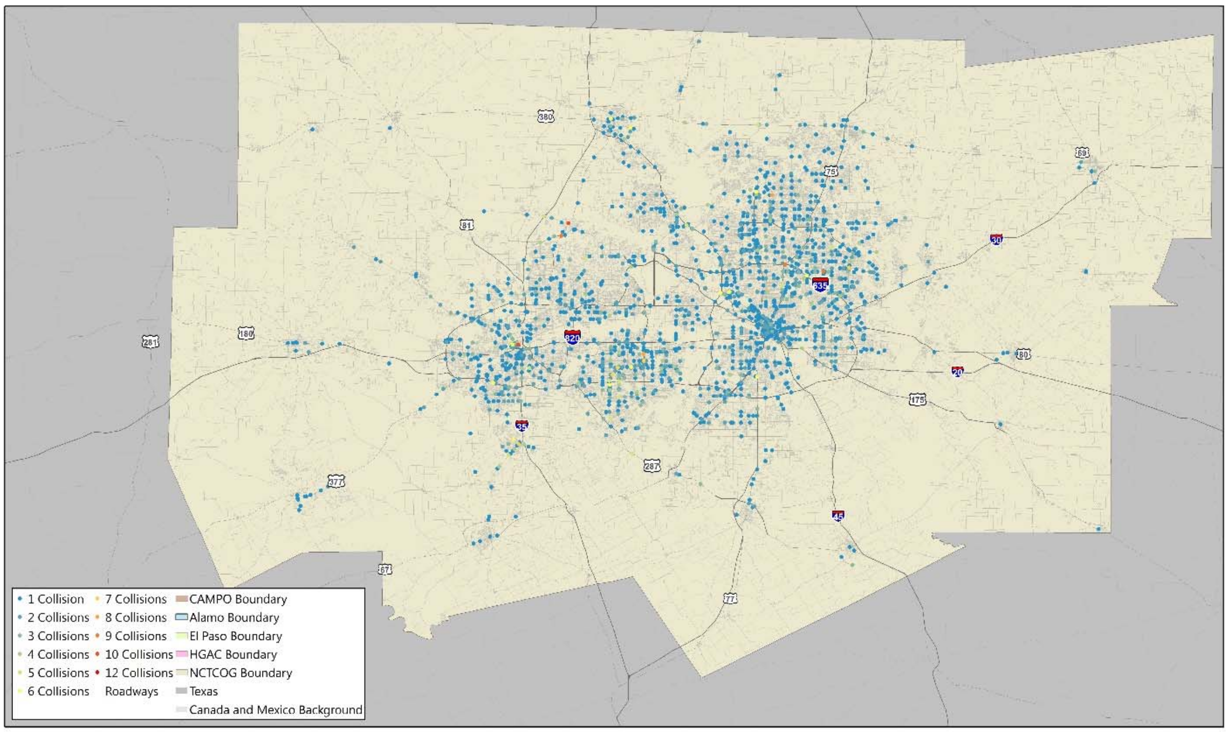
Texas Intersection Safety Implementation Plan

Preliminary Findings for Texas's North Central Texas Council of Governments Region



Urban Signalized KA Crash Locations
NCTCOG

March 30, 2016

Revised June 15, 2016

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.

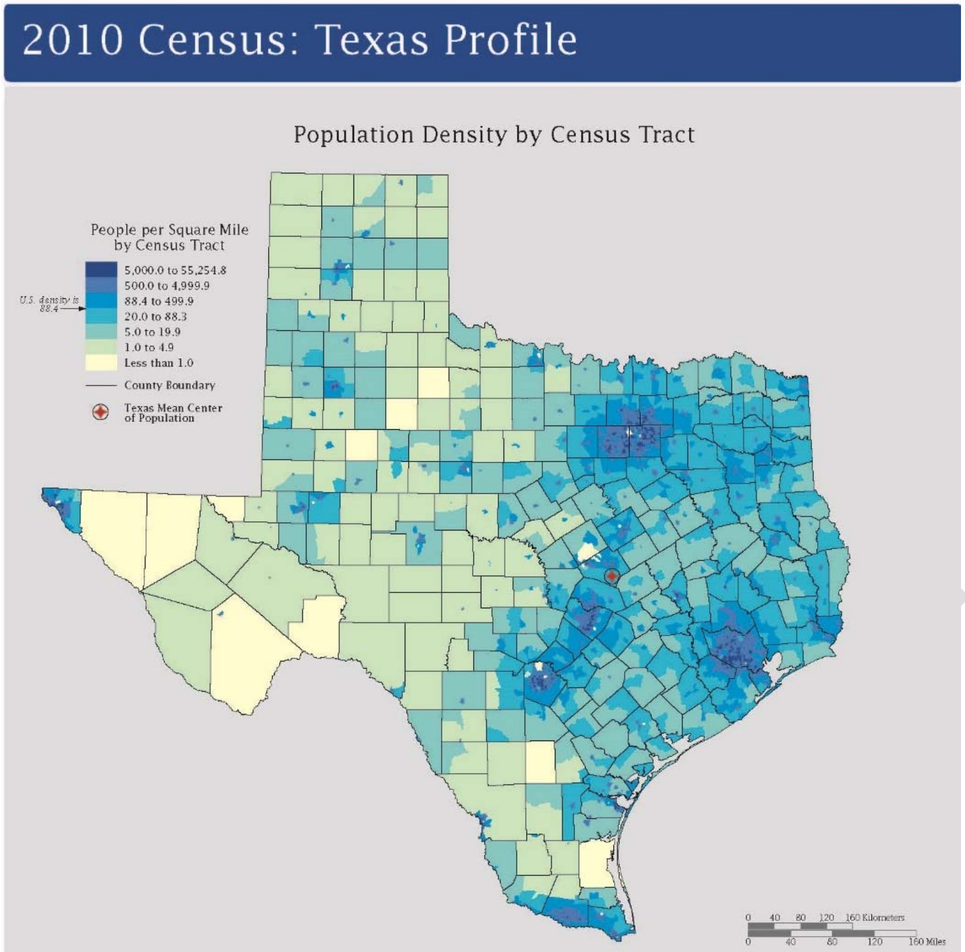


Figure 1. Texas Population Density, 2010 Census. [2]

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

NCTCOG comprises 12 counties in north-central Texas. According to the 2009-2013 ACS, the population of the MPO was 6,567,296. [1] Figure 2 presents the NCTCOG population density map.

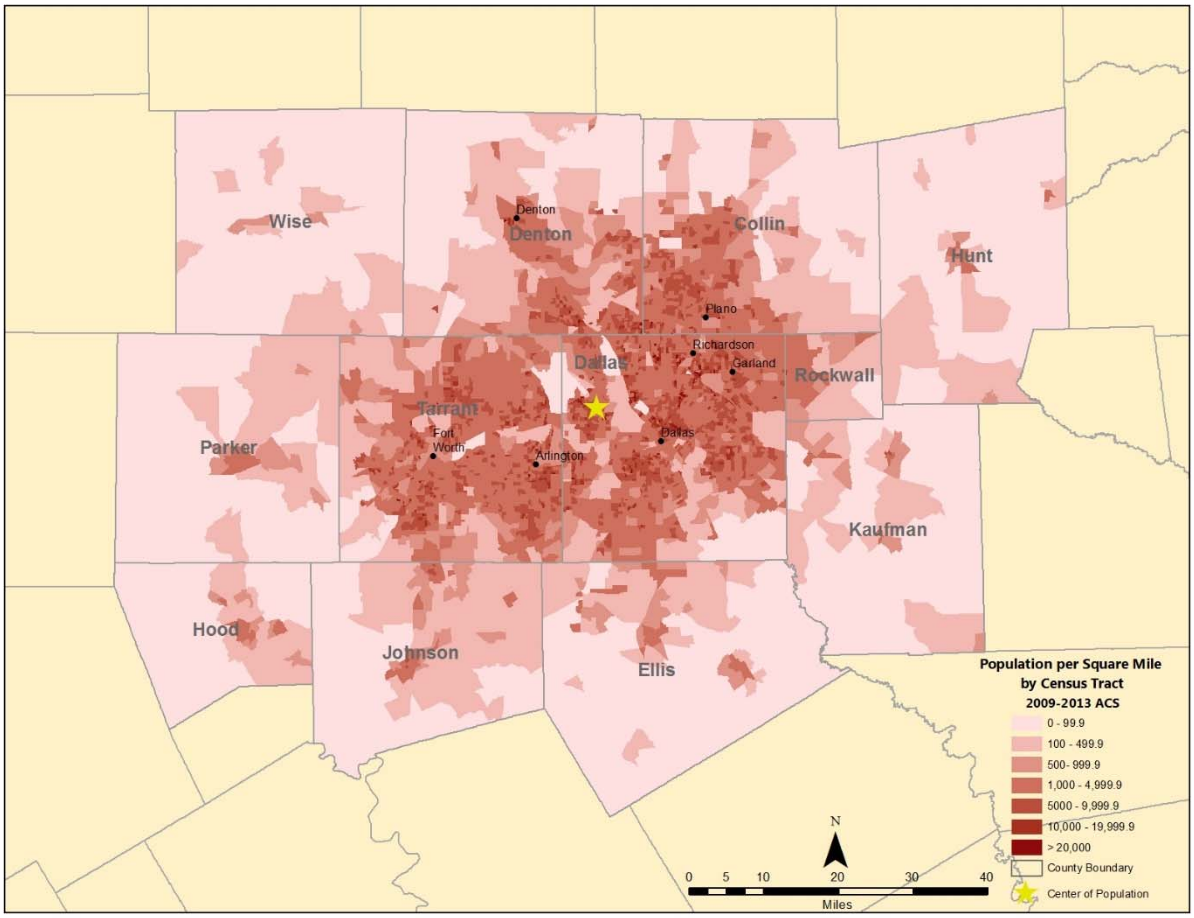


Figure 2. Population density of the NCTCOG region. [1]

Severe intersection crashes typically mirror population. The 10 most populous cities of NCTCOG are presented in Table 3 by severe intersection crashes for the five-year period of 2010-2014 and 2013 population. More than 66 percent of the region's severe intersection crashes occurred within these cities, which compose 55 percent of the region's population. The six cities listed in bolded text are overrepresented in terms of severe intersection crashes relative to their population.

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

City	Severe Int. Crashes (K,A)	Percent of Total Severe Int. Crashes	Population	Population Rank	Percent of Total Population
Dallas	1,552	**23.33%**	1,222,167	1	**18.61%**
Fort Worth	1,112	**16.72%**	761,092	2	**11.59%**
Arlington	508	**7.64%**	371,267	3	**5.65%**
Garland	293	**4.40%**	230,177	5	**3.50%**
Plano	258	3.88%	266,740	4	4.06%
Grand Prairie	191	**2.87%**	178,195	7	**2.71%**
Denton	145	**2.18%**	117,895	9	**1.80%**
Irving	96	1.44%	220,856	6	3.36%
Richardson	95	1.43%	101,528	10	1.55%
Mesquite	91	1.37%	141,201	8	3.36%
Total	4,431	66.61%	3,611,118	---	54.99%

2009-2013 ACS 5-year estimates (Total MPO population 6,567,296)

There are a total of 38,436 public road miles within the NCTCOG 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 62 percent and 22 percent, respectively, for a combined 84 percent of the public road miles in NCTCOG; the State maintains most of the remaining 16 percent. Urban roadways comprise more than 70 percent of the total road mileage.

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

	State Highway Agency	County	Town, Township, Municipal	Other	Federal Agency	Total
RURAL	2,954 7.69%	7,089 18.44%	1,129 2.94%	0 0.00%	26 0.07%	11,198 29.13%
URBAN	3,018 7.85%	1,401 3.65%	22,699 59.06%	120 0.31%	0 0.00%	27,238 70.87%
Total	5,973 15.54%	8,490 22.09%	23,828 61.99%	120 0.31%	26 0.07%	38,436 100.00%

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

	State	Local	Other	Total
RURAL	2,954 7.69%	8,218 21.38%	26 0.07%	11,198 29.13%
URBAN	3,018 7.85%	24,100 62.70%	120 0.31%	27,238 70.87%
Total	5,973 15.54%	32,318 84.08%	146 0.38%	38,436 100.00%

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).
- Non-injury (PDO).

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

Year	K	A	B	C	PDO	Unknown	Total	KA	KA as % of Total Crashes
2010	86	1,136	5,057	9,264	21,129	659	37,331	1,222	3.27%
2011	135	1,080	4,974	9,091	20,782	713	36,775	1,215	3.30%
2012	163	1,128	5,231	9,037	20,483	515	36,557	1,291	3.53%
2013	120	1,293	5,783	9,568	24,907	844	42,515	1,413	3.32%
2014	141	1,370	6,089	10,251	27,695	951	46,497	1,511	3.25%
Subtotal	**645**	**6,007**	**27,134**	**47,211**	**114,996**	**3,682**	**199,675**	**6,652**	**3.33%**

Discounting the crashes of unknown severity, the analysis team estimated the total cost of NCTCOG intersection crashes to be more than $10.6 billion—or $2.1 billion 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 3.3 percent of all intersection crashes and more than 46 percent of the total cost of intersection crashes within the NCTCOG 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 NCTCOG.

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 NCTCOG intersection-related crashes according to area type and owner. Nearly 40 percent of the intersection-related crashes occurred at intersections involving at least one State road, and nearly 98 percent of the crashes occurred in urban areas.

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

	State	Local	Other	Total
RURAL	3,463	764	17	**4,244**
	1.73%	0.38%	0.01%	**2.13%**
URBAN	75,356	116,414	3,661	**195,431**
	37.74%	58.30%	1.83%	**97.87%**
Total	**78,819**	**117,178**	**3,678**	**199,675**
	39.47%	**58.68%**	**1.84%**	**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 6,652 severe injury (KA) intersection crashes in the NCTCOG region. Approximately four percent (272) 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 (6,380) were assigned an intersection ID, resulting in 4,859 identified intersections in NCTCOG 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 NCTCOG travel demand model traffic analysis zone (TAZ) shapefile provided by NCTCOG.

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 the following:
  - 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.

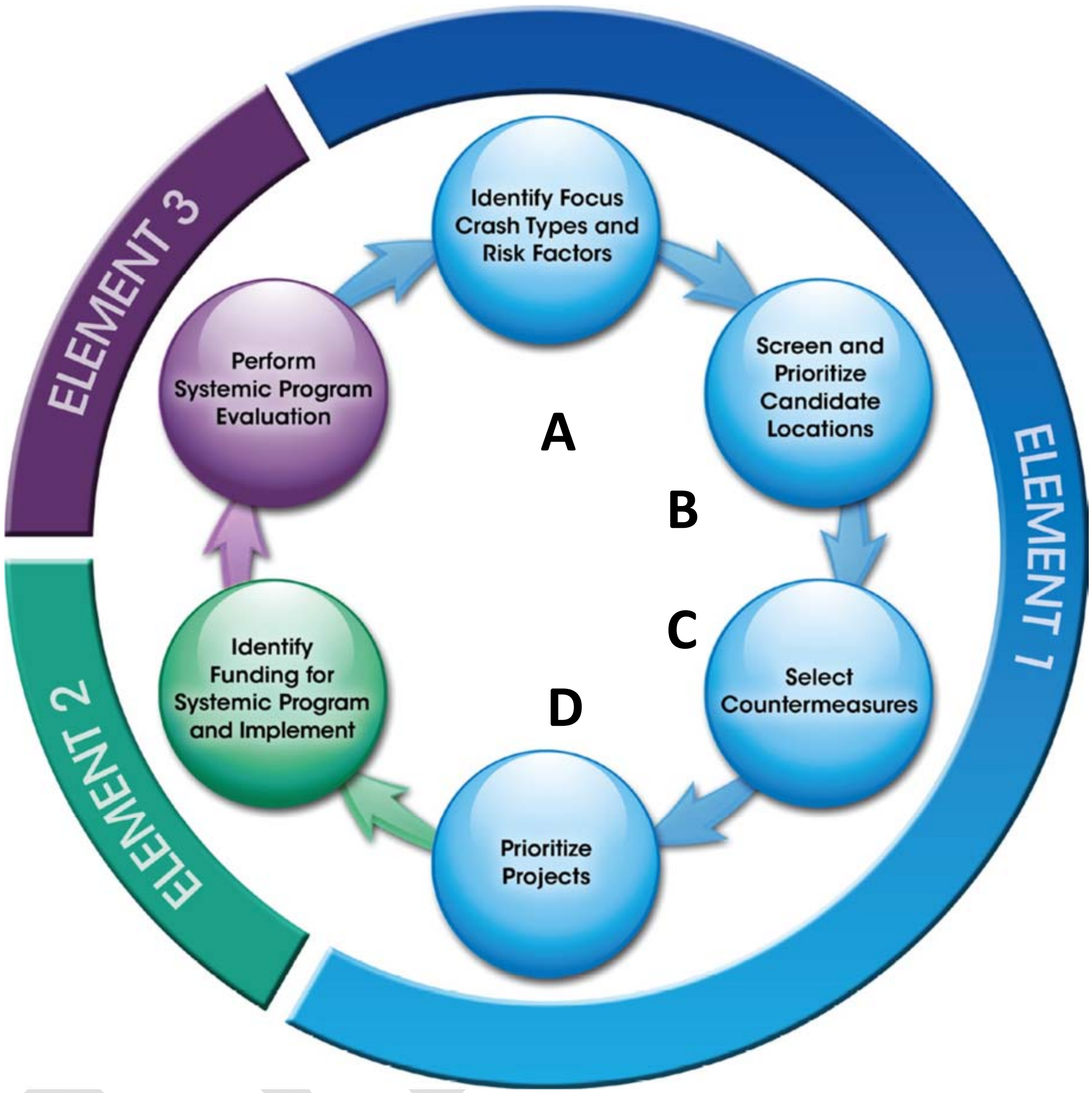


Figure 3. Systemic Safety Project Selection Tool. [5]

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. NCTCOG Intersection-related crashes by roadway owner type.

	State	Local	Other	TOTAL
Intersection Crashes	**78,819**	**117,178**	**3,678**	**199,675**

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 NCTCOG intersection crashes by owner, traffic control, and area type.

STATE	Area Type	Total # of Crashes	Fatal	A	B	C	PDO	Un-known
Signalized	Rural	363	5	16	40	61	236	5
	Urban	42,052	103	1,320	5,923	9,987	24,434	285
Unsignalized	Rural	3,091	52	206	497	472	1,836	28
	Urban	32,935	187	1,007	4,212	7,054	19,980	495
Unknown	Rural	9	0	0	2	0	7	0
	Urban	369	0	5	46	85	231	2
	Subtotal	78,819	347	2,554	10,720	17,659	46,724	815
LOCAL								
Signalized	Rural	7	1	1	1	0	4	0
	Urban	51,260	97	1,438	7,409	13,755	28,211	350
Unsignalized	Rural	752	4	33	89	74	515	37
	Urban	64,669	183	1,859	8,343	14,780	37,077	2,427
Unknown	Rural	5	0	0	0	0	5	0
	Urban	485	2	10	51	113	291	18
	Subtotal	117,178	287	3,341	15,893	28,722	66,103	2,832
OTHER								
Signalized	Rural	0	0	0	0	0	0	0
	Urban	2230	5	80	375	566	1193	11
Unsignalized	Rural	17	0	0	1	2	13	1
	Urban	1422	6	32	141	262	958	23
Unknown	Rural	0	0	0	0	0	0	0
	Urban	9	0	0	4	0	5	0
	Subtotal	3678	11	112	521	830	2169	35

Per Table 10, 98.3 percent of both the total crashes and KA crashes can be captured in the following six intersection types (listed in order of decreasing total crashes):

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

Therefore, the following 12 intersection types (also listed in order of decreasing total crashes) were eliminated from further consideration, as they collectively accounted for less than 2 percent of the KA crashes.

1. Other Urban Unsignalized
2. Local Rural Unsignalized
3. State Rural Signalized
4. Local Urban Unknown
5. State Urban Unknown
6. Local Rural Signalized
7. Other Rural Signalized
8. State Rural Unknown
9. Other Urban Unknown
10. Local Rural Unknown
11. Other Rural Unsignalized
12. Other Rural 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 3.3 percent of all intersection crashes that occurred in the NCTCOG 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 NCTCOG 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 NCTCOG data but also data from the AAMPO, CAMPO, El Paso, and H-GAC 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.

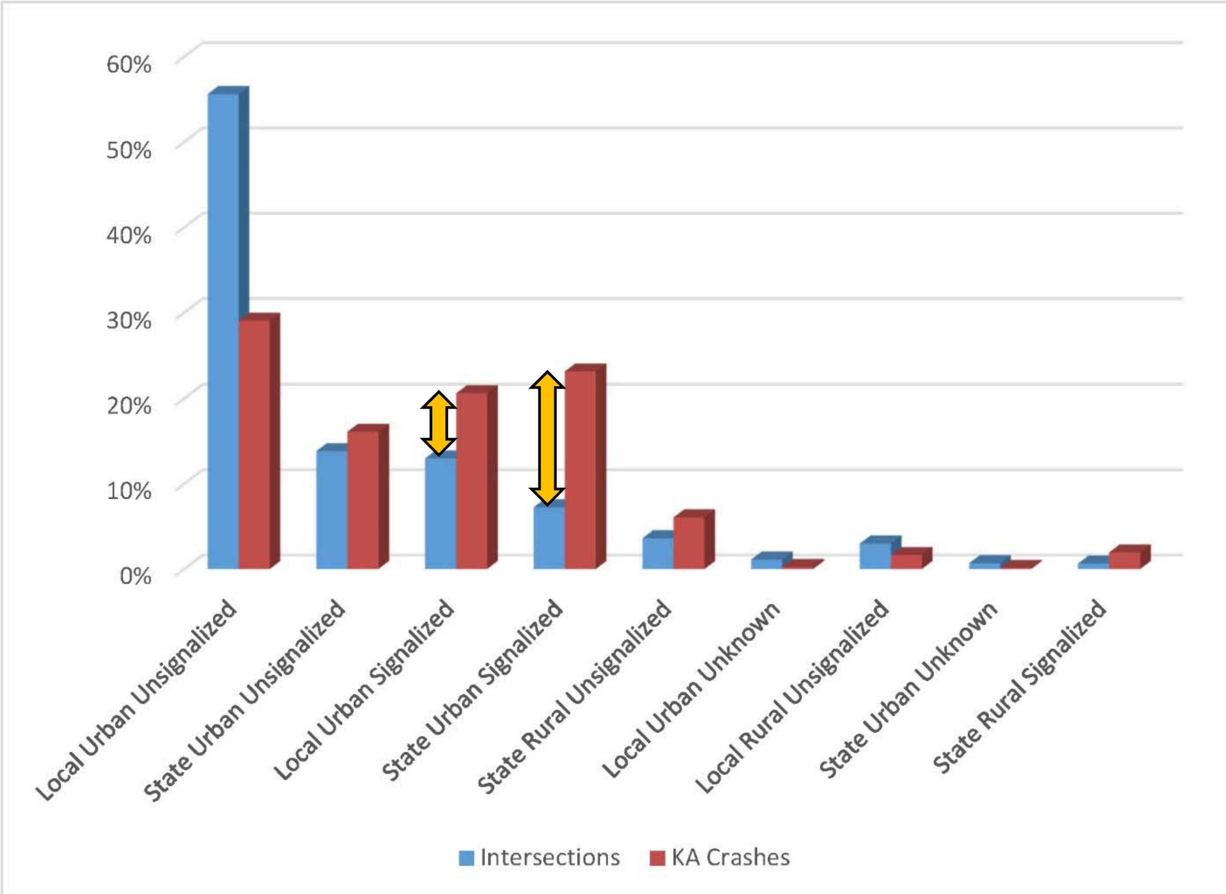


Figure 4. Distribution of the five largest Texas MPOs' severe injury (KA) intersection crashes by area type and traffic control.

NCTCOG Regional Analyses

This section presents the results of the data analyses specific to the NCTCOG 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 NCTCOG severe injury intersection crashes.

Location Type	No. of KA Crashes	Percent KA Crashes	Total No. of Intersections	Percent Intersections
Rural	318	5%	1,824	5%
Urban	6,334	95%	38,103	95%
Subtotal	**6,652**	100%	39,927*	100%
Ownership Type				
State	2,901	44%	9,559	23%
Local	3,628	55%	31,507	76%
Other	123	2%	566	1%
Subtotal	**6,652**	100%	41,632*	100%
Traffic Control Type				
Signalized	3,066	46%	10,089	21%
Unsignalized	3,569	54%	36,660	77%
Unknown	17	0%	749	2%
Subtotal	**6,652**	100%	47,498*	100%

** Because the NCTCOG 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 NCTCOG region was determined to be 39,871.*

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

- Land use—95 percent of NCTCOG's KA intersection crashes occurred in urban areas compared to 5 percent rural.
- Ownership type—44 percent of the KA intersection crashes occurred at intersections involving at least one State-maintained road despite such intersections comprising only 23 percent of NCTCOG's intersections.
- Traffic control—considering the 6,635 KA intersection crashes for which the traffic control type is known, 46 percent occurred at signalized intersections despite the fact that only an estimated 21 percent of NCTCOG 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 six focus categories identified in Table 10—which capture 98.3 percent of the region's total and KA crashes—are listed in boldface type.

Table 13. Distribution of NCTCOG 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	21	0.32%	68	0.14%	2.30
	Urban	**1,423**	**21.39%**	**3,562**	**7.19%**	**2.98**
Unsignalized	**Rural**	**258**	**3.88%**	**1,267**	**2.56%**	**1.52**
	Urban	**1194**	**17.95%**	**7,390**	**14.91%**	**1.20**
Unknown	Rural	0	0.00%	8	0.02%	0.00
	Urban	5	0.08%	292	0.59%	0.13
	Subtotal	2,901	43.61%	12,587	25.39%	-
LOCAL						
Signalized	Rural	2	0.03%	6	0.01%	2.48
	Urban	**1,535**	**23.08%**	**7,122**	**14.37%**	**1.61**
Unsignalized	Rural	37	0.56%	557	1.12%	0.50
	Urban	**2,042**	**30.70%**	**28,149**	**56.79%**	**0.54**
Unknown	Rural	0	0.00%	5	0.01%	0.00
	Urban	12	0.18%	442	0.89%	0.20
	Subtotal	3,628	54.54%	36,281	73.19%	-
OTHER						
Signalized	Rural	0	0.00%	0	0.00%	-
	Urban	**85**	**1.28%**	**188**	**0.38%**	**3.37**
Unsignalized	Rural	0	0.00%	12	0.02%	0.00
	Urban	38	0.57%	493	0.99%	0.57
Unknown	Rural	0	0.00%	0	0.00%	-
	Urban	0	0.00%	9	0.02%	0.00
	Subtotal	123	1.85%	702	1.42%	-
	TABLE SUBTOTAL	6,652	100.00%	49,570	100.00%	

Five of the intersection categories listed in boldface type in Table 13 show a measurable overrepresentation when comparing the proportion of NCTCOG KA crashes to the proportion of total intersections. Figure 5 depicts the comparison of the proportions of NCTCOG 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.

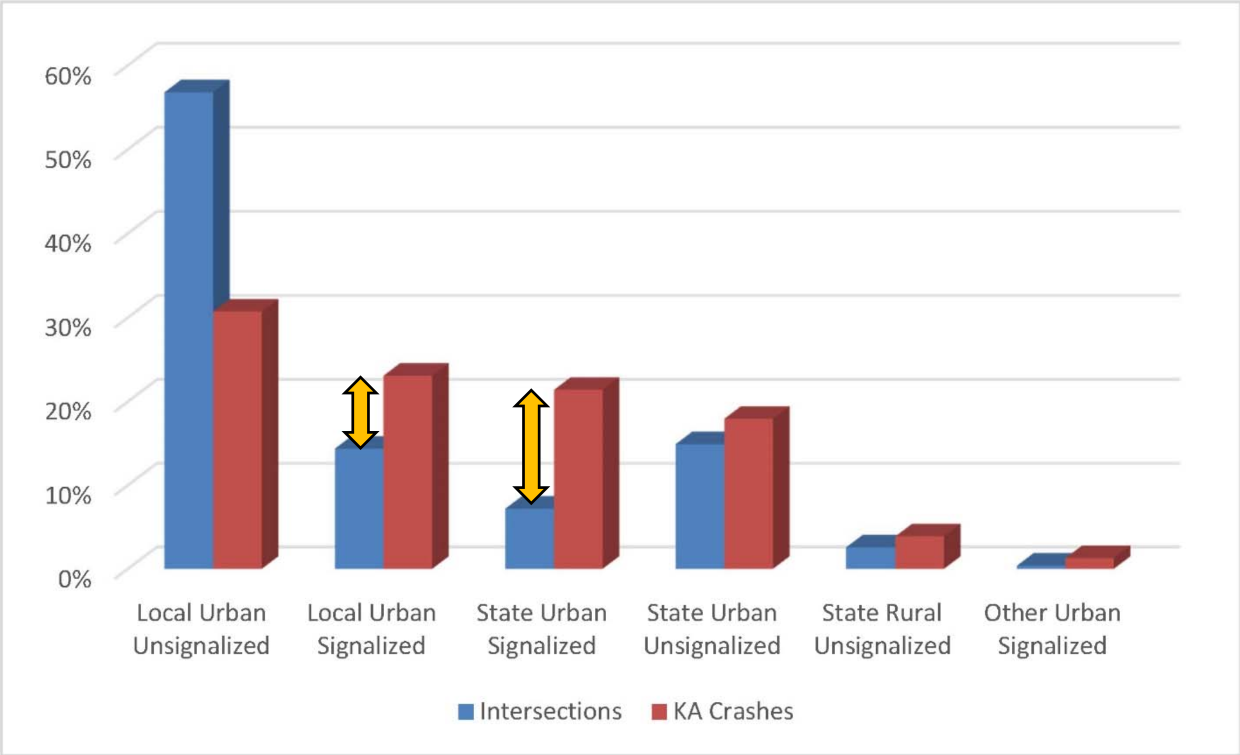


Figure 5. Distribution of NCTCOG severe (KA) intersection crashes by area type and traffic control.

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 22 percent of the intersections within the NCTCOG region, yet nearly 45 percent of the severe (KA) intersection crashes—2,958 of them during the five-year study period—occurred at such intersections. These KA crashes occurred at 1,972 urban signalized intersections, which equates to 5 percent of the 39,871 unique intersections analyzed across the region. 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 NCTCOG 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, 6 of every 7 severe intersection crashes involved more than one vehicle, with 36 percent of these classified as angle type collisions characterized by "two vehicles approaching each other at an angle."

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

Collision Type	Count	Percent
OD one straight-one left turn	938	31.71%
Angle - both going straight	929	31.41%
SD one straight-one stopped	387	13.08%
OMV vehicle going straight	276	9.33%
OMV vehicle turning left	111	3.75%
Angle - one straight-one left turn	104	3.52%
SD both going straight-rear end	48	1.62%
OMV vehicle turning right	36	1.22%
SD one straight-one left turn	25	0.85%
Angle - one straight-one right turn	25	0.85%
OD both going straight	14	0.47%
SD one straight-one right turn	11	0.37%
SD both going straight-sideswipe	10	0.34%
OD one straight-one stopped	9	0.30%
Angle - one right turn-one stopped	8	0.27%
SD both left turn	7	0.24%
SD both right turn	4	0.14%
Angle - both left turn	3	0.10%
SD one left turn-one stopped	2	0.07%
Angle - one straight-one stopped	2	0.07%
OD one right turn-one left turn	2	0.07%
OMV other	2	0.07%
OMV vehicle backing	1	0.03%
Angle - one straight-one backing	1	0.03%
Angle - one left turn-one stopped	1	0.03%
OD both left turns	1	0.03%
OD one left turn-one stopped	1	0.03%
Total	**2,958**	**100%**

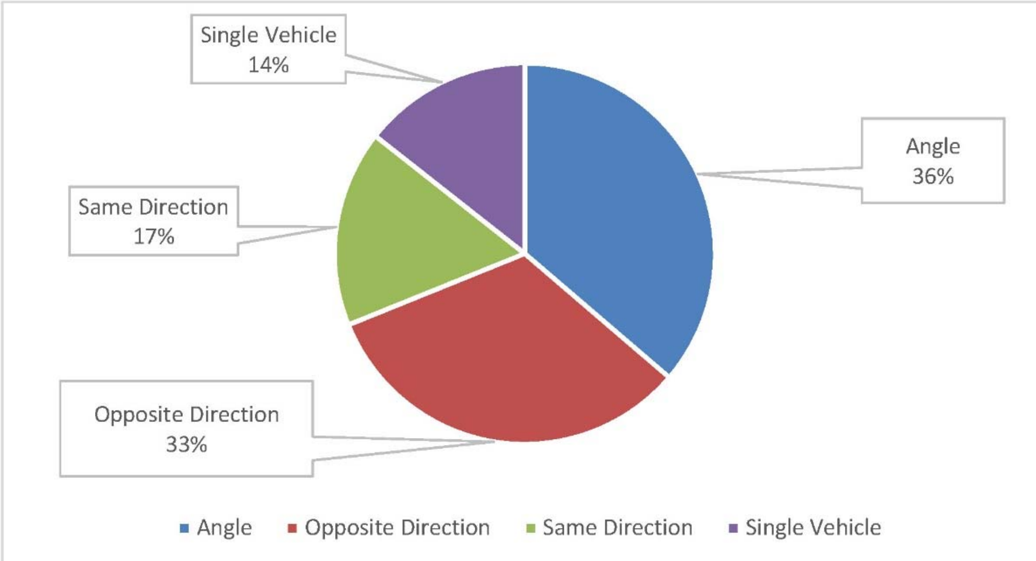


Figure 6. General distribution of NCTCOG severe intersection collision types.

Table 15 presents the nature of the severe (KA) intersection crashes according to the reported harmful event description, which provides additional insight on the nature of the collision. Six (6) of every 7 crashes involved another motor vehicle, while approximately 1 of every 12 crashes involved a pedestrian or bicyclist.

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

Harmful Event	Count	Percent
Motor vehicle in transport	2532	85.60%
Pedestrian	181	6.12%
Fixed object	121	4.09%
Pedalcyclist	62	2.10%
Overturned	46	1.56%
Other non-collision	7	0.24%
RR train	7	0.24%
Parked car	2	0.07%
Total	**2,958**	**100.00%**

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 selected 2,958 severe injury (KA) crashes in the NCTCOG region occurred at 1,972 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, more than one-quarter of NCTCOG's KA intersection crashes can be addressed by targeting just under 10 percent of the KA intersection crash locations; likewise, if a threshold of either three or more KA crashes or two KA crashes and four or more B crashes is applied, then 37 percent of the KA crashes can be addressed by targeting 18 percent of the KA crash locations.

Table 16. Potential crash thresholds for NCTCOG systemic treatments.

Crash Threshold	KA Crashes		Intersections		B Crashes
	Number	Percent	Number	Percent	
2 or more KA crashes	1,431	50.0%	538	27.3%	2,927
3 or more KA crashes	733	25.6%	189	9.6%	1,505
4 or more KA crashes	400	14.0%	78	4.0%	869
3 or more KA crashes OR 2 KA crashes and 10 or more B crashes	785	27.4%	215	10.9%	1,830
3 or more KA crashes OR 2 KA crashes and 8 or more B crashes	841	29.4%	243	12.3%	2,067
3 or more KA crashes OR 2 KA crashes and 6 or more B crashes	919	32.1%	282	14.3%	2,315
3 or more KA crashes OR 2 KA crashes and 5 or more B crashes	985	34.4%	315	16.0%	2,480
3 or more KA crashes OR 2 KA crashes and 4 or more B crashes	1,065	37.2%	355	18.0%	2,640

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***. NCTCOG's 2,958 severe intersection crashes occurred at 1,972 locations across the region, and these crashes comprise 44 percent of the region's total severe intersection crashes.

In order to focus the systemic approach within the NCTCOG 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 NCTCOG, 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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5. "Systemic Safety Project Selection Tool," U.S. Department of Transportation Federal Highway Administration, July 2013, http://safety.fhwa.dot.gov/systemic/fhwasa13019/sspst.pdf