NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
ADVANCED TRAFFIC ANALYSIS CENTER

Pembina – Emerson Border Crossing Interim Measures Microsimulation

Final Report

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Prepared for:
North Dakota Department of Transportation

Prepared by:
Advanced Traffic Analysis Center
Upper Great Plains Transportation Institute
North Dakota State University
Fargo, North Dakota

Contents

INTRODUCTION

This report documents the traffic operations analysis of the proposed interim measures performed at ATAC using microsimulation.

BACKGROUND

NDDOT developed signalization alternatives to improve traffic operations and to reduce delays experienced by northbound vehicles near the United States/Canada border crossing at Pembina - Emerson, especially near the Duty Free Shop (DFS) Exit. The study area is shown in Figure 1 below. Of the two alternatives devised, Alternative 2 was selected for detailed analysis using microsimulation. For details on Alternative 2, refer to Appendix 1.

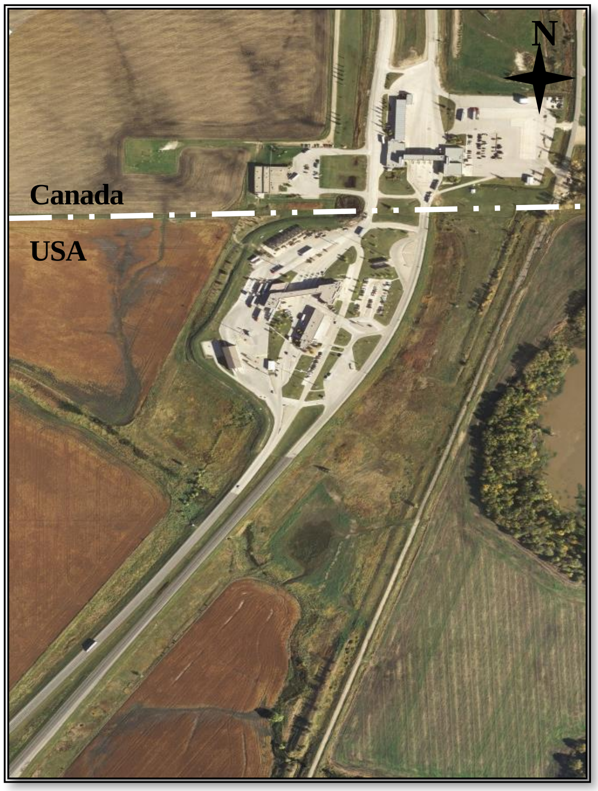

Figure 1 Study Area

METHODOLOGY

To minutely observe the effects of geometric and traffic control changes within the study area, it was decided that microscopic simulation tools would be used. The microsimulation model and the subsequent scenarios created in this study are based on the following data sources:

- Documentation and data provided by NDDOT
- Pembina – Emerson Point Of Entry Transportation Study completed in Feb 2013
- ATAC's data collection efforts

The following models were created for microsimulation:

- Base Model
    - Based on 2015 projected volumes

  - No geometric changes
- Alternative 2
  - Based on 2015 projected volumes and signal timing
  - Geometric changes include additional lane (NB)

Alternative 2 was then tested for sensitivity to changes in percentage of vehicles going through the DFS loop[1]. Thus, two additional scenarios were created:

- Alternative 2 + 5%
- Alternative 2 – 5%

Both passenger cars and trucks going through DFS loop were either increased or decreased

The major assumptions and network coding parameters pertaining to the modeling efforts are:

- Two hours (4:00 – 6:00) in the PM peak period were simulated. [2]
- Only passenger cars and trucks were considered for this study. Buses, NEXUS vehicles, and oversized vehicles were not considered because of their insignificant volumes.
- Only northbound movement, including the Canada Border Services Agency's primary inspection lane booths was simulated.
- Three primary inspection lane (PIL) booths were assumed to be open:
  - Two for passenger cars – on the west end
  - One for trucks – on the east end
- Service rate was assumed to be independent of the number of PIL booths open
- Average time spent stopped in the DFS loop was assumed to be 30 seconds.[3]
- Volume projections were based on 2012 average hourly volumes (by vehicle type).
- Average delay time for passenger cars was assumed to be 10 minutes and that for trucks was assumed to be 30 minutes.
- An average of 30 % of cars and 12% of trucks were assumed to pass through the DFS loop. Hourly variations were incorporated into the model based on data collected during site visit.

NETWORK CODING

The microsimulation networks were coded in VISSIM. The south end of the network is less than a mile from the PIL booths. The north end of the network is just downstream from the PIL booths as shown in figures below.

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[1] Note that the DFS related demand changes were made in addition to the changes in random number seed. All the models and scenarios were run using 10 different seeds in order to make the simulation stochastic and to account for variations in driver behavior and departure time etc.

[2] This excludes the 1-hour simulated to seed the network.

[3] A standard deviation of 3s was assumed.

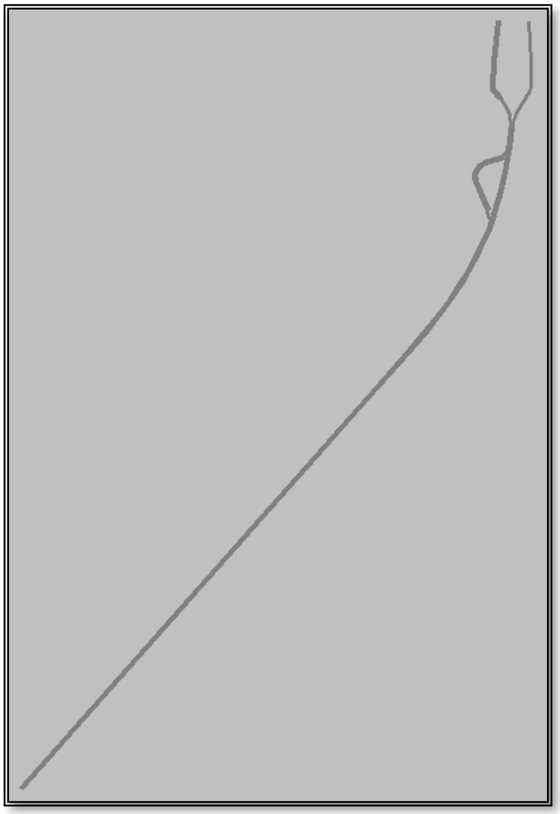

Figure 2 Base Network

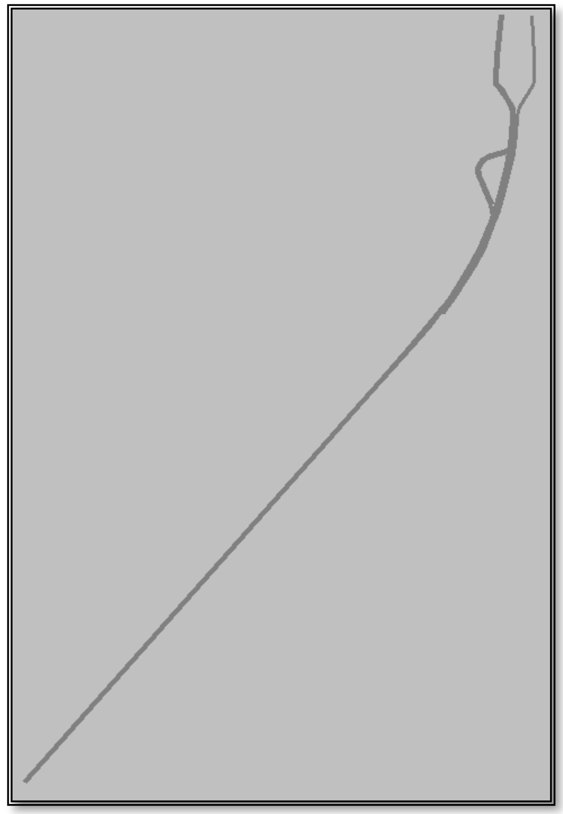

Figure 3 Alternative 2 Network

Additional assumptions based on Alternative 2 are:

- NB I-29 has three lanes approx. 1100 feet upstream of the split into 6-lane section.
- Stop bar (corresponding to the proposed signal control) is placed 150' upstream of the DFS loop entrance. Detectors were coded as laid out in NDDOT's design as shown in figure below. For details, refer to appendix 1.
- It is assumed that the drivers would be courteous to one another, especially around the DFS entrance and exit.
    - Specifically, it is assumed that vehicles exiting the DFS would be readily given opportunities to merge onto the mainline
    - Also, vehicles entering the DFS, specifically trucks (travelling in the far right lane) would be able to complete the exiting maneuver without having to yield to other vehicles.

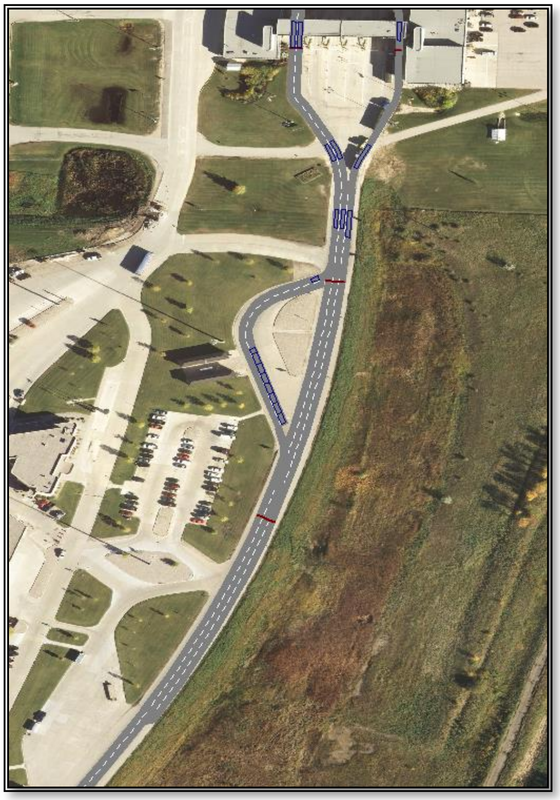

Figure 4 Alternative 2 Geometric and
Traffic Control Changes

CALIBRATION & VALIDATION

Various factors affecting driver characteristics, vehicle characteristics, and link characteristics were modified to realistically represent the conditions and traffic operations in the study area. The factors included driving behavior, car-following, and link behavior etc. Based on the available data, the calibration and validation targets were set to the following:

Traffic Volumes

The volume targets, by vehicle type, are:

Table 1 Modeling Target Volumes

Vehicle Type	Hour	Volume
Passenger Cars	4:00 – 5:00	86
	5:00 – 6:00	88
Trucks	4:00 – 5:00	32
	5:00 – 6:00	32

Delays

The delay targets[4], by vehicle type, are:

Table 2 Modeling Delay Targets

Vehicle Type	Average Delay (s)
Passenger Cars	600
Trucks	1,800

RESULTS

The results of the calibration and validation efforts (for the Base Model) are as below:

Table 3 Base Model Validation Results - Volumes

Parameter	Vehicle Type					
	Passenger Cars		Trucks		Total	
	4:00 – 5:00	5:00 – 6:00	4:00 – 5:00	5:00 – 6:00	4:00 – 5:00	5:00 – 6:00
Target Volume	86	88	32	32	118	120
Model Output	88	88	32	31	120	119
GEH Stat	0.21	0	0	0.18	0.18	0.09

Table 4 Base Model Validation Results - Delays

Parameter	Vehicle Type	
	Passenger Cars	Trucks
	4:00 – 6:00	4:00 – 6:00
Target Delay (s/veh)	600	1,800
Model Output (s/veh)	625	1,796

The modeled output of Alternative 2 and the subsequent scenarios is as below:

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[4] Note: Due to the fact that the focus segments of the study area have essentially stop-and-go traffic, speed targets were not used. Instead, the queue lengths were visually matched to their approximate length respectively.

Table 5 Alternative 2 & Scenario Results - Volumes

Parameter	Vehicle Type					
	Passenger Cars		Trucks		Total	
	4:00 – 5:00	5:00 – 6:00	4:00 – 5:00	5:00 – 6:00	4:00 – 5:00	5:00 – 6:00
Base Model	88	88	32	31	120	119
Alternate 2	88	90	32	32	120	122
Alt 2 + 5% DFS	88	89	32	32	120	121
Alt 2 – 5% DFS	88	90	32	32	120	122

Table 6 Alternative 2 & Scenario Results - Delays

Parameter	Vehicle Type	
	Passenger Cars	Trucks
	4:00 – 6:00	4:00 – 6:00
Base Model (s/veh)	625	1,796
Alternative 2 (s/veh)	569	1,727
Alt 2 + 5% DFS (s/veh)	553	1,744
Alt 2 – 5% DFS (s/veh)	554	1,733

CONCLUSIONS & DISCUSSION

The comparison of alternative 2 scenario outputs to the base model outputs indicate that retrofitting the study area with traffic signals as designed by NDDOT would not affect the traffic operations adversely. The average delay per vehicle (by vehicle type) in alternative scenarios is slightly lower but comparable to the base model. The slight reduction in delays can be attributed to the reallocation of queues. In base model, there is only one origin of queues – PIL booths. However, in the alternative scenarios, the queues are distributed between two origin locations. The two queues are tandem – one at the PIL booths and another at the retrofitted traffic signal (upstream of the traffic signal).

It should also be kept in mind that the signal timings as used in this project may need tweaking once the traffic signals are functional. The red change interval should be such that it is long enough to clear the queue of vehicles beyond the detectors closer to the PIL booths. Also, the green time should be long enough to allow vehicles to from a queue just downstream of the DFS entrance.

It is worthwhile to mention here that any microsimulation model assumes majority, if not all, road users to be familiar with not only the transportation network but also its traffic patterns, traffic control devices etc. Thus, it is very important that the public be well informed and educated of any such changes (irrespective of the fact that they may be interim in nature). Targeted education as well as enforcement efforts must be undertaken to ensure traffic safety.

APPENDIX

Appendix 1: NDDOT’s Technical Memorandum