SHORT TERM STRATEGIES TO IMPROVE TRAFFIC CONDITIONS ON FM 1472 (MINES ROAD)

TTI Project 409217
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Interagency Cooperation Agreement – Technology Transfer & Technical Support Services for the Laredo District – Transportation Operations

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EXECUTIVE SUMMARY

The TxDOT Laredo District requested the Texas A&M Transportation Institute (TTI) to conduct an analysis of approximately 5.25 miles along the FM 1472 (Mines Road) corridor from Loop 20 (now called IH 69W) and FM 3338 (Las Tiendas Road). The purpose of the analysis was to identify potential short-term, medium-range, and long-range improvements along the corridor. For the analysis of short-term improvements, TxDOT requested TTI to focus on the southern portion of the study area, a 2.7-mile section between Loop 20 and the Con-Way truckload facility just north of Pan American Boulevard. This document summarizes TTI's analysis of short-term strategies, which are defined as strategies that can be accomplished quickly with minimal project planning and funds and without adding new pavement, for example re-timing and re-phasing of traffic signals, elimination of movements at intersections, and adding or converting lanes by only using restriping.

METHODOLOGY

TTI analyzed all major intersections within the study limits using Trafficware Synchro 9, which includes the most recent Highway Capacity Manual (HCM) methodologies. TTI calculated current traffic operation conditions based on existing signal timings using traffic data collected in November of 2014 and May of 2015. TTI then analyzed several scenarios for each intersection that involved potential improvements based on changes to roadway striping and optimization of the signal timing. Based on a review of the video data, TTI adjusted Synchro's default passenger car equivalent (PCE) value of 1.5 to a PCE value of 2.5. TTI also evaluated the performance of the best performing scenario for a 10-year and a 20-year horizon using an estimated traffic growth factor. To estimate traffic growth, TTI reviewed annual average daily traffic (AADT) on FM 1472 between 2003 and 2013. Based on available traffic data, TTI applied an annual corridor growth factor of 5 percent to determine future traffic impacts.

Analysis Limitations

The analysis of the each intersection was carried out in isolation but assuming a uniform signal cycle length of 150 seconds to facilitate corridor signal coordination. This cycle length was based on the optimized signal timing at the FM 1472 and Killam intersection, which TTI determined to be the most congested intersection in the corridor.

Readers should note that the results of the Synchro analysis should be evaluated relatively to each other, i.e., by comparing the results of one intersection scenario to another scenario of the same intersection. In many cases, the Synchro analysis provided results that showed intersections performing satisfactory or marginally acceptable, while video evidence indicated that intersections were operating over capacity. This can be attributed to data collection used for the analysis not taking into account the number of underserved vehicles per cycle and not accounting for upstream metering of intersection traffic. In order to model traffic operations jointly at all corridor intersections, TTI developed a microsimulation model of the corridor. The results of the corridor analysis are discussed in a separate document focusing on medium-range strategies. Readers should note that as a result of the analysis using a corridor model, TTI made some revisions to the results of the short-term strategy analysis. The revisions are included in this technical memorandum for reference purposes only in the concluding remarks section. For a detailed description of the revisions, readers should refer to the medium-range strategy technical memorandum.

SHORT TERM STRATEGY ANALYSIS RESULTS

Table 1. Summary of Short-Term Strategies Reviewed and Analysis Results.

Intersection	Short-Term Strategy Reviewed and Analysis Results
Pan American Boulevard	• Optimize signal timing and phasing. • Review the length of the left-turn lanes. The length of the dual northbound to westbound left-turn bay could be too short. There might be room for two westbound lanes at Pan American, but only one lane is striped. • **Results:** Optimize splits, extend NB turn bay and westbound extension, cycle length: 150 s.
Trade Center Boulevard	• Optimize signal timing and phasing. • Extend the length of the left-turn lanes. The length of the dual northbound to westbound left-turn bay might be too short. • **Results:** Add an overlap phase for eastbound right turn (with northbound left-turn), optimize splits, cycle length: 75 s.
Muller Boulevard	• Optimize signal timing and phasing. • Consider eliminating the FM 1472 and Muller Boulevard traffic signal. • **Results:** “Superstreet” configuration, optimize splits, cycle length: 75 s.
Interamerica Boulevard	• Optimize signal timing and phasing. • **Results:** Add an overlap phase for eastbound right turn (with northbound left-turn) and eliminate southbound left/U turn movement, optimize splits, cycle length: 75 s.
Killam Industrial Boulevard	• Optimize signal timing and phasing. • Analyze impact of adding dual westbound to southbound left-turn lanes. • Analyze impact of adding westbound to northbound free right-turn lane. • Analyze impact of adding dual southbound to eastbound left-turn lanes. • Analyze impact of adding southbound to westbound free right-turn lane. • Analyze all intersection radii. They might be too narrow for some type of trucks. • **Results:** Change westbound through lane to through/right shared lane, optimize splits, cycle length: 150 s.
Milo Road	• Optimize signal timing and phasing. • Analyze the impact of eliminating left-turns for southbound to eastbound movement. • Analyze the impact of eliminating westbound to southbound left-turn movements. • **Results:** Eliminate southbound to eastbound movement, optimize splits, cycle length: 150 s.
IH-69W (Loop 20)	• Optimize signal timing and phasing. • **Results:** Change signal to full phased diamond, optimize splits, cycle length: 150s.

Table 2. Intersection Delay and Level of Service for Existing Conditions and Improved Conditions.

Intersection	Existing				Improved			
	AM Peak		PM Peak		AM Peak		PM Peak	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Pan American Boulevard	5.0	A	48.8	D	5.4	A	29.4	C
Trade Center Boulevard	23.8	C	32.0	C	14.0	B	19.3	B
Muller Boulevard	17.0	B	22.9	C	5.8	A	10.2	B
Interamerica Boulevard	13.7	B	69.6	E	7.9	A	61.6	E
Killam Industrial Boulevard	73.1	E	112.7	F	45.6	D	77.9	E
Milo Road	81.3	F	12.4	B	29.8	C	28.1	C
IH-69W (Loop 20) WB Frontage Road	130.5	F	124.3	F	83.8	F	102.9	F
IH-69W (Loop 20) EB Frontage Road	21.6	C	26.0	C	62.6	E	48.1	D

Table 3. Intersection Delay and Level of Service for Improved Conditions, Forecast for 2025 and 2035.

Intersection	2025				2035			
	AM Peak		PM Peak		AM Peak		PM Peak	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Pan American Boulevard	6.9	A	138.9	F	22.1	C	430.9	F
Trade Center Boulevard	17.0	B	85.0	F	35.3	D	185.9	F
Muller Boulevard	9.6	A	63.8	E	20.5	C	173.5	F
Interamerica Boulevard	13.2	B	210.4	F	71.0	E	382.1	F
Killam Industrial Boulevard	131.3	F	288.2	F	451.8	F	779.5	F
Milo Road	128.0	F	115.9	F	477.3	F	460.4	F
IH-69W (Loop 20) WB Frontage Road	131.3	F	282.0	F	567.0	F	624.3	F
IH-69W (Loop 20) EB Frontage Road	71.7	E	77.5	E	292.1	F	454.9	F

SHORT TERM STRATEGIES TO IMPROVE TRAFFIC CONDITIONS ON FM 1472 (MINES ROAD)

INTRODUCTION

The Texas Department of Transportation (TxDOT) Laredo District requested that the Texas A&M Transportation Institute (TTI) conduct an analysis on FM 1472 (Mines Road) to identify potential strategies to improve mobility and safety along the corridor. The focus of the analysis includes short-term, medium-range, and long-range improvement strategies. This document summarizes TTI's analysis of short-term strategies focusing on a 2.7-mile section between Loop 20 and the Con-Way truckload facility just north of Pan American Boulevard on the study corridor (Figure 1). The potential short-term strategies are based on the performance of individual intersections along the study corridor assuming current demand levels.

TTI's involvement was necessary to take advantage of the following research initiatives in which TTI researchers have been involved over the last few years, which had the potential to considerably accelerate the implementation of research findings into standard business practices at the department:

- Recent involvement in the development of a Highway Capacity Manual-styled analytical methodology for investigating vehicle trajectory data for signal control delay calculations[1], including analyzing different levels of simulation outputs.
- Knowledge of the limitations of "typical" truck passenger car equivalency (PCE) values included in the Highway Capacity Manual (HCM) and software packages such as Synchro, which are based on research conducted in the mid-1990s. Team members were aware of recent research conducted in Florida,[2] which developed PCE values considering factors such as geometric characteristics, traffic demand, and truck fleet composition.
- Extensive experience supporting and assisting public agencies in Texas in the implementation and application of emerging travel forecasting modeling techniques.
- Recent research experience on the benefits of raised median access management techniques[3,4], including delay and crash reductions compared to two-way-left-turn lanes.
- Thorough knowledge and expertise using data from the Crash Record Information System (CRIS), including capabilities and limitations of the data.

In connection with these research initiatives, TxDOT was also interested in facilitating the transfer of research findings to TxDOT district officials. As part of this process, TxDOT requested that TTI conduct several meetings with district officials to describe in detail critical

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[1] Li, J., & Washburn, S. S. (2014). Improved operational performance assessment for two-lane highway facilities. *Journal of Transportation Engineering*.
[2] Washburn, S. S., & Ozkul, S. (2013). *Heavy Vehicle Effects on Florida Freeways and Multilane Highways* (No. TRC-FDOT-93817-2013).
[3] Frawley, W. E., & Eisele, W. L. (2004). *Investigation of access point density and raised medians: Crash analysis and micro-simulation* (No. FHWA/TX-05/0-4221-P1,).
[4] Eisele, W. L., Schrank, D. L. & Lomax, T. J. (2005, January). Incorporating Access Management into the Texas Transportation Institute's Urban Mobility Report. In *Presented at the Transportation Research Board's 84th Meeting*.

elements related to the analysis, including, but not limited to, assumptions; analysis scope, methodology, and limitations; feasibility of implementation; and local characteristics.

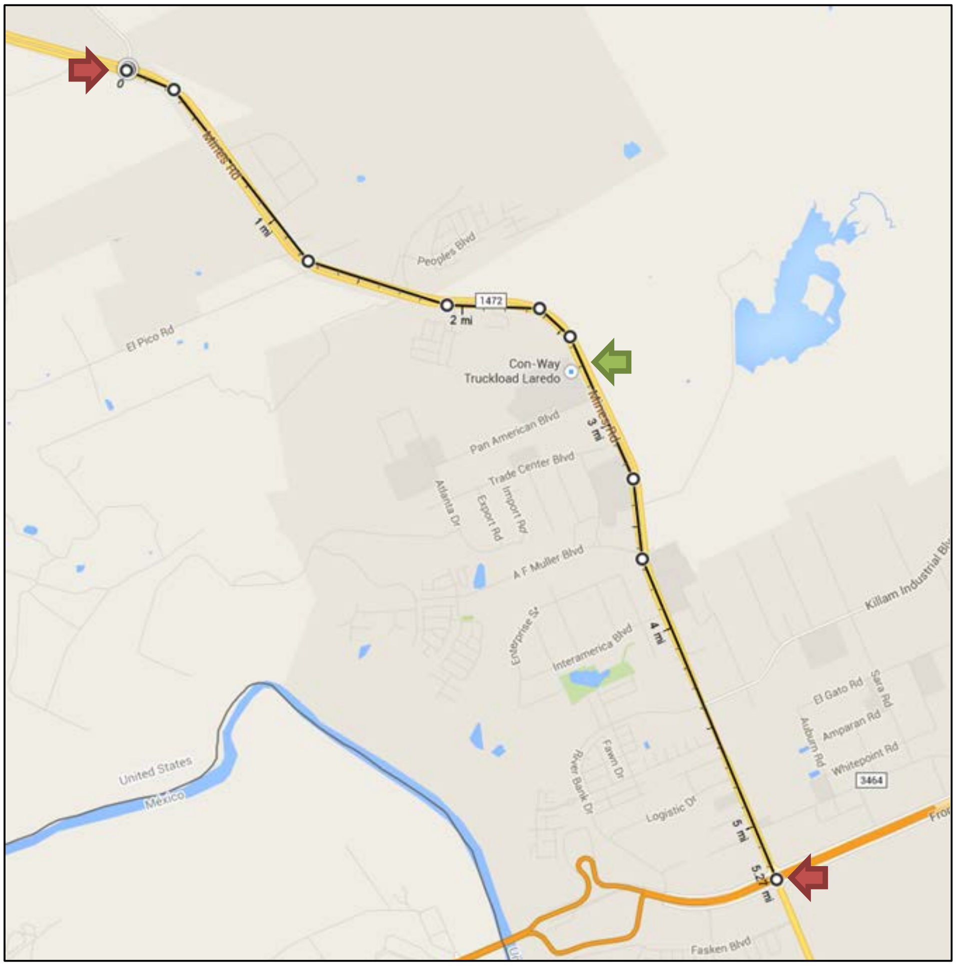


Figure 1. Study Limits along FM 1472 Corridor.

OVERVIEW OF POTENTIAL STRATEGIES ALONG FM 1472 CORRIDOR

TTI and TxDOT developed a list of potential improvements and strategies resulting from brainstorming discussions at TxDOT. The following provides examples of how to classify different types of strategies in to the short-term, medium-range, and long-range categories:

Examples of short-term strategies:

- Strategies that can be accomplished quickly with minimal project planning and funds and without adding new pavement.
- Re-time and re-phase traffic signals.
- Eliminate movements at intersections.

- Add left- or right-turn lanes using restriping only.
- Converting dedicated movement lanes to shared movement lanes, e.g., a dedicated right-turn lane to a shared through and right-turn lane.
- Eliminate traffic signals.
- Consolidate and/or redesign driveways.

Examples of medium-range strategies:

- Add through, left- or right-turn lanes that require new pavement but do not require the purchase of new right-of-way.
- Provide truck U-turn areas within the existing right-of-way.
- Add acceleration and deceleration lanes for right-turn movements.
- Consolidate and/or redesign driveways.
- Add cable barriers or posts to prevent illegal parking on the roadside clear zone. An ongoing problem in the study corridor is that a significant number of trucks park on the green space between the travel lanes and the right-of-way line. The district installed single-cable barriers, but they have not been effective. Large rocks have been deployed at some locations to prevent trucks from entering the green space, possibly by the City of Laredo or adjacent property owners.

Examples of long-range strategies:

- Add lanes, including having three through lanes in each direction from North of Killam Industrial Boulevard to the Con-way truckload facility, as well as left-turn and right-turn lanes at most intersections.
- Add direct connectors and other structures that require the purchase of new right-of-way.
- Add parallel route(s).
- Develop a freeway configuration for FM 1472, considering the possibility of a freeway-standard road connecting FM 1472 with IH-35 somewhere in the vicinity of Uniroyal.

The meetings between TxDOT and TTI also resulted in the following potential strategies and/or topics to improve traffic conditions along FM 1472:

- Improve incident management procedures, particularly for managing truck breakdowns. When a truck breaks down on FM 1472, traffic on this corridor collapses.

- Stagger truck scheduling. The hypothesis is that if truckers are able to coordinate when they schedule trips, traffic along FM 1472 could improve significantly. Evaluation of this strategy would require contacting and working with shippers and trucking companies to evaluate the feasibility of staggering cargo deliveries.

- Consider a City of Laredo traffic impact analysis (TIA) ordinance for new developments, which estimates anticipated truck volumes and the corresponding impact on traffic along FM 1472.

- Consider the establishment of a city task force for Mines Road.

- Consider an agreement between the City of Laredo and TxDOT in which TxDOT would help the city with signal re-timing and re-phasing.

- Examine safety and mobility issues affecting the Green Ranch development (Verde Boulevard) north of the Con-way truckload facility. Residents have complained to TxDOT that they cannot leave the area where they live because of eastbound truck traffic moving at high speeds.

The following recent or current efforts by the TxDOT Laredo District are also relevant to the analysis, including the following:

- A recent safety project between Interamerica Boulevard and Killam Industrial Boulevard changed the median and extended a left-turn lane. The project also eliminated a left-turn lane for a GM part supplier. A change order added a third through southbound lane from Interamerica Boulevard to Killam Industrial Boulevard.

- A safety project completed in 2015 added a raised median from Pellegrino Courtyard to Killam Industrial Boulevard.

Strategies Included in Analysis

TxDOT and TTI developed a list of potential short-term, medium-range, and long-range strategies within the study area. Table 4 provides a listing of these strategies. In some cases, a strategy was evaluated as a short-term solution, but analysis results indicated that a strategy would be more appropriate as a medium-range strategy. An example of this scenario would be the extension of a left-turn bay that required additional pavement. In that case, the strategy was moved from the short-term category to the medium-range category.

Table 4. Potential Location-Specific Short-Term, Medium-Range, and Long Range Strategies.

Location	Short-Term	Medium-Range	Long Range
Con-Way Truckload Facility	• Optimize signal timing and phasing. • Consider closing the median crossover.	• Add third NB and SB through lanes south of the Con-way truckload facility. • Consider closing the median crossover, e.g., by using a superstreet configuration. SB traffic frequently uses the shoulder lane from the bridge that is located some 400 feet north of the Con-way entrance.	
Pan American Boulevard	• Optimize signal timing and phasing. • Review the length of the left-turn lanes. The length of the dual NB to WB left-turn bay might be too short. There might be room for two WB lanes at Pan American, but only one lane is striped.	• Add dual EB to SB right-turn lanes. Issue: Right-turn traffic has difficulty proceeding because through SB movement is substantial. • Add third NB and SB through lanes north of Pan American Boulevard. • Add length to NB to WB left-turn lanes. • Optimize signal timing and phasing as needed.	
Trade Center Boulevard	• Optimize signal timing and phasing.	• Add dual EB to SB right-turn lanes. Right-turn traffic has difficulty proceeding because through SB movement is substantial. • Add third NB and SB through lanes north of Trade Center Boulevard. • Extend the length of the left-turn lanes. The length of the dual NB to WB left-turn bay might be too short. • Optimize signal timing and phasing as needed.	
A F Muller Boulevard	• Optimize signal timing and phasing. • Consider eliminating FM 1472/A F Muller Boulevard traffic signal.	• Replace existing signalization intersection with a superstreet intersection configuration. Turnaround lanes would be located between truck centers. • Add third NB and SB through lanes north of A F Muller Boulevard.	

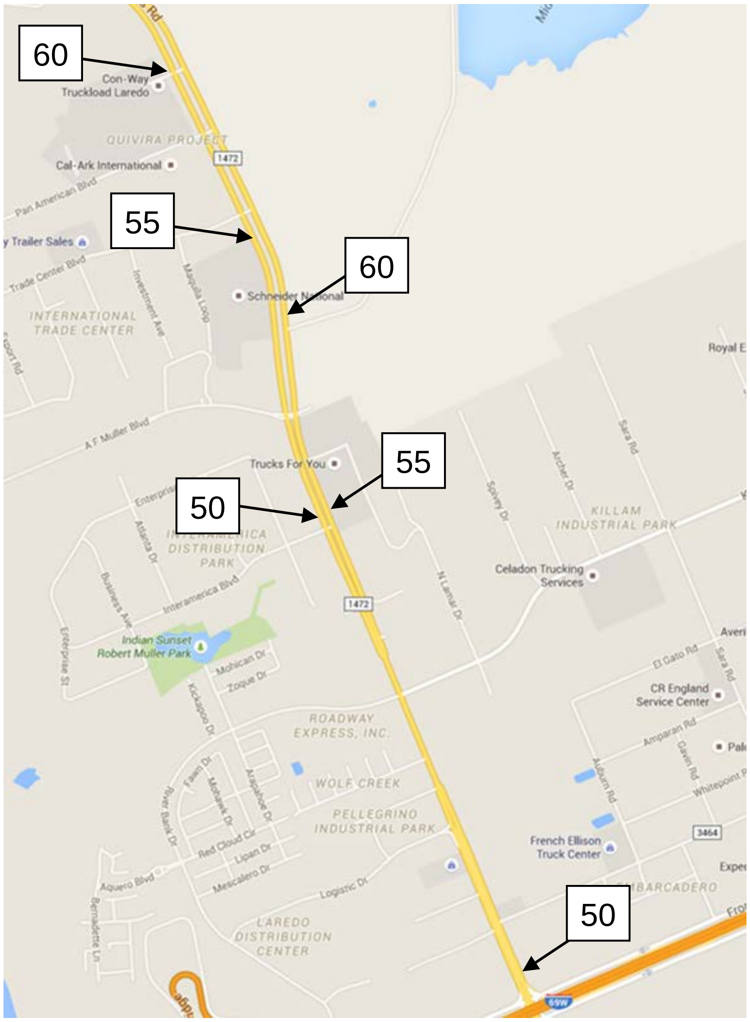
Location	Short-Term	Medium-Range	Long Range
Interamerica Boulevard	• Optimize signal timing and phasing.	• Extend third NB and SB through lanes from Killam Industrial Boulevard. The point where the third lane ends north of Killam Industrial Boulevard is a bottleneck blocking traffic on FM 1472. • Add third NB and SB through lanes north of Interamerica Boulevard.	
Killam Industrial Boulevard	• Optimize signal timing and phasing. • Add dual WB to SB left-turn lanes. • Add WB to NB free right-turn lane. • Add dual SB to EB left-turn lanes. • Add SB to WB free right-turn lane. • Review all radii, they appear to be too narrow. • Revise existing overpass (just south of Killam/I-35 connection) striping to U-turn configuration.	• Add dual NB to WB left-turn lanes. At what point is a dual left-turn lane configuration justified?	
River Bank Dr.		• May provide another exit out of the area if extended further south of LP 20 (IH-69W).	
Old Milo Road	• Optimize signal timing and phasing. • Eliminate left-turns for SB to EB movements. Three lanes of NB traffic on FM 1472 are being stopped to allow very few vehicles that need to make a SB to EB left-turn. Question: What about WB to SB left-turn movements: Are they a problem?	• Evaluate the need for this intersection.	

Location	Short-Term	Medium-Range	Long Range
Loop 20	• Optimize signal timing and phasing. The City of Laredo runs a NEMA configuration, instead of a full-phase diamond configuration.	• Add dual right-turn lanes to the WB to NB movement. It would involve removing part of the concrete island left of the existing right-turn lane. Dual right-turn lanes would address queues on the IH-69W frontage road that affect the IH-69W exit ramp.	• Add direct connectors. Another possibility is to add a flyover (similar to Loop 410 and Bandera). • Study possibility of adding an interchange on LP 20 between FM 1472 and I-35.
Other Connections			• The City may consider mitigating congestion by requesting major future developments to include connecting roadways from FM 1472 to I-35.

OVERVIEW OF STUDY CORRIDOR

The section of FM 1472 from Loop 20 to Con-Way truckload facility is about 2.7 miles long with three lanes in each direction and one two-way left-turn lane. North of the Killam Industrial Boulevard intersection, the road narrows to two lanes per direction with a divided median. Speed limits vary from 60 mph at Con-Way to 50 mph south of Interamerica Boulevard (Figure 2).

Figure 2. Changes in Speed Limits on FM 1472 in Northbound and Southbound Direction.



Traffic along the corridor includes a large percentage of commercial truck traffic. Table 5 shows the percentage of truck traffic for the AM, noon, and PM peaks at several intersections from Con-Way truckload facility to Loop 20. Table 5 shows that depending on location and time of day, truck percentages vary from 12 to 60 percent. The table also shows that percent truck traffic is lowest during the AM peak with a share of 12 to 24 percent of traffic along FM 1472, and highest during the noon peak with a share of 36 to 60 percent of traffic. Truck percentages during the PM peak at most intersections are roughly double or more than the percentages during the AM peak. The table also shows that truck percentages increase in the northbound direction during the AM peak, with the largest value observed at Pan American Boulevard.

Table 5. Percent Trucks in AM, Noon, and PM Peak Traffic Volumes at Intersections along FM 1472.

Intersection	Percent Trucks		
	AM	**Noon**	**PM**
Con-way Truckload Facility	20	N/A	40
Pan American Boulevard	24	N/A	45
Trade Center Boulevard	23	57	42
A F Muller Boulevard	18	N/A	37
Interamerica Boulevard	18	N/A	40
Killam Industrial Boulevard	19	51	34
Pellegrino Court	14	60	57
Old Milo Road	16	N/A	37
Loop 20 Eastbound Frontage Road	12	36	24
Loop 20 Westbound Frontage Road	13	45	40

Traffic along the corridor experiences significant delays during morning, noon, and afternoon peaks. TTI conducted a review of historical travel times during peak travel hours using available travel time data from Google Maps. Table 6 shows Google's estimated travel times between Con-Way and Loop 20 in the southbound direction on Thursday April 30, 2015 during off-peak, AM peak, noon peak, and PM peak hours. The table also shows calculated mean travel speeds based on travel distance (2.7 miles), delay relative to off peak travel time, and the increase in travel time as a percentage of the estimated off peak travel time.

Table 6. Travel Time between Con-Way Truckload Facility and Loop 20 in Southbound Direction on April 30, 2015 (Source: Google Maps.)

	Southbound (minutes)	**Mean Travel Speed (mph)**	**Delay (minutes)**	**Increase in Travel Time (percent)**
Off peak	6	27	0	0
8:30 am	6-8	27 – 20	0 – 2	0 – 33
12:00 pm	6-9	27 – 18	0 – 3	0 – 50
5:00 pm	6-12	27 – 14	0 – 6	0 – 100

Table 7 shows Google's estimated travel times between Con-Way and Loop 20 on Thursday April 30, 2015 in the northbound direction.

Table 7. Travel Time between Con-Way Truckload Facility and Loop 20 in Northbound Direction on April 30, 2015 (Source: Google Maps.)

	Northbound (minutes)	Mean Travel Speed (mph)	Delay (minutes)	Increase in Travel Time (percent)
Off peak	6	27	0	0
8:30 am	6-10	27 – 16	0 – 4	0 – 67
12:00 pm	6-10	27 – 16	0 – 4	0 – 67
5:00 pm	6-9	27 – 18	0 – 3	0 – 50

Table 6 shows that the corridor experiences significant delay in the southbound direction during all traffic peaks, but most significantly during the afternoon peak. In the afternoon, travel time might increase to twice that of the off peak travel time. Table 7 shows that in northbound direction, delays are most prevalent during the morning and noon peaks, and slightly less so during the afternoon peak. Travel times during the morning and noon peaks are about 2/3 higher than off peak travel times and about 50 percent higher during the afternoon peak.

METHODOLOGY

TTI analyzed all major intersections within the study limits using Trafficware Synchro 9, which includes the most recent Highway Capacity Manual (HCM) methodologies. TTI calculated current conditions traffic operation conditions based on existing signal timings using traffic data collected in November 2014 and May 2015. TTI then analyzed several scenarios for each intersection, which involved potential improvements based on changes to roadway striping and optimization of the signal timing. Although the focus of this analysis was on strategies that could be implemented in the short-term, TxDOT was interested in the long-term impact of these strategies. As a result, TTI evaluated the performance of the best performing scenario for a 10-year and a 20-year horizon using an estimated traffic growth factor.

Calibration of Synchro Default Values

A review of the video data indicated that truck traffic consists primarily of four to five-axle semi-trailer trucks. A typical five-axle truck uses approximately two to three times the space of a typical passenger car. Therefore, the default passenger car equivalent (PCE) value of 1.5 that Synchro uses to convert truck traffic to passenger car traffic is not appropriate for the analysis. Since Synchro does not allow the direct modification of the PCE, TTI converted all input volumes into a passenger car equivalent flow rate, using a PCE value of 2.5.

Analysis Limitations

The analysis of the each intersection was carried out in isolation but assuming a uniform signal cycle length to facilitate corridor signal coordination. This cycle length was based on the optimized signal timing at the FM 1472 and Killam intersection, which TTI determined to be the most congested intersection in the corridor, and resulted in a cycle length of 150 seconds.

Readers should note that the results of the Synchro analysis should be evaluated relatively to each other, i.e., by comparing the results of one intersection scenario to another scenario of the same intersection. In many cases, the Synchro analysis produced results that showed intersections performing satisfactory or marginally acceptable, while video evidence indicated that intersections were operating over capacity. This can be attributed to data collection used for the analysis not taking into account the number of underserved vehicles per cycle and not accounting for upstream metering of intersection traffic. TTI developed a microsimulation model of the corridor, which is capable of modeling traffic operations jointly at all corridor intersections. The results of this analysis are included in the medium-range strategy report.

Estimate of Corridor Traffic Growth

To estimate traffic growth, TTI reviewed annual average daily traffic (AADT) on FM 1472 between 2003 and 2013 (Figure 3). The figure shows AADT data from the count station on FM 1472 at Pan American Boulevard (i.e., 1.75 miles north of Killam Industrial Boulevard).

Based on traffic data collected by the Transportation Planning and Programming (TPP) Division at Pan American Boulevard, TTI estimated traffic growth using a linear regression model. Based on the model, TTI calculated an annual growth rate of 3.35 percent (Figure 3). Traffic data collected in 2012 was unusually low at a value of 13,100. Because annual traffic values going back to 2005 were in the range of 16,000 to 20,673, the 2012 traffic value might be considered an outlier. As a result, TTI recalculated annual traffic growth, which resulted in an annual growth factor of 4.94 percent (Figure 3). In the end, it was not possible to completely rule out the 2012 AADT value as an outlier. As a result, TTI decided to adopt an annual corridor growth rate of 5 percent.

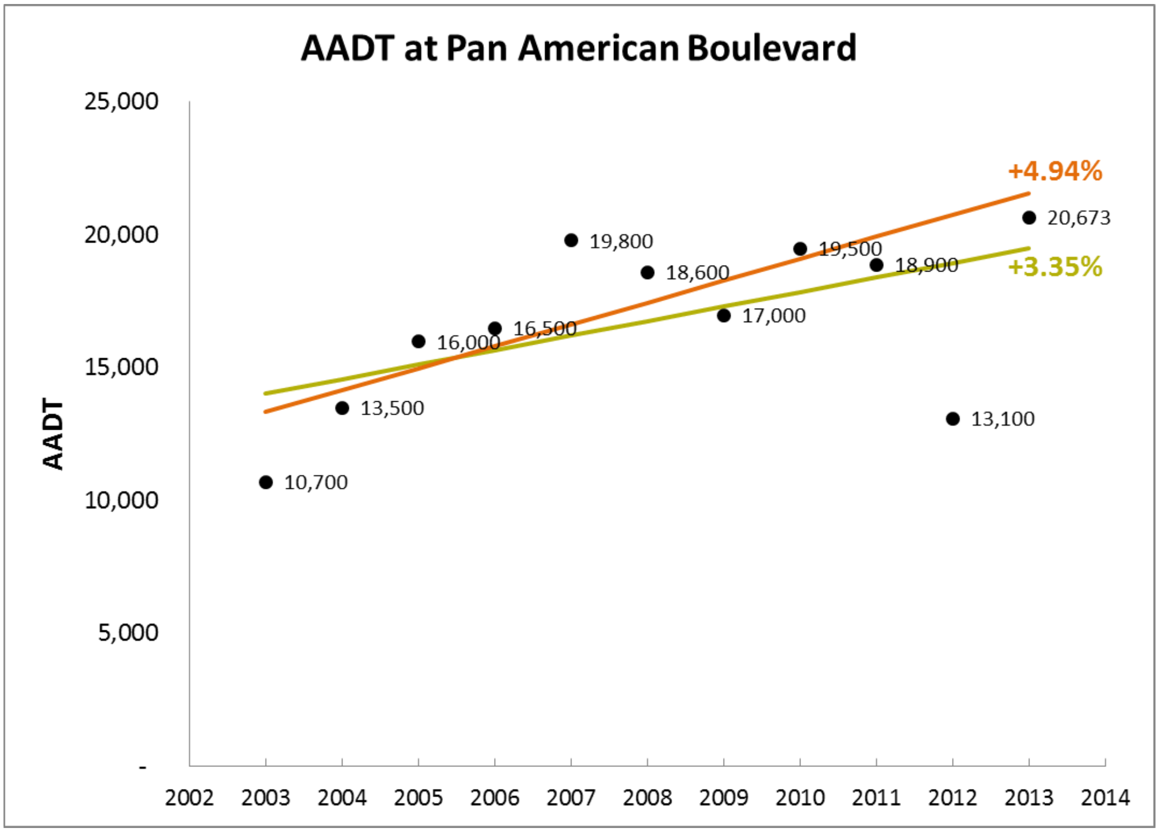


Figure 3. Historical AADT Data on FM 1472 at Pan American Boulevard.

INTERSECTION OF FM 1472 AND PAN AMERICAN BOULEVARD

Intersection Configuration

Pan American Boulevard is a T-intersection with FM 1472 (Figure 4). The detailed configuration is shown in Table 8. TTI reviewed the following potential short-term strategies for Pan American Boulevard:

- Optimize signal timing and phasing.

- Review the length of the left-turn lanes. The length of the dual northbound to westbound left-turn bay could be too short. There might be room for two westbound lanes at Pan American, but only one lane is striped.

Figure 4. Pan American Boulevard Intersection Overview.

Table 8. Intersection Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	2	Yes (storage length of 168 ft.)	No (T-intersection)	No
SB	2	Yes (storage length of 160 ft.)	No (shared with through lane)	No
EB	N/A	Yes (storage length of 292 ft.)	Yes (storage length of 292 ft.)	Yes
WB	N/A	N/A	N/A	N/A

The signal control is fully actuated. Table 9 shows the current signal timing plan (6:30 AM to 7:00 PM), which was provided by the City of Laredo.

Table 9. Signal Timing Plan.

	Phases							
	1	2	3	4	5	6	7	8
Cycle Length (s)	150							
Phase Split (s)	25	95	0	30	35	85	0	30
Max Green (s)	15	110	0	0	25	100	0	30
Min Green (s)	7	15	0	0	5	15	0	8
Gap Extension (s)	2	2.5	0	0	2	2.5	0	2.5
Yellow (s)	4	4.5	3.5	3.5	4	4.5	3.5	3.5
Red (s)	2	1.5	0	0	2	1.5	0	2.5

Figure 5 and Figure 6 provide phasing diagrams to illustrate the use of protected and permissive phases for the major street (FM 1472) and intersecting minor streets.

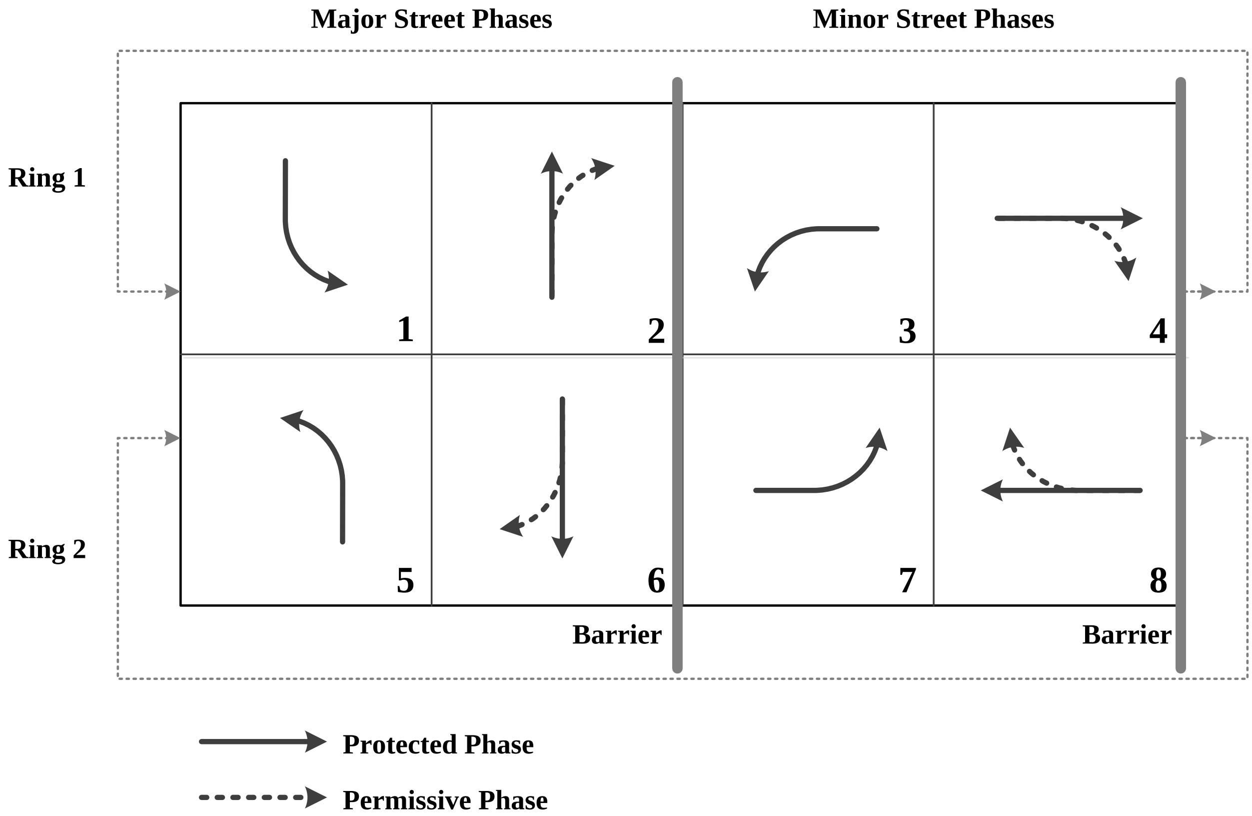


Figure 5. Phasing Diagram Including Protected and Permissive Phases.

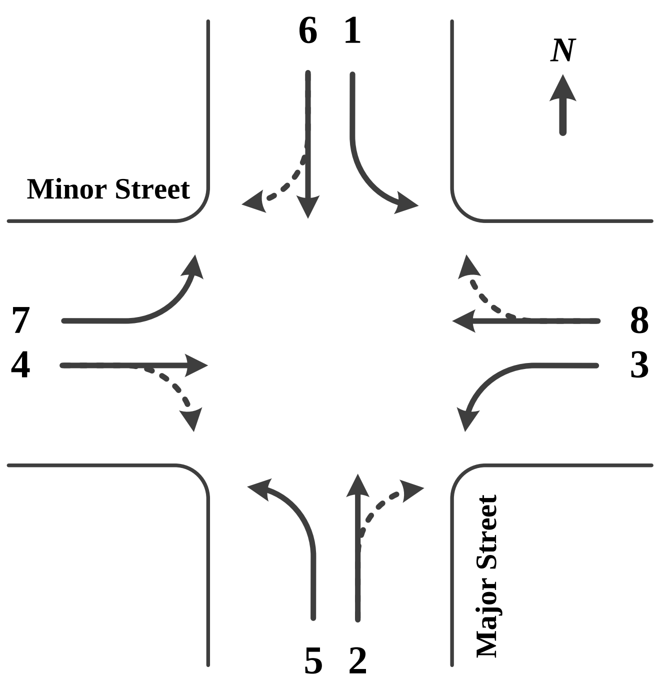


Figure 6. Phasing Diagram for Major and Minor Streets.

Traffic Data Description

TTI collected turning movement counts (TMCs) at each approach of the intersection on September 23, 2014, for two hours in the morning (7 am to 9 am) and in the afternoon (4 pm to 6 pm). The time interval for the traffic count data was 15 minutes. For analysis purposes, TTI selected the peak-15-minute traffic counts to account for the worst-case scenario, and then multiplied these values by four to arrive at peak hour traffic. Based on this calculation, the peak hour turning movements from the morning and afternoon periods are presented in Table 10.

Table 10 shows that the truck percentage during the peak 15-minute period in the afternoon for the northbound to westbound left-turning movement was 18%. In the afternoon peak, the eastbound to southbound right-turning movement rate was 17%. The northbound to westbound left-turning movement represented the highest average truck percentage across two peak 15-minute periods among all approaches. The high truck traffic at these approaches indicates the possible need for longer storage lengths. The adjusted peak hour flow rate for the AM peak, noon peak, and PM peak are also listed in Table 10.

Table 10. Peak Hour Turning Movements.

		NB			**SB**			**EB**		
		Left	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**
AM (7:45 – 8:00)	Volume (veh/h)	144	836			516	16	20		60
	% Trucks	2.8	2.8			3.9	0.0	20.0		11.7
	Adjusted peak hour flow rate (pc/h)	168	974			636	16	44		102
PM (5:00 – 5:15)	Volume (veh/h)	168	608			828	16	8		248
	% Trucks	18	12			10	13	13		17
	Adjusted peak hour flow rate (pc/h)	348	1,040			1,308	28	14		506

Intersection Analysis

AM Peak Period Analysis

TTI first coded the adjusted peak hour flow rate from the AM peak and signal timing in Synchro 9 to represent current conditions. Following the baseline analysis, TTI prepared improvement strategy scenarios, including optimized signal timing, increasing the storage length for the northbound to westbound left-turn movement, and extending the two lanes of westbound Pan American Boulevard. Control delay, as the service measure for intersections, was used to evaluate LOS of each approach of the intersection and the entire intersection. The results are listed in Table 11.

The results show that during the AM peak period, the eastbound traffic experiences the highest delay at the intersection. TTI found that by optimizing phase splits with the same cycle length of 150 seconds, the overall intersection delay slightly increases by 8%.

The first improvement scenario extends the northbound to westbound left-turning bay to 300 feet. Even though the storage for this turning movement is increased from 168 feet to 300 feet, the amount of delay remains the same when simply optimizing phase splits. Westbound Pan American Boulevard is wide enough for two lanes (full roadway width is 40 feet) but is only striped for one lane in each direction. At the intersection with FM 1472, westbound Pan American Boulevard allows for two lanes but tapers to one lane after about 290 feet. For the second improvement scenario, the two westbound lanes of Pan American Boulevard are extended to 600 feet before tapering to one lane to allow for an increase in left turn traffic.

The amount of delay between scenario 1 and scenario 2 is the same when optimizing phase splits. The reason that the improvement scenarios do not show much improvement might be that current conditions resulted in an overall intersection delay of only 5.0 seconds.

Table 11. Results for AM Peak (All Cycle Lengths = 150 s).

		NB	**SB**	**EB**	**WB**
Current conditions	Approach delay (s/veh)	2.0	1.7	44	
	Approach LOS	A	A	D	
	Intersection delay (s/veh) & LOS	5.0		A	
Optimized splits	Approach delay (s/veh)	1.7	3.4	43.5	
	Approach LOS	A	A	D	
	Intersection delay (s/veh) & LOS	5.4		A	
	Reduction of intersection delay	8% increase			
Scenario 1: Optimized splits and extended NB turn bay	Approach delay (s/veh)	1.7	3.4	43.5	
	Approach LOS	A	A	D	
	Intersection delay (s/veh) & LOS	5.4		A	
	Reduction of intersection delay	8% increase			
Scenario 2: Optimized splits, extended NB turn bay, and WB extension	Approach delay (s/veh)	1.7	3.4	43.5	
	Approach LOS	A	A	D	
	Intersection delay (s/veh) & LOS	5.4		A	
	Reduction of intersection delay	8% increase			

PM Peak Period Analysis

TTI also applied the similar approach for the PM peak period analysis. The analysis results are listed in Table 12.

The results show that during the PM peak period, the eastbound traffic experiences the highest delay at the intersection, similar to the morning peak. By optimizing phase splits with the current cycle length of 150 seconds, the overall intersection delay could be reduced by 27.5%.

The first improvement scenario extends the northbound to westbound left-turning bay to a total of 300 feet, which reduces overall intersection delay in the PM period by 39.8%. In the second improvement scenario, the westbound two lanes of Pan American Boulevard are extended to 600 feet before tapering back to one lane. The amount of delay does not change from the second scenario, but the simulation does show much smoother flow in the northbound to westbound turning movement.

In summary, the analysis found that optimizing the current signal timing with a cycle length of 150 seconds and extending the northbound to westbound left-turning bay to at least 300 feet would improve intersection operations. If TxDOT extends the left-turning bay, the City of Laredo might also consider extending the two westbound Pan American Boulevard lanes for at least 600 feet before tapering back to one lane to take advantage of the added capacity on the northbound to westbound turning movement on FM 1472.

Table 12. Results for PM Peak (All Cycle Lengths = 150 s).

		NB	**SB**	**EB**	**WB**
Current conditions	Approach delay (s/veh)	35.3	12.9	177.2	
	Approach LOS	D	B	F	
	Intersection delay (s/veh) & LOS	48.8		D	
Optimized splits	Approach delay (s/veh)	28.6	41.9	37.3	
	Approach LOS	C	D	D	
	Intersection delay (s/veh) & LOS	35.4		D	
	Reduction of intersection delay	27.5%			
Scenario 1: Optimized splits and extended NB turn bay	Approach delay (s/veh)	16.6	30.4	60.8	
	Approach LOS	B	C	E	
	Intersection delay (s/veh) & LOS	29.4		C	
	Reduction of intersection delay	39.8%			
Scenario 2: Optimized splits, extended NB turn bay, and WB extension	Approach delay (s/veh)	16.6	30.4	60.8	
	Approach LOS	B	C	E	
	Intersection delay (s/veh) & LOS	29.4		C	
	Reduction of intersection delay	39.8%			

The analysis resulted in the following optimized signal timings as shown in Table 13.

Table 13. Results of Signal Timing Optimization.

		Phases							
		1	2	3	4	5	6	7	8
Cycle Length (s)		150							
Phase Split (s)	AM		122		36	17	105		
	PM		102		56	22	80		

Note: The following phases are combined: 2 and 5; 4 and 7.

Future Scenario Analysis

Using an overall traffic growth rate of 5 percent, TTI conducted an analysis using the projected traffic volumes for AM and PM peak periods to analyze future traffic impacts on scenario 2. The results for years 2025 and 2035, including improvement as previously discussed, are listed in Table 14.

Table 14. Results of 2025 and 2035 Scenarios with Improvements.

			NB	SB	EB
2025	AM	Approach delay (s/veh)	3.1	5.1	44.2
		Approach LOS	A	A	D
		Intersection delay (s/veh) & LOS	6.9		A
	PM	Approach delay (s/veh)	67.2	179.5	225.8
		Approach LOS	E	F	F
		Intersection delay (s/veh) & LOS	138.9		F
2035	AM	Approach delay (s/veh)	19.1	18.4	62.7
		Approach LOS	B	B	E
		Intersection delay (s/veh) & LOS	22.1		C
	PM	Approach delay (s/veh)	263.2	537.7	604.4
		Approach LOS	F	F	F
		Intersection delay (s/veh) & LOS	430.9		F

The results show that the proposed improvement strategies are not sufficient to deal with anticipated future traffic volumes. Although implementation of short-term strategies will help alleviate traffic in the short-term, dealing with traffic growth and congestion in the long-term will require strategies that are more substantial. These strategies are defined and analyzed in two separate technical memoranda focusing on medium– and long-term strategies.

INTERSECTION OF FM 1472 AND TRADE CENTER BOULEVARD

Intersection Configuration

This intersection is located just south of Pan American Boulevard. At this intersection, FM 1472 has two lanes in each direction, and Trade Center Boulevard is a one-lane facility in each direction (Figure 7). The detailed configuration is listed in Table 15 below. TTI reviewed the following potential short-term strategies for Trade Center Boulevard:

- Optimize signal timing and phasing.
- Extend the length of the left-turn lanes. The length of the dual northbound to westbound left-turn bay might be too short.

Figure 7. Trade Center Boulevard Intersection Overview.

Table 15. Intersection Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	2	Yes (dual left-turn lanes with storage length of 235ft)	No	No
SB	2	Yes (storage length of 200ft)	No (shared with through lane)	No
EB	0	Yes	Yes	No

The intersection signal runs a coordinated full actuation scheme. TTI obtained the signal timing plan employed in the study period (6:30 AM to 7:00 PM) from City of Laredo, as listed in Table 16.

Table 16. Signal Timing Plan.

		Phases							
		1	2	3	4	5	6	7	8
Cycle Length (s)		150							
Phase Split (s)	AM	15	110			30	95		
	PM	15	110			30	95		

Traffic Data Description

For this study, TTI collected TMCs on March 26, 2015 for the AM peak hour (7:00 – 9:00 AM), and PM peak hour (4:00 – 6:00 PM) conditions. The time interval for the traffic count data was 15 minutes. The traffic counts from the morning period and afternoon period are presented in Table 17. The adjusted peak hour flow rate for the AM peak and PM peak based on a PCE of 2.5 are also listed in Table 17.

Table 17. Peak Hour Turning Movements.

		EB			NB			SB		
		Left	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**
AM	Volume (veh/h)	35		69	390	749		23	457	36
	% Trucks	31		46	21	24		4	34	33
	Adjusted peak hour flow rate (pc/h)	52		117	513	1,021		25	690	54
PM	Volume (veh/h)	43		277	212	654		12	982	39
	% Trucks	49		45	54	47		17	34	72
	Adjusted peak hour flow rate (pc/h)	75		465	383	1,119		15	1,480	81

Intersection Analysis

TTI performed two sets of analyses for the AM peak and PM peak, respectively. The adjusted peak hour flow rates were used as inputs in the analyses.

AM Peak Period Analysis

A summary of the results of traffic operation analysis based on adjusted AM peak hour traffic counts is shown in Table 18. Control delays with LOS are used as the service measure for the intersection, as well as for each approach of the intersection. The overall intersection delay during the AM peak was 23.8 seconds (LOS C). The eastbound approach is the most congested approach and has a LOS D.

TTI investigated various scenarios with different improvement strategies. The scenarios included optimizing signal timing, optimizing and coordinating (to be consistent with the critical corridor cycle length of 150 seconds set by the Killam intersection), adding an overlap phase allowing eastbound right turn together with northbound left-turn (northbound U-turn prohibited), and eliminating southbound left-turn and U-turn movement. It is worth noting that in the coordinated timing, the “half cycling” (a minor intersection has half the cycle length of the major intersection) was used. With the relative lower traffic volume in minor intersection like Trade Center Boulevard, this method can often produce substantially lower delays. Eliminating the southbound left-turn and U-turn movements allows more green time for the opposite direction; however, the left-turn and U-turn traffic will travel further south and turn around at the next median open or intersection.

Table 18. Results for AM Peak.

		EB	NB	SB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	37.9	26.9	14.7
	Approach LOS	D	C	B
	Intersection delay (s/veh) & LOS	23.8		C
Optimized timing (Cycle length: 40 s)	Approach delay (s/veh)	12.8	10.4	11.6
	Approach LOS	B	B	B
	Intersection delay (s/veh) & LOS	10.9		B
	Reduction of intersection delay	54.2%		
Scenario 1: Coordinated and Optimized timing (Cycle length: 75 s)	Approach delay (s/veh)	18.7	14.8	13.9
	Approach LOS	B	B	B
	Intersection delay (s/veh) & LOS	14.8		B
	Reduction of intersection delay	37.8%		
Scenario 2: Add an overlap phase for EB right turn (with NB left-turn) (Cycle length: 75 s)	Approach delay (s/veh)	14.0	14.5	13.1
	Approach LOS	B	B	B
	Intersection delay (s/veh) & LOS	14.0		B
	Reduction of intersection delay	41.2%		
Scenario 3: Eliminate SB left/U turn movement (Cycle length: 75 s)	Approach delay (s/veh)	18.7	12.1	13.6
	Approach LOS	B	B	B
	Intersection delay (s/veh) & LOS	13.0		B
	Reduction of intersection delay	45.4%		

The model results indicated significant improvement (54.2%) achieved by optimizing signal timing alone with 40 second cycle length. The improvement however was not as significant when the coordinated cycle length of 75 seconds was used. TTI found that the scenarios of (a) adding an overlap phase for eastbound right turn and (b) eliminating southbound left-turn and U-turn movement provided a similar improvement to the intersection operation. Delay improvement percentages for these two scenarios using signal optimization with a 75-second cycle length were 41.2 percent and 45.4 percent, respectively.

PM Peak Period Analysis

The same improvement scenarios were investigated in the PM peak period analysis. The analysis results are listed in Table 19.

Table 19. Results for PM Peak.

		EB	NB	SB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	45.1	28.4	31.0
	Approach LOS	D	C	C
	Intersection delay (s/veh) & LOS	32.0		C
Optimized timing (Cycle length: 70 s)	Approach delay (s/veh)	42.2	18.6	26.9
	Approach LOS	D	B	C
	Intersection delay (s/veh) & LOS	25.8		C
	Reduction of intersection delay	19.4%		
Scenario 1: Coordinated and Optimized timing (Cycle length: 75 s)	Approach delay (s/veh)	42.9	20.7	26.7
	Approach LOS	D	C	C
	Intersection delay (s/veh) & LOS	26.7		C
	Reduction of intersection delay	16.6%		
Scenario 2: Add an overlap phase for EB right turn (with NB left-turn) (Cycle length: 75 s)	Approach delay (s/veh)	37.7	9.6	22.2
	Approach LOS	D	A	C
	Intersection delay (s/veh) & LOS	19.3		B
	Reduction of intersection delay	39.7%		
Scenario 3: Eliminate SB left/U turn movement (Cycle length: 75 s)	Approach delay (s/veh)	46.7	20.5	28.2
	Approach LOS	D	C	C
	Intersection delay (s/veh) & LOS	27.7		C
	Reduction of intersection delay	13.4%		

For existing conditions, overall intersection LOS is C with a slightly higher delay (32.0 seconds) compared to the AM peak hour. The improvement provided by the signal optimization alone was not as significant as in the AM peak analysis with only a 16.6 percent delay reduction. The scenario of adding an overlapping phase for eastbound right turn provided significant improvement as it directly improved the eastbound approach. The delay reduction by the overlap phase scenario was 39.4%. The scenario of eliminating the southbound left-turn and U-turn movement did not provide a desired benefit.

Suggestions for Improving Current Conditions

Combining the results from both peak hours, the analysis found that adding an overlap phase for the eastbound right turn along with the signal optimization and the coordinated "half cycle length" provided the most benefit. Eliminating the southbound left/U turn movement is not recommended. As a consequence of closing the southbound U-turn, about 20-30 vehicles per hour, depending on the time of the day, would need to travel further south and turn around at the Muller Boulevard intersection. The negative impact of re-routing this traffic on corridor traffic operations would be far greater than the benefit of the U-turn removal at Trade Center Boulevard. The analysis resulted in the following optimized signal timings as shown in Table 20.

Table 20. Results of Signal Timing Optimization.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		75							
Phase Split (s)	AM	11	52		12	27	36		
	PM	8	57		10	23	42		

Future Scenario Analysis

The AADT provided by TPP revealed that the sustained growth and expansion have occurred over time along the FM 1472 corridor and nearby vicinity. A value of 5 percent annual growth was used to analyze the impact of future traffic volume levels on scenario 2.

The evaluation results of the future scenarios in years 2025 and 2035 with improvement (i.e., adding an overlap phase for eastbound right turn) are listed in Table 21. The results indicated that while the existing roadway facility and the proposed strategies may maintain an acceptable operation performance for the intersection over a 10-years horizon, the LOS of the intersection would however fall to level F in 20 years if the current growth trend continues. In the long term, capacity-increasing strategies such as adding lanes and providing alternative routes should be evaluated.

Table 21. Results of 2025 and 2035 Scenarios with Improvements.

			EB	NB	SB
2025	AM	Approach delay (s/veh)	22.2	14.5	20.7
		Approach LOS	C	B	C
		Intersection delay (s/veh) & LOS	17.0		B
	PM	Approach delay (s/veh)	181.8	15.7	117.8
		Approach LOS	F	B	F
		Intersection delay (s/veh) & LOS	85.0		F
2035	AM	Approach delay (s/veh)	45.7	27.3	48.9
		Approach LOS	D	C	D
		Intersection delay (s/veh) & LOS	35.3		D
	PM	Approach delay (s/veh)	346.4	21.7	287.4
		Approach LOS	F	C	F
		Intersection delay (s/veh) & LOS	F		185.9

INTERSECTION OF FM 1472 AND MULLER BOULEVARD

Intersection Configuration

This intersection is located on the north side of the FM 1472 between the Trade Center and Interamerica intersections (Figure 8). FM 1472 has two lanes in each direction, and Muller Boulevard is a two-lane (one for each direction) facility. The detailed configuration is listed in Table 22 below. TTI reviewed the following potential short-term strategies for A F Muller Boulevard:

- Optimize signal timing and phasing.
- Consider eliminating the FM 1472 and Muller Boulevard traffic signal.

Figure 8. Mueller Boulevard Intersection Overview.

Table 22. Intersection Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	2	Yes (storage length of 250ft)	No	No
SB	2	Yes (storage length of 425ft)	No	No
WB	1	No	No	No
EB	1	No	No	Yes

The intersection signal runs a coordinated full actuation scheme. TTI obtained the signal timing plan employed in the study period (6:30 AM to 7:00 PM) from City of Laredo, as listed in Table 23.

Table 23. Signal Timing Plan.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		150							
Phase Split (s)	AM	13	92	20	25	35	70		45
	PM	13	92	20	25	35	70		45

Traffic Data Description

For this study, TTI collected TMCs on March 26, 2015 for the AM peak hour (7:00 – 9:00 AM), and PM peak hour (4:00 – 6:00 PM) conditions. The time interval for the traffic count data was 15 minutes. The traffic counts from the morning period and afternoon period are presented in Table 24. The adjusted peak hour flow rate for the AM peak and PM peak using a PCE of 2.5 are listed in Table 24.

Table 24. Peak Hour Turning Movements.

		NB			SB			EB			WB		
		Left	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**
AM	Volume (veh/h)	126	1,105	5	6	492	52	41		206	1		2
	% Trucks	0	18	20	30	31	2	0		2	0		0
	Adjusted peak hour flow rate (pc/h)	126	1,404	6	8	722	54	41		208	1		2
PM	Volume (veh/h)	197	753	3	15	1,272	48	7		96	15		11
	% Trucks	2	51	0	26	39	1	0		1	73		22
	Adjusted peak hour flow rate (pc/h)	199	1,329	3	21	2,016	49	7		98	32		15

Intersection Analysis

TTI performed two sets of analyses for the AM peak and PM peak, respectively. The adjusted peak hour flow rates were used as inputs in the analyses.

AM Peak Period Analysis

A summary of the results of traffic operation analysis based on adjusted AM peak hour traffic counts is shown in Table 25. Control delay LOS was used as the service measure for the intersection, as well as for each approach of the intersection. Overall intersection delay was 17.0 seconds resulting in a LOS B. The cross street approaches in eastbound and westbound direction have a higher delay with LOS D. Further investigation on the traffic volumes reveals that the cross street traffic volumes, especially the left-turn traffic, are relatively low.

To improve traffic operations, TTI investigated a "superstreet" configuration, which is a divided highway with intersections in which the minor cross-street traffic is prohibited from going straight through or turning left. The minor cross street traffic must turn right and then access a U-turn to proceed to the desired direction. TTI considered that only one new satellite median U-turn and signals would be built, north of Muller Boulevard. Traffic intending to travel north on FM 1472 would need to make a U-turn at the next intersection south of Muller Boulevard, which is Interamerica Boulevard.

Other improvement scenarios were optimizing the signal timing, and optimizing the signal timing using the coordination cycle length of 150 seconds set by the Killam intersection. It is worth noting that in the coordinated timing scenario, a "half cycling" strategy (a minor intersection has half the cycle length of the major intersection) was used. With the relative lower traffic volume in minor intersection like Muller Boulevard, this method can often produce substantially lower delays.

Table 25. Results for AM Peak.

		EB	WB	NB	SB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	50.5	37.7	13.7	12.9
	Approach LOS	D	D	B	B
	Intersection delay (s/veh) & LOS	17.0		B	
Optimized timing (Cycle length: 60 s)	Approach delay (s/veh)	12.7	15.3	10.5	11.7
	Approach LOS	B	B	B	B
	Intersection delay (s/veh) & LOS	11.1		B	
	Reduction of intersection delay	34.7%			
Scenario 1: Coordinated and Optimized timing (Cycle length: 75 s)	Approach delay (s/veh)	17.0	20.3	9.1	10.8
	Approach LOS	B	C	A	B
	Intersection delay (s/veh) & LOS	10.4		B	
	Reduction of intersection delay	38.8%			
Scenario 2: Superstreet Configuration (Cycle length: 75 s)	Approach delay (s/veh)	22.6	0.0	3.7	4.8
	Approach LOS	C	A	A	A
	Intersection delay (s/veh) & LOS	5.8		A	
	Reduction of intersection delay	65.9%			

The results indicated a significant improvement (38.8%) achieved by optimizing and coordinating signal timing. The signal re-timing and half cycle length work especially well for the cross street approaches and produced substantially lower delays. The superstreet strategy further improved the intersection operation by reducing the delay over current conditions by 65.9%. The northbound and southbound throughput movements benefit the most from the strategy. It is worth noting that to achieve the improvement for the throughput traffic, left-turn traffic from the cross street has to travel longer, and downstream intersections (in this case Trade Center and Interamerica) may suffer a delay increase due to the increase in traffic volumes. The delay increases at adjacent intersections was not included in this Muller Boulevard intersection analysis.

PM Peak Period Analysis

The same improvement scenarios were investigated in the PM peak period analysis. The analysis results are listed in Table 26.

Table 26. Results for PM Peak.

		EB	WB	NB	SB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	25.0	142.0	20.3	21.9
	Approach LOS	C	F	C	C
	Intersection delay (s/veh) & LOS	22.9		C	
Optimized timing (Cycle length: 90 s)	Approach delay (s/veh)	15.2	43.9	12.0	35.9
	Approach LOS	B	D	B	D
	Intersection delay (s/veh) & LOS	25.7		C	
	Reduction of intersection delay	-12.2% (increase)			
Scenario 1: Coordinated and Optimized timing (Cycle length: 75 s)	Approach delay (s/veh)	20.2	103.4	14.9	23.2
	Approach LOS	C	F	B	C
	Intersection delay (s/veh) & LOS	20.8		C	
	Reduction of intersection delay	9.2%			
Scenario 2: Superstreet Configuration (Cycle length: 75 s)	Approach delay (s/veh)	27.6	1.4	7.9	11.2
	Approach LOS	C	A	A	B
	Intersection delay (s/veh) & LOS	10.2		B	
	Reduction of intersection delay	55.5%			

Current conditions provide an overall intersection LOS C with a slightly higher delay (22.9 seconds) compared to the AM peak hour. The improvement provided by the signal optimization and coordination was not as significant as in the AM peak analysis, with only 9.2% reduction of delay using the coordinated signal optimization. The superstreet strategy improved the intersection operation by reducing the delay by 55.5% over current conditions. The analysis resulted in the following optimized signal timings as shown in Table 27.

Table 27. Results of Signal Timing Optimization.

		Phases							
		1	2	3	4	5	6	7	8
Cycle Length (s)		150							
Phase Split (s)	AM	10	65			31	44		
	PM	9	66			17	58		

Future Scenario Analysis

The AADT collected by TPP revealed that the sustained growth and expansion have occurred over time along the FM 1472 corridor and nearby vicinity. A value of 5 percent annual growth was used to analyze the impact of future traffic volume levels on scenario 2.

The evaluation results of the future scenarios in years 2025 and 2035 with improvement (i.e., adding an overlap phase for westbound right turn) are listed in Table 28.

Table 28. Results of 2025 and 2035 Scenarios with Improvements.

			EB	WB	NB	SB
2025	AM	Approach delay (s/veh)	33.0	3.0	4.6	12.2
		Approach LOS	C	A	A	B
		Intersection delay (s/veh) & LOS	9.6		A	
	PM	Approach delay (s/veh)	70.5	44.7	22.0	94.3
		Approach LOS	E	D	C	F
		Intersection delay (s/veh) & LOS	63.8		E	
2035	AM	Approach delay (s/veh)	55.7	26.2	15.0	20.4
		Approach LOS	E	C	B	C
		Intersection delay (s/veh) & LOS	20.5		C	
	PM	Approach delay (s/veh)	80.8	99.8	38.6	277.5
		Approach LOS	F	F	D	F
		Intersection delay (s/veh) & LOS	173.5		F	

The results indicated that while the existing roadway facility and the proposed strategies may maintain an acceptable operation performance for the AM peak hour in both 10 years and 20 years horizon, the LOS of the intersection during PM peak hours will fall into level E in 10 years and F shortly after if the current growth trend continues. In the long term, capacity-increasing strategies such as adding lanes and providing alternative routes should be evaluated.

INTERSECTION OF FM 1473 AND INTERAMERICA BOULEVARD

Intersection Configuration

This intersection is located north of Killam Industrial Boulevard intersection (Figure 9). FM 1472 has two lanes in each direction, and Interamerica Boulevard is a two-lane (one lane each per direction) facility. The detailed configuration is listed in Table 29 below. TTI reviewed the following potential short-term strategies for Interamerica Boulevard:

- Optimize signal timing and phasing.

Figure 9. Interamerica Boulevard Intersection Overview.

Table 29. Intersection Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	2	Yes (dual left-turn lanes with storage length of 580 ft.)	No	No
SB	2	Yes (storage length of 225 ft.)	Yes (storage length of 500 ft.)	No
EB	0	Yes	Yes	No

The intersection signal runs a coordinated full actuation scheme. TTI obtained the signal timing plan employed in the study period (6:30 AM to 7:00 PM) from City of Laredo, as listed in Table 30.

Table 30. Signal Timing Plan.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		150							
Phase Split (s)	AM	12	116		22	34	94		
	PM	12	116		22	34	94		

Traffic Data Description

For this study, TTI collected TMCs on March 26, 2015 for the AM peak hour (7:00 – 9:00 AM), and PM peak hour (4:00 – 6:00 PM) conditions. The time interval for the traffic count data was 15 minutes. The traffic counts from the morning period and afternoon period are presented in Table 31. The adjusted peak hour flow rate for the AM peak and PM peak are also listed in Table 31.

Table 31. Peak Hour Turning Movements.

		EB			NB			SB		
		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
AM	Volume (veh/h)	6		59	281	1,307		0	789	24
	% Trucks	33		56	12	19		0	19	38
	Adjusted peak hour flow rate (pc/h)	9		129	362	1,749		0	1,194	38
PM	Volume (veh/h)	35		401	206	905		3	1,366	45
	% Trucks	57		35	59	43		33	34	33
	Adjusted peak hour flow rate (pc/h)	65		661	400	1,548		5	2,212	66

Intersection Analysis

TTI performed two sets of analyses for the AM peak and PM peak, respectively. The adjusted peak hour flow rates were used as inputs in the analyses.

AM Peak Period Analysis

A summary of the results of traffic operation analysis based on adjusted AM peak hour traffic counts is shown in Table 32. Control delays with level of service (LOS) are used as the service measure for the intersection, as well as for each approach of the intersection. Overall intersection delay was 13.7 seconds resulting in a LOS B. The most congested approach eastbound has higher delay with LOS C. Various scenarios with different improvement strategies have been investigated. The scenarios include optimizing signal timing, optimizing and coordinating (to be consistent with the corridor cycle length of 150 seconds set by the Killam intersection), adding an overlap phase allowing eastbound right turn together with northbound left-turn (northbound U-turn prohibited), and eliminating southbound left-turn and U-turn movements.

Table 32. Results for AM Peak.

		EB	NB	SB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	26.8	14.6	10.7
	Approach LOS	C	B	B
	Intersection delay (s/veh) & LOS	13.7		B
Optimized timing (Cycle length: 60 s)	Approach delay (s/veh)	14.1	8.0	12.0
	Approach LOS	B	A	B
	Intersection delay (s/veh) & LOS	9.7		A
	Reduction of intersection delay	29.2%		
Coordinated and Optimized timing (Cycle length: 75 s)	Approach delay (s/veh)	15.0	9.7	12.4
	Approach LOS	B	A	B
	Intersection delay (s/veh) & LOS	10.9		B
	Reduction of intersection delay	20.4%		
Scenario 1: Add an overlap phase for EB right turn (with NB left-turn) (Cycle length: 75 s)	Approach delay (s/veh)	19.6	7.0	6.9
	Approach LOS	B	A	A
	Intersection delay (s/veh) & LOS	7.5		A
	Reduction of intersection delay	45.3%		
Scenario 2: Eliminate SB left/U turn movement (Cycle length: 75 s)	Approach delay (s/veh)	15.0	9.7	12.4
	Approach LOS	B	A	B
	Intersection delay (s/veh) & LOS	10.9		B
	Reduction of intersection delay	20.4%		
Scenario 3: Add an overlap phase for EB right turn (with NB left-turn); and Eliminate SB left/U turn movement (Cycle length: 75 s)	Approach delay (s/veh)	20.6	7.2	7.7
	Approach LOS	C	A	A
	Intersection delay (s/veh) & LOS	7.9		A
	Reduction of intersection delay	42.3%		

It is worth noting that in the coordinated timing, a half cycle length of 75 seconds was used. With the relative lower traffic volume in minor intersection like Trade Center Boulevard, this method can often produce substantially lower delays. Eliminating the southbound left-turn and U-turn movement allows more green split time for the opposite direction; however, the left-turn and U-turn traffic will travel further south and turn around at the next median open or intersection.

The model results indicated a 29.2% delay reduction achieved by optimizing signal timing alone with 60-second cycle length. The improvement however was not as significant when the coordinated timing is applied. It is also found the most significant delay reduction was provided by adding an overlap phase for eastbound right turn (45.3% delay reduction). Eliminating the southbound left-turn and U-turn movement made relative less impact on the operation performance. Combining both the strategies together with coordinated signal optimization can provide a 42.3% delay reduction.

PM Peak Period Analysis

The same improvement scenarios were investigated in the PM peak period analysis. The analysis results are listed in Table 33.

Overall intersection delay was 69.6 seconds, which resulted in a LOS E. The most congested approach eastbound has a delay of 274.3 seconds delay with LOS F. Note that as the traffic volumes increase in the PM peak hour, the cycle lengths also increase. The “half cycling” strategy would not work in the PM peak, thus the 150-second cycle length (consistent with the critical corridor cycle length of 150 seconds set by Killam intersection) was used for all scenarios. The model results indicated that the timing plan used in the existing condition is already optimal. The improvement percentages of the delay reduction for the two scenarios (adding an overlap phase for eastbound right turn and eliminating southbound left-turn and U-turn movement) are 9.3% and 7.0% respectively. Combining both the strategies together with coordinated signal optimization can provide an 11.5% delay reduction.

Table 33. Results for PM Peak.

		EB	NB	SB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	274.3	19.5	47.3
	Approach LOS	F	B	D
	Intersection delay (s/veh) & LOS	69.6		E
Optimized timing (Cycle length: 150 s)	Approach delay (s/veh)	274.3	19.5	47.3
	Approach LOS	F	B	D
	Intersection delay (s/veh) & LOS	69.6		E
	Reduction of intersection delay	0%		
Coordinated and Optimized timing (Cycle length: 150 s)	Approach delay (s/veh)	274.3	19.5	47.3
	Approach LOS	F	B	D
	Intersection delay (s/veh) & LOS	69.6		E
	Reduction of intersection delay	0%		
Scenario 1: Add an overlap phase for EB right turn (with NB left-turn) (Cycle length: 150 s)	Approach delay (s/veh)	159.0	13.5	75.0
	Approach LOS	F	B	E
	Intersection delay (s/veh) & LOS	63.1		E
	Reduction of intersection delay	9.3%		
Scenario 2: Eliminate SB left/U turn movement (Cycle length: 150 s)	Approach delay (s/veh)	228.9	18.7	51.8
	Approach LOS	F	B	D
	Intersection delay (s/veh) & LOS	64.7		E
	Reduction of intersection delay	7.0%		
Scenario 3: Add an overlap phase for EB right turn (with NB left-turn); and Eliminate SB left/U turn movement (Cycle length: 150 s)	Approach delay (s/veh)	180.2	12.7	65.6
	Approach LOS	F	B	E
	Intersection delay (s/veh) & LOS	61.6		E
	Reduction of intersection delay	11.5%		

When combining the results from both peak hours, the analysis showed that adding an overlap phase for the eastbound right turn along with the signal optimization and the coordinated "half cycle length" for the AM peak hour provided the overall best improvement. Eliminating southbound left/U turn movements provided relative little benefit to the operation performance. However, since extremely low traffic volumes were observed on this movement (0 during the AM peak hour and 5 vehicles during the PM peak hour), the impact that re-routing traffic may cause to the corridor should be negligible. As a result, the elimination of the southbound left/U turn movement should be reviewed. The analysis resulted in the following optimized signal timings as shown in Table 34.

Table 34. Results of Signal Timing Optimization.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		150							
Phase Split (s)	AM		63		12	18	45		
	PM		130		20	38	92		

Future Scenario Analysis

The AADT collected by TTP revealed that the sustained growth and expansion have occurred over time along the FM 1472 corridor and nearby vicinity. A value of 5 percent annual growth was used to analyze the impact of future traffic volume levels on scenario 3.

The evaluation results of the future scenarios in 2025 and 2035 with improvement (adding an overlap phase for eastbound right turn and eliminating southbound left/U turn movement) are listed in Table 35.

Table 35. Results of 2025 and 2035 Scenarios with Improvements.

			EB	**NB**	**SB**
2025	AM	Approach delay (s/veh)	27.3	10.2	16.7
		Approach LOS	C	B	B
		Intersection delay (s/veh) & LOS	13.2		B
	PM	Approach delay (s/veh)	394.8	13.1	320.0
		Approach LOS	F	B	F
		Intersection delay (s/veh) & LOS	210.4		F
2035	AM	Approach delay (s/veh)	59.2	74.1	66.9
		Approach LOS	E	E	E
		Intersection delay (s/veh) & LOS	71.0		E
	PM	Approach delay (s/veh)	542.6	32.3	629.6
		Approach LOS	F	C	F
		Intersection delay (s/veh) & LOS	382.1		F

If current growth trend continue, Interamerica Boulevard may maintain an acceptable operation performance for the 10 years horizon during the AM peak hour, but LOS of the intersection will fall to level F during the PM peak hours, most likely even within a few years. In the long term, capacity-increasing strategies such as adding lanes and providing alternative routes should be evaluated.

INTERSECTION OF FM 1472 AND KILLAM INDUSTRIAL BOULEVARD

Intersection Configuration

This intersection is part of the study corridor, located north of Loop 20. Mines Road runs north/south (slightly towards west) as the major road, while Killam Industrial Boulevard runs east/west (slightly towards north) as the minor road (Figure 10). The detailed configuration is listed in Table 36 below. TTI reviewed the following potential short-term strategies for Killam Industrial Boulevard:

- Optimize signal timing and phasing.
- Analyze impact of adding dual westbound to southbound left-turn lanes.
- Analyze impact of adding westbound to northbound free right-turn lane.
- Analyze impact of adding dual southbound to eastbound left-turn lanes.
- Analyze impact of adding southbound to westbound free right-turn lane.
- Analyze all intersection radii. They might be too narrow for some type of trucks.

Figure 10. Killam Industrial/River Bank Intersection Overview.

Table 36. Intersection Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	3	Yes (storage length of 285 ft.)	No (shared with through lane)	Yes
SB	2	Yes (storage length of 483 ft.)	No (shared with through lane)	Yes
EB	2	Yes (storage length of 133 ft.)	Yes (storage length of 133 ft.)	Yes
WB	2	Yes (storage length of 175 ft.)	Yes (storage length of 175 ft.)	Yes

The signal control is fully actuated at this intersection. TTI obtained the signal timing plan employed in the study period (6:30 AM to 7:00 PM) from City of Laredo, as listed in Table 37.

Table 37. Signal Timing Plan.

	Phases							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)	150							
Phase Split (s)	38	59	20	33	20	77	20	33
Max Green (s)	50	80	35	40	25	80	35	40
Min Green (s)	5	15	12	8	5	15	12	8
Gap Extension (s)	3	2.5		2.5	2	2.5		2.5
Yellow (s)	4	4.5	3	3.5	4	4.5	3	3.5
Red (s)	2	1.5	1	2.5	2	1.5	1	2.5

Traffic and Crash Data Description

Traffic Data

TTI collected traffic counts at each approach of the intersection on September 23, 2014, for two hours in the morning (7:00 AM to 9:00 AM), at noon (11:00 AM to 1:00 PM), and in the afternoon (4:00 PM to 6:00 PM), respectively. The time interval for the traffic count data was 15 minutes. For analysis purpose, TTI employed the peak 15-minute traffic counts to account for worst-case scenario. As identified, the peak 15-minute traffic counts from the morning period, noon period, and afternoon period are presented in Table 38.

Table 38 shows that truck percentages at this intersection are high. During the peak 15-minute period at noon, the truck percentage for the southbound to eastbound left-turning movement was 88.5 percent. The westbound to northbound right-turning movement represented the highest average truck percentage across three peak 15-minute periods among all the approaches. This approach has also experienced the highest right-turning volume, which indicates the possible demand for exclusive right-turn lane(s) and longer storage length. The adjusted peak hour flow rate for the AM peak, noon peak, and PM peak are also listed in Table 38.

Table 38. Peak Hour Turning Movements.

Peak 15 minutes		NB			SB			EB			WB		
		Left	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**
8:45am – 9:00am	Volume (veh/h)	9	266	80	14	199	6	77	49	40	27	6	55
	% Trucks	22	19	18	36	34	17	3	6	5	59	50	67
	Adjusted peak hour flow rate (pc/h)	48	1,364	404	86	1,198	30	320	214	172	204	42	442
12:00pm – 12:15pm	Volume (veh/h)	10	210	34	26	287	21	19	10	20	49	17	78
	% Trucks	0	50	62	89	46	24	16	0	0	53	53	83
	Adjusted peak hour flow rate (pc/h)	40	1,476	262	242	1,940	114	94	40	80	352	122	702
5:00pm – 5:15pm	Volume (veh/h)	15	187	34	31	431	30	14	5	41	67	16	80
	% Trucks	13	44	53	68	30	7	14	20	5	48	25	66
	Adjusted peak hour flow rate (pc/h)	72	1,246	244	250	2,492	132	68	26	176	460	88	638

Crash Data

TTI investigated crash data from 2010 to 2014 to identify crashes that occurred within the influence area of the study intersection. Based on the storage lengths for turning movements at each approach, a crash was designated intersection-related if its GPS coordinates placed it directly at the intersection or within 500 feet on both sides of the intersection for the major road (FM 1472) and 250 feet for the minor road (Killam Industrial Boulevard) (see Figure 11).

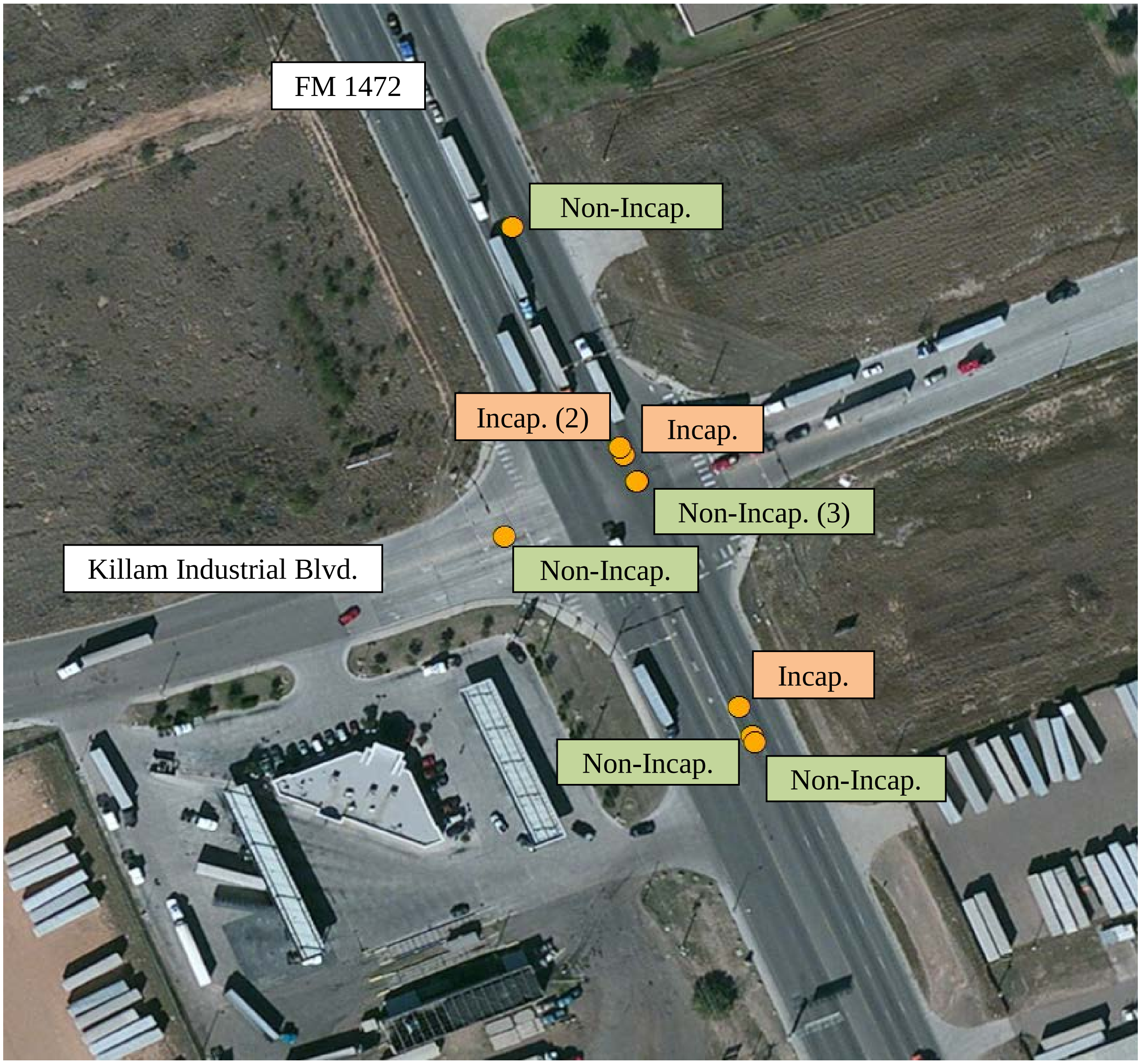


Figure 11. Location and Severity of Crashes at Intersection of Killam Industrial Boulevard and FM 1472.

TTI found a total of eleven crashes near the intersection, ten of which occurred on the major road. Five crashes were defined as intersection related crashes, while the remaining six crashes included four non-intersection related crashes and two driveway access related crashes. Count and severity of crashes are also given in Table 39. Six out of eleven crashes involved commercial motor vehicles, three of which were incapacitating crashes (see Table 40). These crash statistics show that over the last few years, crashes at the intersection have increased in both frequency and severity.

Table 39. Number and Severity of All Crashes at the Intersection of Killam Industrial Boulevard and FM 1472.

	All Crashes					
	2010	**2011**	**2012**	**2013**	**2014**	**Total**
Incapacitating	1	1	0	0	4	**6**
Non-Incapacitating	0	1	1	2	1	**5**
Total	**1**	**2**	**1**	**2**	**5**	**11**

Table 40. Number and Severity of Commercial Motor Vehicle Crashes at the Intersection of Killam Industrial Boulevard and FM 1472.

	Crashes Involving Commercial Motor Vehicles					
	2010	**2011**	**2012**	**2013**	**2014**	**Total**
Incapacitating	1	0	0	0	2	**3**
Non-Incapacitating	0	1	1	1	0	**3**
Total	**1**	**1**	**1**	**1**	**2**	**6**

Intersection Analysis

TTI performed three sets of analyses for the AM peak, noon peak, and PM peak, respectively. The adjusted peak hour flow rates were used as inputs in the analyses.

AM Peak Period Analysis

TTI first coded the adjusted peak hour flow rate from the AM peak and signal timing in Synchro 9 to represent current conditions. TTI then created various scenarios with each single improvement strategy as well as different combinations of the improvement strategies, including optimizing signal timings and restriping pavement markings. Control delay as the service measure for intersections was used to evaluate LOS of each approach of the intersection and the entire intersection. The results are listed in Table 41.

The results show that during the AM peak period, the eastbound traffic experiences the highest delay at the intersection. TTI found that by optimizing phase splits, given the existing cycle length of 150 seconds, the overall intersection delay could be reduced by 26.3 percent. If both cycle length and phase splits are optimized, the reduction of intersection delay is slightly lower at 24.6 percent.

Table 41. Results for AM Peak.

		NB	SB	EB	WB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	63.1	29.6	186.9	66.1
	Approach LOS	E	C	F	E
	Intersection delay (s/veh) & LOS	73.1		E	
Optimized splits (Cycle length: 150 s)	Approach delay (s/veh)	51.6	46.6	58.1	69.5
	Approach LOS	D	D	E	E
	Intersection delay (s/veh) & LOS	53.9		D	
	Reduction of intersection delay	26.3%			
Optimized cycle length (Cycle length: 90 s)	Approach delay (s/veh)	67.5	36.3	52.6	61.0
	Approach LOS	E	D	D	E
	Intersection delay (s/veh) & LOS	55.1		E	
	Reduction of intersection delay	24.6%			
Scenario 1: Change EB through lane to through left shared lane (Cycle length: 90 s)	Approach delay (s/veh)	48.0	33.8	90.0	61.0
	Approach LOS	D	C	F	E
	Intersection delay (s/veh) & LOS	52.4		D	
	Reduction of intersection delay	28.3%			
Scenario 2: Change WB through lane to through right shared lane (Cycle length: 90 s)	Approach delay (s/veh)	67.5	36.3	53.3	28.2
	Approach LOS	E	D	D	C
	Intersection delay (s/veh) & LOS	50.3		D	
	Reduction of intersection delay	31.2%			
Scenario 3: Change WB through lane to through right shared lane, optimize phase splits only (Cycle length: 150 s)	Approach delay (s/veh)	46.4	38.7	56.2	45.8
	Approach LOS	D	D	E	C
	Intersection delay (s/veh) & LOS	45.6		D	
	Reduction of intersection delay	37.6%			

TTI evaluated the restriping of pavement markings for the eastbound and westbound approaches to provide more capacity for turning traffic. During the AM peak, eastbound left-turning traffic is heavier than right-turning, so TTI evaluated changing the through lane to a through and left shared lane. The analysis results show that this strategy can help reduce the intersection delay by 28.3 percent. Although the eastbound approach delay decreases from 186.9 to 90 seconds per vehicle, the approach LOS remains F.

Similarly, TTI analyzed a strategy of changing the westbound through lane to through and right shared lane due to the heavy westbound right-turning traffic. This strategy results in a reduction of 31.2 percent in intersection delay, and improves the westbound approach from a LOS E to a LOS C.

In summary, analysis results show that optimizing the current signal timing would improve intersection operations for the AM period. The existing cycle length of 150 seconds can be retained, whereas the phase splits should be optimized. The westbound through lane could be changed to a through and right shared lane. The analysis showed that a combination of the two strategies would result in an intersection delay reduction of 37.6 percent, as shown in Table 41.

Noon Peak Period Analysis

The results of the noon period results are shown in Table 42. For the noon peak period, TTI found an optimized cycle of 150 seconds. Using optimized phase splits the intersection delay can be reduced by 20.6 percent, which improves the intersection LOS from F to E. However, the westbound approach LOS remains at LOS F, although the approach delay decreases significantly from 203 to 82.3 seconds per vehicle.

By restriping the eastbound through lane into a through and left shared lane, intersection operations improve by 20.0 percent, about the same improvement that can be achieved by simply optimizing cycle length and splits. Changing the westbound through lane to a through and right shared lane significantly improves the westbound approach delay, as well as the overall intersection delay from a LOS F to a LOS D. Note that the optimized cycle length in this scenario was 120 seconds.

In summary, analysis results showed that optimizing the current signal timing would improve intersection operations for the noon peak period. The existing cycle length of 150 seconds can be retained, whereas the phase splits should be optimized. To eliminate the LOS of F for the westbound approach, the westbound through lane could be changed to a through and right shared lane. The analysis showed that a combination of the two strategies would result in a reduction of intersection delay by 37.1 percent.

Table 42. Results for Noon Peak.

		NB	SB	EB	WB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	60.7	41.0	45.1	203.0
	Approach LOS	E	D	D	F
	Intersection delay (s/veh) & LOS	82.4		F	
Optimized cycle length and splits (Cycle length: 150 s)	Approach delay (s/veh)	70.8	54.0	50.1	82.3
	Approach LOS	E	D	D	F
	Intersection delay (s/veh) & LOS	65.4		E	
	Reduction of intersection delay	20.6%			
Scenario 1: Change EB through lane to through left shared lane (Cycle length: 150 s)	Approach delay (s/veh)	70.8	54.0	52.5	84.3
	Approach LOS	E	D	D	F
	Intersection delay (s/veh) & LOS	65.9		E	
	Reduction of intersection delay	20.0%			
Scenario 2: Change WB through lane to through right shared lane (Cycle length: 120 s)	Approach delay (s/veh)	59.0	47.4	36.4	60.7
	Approach LOS	E	D	D	E
	Intersection delay (s/veh) & LOS	53.6		D	
	Reduction of intersection delay	35.0%			
Scenario 3: Change WB through lane to through right shared lane, optimize phase splits only (Cycle length: 150 s)	Approach delay (s/veh)	58.1	44.1	50.7	57.5
	Approach LOS	E	D	D	E
	Intersection delay (s/veh) & LOS	51.8		D	
	Reduction of intersection delay	37.1%			

PM Peak Period Analysis

The results of the PM peak analysis are shown in Table 43. For the PM peak, the analysis found an optimized cycle length of 140 seconds, which reduced intersection delay by 29.4 percent. However, optimizing phase splits using a cycle length of 150 seconds are only slightly lower, improving intersection delay by 28.6 percent.

Increasing the eastbound left-turning capacity by changing the eastbound through lane to a through and left shared lane can improve the intersection operation by 29.3 percent. However, the LOS for the southbound and northbound approaches changes from E to F and D to E, respectively.

Table 43. Results for PM Peak.

		NB	SB	EB	WB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	49.2	78.8	32.0	296.9
	Approach LOS	D	E	C	F
	Intersection delay (s/veh) & LOS	112.7		F	
Optimized splits (Cycle length: 150 s)	Approach delay (s/veh)	60.4	98.6	35.4	73.4
	Approach LOS	E	F	D	E
	Intersection delay (s/veh) & LOS	80.5		F	
	Reduction of intersection delay	28.6%			
Optimized cycle length (Cycle length: 140 s)	Approach delay (s/veh)	60.5	92.3	30.8	85.0
	Approach LOS	E	F	C	F
	Intersection delay (s/veh) & LOS	79.6		E	
	Reduction of intersection delay	29.4%			
Scenario 1: Change EB through lane to through left shared lane (Cycle length: 140 s)	Approach delay (s/veh)	60.5	92.3	31.7	85.6
	Approach LOS	E	F	C	F
	Intersection delay (s/veh) & LOS	79.7		E	
	Reduction of intersection delay	29.3%			
Scenario 2: Change WB through lane to through right shared lane (Cycle length: 120 s)	Approach delay (s/veh)	60.5	92.3	70.8	30.8
	Approach LOS	E	F	C	E
	Intersection delay (s/veh) & LOS	76.7		E	
	Reduction of intersection delay	31.9%			
Scenario 3: Change WB through lane to through right shared lane, optimize phase splits only (Cycle length: 150 s)	Approach delay (s/veh)	60.4	98.6	35.4	60.4
	Approach LOS	E	F	D	E
	Intersection delay (s/veh) & LOS	77.9		E	
	Reduction of intersection delay	30.9%			

During the PM peak, the westbound right-turning traffic was 638 pc/h (adjusted flow rate) while the through traffic was only 88 pc/h. Therefore, changing the westbound through lane to a shared through and right lane will provide more westbound right-turning capacity whereas the through movement will not be affected. Note that this would create dual right turn lanes at the westbound approach. The results showed that westbound LOS changes from F to E, and overall intersection delay is reduced by 31.9%.

In summary, the analysis showed that optimizing the current signal timing by retaining the cycle length of 150 seconds and optimizing phase splits would improve intersection operations for the

PM peak period. Restriping the pavement markings at the westbound approach to create a through and right shared lane should also be considered. The analysis showed that a combination of the two strategies should result in a reduction of intersection delay by 30.9 percent, as shown in Table 43. However, it should be noted that these strategies would increase delays in northbound and southbound directions.

Even with the suggested improvements, the intersection experienced an intersection delay of 77.9 seconds per vehicle, which is only 2.1 seconds of delay per vehicle away from the threshold for LOS F. In other words, only a slight increase in traffic volumes will produce a LOS F at this intersection.

The PM peak period analysis resulted in the following optimized signal timings as shown in Table 44. Changing the westbound through lane to a through and right shared lane should be considered to improve overall intersection operation.

Table 44. Results of Signal Timing Optimization.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		150							
Phase Split (s)	AM	17	66	31	36	15	68	39	28
	Noon	29	60	37	24	12	77	16	48
	PM	31	55	40	24	12	74	16	48

Future Scenario Analysis

Based on the historical AADT data from TPP, and expected rapid industrial development along the study corridor, TTI came up with an overall traffic growth rate of 5 percent. TTI then conducted the analysis using projected traffic volumes for the AM, noon, and PM peak periods. The evaluation results of the future scenarios in years 2025 and 2035 with improvement (i.e., change the westbound through lane to through right shared lane and optimize the phase splits) are listed in Table 45. The results show that the intersection will experience significant delay in the near future.

Table 45. Results of 2025 and 2035 Scenarios with Improvements.

			NB	SB	EB	WB
2025	AM	Approach delay (s/veh)	173.7	58.0	138.0	152.7
		Approach LOS	F	E	F	F
		Intersection delay (s/veh) & LOS	131.3		F	
	Noon	Approach delay (s/veh)	253.6	206.6	82.5	214.5
		Approach LOS	F	F	F	F
		Intersection delay (s/veh) & LOS	218.8		F	
	PM	Approach delay (s/veh)	162.1	406.1	62.7	220.0
		Approach LOS	F	F	E	F
		Intersection delay (s/veh) & LOS	288.2		F	
2035	AM	Approach delay (s/veh)	638.4	284.0	404.6	330.0
		Approach LOS	F	F	F	F
		Intersection delay (s/veh) & LOS	451.8		F	
	Noon	Approach delay (s/veh)	712.5	654.4	146.3	563.4
		Approach LOS	F	F	F	F
		Intersection delay (s/veh) & LOS	633.8		F	
	PM	Approach delay (s/veh)	634.1	1042.1	188.8	469.1
		Approach LOS	F	F	F	F
		Intersection delay (s/veh) & LOS	779.5		F	

Radii Evaluation

TTI investigated the existing radii at FM 1472 and Killam Industrial Boulevard. Figure 12 shows the approximate measure of the radius for each approach using aerial photography available in Google Earth. Figure 12 shows that the radius for the southbound approach measures approximately 103 feet, the one for the westbound approach measures approximately 111 feet, and the one for the northbound approach measures approximately 105 feet. The eastbound corner radius is the smallest with a length of approximately 93 feet.

TTI observed that the prevalent trucks in this area are semi-trailer trucks, with wheelbase lengths ranging from 40 feet (four-axle trucks) to 67 feet (five-axle trucks). According to *A Policy on Geometric Design of Highways and Streets* (AASHTO Green Book), the minimum turning radius is positively correlated with truck wheelbase length. The minimum turning radius for interstate semitrailer (WB-67) design vehicle is 44.8 feet. However, according to the *TxDOT Roadway Design Manual*, turning radii of 75 feet or more are desirable if WB-62 (wheelbase length of 62 feet, 5 axles) design vehicles travel frequently. Therefore, TTI suggests using 75 feet as the minimum radius for the intersection of FM 1472 and Killam Industrial Boulevard. As the current radii all measure greater than 75 feet, TTI concluded that existing curve radii are sufficient to accommodate frequent truck traffic at the intersection.

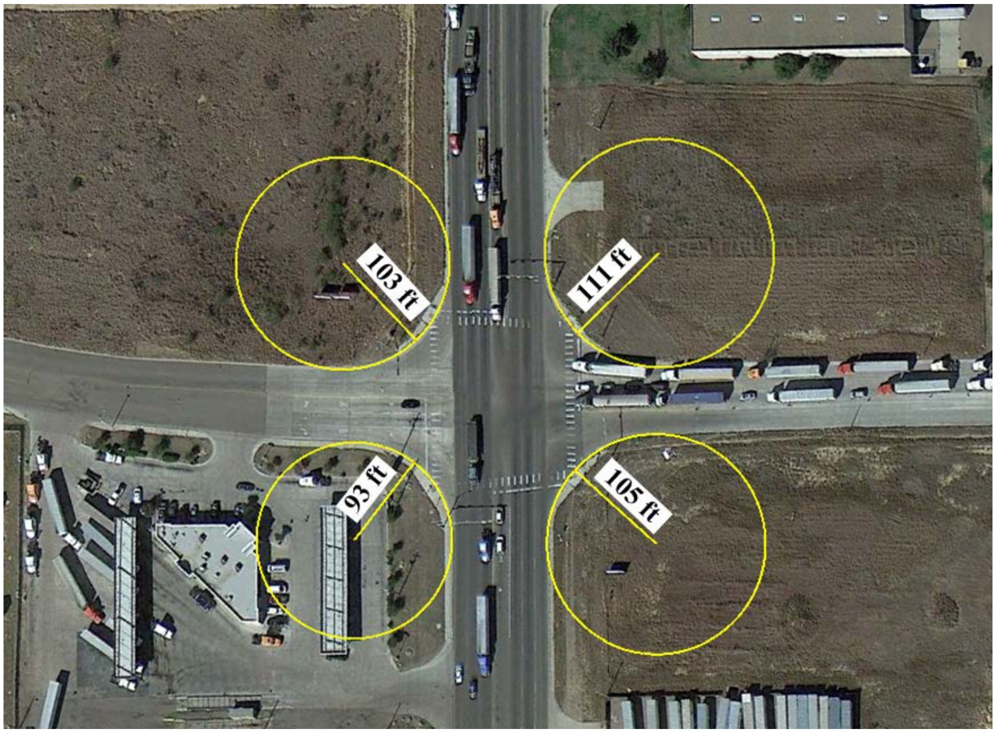


Figure 12. Approximate Radius of Each Right-Turn Approach at the Intersection of Mines Road and Killam Industrial Boulevard (Source: Google Earth.)

INTERSECTION OF FM 1472 AND MILO ROAD

Intersection Configuration

This intersection is located approximately 1,200 feet north of Loop 20 (Figure 13). The detailed configuration is listed in Table 46. TTI reviewed the following potential short-term strategies for Milo Road

- Optimize signal timing and phasing.
- Analyze the impact of eliminating left-turns for southbound to eastbound movement.
- Analyze the impact of eliminating westbound to southbound left-turn movements.

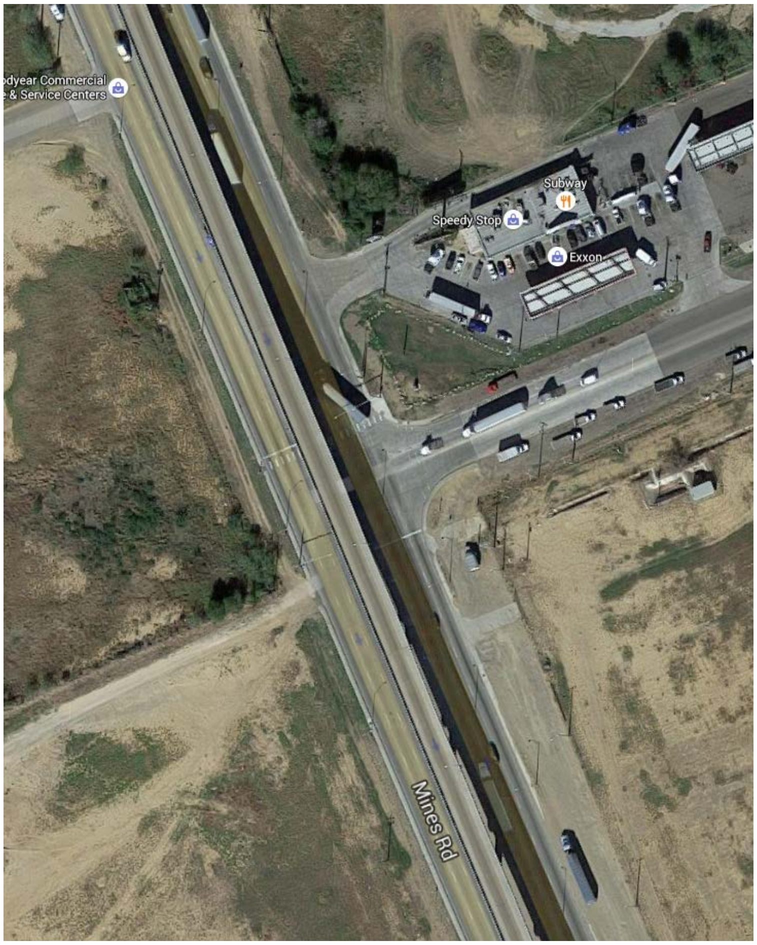


Figure 13. Old Milo Intersection Overview.

Table 46. Intersection Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	3	Yes (not in use)	No (shared with through lane)	No
SB	3	Yes (storage length of 180 ft.)	No (shared with through lane)	Yes
WB	2	Yes (storage length of 197 ft.)	Yes (no through movement)	Yes

The signal control is fully actuated at this intersection. TTI obtained the signal timing plan employed in the study period (6:30 AM to 7:00 PM) from City of Laredo, as shown in Table 47.

Table 47. Signal Timing Plan.

	Phases							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)	150							
Phase Split (s)	27	85				112		38
Max Green (s)	30	80				100		35
Min Green (s)	4	10				10		5
Gap Extension (s)	2	2				2		0.5
Yellow (s)	4.5	4.5				4.5		4.5
Red (s)	1.5	1.5				1.5		3.5

Traffic and Crash Data Description

Traffic Data

TTI collected traffic counts at each approach of the intersection on March 26, 2015, for two hours in the morning (7:00 AM to 9:00 AM), and in the afternoon (4:00 PM to 6:00 PM), respectively. The time interval for the traffic count data was 15 minutes. For the purpose of the analysis, the peak-15-minute traffic counts were employed to account for the worst-case scenario. As identified, the peak-15-minute traffic counts from the morning period and afternoon period are presented in Table 48. Table 48 shows that the truck percentage in every approach is high, especially in the PM peak period. The adjusted peak hour flow rate for the AM peak and PM peak are also listed in Table 48.

Table 48. Peak Hour Turning Movements.

Peak 15 minutes		NB			SB			WB		
		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
7:45am – 8:00am	Volume (veh/h)	-	603	65	13	96	-	7	-	27
	% Trucks	-	9	14	8	16	-	57	-	26
	Adjusted peak hour flow rate (pc/h)	-	2,736	314	58	474	-	52	-	150
5:00pm – 5:15pm	Volume (veh/h)	-	300	36	19	320	-	54	-	60
	% Trucks	-	36	31	90	25	-	44	-	52
	Adjusted peak hour flow rate (pc/h)	-	1,845	210	178	1,766	-	360	-	426

Crash Data

TTI investigated crash data from 2010 to 2014 to identify crashes that occurred within the influence area of the study intersection. Based on the storage lengths for turning movements at each approach, a crash was designated intersection-related if its GPS coordinates placed it directly at the intersection or within 300 feet on both sides of the intersection for the major road (FM 1472) and 250 feet for the minor road (Milo Road).

TTI found only one crash near the intersection over the last four years, which was identified as a non-intersection, non-incapacitating commercial motor vehicle crash. TTI found two additional crashes that occurred on Milo Road within 500 feet of the study intersection, both of which were driveway access related.

Intersection Analysis

TTI performed two sets of analyses for the AM peak and PM peak, respectively. The adjusted peak hour flow rates were used as inputs in the analyses.

AM Peak Period Analysis

TTI first coded the adjusted peak hour flow rate from the AM peak and signal timing in Synchro 9 to represent the current conditions. TTI then created various scenarios with each single improvement strategy and different combinations of the improvement strategies including optimizing signal phase splits retaining the existing cycle length of 150 seconds to be consistent with the Killam intersection, eliminating southbound to eastbound left-turning movement, and eliminating westbound to southbound left-turning movement. By eliminating the southbound to eastbound left-turning movement, TTI added the amount of traffic from this movement to the southbound through traffic and the northbound to eastbound right-turning traffic. Similarly, to reroute the westbound to southbound traffic after eliminating this movement, TTI added the amount of traffic from the westbound to southbound movement to the westbound to northbound right-turning traffic and the southbound through traffic. TTI used control delay as the service measure for intersections to evaluate to level of service (LOS) of each approach of the intersection and the entire intersection. The results are listed in Table 49.

Table 49. Results for AM Peak.

		NB	SB	WB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	97.3	12.3	20.0
	Approach LOS	F	B	B
	Intersection delay (s/veh) & LOS	81.3		F
Optimized splits (Cycle length: 150 s)	Approach delay (s/veh)	22.6	12.4	38.2
	Approach LOS	C	B	D
	Intersection delay (s/veh) & LOS	22.0		C
	Reduction of intersection delay	72.9%		
Eliminate SB to EB movement (Cycle length: 150 s)	Approach delay (s/veh)	14.4	1.1	62.6
	Approach LOS	B	A	E
	Intersection delay (s/veh) & LOS	15.1		B
	Reduction of intersection delay	81.4%		
Eliminate WB to SB movement (Cycle length: 150 s)	Approach delay (s/veh)	22.6	11.4	14.2
	Approach LOS	C	B	B
	Intersection delay (s/veh) & LOS	20.5		C
	Reduction of intersection delay	75.2%		
Eliminate SB to EB and WB to SB movements (Cycle length: 150 s)	Approach delay (s/veh)	11.5	0.5	61.1
	Approach LOS	B	A	E
	Intersection delay (s/veh) & LOS	12.4		B
	Reduction of intersection delay	84.8%		

The results show that during the AM peak period, the northbound traffic experiences the highest delay at the intersection. TTI found that by optimizing phase splits given the existing cycle length of 150 seconds, overall intersection delay can be reduced by 72.9%. TTI also found that eliminating the southbound to eastbound and westbound to southbound movements would provide more benefits to intersection operations than only optimizing the signal timing. Specifically, eliminating the southbound to eastbound movement can significantly improve the operations of the northbound approach and southbound approach. However, the westbound operation performs worse after eliminating the southbound to eastbound movement. By eliminating both movements, the overall intersection delay can be reduced as much as 84.8%. In summary, the analysis found that optimizing the signal timing and eliminating the southbound to eastbound and westbound to southbound movements would provide the most benefit.

PM Peak Period Analysis

TTI also applied the similar approach for the PM peak period analysis. The analysis results are listed in Table 50.

Table 50. Results for PM Peak.

		NB	SB	WB
Current conditions (Cycle length: 150 s)	Approach delay (s/veh)	30.2	13.0	70.2
	Approach LOS	C	B	E
	Intersection delay (s/veh) & LOS	29.8		C
Optimized splits (Cycle length: 150 s)	Approach delay (s/veh)	41.5	17.4	42.3
	Approach LOS	D	D	B
	Intersection delay (s/veh) & LOS	31.9		C
	Reduction of intersection delay	-7.0%		
Eliminate SB to EB movement (Cycle length: 150 s)	Approach delay (s/veh)	29.8	15.6	46.0
	Approach LOS	C	B	D
	Intersection delay (s/veh) & LOS	26.8		C
	Reduction of intersection delay	10.1%		
Eliminate WB to SB movement (Cycle length: 150 s)	Approach delay (s/veh)	40.1	15.8	23.4
	Approach LOS	D	B	C
	Intersection delay (s/veh) & LOS	26.7		C
	Reduction of intersection delay	10.4%		
Eliminate SB to EB and WB to SB movements (Cycle length: 150 s)	Approach delay (s/veh)	28.8	20.6	48.3
	Approach LOS	C	C	D
	Intersection delay (s/veh) & LOS	28.1		C
	Reduction of intersection delay	5.7%		

The results show that the existing signal timing suits the PM peak period much better than the AM peak period. Analysis of current conditions resulted in a LOS of C with an intersection delay of 29.8 seconds per vehicle. However, the westbound approach experiences significant delay with a LOS of E. By optimizing the signal phase splits, more green time is allocated to the westbound approach so that the LOS of the westbound approach is improved significantly and the intersection operates more balanced. However, northbound and southbound approaches that carry the majority of the traffic start to experience more delay and the overall intersection delay thus becomes worse.

TTI evaluated the scenarios where the southbound to eastbound movement was eliminated, the westbound to southbound movement was eliminated, and both were eliminated, respectively.

All strategies reduced intersection delay. However, eliminating both movements shows less benefit than removing either strategy by itself during the PM peak. For the PM peak, the analysis founds that eliminating the southbound to eastbound movement and optimizing the signal phase splits for the PM peak period provides the most benefit.

The analysis resulted in the following optimized signal timings as shown in Table 51. Elimination of the southbound to eastbound movement will provide improved traffic operations. Eliminating the westbound to southbound movement will improve AM peak traffic but will reduce some benefits during the PM peak, so the overall effect of eliminating this movement will cancel each other out. However, if TxDOT chose to eliminate the southbound to eastbound movement, it would make sense to simply close the median at this intersection and remove the signal completely.

Table 51. Results of Signal Timing Optimization.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		150							
Phase Split (s)	AM		118				118		32
	PM		88				88		62

Future Scenario Analysis

Based on the historical AADT and the expected rapid industrial development along the study corridor, TTI came up with an overall traffic growth rate of 5 percent. TTI then conducted the analysis using the projected traffic volumes for the AM and PM peak periods. The evaluation results of the future scenarios in years 2025 and 2035 with improvement (i.e., eliminate the southbound to eastbound movement and optimize the phase splits) are listed in Table 52.

The results show that the proposed improvement strategies extend the time before intersection LOS degrades to F by a few years. In the long term, capacity-increasing strategies such as adding lanes and providing alternative routes should be evaluated to accommodate demand.

Table 52. Results of 2025 and 2035 Scenarios with Improvements.

			NB	SB	WB
2025	AM	Approach delay (s/veh)	149.3	1.0	134.0
		Approach LOS	F	A	F
		Intersection delay (s/veh) & LOS	128.0	F	
	PM	Approach delay (s/veh)	152.6	68.4	128.6
		Approach LOS	F	E	F
		Intersection delay (s/veh) & LOS	115.9	F	
2035	AM	Approach delay (s/veh)	578.5	2.2	172.5
		Approach LOS	F	A	F
		Intersection delay (s/veh) & LOS	477.3	F	
	PM	Approach delay (s/veh)	547.0	404.2	352.0
		Approach LOS	F	F	F
		Intersection delay (s/veh) & LOS	460.4	F	

INTERSECTION OF FM 1472 AND IH-69W (LOOP 20)

Intersection Configuration

The FM 1472 and IH-69W (Loop 20) interchange is the southern limit of the study corridor (Figure 14). IH-69W runs east/west and is a freeway facility. The detailed configuration is listed in Table 53 below. TTI reviewed the following potential short-term strategies at IH-69W:

- Optimize signal timing and phasing.

Figure 14. IH-69W (Loop 20) Intersection Overview.

Table 53. Interchange Configuration.

Approach	No. of Through Lanes	Exclusive Left-Turn lane?	Exclusive Right-Turn Lane?	Crosswalk?
NB	3	Yes (storage length of 250 ft.)	No (shared with through lane)	Yes
SB	3	Yes (storage length of 169 ft.)	No (shared with through lane, but is free flow condition)	Yes
EB (frontage road)	1 (shared through and left)	Yes (includes turnaround lane with storage length of 305 ft.)	Yes (storage length of 305 ft. and is free flow condition)	Yes
WB (frontage road)	1 (shared through and left)	Yes (includes turnaround lane with storage length of 252 ft.)	Yes (storage length of 252 ft. and is free flow condition)	Yes

The lane configuration underneath the overpass on FM 1472 is three lanes with a dedicated left-turn lane in each direction. The signal control is fully actuated at this interchange. The interchange runs a NEMA configuration, instead of a full-phase diamond configuration. TTI obtained the signal timing plan employed in the study period (6:30 AM to 7:00 PM) from The City of Laredo, as shown in Table 54.

Table 54. Signal Timing Plan.

	Phases							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)	150							
Phase Split (s)	0	81	0	35	77	2	0	35
Max Green (s)	15	55	0	45	35	55	7	25
Min Green (s)	6	15	0	6	6	15	7	6
Gap Extension (s)	2.5	2	2	2.5	2.5	2	2	2.5
Yellow (s)	4	4	0	4	4	4	4	4
Red (s)	1	1.5	1	1.5	1	1.5	1	1.5

Traffic Data Description

TTI collected traffic counts at each approach of the interchange, except for the main lanes, on September 24, 2014, for two hours in the morning (7:00 AM to 9:00 AM), at noon (11:00 AM to 1:00 PM), and in the afternoon (4:00 PM to 6:00 PM), respectively. The IH-69W main lanes were not part of this study. The time interval for the traffic count data was 15 minutes. For analysis purpose, TTI employed the peak-15-minute traffic counts to account for worst-case scenario. As identified, the peak-15-minute traffic counts from the morning period, noon period, and afternoon period are presented in Table 55.

Table 55 shows that the truck percentage at this intersection is high. During the peak 15-minute period in the morning, the truck percentage for the southbound to eastbound left-turning movement at the westbound frontage road is 41.7 percent. The table also shows that the major vehicular movements are in north-south directions. The morning peak has a high westbound to northbound right-turning movement at 1082 pc/h, which indicates the possible demand for an additional exclusive right-turn lane and longer storage length. The adjusted peak hour flow rate for the AM peak, noon peak, and PM peak are also listed in Table 55.

Table 55. Peak Hour Turning Movements.

Peak 15 minutes		NB			SB			EB			WB		
		Left	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**
WB Frontage Rd. 8:00am – 8:15am	Vol (veh/h)	128	1,256			524	96				200	52	920
	% Trucks	9	11			16	42				14	39	12
	Adjusted peak hour flow rate (pc/h)	146	1,460			650	156				242	82	1,082
EB Frontage Rd. 8:30am – 8:45am	Vol (veh/h)		1,360	300	16	544		184	84	76			
	% Trucks		0	0	13	3		17	7	9			
	Adjusted peak hour flow rate (pc/h)		1,396	306	40	652		370	120	118			
WB Frontage Rd. 12:00pm – 12:15pm	Vol (veh/h)	92	748			720	156				472	60	180
	% Trucks	8	15			10	17				9	12	7
	Adjusted peak hour flow rate (pc/h)	134	1,408			1,158	318				712	102	252
EB Frontage Rd. 11:45am – 12:00pm	Vol (veh/h)		472	224	132	724		272	88	120			
	% Trucks		7	5	17	7		21	14	7			
	Adjusted peak hour flow rate (pc/h)		676	270	270	1,024		614	160	168			
WB Frontage Rd. 4:00pm – 4:15pm	Vol (veh/h)	296	840			960	108				280	108	524
	% Trucks	20	14			7	6				3	14	7
	Adjusted peak hour flow rate (pc/h)	656	1,518			1,332	144				322	198	740
EB Frontage Rd. 5:45pm – 6:00pm	Vol (veh/h)		480	316	108	1,204		220	56	188			
	% Trucks		8	4	12	3		22	14	7			
	Adjusted peak hour flow rate (pc/h)		696	388	186	1,414		508	104	266			

Intersection Analysis

TTI performed three sets of analyses for the AM peak, noon peak, and PM peak, respectively. The adjusted peak hour flow rates were used as inputs in the analyses.

AM Peak Period Analysis

TTI first coded the adjusted peak hour flow rates from the AM peak and signal timing in Synchro 9 to represent current conditions. TTI then created the improvement strategy, a full phased diamond interchange signalization. Control delay as the service measure for intersections was used to evaluate the level of service (LOS) of each approach within the interchange and the overall interchange. The results are listed in Table 56.

Table 56. Results for AM Peak.

		NB	**SB**	**EB**	**WB**
Current conditions at WB frontage road (Cycle length: 115 s)	Approach delay (s/veh)	23.2	37.0		306.5
	Approach LOS	C	D		F
	Intersection delay (s/veh) & LOS	130.5		F	
Current conditions at EB frontage road (Cycle length: 115 s)	Approach delay (s/veh)	26.6	5.5	26.2	
	Approach LOS	C	A	C	
	Intersection delay (s/veh) & LOS	21.6		C	
Scenario 1: Change to full phased diamond interchange at WB frontage road (Cycle length: 150 s)	Approach delay (s/veh)	109.5	59.7		68.1
	Approach LOS	F	E		E
	Intersection delay (s/veh) & LOS	83.8		F	
Scenario 2: Change to full phased diamond interchange at EB frontage road (Cycle length: 150 s)	Approach delay (s/veh)	94.8	14.9	26.9	
	Approach LOS	F	B	C	
	Intersection delay (s/veh) & LOS	62.6		E	
	Reduction of interchange delay	3.7%			

During the AM peak period, the westbound frontage road traffic experiences the highest delay at the interchange. TTI found that by having a full phased diamond interchange signalization and optimizing phase splits given the cycle length of 150 seconds, the overall interchange delay can be slightly reduced by 3.7 percent. There are considerable delays on all approaches of the interchange, especially the westbound frontage road to northbound FM 1472.

Noon Peak Period Analysis

TTI used the similar approach for the noon peak period analysis. The analysis results are listed in Table 57.

Table 57. Results for Noon Peak.

		NB	SB	EB	WB
Current conditions at WB frontage road (Cycle length: 115 s)	Approach delay (s/veh)	14.2	28.5		102.8
	Approach LOS	B	C		F
	Intersection delay (s/veh) & LOS	42.5		D	
Current conditions at eastbound frontage road (Cycle length: 115 s)	Approach delay (s/veh)	18.7	88.9	49.5	
	Approach LOS	B	F	D	
	Intersection delay (s/veh) & LOS	56.3		E	
Scenario 1: Change to full phased diamond interchange at westbound frontage road (Cycle length: 150 s)	Approach delay (s/veh)	49.9	47.7		33.9
	Approach LOS	D	D		C
	Intersection delay (s/veh) & LOS	44.9		D	
Scenario 2: Change to full phased diamond interchange at eastbound frontage road (Cycle length: 150 s)	Approach delay (s/veh)	54.6	36.0	58.3	
	Approach LOS	D	D	E	
	Intersection delay (s/veh) & LOS	48.1		D	
	Reduction of interchange delay	5.9%			

For the noon peak period, TTI found that by having a full phased diamond interchange signalization and optimizing phase splits given the cycle length of 150 seconds, the overall interchange delay can only be reduced by 5.9%. There are considerable delays on the westbound frontage road to northbound FM 1472 and eastbound frontage road to northbound FM 1472 movements.

PM Peak Period Analysis

TTI also applied the similar approach for the PM peak period analysis. The analysis results are listed in Table 58.

Table 58. Results for PM Peak.

		NB	SB	EB	WB
Current conditions at westbound frontage road (Cycle length: 115 s)	Approach delay (s/veh)	86.7	29.1		300.7
	Approach LOS	F	C		F
	Intersection delay (s/veh) & LOS	124.3		F	
Current conditions at eastbound frontage road (Cycle length: 115 s)	Approach delay (s/veh)	19.8	25.2	35.1	
	Approach LOS	B	C	D	
	Intersection delay (s/veh) & LOS	26.0		C	
Scenario 1: Change to full phased diamond interchange at westbound frontage road (Cycle length: 150 s)	Approach delay (s/veh)	82.3	126.8		110.4
	Approach LOS	F	F		F
	Intersection delay (s/veh) & LOS	102.9		F	
Scenario 2: Change to full phased diamond interchange at eastbound frontage road (Cycle length: 150 s)	Approach delay (s/veh)	60.3	53.3	23.6	
	Approach LOS	E	D	C	
	Intersection delay (s/veh) & LOS	48.1		D	
	Reduction of interchange delay	0 %			

For the PM peak period, TTI found that by having a full phased diamond interchange signalization and optimizing phase splits given the cycle length of 150 seconds, there was no change in the overall interchange delay.

Suggestions for Improving Current Conditions

Based on the analysis results for the AM, noon, and PM peak periods, the current signal would benefit from a change to a full phased diamond. The results of the analysis provided that the existing cycle length of 115 seconds should be revised to 150 seconds with optimized phase splits, as shown in Table 59.

Table 59. Results of Signal Timing Optimization.

		Phases							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle Length (s)		150							
Phase Split (s)	AM	12	56		82	16	31		103
	Noon	44	37		69	26	54		70
	PM	30	40		80	52	36		62

Note: Phase 3 is combined with phase 8, and phase 7 is combined with phase 4.

Future Scenario Analysis

Based on historical AADT from TPP and the expected rapid industrial development along the study corridor, TTI came up with an overall traffic growth rate of 5 percent. TTI then conducted the analysis using the projected traffic volumes for the AM, noon, and PM peak periods. The evaluation results of the future scenarios in years 2024 and 2034 with diamond interchange improvement are listed in Table 60.

The results show that the proposed improvement strategies only extend the time before the intersection degrades to a LOS F by a few years. Adding more capacity at the frontage roads as previously described and other strategies that seek to shift traffic away from this interchange should be evaluated as a long-term strategy to accommodate increasing demand in the future.

Table 60. Results of 2025 and 2035 Scenarios with Improvements.

				NB	SB	EB	WB
2025	AM	WB FR	Approach delay (s/veh)	258.6	96.5		353.0
			Approach LOS	F	F		F
			Intersection delay (s/veh) & LOS	131.3		F	
		EB FR	Approach delay (s/veh)	87.4	16.8	90.3	
			Approach LOS	F	B	F	
			Intersection delay (s/veh) & LOS	71.7		E	
	Noon	WB FR	Approach delay (s/veh)	79.3	97.4		77.6
			Approach LOS	E	F		E
			Intersection delay (s/veh) & LOS	85.4		F	
		EB FR	Approach delay (s/veh)	110.9	94.2	70.6	
			Approach LOS	F	F	E	
			Intersection delay (s/veh) & LOS	92.1		F	
	PM	WB FR	Approach delay (s/veh)	224.4	339.9		313.7
			Approach LOS	F	F		F
			Intersection delay (s/veh) & LOS	282.0		F	
		EB FR	Approach delay (s/veh)	101.4	66.4	68.1	
			Approach LOS	F	E	E	
			Intersection delay (s/veh) & LOS	77.5		E	
2035	AM	WB FR	Approach delay (s/veh)	414.8	151.2		979.1
			Approach LOS	F	F		F
			Intersection delay (s/veh) & LOS	567.0		F	
		EB FR	Approach delay (s/veh)	456.0	70.6	85.0	
			Approach LOS	F	E	F	
			Intersection delay (s/veh) & LOS	292.1		F	
	Noon	WB FR	Approach delay (s/veh)	255.1	357.5		276.3
			Approach LOS	F	F		F
			Intersection delay (s/veh) & LOS	297.7		F	
		EB FR	Approach delay (s/veh)	318.5	148.5	253.4	
			Approach LOS	F	F	F	
			Intersection delay (s/veh) & LOS	230.1		F	
	PM	WB FR	Approach delay (s/veh)	487.0	706.8		764.4
			Approach LOS	F	F		F
			Intersection delay (s/veh) & LOS	624.3		F	
		EB FR	Approach delay (s/veh)	558.0	599.7	63.9	
			Approach LOS	F	F	E	
			Intersection delay (s/veh) & LOS	454.9		F	

Note: FR = Frontage Road

MEDIAN CROSSING AT CON-WAY TRUCKLOAD FACILITY

TxDOT is considering the removal of the median crossing at the Con-Way truckload facility to improve safety and operations along the FM 1472 corridor (Figure 15). If the median would be closed, ingress into the trucking facility for northbound traffic would be provided by the next median opening to the north located at a distance of about 3,000 feet. Egress out of the trucking facility in northbound direction would be provided by a turnaround located approximately 917 feet south at the Pan American Boulevard intersection.

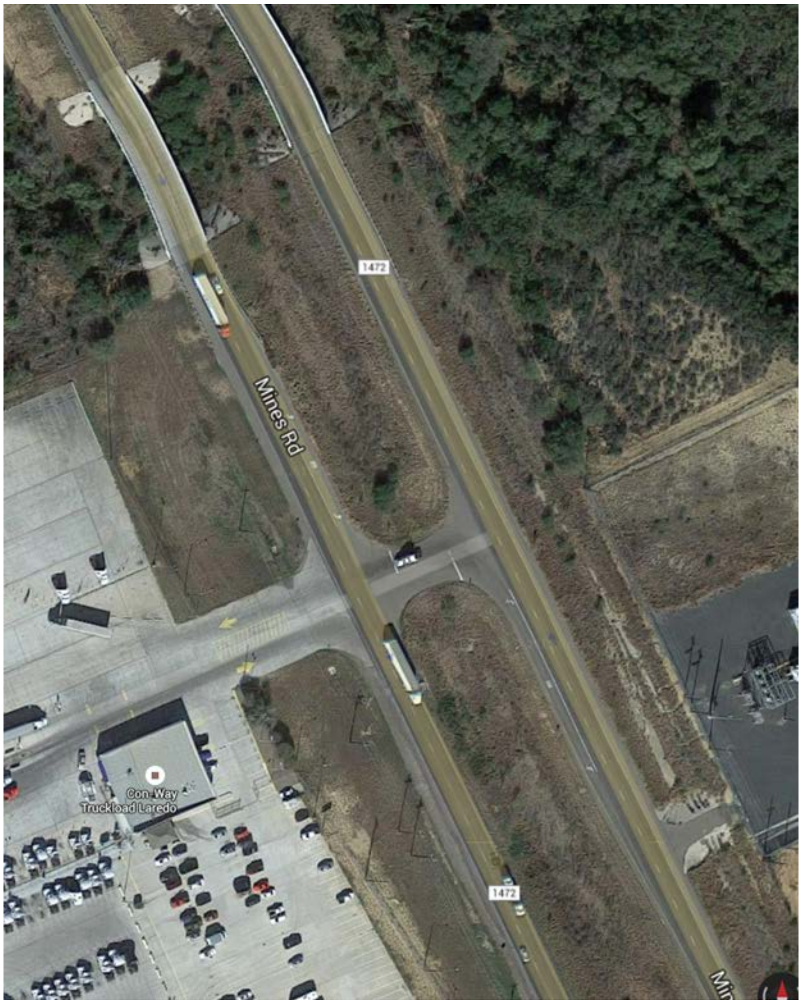


Figure 15. Overview of Median Crossing at Con-Way Truckload Facility.

Table 61 shows the turning movements at the intersection during AM and PM peak traffic. During the morning peak, 46 vehicles used the median opening into the trucking facility, and no vehicle used the median to turn left onto northbound FM 1472. During the PM peak, 40 vehicles crossed the median to turn into the trucking facility, and one vehicle turned left onto northbound FM 1472. Based on these numbers, a relatively small number of vehicles would be forced to use turnaround located north and south of the Con-Way trucking facility. The large majority of these vehicles would use the turnaround located at the intersection north of Con-Way.

Table 61. Peak Hour Turning Movements.

		NB			SB			EB		
		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
AM	Volume (veh/h)	46	679			466	4	0		17
	% Trucks	20	13			13	0	0		82
	Adjusted peak hour flow rate (pc/h)	60	808			559	4	0		38
PM	Volume (veh/h)	40	530			787	1	1		31
	% Trucks	78	38			33	0	0		61
	Adjusted peak hour flow rate (pc/h)	87	833			1,171	1	1		60

The turnaround north of Con-Way is built adequately to support truck turnarounds. The current width from the outside of the northbound left-turn lane to the outside of the southbound lane is approximately 153 feet, sufficient for the required turning radius of 75 feet that would be needed to accommodate a WB-62 truck. In addition, the location has an acceleration lane in southbound direction that provides an additional 15 feet.

At Pan America Boulevard, a turnaround lane is already in place with an acceleration lane in northbound direction. The width from the outside southbound turnaround lane to the outside of the northbound acceleration lane is about 139 feet, which is insufficient to accommodate a WB-62 truck. This type of truck would need to use the left-hand northbound lane to complete the turnaround maneuver. This should be taken into consideration for the signal timing of the intersection. Specifically, a protected phase should be provided for the turnaround movement. Due to the low volume that is expected to use the turnaround, an actuated traffic signal should be used for the turnaround movement.

CONCLUDING REMARKS

TTI analyzed the main intersections of FM 1472 from Con-Way truckload facility to IH-69W in terms of strategies that should be deployed in the short-term to alleviate and improve traffic operations of the corridor. Short-term strategies included efforts that TxDOT will be able to implement quickly with minimal project planning and available funds, and without adding new pavement. Short-term strategies included the re-timing and re-phasing of traffic signals, elimination of movements at intersections, adding left- or right-turn lanes using restriping only, converting dedicated movement lanes to shared movement lanes, and eliminating traffic signals.

TTI found that several potential strategies resulted in significant benefits to some of the intersections included in the analysis. TTI also found that in most cases, short-term improvements have only a limited impact on traffic operations. In most cases, intersection LOS degrades to a LOS F within a few years, assuming a traffic growth rate of 5 percent.

TxDOT suggested a number of additional strategies that would fall either in the medium-range or long-range category. As mentioned above, the results of an evaluation of medium- and long-range strategies are provided in separate documents.

As part of the medium-range strategy analysis, TTI developed an integrated corridor model for FM 1472. The result of the analysis using the integrated model led to the revision of some of the results described in this technical memorandum. Table 62 provides an overview of the results of the short-term strategy review and a summary of revisions following the medium range analysis. The medium-range strategy review technical memorandum provides detailed information about each revision.

Table 62. Revision of Short-Term Strategies.

Location	Results of Short-Term Strategy Review	Modified Short-Term Strategies	
		AM Peak	PM Peak
Con-Way Truckload Facility	• Close median.	Implement as recommended	Implement as recommended
Pan American Boulevard	• Optimize signal splits within 150-second cycle.	Implement as recommended	Implement as recommended
Trade Center Boulevard	• Add overlap phase for EB right turn with NB left turn. • Optimize signal splits within 75-second cycle.	Implement as recommended	Implement as recommended
A F Muller Boulevard	• Use superstreet configuration. • Optimize signal splits within 75-second cycle.	Implement as recommended	Implement as recommended
Interamerica Boulevard	• Eliminate SB left/U turn. • Add overlap phase for EB right turn with NB left turn. • Optimize signal splits within 150-second cycle.	Southbound U-turns cannot be eliminated because A F Muller intersection will be changed to superstreet configuration. The original EB to NB left-turn vehicle will have to make a SB to NB U-turn at Interamerica Intersection.	Implement as recommended
Killam Industrial Boulevard	• Change WB through lane to through right shared lane. • Optimize signal splits within 150-second cycle.	Implement as recommended	Signal optimization should consider allocating less green time for WB to SB left-turn traffic, otherwise it would result in continuous SB traffic south of Killam Industrial Boulevard, which may block any turning traffic and both Wolf Creek Intersection and Pellegrino Intersection.
Old Milo Road	• Eliminate SB to EB movement and WB to SB movements by closing median. • Optimize signal splits within 150-second cycle.	Closing median would aggravate congestions at adjacent intersections, so the first strategy was removed.	The first strategy was removed. The second strategy was modified to: optimize signal splits within 75-second cycle.
Loop 20	• Optimize signal timing and phasing using a full-phase diamond configuration.	Implement as recommended	Implement as recommended