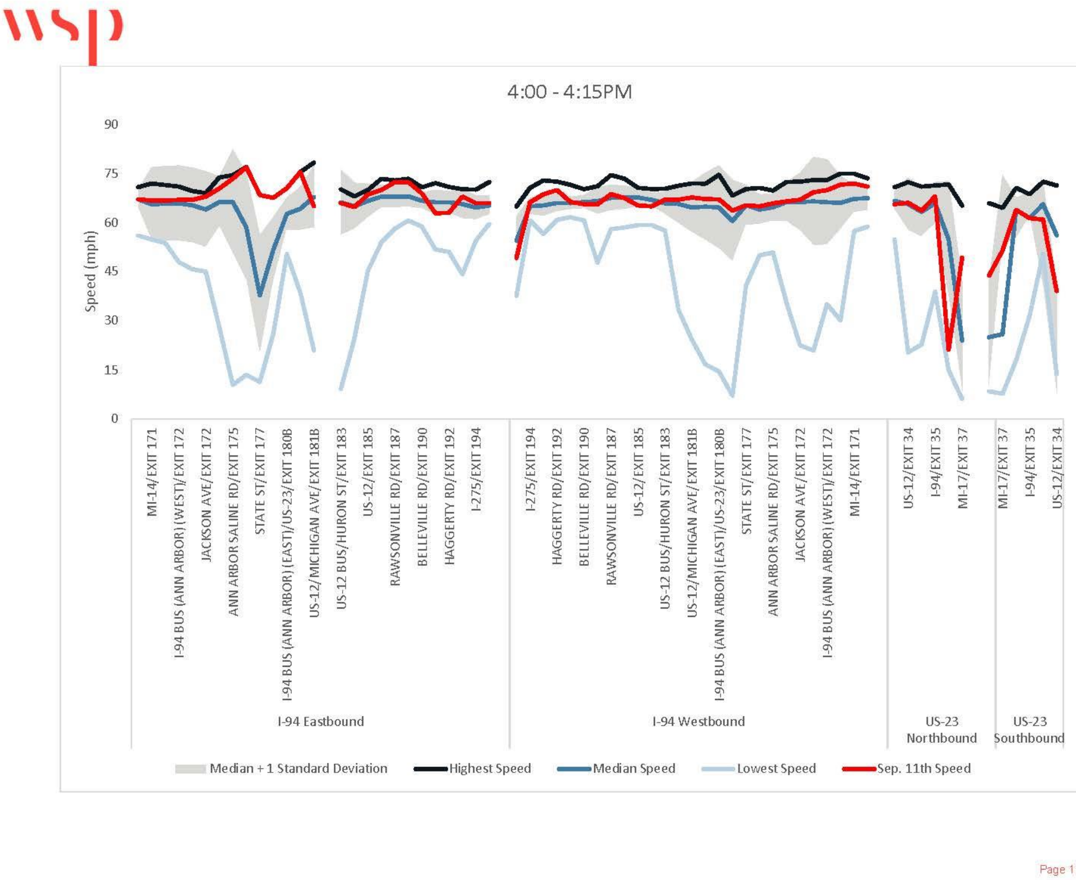
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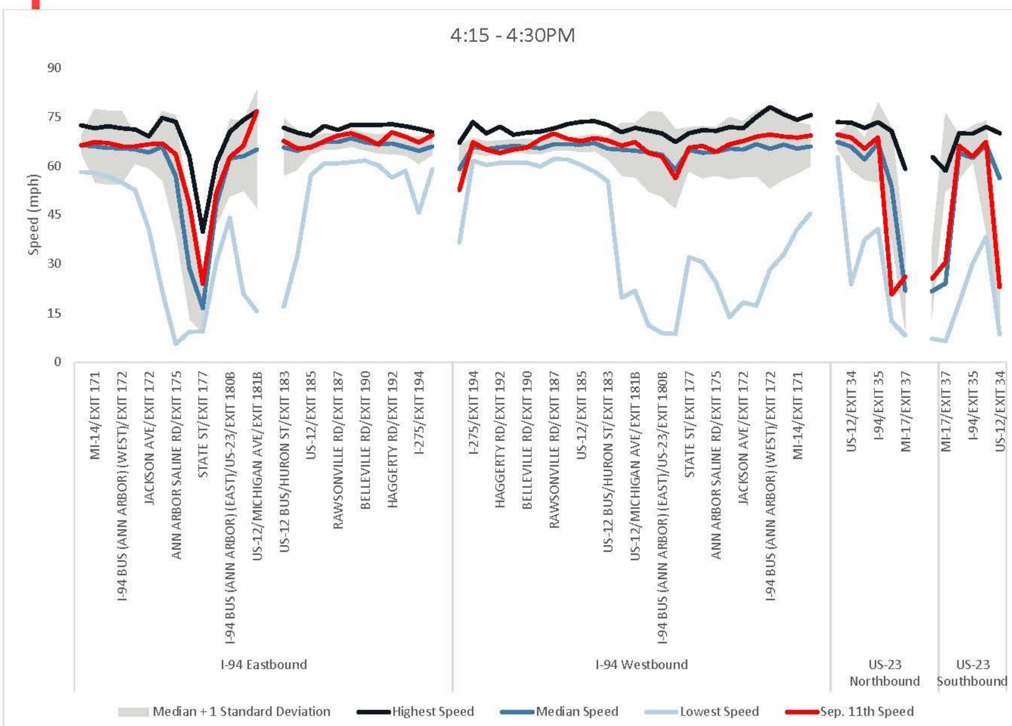
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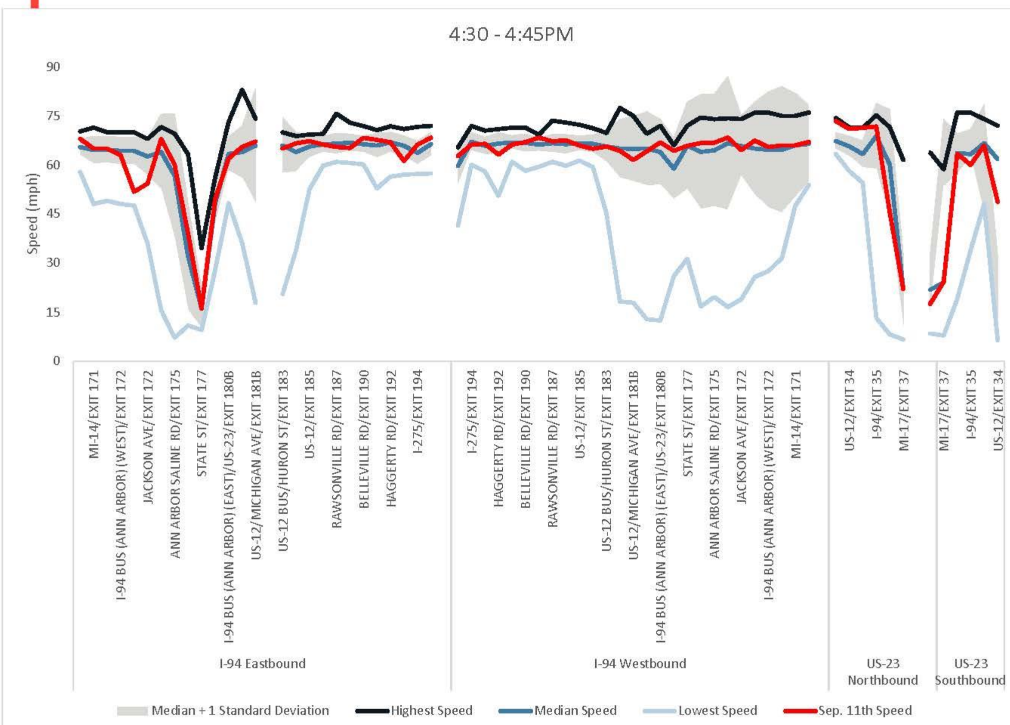
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Sep. 11th Speed

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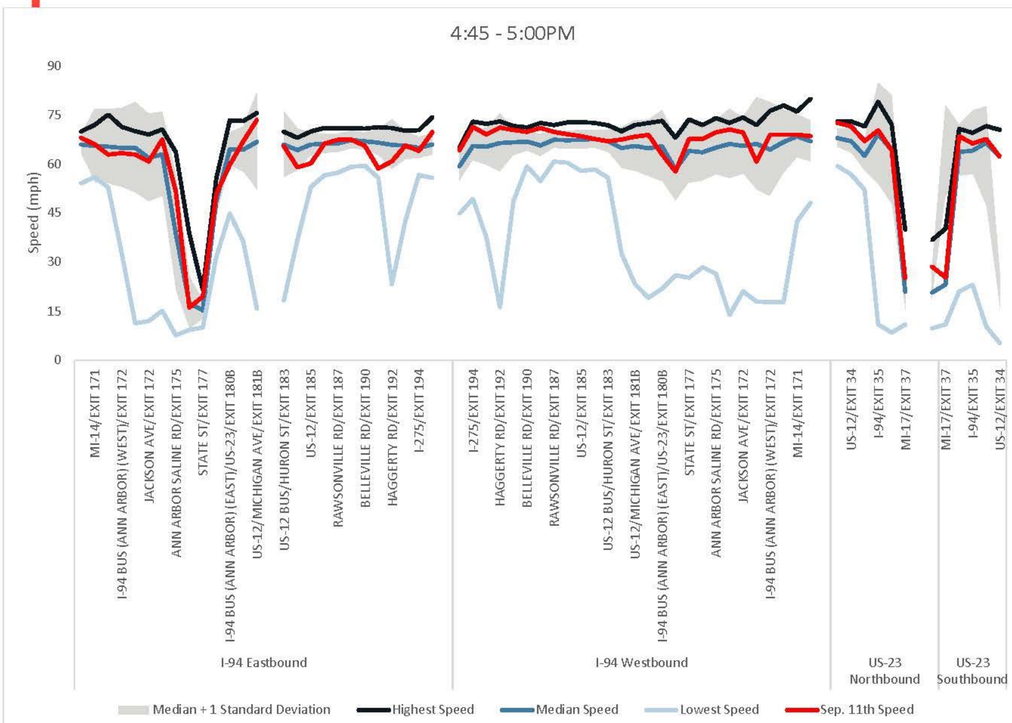
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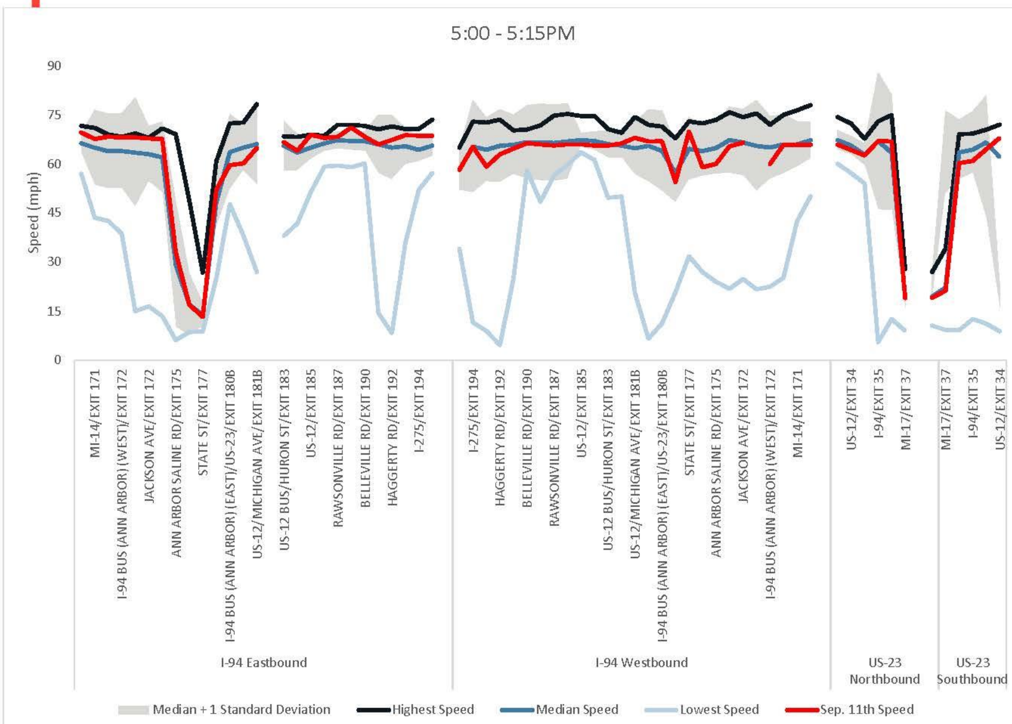
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Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed

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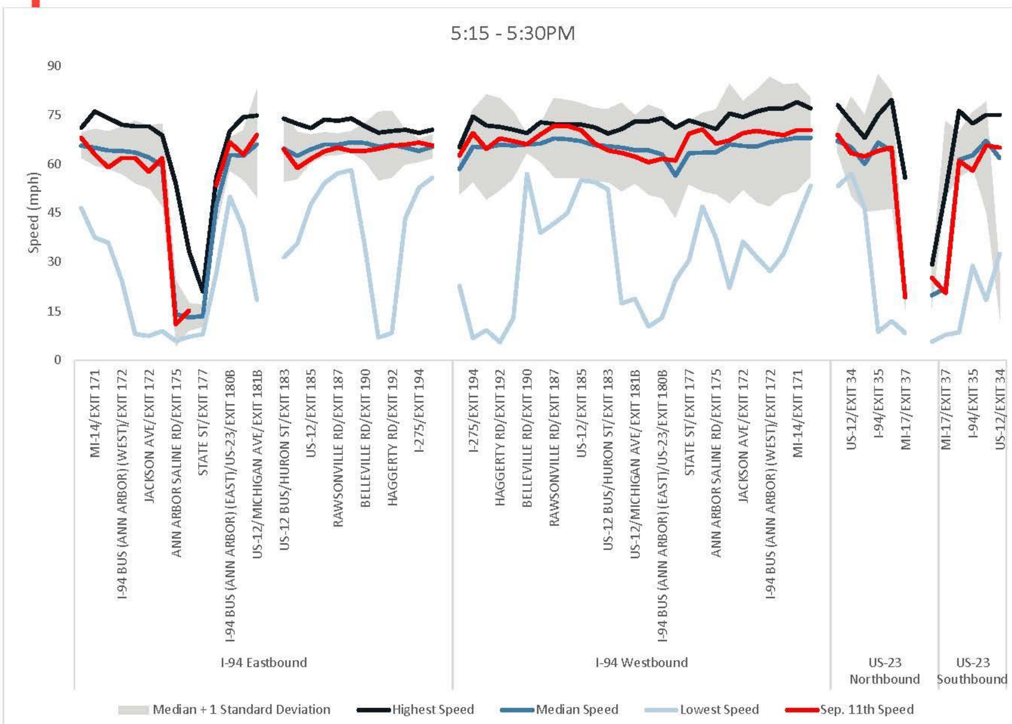
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Sep. 11th Speed

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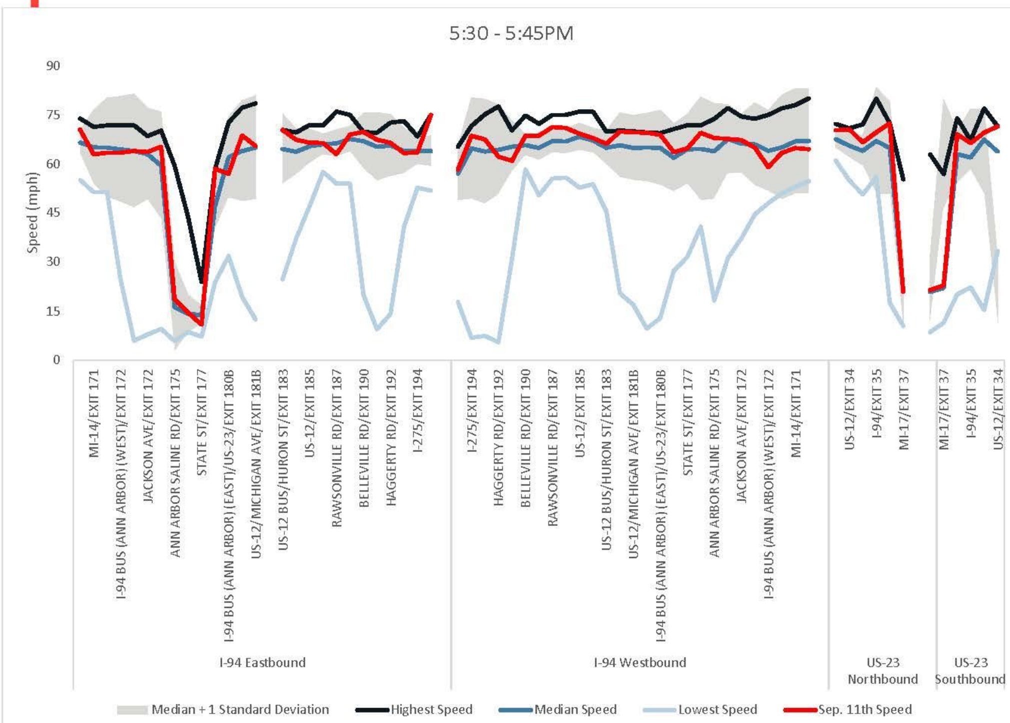
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Median + 1 Standard Deviation
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Lowest Speed
Sep. 11th Speed

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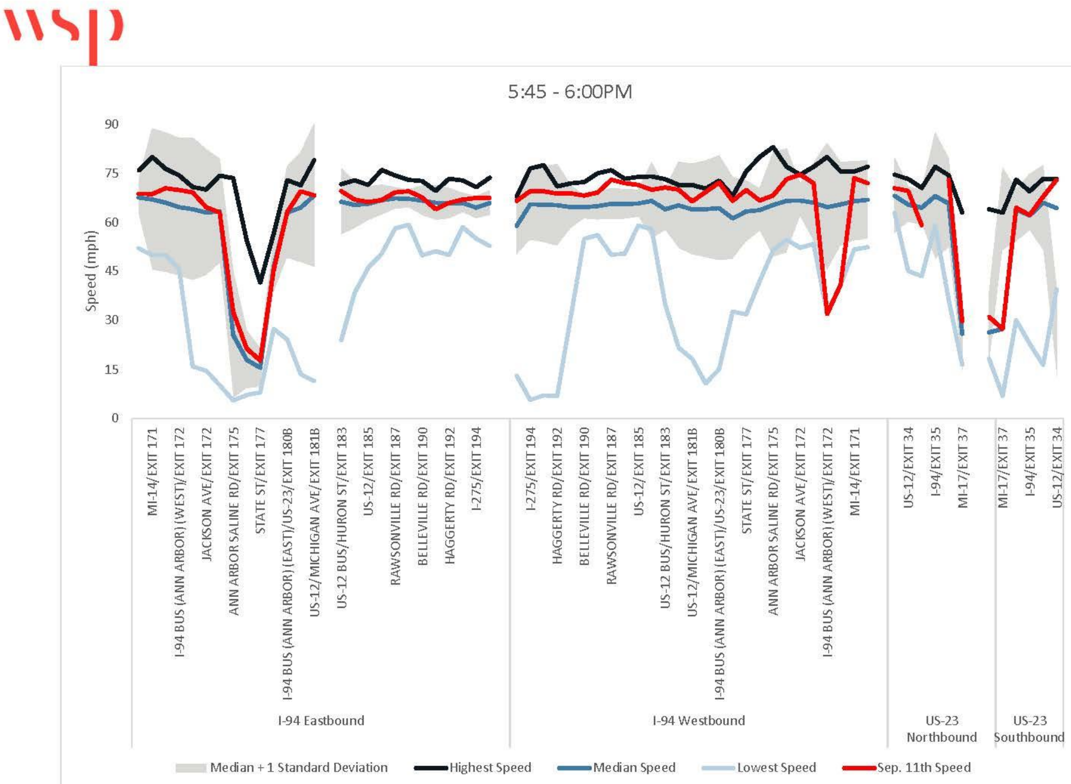
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Median + 1 Standard Deviation
Highest Speed
Median Speed
Lowest Speed
Sep. 11th Speed

APPENDIX E.3: VISSIM Modeling Calibration and Validation Memo Sample

MEMO

TO: Michelle O'Neill, PE

FROM: Lauren Warren, PE, PTOE; Trevor J. Kirsch, MS, EIT; Matt Hill, PE, PTOE

SUBJECT: Calibration and Validation Memo

DATE: October 30, 2019

VALIDATION CRITERIA

A validation methodology is necessary to ensure that the microsimulation model is as representative of real-world traffic conditions as possible. This is achieved through a rigorous calibration process to ensure adequate model reliability and the validity of calculated measures of effectiveness (MOEs). Best practice for microsimulation modeling is to have at least two separate validation criteria to ensure the existing condition microsimulation model is representative of the provided data. For this analysis, three metrics were utilized for validation:

1. Traffic volumes on critical segments
2. Traffic volumes within the network
3. Queue patterns

Traffic volumes on critical segments: The first measure of validity is how closely the microsimulation traffic volumes match the real-world traffic volumes temporally on critical segments within the modeled study area. A simple percentage difference between the model and real-world characteristics is not an accurate temporal comparison of the wide range of mainline segment or turning movement volumes possible in the model. Thus, a universal measure to temporally compare the microsimulation data with the real-world data is the GEH statistic. The GEH formula is displayed below:

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

where m (vehicles/hour) is the traffic volume on the desired segment from the microsimulation model and c (vehicles/hour) is the traffic volume on the desired segment from the real-world data. The intent of the GEH analysis is to ensure that microsimulation volumes are temporally reflective of real-world conditions. Based on best practices, generally acceptable criteria for GEH statistics are shown in Table 1.

Table 1. GEH Statistic Criteria

Facility Type	Criteria
Mainline Segments	GEH<3.0
On Ramp/Off Ramp Segments	GEH<3.0
Network Entry and Exit Segments	GEH<3.0
Other Local Segments	GEH<5.0 for at least 85% of applicable segments

Traffic volumes within the network: The second measure of validity is to compare the entire traffic volume within the study area of the microsimulation model with the traffic volume in the real-world over the entire analysis period. The intent of this comparison is to ensure that the satisfied traffic demand under real-world conditions is accurately reflected in the microsimulation model. Based on best practices, the traffic volume within the microsimulation model during the entire analysis period should be within +/-5% of the real-world traffic volume.

Queue patterns: The third measure of validity is how closely the microsimulation model queue patterns match the real-world queue patterns. The queue patterns of interest for the study area were established from MDOT feedback, field review, and video observation.

ASSUMPTIONS

To begin, default driver behavior parameters (Wiedemann 99) were assumed for all interstate segments and entry ramp segments within the modeled influence area. Adjustments were made as necessary during the calibration process to more appropriately match real-world conditions. Lane change distances were also adjusted to ensure that congestion was formed as expected based on the previously mentioned observations.

Likewise, the default driver behavior parameters (Wiedemann 74) were assumed for all surface street segments and interstate exit ramp segments within the modeled influence area. Adjustments were made as necessary during the calibration process to more appropriately match real-world conditions. Lane change distances were also adjusted to ensure that congestion was formed as expected based on the previously mentioned observations and feedback provided by MDOT.

INITIAL FINDINGS

After the initial simulation was completed, the desired GEH criteria and traffic volume requirement were not met. The queue patterns were also not generated as expected. Based on the results, the simulation vehicles were not aggressive enough at merge, diverge, and weave segments throughout the study area. To correct this, the default driver behaviors were adjusted for the merge, diverge, and weave segments to more accurately represent the aggressiveness that is present in real-world conditions.

CALIBRATION

To correct the under aggressiveness of the simulation vehicles on merge, diverge, and weave segments, the lane change driver behavior was adjusted to increase the willingness of simulation vehicles to complete their desired lane changes more aggressively. The lane change characteristics control the cooperative attributes of the simulation vehicles during lane change interactions, such as minimum headway and allowable deceleration rate, among others. The lane change characteristics that were changed from their default values are listed in Table 2:

Table 2. Adjusted Lane Change Characteristics

Parameter	Definition	Default	Adjusted
-1 ft/s^2 per Distance	Controls the acceptable distance needed to decelerate to facilitate a lane change	200 ft	100 ft
Minimum Headway	Minimum distance between two vehicles that must be available to complete a lane change	1.64 ft	1.00 ft
Safety Distance Reduction Factor	Reduction factor that controls the safety distance	0.60	0.35
Maximum Deceleration for Cooperative Braking	The maximum acceptable rate of deceleration to allow a vehicle to change lanes	-9.84 ft/s^2	-25.00 ft/s^2
Cooperative Lane Change Maximum Speed Difference	The maximum speed difference at which a vehicle will not change lanes to facilitate another vehicles lane change	6.71 mph	10.00 mph

Following these adjustments to the driver behavior at merge, diverge, and weave segments, the resultant MOEs passed most of the validation criteria. Based on these results, the microsimulation model was considered to be calibrated appropriately.

MODEL CONFIDENCE

Because VISSIM is a dynamic traffic microsimulation software, each simulation is controlled by a random seed number. This random seed number is correlated to various distributions within the microsimulation model. As such, each simulation run uses a different random seed number, therefore changing the interactions between simulation vehicles and generating different MOEs. Just as real-world traffic conditions are not identical every day, each simulation run is different than the previous based on this random seed number. Because of this, the confidence level in the microsimulation models must be calculated to ensure that significant differences are not present in varying simulation runs that would skew the reporting of MOEs. The confidence level is a statistical test that quantifies how reliable a specific metric is based on a range of values. In short, the confidence level defines how accurate the models are based on the measured variability in a parameter of interest.

For this analysis, the confidence level was established using various travel times throughout the study area. The travel time metric was selected to ensure that the experienced congestion in each simulation run was within a statistically reasonable threshold and no outliers interfered with the reported MOEs.

To determine the amount of simulation runs required to meet the confidence threshold, the travel time along I-94 westbound (WB), US-131 northbound (NB), and I-94 WB to US-131 NB were captured. The travel time MOEs were averaged over a period of ten simulation runs. This quantity of simulation runs was initially selected based on best practices. Each of the three travel times were analyzed per hour, meaning that each travel time has four results given the four-hour analysis period. Table 3 contains the confidence interval results at an 85% confidence level:

Table 3. Travel Time Confidence Intervals

Route	Time Period	Travel Time (s)	Standard Deviation (s)	Simulation Runs Required
I-94 WB	3:00 PM-4:00 PM	415	1	0
	4:00 PM-5:00 PM	417	1	0
	5:00 PM-6:00 PM	424	6	0
	6:00 PM-7:00 PM	418	10	1
US-131 NB	3:00 PM-4:00 PM	217	1	0
	4:00 PM-5:00 PM	216	1	0
	5:00 PM-6:00 PM	217	0	0
	6:00 PM-7:00 PM	213	1	0
I-94 WB to US-131 NB	3:00 PM-4:00 PM	434	6	0
	4:00 PM-5:00 PM	449	23	3
	5:00 PM-6:00 PM	541	38	8
	6:00 PM-7:00 PM	492	28	5

As depicted in Table 3, the maximum number of simulation runs required to maintain an 85% confidence level in the microsimulation model is eight. As previously stated, ten simulation runs were conducted to establish this confidence threshold. Because the amount of simulation runs utilized is greater than those required, the microsimulation model is considered accurate at an 85% confidence level. Although a higher confidence interval could be utilized, this would require significantly more simulation runs, which would increase the level of effort for post-processing results and have a marginal impact on resultant MOEs. Therefore, an 85% confidence level was considered acceptable for this analysis.

Note that although the microsimulation model is acceptable at an 85% confidence level, most of the variability is in the area of interest (the interchange ramp between I-94 WB to US-131 NB). This variability is especially prevalent during the 5:00 PM to 6:00 PM period, which contains most of the PM peak for this analysis (4:45 PM to 5:45 PM). Also MDOT feedback indicated the congestion in this area of interest is frequent but volatile, as the typical queue length in this area can range from localized slowing to extreme backups which persist along the mainline. This variability in congestion is captured in the microsimulation model as this location and this peak hour time period has the greatest standard deviation and requires the most simulation runs for acceptability, as shown in Table 3.

COMPARISON

After determining that the microsimulation model was accurate at an 85% confidence level, the resultant MOEs from the ten simulation runs were compared with the GEH, traffic volume, and queue pattern validation criteria. The GEH criteria were compared on a per hour interval for the four-hour analysis period, as well as a total for the entire analysis period. Table 4 contains the results from the mainline segment GEH validation:

Table 4. Mainline Segment GEH Validation

Route	To	From	GEH 3:00 PM-4:00 PM	GEH 4:00 PM-5:00 PM	GEH 5:00 PM-6:00 PM	GEH 6:00 PM-7:00 PM	GEH Total
I-94 WB	Lovers Ln	Westnedge Ave Off Ramp	0.3	0.1	0.2	0.5	0.1
	Westnedge Ave Off Ramp	Westnedge Ave On Ramp	0.7	0.3	0.3	1.1	0.0
	Westnedge Ave On Ramp	Oakland Dr Off Ramp	1.1	0.8	0.1	1.0	0.7
	Oakland Dr Off Ramp	Oakland Dr On Ramp	1.0	0.5	0.1	1.6	0.1
	Oakland Dr On Ramp	US-131 NB Off Ramp	2.1	2.0	1.9	2.2	2.3
	US-131 NB Off Ramp	US-131 NB On Ramp	0.7	0.8	0.1	2.9	0.3
	US-131 NB On Ramp	US-131 SB Off Ramp	1.5	1.7	0.9	2.7	1.1
	US-131 SB Off Ramp	US-131 SB On Ramp	1.2	1.5	0.3	2.5	0.6
	US-131 SB On Ramp	9th St Off Ramp	1.1	1.4	0.2	2.4	0.5
	9th St Off Ramp	9th St On Ramp	0.8	1.0	0.4	1.9	0.1
	9th St On Ramp	6th St	0.8	1.0	0.5	2.1	0.1
US-131 NB	Milham Ave	I-94 EB Off Ramp	0.1	0.0	0.2	0.0	0.2
	I-94 EB Off Ramp	I-94 EB On Ramp	0.2	0.3	0.5	0.2	0.2
	I-94 EB On Ramp	I-94 WB Off Ramp	1.0	0.6	1.2	0.4	1.7
	I-94 WB Off Ramp	I-94 WB On Ramp	0.0	0.3	0.3	0.1	0.1
	I-94 WB On Ramp	Stadium Dr Off Ramp	1.1	0.9	2.0	2.8	0.9
	Stadium Dr Off Ramp	Stadium Dr On Ramp	0.6	0.2	1.4	3.1	0.3
	Stadium Dr On Ramp	KI Ave	0.7	0.2	1.3	2.7	0.2

Similarly, the resultant MOEs were compared to the GEH validation criteria for on ramp and off ramp segments within the influence area. The results of this comparison are in Table 5:

Table 5. On Ramp and Off Ramp Segment GEH Validation

Route	Segment	GEH				
		3:00 PM-4:00 PM	4:00 PM-5:00 PM	5:00 PM-6:00 PM	6:00 PM-7:00 PM	Total
I-94 WB	Westnedge Ave Off Ramp	1.2	0.9	0.7	0.1	1.4
	Westnedge Ave On Ramp	0.5	1.0	0.9	0.3	1.4
	Oakland Dr Off Ramp	0.8	1.3	1.0	0.5	1.4
	Oakland Dr On Ramp	0.4	0.4	0.5	0.1	0.7
	US-131 NB Off Ramp	0.4	0.4	1.4	3.9	0.5
	US-131 NB On Ramp	0.6	0.4	0.6	0.9	0.5
	US-131 SB Off Ramp	0.4	0.0	0.7	1.9	0.2
	US-131 SB On Ramp	0.1	0.1	0.1	0.0	0.2
	9th St Off Ramp	0.6	0.8	0.2	2.5	0.5
	9th St On Ramp	0.1	0.1	0.1	0.0	0.2
US-131 NB	I-94 EB Off Ramp	0.1	0.4	0.0	0.2	0.4
	I-94 EB On Ramp	0.0	0.1	0.0	0.1	0.0
	I-94 WB Off Ramp	See "US-131 NB On Ramp" above				
	I-94 WB On Ramp	See "US-131 NB Off Ramp" above				
	Stadium Dr Off Ramp	1.6	1.5	2.1	1.4	2.1
	Stadium Dr On Ramp	0.1	0.1	0.1	0.1	0.2

Likewise, the resultant MOEs were compared to the GEH validation criteria for the network entry and exit segments within the influence area. Table 6 contains the network entry segment comparison, while Table 7 contains the network exit segment comparison.

Table 6. Network Entry Segment GEH Validation

Segment	GEH				
	3:00 PM-4:00 PM	4:00 PM-5:00 PM	5:00 PM-6:00 PM	6:00 PM-7:00 PM	Total
I-94 WB	0.3	0.1	0.2	0.5	0.1
Westnedge Ave NB	0.0	0.0	0.0	0.0	0.0
Westnedge Ave SB	0.0	0.0	0.0	0.0	0.0
I-94 EB to Westnedge Ave	0.2	0.3	0.3	0.2	0.5
Oakland Dr NB	1.1	1.1	1.2	1.0	2.2
Oakland Dr SB	0.7	0.8	0.8	0.7	1.5
I-94 EB to Oakland Dr	0.2	0.2	0.2	0.2	0.4
US-131 SB to I-94 WB	0.1	0.1	0.1	0.0	0.2
9th St to I-94 WB	0.1	0.1	0.1	0.0	0.2
US-131 NB	0.1	0.0	0.2	0.0	0.2
I-94 EB to US-131 NB	0.0	0.1	0.0	0.1	0.0
Stadium Dr to US-131 NB	0.1	0.1	0.1	0.1	0.2

Table 7. Network Exit Segment GEH Validation

Segment	GEH				
	3:00 PM-4:00 PM	4:00 PM-5:00 PM	5:00 PM-6:00 PM	6:00 PM-7:00 PM	Total
Westnedge Ave NB	0.2	0.2	0.2	0.6	0.4
Westnedge Ave SB	0.6	0.1	0.1	0.8	0.7
Westnedge Ave to I-94 EB	0.2	0.0	0.0	0.8	0.5
Oakland Dr NB	0.1	0.4	0.3	0.7	0.2
Oakland Dr SB	0.0	0.5	0.1	0.7	0.0
Oakland Dr to I-94 EB	0.6	0.4	0.1	0.4	0.2
I-94 WB to US-131 SB	0.4	0.0	0.7	1.9	0.2
9th St Off Ramp	0.6	0.8	0.2	2.5	0.5
I-94 WB	0.8	1.0	0.5	2.1	0.1
I-94 EB Off Ramp	0.1	0.4	0.0	0.2	0.4
Stadium Dr Off Ramp	1.1	0.9	1.5	1.9	0.9
US-131 NB	0.8	0.1	1.5	2.7	0.0

Furthermore, the resultant MOEs from the other local segments were compared to the applicable GEH validation criteria. The results of this comparison are displayed in Table 8:

Table 8. Other Local Segment GEH Validation

Segment	GEH				
	3:00 PM-4:00 PM	4:00 PM-5:00 PM	5:00 PM-6:00 PM	6:00 PM-7:00 PM	Total
Westnedge Ave NB to I-94 WB	1.2	1.1	1.0	1.0	2.2
Westnedge Ave NB to I-94 EB	0.5	0.5	0.9	0.9	1.4
Westnedge Ave SB to I-94 EB	0.6	0.2	0.5	1.4	0.7
Westnedge Ave SB to I-94 WB	0.4	1.1	0.8	1.3	1.7
Oakland Dr NB to I-94 WB	1.2	1.1	1.5	1.0	2.4
Oakland Dr NB	0.5	0.6	0.1	0.0	0.6
Oakland Dr NB to I-94 EB	2.1	2.2	1.9	1.3	3.8
Oakland Dr SB to I-94 EB	1.0	0.6	0.3	0.0	1.0
Oakland Dr SB	0.4	0.3	0.3	0.9	0.9
Oakland Dr SB to I-94 WB	0.0	0.1	0.1	0.1	0.0

Additionally, the entire traffic volume from the microsimulation model was compared to the real-world traffic volume within the study area over the entire analysis period to determine if the model satisfied the traffic volume validation criteria. The results of this comparison are in Table 9:

Table 9. Traffic Volume Validation

Real World Traffic Volume			Microsimulation Traffic Volume	
Total	Lower Bound (5%)	Upper Bound (5%)	Total	Percent Difference
273,387	259,718	287,056	271,451	1%

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Lastly, the queue patterns of the ten simulation runs were analyzed to determine if the microsimulation model was accurately representing the congestion as determined by MDOT feedback, field review, and video observation. The results of this qualitative analysis are discussed in the next section.

SUMMARY

After the rigorous calibration of the microsimulation model and establishing confidence in the results, the calculated MOEs were compared to the relevant validation criteria contained in Table 1 and listed in the first section of this memo. Table 4 contains the validation results of the mainline segments within the influence area. Based on these results, most of the mainline segments pass the GEH statistic threshold, except for the US-131 NB mainline between the Stadium Dr off ramp and the Stadium Dr on ramp. This was the only mainline segment to not pass the validation criteria, with a GEH of 3.1 during the final hour (6:00 PM to 7:00 PM) of the analysis period. This is likely due to the volatility of the congestion experienced at the upstream I-94 WB to US-131 NB interchange. Because this location is immediately upstream of this mainline segment, the desired traffic demand is highly sensitive to the time at which this congestion dissipates and vehicles are able to successfully merge onto US-131 NB. Despite this, 94% of the mainline segments meet the validation criteria.

Similarly, Table 5 contains the validation results of the on ramp segments and off ramp segments within the influence area. Based on these results, one of the ramps does not meet the required GEH statistic. The interchange ramp between I-94 WB and US-131 NB has a GEH statistic equal to 3.9 during the 6:00 PM to 7:00 PM period. Although this does not meet the GEH threshold, this area experiences frequent congestion that is volatile in nature, as determined by MDOT feedback. This is also the period with the most volatility, as noted during the confidence interval calculation. Based on the computation of the GEH, it seems that the microsimulation model is temporally shifting the congestion later in the analysis period in comparison to real-world operations, meaning that the congestion in the model is occurring later than in the real-world. Because of this variability, it is difficult to maintain a consistent GEH statistic which passes the validation criteria at this location because the traffic counts vary slightly between the model and the real-world due to this temporal shift. Despite this, the GEH criteria is met for all remaining on ramp and off ramp segments during all other time periods. Based on the validation results, 94% of all ramp segments pass the validation criteria.

Table 6 and Table 7 depict the validation results for the network entry segments and exit segments within the study area, respectively. Based on these results, all the network entry and exit segments pass the validation criteria with GEH statistics less than 3.0 under all time periods considered.

Furthermore, Table 8 contains the validation results for the other local segments within the influence area. Based on these results, all the applicable local segments pass the validation criteria with GEH statistics less than 5.0 under all time periods considered.

As mentioned previously, the total traffic volume in the microsimulation model must be within 5% of the real-world traffic volume within the influence area over the entire analysis period. Table 9 outlines the results of this comparison. Ultimately, the microsimulation model passes this validation criteria. The traffic volume in the microsimulation model is within 1% of the real-world traffic volume, which indicates that the model should be accurately representing the existing conditions.

Lastly, the queue patterns of the model were analyzed to determine if the congestion in the microsimulation model was representative of the congestion documented through MDOT feedback, field review, and video observation. As mentioned previously, most of the congestion within the study area is generated from the interchange ramp between I-94 WB and US-

131 NB. This area of the microsimulation was observed during the entire analysis period, and the resultant congestion shown in the ten simulation runs was determined to be representative of the documented congestion. The extent of the typical queue in the microsimulation models mirrored the queue length observed in the video observations, while the volatility of the queue was recognized in the various simulation runs due to the random seed number.

In conclusion, the results of each validation that was performed on the microsimulation model are summarized below:

- Mainline Segments – All the mainline segments meet the appropriate validation criteria over all the time periods considered.
- On Ramp/Off Ramp Segments – Most of the on ramp/off ramp segments meet the validation criteria. The only ramp segment to not meet the validation criteria was the system interchange ramp between I-94 WB and US-131 NB during the last hour of the analysis period. As previously discussed, this is likely due to the congestion volatility that is present under existing conditions.
- Network Entry and Exit Segments – All the network entry and exit segments meet the appropriate validation criteria over all the time periods considered.
- Other Local Segments – All the local segments within the microsimulation model meet the appropriate validation criteria over all the time periods considered.
- Traffic Volume - The microsimulation traffic volume is within the acceptable tolerance range of the real-world traffic volume for the entire analysis period
- Queue Patterns – The queue patterns present in the existing condition models are representative of current, real-world congestion, based on MDOT feedback

APPENDIX E.4: VISSIM Modeling Base Conditions Memo Sample

MEMO

TO: Michelle O'Neill, PE

FROM: Lauren Warren, PE, PTOE; Trevor J. Kirsch, MS, EIT; Matt Hill, PE, PTOE

SUBJECT: Base Conditions Memo

DATE: November 11, 2019

PURPOSE

The intent of this memorandum is to summarize the performance of the base conditions microsimulation model. Base conditions represent the PM peak period (3:00pm – 7:00pm) with traffic count data from March of 2018 and September of 2019 as described in the previously prepared ***VISSIM Modeling Methodology and Assumptions Memo*** dated 10/1/2019 by WSP. The model was prepared in VISSIM and was validated and calibrated as described in the previously prepared ***Calibration and Validation Memo*** dated 10/30/2019 by WSP. Figure 1 illustrates the modeled study area of the WB I-94 corridor at US-131.

TRAFFIC VOLUMES

A balanced set of traffic volumes in 15-minute intervals was established for the study area for the entire four hour PM peak period (3:00pm – 7:00pm). VISSIM requires that all traffic be balanced within the model, as the software does not allow vehicles to enter or exit the network at internal junctions. In other words, all vehicles which are generated in the model must enter and exit the network appropriately. To develop the balanced volume set, one mainline count on each freeway segment was considered as ground truth, as well as all the entry and exit ramp counts. Using this information, the subsequent mainline segment volumes were adjusted accordingly to balance based on the entry and exit ramp counts. The volume exhibits in Figure 2 through Figure 6 reflect the established balanced volume set during the PM peak hour (4:45 PM to 5:45 PM) within the study area.

MEASURES OF EFFECTIVENESS

The base condition model was run ten times using different random number seeds and the MOEs from these runs averaged together. The 10 runs were based on previous confidence interval calculations in the ***Calibration and Validation Memo*** dated 10/30/2019 by WSP. Ten simulation runs should capture all reasonable variability in MOE results when reporting the average of these runs.

Figure 1. Study Area

Figure 2. Westnedge Ave Volume Exhibit

Figure 3. Oakland Dr Volume Exhibit

Figure 4. I-94 and US-131 Interchange Volume Exhibit

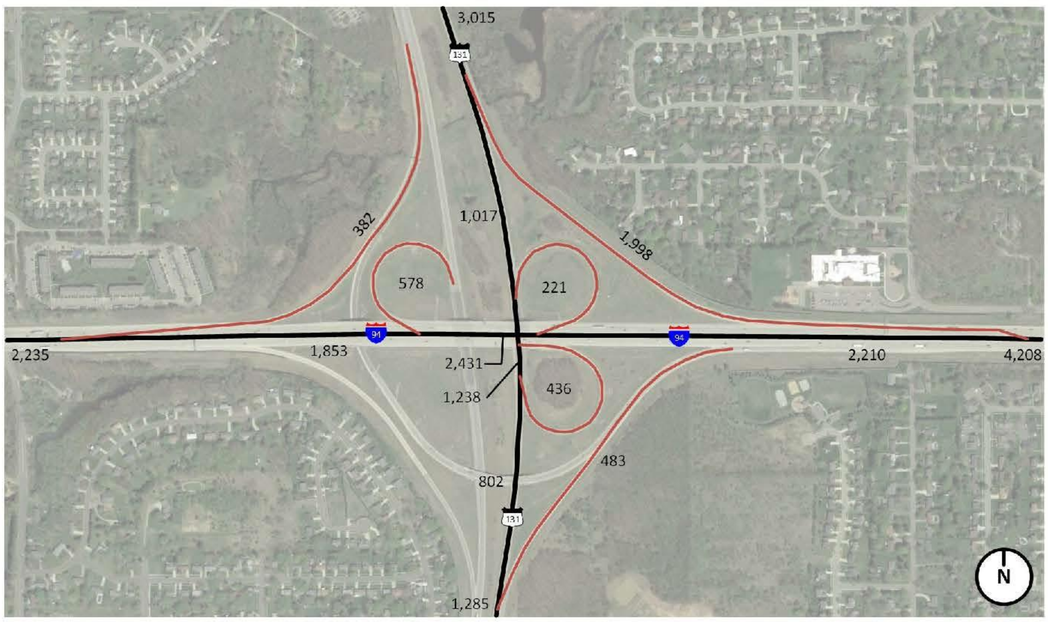


Figure 5. 9th St Volume Exhibit

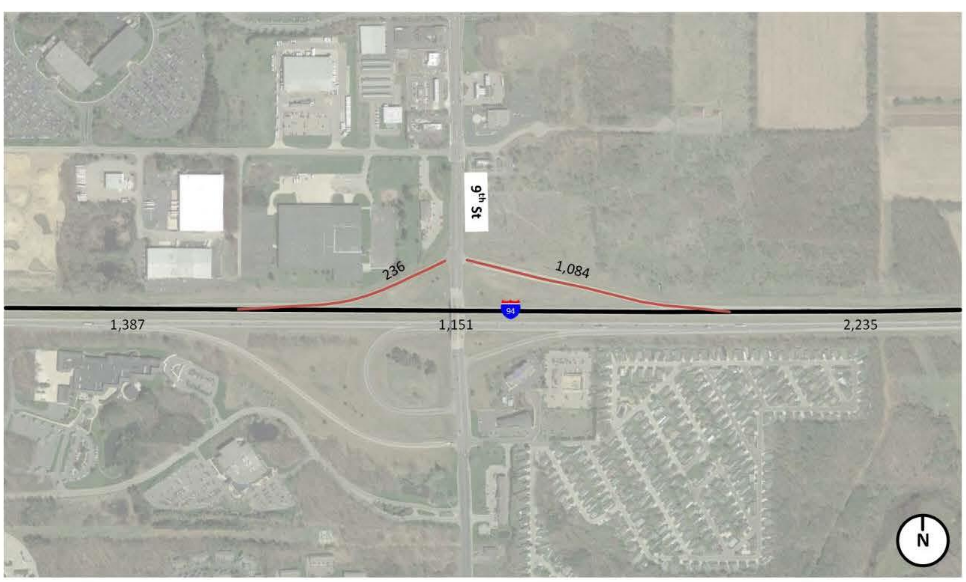
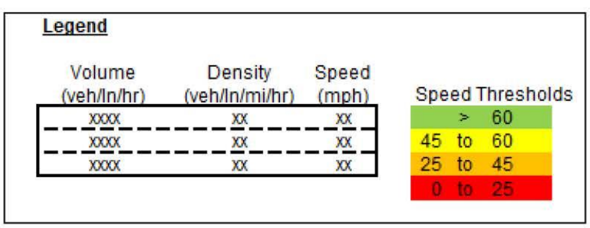


Figure 6. Stadium Dr Volume Exhibit

FREEWAY MOES

Lane schematics were created for both I-94 WB and US-131 NB. The lane schematics depict various MOEs, including volume (vehicle throughput), density, and speed per lane. Figure 7 contains a legend that depicts the layout of the MOEs for each lane segment, the units for each MOE, and how the segments are color coded:

Figure 7. Lane Schematic Legend



Note that the results displayed within the following schematics are averaged over the ten simulation runs and include MOEs during the peak hour of the PM peak period (4:45 PM to 5:45 PM). Figure 8 contains the lane schematic for I-94 WB, while Figure 9 contains the lane schematic for US-131 NB.

Figure 8. I-94 WB Corridor Lane Schematic

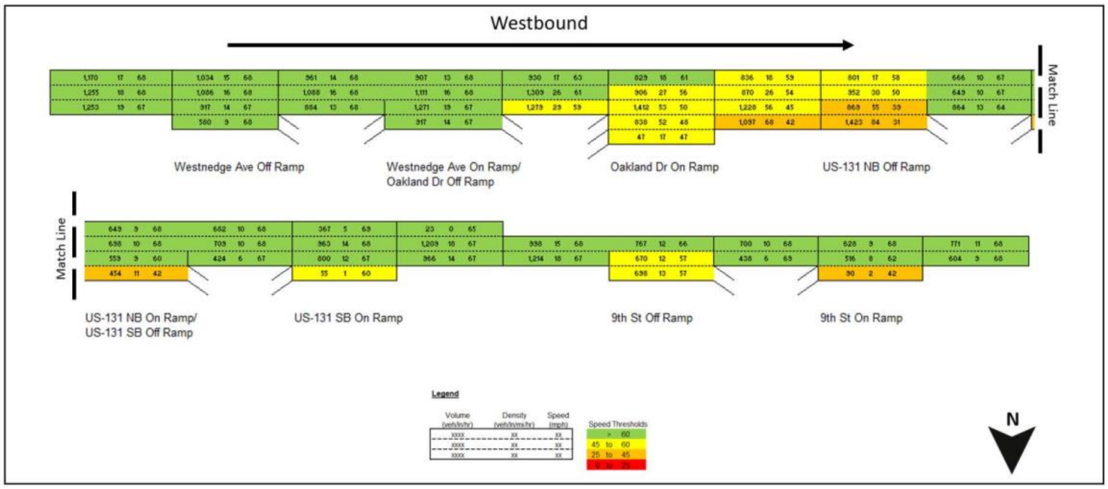
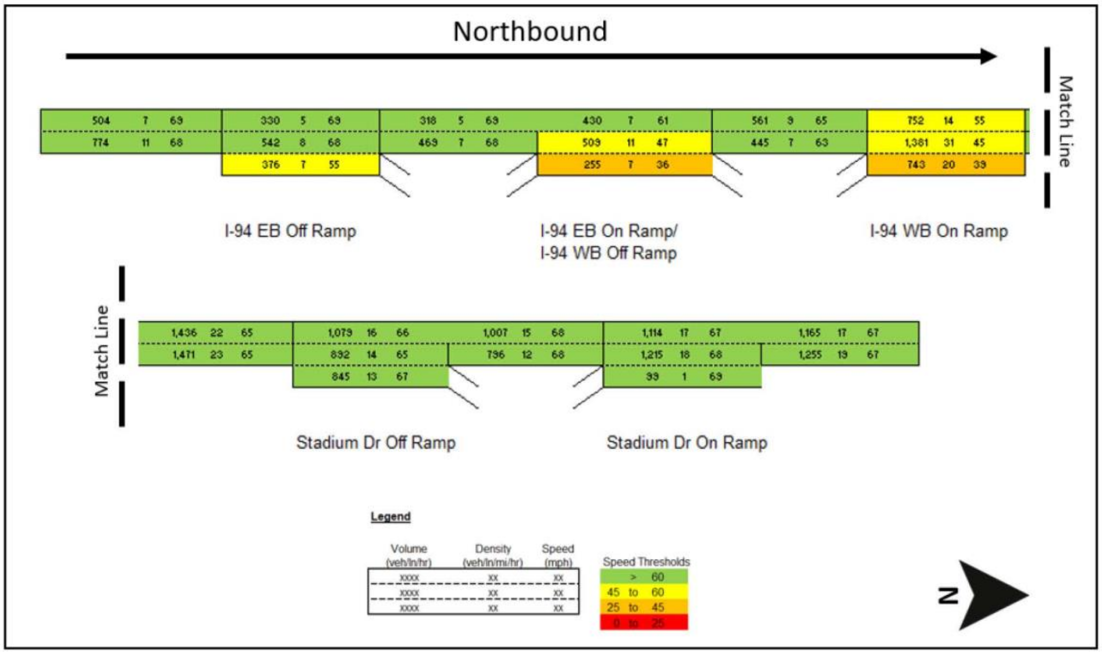


Figure 9. US-131 NB Corridor Lane Schematic



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SURFACE STREET MOES

The intersections within the study area were analyzed to determine the base operational performance of the surface street network. The MOEs used to measure the performance of intersections in this analysis were intersection delay and queue length.

Delay can be converted to a level of service (LOS) benchmark at an individual movement, approach, and an intersection-level. The LOS is a scale-based metric for the amount of experienced delay. The LOS criteria utilized in this analysis are from the *Highway Capacity Manual (2016)* and are displayed in Table 1. LOS D or better are typically considered acceptable in urban areas.

Table 1. Highway Capacity Manual (2016) LOS Thresholds for Signalized Intersections

LOS	Description	Average Control Delay Per Vehicle (s)
A	Operations with very low control delay occurring with favorable progression and/or short cycle lengths.	≤ 10.0
B	Operations with low control delay occurring with good progression and/or short cycle lengths.	> 10.0 and ≤ 20.0
C	Operations with average control delays resulting from fair progression and/or longer cycle lengths. Individual cycle failures begin to appear.	> 20.0 and ≤ 35.0
D	Operations with longer control delays due to a combination of unfavorable progression, long cycle lengths, or high volume-to-capacity ratios. Many vehicles stop and individual cycle failures are noticeable.	> 35.0 and ≤ 55.0
E	Operations with high control delay values indicating poor progression, long cycle lengths, and high volume-to-capacity ratios. Individual cycle failures are frequent occurrences. This is considered the limit of acceptable delay.	> 55.0 and ≤ 80.0

The other surface street MOE considered in this analysis is queue length. The queue length at an approach is related to the congestion experienced, as a longer queue typically means more congestion. For the intersections within the study area, two queue-related MOEs were collected: (1) average queue length and (2) maximum queue length. Each of these parameters were collected during the PM peak hour and averaged over the ten simulation runs.

The surface street MOEs are summarized in Table 2 and Table 3. Table 2 displays the LOS results, while Table 3 contains the queue length information. Note that the results in both tables are averaged over ten simulation runs during the PM peak (4:45 PM to 5:45 PM).

Table 2. Surface Street LOS Results

Intersection	Northbound				Southbound				Eastbound				Westbound				Total
	LT	TH	RT	Approach	LT	TH	RT	Approach	LT	TH	RT	Approach	LT	TH	RT	Approach	
I-94 and Westnedge Ave	E	C	A	C	E	C	A	C	E	NA	C	D	E	NA	B	E	D
I-94 EB and Oakland Dr	NA	C	B	C	C	A	NA	A	D	NA	C	D	NA	NA	NA	NA	B
I-94 WB and Oakland Dr	E	A	NA	B	NA	D	C	C	NA	NA	NA	NA	D	NA	C	D	C

Table 3. Surface Street Queue Results

Intersection	Northbound		Southbound		Eastbound		Westbound	
	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)
I-94 and Westnedge Ave	68	320	53	246	102	416	125	431
I-94 EB and Oakland Dr	170	968	34	413	92	282	NA	NA
I-94 WB and Oakland Dr	31	396	310	1,042	NA	NA	82	301

SUMMARY

WB I-94

Based on the results depicted in Figure 8, most of the congestion on I-94 WB is related to the interchange ramp between I-94 WB and US-131 NB. During the PM peak period, the speeds on the lanes near this diverge are below 35 mph. Additionally, the congestion is focused between the area of the diverge to US-131 NB and the Oakland Dr on ramp, as shown by the various MOEs. This modeled congestion is similar to the congestion that was identified through MDOT feedback, field review, and video observations. This congestion is due to the heavy volume of I-94 WB traffic exiting to US-131 NB during this time period (1,998 during the PM peak hour, which is approximately **47%** of the I-94 WB traffic approaching the system interchange). Outside of this area, few lanes experience significantly reduced speeds due to congestion during the PM peak with the exception of some localized slowing of the WB I-94 weave lane between the US-131 NB on ramp and the US-131 SB off ramp.

NB US-131

Based on the results shown in Figure 9 , there are two locations with reduced speeds on US-131 NB within the study area. As expected, one location with reduced speeds is at the merge of the I-94 WB entrance ramp to US-131 NB. The other segment with reduced speeds is the weave lane between the I-94 EB on ramp and the I-94 WB off ramp.

Oakland Drive Ramp Terminals

The I-94 EB and Oakland Dr intersection has one approach with an LOS D. This approach is the ramp terminal from I-94 EB to the Oakland Dr surface street. The eastbound approach at this intersection has a LOS D for the left-turn movement and an LOS C for the right-turn movement. The other approaches (i.e. northbound and southbound) have an LOS C and LOS A, respectively. Overall, the intersection has an LOS B. Considering the queue analysis, the longest average queue length among all approaches at this intersection is the northbound approach, with an average queue length of 170 ft. This approach also has the greatest maximum queue length at 968 ft.

The I-94 WB and Oakland Dr intersection has similar results to the previous intersection. At this intersection, the ramp terminal is also the approach with an LOS D. Similarly, the left-turn movement has an LOS D and the right-turn movement has an LOS C. The other approaches (i.e. northbound and southbound) have an LOS B and LOS C, respectively. Additionally, the SB through movement has an LOS D at this location. Ultimately, the entire intersection operates at a LOS C. Considering the queue analysis, the results are also similar to the previous intersection, as the longest average queue is 310 ft along the southbound approach. Likewise, the greatest maximum queue length is 1,042 ft for the same approach.

Westnedge Avenue Ramp Terminals

As displayed in Table 2, two of the approaches have a LOS C for the intersection of I-94 and Westnedge Ave. These approaches (i.e. northbound and southbound) have identical LOS results, with a LOS E for the left-turn movement, LOS C for the through movement, and LOS A for the right-turn movement. The eastbound approach has a LOS E for the left-turn movement and a LOS C for the right-turn movement, with a LOS D for the approach. The westbound approach has a LOS E for the left-turn movement and a LOS B for the right-turn movement. This approach has an overall LOS E. As a whole, the intersection has a LOS D. The queue results in Table 3 show that the longest average queue is 125 ft for the westbound approach. This approach also has the longest maximum queue with a length of 431 ft.

APPENDIX E.5: VISSIM Modeling Alternatives Analysis Memo Sample

MEMO

TO: Michelle O'Neill, PE

FROM: Lauren Warren, PE, PTOE; Trevor J. Kirsch, MS, EIT; Matt Hill, PE, PTOE

SUBJECT: Alternatives Analysis Memo

DATE: December 17, 2019

PURPOSE

The intent of this memorandum is to summarize the anticipated performance of the various improvement alternatives at the I-94/US-131 system interchange developed collaboratively with the Michigan Department of Transportation (MDOT), the Kalamazoo Area Transportation Study (KATS), and the City of Portage. The alternatives were all analyzed in VISSIM for a 20-year future forecast (2039) per TSMO funding template requirements. A description of the alternatives follows as well as a summary of the analysis methodology and resulting measures of effectiveness (MOEs) for each alternative model.

ALTERNATIVES

Several improvement alternatives were developed to address the current congestion for the I-94 WB to US-131 NB movement. This operational issues were verified through MDOT feedback, field review, video observation. Based on discussions with local MDOT staff, the congestion is frequent but volatile, as the typical queue length in this area can range from localized slowing to extreme backups which persist along the mainline.

To address this congestion, alternatives ranged from geometric capacity improvements to transportation system management (TSM) strategies such as ramp metering and traffic signal retiming. The alternatives considered in this analysis are outlined in Table 1 and a more detailed description follows.

Table 1. Alternatives Overview

Alternative	Description
0	**No-build**: No changes to the existing roadway network
1	**Two Lane Ramp**: Two lane ramp for I-94 WB to US-131 NB
2	**Auxiliary Lane**: Auxiliary lane on US-131 NB from I-94 WB on ramp to Stadium Dr off ramp
3	**Acceleration Lane Extension**: Acceleration lane extension on US-131 NB from I-94 WB on ramp
4	**Traffic Signal Retiming**: Signal retiming at I-94 EB and Oakland Dr and I-94 WB and Oakland Dr
5	**Ramp Meter Local**: Ramp meter infrastructure at I-94 WB Oakland Dr on ramp
6	**Ramp Meter System**: Ramp meter infrastructure at I-94 WB Oakland Dr on ramp and I-94 WB Westnedge Ave on ramp

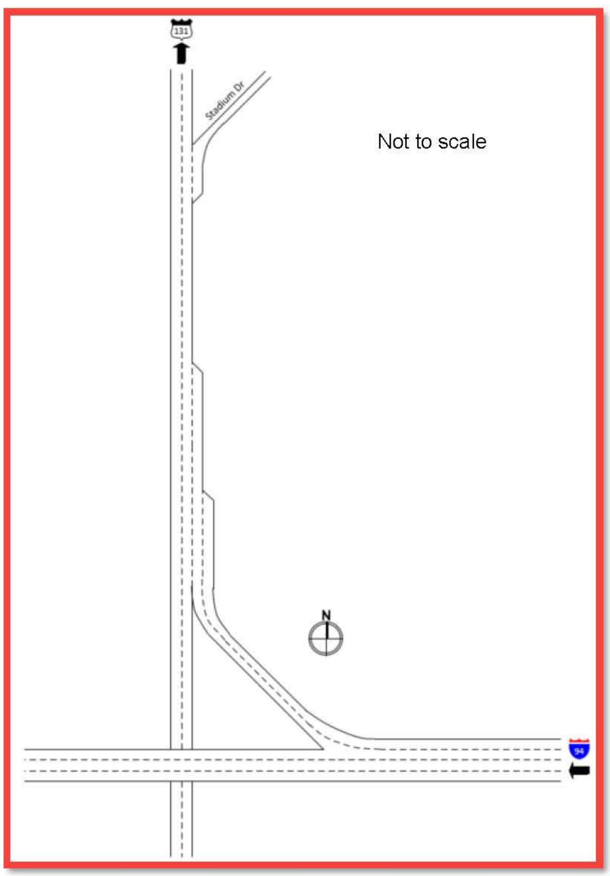
ALTERNATIVE 0: NO-BUILD

Alternative 0 is the No-Build alternative. Under the No-Build alternative, the existing geometry and laneage is assumed for the future year condition. This alternative provides a baseline set of MOEs to compare against the other improvement alternatives.

ALTERNATIVE 1: TWO LANE RAMP

Alternative 1 expands the capacity of the I-94 WB to US-131 NB interchange ramp. Under this alternative, an additional ramp lane would be constructed to increase the ramp laneage from one lane to two lanes. This additional lane would be a shared through/exit lane on the I-94 WB corridor and terminate with two sequential merges on the US-131 NB corridor. To accommodate these merges, the existing US-131 NB mainline lanes will be shifted towards the median and then transitioned back to the original alignment after the sequential merges. The intent of this alternative is to provide additional capacity at the I-94 WB diverge to US-131 NB as well as a lengthened merge area along US-131 NB for this ramp. This alternative is conceptually illustrated in Figure 1.

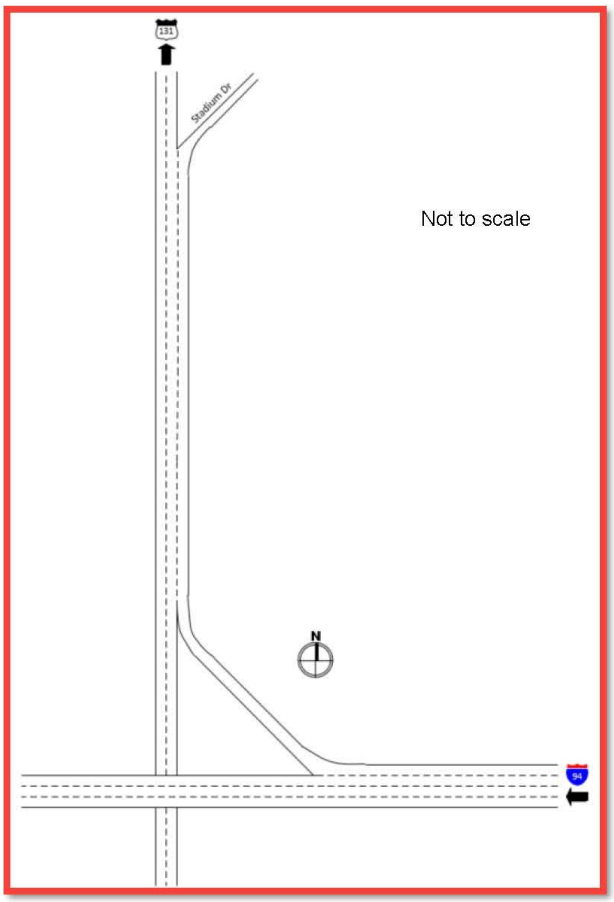
Figure 1. Alternative 1



ALTERNATIVE 2: AUXILIARY LANE

Alternative 2 expands the capacity of the US-131 NB corridor after the I-94 WB on ramp. Under this alternative, an auxiliary lane would be constructed on the US-131 NB corridor between the I-94 WB on ramp and the Stadium Dr off ramp. The intent of this alternative is to reduce the immediate merging behavior of vehicles entering US-131 NB from the I-94 WB on ramp and allowing additional time and space for the merge from I-94 WB to US-131 NB to be completed. Note that this alternative maintains the existing single lane ramp from I-94 WB to US-131 NB. This alternative is conceptually shown in Figure 2.

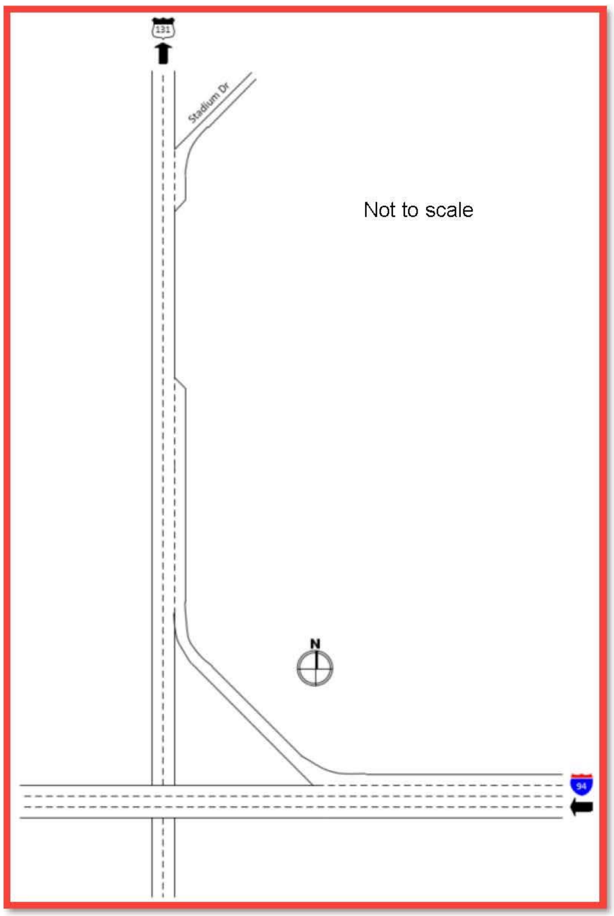
Figure 2. Alternative 2



ALTERNATIVE 3: ACCELERATION LANE EXTENSION

Alternative 3 lengthens the merge area along US-131 NB where the I-94 WB on ramp joins. Under this alternative, the acceleration lane on US-131 NB from the I-94 WB on ramp would be extended about 2,300 ft further than base conditions. The remainder of US-131 NB would remain two lanes after this extension. The intent of this alternative is to reduce the immediate merging behavior of vehicles entering US-131 NB from the I-94 WB on ramp and allowing additional time and space for the merge to be completed. Note that this alternative maintains the existing single lane ramp from I-94 WB to US-131 NB. This alternative is depicted in Figure 3.

Figure 3. Alternative 3



ALTERNATIVE 4: TRAFFIC SIGNAL RETIMING

Alternative 4 optimizes the signal timings at the intersections of the I-94 EB off ramp and Oakland Dr and the I-94 WB off ramp and Oakland Dr. The intent of this alternative is to determine if signal optimization at the Oakland Dr intersections can improve operations along I-94 WB between Oakland Drive and the I-94 WB to US-131 NB ramp.

ALTERNATIVE 5: RAMP METER LOCAL

Alternative 5 is an optimization and infrastructure alternative which optimizes the signal timings at the intersections of the I-94 EB off ramp and Oakland Dr and the I-94 WB off ramp and Oakland Dr. Additionally, ramp meter infrastructure will be included at the I-94 WB Oakland Dr on ramp. The intent of this alternative is to see if TSM strategies such as signal retiming and ramp metering can provide enough gaps in the traffic stream along I-94 WB to better facilitate the weaving operations and reduce congestion along I-94 WB between Oakland Drive and the I-94 WB to US-131 NB ramp.

ALTERNATIVE 6: RAMP METER SYSTEM

Alternative 6 includes ramp meter infrastructure at the I-94 WB Oakland Dr on ramp and the I-94 WB Westnedge Ave on ramp. The intent of this alternative is to see if TSM strategies such as ramp metering can provide enough gaps in the traffic stream along I-94 WB to better facilitate the weaving operations and reduce congestion along I-94 WB between Westnedge Ave and the I-94 WB to US-131 NB ramp.

METHODOLOGY

As mentioned previously, a 2039 future year was established as the desired future year for the alternatives analysis by MDOT. The traffic growth factors to establish future 2039 conditions were provided by MDOT's Planning Department and were applied to the calibrated and validated base condition model to grow the traffic volumes to anticipated 2039 conditions and create the No-Build model (Alternative 0). Table 2 contains the growth factors that were utilized for this analysis:

Table 2. Future Condition Growth Factors

Facility	Growth (%)
I-94 WB	12.3
US-131 NB	8.7
All Others	2

Note: Growth reported is total growth from 2019 to 2039

Figure 4 through Figure 8 illustrate the anticipated traffic volumes for the year 2039 within the study area for the PM peak hour (4:45pm – 5:45pm). Note that all traffic volumes within these figures are directional in nature.

Figure 4. Westnedge Ave Volume Exhibit

Figure 5. Oakland Dr Volume Exhibit

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Figure 6. I-94 and US-131 Interchange Volume Exhibit

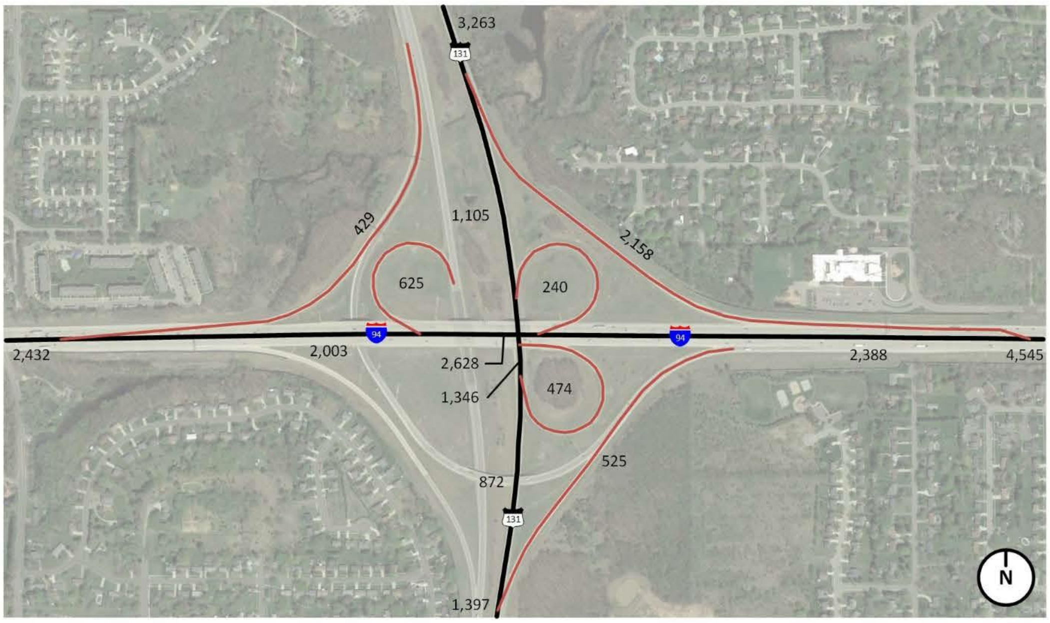


Figure 7. 9th Street Volume Exhibit

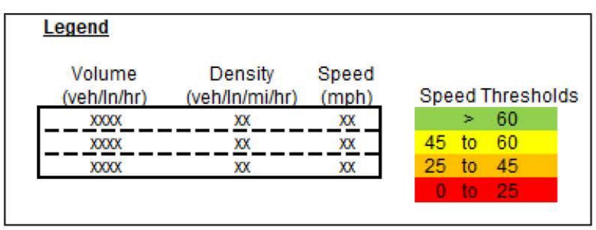
Figure 8. Stadium Dr Volume Exhibit

The No-Build model was then modified either geometrically, operationally, or both to create the models for the subsequent improvement alternatives (Alternatives 1 through 6). MOEs reported for each alternative are based on the average of 10 iterations using different random number seeds, consistent with the base conditions MOE summaries.

MEASURES OF EFFECTIVENESS

Following the completion of the ten simulation runs for each alternative model, lane schematics were created for both the I-94 WB corridor and the US-131 NB corridor for each alternative. The lane schematics depict various MOEs, including volume (vehicle throughput), density, and speed per lane. Figure 9 contains a legend that depicts the layout of the MOEs for each lane segment, the units for each MOE, and how the segments are color coded:

Figure 9. Lane Schematic Legend



Note that the results displayed for the following schematics are averaged over ten simulation runs and include MOEs during the PM peak period (4:45 PM to 5:45 PM). Figure 10 and Figure 11 contain the lane schematics for both corridors for all the alternatives and a brief summary of these results follows.

Figure 10: All Alternative I-94 WB Lane Schematics

Figure 11. All Alternative US-131 NB Lane Schematics

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ALTERNATIVE 0: NO-BUILD (NOT RECOMMENDED)

- The congestion along the I-94 WB corridor is expected to worsen significantly during the PM peak period under future conditions with regular queuing in all lanes along I-94 WB from the diverge to US-131 NB to Westnedge Ave.
- The two locations with localized speed reductions along US-131 NB are the weave area between the I-94 EB on ramp and the I-94 WB off ramp, as well as the merge area for the I-94 WB on ramp. These results are consistent with existing conditions.

ALTERNATIVE 1: TWO LANE RAMP (RECOMMENDED)

- This alternative reduces the weaving required between I-94 WB mainline motorists and Oakland Dr on ramp motorists and allows for smoother merging behavior in this area. The two lanes for the system interchange also do not experience the capacity restrictions that are present in the other alternatives.
- As shown in the lane schematics, the major bottleneck congestion along I-94 WB to US-131 NB is alleviated with this alternative.
- The two locations with localized speed reductions along US-131 NB are the weave area between the I-94 EB on ramp and the I-94 WB off ramp, as well as the merge area for the I-94 WB on ramp. Both of these localized speed reductions are expected due to the geometrics.

ALTERNATIVE 2: AUXILIARY LANE (NOT RECOMMENDED AT THIS TIME)

- Alternative 2 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that a capacity improvement or TSM strategy is necessary along I-94 WB for any improvement in congestion to be realized.
- Alternative 2 provided some improvement to the localized speed reduction along US-131 NB where I-94 WB entered, but this improvement of providing an auxiliary lane along US-131 NB is not anticipated to alleviate the current congestion along I-94 WB from the diverge to US-131 NB.

ALTERNATIVE 3: ACCELERATION LANE EXTENSION (NOT RECOMMENDED AT THIS TIME)

- Alternative 3 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that a capacity improvement or TSM strategy is necessary along I-94 WB for any improvement in congestion to be realized.
- Alternative 3 provided some improvement to the localized speed reduction along US-131 NB where I-94 WB entered, but this improvement of providing a longer acceleration lane along US-131 NB is not anticipated to alleviate the current congestion along I-94 WB from the diverge to US-131 NB.

ALTERNATIVE 4: TRAFFIC SIGNAL RETIMING (NOT RECOMMENDED AT THIS TIME)

- Alternative 4 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that signal timing adjustments alone at the Oakland Dr. interchange are not expected to significantly reduce congestion along I-94 WB.
- Alternative 4 congestion along the US-131 NB corridor is expected to be similar to the No-Build.

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ALTERNATIVE 5: RAMP METER LOCAL (NOT RECOMMENDED AT THIS TIME)

- Alternative 5 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that ramp metering alone at the Oakland Dr. WB on ramp is not expected to significantly reduce congestion along I-94 WB.
- Alternative 5 congestion along the US-131 NB corridor is expected to be similar to the No-Build.

ALTERNATIVE 6: RAMP METER SYSTEM (NOT RECOMMENDED AT THIS TIME)

- Alternative 6 congestion along the I-94 WB corridor is expected to be similar to the No-Build, indicating that ramp metering alone at the Oakland Dr. WB on ramp and the Westnedge Ave. WB on ramp are not expected to significantly reduce congestion along I-94 WB.
- Alternative 4 congestion along the US-131 NB corridor is expected to be similar to the No-Build.

Based on these results, it is recommended that **Alternative 1** be considered for future implementation. This alternative is the only alternative analyzed which improves the future condition MOEs for both the I-94 WB corridor and the US-131 NB corridor. All other considered alternatives have similar congestion along I-94 WB to the No-Build. The surface street intersection LOS and queue summaries for Alternative 1 are included in Table 3 and Table 4, respectively. Signal timing adjustments are anticipated to alleviate the failing LOS F (anticipated in 2039) for the westbound left-turn at the Westnedge Avenue interchange but were not incorporated into the modeling since the queuing on this approach was not spilling back and impacting mainline I-94.

Table 3. Alternative 1 LOS Results

Intersection	Northbound				Southbound				Eastbound				Westbound				Total
	LT	TH	RT	Approach	LT	TH	RT	Approach	LT	TH	RT	Approach	LT	TH	RT	Approach	
I-94 and Westnedge Ave	E	C	A	C	E	C	A	C	E	NA	C	D	F	NA	B	F	D
I-94 EB and Oakland Dr	NA	C	B	C	C	A	NA	A	D	NA	C	D	NA	NA	NA	NA	C
I-94 WB and Oakland Dr	E	A	NA	B	NA	D	D	D	NA	NA	NA	NA	D	NA	C	D	C

Table 4. Alternative 1 Queue Results

Intersection	Northbound		Southbound		Eastbound		Westbound	
	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)	Average (ft)	Maximum (ft)
I-94 and Westnedge Ave	72	333	53	245	108	424	229	823
I-94 EB and Oakland Dr	227	1,091	39	439	93	291	NA	NA
I-94 WB and Oakland Dr	33	363	443	1,047	NA	NA	88	313

ADDITIONAL ANALYSES

Following a meeting with MDOT, additional analyses were recommended. The recommended analyses were as follows:

1. **Base Condition Ramp Metering**: Establish the performance of the base condition model with ramp meter infrastructure at the I-94 WB Oakland Dr on ramp.
2. **Sensitivity Analysis**: Perform a sensitivity analysis on the preferred (recommended) alternative.
3. **I-94 WB Inside Lane Drop**: Determine if the inside lane drop on the I-94 WB mainline has a negative impact on traffic operations.

The additional analyses were performed, and the results are discussed in detail in the following sections.

BASE CONDITION RAMP METERING

This analysis was to incorporate ramp metering into the base conditions model at the I-94 WB Oakland Dr on ramp. The intent of this analysis is to determine if adding ramp meter infrastructure to the existing conditions would create better performance at the area of interest as a low-cost interim improvement until a second lane can be constructed for the I-94 WB to US-131 NB ramp. The previous base condition model was altered to include ramp meter infrastructure at the I-94 WB Oakland Dr on ramp. Like the previous alternative models, ten simulation runs were completed to ensure that all reasonable variability was captured in the resultant MOEs. Following these runs, lane schematics were generated to compare the MOEs with the original base conditions. Figure 12 contains the lane schematics for the I-94 WB corridor, while Figure 13 depicts the lane schematics for the US-131 NB corridor.

Figure 12: Base Condition Ramp Metering I-94 WB Lane Schematics

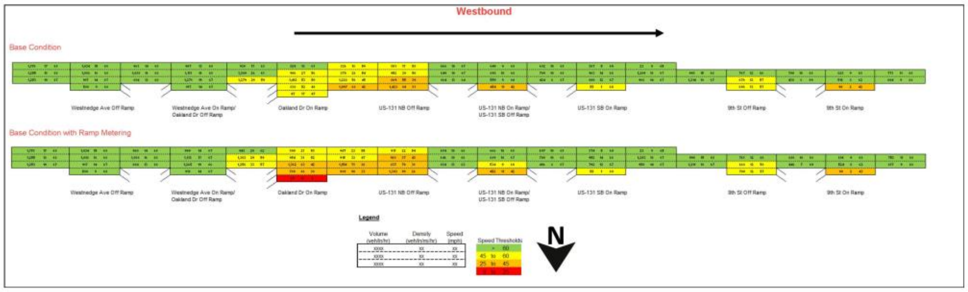
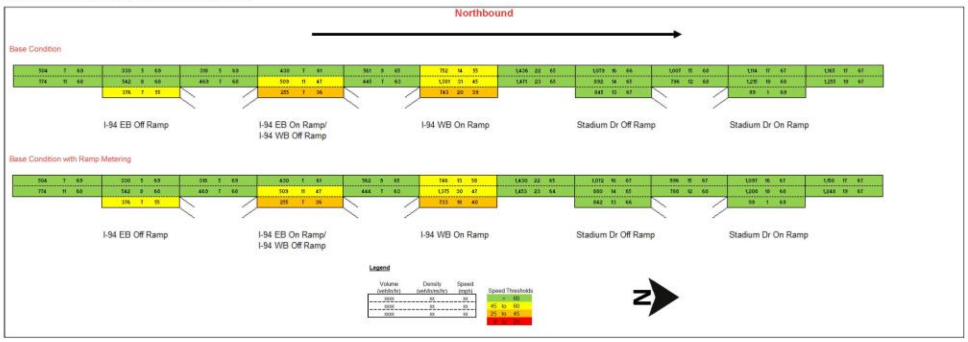


Figure 13: Base Condition Ramp Metering US-131 NB Lane Schematics



Based on the resultant lane schematics, adding ramp meter infrastructure to the I-94 WB Oakland Dr on ramp does not result in a benefit to the base condition operations. Comparing the I-94 WB base condition lane schematic with the base conditions with ramp metering lane schematic (Figure 12), the Oakland Dr on ramp experiences lower speeds when the ramp meter infrastructure is implemented. This may be due to the location of the ramp meter infrastructure. The ramp meter is placed approximately 650 ft. upstream of the subsequent merge point. This placement ensures that any ramp meter queueing does not exceed the ramps capacity and impact the signal operations at the upstream intersection. However, the trade-off with this placement is that the acceleration distance is reduced for vehicles entering the interstate system. This distance reduction is likely the cause of the reduced speeds documented in the lane schematics. Also, it seems that the ramp metering infrastructure is not impactful on the downstream congestion at the I-94 WB diverge to US-131 NB, as both lane schematics depict similar results. As expected, the ramp meter infrastructure at the I-94 WB Oakland Dr on ramp did not have any significant impact on the US-131 NB corridor, as the performance between the base conditions and the base conditions with ramp metering (Figure 13) is similar. Because of this, it is not recommended to install ramp meter infrastructure at the I-94 WB Oakland Dr on ramp as an interim improvement.

SENSITIVITY ANALYSIS

The intent of this analysis is to determine the robustness of the preferred alternative by adding additional artificial traffic volume to the study area until the modeled performance of the alternative becomes unacceptable. In other words, the sensitivity analysis will estimate the amount of traffic growth the preferred alternative can handle before operations begin to deteriorate significantly.

The sensitivity analysis was performed on Alternative 1, as this is the preferred alternative. To test the robustness of the microsimulation model, the traffic volumes on the mainline corridors (i.e. I-94 WB and US-131 NB) were increased in 5% increments for each consecutive simulation run. Each of these simulation runs was viewed for qualitative performance, with specific attention directed toward queue length and congestion. Ultimately, the sensitivity analysis determined that the preferred alternative (Alternative 1) can handle approximately a **30% increase** in traffic volume (from existing 2019 traffic volumes) before some localized congestion starts to form again at the I-94 WB to US-131 NB diverge along I-94 and subsequent merge along US-131. Current forecasts provided by MDOT indicate an anticipated total growth of approximately 12.3% along I-94 WB and 8.7% along US-131 NB in the next 20 years (2039). Lane schematics results are displayed in Figure 14 and Figure 15.

Figure 14. Sensitivity Analysis I-94 WB Lane Schematics

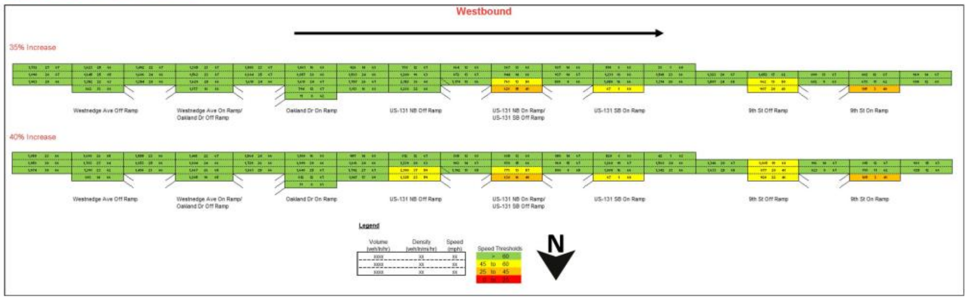
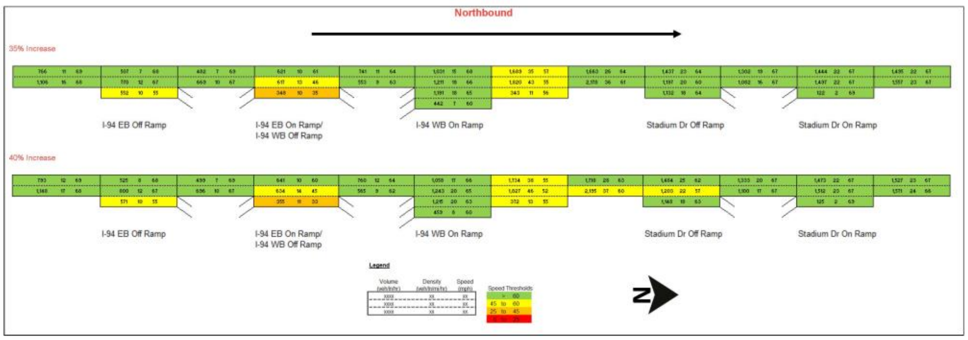


Figure 15. Sensitivity Analysis US-131 NB Lane Schematic



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I-94 WB INSIDE LANE DROP

This analysis was to determine if the inside lane drop on I-94 WB mainline results in a negative impact on traffic operations. The lane drop of concern is on I-94 WB immediately after the US-131 SB on ramp. While the traffic from the on ramp is merging from the right onto a three-lane roadway, the inside lane begins to drop before this merge is completed, ultimately ending in a two-lane roadway after both merges. The concern in this area is that the merge maneuvers create negative impacts on traffic operations as traffic merges from both sides of the roadway simultaneously.

The lane schematics of the preferred alternative (Alternative 1) were reviewed to see if the resultant MOEs indicated any negative impacts from the inside lane drop at this location. Based on the results in Figure 10, the inside lane drop did not show any significant negative impact on any of the MOEs based on the simulation model. Field review indicated that typically free-flow speeds can be maintained through this area during the PM peak period, but there are frequent instances of slow downs and point congestion from merging behavior that is able to recover quickly. The inside lane drop within the same influence area of the outside lane drop may be more of a safety concern than an operational concern, and subsequent analysis may be better through a safety lens to determine if alternatives should be considered in this area. Suggested analyses could include a review of existing crash data, a “Near Miss” analysis using video analytics to determine if there is an above normal risk for crashes because of the current geometrics, or a Surrogate Safety Assessment Model (SSAM) that would utilize the microsimulation modeling results to review individual vehicle trajectories and statistically quantify safety risk in this area.