Traffic Safety Study Memo

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To: Spack Consulting

From: Derek Leuer, PE

RE: Median Acceleration Safety Study

In the fall of 2016, the Minnesota Department of Transportation (MnDOT) Office of Traffic, Safety and Technology (OTST) commissioned a study with Spack Consulting to observe, record, and analyze the use and utilization of Median Acceleration Lanes (MAL) on divided expressways across Minnesota. Twelve separate sites were selected across Minnesota. The final technical paper regarding the use of MAL across the state can be found here:

http://www.dot.state.mn.us/trafficeng/safety/docs/Acceleration%20Lane%20Memo%20-%202-17-2017.pdf

Some of the key finds included:

- An average of 82% of vehicles will enter the beginning of the MAL over the course of the day.
- An average of 20% of all vehicles will use the entire length of the MAL to accelerate up to mainline speeds, and will then merge into the through mainline.
- A higher percentage of passenger cars enter the MAL than heavy vehicles. However, a higher percentage of heavy vehicles will use the entire MAL versus passenger cars.
- A safety evaluation was not part of the initial study due to time and budget constraints.

Prior Traffic Safety Evaluation

Median Acceleration Lanes have often been thought of as an improvement to increase the safety performance of an intersection by lowering the number of conflict points and reducing the amount of “friction” within an intersection.

MnDOT completed a traffic engineering study in 2002 and can be found here:

http://www.dot.state.mn.us/trafficeng/safety/medianaccelerationlanestudy.pdf

The sample size was small, consisting of two intersections with MAL, and two intersections without MAL. The findings found that some crash types were reduced, while others had increased. The overall crash rate was higher for those without MAL then those with MAL. It is important to note that the sites with MAL only had two years of crash data per site.

Revised Traffic Safety Evaluation

With the completion of the 2017 Median Acceleration Lane Utilization Study, the selected sites were evaluated for their safety performance to see if the MAL were making a positive difference in regards to crash performance as well. For a better understanding of terms and acronyms, please see the appendix.

The twelve sites that were monitored, recorded, and analyzed for the MAL Utilization Study become the treatment group. Crash data was selected for years 2011-2015. Crashes that happened before the MAL was constructed were removed from the sample. A total of 45 site years remained for the analysis.

In order to better understand how these intersections performed compared to similar non-MAL intersections, a comparison group of intersections was needed. Fortunately, a similar study looking at Reduced Conflict Intersections (RCI) and at-grade expressway intersections was completed in the autumn of 2016. While evaluating RCI's, a comparison group of 31 similar intersections was also found and used to compare to the RCI treatment sites. In an effort to save time and resources, this group was used again. The comparison group was divided into two groups in the prior report; Crash and Traffic Data from 2009-2011, and Crash and Traffic Data from 2012-2015.

The treatment site data (2011-2015) and the control site data are shown below.

Crash and Traffic Data (2011-2015)	Vehicles Entering	Total	K	A	B	C	PDO
MAL SITES Frequency	267,140,306	98	0	3	17	24	54
MAL SITES RATES		0.37	0.00	0.01	0.06	0.09	0.20

Table 1: Median Acceleration Lane Sites Crash and Traffic Data. Crash Data is by Severity

Crash and Traffic Data (2009-2011)	Vehicles Entering	Total	K	A	B	C	PDO
Control Sites Frequency	452,051,588	125	6	2	20	34	63
Control Sites -Rates		0.28	0.01	0.00	0.04	0.08	0.14

Table 2: Control Sites Crash and Traffic Data. 2009-2011. Crash Data is by Severity.

Crash and Traffic Data (2013-2015)	Vehicles Entering	Total	K	A	B	C	PDO
Control Sites -Frequency	447,696,225	153	5	6	25	34	83
Control Sites -Rates		0.34	0.01	0.01	0.06	0.08	0.19

Table 3: Control Sites Crash and Traffic Data. 2013-2015. Crash Data is by Severity.

Crash and Traffic Data (2011-2015)	Rear End	Right Angle	ROR	HOSSO	Left Turn	Other	Multi-Vehicle
MAL SITES Frequency	16	43	9	14	7	9	84
MAL SITES RATES	0.06	0.16	0.03	0.05	0.03	0.03	0.31

Table 4: Median Acceleration Lane Sites Crash and Traffic Data. Crash Data is by Diagram and Type.

Crash and Traffic Data (2009-2011)	Rear End	Right Angle	ROR	HOSSO	Left Turn	Other	Multi-Vehicle
Control Sites Frequency	17	70	17	7	5	9	108
Control Sites -Rates	0.04	0.15	0.04	0.02	0.01	0.02	0.24

Table 5: Control Sites Crash and Traffic Data. 2009-2011. Crash Data is by Diagram and Type.

Crash and Traffic Data (2013-2015)	Rear End	Right Angle	ROR	HOSSO	Left Turn	Other	Multi-Vehicle
Control Sites -Frequency	17	70	22	17	5	21	123
Control Sites -Rates	0.04	0.16	0.05	0.04	0.01	0.05	0.27

Table 6: Control Sites Crash and Traffic Data. 2013-2015. Crash Data is by Diagram and Type.

The data contained in Tables 1-6 are reduced and analyzed to the crash performance measures that MnDOT is most concerned about into Table 7. These crash performance measures are:

FAR: Fatal and Serious Injury Crash Rate. The total number of Fatal (K) and Serious Injury (A) Crashes, multiplied by 1,000,000 and divided by the exposure to traffic (vehicles entering the intersection).

Crash Rate: The total number of crashes multiplied by 1,000,000 and divided by the exposure to traffic (vehicles entering the intersection).

Injury Rate: The total number of Serious Injury (A), Non-Incapacitating Injury (B) and Minor Injury (C) crashes, multiplied by 1,000,000 and divided by the exposure to traffic (vehicles entering the intersection).

Right Angle Rate: The total number of right angle crashes multiplied by 1,000,000 and divided by the exposure to traffic (vehicles entering the intersection).

Description	FAR	Crash Rate	Injury Rate	Right Angle Rate
Control Sites (2009-11)	1.77	0.28	0.12	0.15
Control Sites (2013-15)	2.46	0.34	0.15	0.16
Control Sites (Ave)	2.11	0.31	0.13	0.16
MAL Sites (2011-15)	**1.12**	**0.37**	**0.16**	**0.16**
Change +/-%	**-47%**	**+19%**	**+22%**	**+3%**

Table 7: Comparison of the Median Accelerations Lanes to the Control Sections (2009-2011, 2011-2013, and averaged)

The "Change +/-" was compared against the two data sets of Control Sites (2009-2011 and 2013-2015) that were averaged together.

Based on these four metrics, it appears that Median Acceleration Lanes do not provide a reduction in overall crashes, injury crashes, nor right angle crashes. However, it does appear, based on this data that fatal and serious injury crashes may be reduced by the median acceleration lanes. This is explored in the next section.

Exploration of Fatal and Serious Injury Crashes

The reduction of fatal and serious injury crashes at median acceleration lane sites was explored in greater depth than the analysis above to have a better understanding of what may be contributing to this reduction, or if this is just coincidental and "regression-to-the-mean". The primary problem at most-at grade, high speed expressway intersections tends to be severe right angle crashes that occur when a minor road driver attempts to cross all lanes of the highway, and collides with a vehicle going straight on the expressway, often at a high rate of speed (>55 MPH). Considering that median acceleration lanes would do little to mitigate this type of error, the reduction warranted further examination. Some facts to note:

- 10 out of the 12 treatment sites did not have any fatal and serious injury crashes in the review period. One site, US 61 and CSAH 18 had two severe crashes in the review period.
- 24 out of the 31 control sites from 2009-2011 did not have any fatal or serious injury crashes in the review period. One site had one fatal and one serious injury crash (US 169 and CSAH 11)
- 22 out of the 31 control sites from 2013-2015 did not have any fatal or serious injury crashes in the review period. One site had two fatal and one serious injury crash (MN 23 and Saratoga Street in Marshall, MN)
- 19 of the 31 control sites had no fatal or serious injury crashes in either review periods.

A review of the 22 fatal and serious injury crashes at the treatment and control sites provided a better understanding of the crashes.

- The three crashes at sites with Median Acceleration Lanes were all near-side right angle crashes. It seems unlikely that the MAL contributed to any of these crashes. It also seems unlikely that the presence of the MAL would have prevented these crashes.
- Of the 19 crashes that occurred at the control sites, 9 of the crashes were on the near-side of the intersection (the closest lanes to the driver pulling out into the intersection), 8 were on the far-side of the intersection (the furthest lanes to the driver pulling out into the intersection), one was a driver turning left from the main line onto the minor street, and one was a driver attempting to turn left onto the main line from the minor street.
- After reviewing the 19 crashes at the control sites, it seems likely that none of the crashes would have been prevented with the installation of a MAL. The majority (18 of 19) involved drivers either attempting to go straight across, or turning from the major road to the minor road.

Based on the review of these crashes, it seems more coincidental that MAL sites have a reduced FAR Crash Rate then the control site counter parts. However, this trend should be continued to be monitored. With the vast majority of the severe crashes at these types of intersections being right-angle related, it seems unlikely that a MAL would reduce fatal and serious injury crashes.

To be more confident in this assessment, a statistical test was done on a subset of the data to see if the reduction in fatal and serious injury crashes is meaningful, or just coincidental.

Statistical Testing of Fatal and Serious Injury Crashes

With potential department practices being evaluated, it is important to know if the reduction is statistically meaningful, or just coincidental.

The treatment sites contained a total of 45 years. To make a fair comparison, 15 sites from the control group were randomly selected, and 2013-2015 crash data was evaluated. The test was an independent sample t-test that measures the difference between the Mean of the treatment group against the mean of the non-treatment group. The treatment group shows a lower Mean FAR Score compared to the non-treatment group; however, the difference is not statistically significant. This analyses was somewhat fettered by small sample size and we may have different findings with a larger sample size.

The two statistical evaluation tables are shown below:

Group Statistics

Tx_NonTx		N	Mean	Std. Deviation	Std. Error Mean
FAR Score	Tx	45	.0099	.03780	.00564
	Non-Tx	45	.0300	.10704	.01596

Independent Samples Test

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
FAR Score	Equal variances assumed	-1.187	88	.238	-.02009	.01692	-.05372	.01354
	Equal variances not assumed	-1.187	54.809	.240	-.02009	.01692	-.05400	.01383

The results from the statistical testing show that the randomly selected control sites do have a higher fatal and serious injury crash rate, but that it is not statistically significant.

Reviewing the other types of crashes and crash rates, it would appear the Median Acceleration Lanes are not driving any serious reduction in the total number, severity, or target types of crashes at these intersections.

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Appendix

How to Read This Report

Crash Records Data

These analyses used Minnesota crash data to assess crash frequency and severity.

A *site-year* is a way to quantify the amount of exposure to traffic by site. For example, a site with three years of data would have three site-years and another with four years would have four site-years. Combined, the two sites have seven site-years.

Vehicles Entering was another metric to adjust for exposure to traffic. Most sites used the Minnesota Traffic Mapping Application and associated Geographic Information System (GIS) layers to establish how much traffic had entered the intersection during the review years. When traffic volumes were missing or had gaps, traffic volume was either interpolated or extrapolated.

Injury Severity of Crash

Crash severity means the greatest level of injury sustained by all persons involved in a crash. One fatal crash may include one or more person killed and any number of persons who sustained other levels of injury, but it is a *K Injury Crash.*

K-Injury (Fatal) Crash: One or more person involved in the crash died due to injuries sustained in the crash

A - Injury Crash: One or more person involved in the crash sustained a serious life-altering injury due to the crash

B-Injury Crash: One or more person involved in the crash sustained moderate injury, e.g. broken bones in the crash

C- Injury Crash: One or more person involved in the crash sustained a minor injury in the crash

PDO-Injury Crash: No person involved in the crash sustained an injury and only vehicular or property damage occurred

Crash Type/Diagram

Crash type means the manner in which one or more vehicles collided with one another.

Right angle crash: When two vehicles collide perpendicular to each other, also known as a T-bone or broadside crash. This type of crash is among the highest risk of death and serious injury.

Rear-end crash: When two vehicles traveling the same direction collide with the front of the following vehicle colliding with the rear of the leading vehicle. This is the most common type of crash in Minnesota; however, it is typically of lower risk of death and serious injury.

Run-off-the-road crash: When a single vehicle departs the roadway surface and collides with a roadside object or rolls over. This includes both departing right and left from the roadway surface. This type of crash is among the highest risk of death and serious injury.

Head-On: Two vehicles collide directly into each other while heading in opposite directions striking at the front of both vehicles. This type of crash is among the highest risk of death and serious injury.

Sideswipe crash: Two vehicles collide off-center and scrape the sides of both vehicles. Sideswipe includes vehicles heading in the same direction or vehicles traveling in opposing directions. This type of crash is typically at lower risk of death and serious injury.

Left-Turn-Into-Traffic: A left turning vehicle, from either the major or the minor road collides with a vehicle crossing its intended path. This type of crash typically results in a right-angle crash or a sideswipe crash.

Other/Not Applicable/Unknown/Blank: These crash types were used when one of the above types or diagrams did not adequately address what had occurred. These four tended to be a catch-all for crashes that did not fit the above descriptions.

Multi-vehicle crash*: Involves two or more motor vehicles. This is mutually exclusive of the crash types/diagrams described above.

*Multi-Vehicle are mutually exclusive from Right Angle, Rear-End, Run-off-the-Road, Head-On, Sideswipes, Left-Turn-Into-Traffic, Other/NA/Unknown, and Blank. As an example, a crash could be both a collision with a pedestrian and be coded as “Other” as well.

List of Acronyms and Terms

AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
A Rate	Serious injury (A crash) crashes are totaled, multiplied by one hundred million, and divided by the total number of entering vehicles in the same time span
B Rate	Major Injury (B crash) crashes are totaled, multiplied by one million, and divided by the total number of entering vehicles in the same time span.
C Rate	Minor injury (C crash) crashes are totaled, multiplied by one million, and divided by the total number of entering vehicles in the same time span.
Crash Rate	Total number of crashes in a given time span, multiplied by one million, and divided by the total number of entering vehicles in the same time span
CSAH	County State Aid Highway
FA (K+A) Rate	Fatal(K crash) and Serious(A crash) injury crashes are added, multiplied by one hundred million, and divided by the total number of entering vehicles in the same time span
F(or K) Rate	Fatal(K crash) crashes are totaled, multiplied by one hundred million, and divided by the total number of entering vehicles in the same time span
FHWA	Federal Highway Administration
MEV	Million Entering Vehicles (into an intersection)
MnDOT	Minnesota Department of Transportation
MUTCD	Manual of Uniform Traffic Control Devices
NCHRP	National Cooperative for Highway Research Program
OTST	Office of Traffic, Safety, and Technology (MnDOT)
PDO Rate	Property Damage (PDO crash) crashes are totaled, multiplied by one million, and divided by the total number of entering vehicles in the same time span.
TH	Trunk Highway