Appendix D: Microsimulation Memos

Appendix D includes two memos detailing the microsimulation model development and application for the Interstate Operations Study.

- TransModeler Microsimulation Methodology & Calibration Memo
- Microsimulation Application & Results Memo

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TransModeler Methodology & Calibration Memo

Interstate Operations Study & Plan for Future Improvements

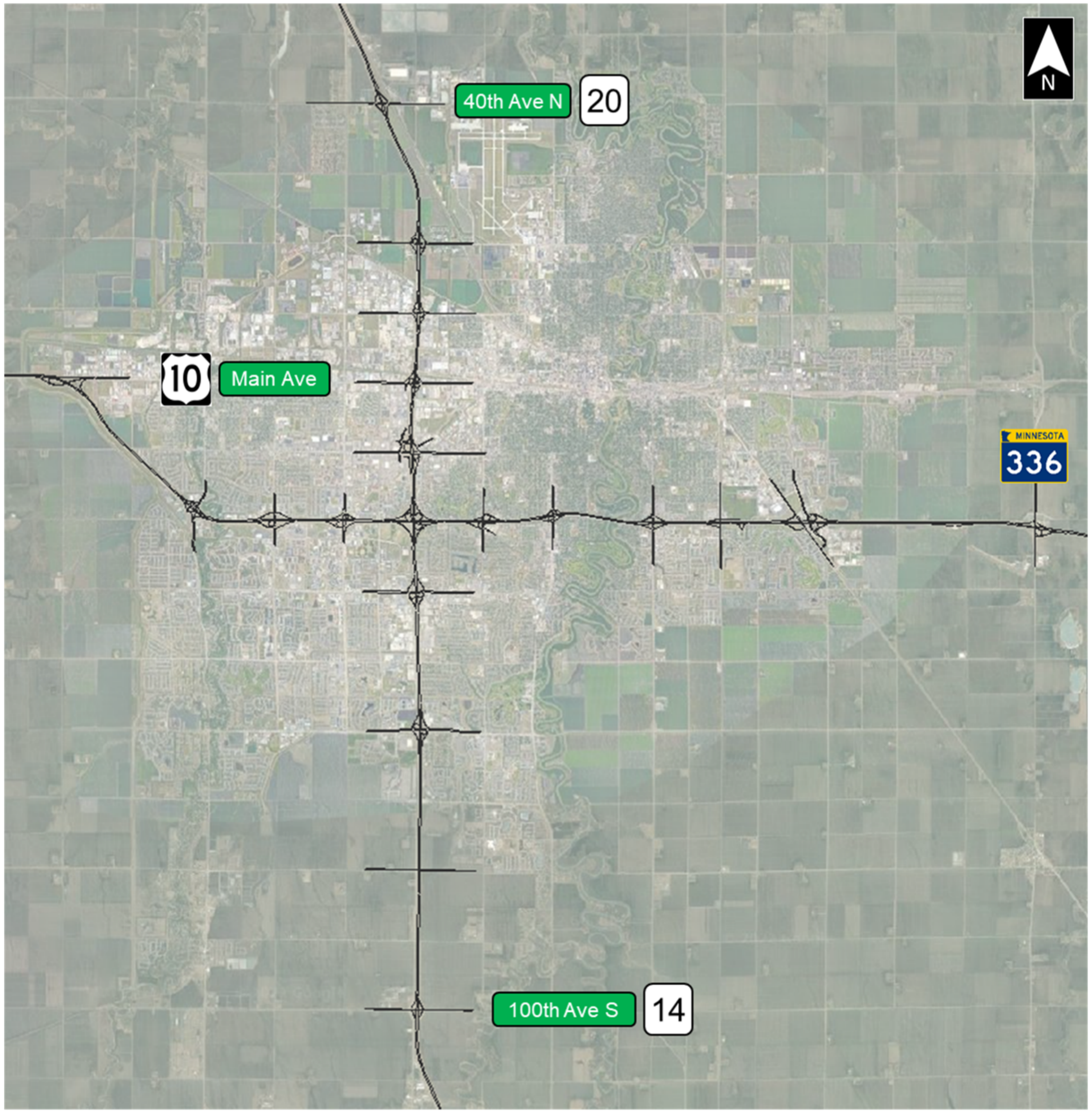
August 2022

Introduction

This memo details the development and calibration of the microsimulation model for the Interstate Operations Analysis and Plan for Future Improvements. The microsimulation model was developed utilizing Caliper's TransModeler Traffic Simulation Software Version 6.0. The study area for the microsimulation model is shown on the right. It is located in the Fargo-Moorhead Metropolitan Area and is defined by the following limits:

- Interstate 94
  - West Limit: West of Main Ave
  - East Limit: East of Minnesota 336
- Interstate 29
  - North Limit: North of 40th Ave N / Cass County 20
  - South Limit: South of 100th Avenue S / Cass County 14

The study area includes Interstate mainline segments, system ramps, service ramps, rest areas, and ramp terminal intersections along I-29 and I-94.



Model Development

Network

Roadway Network

The roadway network of interstates, ramps, and intersections were drawn using Google satellite imagery. Acceleration, deceleration, and turn bay lengths were coded to match satellite imagery. Appropriate roadway classifications and speeds were coded onto the network.

Traffic Control

Traffic control was added at intersections where stop, yield, and signalized conditions are present. The study team reviewed available signal timing plans to establish planning level signal timing cycle lengths, clearance intervals, and minimum green times. Google Streetview was used to determine intersection phasing (i.e. permitted / protected lefts, overlaps, right-turn-on-red, etc).

Demand

Existing Traffic Demand

Traffic data were collected from the following sources:

- Miovision Counts (Fall 2021)
- MetroCOG Interstate Counts
- NDDOT Interstate Counts
- Automatic Traffic Recorder Counts

Existing and Future traffic flowmaps were developed for the AM and PM peak periods. These demand sets were coded into the microsimulation model as demand "targets" for model calibration.

Origin & Destination (OD) Data

StreetLight data were collected from MetroCOG's StreetLight data subscription. This data was used to develop seed matrices for AM and PM peak periods for OD-Matrix-Estimation (ODME). StreetLight zones were coded at all entry and exit nodes in the microsimulation model, creating a "closed" OD system to develop seed matrices.

Origin Destination Matrix Estimation

The study team utilized ODME to develop the base year and future year demand sets. ODME is a procedure that takes a seed matrix (i.e. StreetLight) and modifies the matrix to match measured traffic demand coded into the microsimulation network (i.e. Miovision counts, MetroCOG counts, NDDOT counts, etc).

The study team used TransModeler's built in ODME tool to develop the existing and future demand sets. Link weights were used to give priority to matching Interstate and ramp demand. Value change constraints were also used to restrict the amount the original OD demand can change, preserving the trip lengths in the model.

Utilizing both Streetlight and existing traffic count data sources reduces the amount of error that can occur by using a single data source, resulting in a more well calibrated demand set.

Model Calibration

Parameters

Microsimulation parameters were changed globally in TransModeler to reflect local conditions. The following parameters were modified from defaults:

- Vehicle Fleet: The mix of cars, trucks, and heavy trucks were modified to match local traffic data

Vehicle Type	Default	Modified
Low Performance Passenger Cars	12%	12%
Medium Performance Passenger Cars	48%	25%
High Performance Passenger Cars	12%	6%
Pickup Trucks, Vans, SUVs	20.2%	50%
Single-Unit Trucks	3.2%	3%
Tractor-Trailer Trucks (Semis)	1%	4%
Bus	0.3%	-
Motorcycle	3.3%	-

- Lane Changing
  - Mandatory Lane Changing (MLC): MLC refers to the upstream distance that vehicles get into a specific lane to follow their desired path (i.e. exit the Interstate). The MLC distribution was increased to emulate the desire to get into a specific lane a farther distance upstream.
  - Discretionary Lane Changing (DLC): DLC refers to the willingness to use an adjacent lane to pass a vehicle if their desired speeds are different. The DLC constant was modified to reduce the amount of lane changing to pass slower moving vehicles or trucks that may be in front of the user.
- Headway Buffers: Headway buffers refer to the additional gap that a driver will maintain to the vehicle in front of them. The headway buffer for all users were increased to reduce the capacity of the Interstate system to match probe data speed targets.
- Speed Distribution: Excessive speeding parameters were reduced to remove desired speeds of 20+ mph which do not typically occur during peak hours in urban areas.

- Demand Curves: 15-minute demand curves were developed to match the peaking characteristics of the AM and PM peak periods. These curves were adjusted to match demand targets and probe data speed targets.
- Lane Connectivity: Lane connectivity throughout the model is defaulted to 1.0. In areas where users will shy away from a lane since it is dropped downstream, connectivity was reduced to reflect the lane utilization at drop lane locations.

Note that parameter makers were used in select areas to fine-tune areas of the model that were not fully calibrated using global parameter adjustments. These adjustments focused on headway buffers and lane changing parameters at select locations.

Simulated Volume vs Demand Targets

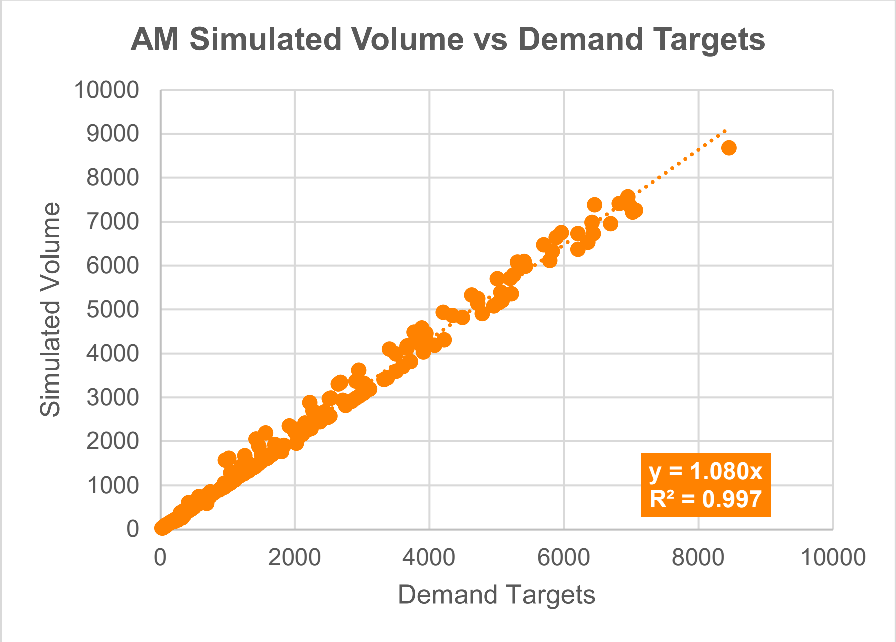
Results for the goodness-of-fit of simulated volume vs demand targets is shown on the right. Volumes that were collected through MetroCOG's count program and this study's data collection efforts at all service and system interchanges in the study area were used to developed an AM and PM 2-hour demand set. Once ODME was complete, the final demand set was run through a 2-hour simulation to calculate goodness-of-fit.

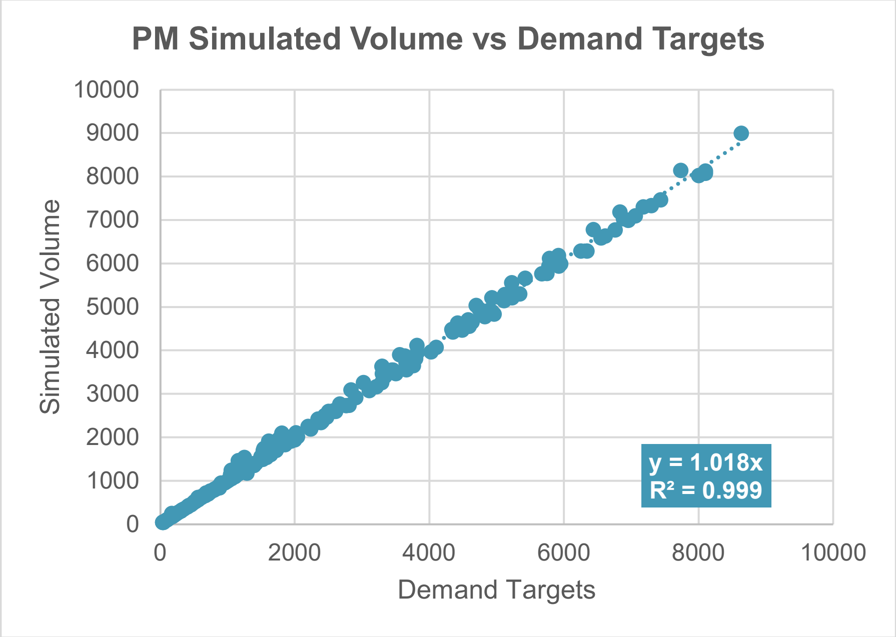
The AM and PM graphs include all mainline and ramp directional segments within the mircrosimulation study area shown in **Page 1**. Note that the slope of the AM and PM graphs are very close to 1 which indicates that the overall simulated volume is not above or below the input demand volumes.

Simulated Speeds vs Probe Data Speeds (NPMRDS)

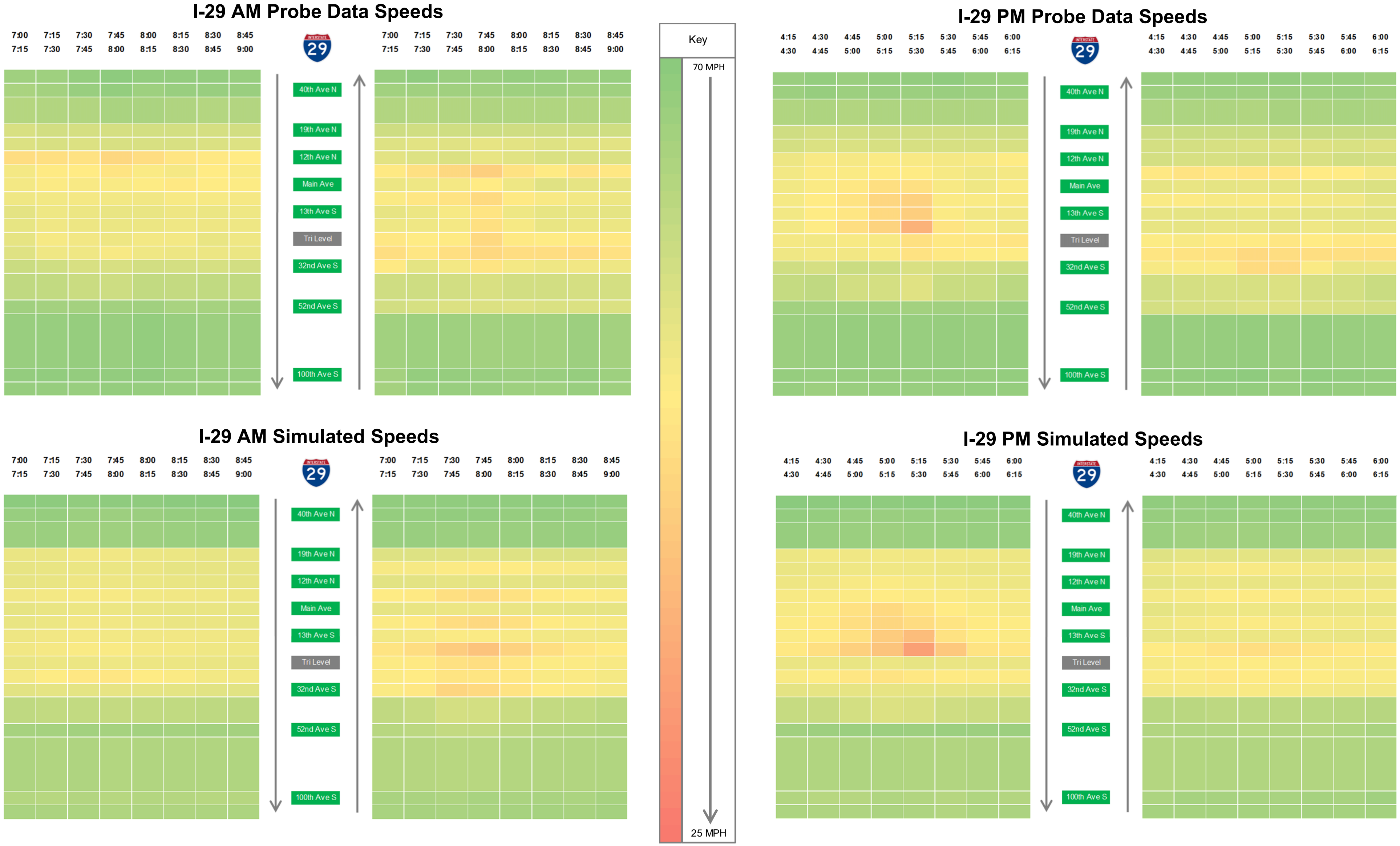
Another main component of a calibrated system-wide simulation model is speed and travel time data comparisons. **Page 4** and **Page 5** include the comparison of simulated speeds from TransModeler to probe data speeds collected from the National Performance Management Research Data Set.

Comparisons were developed at the 15-minute time slice to calibrate to the reduction in speed on various Interstate segments and to match the duration of congestion throughout the study area.



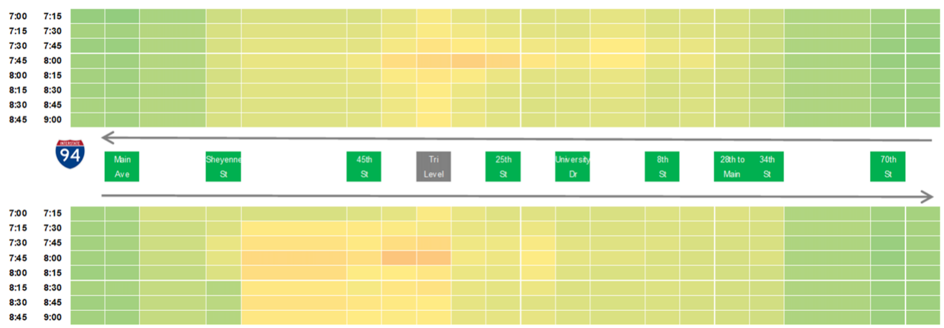


Congestion on I-29 is concentrated between 12th Avenue N and I-94. Probe data speed slowdowns were emulated in the microsimulation model through demand peaking and other various parameter changes mentioned on **Page 2**.

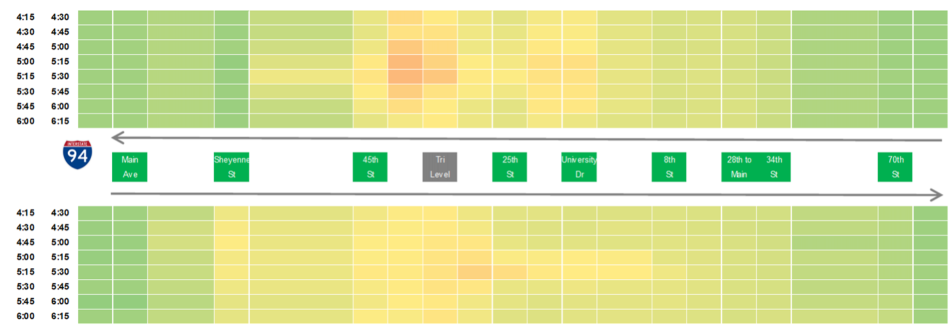


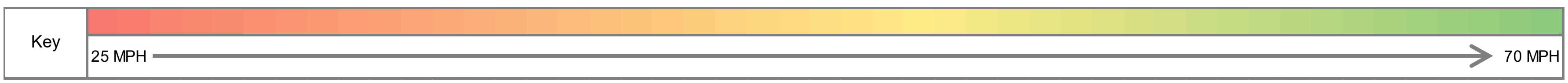
Congestion on I-94 is concentrated around the I-29 interchange during the AM and PM peak hour. Heavy weaving movements between the system and service interchanges cause these slowdowns of 10-20 mph. These slowdowns were emulated to match the weaving conditions and duration of congestion. A good example of this calibration effort is the comparison of westbound PM speeds between I-29 and 45th Street.

I-94 AM Probe Data Speeds



I-94 PM Probe Data Speeds



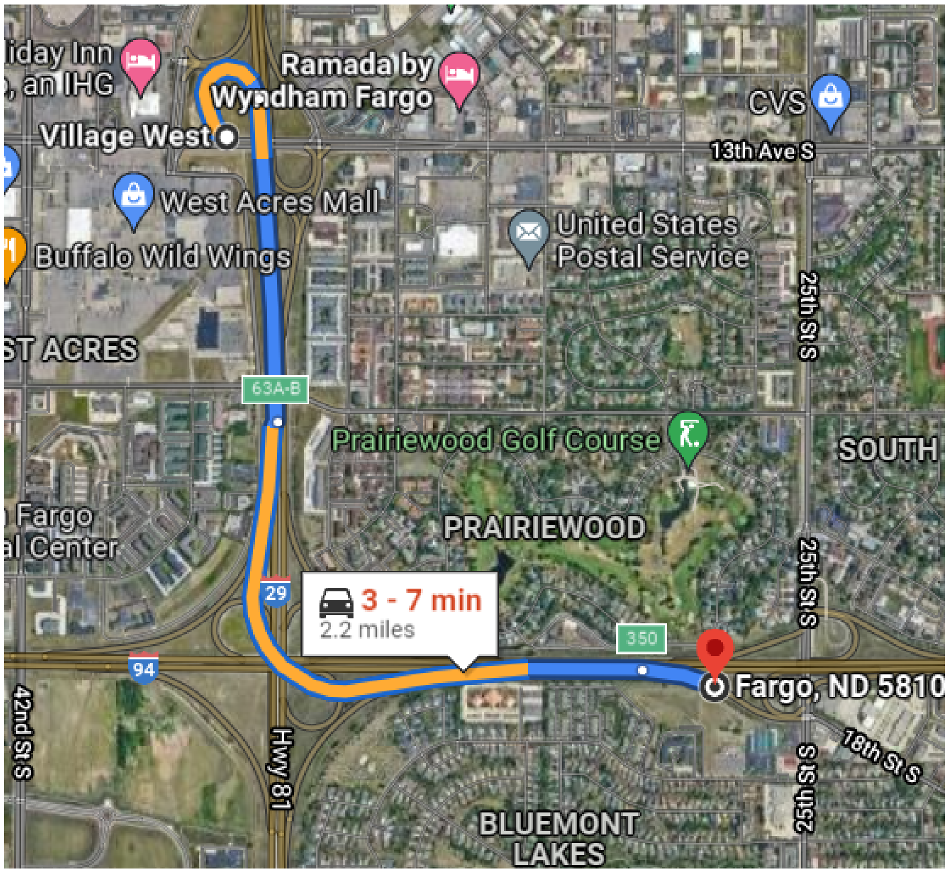


I-94 PM Simulated Speeds

I-94 PM Simulated Speeds

Other Checks & Local Knowledge
A calibration check was performed between 13th Avenue S and 25th Street. A comparison between TransModeler congested travel times and Google Maps typical weekday congestion travel times is shown below. Google Maps shows some approximate travel times with more variability in orange. Variability is shown during later intervals during the PM period on weekdays.

- Simulated Travel Times Range:
  - 4 – 7 minutes
- Google Maps Travel Time Range:
  - 3 – 7 minutes



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Microsimulation Application & Results Memo

Interstate Operations Study & Plan for Future Improvements

June 2023

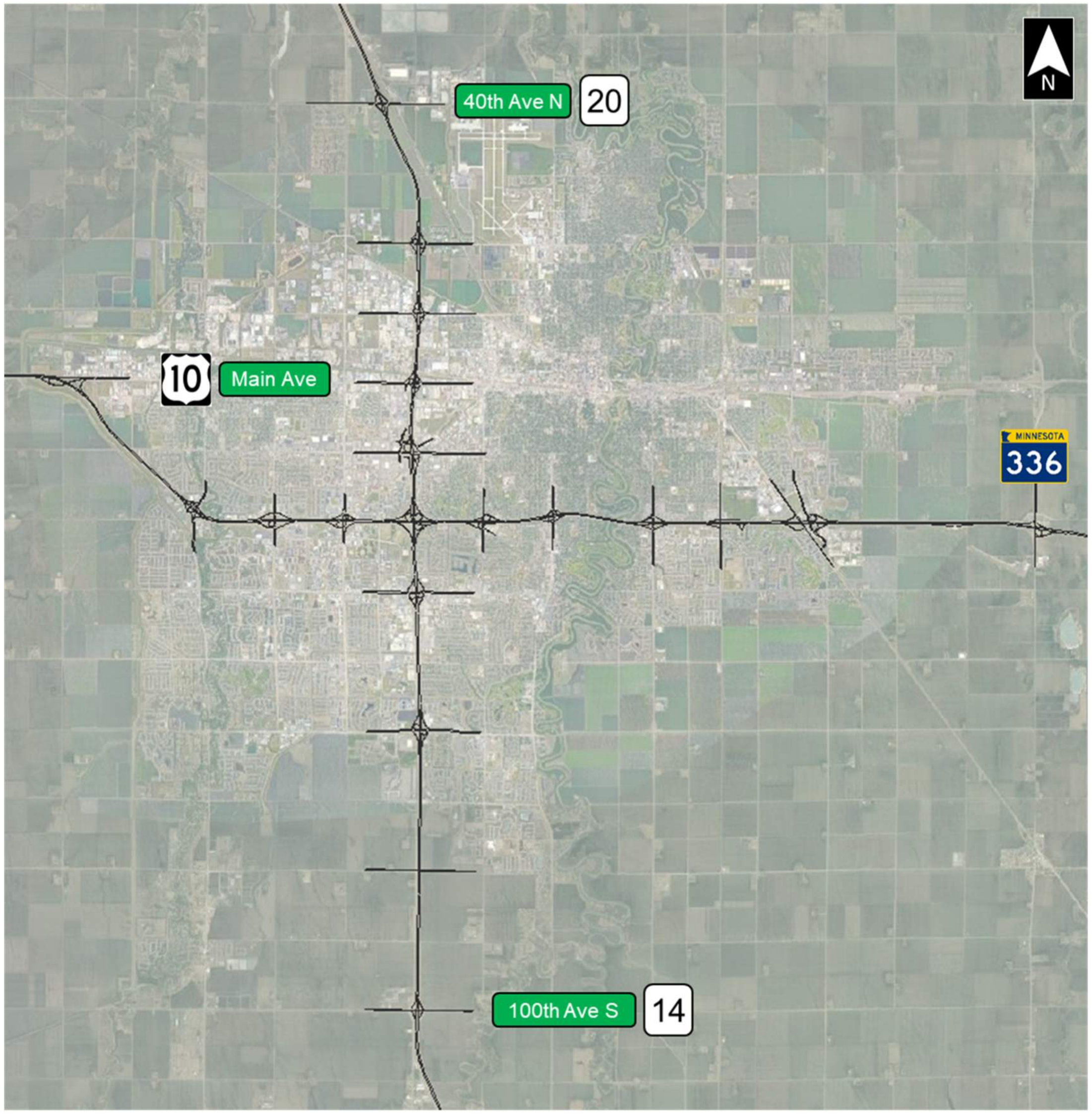
Introduction

This memo details the microsimulation modeling efforts for the Interstate Operations Study. The study area for the microsimulation model is shown on the right. It is located in the Fargo-Moorhead Metropolitan Area and is defined by the following limits:

- Interstate 94
  - West Limit: West of Main Ave
  - East Limit: East of Minnesota 336
- Interstate 29
  - North Limit: North of 40th Ave N / Cass County 20
  - South Limit: South of 100th Avenue S / Cass County 14

The study area, shown in **Figure 1**, includes Interstate mainline segments, system ramps, service ramps, rest areas, and ramp terminal intersections along I-29 and I-94.

Figure 1. Microsimulation Study Area



Model Development

Future Demand

AM and PM peak period demand was developed for the base year (2021) and future year (2045). The study team used TransModeler's built in ODME tool to develop the future demand sets. Link weights were used to give priority to matching Interstate and ramp demand. Value change constraints were also used to restrict the amount the original OD demand can change, preserving the trip lengths in the model.

In a microsimulation model, bottlenecks that occur along the Interstate system or Ramp Terminal intersections will propagate throughout the model causing gridlock depending on the total input demand. Because of this, the study team developed a series of interim year demand sets via interpolation between 2021 and 2045 Origin-Destination matrices. Strategies discussed later in this memo were tested with a variety of interim year demand sets to limit gridlock scenarios that would skew results.

Strategy Development

Model coding for strategy development was split into two distinct phases during the IOS: Initial Strategy Development & Refined Implementation Strategies

Initial Strategy Development

Several microsimulation models were developed to test the effectiveness of the initial geometric strategies identified during the Strategy Development and Analysis SRC meetings in May and September 2022. These two meetings established the geometric improvements that were coded in microsimulation to test their effectiveness. The following models were developed in TransModeler:

- No-Build
- Near- & Mid-Term Projects – shown in **Figure 2**
- Long-Term Options – shown in **Figure 3**
  - With Collector-Distributor Roads – Shown in **Figure 4**
  - With Braided Ramps (Full & Partial) – Shown in **Figure 5** & **Figure 6**

Refined Implementation Strategies

Following the SRC meeting in September 2022, the study team met with various agencies to modify and add strategies based on the initial strategy development results discussed later in this memo. These adjustments included additional geometric and TSMO strategies that aligned with major upcoming reconstruction activities within the metro area. The following models were developed for the implementation strategies:

- Near-Term Implementation Strategies – shown in **Figure 7**
- Mid-Term Implementation Strategies – shown in **Figure 8**
- Long-Term Implementation Strategies – shown in **Figure 9**

Note that some improvement strategies (TSMO and service interchange expansions) were not coded in the microsimulation model for various reasons. Details on model specifics can be found in the Appendix.

Figure 2. Near- & Mid-Term Projects

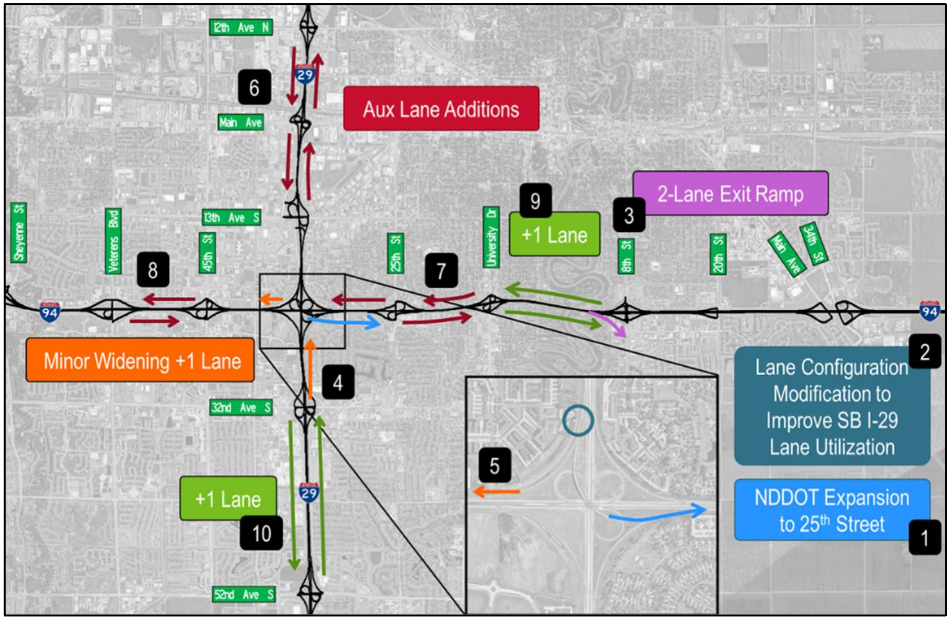


Figure 3. Long-Term Projects

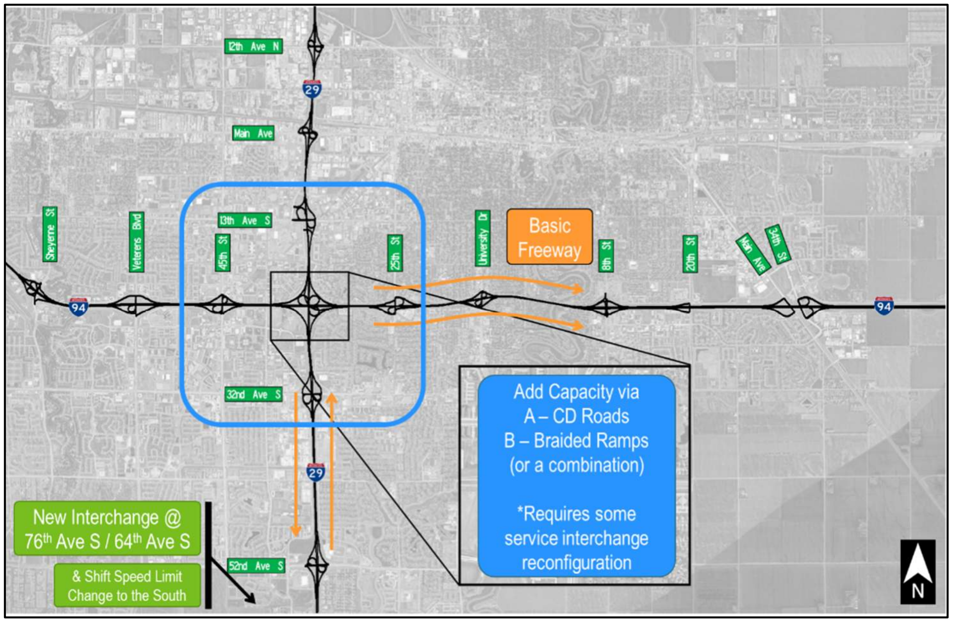


Figure 4. Collector-Distributor Roads

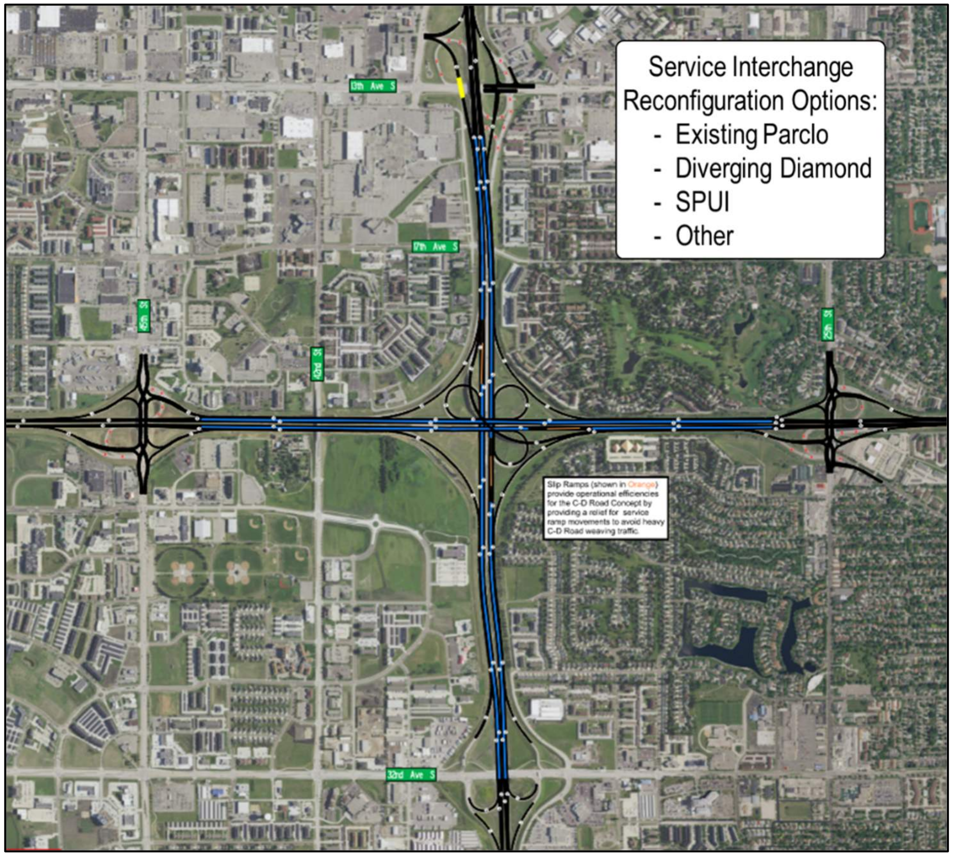


Figure 5. Braided Ramps (Full)

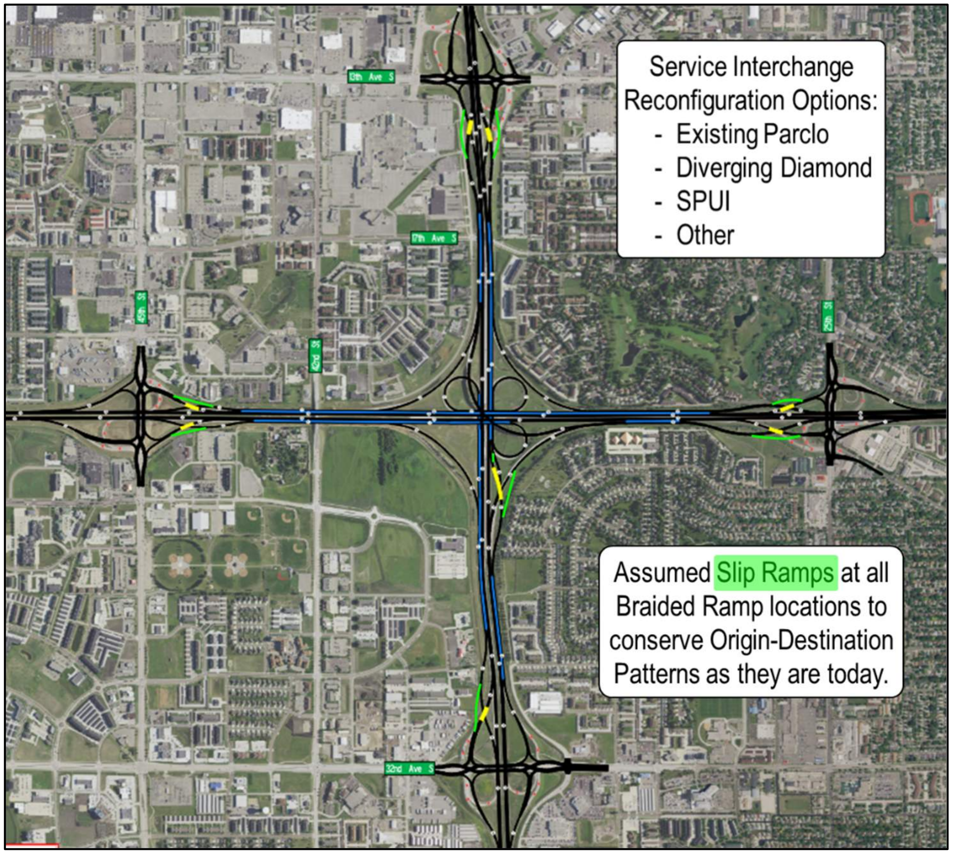


Figure 6. Braided Ramps (Partial)

Figure 7. Near-Term Implementation Strategies

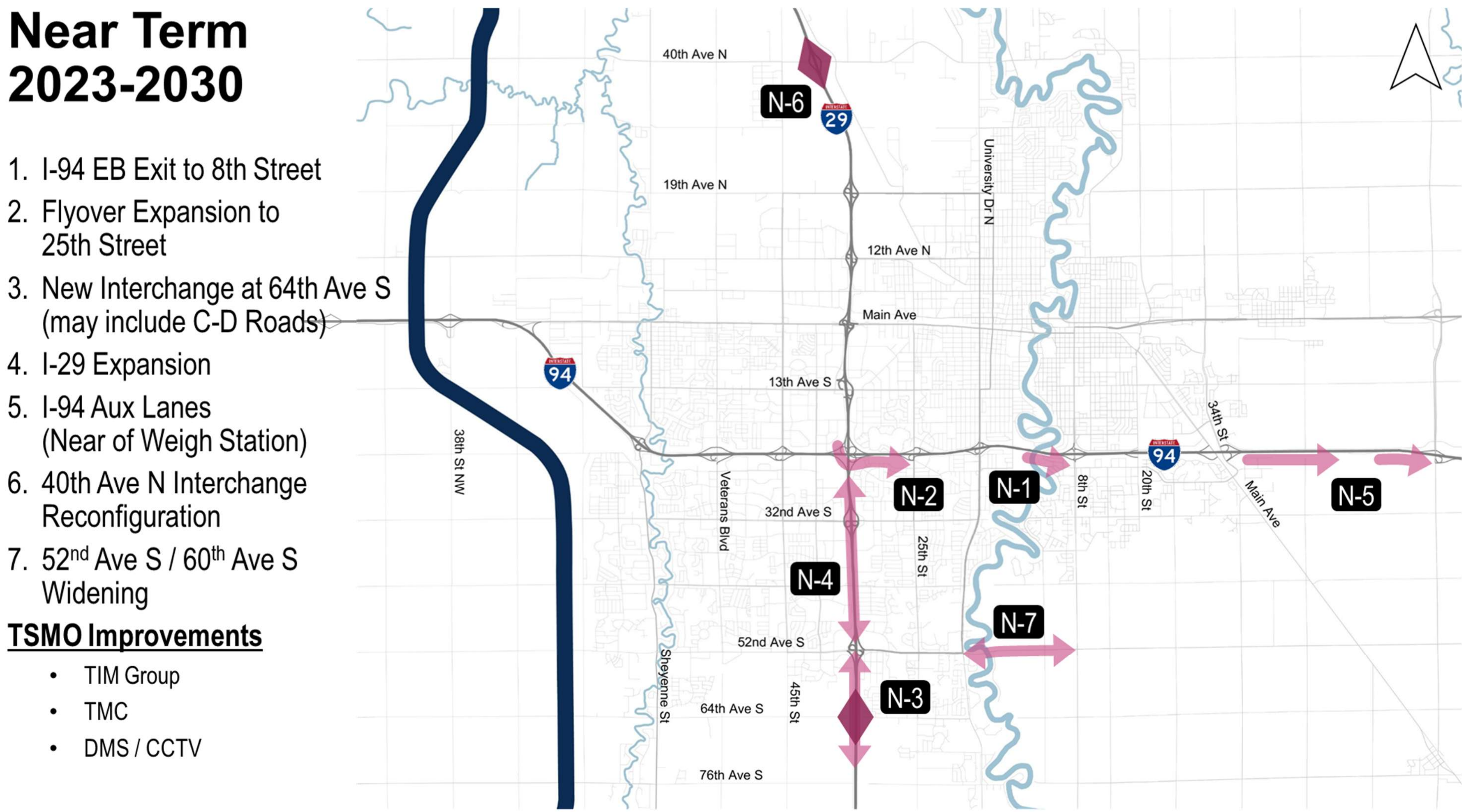
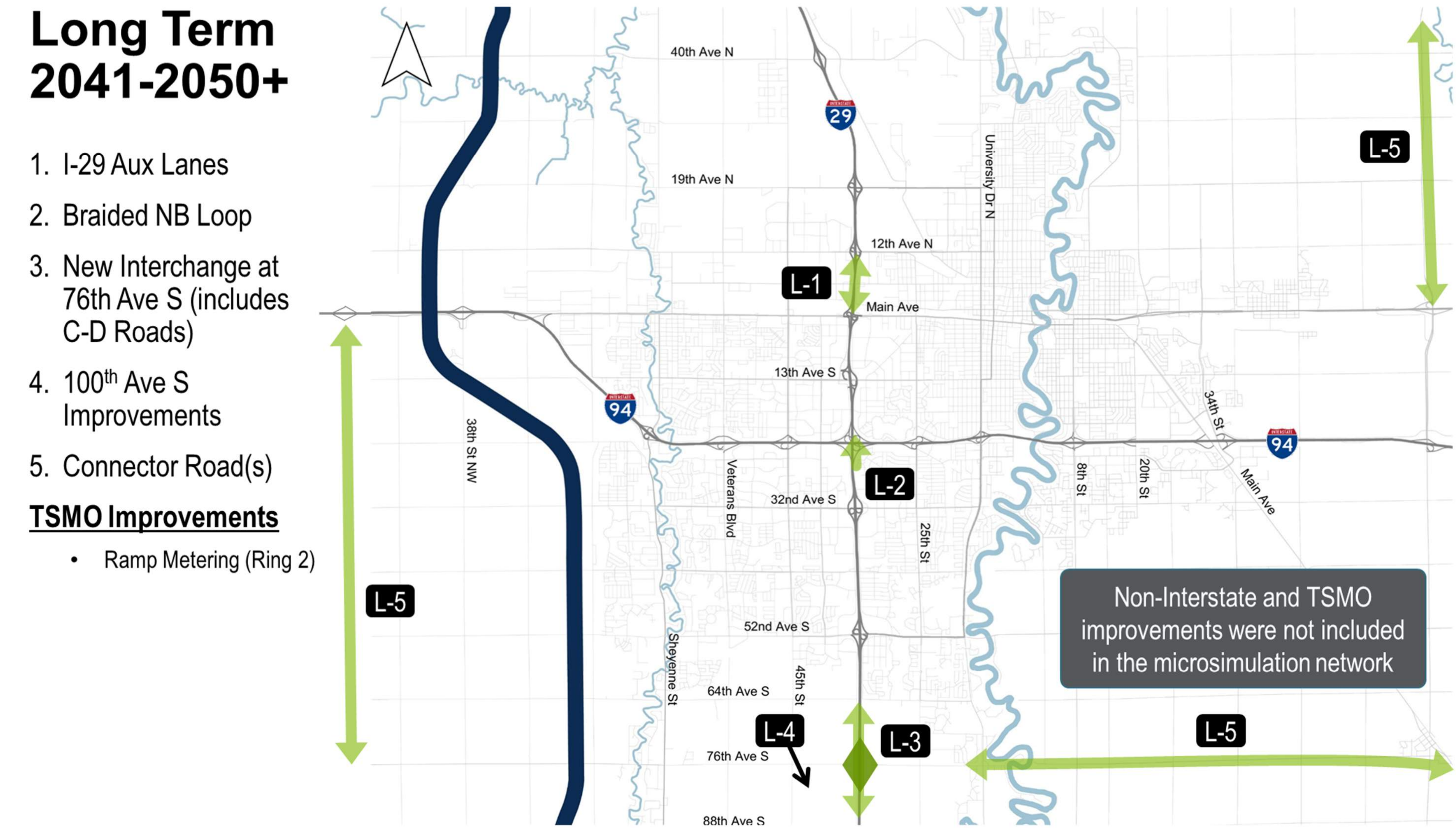


Figure 8. Mid-Term Implementation Strategies

Figure 9. Long-Term Implementation Strategies



Results

Methodology

For the initial strategy results, two measures of effectiveness (MOEs) were used to gauge the operational benefits of initial strategies: model delay and segment speeds. Since the IOS was focused on I-29 and I-94 operations, total delays were pulled from the locations in **Figure X** highlighted in red.

Figure 10. Total Delay Limits

In order to isolate an individual near- & mid-term strategies, the study team compared all initial near- & mid-term projects shown in **Figure 2** with a model with one of the projects removed.

Example: The effectiveness of ID 10 - I-29 expansion between 32nd Ave S to 52nd Ave S is the delay / congestion increase when ID 10 is removed from the model, re-run, and compared to all 10 proejcts in **Figure 2**.

For long-term strategies, MOEs were compared to each other to determine operational benefits vs order of magnitude costs for major investment improvements

Initial Strategy Results

PM peak period results for near- & mid-term strategies are shown in **Table 1.** For reference, the total delay in the 2-hour PM peak period calibrated 2021 model was 235 hours for the areas highlighted in red in **Figure 10**.

Table 1. Initial Near- & Mid-Term Strategy Results

ID	Description	2030 PM Operations	
		Delay (hrs)	Speed (mph)*
1	Flyover to 25th	560 ↓	17 ↑
2	I-29 → I-94 Exit		
3	2-Lane Exit to 8th	35 ↓	13 ↑
4	I-29 NB Aux @ 32nd Ave S	5 ↓	–
5	I-94 WB Add	10 ↓	6 ↑
6	I-29 4 Aux (N of I-94)	–	2 ↑
7	I-94 3 Aux (E of I-29)	–	3 ↑
8	I-94 2 Aux (W of I-94)	–	2 ↑
9	I-94 Widen over Red River	40 ↓	13 ↑
10	I-29 Widen S of 32nd Ave S	250 ↓	28 ↑

* Average peak hour speed increase within or upstream of the improvement area

Example: Without ID 10 - I-29 expansion between 32nd Ave S to 52nd Ave S, core Interstate delay would increase 250 hours during the PM peak period (more than double the amount of 2021 base year PM peak period delay).

PM peak period results for long-term strategies are shown in **Table 2**.

Table 2. Long-Term Strategy Results

ID	Total	2040 PM Delay (Hours)	
		Total	Change (Compared to ID 1)
1 (Base)	Near- & Mid-Term	549	
2	C-D Road (Full)	378	171
3	Braided Ramp (Full)	368	184
4	Braided Ramp (Partial)	387	162

For reference, the total delay in the 2-hour PM peak period 2030 model for ID 1 (Base – shown in **Figure 2**) was 240 hours for the areas highlighted in red in **Figure 10**. With a 2040 demand set, the same model network increases to 549 total hours of delay. ID 4 provides significant operational benefits at a much lower cost than the full C-D road or braided ramp concepts.

Refined Implementation Strategy Results

Refined strategy results are shown in **Table 3**. The table shows the overall delay (from the Interstate segments highlighted in **Figure 10**) between the no-build, near-term, mid-term, and long-term strategies Results in **Table 3** were pulled from an average of 5 model runs. Model results were pulled during the timeframes expected for implementation (i.e., long-term strategies were not run on the 2021 or 2030 demand sets).

Table 3. Refined Strategy Results

Scenario	PM Peak Period Delay (Hours)			
	2021 Demand	2030 Demand	2040 Demand	2045 Demand
No-Build	235	497		
Near-Term	204	355	1,068	
Mid-Term		193	251	310
Long-Term			247	301

The No-Build delay shown in 2021 represents a baseline of the amount of delay the Fargo-Moorhead area experienced on the Interstate system today during the PM peak. Fast forward to 2030 demand, total delay more than doubles in a "do nothing" scenario. Providing the near-term improvements, specifically the projects in **Table 1** that provided the most delay reduction help reduce the delay back down towards a reasonable level.

Significant delay reduction in the mid-term scenario is driven by the inclusion of the braided ramps on I-29 and basic freeway capacity improvements on I-94. This accounts for a large portion of the geometric improvements recommended in this study. Project recommended in the long-term don't results in significant delay reductions within the model, but likely improve safety and day-to-day reliability / resiliency in portions of the metro area.

Appendix

- Model Files
- Model Details

Model Files

The following model files were developed as part of the Interstate Operations study. Note that AM and PM models were developed, but the study team focused on PM operations due to the level of congestion / demand in all directions during the PM peak hour compared to the AM.

- Baseline / No-Build: Used for existing calibration
- Initial Strategy Development Models
  - Near- & Mid-Term Projects
  - Collector-Distributor Roads
  - Braided Ramps (Full)
  - Braided Ramps (Partial)
- Refined Strategy Development Models
  - Near-Term
  - Mid-Term
  - Long-Term

Running TransModeler Microsimulation Models

Models were archived and submitted to MetroCOG for future follow-on studies. The microsimulation models were developed utilizing TransModeler 6.0 Build 8090. During the model development process, Caliper released version updates 6.1 and 7.0. Since planning level calibration efforts utilized version 6.0, the study team kept the original version for documentation throughout the project.

To emulate modelling results, any user should utilize version 6.0. If a newer version is needed, an updated planning level calibration shall be performed to re-validate the model assumptions. Caliper has noted that model results will change moderately from one project to another as the project is continually updated to better reflect real-world driver behaviors.

Each model has multiple demand sets loaded into the project settings that correspond with base year and future year demand sets. In order to closely match model results shown in this memo, the correct demand set must be selected and Version 6.0 Build 8090 must be utilized. Delay results may differ slightly since the study team did not fix random seeds during batch simulations.

Model Details

Model Purpose

The intent of these models are to provide a baseline list of projects that can be modified based on agency needs, funding, and other factors. Similar to the initial strategy results, projects can be removed from the refined near-, mid-, or long-term models to test their overall effectiveness at reducing total model delay.

Interchange Modifications

Adjustments were made at service interchanges within the study area to test some service interchange strategies, but mostly to reduce potential queue spillback that would skew model results and to provide full demand onto the Interstate system. During the initial strategy development, the study team tested various combinations of interchange reconfigurations. Due to study direction, specific interchange configurations were not recommended and will be addressed in follow-on independent studies. The following service interchange adjustments were included in the refined strategies:

- I-94 & Sheyenne St: EB Dual Rights for the Long-Term
- I-94 & Veterans Blvd: WB Dual Rights, Additional SB Through, and NB Dual Lefts at WB Terminal
- I-94 & 25th St: EB Dual Lefts

Note that these modifications aren't included in the study recommendations, and locations should continue to be monitored during peak times to check queue spillback and interchange capacity needs.

Other adjustments to the models include:

- Exit ramp storage throughout the models were increased to reduce queue spillback that may skew model results. This was intended to emulate minor signal timing adjustments or widening that DOTs continually do to mitigate congested interchanges.
- Unsignalized ramp terminal intersections were signalized or modified to roundabouts where increased demand caused queueing or metered demand onto the Interstate.

Note that interchange configurations in future year models are not the recommended alternative. The IOS focused on Interstate Operations, so service interchange configuration in the microsimulation models were intended to emulate the platooning of vehicles entering the Interstate system while providing enough capacity to eliminate queue spillback that would skew Interstate model results. Examples of this include:

- I-29 & 13th Ave S: The existing configuration was modified slightly in the models to serve the demand needs at the interchange. It is assumed that this interchange location would be analyzed in detail in an independent study to determine the recommended configuration to fit with the proposed braided ramps to the south.
- I-29 & 64th Ave S / 76th Ave S: The refined models did not include both interchange connections since the City of Fargo had selected a consultant to study this location independently. The study team assumed the independent study would provide a solution that fits with the context of I-29 near 52nd Ave S interchange.
- I-94 & 20th St: The refined models kept the existing half interchange the City of Moorhead and MAPA had selected a consultant to study this location independently. This potential interchange reconfiguration would likely not impact I-94 operations, so Interstate delay results with / without a full interchange at 20th Street will be similar.
- I-94 & Main Ave (West Fargo): The refined models kept the existing interchange at Main Ave. MetroCOG's NW Transportation Plan included looked at the City of West Fargo's growth assumptions and connectivity needs in the area resulting in an interchange modification. The study team utilized base 2045 growth assumptions for demand development which didn't show a need at the Main Avenue interchange. As local connectivity and growth assumptions change, this area of the model should be re-run to determine impacts to I-94.

Interstate Modifications

I-94 Mobility Improvements in Minnesota were not modelled as a 6-Lane I-94 section to MN 336. Expansion of I-94 from 4 lanes to 6 under 8th Street was included in the Mid- and Long-Term models due to capacity needs.

TSMO Modifications

TSMO strategies recommended in the near-, mid-, and long-term were not included in the microsimulation models. TransModeler has the capability to test ramp metering strategies, but the study team used the model to focus on geometric improvements. As the ramp metering strategy progresses and implementation areas are determined in future studies, TransModeler could be used to emulate the impact to the arterial and Interstate system.

Demand

The study team developed 4 AM and PM demand sets:

- Base Year (2021)
- 2030 (40% Growth from 2021 - 2045)*
- 2040 (80% Growth from 2021 - 2045)*
- 2045

*O-D Matrices are named 40% & 80% in TransModeler project settings.