MEMO

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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.

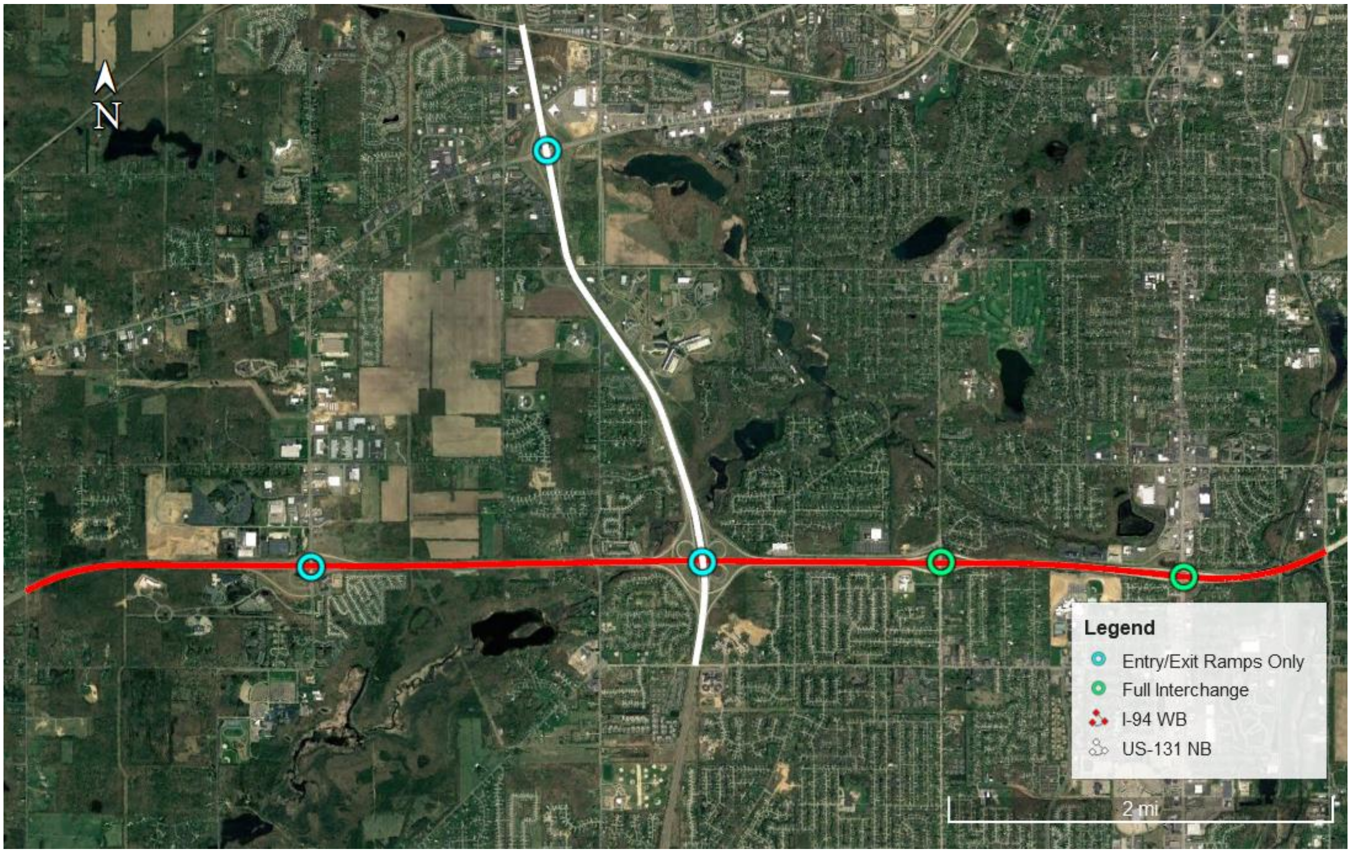
Figure 1. Proposed I-94/US-131 Operations Study Modeling Workflow

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

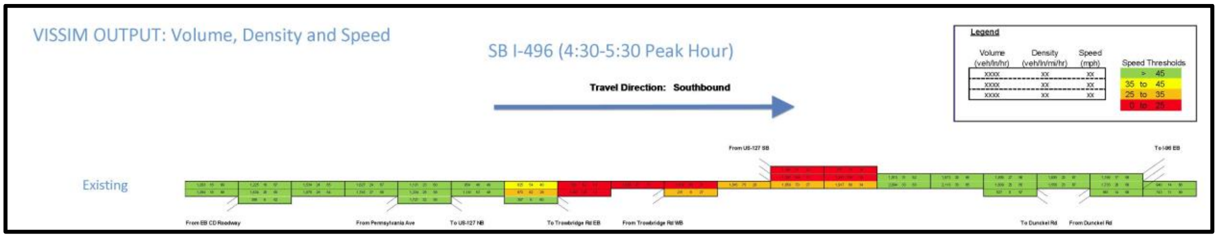
Freeway MOEs

- 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 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

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