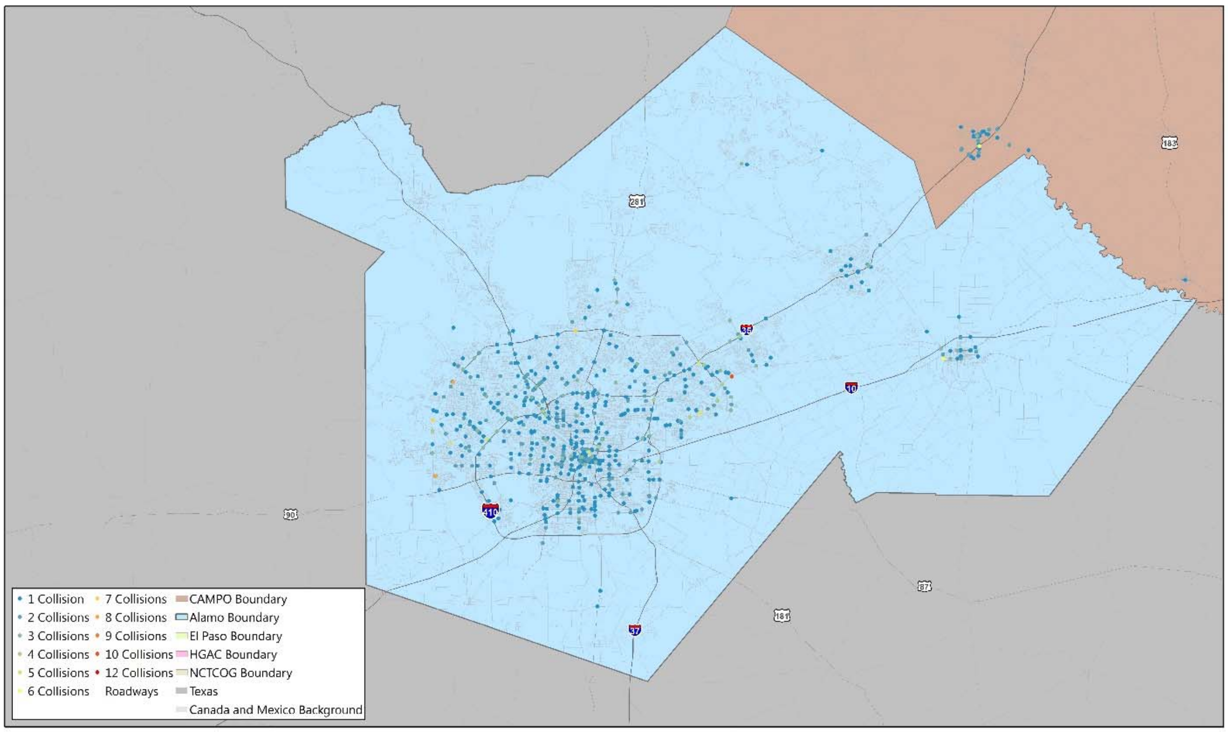
Texas Intersection Safety Implementation Plan

Preliminary Findings for Texas's Alamo Area Metropolitan Planning Organization



Urban Signalized KA Crash Locations
ALAMO

March 30, 2016

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Introduction

The overall objective of this effort is to develop an Intersection Safety Implementation Plan (ISIP) for the State of Texas by focusing on its five largest Metropolitan Planning Organizations (MPOs):

- Alamo Area MPO (AAMPO) in the San Antonio region.
- Capital Area MPO (CAMPO) in the Austin region.
- El Paso MPO in the El Paso region.
- Houston-Galveston Area Council MPO (H-GAC) in the Houston region.
- North Central Texas Council of Governments (NCTCOG) in the Dallas-Fort Worth region.

The purpose of this report is to present the preliminary findings from the data analyses completed to date and to select which intersection types have the best potential to be enhanced by systemic measures.

The analysis team analyzed intersection crash trends for the five-year period from January 2010 to December 2014. The Texas Strategic Highway Safety Plan (SHSP) reports that more than a third of Texas's fatal and incapacitating-injury crashes in 2013—5,624 in total—were intersection related. Three-quarters of these (74 percent) occurred in urban areas.

The analysis team coordinated with the Texas Department of Transportation (TxDOT) Crash Data and Analysis Section of the Traffic Operations Division and the five MPOs to obtain crash and roadway data from 2010 – 2014. The team obtained intersection crash data from TxDOT's Crash Records Information System (CRIS) and analyzed each region's intersection crashes both at the regional level and at the intersection level, identifying macro trends at the regional level and tailoring the analysis at the intersection level to prioritize intersections based on various risk factors and facility types. The following sections describe the method for each level of analysis.

State Data Analysis

Population data from the 2009-2013 American Community Survey (ACS) reported the population of Texas as 25,639,373—a 2013 estimation based on survey data collected over a five-year period. [1] Texas has 254 counties and 1,209 municipal governments, which consist of cities, towns, and villages. Figure 1 depicts the population density by census tract for the entire State.

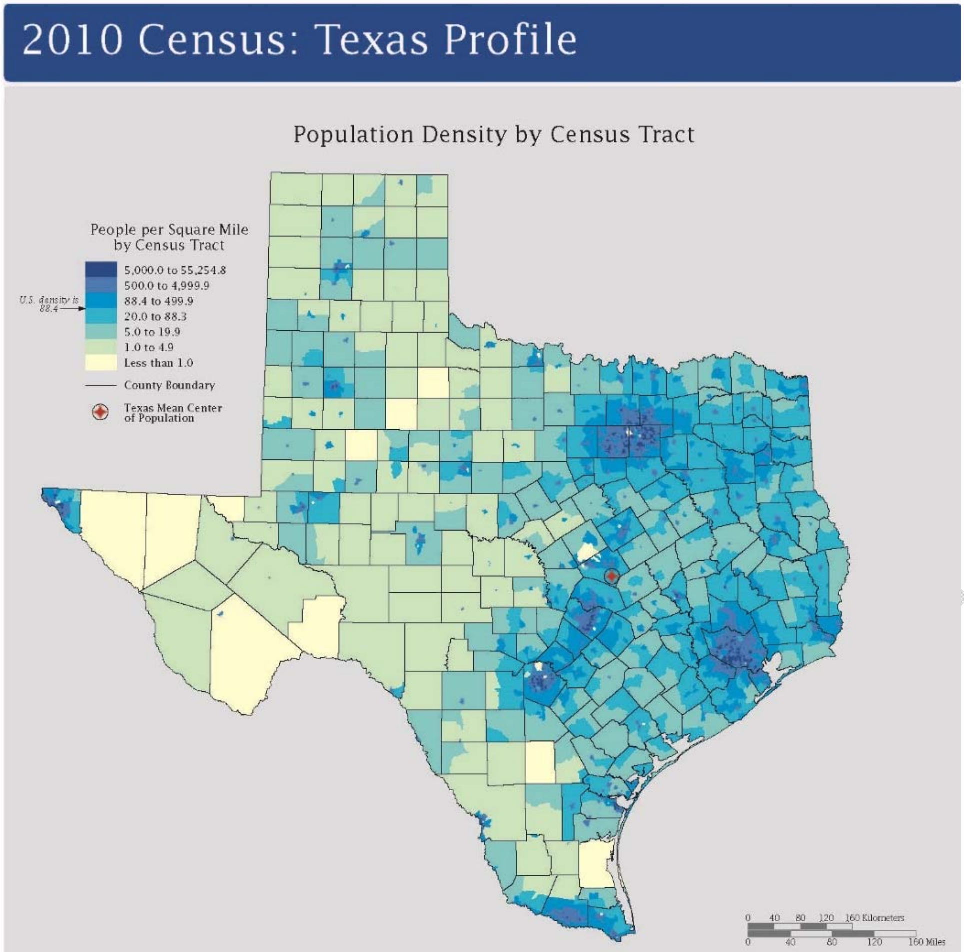

Figure 1. Texas Population Density, 2010 Census. [2]

Table 1 presents the State's largest cities by severe intersection crashes and population. For the purpose of this effort, "severe" crashes refer to those resulting in a fatality (K) or incapacitating injury (A), as defined by Texas's crash report form. Three (3) of every 10 severe intersection crashes statewide occurred in these cities.

Table 1. Six largest Texas cities by 2013 severe intersection crashes and population. [1]

City	Severe (K,A) Int. Crashes	Percent of State Severe Int. Crashes	Population (2)	Population Rank	Percent of State Population
Houston	459	8.2%	2,134,707	1	8.3%
San Antonio	360	6.4%	1,359,033	2	5.3%
Dallas	351	6.2%	1,222,167	3	4.8%
Austin	194	3.4%	836,800	4	3.3%
Fort Worth	240	4.3%	761,092	5	3.0%
El Paso	81	1.4%	660,795	6	2.6%
Total	**1,685**	**30.0%**	**6,974,594**	**---**	**27.2%**

Expanding the focus from the city level to the regional level, Table 2 presents the five largest MPOs in Texas by severe intersection crashes and population. Collectively these regions comprise 62 percent of the severe intersection crashes in the State and 67 percent of its population.

Table 2. Five largest Texas MPOs by 2013 severe intersection crashes and population. [1]

MPO	Severe (K,A) Int. Crashes	Percent of Total Severe Int. Crashes	Population(2)	Population Rank	Percent of Total Population
NCTCOG	1,413	25.1%	6,567,296	1	25.6%
H-GAC	1,070	19.0%	6,034,967	2	23.5%
AAMPO	496	8.8%	2,024,087	3	7.9%
CAMPO	429	7.6%	1,825,262	4	7.1%
El Paso MPO*	97	1.7%	813,015	5	3.2%
Total	**3,505**	**62.3%**	**17,264,627**	**---**	**67.3%**

** Includes only Texas portion of El Paso MPO*

Regional Data Analysis

AAMPO comprises Bexar, Comal, and Guadalupe Counties and part of Kendall County in south-central Texas. According to the 2009-2013 ACS, the population of the MPO was 2,024,087. [1] Figure 2 presents the AAMPO population density map.

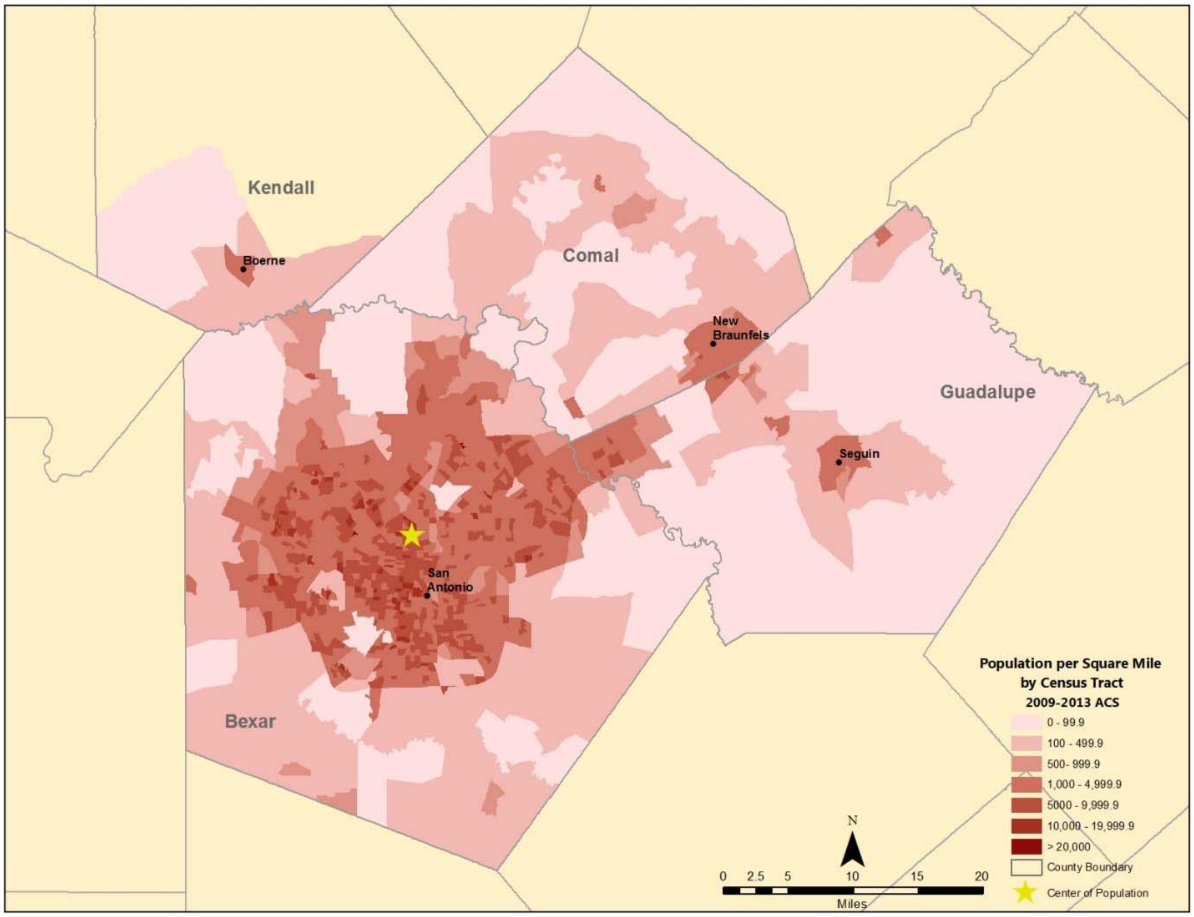

Figure 2. Population density of the AAMPO region. [1]

Severe intersection crashes typically mirror population. The 10 most populous cities of AAMPO are presented in Table 3 by severe intersection crashes for the five-year period of 2010-2014 and 2013 population. Nearly 87 percent of the region's severe intersection crashes occurred within these cities, which compose nearly 77 percent of the region's population. The nine cities listed in bold text are overrepresented in terms of severe intersection crashes relative to their population.

Table 3. Ten largest AAMPO cities by severe intersection (KA) crashes and population.

City	Severe Int. Crashes (K,A)	Percent of Region Severe Int. Crashes	Population in 2013	Population Rank	Percent of Region Population
San Antonio	1,483	**69.01%**	1,359,033	1	67.14%
New Braunfels	87	**4.05%**	59,620	2	2.95%
Seguin	86	**4.00%**	25,848	4	1.28%
Converse	44	**2.05%**	19,023	5	0.94%
Leon Valley	44	**2.05%**	10,429	8	0.52%
Universal City	37	**1.72%**	18,844	6	0.93%
Schertz	35	1.63%	33,758	3	1.67%
Live Oak	19	**0.88%**	13,750	7	0.68%
Helotes	18	**0.84%**	7,624	9	0.38%
Castle Hills	15	**0.70%**	4,187	10	0.21%
Total	**1,868**	**86.93%**	**1,552,116**	**---**	**76.68%**

2009-2013 ACS 5-year estimates (Total MPO population 2,024,087)

There are a total of 10,618 public road miles within the AAMPO service region that are owned by various agency types, including State, county, town, Federal agency, or other, as presented in Table 4. Municipal agencies and counties maintain approximately 57 percent and 26 percent, respectively—for a combined 83 percent—of the public road miles in AAMPO. The State maintains the remaining 17 percent. Urban roadways comprise more than 70 percent of the total road mileage.

Table 4. AAMPO public road length (mi) by type of owner. [3]

	State Highway Agency	County	Town, Township, Municipal	Other	Federal Agency	Total
RURAL	711	2,010	232	0	0	2,953
	6.70%	18.93%	2.18%	0.00%	0.00%	27.81%
URBAN	1,053	774	5,838	0	0	7,665
	9.92%	7.29%	54.98%	0.00%	0.00%	72.19%
Total	1,764	2,784	6,070	0	0	10,618
	16.61%	26.22%	57.17%	0.00%	0.00%	100.00%

Table 5 simplifies the information in Table 4 by combining the county and municipal categories into a "local" group and the Federal agency and other categories into an "other" group.

Table 5. AAMPO public road length (mi) by State, local, or other. [3]

	State	Local	Other	Total
RURAL	711	2,242	0	2,953
	6.70%	21.11%	0.00%	27.81%
URBAN	1,053	6,612	0	7,665
	9.92%	62.27%	0.00%	72.19%
Total	1,764	8,854	0	10,618
	16.61%	83.39%	0.00%	100.00%

Table 6 presents the distribution of intersection crashes by severity for the analysis. Each crash is described by the most severe injury that resulted. The following crash severities are used in Texas:

- Fatal (K);
- Incapacitating injury (A);
- Non-incapacitating injury (B);
- Possible Injury (C); and
- Non-injury (PDO).

Table 6. Approximate number of AAMPO intersection crashes by severity and year.

Year	K	A	B	C	PDO	Unknown	Total	KA	KA as % of Total Crashes
2010	40	316	1,372	4,239	11,273	410	17,650	356	2.02%
2011	37	331	1,282	4,201	10,749	454	17,054	368	2.16%
2012	40	415	1,588	4,298	10,996	316	17,653	455	2.58%
2013	53	443	1,706	4,231	12,353	401	19,187	496	2.59%
2014	55	419	1,880	4,656	13,981	462	21,453	474	2.21%
Subtotal	**225**	**1,924**	**7,828**	**21,625**	**59,352**	**2,043**	**92,997**	**2,149**	**2.31%**

Discounting the crashes of unknown severity, the analysis team estimated the total cost of AAMPO intersection crashes to be nearly $4 billion—or $772 million annually—over the five-year analysis period. The total estimated cost of the KA intersection crashes across the five regions for the same period was $29.6 billion, which corresponds to nearly $6 billion per year. These costs were based on the 2013 average comprehensive costs by injury severity presented in the National Safety Council's *Estimating the Costs of Unintentional Injuries, 2013*. [4] Severe (KA) intersection crashes accounted for 2.3 percent of all intersection crashes and nearly 44 percent of the total cost of intersection crashes within the AAMPO region.

Since KA crashes comprise such a significant portion of the total crash costs, the intersection-level analysis in the following sections will primarily focus on severe crashes. The KA crashes also represent an opportunity to focus the potential countermeasure packages.

Intersection-Level Analysis

The analysis team joined TxDOT's CRIS data with pertinent roadway inventory data from its Road-Highway Inventory Network (RHiNo) database as the primary data source to determine the ownership (State, County, local, Federal or other) of the roadway on which the crash occurred and analyze the focus intersection types and crash types by severity. The RHiNo data included the classification of government agency associated with the street on which the crash occurred. The urban/rural classifications were extracted from the traffic analysis zone (TAZ) shapefiles from the travel demand model provided by AAMPO.

For the purposes of this effort, "intersection ownership" is determined by the ownership of the intersecting streets. An intersection involving at least one TxDOT-maintained cross street is considered State-owned. An intersection involving at least one local street but not involving a TxDOT-maintained street is considered locally-owned. All other intersections fall under the "other" category.

Table 7 presents a breakdown of AAMPO intersection-related crashes according to area type and owner. Nearly half of the intersection-related crashes occurred at intersections involving at least one State road, and 94 percent of the crashes occurred in urban areas.

Table 7. Distribution of AAMPO intersection crashes by owner and area type.

	State	Local	Other	Total
RURAL	4,255	1,196	44	**5,495**
	4.58%	1.29%	0.05%	**5.91%**
URBAN	40,611	46,740	151	**87,502**
	43.67%	50.26%	0.16%	**94.09%**
Total	**44,866**	**47,936**	**195**	**92,997**
	48.24%	**51.55%**	**0.21%**	**100.00%**

The analysis team used crash data as the starting point to extract and interpolate locations and characteristics and to determine where the severe crashes are concentrated (e.g., urban intersections, unsignalized intersections, etc.). A unique field for intersection number did not exist. The analysis team used geographic information system (GIS) analysis with a 528-foot buffer to identify the potential intersection node ID at which an individual crash occurred. The corresponding ESRI Street file was used to identify the node locations, as its shapefile is more detailed than that of RHiNo since ESRI includes private roads in its database. (ESRI is a leading GIS software and mapping developer.) Crashes with an identical node ID value were flagged as occurring at the same location, allowing the analysis team to quantify the total number of crashes and compare with the total number of unique (non-duplicating) locations. This initial level of analysis helped to determine the primary intersection types on which to focus. It is likely this method underestimated the number of intersections; however, the method was not expected to bias the preliminary results as it was assumed the approach would treat all intersection types in a similar manner. Nodes were underestimated because approximately two percent of crashes occurred at the intersection with a private driveway or dirt road and were not included in the ESRI database.

Only the severe (KA) crashes that could be assigned to an intersection are included in this portion of the analysis, as it is an intersection-level analysis. More discussion on assigning crashes to intersections is provided in the *Analysis Methodology* section.

Analysis Methodology

Assigning Crashes to Intersections

TxDOT does not currently have a single database of all intersections in the State, so the analysis team manually compiled an intersection inventory from ESRI Street layer datasets. The team considered all intersection crashes (regardless of severity) within the CRIS database to develop the inventory and assigned a unique intersection identification number to each intersection with one or more crashes in the five-year analysis period.

During the analysis period, there were 2,149 severe injury (KA) intersection crashes in the AAMPO region. Approximately four percent (81) of these crashes were not assigned an intersection identification number because they occurred at an intersection involving a private driveway or dirt road not included in the ESRI database. The remaining crashes (2,068) were assigned an intersection ID, resulting in 1,504 identified AAMPO intersections with at least one severe injury crash in the five-year period.

Characterizing Intersections

The intersections identified were characterized by maintenance jurisdiction and traffic control and area type. This was done using a combination of fields from CRIS crash data and roadway inventory data.

The analysis team divided maintaining jurisdiction between State maintained, locally-owned, or other. The traffic control at each of these intersections was estimated as signalized or unsignalized based on the CRIS crash data. The criteria listed in Table 8 were used for classifying the control type for the intersection based on the traffic control description (TRAFFIC_CNTL_DESC) field within the crash data.

Table 8. Interpreted traffic control type based on police-reported crash data.

ID	TRAFFIC_CNTL_DESC	Interpreted Control Type
1	NONE	Unsignalized
2	INOPERATIVE (EXPLAIN IN NARRATIVE)	Unknown
3	OFFICER	Unknown
4	FLAGMAN	Unknown
5	SIGNAL LIGHT	Signalized
6	FLASHING RED LIGHT	Unsignalized
7	FLASHING YELLOW LIGHT	Unsignalized
8	STOP SIGN	Unsignalized
9	YIELD SIGN	Unsignalized
10	WARNING SIGN	Unsignalized
11	CENTER STRIPE/DIVIDER	Unsignalized
12	NO PASSING ZONE	Unsignalized
13	RR GATE/SIGNAL	Signalized
15	CROSSWALK	Unsignalized
16	BIKE LANE	Unsignalized
17	OTHER (EXPLAIN IN NARRATIVE)	Unsignalized
20	MARKED LANES	Unsignalized
21	SIGNAL LIGHT WITH RED LIGHT RUNNING CAMERA	Signalized
94	REPORTED INVALID	Unknown
95	NOT REPORTED	Unknown

This method is described as "estimating" the traffic control at the intersection because the TRAFFIC_CNTL_DESC field of the crash database has some inherent unreliability. The law enforcement officer reports the control under which crash-involved vehicles were operating, not necessarily the traffic control for the intersection. This reporting likely underestimates the occurrence of signalized control.

The rural/urban classifications were extracted from the AAMPO travel demand model traffic analysis zone (TAZ) shapefile provided by AAMPO.

Prioritizing Intersections

The analysis team developed a Microsoft Access database of the severe injury crashes at each intersection that allows focus on and consideration of the following intersection attributes and crash characteristics:

- Location identification information including:
  - Intersection ID,
  - Street names,
  - Jurisdiction.

- Intersection characteristics including:
    - Traffic control.
    - Area type.
- Total fatal and severe injury crashes (injury severity K, or A) occurring at the intersection from 2010 to 2014.
- Crash characteristics (fatal and incapacitating-injury only) including:
    - Injury severity level.
    - Lighting condition.
    - Surface condition (e.g., dry).
    - Collision type (e.g., angle – both going straight).
    - Reported harmful event (e.g., motor vehicle in transport).

Analysis of the Results

The analysis team used the Systemic Safety Project Selection Tool to provide a consistent framework for the ISIP process. [5] The tool is a process that focuses on identifying statewide or regional roadway safety concerns and strategies to address these concerns. Based on the safety data provided, the Tool allows analysts to determine which common risk factors are influencing driver behavior and how crashes occur. Different risk factors may include various system, crash, or facility types.

There are three distinct components of the Systemic Safety Project Selection Tool, as depicted in Figure 3: [5]

- Element 1: Systemic Safety Planning Process.
- Element 2: Framework for Balancing Systemic and Traditional Safety.
- Element 3: Evaluation of a Systemic Safety Program.

Element 1 is the focus of this preliminary findings report. The Systemic Safety Planning Process comprises four steps: identifying focus crash types and risk factors; screening and prioritizing candidate locations; selecting low-cost, highly effective countermeasures; and prioritizing the resulting projects. Each of the four steps is discussed in the following sections.

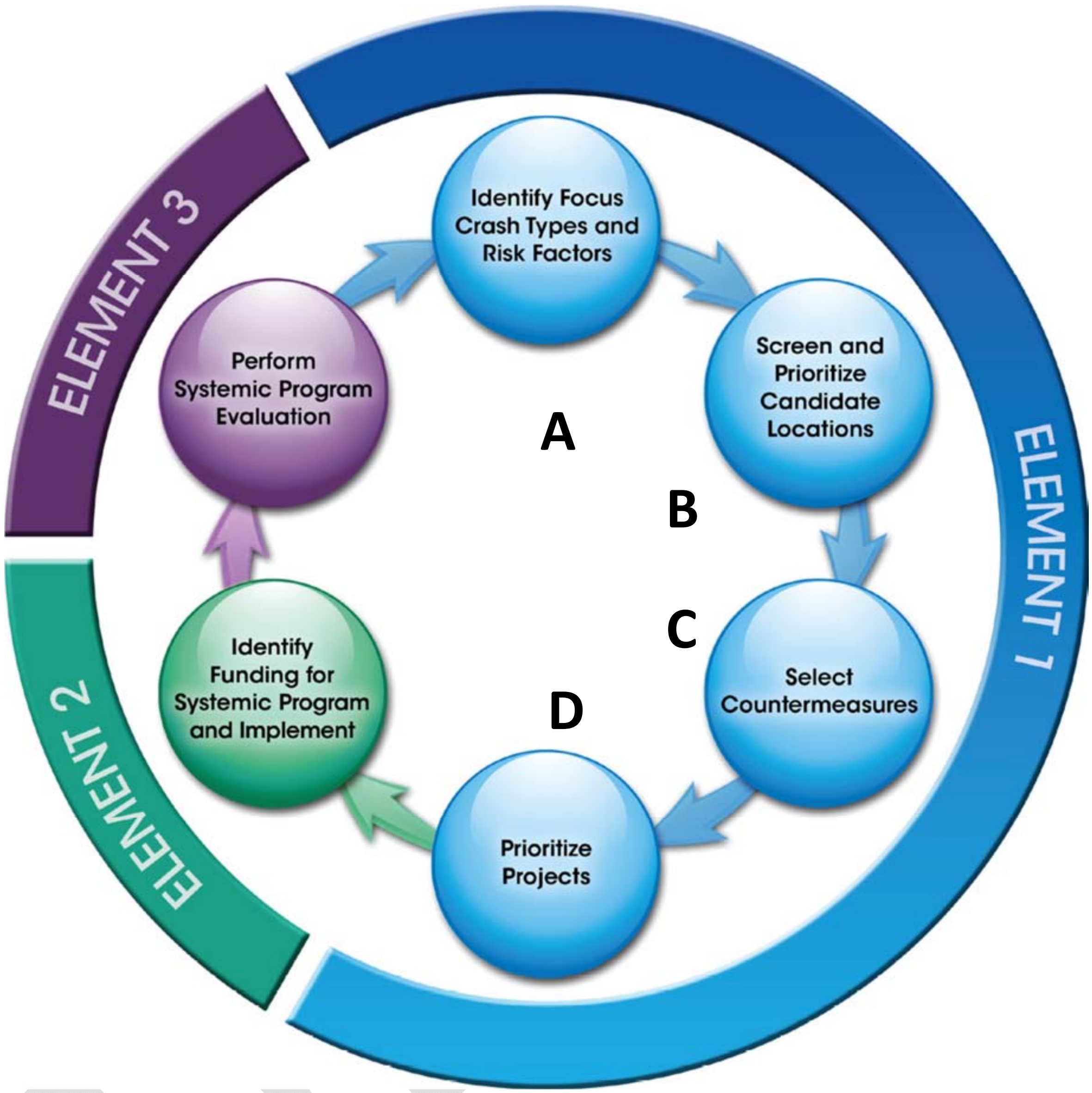

Figure 3. Systemic Safety Project Selection Tool. [5]

A. Identify Focus Crash Types and Risk Factors

The objective of Step A in the process is to identify risk factors commonly associated with each focus crash type experienced across a system. The analysis team examined regional safety data in order to determine common risk factors among the crashes by looking not only at the specific location of the crash but also at the characteristics of the locations. Within this first step are three tasks that allow for improved analysis—

- Task A-1: Selecting Focus Crash Types.
- Task A-2: Selecting Focus Facilities.
- Task A-3: Identifying and Evaluating Risk Factors.

Task A-1: Select Focus Crash Types

The objective of this task is to identify whether the systemic approach will be applied to segments, curves, or intersections. The Texas SHSP identifies four roadway safety emphasis areas, the first of which is *Crash Type & Location*. Included in this area are intersection crashes. According to the SHSP, "an intersection crash is one that occurs within the boundaries of an intersection or in which the first harmful event occurred on an approach to or exit from an intersection and resulted from an activity, behavior, or control related to the movement of traffic through an intersection."

The strategies that should be considered to reduce intersection crashes include countermeasures installed under the Texas Highway Safety Improvement Program (HSIP) and other emerging treatments, as well as the following countermeasures identified in the Texas SHSP:

Engineering

- Implement engineering solutions to reduce red-light running, such as changes in signal timing (i.e., longer yellow, all-red phase).
- Enhance advanced warning at intersections through the use of signing, flashing beacons or transverse rumble strips.
- Provide high friction surface treatments at intersection approaches to reduce vehicle stopping distances.
- Consider the use of roundabouts to reduce the number of incapacitating crashes.
- Add more turn bays and acceleration lanes on high speed rural roads.
- Eliminate limited sight distance on all roads. This includes high speed rural and urban intersections where sight distance limitations exist due to vegetation, signing, and other obstructions.
- Construct grade separations.

Enforcement

- Consider the use of photographic traffic signal enforcement (red light cameras) by municipalities.

Education

- Add information on gap acceptance and intersection crash frequency to a standardized driver education curriculum and to programs targeting elderly drivers.
- Promote better access management policies and practices by educating consultants and developers on driveway regulations in relation to intersections and by coordinating with city, county, and state engineers.

EMS

- Encourage the use of emergency vehicle signal preemption.

Table 9 presents a breakdown of the intersection crashes occurring along State-maintained, locally-owned, or other roadways for the five-year period.

Table 9. AAMPO intersection-related crashes by roadway owner type.

	State	Local	Other	TOTAL
Intersection Crashes	**44,866**	**47,936**	**195**	**92,997**

Task A-2: Select Focus Facilities

Task A-2 concentrates on the details of where each crash took place, such as in rural or urban areas, at signalized or unsignalized intersections, along State-owned or locally-owned roads, etc. Table 10 depicts the distribution of intersection crashes by owner type, traffic control type, and area type.

Table 10. Distribution of AAMPO intersection crashes by owner, traffic control, and area type.

STATE	Area Type	Total # of Crashes	Fatal	A	B	C	PDO	Un-known
Signalized	Rural	1,589	6	49	155	329	1,041	9
	Urban	23,833	43	513	1,973	5,717	15,413	174
Unsignalized	Rural	2,650	27	97	318	496	1,662	50
	Urban	16,596	44	316	1,238	3,614	11,175	209
Unknown	Rural	16	1	1	2	3	9	0
	Urban	182	0	2	19	43	117	1
	Subtotal	44,866	121	978	3,705	10,202	29,417	443
LOCAL								
Signalized	Rural	160	0	2	14	32	111	1
	Urban	19,228	45	357	1,605	5,096	11,907	218
Unsignalized	Rural	1,034	2	24	104	158	697	49
	Urban	27,293	57	555	2,369	6,059	16,932	1,321
Unknown	Rural	2	0	0	0	0	2	0
	Urban	219	0	5	19	48	143	4
	Subtotal	47,936	104	943	4,111	11,393	29,792	1,593
OTHER								
Signalized	Rural	0	0	0	0	0	0	0
	Urban	31	0	1	1	6	23	0
Unsignalized	Rural	44	0	1	4	5	33	1
	Urban	120	0	1	7	19	87	6
Unknown	Rural	0	0	0	0	0	0	0
	Urban	0	0	0	0	0	0	0
	Subtotal	195	0	3	12	30	143	7

Per Table 10, 99.2 percent of the total crashes and 99.3 percent of the KA crashes can be captured in the following seven intersection types (listed in order of decreasing total crashes):

1. Local Urban Unsignalized
2. State Urban Signalized
3. Local Urban Signalized
4. State Urban Unsignalized
5. State Rural Unsignalized
6. State Rural Signalized
7. Local Rural Unsignalized

Therefore, the following 11 intersection types (also listed in order of decreasing total crashes) were eliminated from further consideration, as they collectively accounted for less than one percent of the KA crashes and associated crash costs.

1. Local Urban Unknown
2. State Rural Unknown
3. State Urban Unknown
4. Local Rural Signalized
5. Other Urban Signalized
6. Other Rural Unsignalized
7. Other Urban Unsignalized
8. Local Rural Unknown
9. Other Rural Signalized
10. Other Rural Unknown
11. Other Urban Unknown

Task A-3: Identify and Evaluate Risk Factors

In the current analysis, the analysis team identified the following potential risk factors using engineering judgment based upon the focus intersection types selected in Task A-2. Many of these risk factors will be reviewed in Step C as a random sample of selected intersection types are reviewed using online visualization tools:

- Number of lanes.
- Number of legs.
- Traffic volumes.
- Lane and shoulder widths.
- Channelization.
- Median width and type.
- Pavement condition and friction.
- Driveway presence, design, and density.
- Presence of lighting.
- Presence of on-street parking.
- Intersection skew angle.
- Intersection traffic control device.
- Number of signal heads vs. lanes.
- Presence of backplates.
- Presence of advanced warning signs.
- Intersection located in or near horizontal curve.
- Presence of left-turn or right-turn lanes.
- Left turn phasing.
- Allowance of right-turn on red.
- Overhead vs. pedestal-mounted signal heads.
- Pedestrian crosswalk presence, crossing distance, and signal head type.
- Posted speed limit or operating speed.
- Presence of automated enforcement.
- Adjacent land use type.
- Location and presence of bus stops.

B. Screen and Prioritize Candidate Locations

The objective of Step B of the Systemic Safety Planning Process is "to develop a prioritized list of potential locations on the roadway system that could benefit from systemic safety improvement projects." The process to screen and prioritize candidate locations helps to further explore the specific risk factors found in Step A. In order to do this, the analysis team performed the following three tasks (with the first two presented together below):

- Task B-1: Identify Network Elements to Analyze.
- Task B-2: Conduct Risk Assessment.
- Task B-3: Prioritize Focus Facility Elements.

Using the information collected in Step A, the main focus of Step B is crashes classified as K or A. KA crashes account for 2.3 percent of all intersection crashes that occurred in the AAMPO region during the analysis period.

Task B-1: Identify Network Elements to Analyze and Task B-2: Conduct Risk Assessment

This section presents the following:

- A summary of the combined results of the data analyses of the five largest MPOs in Texas.
- The results of the data analyses specific to the AAMPO region.
- The recommended intersection type(s) on which the ISIP should focus.

Combined Analysis of Texas's Five Largest MPOs

The statewide ISIP is being developed from the analyses of not only the AAMPO data but also data from the CAMPO, El Paso, H-GAC and NCTCOG regions. Table 11 presents a general summary of the intersections at which the KA crashes occurred relative to the total number of intersections across the five regions. Some key takeaways include the following:

- More than 9 out of 10 KA intersection crashes occur in urban areas.
- There is nearly a 50/50 split between crashes at State- and locally-maintained intersections (i.e., between intersections comprising at least one State-maintained road and intersections not comprising a State-maintained road).
- Signalized intersections are significantly overrepresented in terms of comparing the proportion of KA crashes to the proportion of intersections.

Table 11. Common attributes related to the severe injury (KA) intersection crashes in the five largest MPOs in Texas.

Location Type	No. of KA Crashes	Percent KA Crashes	Total No. of Intersections	Percent of Intersections
Rural	1,623	9.9%	8,817	8.4%
Urban	14,854	90.1%	95,777	91.6%
Subtotal	**16,477**	100%	104,594*	100%
Ownership Type				
State	7,810	47.4%	25,054	22.9%
Local	8,518	51.7%	83,345	76.1%
Other	149	0.9%	1,132	1.0%
Subtotal	**16,477**	100%	109,531*	100%
Traffic Control Type				
Signalized	7,653	46.4%	25,512	20.3%
Unsignalized	8,756	53.1%	97,709	77.7%
Unknown	68	0.4%	2,499	2.0%
Subtotal	**16,477**	100%	125,720*	100%

** As the safety data were derived from various sources (e.g., CRIS and ESRI Street layer), the intersection characteristic data correlate to the crashes rather than the intersections themselves. Consequently, there were instances when conflicting data elements (e.g., signalized and unsignalized) were coded to the same intersection due to multiple crash reports tied to the same location. This created duplicate intersections within the database, which led to the variable intersection subtotals among the categories.*

Figure 4 depicts the comparison of the proportions of the five MPOs' KA intersection crashes to the specific intersection types. Five intersection categories show a measurable overrepresentation when comparing the proportion of KA crashes to the proportion of total intersections. The most meaningful overrepresentation in terms of KA crashes is seen in the State Urban Signalized and Local Urban Signalized categories.

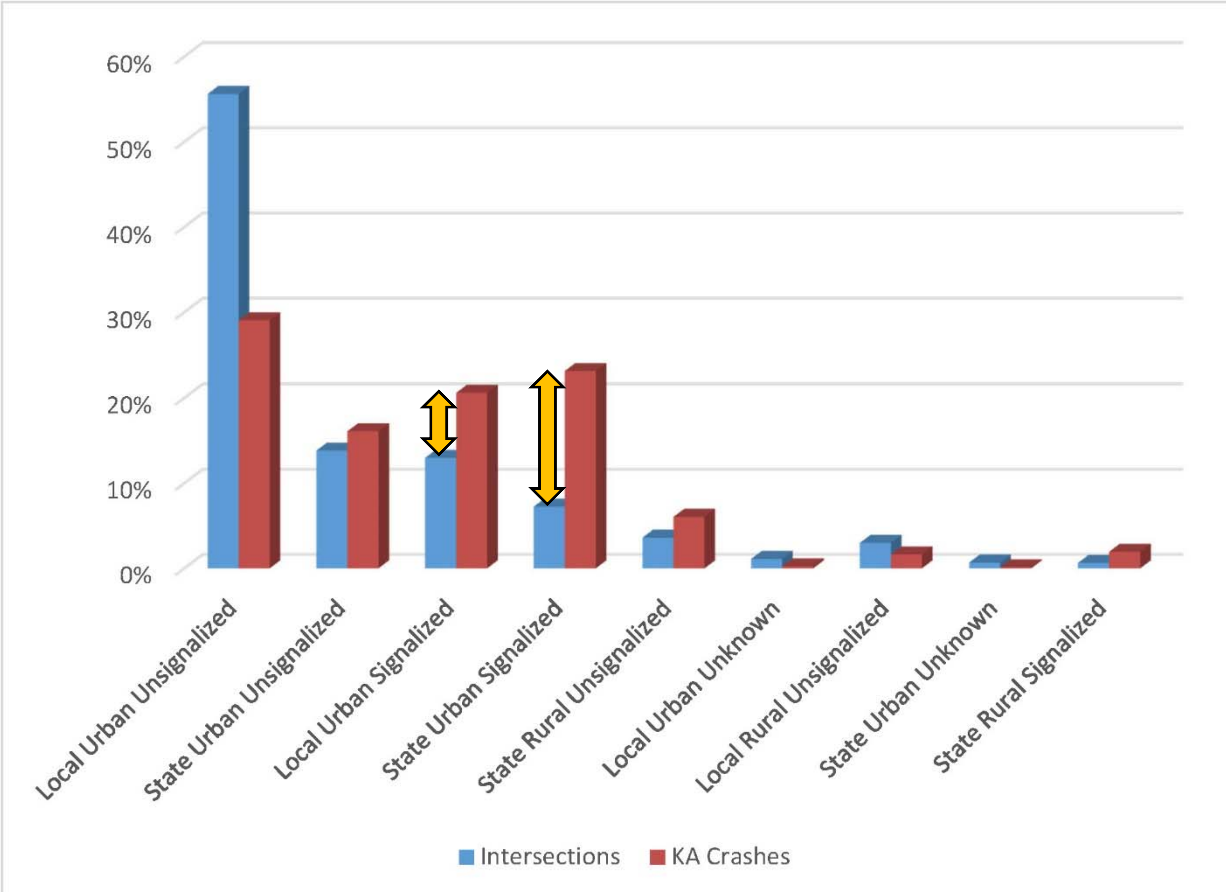

Figure 4. Distribution of the five largest Texas MPOs' severe injury (KA) intersection crashes by area type and traffic control.

AAMPO Regional Analyses

This section presents the results of the data analyses specific to the AAMPO region. Table 12 presents a general summary of the intersections at which the KA crashes occurred relative to the total number of intersections across the region.

Table 12. Common attributes related to AAMPO severe injury (KA) intersection crashes.

Location Type	No. of KA Crashes	Percent KA Crashes	Total No. of Intersections	Percent Intersections
Rural	210	10%	1,272	9%
Urban	1,939	90%	12,873	91%
Subtotal	2,149	100%	14,145	100%
Ownership Type				
State	1,099	51%	3,251	22%
Local	1,047	49%	11,578	78%
Other	3	0%	87	1%
Subtotal	2,149	100%	14,916	100%
Traffic Control Type				
Signalized	1,016	47%	3,220	19%
Unsignalized	1,124	52%	13,374	79%
Unknown	9	0%	355	2%
Subtotal	2,149	100%	16,949	100%

** Because the AAMPO safety data were derived from various sources (e.g., CRIS and ESRI Street layer), the intersection characteristic data correlate to the crashes rather than the intersections themselves. Consequently, there were instances when conflicting data elements (e.g., signalized and unsignalized) were coded to the same intersection due to multiple crash reports tied to the same location. This created duplicate intersections within the database, which led to the variable intersection subtotals among the categories. The actual intersection count for the AAMPO region was determined to be 14,054.*

The analysis team highlights the following roadway inventory attributes to describe where these KA intersection crashes occurred:

- Land use—91 percent of the AAMPO's intersection crashes occurred in urban areas compared to 9 percent rural.
- Ownership type—51 percent of the KA intersection crashes occurred at intersections involving at least one State-maintained road despite such intersections comprising only 22 percent of AAMPO's intersections.
- Traffic control—considering the 2,140 crashes for which the traffic control type is known, nearly half (47 percent) occurred at signalized intersections, despite the fact that only an estimated 19 percent of AAMPO intersections is signalized.

Each of the focus intersection types are further divided into different elements to determine which would be the most beneficial to analyze. Table 13 depicts the number of KA intersection crashes and the number of associated intersection types categorized by the following attributes:

- Owner type (State-maintained, locally-owned, or other intersections).
- Land use (rural or urban area).
- Traffic control (signalized, unsignalized, or unknown).

The seven focus categories identified in Table 10—which capture 99.3 percent of the region's total and KA crashes—are listed in boldface type.

Table 13. Distribution of AAMPO severe intersection crashes by traffic control and area type.

STATE	Area Type	KA Crashes	Percent of KA	Total Intersections	Percent of Intersections	Ratio of % KA to % Ints
Signalized	**Rural**	**55**	**2.56%**	**145**	**0.80%**	**3.20**
	Urban	**556**	**25.87%**	**1,288**	**7.11%**	**3.64**
Unsignalized	**Rural**	**124**	**5.77%**	**690**	**3.81%**	**1.51**
	Urban	**360**	**16.75%**	**2,357**	**13.01%**	**1.29**
Unknown	Rural	2	0.09%	15	0.08%	1.12
	Urban	2	0.09%	142	0.78%	0.12
	Subtotal	1,099	51.14%	4,637	25.60%	-
LOCAL						
Signalized	Rural	2	0.09%	39	0.22%	0.43
	Urban	**402**	**18.71%**	**2,189**	**12.09%**	**1.55**
Unsignalized	**Rural**	**26**	**1.21%**	**596**	**3.29%**	**0.37**
	Urban	**612**	**28.48%**	**10,357**	**57.19%**	**0.50**
Unknown	Rural	0	0.00%	2	0.01%	0.00
	Urban	5	0.23%	199	1.10%	0.21
	Subtotal	1,047	48.72%	13,382	73.89%	-
OTHER						
Signalized	Rural	0	0.00%	0	0.00%	-
	Urban	1	0.05%	11	0.06%	0.77
Unsignalized	Rural	1	0.05%	18	0.10%	0.47
	Urban	1	0.05%	62	0.34%	0.14
Unknown	Rural	0	0.00%	0	0.00%	-
	Urban	0	0.00%	0	0.00%	-
	Subtotal	3	0.14%	91	0.50%	-
	TABLE SUBTOTAL	2,149	100.00%	18,110	100.00%	-

Five of the intersection categories listed in boldface type in Table 13 show a measurable overrepresentation when comparing the proportion of KA crashes to the proportion of total AAMPO intersections. Figure 5 depicts the comparison of the proportions of AAMPO KA intersection crashes to intersection types. The most meaningful overrepresentation in terms of KA crashes is seen in the State Urban Signalized and Local Urban Signalized categories.

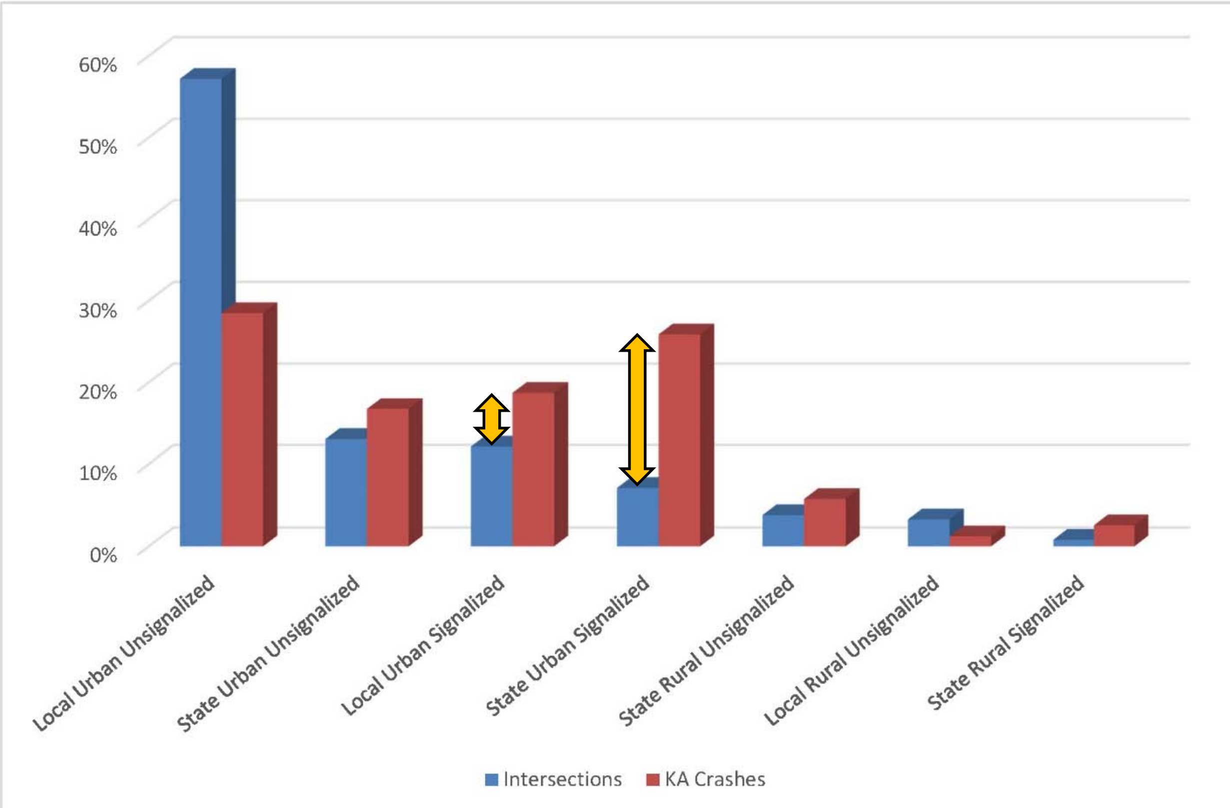

Figure 5. Distribution of AAMPO severe (KA) intersection crashes by area type and traffic control.

Recommended ISIP Focus

The analysis team suggests to focus on urban signal-controlled intersections, regardless of whether these intersections are State-maintained or locally-owned. State and Local Urban Signalized intersections comprise less than 20 percent of the intersections within the AAMPO region, yet nearly 45 percent of the severe (KA) intersection crashes—958 of them during the five-year study period—occurred at such intersections. These KA crashes occurred at 616 urban signalized intersections, which equates to 4 percent of the 14,054 intersections analyzed. Similar trends emerge when considering all five MPO regions collectively, as approximately 20 percent of the intersections are State and Local Urban Signalized, yet nearly 44 percent of the KA crashes occur at such intersections.

The distribution of the AAMPO State and Local Urban Signalized KA intersection crashes in terms of the TxDOT collision types is presented in Table 14 and Figure 6 for the intersection types selected. Not surprisingly, four of every five severe intersection crashes involved more than one vehicle, with 30 percent classified as angle type collisions characterized by “two vehicles approaching each other at an angle.”

Table 14. Detailed distribution of AAMPO severe intersection collision types.

Collision Type	Count	Percent
OD ONE STRAIGHT-ONE LEFT TURN	259	27%
ANGLE - BOTH GOING STRAIGHT	236	25%
SD ONE STRAIGHT-ONE STOPPED	159	17%
OMV VEHICLE GOING STRAIGHT	124	13%
OMV VEHICLE TURNING LEFT	47	5%
ANGLE - ONE STRAIGHT-ONE LEFT TURN	37	4%
SD BOTH GOING STRAIGHT-REAR END	24	3%
OMV VEHICLE TURNING RIGHT	21	2%
SD ONE STRAIGHT-ONE LEFT TURN	11	1%
SD BOTH GOING STRAIGHT-SIDESWIPE	8	1%
ANGLE - ONE STRAIGHT-ONE RIGHT TURN	8	1%
SD ONE STRAIGHT-ONE RIGHT TURN	7	1%
SD BOTH LEFT TURN	4	0%
OD BOTH GOING STRAIGHT	3	0%
ANGLE - ONE RIGHT TURN-ONE STOPPED	2	0%
ANGLE - ONE STRAIGHT-ONE STOPPED	2	0%
OD ONE RIGHT TURN-ONE LEFT TURN	1	0%
SD BOTH RIGHT TURN	1	0%
ANGLE - ONE RIGHT TURN-ONE LEFT TURN	1	0%
OD BOTH LEFT TURNS	1	0%
OD ONE BACKING-ONE STOPPED	1	0%
OTHER	1	0%
Total	**958**	**100%**

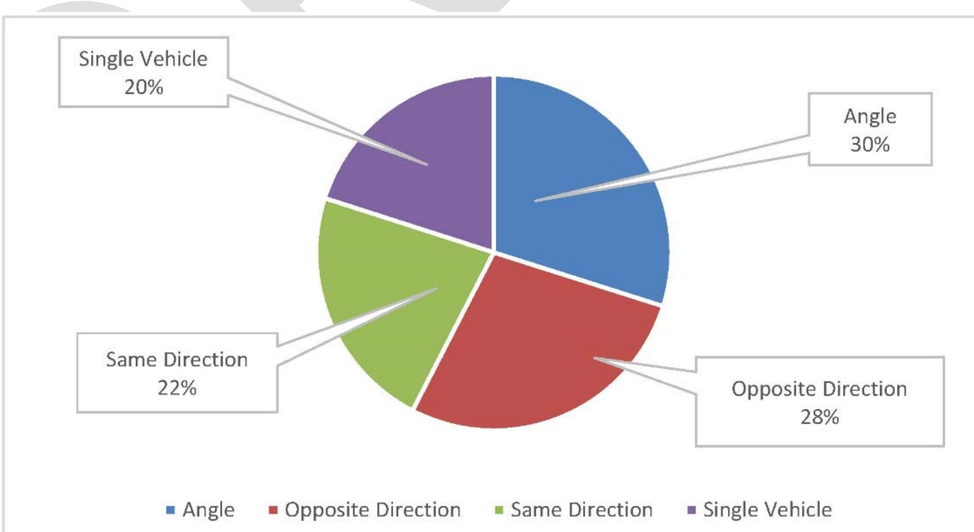

Figure 6. General distribution of AAMPO severe intersection collision types

Table 15 presents the nature of the severe (KA) intersection crashes according to the reported harmful event description, which provides additional insight related to the nature of the collision. Four (4) of every 5 crashes involved another motor vehicle, and approximately 1 of every 8 crashes involved a pedestrian or bicyclist.

Table 15. Reported harmful event for AAMPO severe intersection collisions.

Harmful Event	Count	Percent
MOTOR VEHICLE IN TRANSPORT	766	80%
PEDESTRIAN	102	11%
FIXED OBJECT	49	5%
PEDALCYCLIST	21	2%
OVERTURNED	16	2%
OTHER OBJECT	2	0%
ANIMAL	1	0%
OTHER NON COLLISION	1	0%
Total	**958**	**100%**

Basic crash analyses were also conducted to explore trends in the reported lighting condition, surface condition, and weather condition for the severe intersection crashes, and these will be considered when selecting crash countermeasures.

Task B-3: Prioritize Focus Facility Elements

The 958 severe injury (KA) crashes in the AAMPO region occurred at 616 intersections, which may be too many locations to effectively treat in a short timeframe with limited resources. Therefore, the analysis team suggests applying a threshold to the crashes to assist with prioritizing a subset of the urban signalized intersections. While the analyses have centered on KA crashes, additional prioritization alternatives are derived by also considering the number of non-incapacitating injury (B) crashes that occurred at the focus intersections. Table 16 presents a breakdown of intersections that can be targeted based on various crash thresholds. The first three rows consider only KA crashes, while the remaining rows also apply thresholds to the B crashes occurring during the analysis period. If a threshold of three or more KA crashes is selected, 28 percent of AAMPO's KA intersection crashes can be addressed by targeting 11 percent of the KA intersection crash locations; likewise, if a threshold of either three or more KA crashes or two or more KA crashes and four or more B crashes is applied, then more than 40 percent of the KA crashes can be addressed by targeting less than 21 percent of the KA crash locations.

Table 16. Potential crash thresholds for AAMPO systemic treatments.

Crash Threshold	KA Crashes		Intersections		B Crashes
	Number	Percent	Number	Percent	
2 or more KA crashes	527	55.9%	199	32.4%	996
3 or more KA crashes	265	28.1%	68	11.1%	494
4 or more KA crashes	133	14.1%	24	3.9%	283
3 or more KA crashes OR 2 KA crashes and 10 or more B crashes	281	29.8%	76	12.4%	588
3 or more KA crashes OR 2 KA crashes and 8 or more B crashes	305	32.3%	88	14.3%	686
3 or more KA crashes OR 2 KA crashes and 6 or more B crashes	329	34.9%	100	16.3%	761
3 or more KA crashes OR 2 KA crashes and 5 or more B crashes	349	37.0%	110	17.9%	811
3 or more KA crashes OR 2 KA crashes and 4 or more B crashes	383	40.6%	127	20.7%	879

Similarly, Table 17 presents the potential crash thresholds and their corresponding reach for the five MPOs combined. The rightmost column provides a simple estimate of how an overall statewide funding amount—$45 million in this case—would translate as a per-intersection average for the various thresholds identified. For example, selecting a threshold of three or more KA crashes or two KA crashes and four or more B crashes would allow nearly 40 percent of the five regions' KA intersection crashes to be addressed by targeting 19 percent of the KA intersection crash locations, with an allowable average cost of nearly $50,000 per intersection.

Table 17. Potential crash thresholds for statewide systemic treatments.

Crash Threshold	KA Crashes		Intersections		B Crashes	Avg. per-intersection cost assuming $45M funding
	Number	Percent	Number	Percent		
2 or more KA crashes	3,782	52.5%	1,373	28.7%	8,242	$ 32,775
3 or more KA crashes	2,006	27.9%	485	78.9%	4,507	$ 92,784
4 or more KA crashes	1,178	16.4%	209	34.0%	2,919	$ 215,311
3 or more KA crashes OR 2 KA crashes and 10 or more B crashes	2,162	30.0%	563	11.8%	5,518	$ 79,929
3 or more KA crashes OR 2 KA crashes and 8 or more B crashes	2,298	31.9%	631	13.2%	6,088	$ 71,315
3 or more KA crashes OR 2 KA crashes and 6 or more B crashes	2,506	34.8%	735	15.4%	6,751	$ 61,224
3 or more KA crashes OR 2 KA crashes and 5 or more B crashes	2,660	37.0%	812	17.0%	7,136	$ 55,419
3 or more KA crashes OR 2 KA crashes and 4 or more B crashes	2,846	39.5%	905	18.9%	7,508	$ 49,724

Ultimately, the threshold applied for this effort will be determined by TxDOT and the participating local agencies based on the (1) selected package of systemic countermeasures (and its associated cost), (2) actual funding level available, and (3) decisions on prioritization across all participating MPOs.

C. Select Countermeasures

The third step of the Systemic Safety Planning Process involves developing "low-cost, highly effective countermeasures" that can be utilized at the candidate locations. Once the preliminary findings are approved and the selection of the suggested intersection types receive concurrence from the MPOs, TxDOT, and FHWA, the analysis team will move forward to estimate current deployment levels, crash thresholds, and a planning-level benefit-cost ratio analysis for each possible systemic countermeasure that may address the selected intersection types and current crash types. The team also will ask for feedback on the current use or acceptance of the proposed countermeasures and eliminate any measures that may not be used in Texas.

D. Prioritize Projects

Developing a list of safety-improvement projects is the last step in the Systemic Safety Planning process. Throughout this step, each crash location will be evaluated using the criteria calculated in Step C to help determine which countermeasures would be most effective for these areas. Finally, each countermeasure package will be prioritized based on its cost relative to current funding availability, benefits through expected crash reduction, and ability to be quickly deployed relative to any contractual issues or institutional constraints.

Conclusions and Next Steps

The methodology utilized to identify the best systemic approach aligns with the State SHSP's statement that "Texas must continue to seek safety improvements by deploying a diverse set of countermeasures that address both engineering and behavioral issues." The selected approach embodies the data-driven decision-making noted by the SHSP to achieve Texas's mission of reducing the "human and societal costs of motor vehicle crashes, deaths, and injuries by implementing effective highway safety countermeasures." As roadway safety data—particularly intersection data (e.g., number of approach legs, entering traffic volumes, maintenance jurisdiction)—become more available and more accurate, this approach can be modified to better address intersection safety systemically and encompass all public roadways.

The SHSP identifies intersections as a focus of its critical emphasis area, *Crash Type & Location*. This proposed systemic approach will complement the ongoing SHSP initiative to reduce the number of fatal and incapacitating injury intersection-involved crashes by five percent. Based on the preliminary analysis, the project team proposes that the best systemic approach is to target the severe KA intersection crashes. The severe crashes comprise nearly 50 percent of the total cost of intersection crashes. Analyzing the severe crash intersections further reveals the top intersection type as ***urban signalized***. AAMPO's 958 severe intersection crashes occurred at 616 locations across the region, and these crashes comprise 45 percent of the region's total severe intersection crashes.

In order to focus the systemic approach within the AAMPO region, the project team suggests looking at a subset of the urban signalized intersections. Several thresholds were presented in Table 16 to indicate how many crashes could be targeted relative to the number of intersections treated. The project team will assist the MPOs, TxDOT, and FHWA in determining the final threshold to be applied for the entire effort.

Based upon feedback from AAMPO, TxDOT, and FHWA, the project team will continue to develop and refine a number of countermeasure packages as part of Step C. These packages will be presented in a straw man outline as part of Step D.

References

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