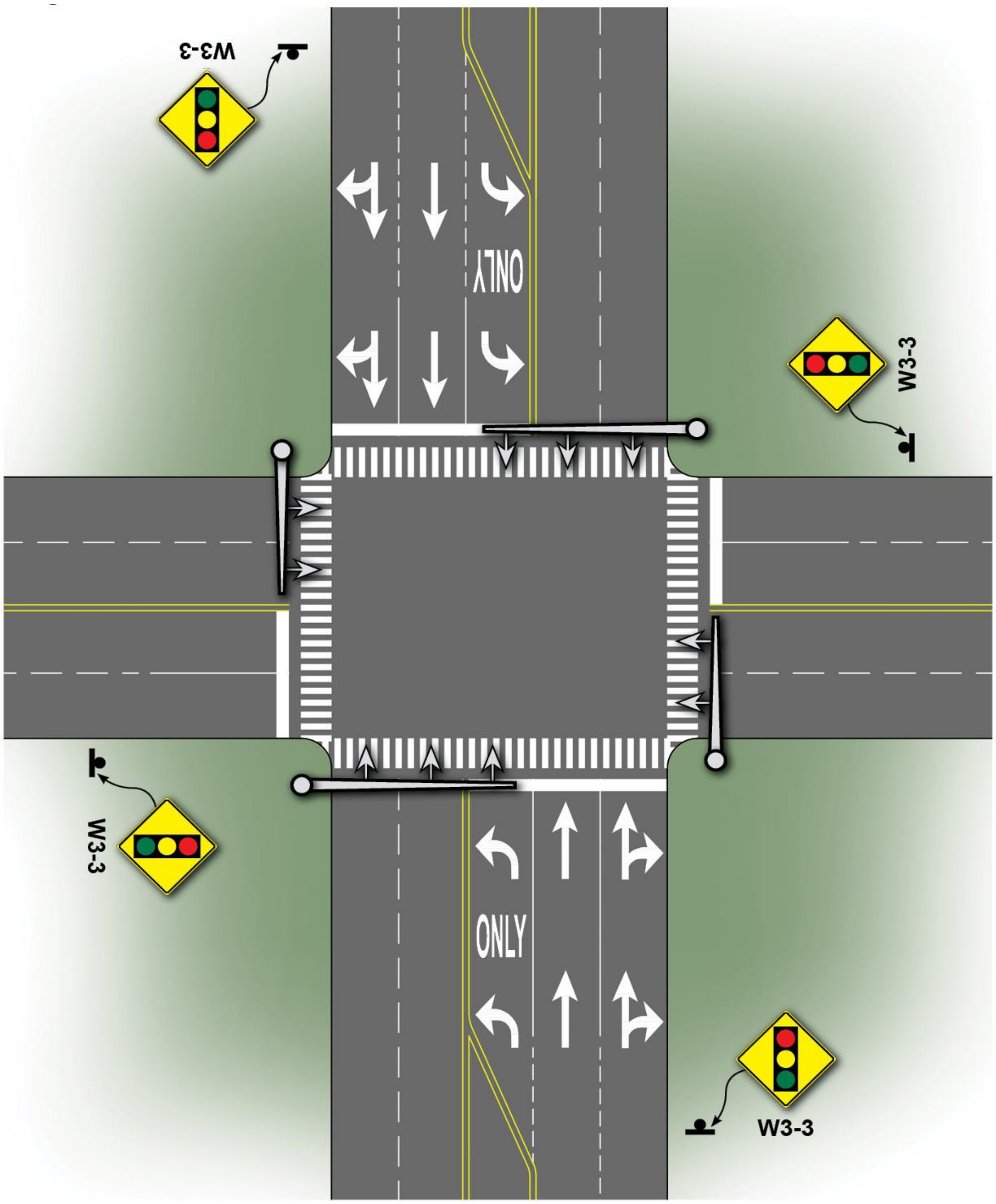
North Central Texas Council of Governments

Intersection Safety Implementation Plan

FINAL REPORT



March 2013

Developed in Partnership with

Federal Highway Administration

North Central Texas Council of Governments

Safe Roads for a Safer Future
Investment in roadway safety saves lives

This page is intentionally blank

North Central Texas Council of Governments

Intersection Safety Implementation Plan Report Legend

ACRONYM	DEFINITION
ADA	American Disabilities Act
FHWA	Federal Highway Administration
FYA	Flashing Yellow Arrow
ISIP	Intersection Safety Implementation Plan
ITE	Institute of Transportation Engineers
KABCO Injury Scale	K – Fatal A – Incapacitating Injury B – Non-Incapacitating Injury C – Possible Injury O – No Injury
LTAP	Local Technical Assistance Program
NCHRP	National Cooperative Highway Research Program
NCTCOG	North Central Texas Council of Governments
RSAC	Regional Safety Advisory Committee
SHSP	Texas Strategic Highway Safety Plan
TxDOT	Texas Department of Transportation

TABLE OF CONTENTS

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS' INTERSECTION SAFETY IMPLEMENTATION PLAN

The Dallas – Fort Worth Region has embarked upon a journey to reduce the human and societal costs of highway traffic crashes, deaths, and injuries by implementing effective highway safety countermeasures and changing the current driving culture in Texas to a traffic safety culture, emphasizing safety, economy, and civility. This vision has been adopted by the North Central Texas Council of Governments (NCTCOG) and is the charge of each member jurisdiction through the Regional Safety Advisory Committee (RSAC). The RSAC developed a safety vision through a purpose and goal statement. The success of the RSAC to achieve its safety goals depends on the implementation of its recommended elements. One of the critical strategies listed by the RSAC is to "develop and implement countermeasures that address recurring crash types and locations." This proactive approach led to the development of this intersection safety implementation plan (ISIP).

Data Analysis Results

The NCTCOG serves a 16-county region of North Central Texas, centered around the cities of Dallas and Fort Worth. During the five-year period from 2006 through 2010, 215,043 crashes (or 42 percent) of the 510,692 crashes occurred at intersections. The project team proposes that the best systemic approach is to target the severe intersection crashes. The severe crashes comprise 77 percent of the total cost of intersection crashes.

Analyzing the top ten percent of intersections with severe crashes reveals the top intersection type as urban signalized intersections. Out of the total 15,008 intersections reviewed, 1,522 intersections, or approximately the top ten percent, had five or more severe crashes over the five-year analysis period and comprised 40 percent of the severe intersection crashes. The recommended subset of selected intersections (all urban signalized intersections with more than five fatal or severe injury crashes) would focus systemic measures on 1,225 (eight percent) of the 15,008 intersections reviewed and target approximately 11,054 severe crashes.

The selected approach ties directly to the goals of Texas' Strategic Highway Safety Plan (SHSP) and falls within the purpose and safety goals outlined by the RSAC to be data-driven and utilize best practices. The SHSP identifies intersections as a critical crash type and this approach will assist with meeting milestones in the following performance measures:

- Number of intersections receiving cost effective safety improvements.
- Increased number of intersections meeting design standards.
- Intersection safety maintenance improvements.

FHWA Technical Support

The Federal Highway Administration (FHWA) Office of Safety's mission supports Texas' and NCTCOG's vision to reduce highway fatalities and serious injuries by making roads safer through a data-driven, systemic approach and addressing all of the "4Es" of safety: engineering, education, enforcement, and emergency medical services. Recognizing the significant safety problem at intersections, FHWA views intersection safety as one of its key focus areas. FHWA proactively addresses intersection safety challenges in many ways which include:

- Conducting research and developing guidebooks on intersection safety for State and local agencies.
- Providing technical assistance, technology deployment, workforce training, and other support to those State agencies through the Focused Approach to Safety.

These resources are provided in the latest version of the *Comprehensive Intersection Resource Library*.

A key element of FHWA's Intersection Safety Program is the ISIP. FHWA developed the ISIP process to create an implementation plan and guide activities. FHWA follows a 10-step process documented in *Intersection Safety Implementation Plan Process* (FHWA-SA-10-01). The three primary outcomes of the ISIP process are:

- A data analysis package.
- Technical assistance to deliver a workshop.
- A straw man outline.

NCTCOG's ISIP is a culmination of these efforts. The countermeasure packages proposed in the ISIP process are summarized in this document.

Moving Ahead: Implementing NCTCOG's Plan

Successful implementation of the low-cost, systemic intersection safety countermeasure packages described in Table 1 will require consistent leadership and management support. It is expected that as these recommended initiatives are implemented, unforeseen challenges may arise, new opportunities will develop, and changes in direction and emphasis will be needed to take advantage of changing conditions. As such, the following actions should be taken to ensure success:

- The RSAC, comprised of members from the local traffic engineering community, should provide guidance and address issues and challenges that arise during the implementation of the program. The RSAC should continue to meet on a planned quarterly basis throughout the implementation phase. These members could also include members from the State, Federal, and local levels on an ad-hoc basis:
    - Office of Safety
    - Office of Traffic Engineering Operations

  - Governors Highway Safety Representative
  - FHWA Safety Representative
  - District Traffic/Safety Representative
  - Local Traffic Engineering Representatives

- The NCTCOG should develop and deploy a tracking system to monitor the implementation of the various types of countermeasures that are deployed. This system should include forms designed to secure before and after targeted crash histories, dates of implementation, links to other improvements implemented at the intersection, and other information deemed pertinent by the RSAC.

The remainder of this section provides a detailed description and key implementation steps for each countermeasure package. A tabulation of the countermeasures and type of approach is shown in Table 1.

Table 1: Intersection Safety Countermeasures by Approach Type

Number	Countermeasure	Approach
1	**State-maintained** signalized intersections: Basic set of sign and marking improvements with the following options: • Advance intersection warning signs for signal-controlled approaches.	Systemic
2	**State-maintained** signalized intersections: Re-time traffic signals for better coordination and proper red and yellow change intervals with options to: • Evaluate left-turn phasing for flashing yellow left-turns or protected only left-turns. • Install additional signal head per approach.	Systemic
3	**Locally-maintained** signalized intersections: Basic set of sign and marking improvements with the following options: • Advance intersection warning signs for signal-controlled approaches.	Systemic
4	**Locally-maintained** signalized intersections: Re-time traffic signals for better coordination and proper red and yellow change intervals with options to: • Evaluate left-turn phasing for flashing yellow left-turns or protected only left-turns. • Install additional signal head per approach.	Systemic
5	**Regionally**: 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.	

NOTE: American Disabilities Act (ADA) compliance – State and local jurisdictions will meet any ADA improvements through their adopted ADA Transition Plan. The low-cost, systemic safety improvements will not necessarily address ADA issues due to limited scale and scope of the proposed improvements.

This page is intentionally blank

State-Maintained Signalized Intersections:

1. STATE-MAINTAINED SIGNALIZED INTERSECTIONS: BASIC SET OF SIGN AND MARKING IMPROVEMENTS

Description

This countermeasure package involves the installation of a set of basic signing and marking improvements that are low-cost and designed to lower the potential for severe crashes. These countermeasures are to be applied predominantly at multi-lane approach, signal-controlled, State-maintained intersections in urban areas with severe crashes.

Basic enhancements considered for improvement at signal-controlled intersections are illustrated in Figure 1-1 and include the following:

- Enhanced crosswalks.
- Stop bars.
- Lane control arrows.
- Longitudinal lines marking intersection influence area.
- Regulatory signs (e.g. No Left Turn, No U-Turn, etc.)
- Oversized street name signs.
- Advance cross street name signs for approaches with speed limits greater than 45 MPH

Appendix A summarizes the methodology utilized to determine where the basic set of signing and marking improvements are to be considered for installation. The RSAC has a complete listing of all intersections that meet or exceed the crash threshold level for each group of intersections discussed in this report. In addition to this listing, detailed crash information for each crash that occurred at these intersections can also be obtained.

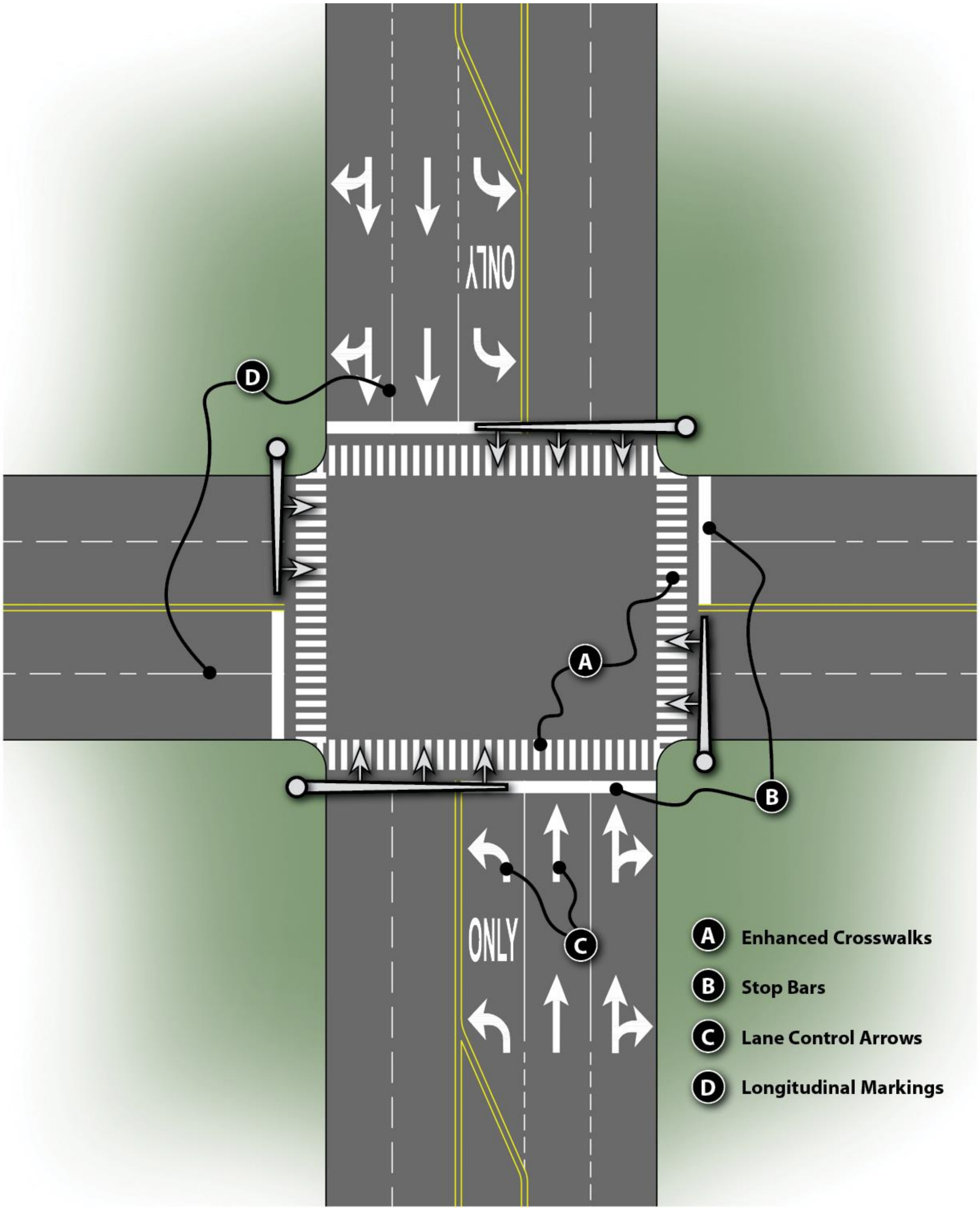


Figure 1-1. Examples of basic low-cost countermeasures for signalized intersections – enhanced crosswalks, stop bars, lane control arrows, longitudinal lines marking intersection influence area, regulatory signs, and oversized street name signs.

Key Implementation Steps

Table 1-1 lists the key steps necessary for implementing this countermeasure package and realizing the full safety benefits of the improvements. The table also includes the organization responsible for each key step, and the implementation schedule.

Table 1-1: Key Implementation Steps for Basic Set of Sign and Marking Improvements – State Signalized Intersections

Step	**Organization Responsible for Step**	**Completion Date** (Months After Implementation Plan Acceptance)
1. Identify and secure funding	NCTCOG / TxDOT / Localities	6 months – 12 months
2. Develop guidelines for District review of signal-controlled intersections with crashes above the crash threshold including: basic set of upgraded signs and markings; and option to include advance intersection warning signs.	TxDOT	1 month
3. Establish field review teams (District Office Traffic Engineering Operations and/or Safety Engineer and/or consultant) to determine appropriate optional improvements, determine means to implement (department forces, new District-wide contract) and prepare appropriate contract plans.	TxDOT	3 months
4. Train team on guidelines, field review requirements, and contract plan preparation.	TxDOT	6 months
5. Establish a monitoring and tracking system to ensure that improvements at intersections are properly identified and implemented.	TxDOT	9 months
6. Commence and complete field reviews of first phase of intersections, identify intersections where optional improvements are appropriate, identify which Districts will implement using department forces, prepare statewide or area contract plans for remaining work.	TxDOT	12 months
7. Let contracts (if applicable) and implement improvements.	TxDOT	24 months
8. Using lessons learned, identify next phase of intersection reviews, and repeat steps 6 and 7. Repeat as necessary based upon safety data review.	TxDOT	30 months (Phase II step 6); 42 months (Phase II step 7); 48 months (Phase III step 6); 60 months (Phase III step 7)

Options

In addition to the basic package of countermeasures, additional individual countermeasures can be considered to address certain crash types at select intersections that have a severe crash frequency higher than the threshold.

- **Option 1A: Advance intersection warning signs for signalized intersections.** Figure 1-2 depicting advance left and right "Signal Ahead" oversize warning signs for isolated traffic signals or intersections are appropriate where the signal heads or stop signs are not readily visible due to alignment or sight distance obstructions. A technical working committee reporting to RSAC representatives can develop appropriate installation criteria to promote consistency throughout the region.

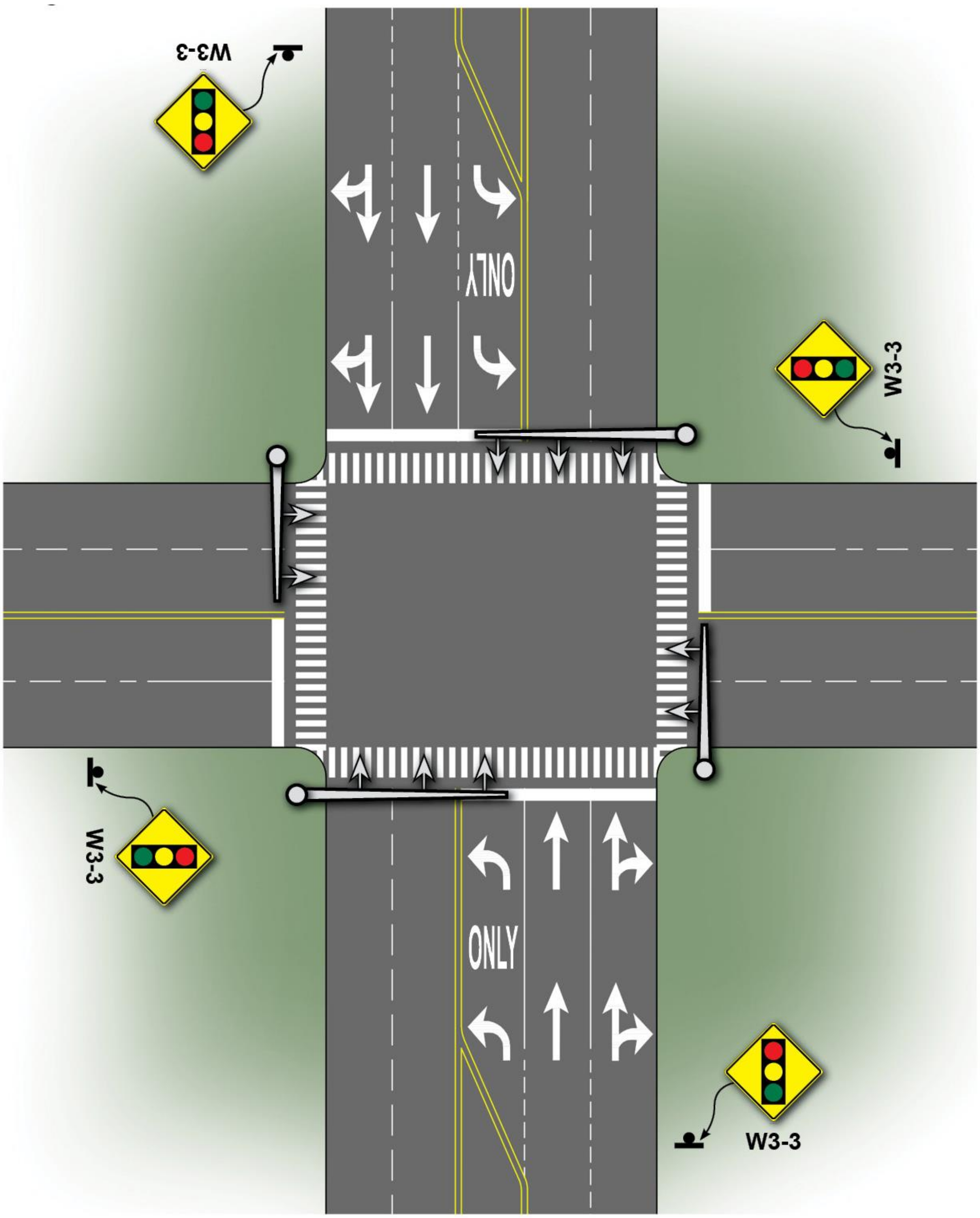


Figure 1-2 Example of an optional low-cost countermeasure for signalized intersections: advance signal ahead warning signs.

2. STATE-MAINTAINED SIGNALIZED INTERSECTIONS: RE-TIME TRAFFIC SIGNALS FOR BETTER COORDINATION AND FOR PROPER RED AND YELLOW CHANGE INTERVALS

Description

Clearance intervals provide safe, orderly transitions in right-of-way assignment between conflicting streams of traffic. Clearance intervals always include a yellow change interval and, in most cases, an all-red clearance interval.

Clearance intervals are a function of operating speed, the width of the intersection area, lengths of vehicles, and driver operational parameters such as reaction, braking, and decision-making time. The Institute of Transportation Engineers (ITE) has developed an equation for determining the length of the clearance interval.

Clearance intervals that are too short in duration (compared to the ITE method) can contribute to rear-end crashes related to drivers stopping abruptly, and right-angle crashes resulting from signal violations. In the extreme, a too short interval can result in drivers operating at the legal speed limit being forced to violate the red phase.

It is recommended to establish a policy to consistently determine clearance interval duration throughout each jurisdiction within NCTCOG.

NCHRP 731: Guidelines for Timing Yellow and Red Intervals at Signalized Intersections was released in October 2012. The following statement, regarding the new NCHRP guidelines, provides key benefits to a single policy:

> "One of the precepts on the use of all traffic control devices is that they be applied uniformly so that drivers can expect to experience the same device and its operation throughout their travels, within and outside of their jurisdiction. This would pertain to the timing of the yellow change and red clearance intervals. To maintain this precept, the recommended guideline strives to achieve national acceptance for a uniform practical application. The guideline is succinct in scope and requires little user interpretation. As such, it provides a solid framework based on research and accepted practice that can be easily adopted into State or local transportation agency practice."

Key Implementation Steps

Table 2-1 lists the key steps necessary to fully implement this countermeasure package and realize the safety benefits of the improvements. The table also includes the organizations responsible for each key step and the schedule for this activity.

Table 2-1: Key Implementation Steps for Retiming Traffic Signals –
State Signalized Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Form a technical working committee to review the latest research on intervals for signalized intersections. The objective of the committee will be to work with the RSAC representatives to determine a common method for intervals in the NCTCOG member jurisdictions for consistency and to meet driver expectancy. The technical working committee would also review the latest best practices regarding left-turn phase selection at signalized intersections. The objective of the committee will be to work with the RSAC representatives to determine a common method for left-turn phase selection in the NCTCOG member jurisdictions for consistency and to meet driver expectancy.	NCTCOG	Up to 12 months
2. Identify and secure funding	NCTCOG / TxDOT / Localities	6 to 12 months
3. Develop guidelines for District review of signal intersections with crashes above the crash threshold to re-time traffic signals for coordination and change intervals consistent with policy; and option to include additional signal heads to each lane and evaluate left-turn lane phasing.	TxDOT	1 month
4. Establish field review teams (District Office Traffic Engineering Operations and/or Safety Engineer and/or consultant) to determine appropriate optional improvements, determine means to implement (department forces, new District-wide contract), and prepare appropriate contract plans.	TxDOT	3 months
5. Train team on guidelines, field review requirements, and contract plan preparation.	TxDOT	6 months
6. Establish a monitoring and tracking system to ensure that improvements at intersections are properly identified and implemented.	TxDOT	9 months
7. Commence and complete field reviews of first phase of intersections, identify intersections where optional improvements are appropriate, identify which Districts will implement using department forces, and prepare statewide or area contract plans for remaining work.	TxDOT	12 months
8. Let contracts (if applicable) and implement improvements.	TxDOT	24 months
9. Using lessons learned, identify next phase of intersection reviews, and repeat steps 7 and 8. Repeat as necessary based upon safety data review.	TxDOT	30 months (Phase II step 7); 42 months (Phase II step 8); 48 months (Phase III step 7); 60 months (Phase III step 8)

Options

In addition to the basic package of countermeasures, additional individual countermeasures can be considered to address certain crash types at select intersections that have a severe crash frequency higher than the threshold.

- **Option 2A: Install signal back plates and/or additional signal head per approach.** This countermeasure may be appropriate for signalized intersections with a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see traffic signals sufficiently in advance to safely negotiate the intersection. Visibility of traffic signals may be obstructed by physical objects, or may be obscured by weather conditions. Also, a driver's attention may be focused on other objects at the intersection, such as signs. This visual clutter can make it difficult for the driver to extract the information from the signs required to execute the driving task. Poor visibility of signals may result in vehicles not being able to stop in time for a signal change. Providing adequate visibility of signals also aids in drivers' advance perception of the upcoming intersection. The FHWA *Older Driver Highway Design Handbook* should be consulted to ensure that improvements to visibility of traffic control devices will be adequate for older drivers. Installing back plates and/or additional signal heads provides additional visibility to the motorist to make safer decisions.

- **Option 2B: Evaluate left-turn phasing for flashing yellow left-turns, protected only left-turns, or split phasing.** One major crash pattern that needs to be addressed individually is signalized intersections with a significant number, or potential for, left-turn, opposing-flow crashes. A potential change at these intersections is to modify the left-turn signal phase from permitted-protected to protected. This can be considered for intersections with high numbers of left-turn, opposing flow crashes, three or more opposing approach lanes, or high opposing volumes with few acceptable turning gaps. Signalized intersections with a high frequency of angle crashes involving left-turning and opposing through vehicles are prime candidates for review. A properly timed protected left-turn phase can also help reduce rear-end and sideswipe crashes between left-turning vehicles and the through vehicles behind them. This option includes using flashing yellow arrows, protected left-turn phases, and split phases. A two-phase signal is the simplest method for operating a traffic signal, but multiple phases could improve safety. Left-turns are widely recognized as the highest-risk movements at signalized intersections.

    - Flashing Yellow Arrow (FYA) control has been demonstrated to have less probability for driver mistakes and can use the most optimal type of control, depending on traffic conditions, to keep vehicles moving safely during heavy traffic while reducing delay when traffic is light. This flexibility allows FYA to be used in places where the more restrictive protected left-turn signal would have otherwise been required.

- Protected left-turn phases significantly improve the safety for left-turn maneuvers by removing conflicts with the left-turn.
- Split phasing, which provides individual phases for opposing approaches, could improve intersection safety but increases the overall delay and should be used cautiously.

Locally Maintained Signalized Intersections:

1. LOCALLY MAINTAINED SIGNALIZED INTERSECTIONS: BASIC SET OF SIGN AND MARKING IMPROVEMENTS

Description

This implementation package involves the installation of a basic set of signing and marking improvements that are low-cost, designed to lower the potential of future crashes, and are to be applied predominantly at multi-lane approach, locally maintained, signal-controlled intersections in urban areas with severe crashes.

Since the level of effort to obtain Federal funds for multiple low-cost improvements on local roads and transfer them to local governments may exceed the costs of the low-cost improvements, the State initiative may include the following:

- An assessment of the potential for manufacturing the appropriate signs by the State Sign Shop using 100 percent Federal funds for local use at the designated intersections.
- Distribution of information on the high-crash intersection locations to appropriate local governments and guidance on low-cost sign and marking enhancements to reduce future crash potential.
- Coordination and facilitation of local government training, either by the Local Technical Assistance Program (LTAP) or the FHWA Resource Center, on the application of low-cost countermeasures at high-crash intersections.

Basic enhancements considered for improvement at signal-controlled intersections are illustrated in Figure 3-1 and include the following:

- Enhanced crosswalks.
- Stop bars.
- Lane control arrows.
- Longitudinal lines marking intersection influence area.
- Regulatory signs (e.g. No Left Turn, No U-Turn, etc.)
- Oversize street name signs.
- Advance cross street name signs for approaches with speed limits greater than 45MPH

The methodology utilized to determine where the basic set of sign and marking improvements should be considered is summarized in Appendix A.

Key Implementation Steps

Table 3-1 lists the key steps necessary for implementing this countermeasure package and realizing the full safety benefits of the improvements. The table also includes the organizations responsible for each key step and the implementation schedule.

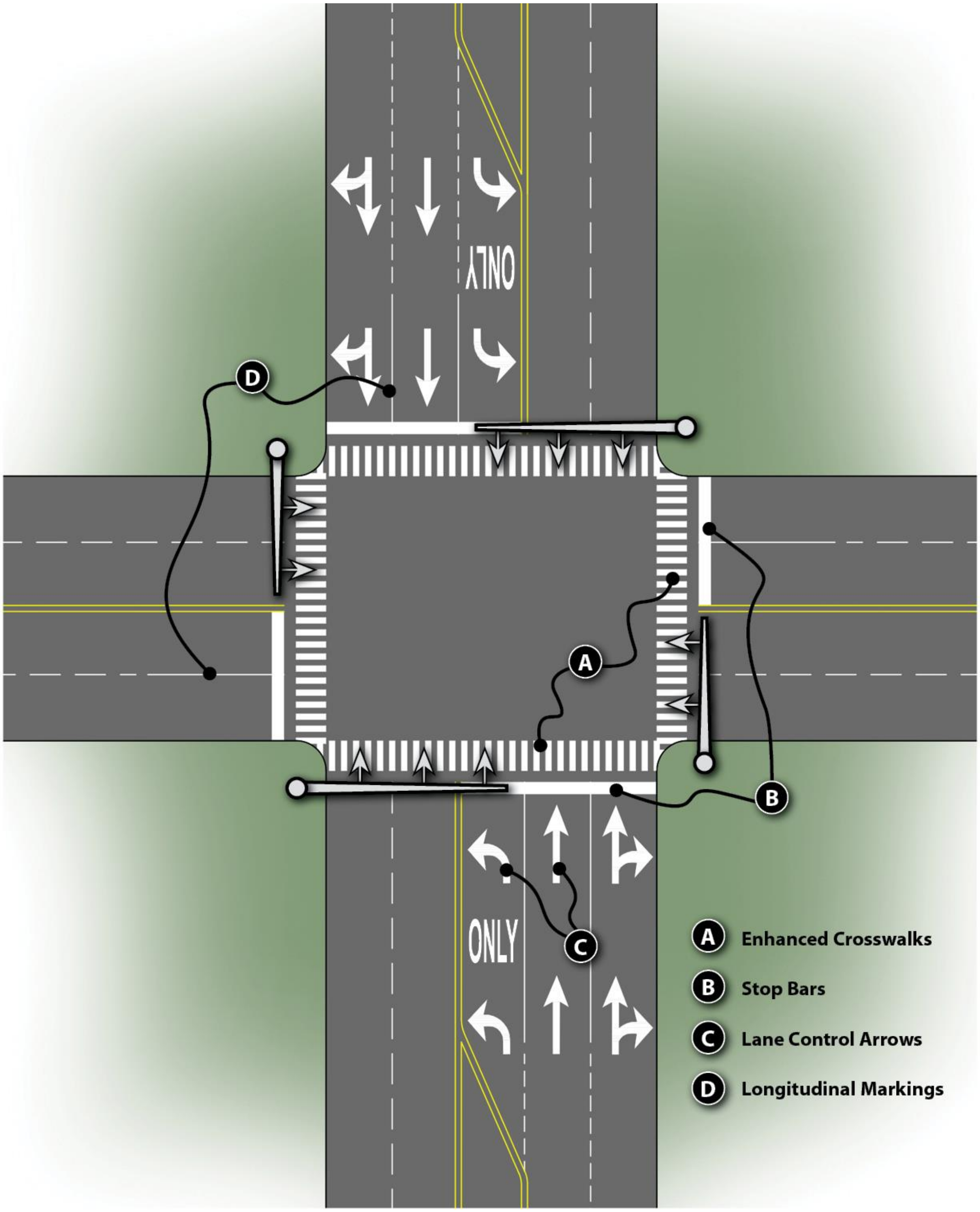


Figure 3-1. Examples of basic low-cost countermeasures for signal-controlled intersections – enhanced crosswalks, stop bars, lane control arrows, longitudinal lines marking intersection influence area, regulatory signs, and oversize street name signs.

Table 3-1. Key Implementation Steps for Basic Set of Sign and Marking Improvements – Local Signal-Controlled Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Identify and secure funding.	NCTCOG / TxDOT / Localities	6 months – 12 months
2. Develop guidelines for local government review of signal-controlled intersections with crashes above the crash threshold, including: basic set of upgraded signs and markings; and option to include advance intersection warning signs.	Localities	1 month
3. Perform an assessment of benefits, disadvantages, complexities, and issues associated with producing signs using 100 percent Federal safety funds to provide to locals for installation at high-crash local intersections.	Localities	1 month (assessment completed); 2 months (decision to provide signs); 3 months (additional requirements, if any, added to guidelines).
4. Estimate the number of local governments that will need training based upon the high-crash intersection data. Determine the type of training needed for implementing the improvements. Assess the availability, capability, and capacity of LTAP, FHWA Resource Center, or other sources to provide the training.	Localities / NCTCOG	4 months
5. Provide crash data; guidelines for sign and marking improvements; information on availability of signs for designated intersections to municipalities (if appropriate); and training schedule and location for local governments.	Localities / NCTCOG	6 months
6. Train local teams on guidelines; field review requirements; improvement determination; and sign, marking installation.	Localities	9 months
7. Establish a monitoring and tracking system to ensure that improvements at local intersections are properly identified and implemented.	Localities	12 months
8. Localities commence and complete field reviews of first phase of intersections, identify intersections where optional improvements are appropriate, identify which method localities will implement improvements using local or State forces, prepare statewide or area contract plans for remaining work.	Localities	12 months
9. Let contracts (if applicable) and implement improvements.	Localities / NCTCOG	24 months
10. Using lessons learned, identify next phase of intersection reviews, and repeat steps 8 and 9. Repeat as necessary based upon safety data review.	Localities	30 months (Phase II step 8); 42 months (Phase II step 9); 48 months (Phase III step 8); 60 months (Phase III step 9)

Options

In addition to the basic package of countermeasures, additional individual countermeasures can be considered to address certain crash types at select intersections that have a severe crash frequency higher than the threshold.

Option 3A: Advance intersection-warning signs for signalized intersections. As shown in Figure 3-2, advance "Signal Ahead" oversize warning signs for isolated traffic signals or intersections are appropriate where the signal heads are not readily visible due to alignment or sight distance obstructions. A technical working committee reporting to RSAC representatives can develop appropriate installation criteria to promote consistency throughout the region.

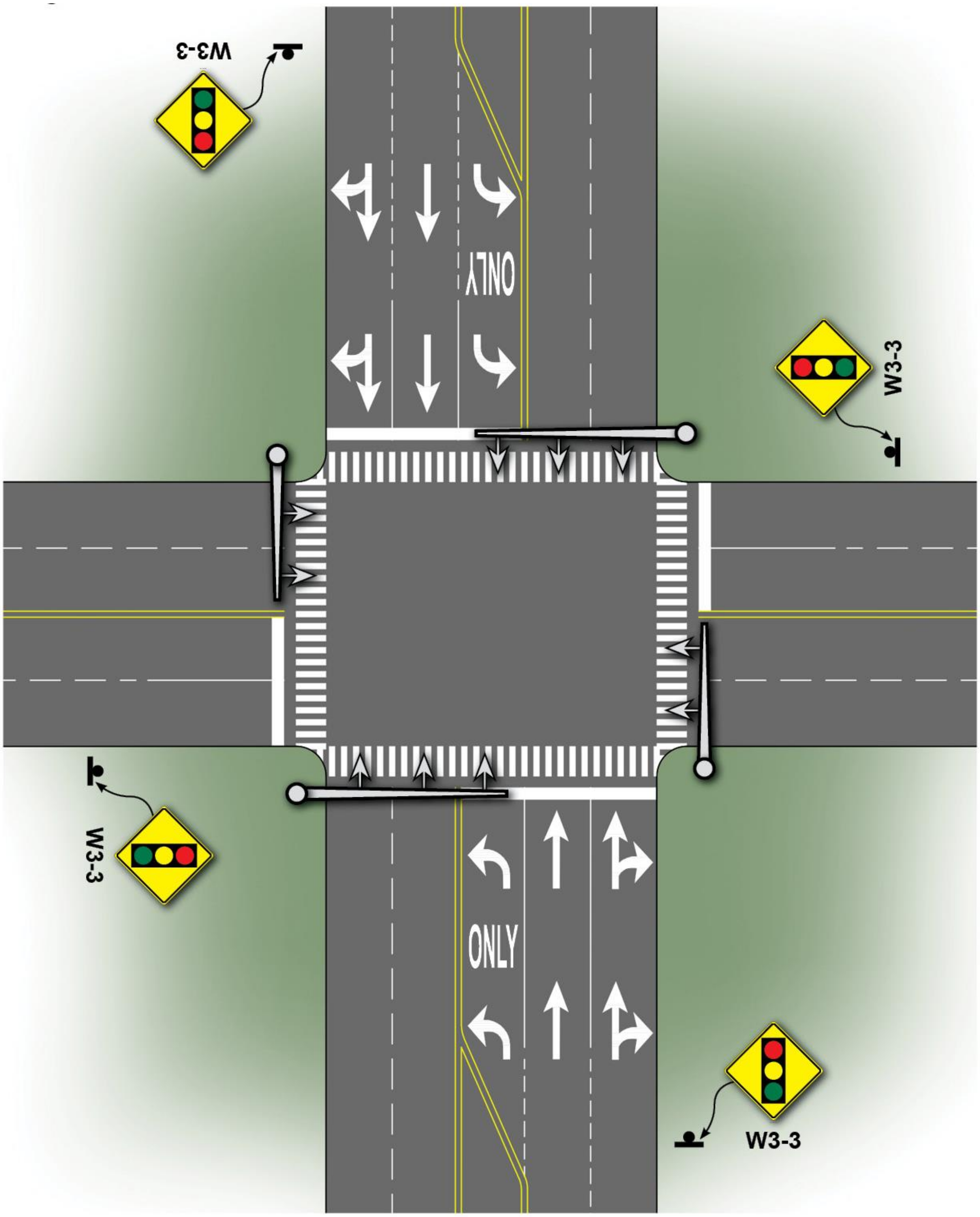


Figure 3-2 Example of an optional low-cost countermeasure for signalized intersections: advance signal ahead warning signs.

2. LOCALLY-MAINTAINED SIGNALIZED INTERSECTIONS: RE-TIME TRAFFIC SIGNALS FOR BETTER COORDINATION AND FOR PROPER RED AND YELLOW CHANGE INTERVALS

Clearance intervals provide safe, orderly transitions in right-of-way assignment between conflicting streams of traffic. Clearance intervals always include a yellow change interval and, in most cases, an all-red clearance interval.

Clearance intervals are a function of operating speed, the width of the intersection area, lengths of vehicles, and driver operational parameters such as reaction, braking, and decision-making time. The Institute of Transportation Engineers (ITE) has developed an equation for determining the length of the clearance interval.

Clearance intervals that are too short in duration (compared to the ITE method or NCHRP research) can contribute to rear-end crashes related to drivers stopping abruptly and right-angle crashes resulting from signal violations. In the extreme, a too short interval can result in drivers operating at the legal speed limit being forced to violate the red phase.

Establishment of a policy for determining clearance interval duration is necessary to provide consistency throughout each jurisdiction within NCTCOG.

NCHRP 731 Guidelines for Timing Yellow and Red Intervals at Signalized Intersections was released in October 2012. A summary statement on the new guidelines provides an excellent point:

> "One of the precepts on the use of all traffic control devices is that they be applied uniformly so that drivers can expect to experience the same device and its operation throughout their travels, within and outside of their jurisdiction. This would pertain to the timing of the yellow change and red clearance intervals. To maintain this precept, the recommended guideline strives to achieve national acceptance for a uniform practical application. The guideline is succinct in scope and requires little user interpretation. As such, it provides a solid framework based on research and accepted practice that can be easily adopted into State or local transportation agency practice."

Key Implementation Steps

The key steps necessary to fully implement this initiative and realize the safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 4-1.

Table 4-1. Key Implementation Steps for Retiming Traffic Signals – Locally-maintained Signalized Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Form a technical working committee to review the latest research on intervals for signalized intersections. The objective of the committee will be to work with the RSAC representatives to determine a common method for intervals in the NCTCOG member jurisdictions for consistency and to meet driver expectancy. This technical working committee would also review the latest best practices regarding left-turn phase selection at signalized intersections. The objective of the committee will be to work with the RSAC representatives to determine a common method for left-turn phase selection in the NCTCOG member jurisdictions for consistency and to meet driver expectancy.	NCTCOG	Up to 12 months
2. Identify and secure funding.	NCTCOG / TxDOT / City	6 to 12 months
3. Develop guidelines for local government review of signalized intersections with crashes above the crash threshold to re-time traffic signals for coordination and change intervals consistent with policy; and option to include additional signal heads to each lane and evaluate left-turn lane phasing.	Localities	1 month
4. Perform an assessment of benefits, disadvantages, complexities, and issues associated with retiming signals and other options available in this countermeasure package using 90 to 100 percent Federal safety funds at high-crash signal-controlled local intersections.	Localities	1 month (assessment completed); 2 months (decision); 3 months (additional requirements, if any, added to guidelines).
5. Estimate the number of local governments that will need training based upon the data analysis. Determine the type of training needed for implementing the improvements. Assess the availability, capability, and capacity of LTAP, FHWA Resource Center, or other sources to provide the training.	Localities / NCTCOG	4 months
6. Provide data analysis results; guidelines for signal retiming, and signal visibility; information on availability of services for designated intersections to municipalities (if appropriate); and training schedule and location for local governments.	Localities / NCTCOG	6 months
7. Train local team on guidelines; field review requirements; improvement determination and installation.	Localities	9 months
8. Establish a monitoring and tracking system to ensure that improvements at local intersections are properly identified and implemented.	NCTCOG	12 months

Table 4-1. (Cont.) Key Implementation Steps for Retiming Traffic Signals – Locally-maintained Signalized Intersections		
Step	**Organization Responsible for Step**	**Completion Date (Months After Implementation Plan Acceptance)**
9. Localities commence and complete field reviews of first phase of intersections, identify intersections where optional improvements are appropriate, identify which method localities will implement improvements using local or State forces, prepare statewide or area contract plans for remaining work.	Localities	12 months
10. Let contracts (if applicable) and implement improvements.	Localities / NCTCOG	24 months
11. Using lessons learned, identify next phase of intersection reviews, and repeat steps 9 and 10. Repeat as necessary based upon safety data review.	Localities	30 months (Phase II step 9); 42 months (Phase II step 10); 48 months (Phase III step 9); 60 months (Phase III step 10)

Options

In addition to the basic package of countermeasures, additional individual countermeasures can be considered based upon higher frequencies of crashes beyond the crash threshold for basic countermeasures or at intersections that have specific crash types that the countermeasure can address.

- **Option 4A: Install Signal Back plates and/or additional signal head per approach.** Signalized intersections with a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see traffic signals sufficiently in advance to safely negotiate the intersection being approached. Lack of visibility of traffic control devices may contribute to crash experience at signalized intersections. Visibility of traffic signals may be obstructed by physical objects or may be obscured by weather conditions. Also, a driver's attention may be focused on other objects at the intersection, such as signs. This visual clutter can make it difficult for the driver to extract the information from the signs required to execute the driving task. Poor visibility of signals may result in vehicles not being able to stop in time for a signal change. Providing adequate visibility signals also aids in drivers' advance perception of the upcoming intersection. The FHWA *Older Driver Highway Design Handbook* should be consulted to ensure that improvements to visibility of traffic control devices will be adequate for older drivers. Installing back plates or additional signal heads provides additional visibility to the motorist to make safer decisions.

- **Option 4B: Evaluate left-turn phasing for flashing yellow left-turns, protected only left-turns, or split phasing.** One major crash pattern that needs to be addressed individually is signalized intersections with a significant number or potential for left-turn, opposing-flow crashes. At these traffic signals the potential change is to modify the signal phase from permitted and protected left-turn phases to protected-only. This can be considered for intersections with high numbers of left-turn, opposing flow crashes, three or more opposing approach lanes, or high opposing volumes with few acceptable turning gaps. Signalized intersections with a high frequency of angle crashes involving left-turning and opposing through vehicles are prime candidates for review. A properly timed protected left-turn phase can also help reduce rear-end and sideswipe crashes between left-turning vehicles and the through vehicles behind them. This option includes using flashing yellow arrows, protected left-turn phases, and split phases. A two-phase signal is the simplest method for operating a traffic signal, but multiple phases could improve safety. Left-turns are widely recognized as the highest-risk movements at signalized intersections.

    - Flashing Yellow Arrow (FYA) Control has been demonstrated to have less probability for driver mistakes and can use the most optimal type of control depending on traffic conditions to keep traffic flow moving safely during heavy traffic while reducing delay when traffic is light. This flexibility allows FYA to be used in places where the more restrictive protected left-turn signal would have otherwise been required.
    - Protected left-turn phases significantly improve the safety for left-turn maneuvers by removing conflicts with the left-turn.
    - Split phasing, which provides individual phases for opposing approaches, could improve intersection safety but increases the overall delay and should be used cautiously.

Conclusion
NCTCOG's safety culture created a proactive vision to develop an ISIP. This is one critical step to achieving RSAC's intersection safety goals. With the appropriate level of resources allocated and steady leadership, serious injuries and fatalities can be addressed systemically on identified State and locally-maintained intersections. Through innovative regional partnerships and following the state-of-practice in highway safety, intersection safety can improve for the entire NCTCOG region.

Contact Information

NCTCOG
616 Six Flags Drive
P.O. Box 5888
Arlington, TX 76005-5888
(817) 640-3300

Sonya Landrum
slandrum@nctcog.org
817-695-9273

Jory Dille
jdille@nctcog.org
817-704-5644

Camille Fountain
cfountain@nctcog.org
817-704-2521

This page is intentionally blank

Appendix A

ANALYSIS OF NORTH CENTRAL TEXAS

The North Central Texas Council of Governments (NCTCOG) serves a 16-county region of North Central Texas, centered around the cities of Dallas and Fort Worth. The VHB team analyzed severe intersection crashes trends occurring within the NCTCOG study area during the five-year period from 2006 to 2010 to guide the development of NCTCOG's Intersection Safety Implementation Plan (ISIP). During the analysis period, 215,043 crashes (or 42 percent) of the 510,692 crashes occurred at intersections.

VHB analyzed the NCTCOG intersection crashes both at the regional level and at the intersection level. The analysis at the regional level revealed large-scale trends in intersection crashes within the NCTCOG study area. The intersection-level analysis prioritized intersections based on various roadway and crash criteria. The following sections describe each type of analysis.

Regional Analysis

The estimated 2012 population for the NCTCOG Region is 6,640,290 *(1)*. NCTCOG has over 230 member governments including 16 counties, numerous cities, school districts, and special districts.

Figure 1 depicts the estimated population density by census tract in 2030. Table 1 depicts the top ten jurisdictions with the highest population totals. These ten jurisdictions comprise over 60 percent of the population of NCTCOG with the largest population change occurring in McKinney, Fort Worth, and Grand Prairie.

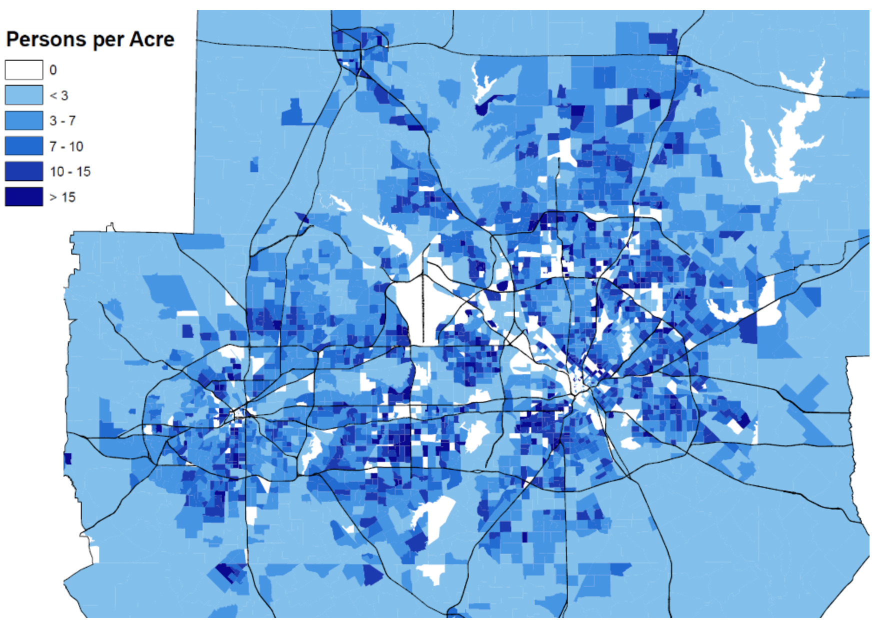


Figure 1. 2030 Population Density Estimates for NCTCOG by Census Tract *(2)*.

Table 1. Top Ten NCTCOG Jurisdictions by Population *(3)*

City	2000	2010	Population Change	Percent Change	Percent NCTCOG Population
Dallas	1,188,580	1,197,816	9,236	0.80%	20%
Fort Worth	534,694	741,206	206,512	38.60%	12%
Arlington	332,969	365,438	32,469	9.80%	6%
Plano	222,030	259,841	37,811	17.00%	4%
Garland	215,768	226,876	11,108	5.10%	4%
Irving	191,615	216,290	24,675	12.90%	4%
Grand Prairie	127,427	175,396	47,969	37.60%	3%
Mesquite	124,523	139,824	15,301	12.30%	2%
McKinney	54,369	131,117	76,748	141.20%	2%
Carrollton	109,576	119,097	9,521	8.70%	2%
Top Ten Percentage of Total NCTCOG Population					60%

While many of the same top ten jurisdictions for population appear in the top ten jurisdictions for severe crashes, there are two jurisdictions, Denton and Richardson, which are overrepresented for severe intersection crashes. Severe crashes are those coded as K, A, or B on the KABCO injury scale. **"KABCO" Injury Scale** is frequently used by law enforcement for classifying injuries and also can be used for establishing crash costs. (K – Fatal; A – Incapacitating injury; B – Non-incapacitating injury; C – Possible injury; and O – No injury.) Of note, while 60 percent of the population is concentrated in the ten jurisdictions shown in Table 1, only 26 percent of the severe intersection crashes are in the ten jurisdictions shown in Table 2. This is a counterintuitive finding. Typically, severe intersection crashes follow population. For instance, Dallas has 20 percent of the NCTCOG population; yet only nine percent of the severe intersection crashes. It appears the NCTCOG study area has a more dispersed severe intersection crash challenge.

Table 2. Top Ten NCTCOG Jurisdictions by Severe Intersection Crashes

Top Ten Jurisdiction	Severe Crashes (KAB)	Percent of Total KAB
Dallas	3,030	9%
Fort Worth	2,140	6%
Arlington	824	2%
Plano	585	2%
Garland	516	2%
Denton	329	1%
Mesquite	311	1%
Grand Prairie	304	1%
Irving	285	1%
Richardson	282	1%
Top Ten Percentage of Total Severe Crashes		26%

The Texas Department of Transportation (TxDOT) maintains 26 percent of the over 300,000 miles of roadways in Texas, which carries approximately 75 percent of the vehicle miles traveled. Within the NCTCOG study area, several surface transportation systems *(4)* work in concert to support the regional economy, including:

- 750 centerline miles of freeways.
- 62 centerline miles of toll roads.
- 50 miles of high occupancy vehicle lanes.
- 1,754 miles of regional arterials.
- 45 miles of light rail transit.
- 35 miles of commuter rail transit.

The distribution of roadways by functional classification and classified by rural or urban roads is presented in Table 3. Over 40 percent of the total network is classified as urban arterial or collector roads. Approximately 52 percent of the total mileage in NCTCOG is classified as rural, leaving 48 percent classified as urban.

Table 3: Rural and Urban Centerline Miles by Functional Classification from TxDOT FFCS GIS Data (2008)

Land Use	Arterials / Collectors	Local Roads	Total
Rural	3,315	6,666	9,981
Urban	8,195	1,021	9,216
Total	**11,510**	**7,687**	**19,197**

Table 4 presents the distribution of intersection crashes by severity from 2006 through 2010, the period of this analysis. Severe intersection crashes (those crashes resulting in an injury severity of fatal, incapacitating injury, or non-incapacitating injury) decreased from 2006 to 2010; however, the percentage of severe crashes remained constant at between 16 to 18 percent.

Table 4. Approximate Number of Intersection Crashes by Severity and by Year

Year	K	A	B	C	O	Unknown	Total	KAB Total	% KAB
2006	156	1,342	5,856	12,101	26,397	1,314	47,166	7,354	16%
2007	174	1,333	6,039	12,017	22,387	935	42,885	7,546	18%
2008	157	1,276	5,834	11,003	22,901	882	42,053	7,267	17%
2009	125	1,191	5,619	11,379	23,600	1,017	42,931	6,935	16%
2010	92	1,215	5,414	9,831	22,779	677	40,008	6,721	17%
Total	704	6,357	28,762	56,331	118,064	4,825	215,043	35,823	17%

The total cost of intersection crashes in NCTCOG is estimated to be $11.6 billion over a five-year period or $2.3 billion annually *(*5*)*. Severe intersection crashes accounted for 17 percent of all intersection and intersection-related crashes, and 77 percent of the total cost of intersection crashes in NCTCOG. Severe crashes are those coded as K, A, or B on the KABCO injury scale. Since the majority of the cost is comprised of severe intersection crashes, the intersection-level analysis in the following section addresses only severe crashes. The severe crashes represent an opportunity to focus the countermeasure packages.

Intersection-Level Analysis

The intersection analysis focused on the severe crashes as they constitute the majority of the total cost of intersection crashes in the region. Crash data were used as the primary data source to classify and analyze intersections. NCTCOG does have an intersection database, but it currently only includes signalized intersections. Without knowing where the severe crashes are concentrated (e.g., rural intersections, stop-controlled intersections, etc.), the analysis team used the crash data as the starting point to extract and interpolate intersection locations and characteristics.

Crash data, however, do have limitations. Only the severe crashes that could be assigned to an intersection are included in this portion of the analysis as it is an intersection-level analysis. There are likely other intersections in NCTCOG that are not included in this analysis either because there were no crashes reported at the intersections during the five-year period, or because the crashes occurring at the intersections were reported with insufficient location information. More discussion on assigning crashes to intersections is provided in the *Analysis Methodology* section.

Analysis Methodology

Assigning Crashes to Intersections

NCTCOG does not currently have an intersection database of all intersections in the region, so the analysis team manually developed an intersection inventory. For the purpose of this analysis, only fatal and severe injury crashes coded as intersection or intersection-related were used to develop the inventory. Each intersection that experienced one or more crashes in the five-year period fitting these conditions was assigned a unique eight-digit intersection identification number. The first three digits of the identification number represent the county where the crash occurred. The remaining five digits were sequentially assigned in alphabetical order by intersecting street.

During the 2006 through 2010 analysis period there were 35,823 fatal and serious injury intersection and intersection-related crashes in NCTCOG. Approximately seven percent (2,620) of these crashes were not assigned an intersection identification number. This was due to limited information from the crash data such as an intersecting street listed as “unknown” or “not reported.” The remaining crashes (33,203) were assigned an intersection ID, resulting in 15,008 identified intersections in the NCTCOG region with at least one fatal or serious injury crash.

Characterizing Intersections

The intersections identified were characterized using the police-reported crash data. The intersections were characterized by traffic control, intersection type (i.e., number of legs) and area type.

The traffic control at each of these intersections was estimated as signalized or non-signalized based on the police reported crash data. If one or more crashes at the intersection are coded as "traffic signals" in the crash data, the intersection is considered signalized. All other intersections are considered non-signalized. This method is described as estimating the traffic control at the intersection because this field in the crash data has some unreliability as the officer is reporting the control under which crash-involved vehicles were operating, not necessarily the traffic control for the intersection. It likely underestimates the occurrence of signalized control.

Approximately 30 percent of the intersections had at least one associated crash with area type coded on the crash report. For these intersections, the crash report area type was used to classify area type for that intersection. For the remaining 70 percent of intersections, roadway data were used to classify the area type; however, this was only done for signalized intersections. (More discussion will follow on why the analysis focused on signalized intersections). Both the crash data and roadway data distinguish various sizes of urban areas. To simplify the analysis, the different urban classifications were grouped together to classify each intersection area type as rural, urban, or unknown.

Prioritizing Intersections

The Excel file presents a summary of the fatal and severe injury crashes at each intersection. The data are provided in this format to allow for maximum flexibility in interpreting the results and targeting improvements. The following information is presented in each worksheet:

- Location identification information including intersection ID, street names, city, and county.
- Intersection characteristics including:
    - Intersection type.
    - Traffic control.
    - Area type.
- Total fatal and severe injury crashes (injury severity K, A, or B) occurring at the intersection from 2006 through 2010.
- Crash characteristics (fatal and severe injury only) including:
    - Total daylight crashes (including daylight, dawn, and dusk).
    - Total dark crashes.
    - Total dark but street lit crashes.
    - Total poor surface condition crashes (including wet, standing water, snow, slush, ice, and sand/mud/dirt).
    - Total adverse weather condition crashes (including rain, sleet/hail, snow, fog, blowing sand/snow, and severe crosswinds).
    - Total crashes by crash type (angle, rear-end, opposite direction, same direction, single-vehicle, other, and unknown).

Each worksheet includes filters that can be used to isolate conditions (e.g., only signalized intersections) for prioritization.

Analysis of the Results

The distribution of severe crashes by area type and traffic control is presented in Table 5 for the identified intersections. The severe crashes at signalized intersection are overrepresented. Signalized intersections make up 34 percent of the intersections with at least one fatal or severe injury crash; however, 58 percent of those crashes occur at signalized intersection.

Table 5: Distribution of Severe Intersection Crashes by Traffic Control and Area Type for the Identified Intersections

Traffic Control	Area Type	KAB Crashes	% of KAB Crashes	Intersections	% of Intersections
Signalized	Rural	411	1%	170	1%
	Urban	17,908	54%	4,740	32%
	Unknown	928	3%	215	1%
Non-Signalized	Rural	1,157	3%	782	5%
	Urban	3,445	10%	1,881	13%
	Unknown	9,353	28%	7,220	48%
Total		33,202	100%	15,008	100%

Breaking the analysis down further, Table 6 represents the distribution of intersection crashes by area type, intersection type (i.e. number of legs), and traffic control for the identified intersections with fatal and severe crashes. The intersection types with an over-representation of crashes (i.e. a greater percent of crashes compared to the percent of intersections) include:

- Urban, 3-leg, signalized.
- Urban, 4-leg, signalized.
- Unknown area type, 4-leg, signalized.

Urban, 4-legged, signalized intersections by far represent the largest number of severe intersection crashes (50 percent), while only comprising 28 percent of the identified intersections. Based on the information presented in Table 5 and Table 6, focused systemic solutions could be narrowed to ***urban signalized intersections***. These intersections comprise 32 percent of the total number of intersections with severe crashes; yet, they account for 54 percent of the fatal and severe injury crashes.

Table 6: Distribution of Severe Intersection Crashes by Area Type, Intersection Type, and Traffic Control for the Identified Intersections

Area Type	Intersection Type	Traffic Control	KAB Crashes	% of KAB Crashes	Intersections	% of Intersections
Rural	3 Legs	Signalized	48	0%	21	0%
		Non-Signalized	604	2%	406	3%
	4 Legs	Signalized	347	1%	137	1%
		Non-Signalized	432	1%	261	2%
	Multi-Leg	Signalized	0	0%	0	0%
		Non-Signalized	0	0%	0	0%
	Other/Unknown	Signalized	16	0%	12	0%
		Non-Signalized	122	0%	116	1%
Urban	3 Legs	Signalized	833	3%	373	2%
		Non-Signalized	1,262	4%	782	5%
	4 Legs	Signalized	16,724	50%	4,185	28%
		Non-Signalized	1,706	5%	809	5%
	Multi-Leg	Signalized	6	0%	6	0%
		Non-Signalized	0	0%	0	0%
	Other/Unknown	Signalized	345	1%	176	1%
		Non-Signalized	477	1%	290	2%
Unknown	3 Legs	Signalized	93	0%	25	0%
		Non-Signalized	3,169	10%	2,656	18%
	4 Legs	Signalized	826	2%	184	1%
		Non-Signalized	5,269	16%	3,707	25%
	Multi-Leg	Signalized	0	0%	0	0%
		Non-Signalized	7	0%	7	0%
	Other/Unknown	Signalized	9	0%	6	0%
		Non-Signalized	908	3%	849	6%
Total			33,203	100%	15,008	100%

The cumulative distribution of crashes is important for targeting the deployment of strategies. As shown in Table 7, 1,522 intersections out of the total 15,008 intersections reviewed, or approximately the top ten percent, had five or more severe crashes over the five-year period analyzed and comprised 40 percent of the severe intersection crashes. This is the best opportunity observed to reduce a large percent of severe crashes by targeting a select group of intersections.

Table 7: Distribution of Intersections with Five or more KAB Crashes in 5-year Period

Area Type	Intersection Type	Traffic Control	KAB Crashes	% of KAB Crashes	Intersections	% of Intersections
Rural	3 Legs	Signalized	12	0%	2	0%
		Non-Signalized	68	1%	10	1%
	4 Legs	Signalized	146	1%	19	1%
		Non-Signalized	64	0%	10	1%
Urban	3 Legs	Signalized	236	2%	35	2%
		Non-Signalized	149	1%	22	1%
	4 Legs	Signalized	10,688	81%	1,176	77%
		Non-Signalized	486	4%	69	5%
	Other/Unknown	Signalized	130	1%	14	1%
		Non-Signalized	131	1%	12	1%
Unknown	3 Legs	Signalized	59	0%	9	1%
		Non-Signalized	96	1%	16	1%
	4 Legs	Signalized	563	4%	63	4%
		Non-Signalized	389	3%	64	4%
	Other/Unknown	Signalized	0	0%	0	0%
		Non-Signalized	13	0%	1	0%
Total			**13,230**	**100%**	**1,522**	**100%**

Conclusions and Next Steps

The methodology utilized to identify the best systemic approach ties directly to the goals of Texas' Strategic Highway Safety Plan *(6)*, which strives to reduce the number of fatal and serious injury intersection-involved crashes by 10 percent and to "identify and implement systemwide, corridor, and location-specific best practices for improving safety and develop an approach to guide investment decisions." The selected approach falls within the principles outline in the SHSP to be data driven and utilize best practices. As the intersection inventory improves, this approach can be modified to better identify ownership responsibilities, better define traffic control, and encompass all public roadways.

The SHSP identifies intersections as a critical emphasis area and this approach will assist with meeting milestones in the following performance measures:

- Implement engineering solutions to reduce red-light running, such as changes in signal timing (i.e., longer yellow, all-red phase, etc.).
- Eliminate limited sight distance on all roads. This includes high speed rural intersection and urban intersection where there are sight distance limitations due to vegetation, signing and other obstructions.
- Enhance advanced warning at intersections through the use of signing and textured pavements.

From the preliminary analysis, the project team proposes that the best systemic approach is to target the severe intersection crashes. The severe crashes comprise 77 percent of the total cost of intersection crashes. Analyzing the severe crash intersections further reveals the top intersection type as all ***urban***

signalized intersections. These intersections comprise 4,740 intersections, or 32 percent of all the intersections analyzed, and combine for over 17,900 severe crashes or 54 percent of the total severe intersection crashes.

In order to better focus the systemic approach in the Dallas – Fort Worth region, the project team recommends looking at a subset of the urban signalized intersections. Of the 15,008 intersections analyzed, there were 1,522, or 10 percent, that had five or more severe crashes. These intersections accounted for 13,320 severe crashes, or 40 percent of the total severe intersection crashes. The recommended subset of selected intersections (all urban signalized intersections with more than five KAB crashes) would focus systemic measures on 1,225 or eight percent of the 15,008 intersections reviewed. The subset of intersections listed above will address 11,054 severe crashes, or 84 percent of the severe crashes occurring at intersections with five or more severe crashes.

Based upon feedback from NCTCOG and FHWA, the project team will continue to develop and refine a number of countermeasure packages. These packages will be presented in a straw man outline.

References

1. "2012 Population Estimates," North Central Texas Council of Governments, Arlington, Texas, March 2012, <http://www.nctcog.org/ris/demographics/population/2012PopEstimates.pdf>
2. "2030 Forecast Population Density," North Central Texas Council of Governments, Arlington, Texas, <http://www.nctcog.org/trans/sustdev/demographics/2030%20Forecast%20Population%20Density.pdf>
3. "Census Population by City, 1970-2010," North Central Texas Council of Governments, Arlington, Texas, February 2011, <http://www.nctcog.dst.tx.us/ris/census/2010/City_Pop_1970_2010.pdf>
4. " Congestion Management Processes: Section I – Overview of the Dallas-Fort Worth Congestion Management Process (CMP)," North Central Texas Council of Governments, Arlington, Texas, <http://www.nctcog.org/trans/cmp/SECTION1-CMPOverview.pdf>
5. Memorandum from Polly Trottenberg, Assistant Secretary for Transportation Policy to Secretarial Officers and Modal Administrators, "Treatment of the Economic Value of a Statistical Life in Departmental Analyses – 2011 Interim Adjustment." Dated July 29, 2011.
6. "Texas Strategic Highway Safety Plan," Texas Department of Transportation, Austin, Texas,